St. Marys Flood Resiliency Project

Final Report

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Authors: Jill Gambill, Madeleine Russell, Kelly Spratt, Jessica Whitehead, Marianna Alfonso, Charles S. Hopkinson, Jason M. Evans

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Administered by the National Oceanic and Atmospheric Administration (NOAA), Sea Grant conducts research, outreach and education in 33 coastal and Great Lakes states.

Acknowledgements

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Executive Summary

Since 2013, the City of St. Marys has collaborated with Georgia Sea Grant, Stetson University, and North Carolina Sea Grant to engage in flood resiliency planning. The historic, low-lying community has already experienced approximately nine inches of sea-level rise since 1897, and this trend is expected to accelerate in the future. This project has paired local knowledge with academic expertise to analyze risks to the City's infrastructure and provide initial recommendations to manage flooding risks over the next 50 years. A model for other communities, this effort has grown to include other cities and counties throughout the U.S. southeast Atlantic region.

Participatory Research to Identify and Mitigate Flood Hazards

The project began with a series of stakeholder interviews, town hall public meetings, and facilitated discussion sessions that documented local knowledge about flood hazards in St. Marys. This participatory engagement process was based upon the Vulnerability, Consequences, and Adaptation Planning Scenarios (VCAPS) structural modeling approach. Results from the VCAPS process were then used to inform a series of custom geo-spatial vulnerability assessments that analyzed current and future flood risks to property and infrastructure under different sea-level rise scenarios.

The VCAPS process and geo-spatial assessments both indicated the high vulnerability of historic downtown St. Marys, which is located along the banks of the St. Marys River estuary, to current and future coastal flooding. While the most serious and acute flood risks in St. Marys are associated with storm surges from tropical cyclones, there are increasing concerns about more chronic flood events associated with intense rain storms that occur at or near high tide. Detailed analysis of the City's infrastructure indicates that the configuration of the stormwater drainage system, which was built many decades ago without any knowledge of long-term sea-level rise, is a major source of flood vulnerability. This vulnerability is expected to worsen as a direct function of sea-level rise unless the local stormwater infrastructure system is upgraded over time. Although there are substantial challenges, much of St. Marys flood vulnerability likely can be managed with appropriate planning and investments over the next several decades.

Community Rating System

A complementary objective of this project was for Georgia Sea Grant personnel to assist the City of St. Marys with its application to join the Federal Emergency Management Agency's (FEMA) Community Rating System (CRS). CRS is a voluntary FEMA program that rewards communities for exceeding minimum floodplain management standards, thereby improving public safety and economic stability within the community.

On May 1, 2016, St. Marys successfully joined CRS with a Class 7 score. This translates into a 15% reduction in National Flood Insurance Program premiums for properties located within the Special Flood Hazard Area. In the first year following this successful CRS application, it is estimated that City residents saved over $87,000 on their flood insurance premiums.

The unique model of Sea Grant personnel providing CRS assistance to a local government resulted in several outcomes of local, regional, and national interest.

- Documentation of public processes that educate and engage the public about the hazards of flooding, storm surge and sea-level rise can be used to strengthen a community's CRS application.
- The City of St. Marys and Camden County joined the Coastal Georgia CRS Users Group, an innovative partnership that allows for local governments and their floodplain managers to share best practices and lessons learned that strengthen local flood resiliency.
- The floodplain managers of Camden County and St Marys have collaborated to create **the state's first Program for Public Information (PPI)**, an outreach program designed to increase local awareness of flooding and coastal hazards.
- Georgia Sea Grant collaborated with the City of St Marys staff and Georgia Department of Natural Resources (DNR) to document and calculate the amount of **open space** within the city boundaries. CRS points are awarded for the amount of open space areas that are preserved, or in the process of becoming preserved, to their natural state.
- The City of adopted an ordinance requiring that all new construction have **two feet of freeboard**. Freeboard is elevating the lowest floor of a building, in this case houses, by a set additional height above the National Flood Insurance Program's minimum height requirements. This freeboard requirement provides added margins of safety to that can be expected to reduce damage to structures in the event of future flooding events.

Chapter I: Introduction

INTRODUCTION

The southeastern U.S. Atlantic coast is highly vulnerable to climate-related stressors such as hurricanes, extreme rainfall, extreme drought and sea-level rise. This region has also experienced exceptional growth in both population and the built environment over the past several decades and is expected to continue growing above the pace of other U.S. regions for the foreseeable future. Without appropriate planning for coastal hazards, an increasing number of people, property, infrastructure and natural systems in southeast U.S. coastal communities are likely to become vulnerable to climate-related risks.[1]

An increasing body of scientific knowledge and local observations indicate that sea-level rise is already impacting U.S. communities. Some of the most visible effects include flooding of low-lying roads during high tide events, inland movement of saltwater ecosystems, and increased erosion and flooding of waterfront areas during storm events. As these impacts and changes occur, more local governments within the coastal zone are initiating long-term resilience planning programs to help their communities better adapt to current and future conditions.[2]

AN INNOVATIVE PARTNERSHIP

In 2013, St. Marys was selected through a nationwide grant competition as one of five locations in the United States to undergo community resilience and adaptation planning. Funded by National Oceanic and Atmospheric Administration's (NOAA) National Sea Grant Program, the overall project was designed to assess and make initial recommendations for addressing local vulnerability to coastal flooding and sea-level rise over a 50-year horizon. Formal partners in this project included the City of St. Marys, Georgia Sea Grant, the University of Georgia, Stetson University and North Carolina Sea Grant. Additional technical assistance and collaboration was also provided by the St. Marys Earthkeepers, Camden County, Georgia Department of Natural Resources, Coastal Regional Commission of Georgia, and Ecological Planning Group, LLC. Students and faculty from the University of Georgia's Lamar Dodd School of Art and the College of Environment and Design also contributed to project outreach and implementation.

Conversations forming this collaboration began in February 2013, when the St. Marys Earthkeepers organized a public seminar on local vulnerabilities to sea-level rise. This event featured speakers from Georgia Sea Grant and attracted approximately 100 members of the local community, including several elected officials and local government staff. From these initial discussions, the St. Marys Earthkeepers built bridges between City government and Georgia Sea Grant researchers to develop this project's focus, methodology and goals.

The methods for the St. Marys project were partially modeled after an ongoing sea-level rise adaptation project implemented by Georgia Sea Grant in the City of Tybee Island.[3] However, discussions with personnel from North Carolina Sea Grant indicated the potential for synergies in expertise among the two Sea Grant programs if a collaborative project was developed and implemented in communities within both states. Accordingly, the overall project was designed to include concurrent development of a flood resilience planning process in Hyde County, North Carolina, using similar methods as those utilized in St. Marys. Under this project design, North Carolina Sea Grant researchers led the implementation of stakeholder engagement through the Vulnerabilities, Consequences and Adaptations Planning Scenario (VCAPS) process, while Georgia Sea Grant researchers provided geo-spatial modeling of flood hazards. Both Sea Grant programs collaborated to provide targeted assistance to the local governments for the purpose of improving Community Rating System (CRS) scores, thereby enhancing flood resilience and lowering local flood insurance premiums as set by the National Flood Insurance Program (NFIP).

A RESILIENT ST. MARYS

In the context of local planning, **resilience** means the ability of a community to absorb or bounce back from a natural or man-made event with minimal impact and damage. This planning effort investigated how to make St. Marys more resilient to the climate-related hazards of flooding, storm surge and sea-level rise.

Planning for coastal hazards is necessary in order to:

- Ensure the safety of residents and visitors
- Reduce the loss of property
- Maintain the quality of life
- Protect the history of the community
- Decrease disruption of commerce
- Aid decision-making, such as prioritizing, budgeting, investment and development
- Minimize threats to public health

BOX:

DEFINITIONS

Hazard: Natural or man-made event with potential to damage communities, ecosystems, buildings and infrastructure.
Vulnerability: Resources at risk from the damaging effects of a natural or man-made disaster.
Resilience: Ability to bounce back from or cope with a hazard event with minimum impact and damage.
Adaptation: Actions taken to help communities avoid, manage or reduce consequences of actual or expected hazards.

REPORT OVERVIEW

Following this introduction, the remainder of this report is organized into five chapters. Chapter 2 provides a general overview St. Marys' vulnerability to flooding and sea-level rise, describing drivers and trends of hydrological changes and coastal hazards affecting the community. Chapter 3, *Community Outreach and Engagement*, provides a specific history of the public participation processes used to inform the planning effort in St. Marys. This includes an analysis of stressors, impacts, barriers and innovative strategies to address flooding in St. Marys. Chapter 4, *Cost-Benefit Assessment of Adaptation Options*, describes flood risk calculations and associated benefit-cost analyses of potential adaptation actions. Chapter 5, *Community Rating System*, concludes the report by describing efforts in St. Marys and other coastal Georgia communities to reduce flood insurance rates through participation in FEMA's Community Rating System.

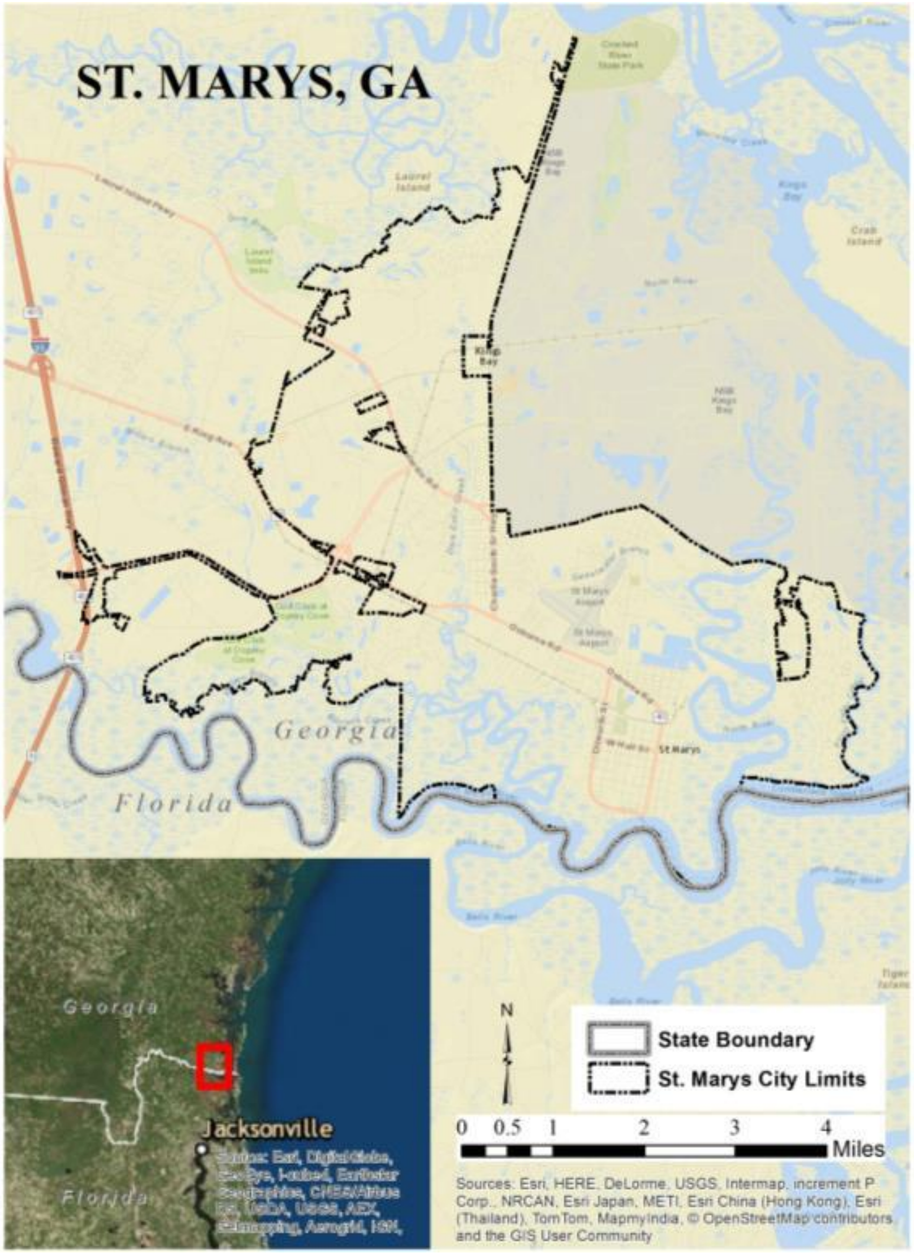


Figure 2.1: Overview map of St. Marys, GA.

Chapter 2: Coastal Hazards in St. Marys

St. Marys, located in Camden County, is coastal Georgia's southernmost city (Figure 2.1). Separated from Florida by the St. Marys River, initial settlement of St. Marys began in 1787 and the City was incorporated in 1802. The community is home to valuable historical assets, including ante-bellum homes, churches, cemeteries, and other important sites that span over two centuries of American history.

As of the 2010 U.S. Census, the City of St. Marys covered an area of roughly 22.51 square miles and was home to approximately 18,000 residents. St. Marys is perhaps best known as the gateway to Cumberland Island, Georgia's largest and southernmost barrier island. Designated by Congress in 1972 as a national seashore, most of Cumberland Island is owned and managed by the National Park Service. A passenger ferry to Cumberland Island departs from downtown St. Marys, which contributes to the City's popularity as a tourist destination. St. Marys is also located adjacent to the U.S. Navy Kings Bay Naval Submarine Base.

FLOODING IN ST. MARYS

Records from the NOAA tide gauge at Fernandina Beach, FL, located just a few miles south of St. Marys, show a daily tide range of approximately 6.6 feet. During full moon spring tide cycles, the tide range can increase to almost 9 feet between high and low tides. While these relatively large tidal amplitudes help to support the very extensive and highly productive marshlands found throughout coastal Georgia, they can also bring about enhanced flood risks when major rainfall or storm surge events co-occur with a high tide cycle.

St. Marys is vulnerable to three types of flooding: coastal flooding, shallow flooding, and riverine flooding from the St. Marys River. Coastal flooding includes storm surge and saltwater inundation from extreme high tides. Shallow flooding occurs mostly in the spring and summer and is due to heavy rainfalls that cannot be effectively drained by the local stormwater infrastructure. Strong easterly winds and high tides can increase the severity of shallow flooding, as high waters in the tidal St. Marys River effectively reduce the stormwater drainage potential. Riverine floods are associated with large amounts of rainfall throughout the entire St. Marys River watershed, which extends upstream to the eastern portions of the Okefenokee Swamp, that eventually drain downstream through the lower St. Marys River. Due to these flood risks, approximately 62% of St. Marys is designated as a Special Flood Hazard Area by the Federal Emergency Management Agency (FEMA).[4] Figure 2.2 provides a visual representation of the amount of the City's land located within and outside of the FEMA designated floodplain.

Although these hazards are an inherent feature of the coastal zone, the high quality of life and natural beauty of Georgia's coastal region is attracting more and more people from around the country. Coastal Georgia experienced an 82 percent increase in population from 1960-2010,[5] while St. Marys specifically experienced a 21.2 percent population increase 2000 to 2014.[6] [7] Looking forward, this trend appears to be accelerating. For example, a recent study projects a 62 percent population growth in the state's six coastal counties by 2050 and further suggests that sea-level rise would put approximately 93,000 to 178,000 people in coastal Georgia at risk of daily tidal flooding impacts by 2100.[8]

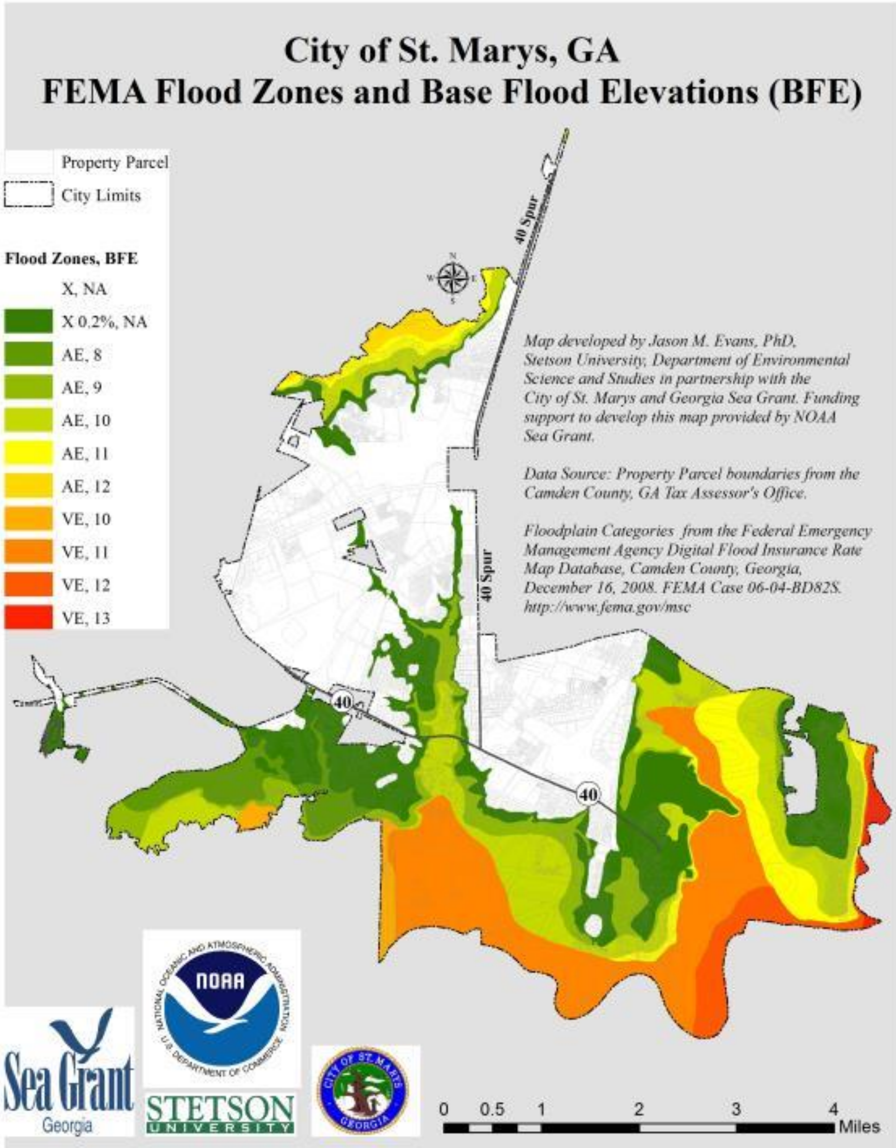


Figure 2.2: FEMA floodplain categories in the City of St. Marys. The FEMA base flood elevation (BFE) heights are in feet above the North American Vertical Datum of 1988 (NAVD88).

Hurricanes and Storm Surges

Storm surge is defined by the National Hurricane Center as "an abnormal rise in sea level accompanying a hurricane or other intense storm".[9] It is well understood that much of coastal Georgia and broader southeast United States is highly vulnerable to coastal flooding, both from extreme rainfall events and tidal storm surges. [10] Much of this vulnerability is due to the region's low coastal elevations, as shallow water tables and very low slopes within the landscape prevent rapid drainage in the event of large rainfall events. Additional factors such as the concave configuration of the Georgia bight, the very large and shallow coastal shelf, and high local tidal amplitude also create the potential for very large storm surges within coastal Georgia. Storm surges in excess of 30 feet above normal tidal levels, which could in some areas travel up to 30 miles inland, are possible in the case of an extremely large and powerful hurricane making a direct landfall along the Georgia coast. [11]

The relative infrequency of hurricane strike in coastal Georgia since the beginning of the 20th century has led to some public perception that the region is unlikely to experience major hurricane impacts.[12] It is important to stress that historical records do not support this perception, as it is well-documented that coastal Georgia experienced at least six direct hits from major hurricanes during the 19th century. [13] Several of these 19th century storms produced large and destructive storm surges, resulting in many destroyed buildings, severely damaged agricultural fields, and major loss of human life. Geologic records further show that Georgia coast has been regularly impacted by large hurricanes over the past several thousand years.[14]

On October 7, 2016, the passing of Hurricane Matthew just off the coast coastal Georgia resulted in significant coastal flooding and wind damage within St. Marys. Fortunately, Hurricane Matthew did not make direct landfall near St. Marys and the peak storm surge did not correspond with a high tide, both of which mitigated the storm's flood effects within the City. Nevertheless, the nearby NOAA tide gauge at Fernandina Beach, FL, recorded a peak tide level of 6.91 feet (NAVD88), or 4.17 feet above mean higher high water (MHHW; the height of an average daily high tide), during Hurricane Matthew. This storm surge was the second highest water level recorded at Fernandina Beach since the tide gauge was originally installed in 1897. The only larger storm surge event within the local tide gauge record was associated with a large hurricane that made a direct strike at Cumberland Island on October 2, 1898. This 1898 storm produced a peak water level of 9.65 feet (NAVD88), or 6.91 feet above MHHW, at Fernandina Beach. Other storm surge events of note within the Fernandina Beach tide gauge record include the 1944 Cuba-Florida hurricane (peak water level of 6.48 feet above NAVD88 on October 19, 1944), Hurricane Dora (peak water level of 6.68 feet above NAVD88 on September 9, 1964), and Hurricane Frances (peak water level of 5.50 feet above NAVD88 on September 27, 2004).[15]

Sea-Level Rise

The full dataset record from the Fernandina Beach tide gauge indicates a long-term sea-level rise of approximately 9 inches since 1897. This amounts to a local trend of about 8.1 inches in sea-level rise over the course of a 100-year period (Figure 2.3). This sea-level rise trend is expected to accelerate over the next several decades. Recent NOAA projections suggest a minimum sea-level rise of eight inches by the year 2100 if global efforts to reduce greenhouse gases prove effective and climate sensitivity is low. However, up to 6.6 feet of sea-level rise by 2100 is possible if polar ice caps begin a large-scale melt event similar to those observed at the end of the last ice age.[16] Many scientists and planners in coastal Georgia suggest that local governments should prepare for a scenario of approximately 3.3 feet of sea-level rise by 2100.[17] Figure 2.4 summarizes the range of sea-level rise scenarios through 2100 as projected by NOAA.

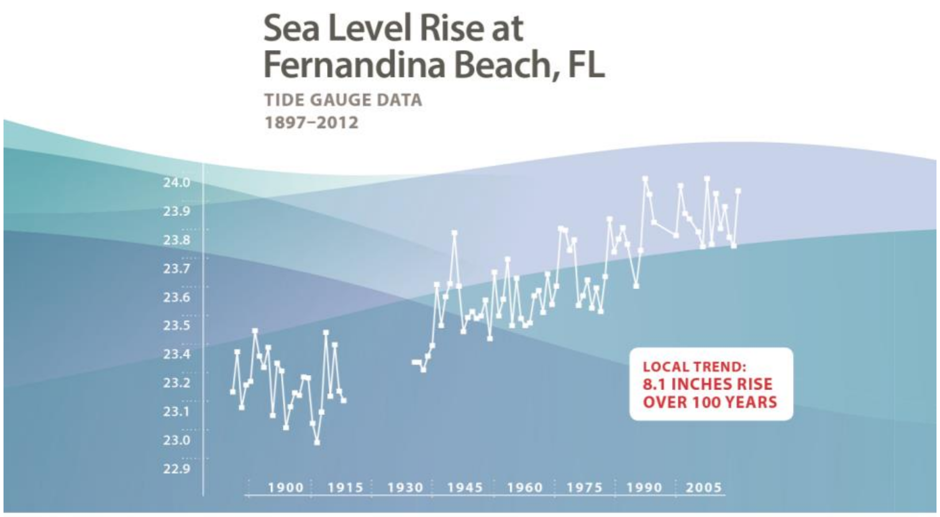


Figure 2.3

NOAA scientists have found that sea-level rise is increasing the amount of "nuisance" or "sunny-day" tidal flooding events that are occurring in coastal communities across the United States. [18] Such nuisance floods occur during regular high tide events and are not associated with major rainfall events or storm surges. Direct impacts of these nuisance flood events can include tidal infiltration into wastewater systems, saltwater flooding of roads and yards, and temporary economic disruption within affected communities. Extreme high tide events also are known to infiltrate into stormwater infrastructure systems, resulting in loss of drainage capacity that can result in further flooding with the co-occurrence of even moderate rainfall events (Figure 2.5).

At the Fernandina Beach tide gauge, NOAA has defined the nuisance flooding threshold as an event exceeding 4.68 feet above NAVD88 (1.94 feet above MHHW). In 2015, a total of seven nuisance flooding events were observed at the Fernandina Beach tide gauge, which was the highest amount for any year on record since the installation of the tide gauge in 1897. Many other tide gauges throughout the southeast United States also showed a record amount of nuisance flood events in 2015. It is generally believed that long-term sea-level rise combined with the occurrence of strong El Nino climate conditions were responsible for the increased number of nuisance flood events observed at Fernandina Beach and other tide gauges in 2015.[19]

In addition to the frequency and severity of nuisance tidal flooding, sea-level rise has the effect of increasing the height of storm surges. For example, the storm surge experienced as an effect of Hurricane Matthew was at least 8 inches higher than would have occurred as a result of a similar storm affecting St. Marys approximately 100 years ago. To put another way, without sea-level rise the storm surge from Hurricane Matthew would have been somewhat lower than what was experienced from Hurricane Dora in 1964, instead of a few inches higher. These differences in water height can translate into significant differences in the extent and amount of flood damages experienced by affected homes and businesses.

Figure 2.4 Box on Sea-Levels and Global Climate Change

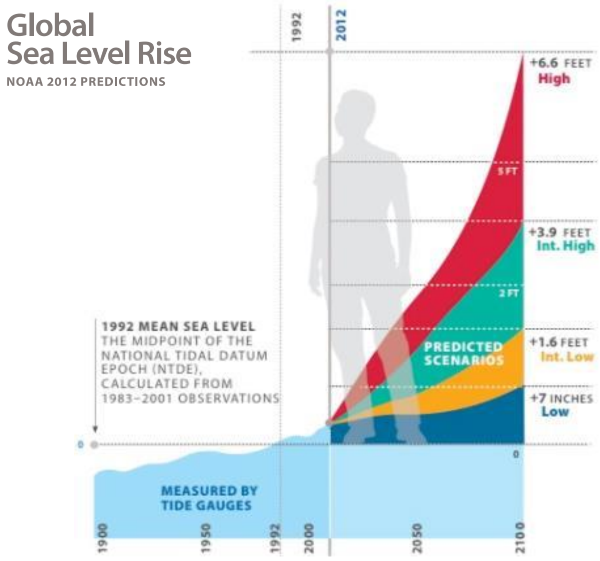
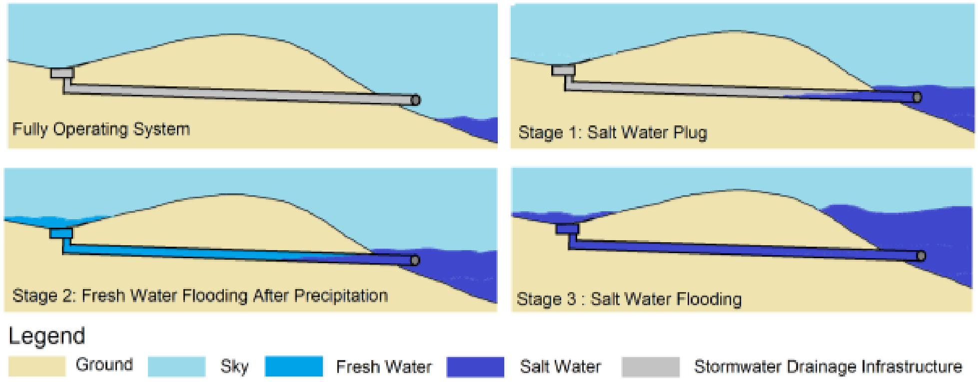


Figure 2.5: Stages of stormwater drainage failure due to sea-level rise. Graphic by Emily Niederman, Stetson University.



Chapter 3: Community Outreach and Engagement

Initial conversations that led to this planning effort took place during a two-hour seminar and public discussion about the City's vulnerability to sea-level rise, hosted by the St. Marys Earthkeepers, on February 28, 2013. Faculty and staff from Georgia Sea Grant gave a series of presentations about sea-level rise science in the context of the Georgia coast, as well as preliminary hazard and vulnerability analyses specific to infrastructure and property in St. Marys. These analyses were tailored to a range of sea-level rise scenarios that could be reasonably expected over the next 30 years. The presentations were followed by an open-ended audience question and answer period.

The St. Marys Flood Resiliency Project began with a participatory framework previously implemented in Tybee Island and other southeastern communities planning for flood hazards. The project endeavored to capture local, first-hand perspectives on the challenges and opportunities of addressing coastal hazards. This entailed partnering with the City and community as equal participants in the research and planning process. The planning process also utilized multidisciplinary perspectives in order to approach research and public engagement efforts from diverse viewpoints.

PUBLIC INPUT

A key component of the project was extensive public input that included in-depth interviews, town hall meeting, extensive conversations with city department leaders and a two-day brainstorming session with a stakeholder advisory committee. The interviews and public meetings helped to locate places that are vulnerable to flooding. The facilitated discussions further identified which vulnerable assets are most valued or critical to the community's wellbeing and potential adaptation actions to explore.

To better understand the opportunities and challenges of resilience planning in St. Marys, the project team gathered feedback and on-the-ground insights from constituents, elected officials and community leaders. A series of 20 in-depth interviews were conducted with government officials and other knowledgeable members of the St. Marys community from February–March 2014. These interviews aimed to capture common local concerns and observations associated with flooding and other climate hazards. Following this interview process, the project team hosted a public Town Hall meeting on March 19, 2014, to collect additional input on local vulnerabilities.

Formal stakeholder discussion sessions were conducted over the course of two days (March 20–21, 2014) with public officials and members of the community known to have extensive expertise about local flooding issues. These stakeholder sessions utilized the Vulnerability, Consequences and Adaptation Planning Scenarios (VCAPS) structural modeling approach, with the specific intention of examining how flood risk translates into social, economic, health and other consequences in St. Marys. The group also identified potential strategies for preventing or responding to these impacts.

What the project team found based upon local feedback was concern about the stormwater and wastewater treatment systems and property vulnerability, especially historic structures. Participants also identified specific locations of concern, such as the historic downtown area and Point Peter. Many residents expressed that nor'easters are more of a concern than hurricanes, as well as beliefs that the city is fairly protected from hurricanes by the Georgia bight. Co-producing knowledge with the local community provided the project team with an opportunity to facilitate a more comprehensive planning process, as well as identify where additional educational efforts would be best served.

INTERVIEWS

In February and March 2014, the project team conducted 20 one-hour interviews with key stakeholders with knowledge about local flooding issues. These interviews endeavored to gain insight into the local concerns and priorities in relation to flooding. The confidential conversations explored local opinions on how weather and climate hazards might affect planning processes and how local governments are able to respond. This included identifying places most vulnerable to flooding and past efforts to respond to these threats. The interviews also touched on livelihood impacts, barriers to taking action and interviewees feelings about their own abilities to contribute to the community's decision-making process.

The project team then conducted qualitative data analysis of the transcribed interviews using NVivo software to capture insights and patterns within the text (Figure 3.1). This analysis revealed that interviewees identified the following areas as vulnerable to flooding and that are considered important by residents and members of the community:

- **Downtown St. Marys**
  Downtown St. Marys contains historic properties that are already vulnerable and
- **Point Peter –** site of a housing development, as well as the archaeological ruins and marker of a U.S. Army post established in 1795. The battery experienced the last invasion and occupation by foreign troops of the U.S. mainland, which occurred as part of the War of 1812.
- **Housing –** According to 2014 U.S. Census data, the City of St. Marys contains over 7,400 housing units with a median value of $166,000. Approximately, 11 percent of these properties are within the flood hazard area, including many of the City's historical structures.

The analysis also revealed public perceptions that Nor'easters pose a significant risk to St. Marys, as well as that the Georgia bight shields St. Marys from hurricanes. Research indicates that the latter sentiment is not accurate, which indicated a need for further analysis and educational outreach to help shift public perceptions of the risk for future hurricanes in the area and potential impacts and damages that could affect the region in the future.

The anonymous results of the interviews were used to develop a series of meetings with planning officials and additional key stakeholders to diagram the environmental impacts of flooding hazards and potential responses, collaboratively building scenarios of how changes in zoning and ordinance might affect St. Marys' resilience to weather and climate hazards.

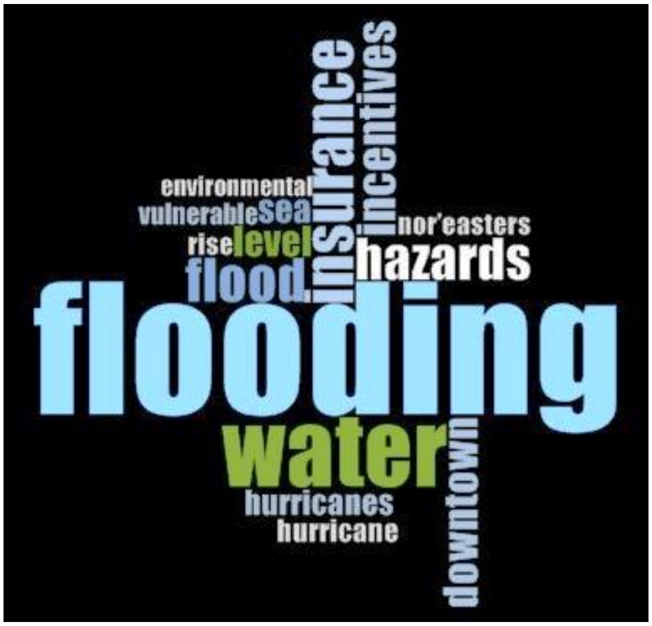


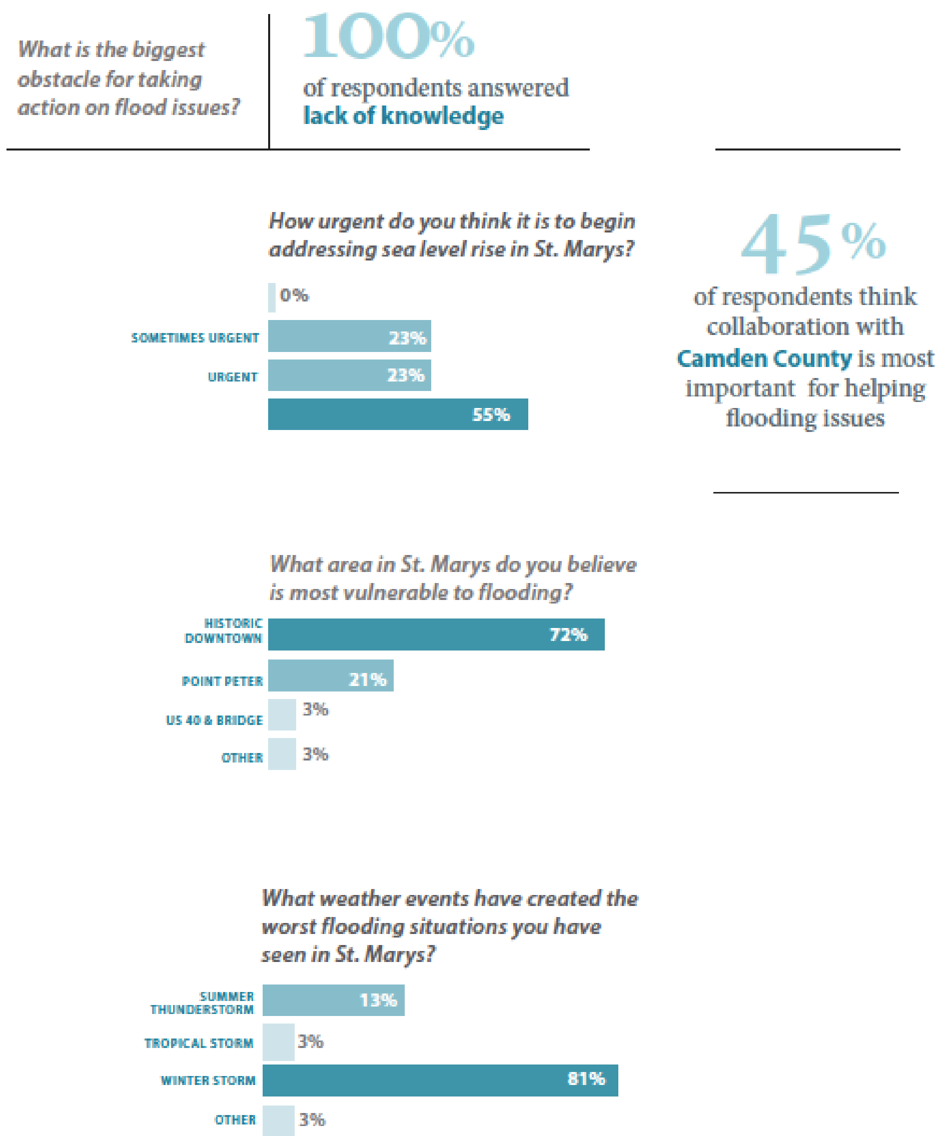
Figure 3.1: Top 15 words most mentioned in St Marys interviews..

SEA GRANT TOWN HALL MEETING

On March 19, 2014, St. Marys residents and municipal leaders attended a Sea Grant Town Hall Meeting to learn about resilience planning efforts and to share feedback on issues related to flooding, sea-level rise and storm surge.

The public meeting included summaries of the plan by researchers from Georgia Sea Grant, UGA Carl Vinson Institute of Government, UGA Marine Extension and North Carolina Sea Grant. Attendees had the opportunity to ask questions and offer comments. They also provided input into the plan's development by providing feedback through clicker voting keypads.

Results of key questions included in the audience polling at the Sea Grant Town Hall meeting:

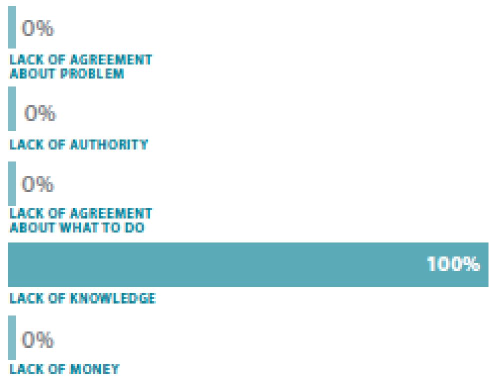


Comment [WU1]: Top graph is missing "Very Urgent" for the 55% bar.

How urgent do you think it is to begin addressing sea level rise in St. Mary's?

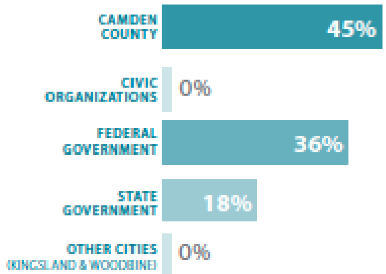
55% of respondents answered **very urgent**

What is the biggest obstacle for taking action on flood issues?



72% of respondents think **historic downtown** is most vulnerable to flooding

What collaborations do you think are most important for helping St. Marys address flooding issues?



81% of respondents think **winter storms** are creating the worst flooding in St. Marys

FACILITATED DISCUSSIONS ON FLOOD VULNERABILITY

The Vulnerability Consequences and Adaptation Planning Scenarios (VCAPS) process was developed by the Social and Environmental Research Institute, the Carolinas Integrated Sciences and Assessments Center at the University of South Carolina, and the South Carolina Sea Grant Consortium.

[20] To date, VCAPS has been used to explore hazard mitigation and climate adaptation in coastal communities in North Carolina, South Carolina and Georgia. VCAPS is a facilitated participatory process based in the causal structure of hazards and vulnerability assessment. The specific purpose of VCAPS is to assist communities in diagramming the outcomes and consequences of climate stressors on aspects of municipal management. Real-time projection of a diagram documenting the group conversation assists community members with discussion of potential adaptation and response options that public and private entities may implement, while also facilitating consideration of positive outcomes as well as potential negative consequences of interventions.

Participants decided to categorize flooding occurrences as either episodic (heavy rainstorms, upstream flooding, storm surges and category 1 hurricanes) or long-term events (rise in the water table and sea-level rise), evaluating their effects on three important issues:

1) **Stormwater infrastructure;**
2) **Wastewater treatment infrastructure;**
3) **Managing risks to private properties.**

Additionally, the group prioritized the issue of emergency management planning; however, because the City of St. Marys and Camden County are currently addressing this topic through ongoing Hazard Mitigation Plan updates, a decision was made to focus the discussion on flood planning in relation to stormwater, wastewater and private property concerns. These ideas, generated by St. Marys participants, are summarized in the following sections.

Dr. Jessica Whitehead uses a diagramming tool to capture discussion on flood vulnerability

SCENARIO 1:

STORMWATER AND WASTEWATER TREATMENT PLANNING

Vulnerability discussions indicated that episodic and long-term flooding can potentially impact both stormwater and wastewater management (Figure 3.2). Although stormwater and wastewater are distinct management concerns, it was decided that both issues must be considered simultaneously in St. Marys. Failures in the drainage and retention of stormwater during flood events could lead to excess water in wastewater systems, thus overloading treatment plants and potentially causing wastewater spills.

Participants identified two major outcomes of episodic flooding in St. Marys. The first outcome relates to **water quality.** Water flowing over impervious surfaces and developed areas can cause runoff. This runoff has increased volumes and velocities in comparison to water flowing over a natural or vegetated landscape. Runoff often picks up and transports sediment and other nonpoint source pollution as it moves over impervious surfaces, reducing water quality.

Water can also collect in stormwater retention ponds. When capacity is reached, overflow may occur. This overflow could result in flooding, which can cause property damage. The resulting flow into marshes carries sediments and contaminants that reduce water quality. Water may also sit in ponds for days, and this sitting water could create health problems. Participants additionally expressed concerns about possible wastewater overflows from treatment plants during flood events that could impact water quality and become a health hazard.

The second major outcome from episodic flooding discussed was **power outages,** which could affect both wastewater treatment plants and lift stations. The occurrence of flooding at non-functional plants and stations could lead to sewage spills and water contamination, resulting in health hazards and heavy fines for the City.

The group noted several public and private sector actions that could reduce the negative consequences of flooding on stormwater and wastewater management in St Marys. The City's drainage capacity could be increased by cleaning ditches more frequently, planting more vegetation and using permeable pavement. Other suggestions included educating the public on the effects of littering and stormwater retention laws, as well as improving litter law enforcement. Comments were made concerning the need to educate homeowners who commonly uncover sewer drains as a way of reducing flooding on their properties.

To reduce the negative effects of power outages, participants discussed flood-proofing lift stations and strategically placing generators for back up. They also discussed raising lift stations to reduce flood risks and partnering with the Naval Base to interconnect wastewater systems.

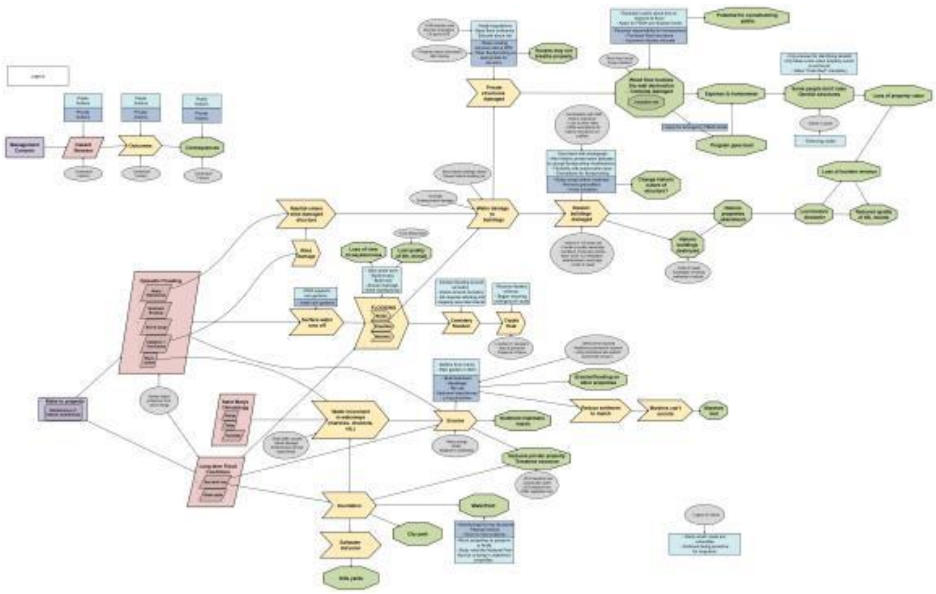


Figure 3.2*: VCAPS diagram of stakeholder concerns about stormwater and wastewater planning*

SCENARIO 2:
MANAGING RISKS TO PROPERTIES

In the second session, the group discussed the impacts of episodic flooding and long-term flood conditions on properties (Figure 3.3). Participants identified that surface water runoff is currently the most common cause of flooding, and, consequentially, water damage to buildings. Additionally, the group mentioned that wind damage could leave buildings vulnerable to rainfall during storm events, which could lead to properties experiencing water damage.

Private property damage generates expenses to home and business owners. Extensive damage could cause property loss and lead to derelict structures. Participants expressed significant concern over the historic character of the City and the protection of historic properties. Damage to such structures could result in the abandonment of property due to the extensive financial burden of restoration, as well as the potential for property loss. As a historic City, the loss of historic properties could lead to loss of character, and, consequentially, loss of tourism. In return, abandonment and loss of property could reduce the quality of life and the morale of the community and also render the City unattractive to potential future investors.

When focusing on the long-term flood risks and the impacts to properties, participants discussed how erosion affects properties along waterways. Erosion currently occurs as a result of water movement caused mainly by waves during storms and by boats. However, as sea levels rise, there is concern that erosion will increase, leading to a reduction in property size and jeopardizing built structures. Additionally, rising water and inundation could impact the City's waterfront park, and saltwater intrusion could kill yards.

The group noted strategies that could be used to reduce the risks of property damage, such as stipulating height regulations and educating property owners on how to protect buildings and properties. Discussions also pointed to the possibility of raising buildings and educating the population on the benefits of such measures in the reduction of flood insurance premiums. However, there were concerns that property owners might become overwhelmed and that additional regulations and costs could potentially inhibit people from moving to St. Marys and/or investing in the City.

From a historic standpoint, the group discussed constraints currently in place for adapting historic buildings and suggested the revision of codes pertaining to such structures, which would allow property owners to flood-proof their historic properties. Alternatively, the group discussed taking pictures of existing historic landmarks, as a way of registering their existence and preserving the memory of properties that could be lost in future flood events. When discussing the waterfront park, participants suggested looking at solutions used by the National Parks Service for similar properties as a way of deciding upon future actions.

> ***"Ninety percent of the historic structures in our historic district have their lowest floor elevation located below the current 100-year flood elevation."***
>
> ***- William DeLoughy, former St. Marys Mayor***

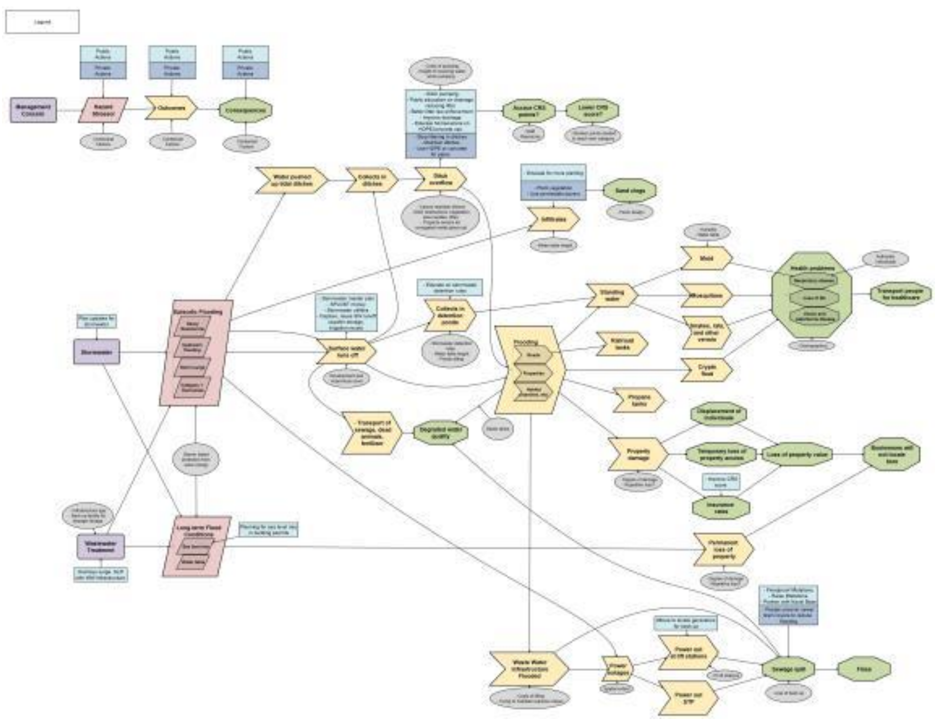


***Figure 3.3**: VCAPS diagram of stakeholder concerns about private property flooding*

Chapter 4: Flood Vulnerability Assessment

Following the VCAPS scenario-building exercises, a technical flooding vulnerability assessment, including consideration of future hydrologic conditions associated with sea-level rise, was conducted for the City of St. Marys. This vulnerability assessment was developed through integration of various datasets collected and analyzed through geographic information system (GIS) methods, most of which were implemented with ESRI's ArcGIS 10.2.2 software platform.

Public assets that were assessed for current and future flood vulnerability in the City of St. Marys include roads, police stations, fire stations, schools, wastewater treatment facilities, and stormwater infrastructure. Specific vulnerability assessment results for these public facilities are provided in this report. Private buildings and associated property were also assessed for current and future flood vulnerability. Vulnerability assessment results for private property are pooled to a City-wide scale. Base flood heights for 10-year, 50-year, 100-year, and 500-year storm events under current conditions were based upon Flood Insurance Rate Maps (FIRMs) as defined through the Federal Emergency Management Agency's 2005 Flood Insurance Study for Camden County.
[21] Various sea-level rise scenarios were added onto these currently defined flood heights to assess future flood vulnerability.

Dataset Inventory

A variety of GIS datasets, as collected from various governmental agency sources, were used to develop the flood vulnerability assessment for the City of St. Marys (Table 4.1). For consistency of analysis, all original datasets were transformed into the Georgia East (FIPS 1001) State Plane projected coordinate system, as referenced to the North American Datum of 1983 (NAD83) and incorporating the National Adjustment of 2011 (NA2011).

Table 4.1: Original Geographic Information System (GIS) Dataset List

Original Dataset Description	File Name	Source
Digital Elevation Model (Raster)	CamdenDEM.tif	Coastal Regional Commission of Georgia, as derived from LiDAR points obtained with the 2010 Coastal Georgia Elevation Project

Digital Flood Insurance Rate Map (DFIRM) (Polygon)	s_fld_haz_ar.shp (For Flood Insurance Study 13039, Camden County, Georgia)	Federal Emergency Management Agency
Property Parcels with 2013 valuations (Geodatabase)	Camden_2013.gdb	Camden County Tax Assessor's Office
Roads (Geodatabase)	Roads.mdb	City of St. Marys
Schools (Point)	Schools.shp	City of St. Marys
Fire and Police Stations (Points)	Fire_Police_stations.shp	City of St. Marys
Building Footprints (Polygon)	Buildings.shp	Coastal Regional Commission of Georgia
Stormwater infrastructure (Geodatabase)	StormWaterCollectionSystem.mdb	City of St. Marys
Wastewater treatment plants (Point)	WWTP.shp	City of St. Marys
City limits for St. Marys (Polygon)	St_Marys.shp	City of St. Marys

Elevation

A digital elevation model (DEM) of the City of St. Marys and nearby areas of surrounding Camden County is shown in Figure 4.1. This DEM is derived from Light Detection and Ranging (LiDAR) points collected through the 2010 Coastal Georgia Elevation Project and is vertically referenced to the North American Vertical Datum of 1988 (NAVD88). Tide ranges and tidal elevation datums for coastal waters in and around the City of St. Marys closely match those recorded at NOAA tide gauge #8720030, located in nearby Fernandina Beach, FL (Figure 4.2). Current elevation datums for the Fernandina Beach tide gauge are based upon the 1992 National Tidal Datum Epoch, which includes water levels from 1983 – 2001.

The lowest areas of St. Marys are composed of undeveloped tidal saltwater creeks and marshes, which have elevations that are below or just above the North American Vertical Datum of 1988 (NAVD88). The developed portions of St. Marys are located on elevations that range between approximately 5 feet and 35 feet above NAVD88, with the lowest-lying developed areas generally found near coastal marshes and waterways. The highest areas of St. Marys, at over 60 feet above NAVD88, are located on a fill mound just east of waste ponds associated with the former Durango-Georgia paper mill.

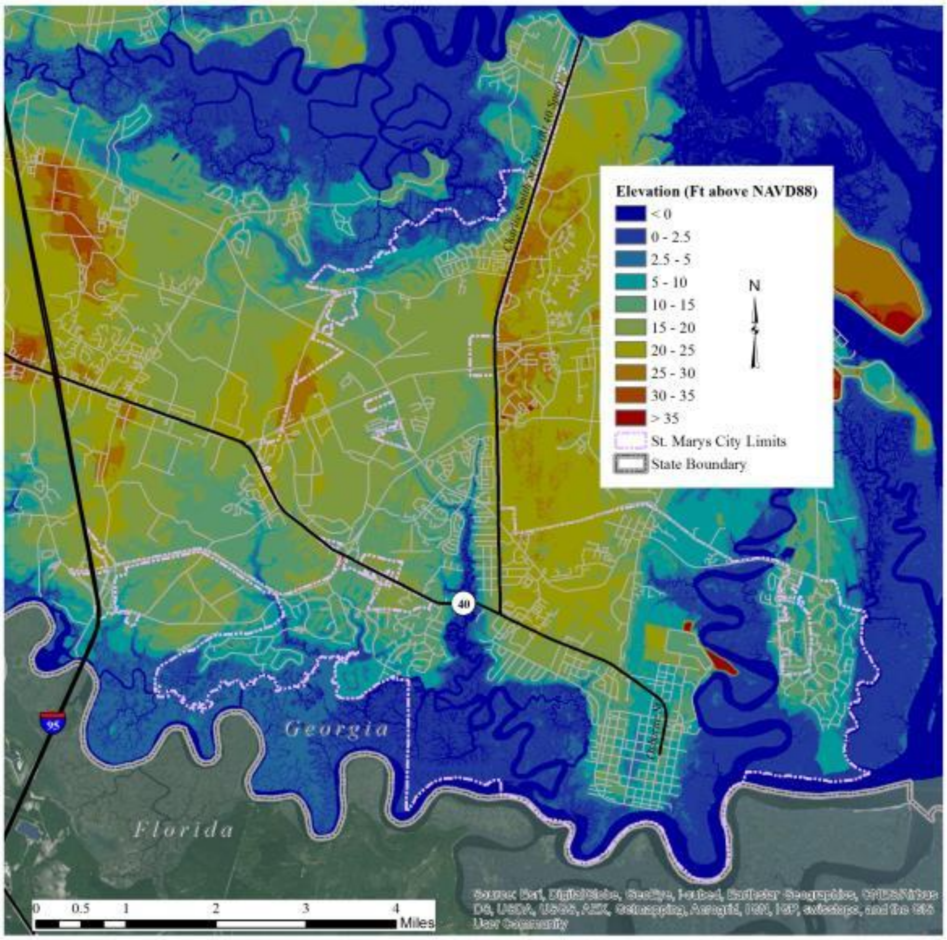


Figure 4.1: Elevation map of St. Marys, GA, and vicinity

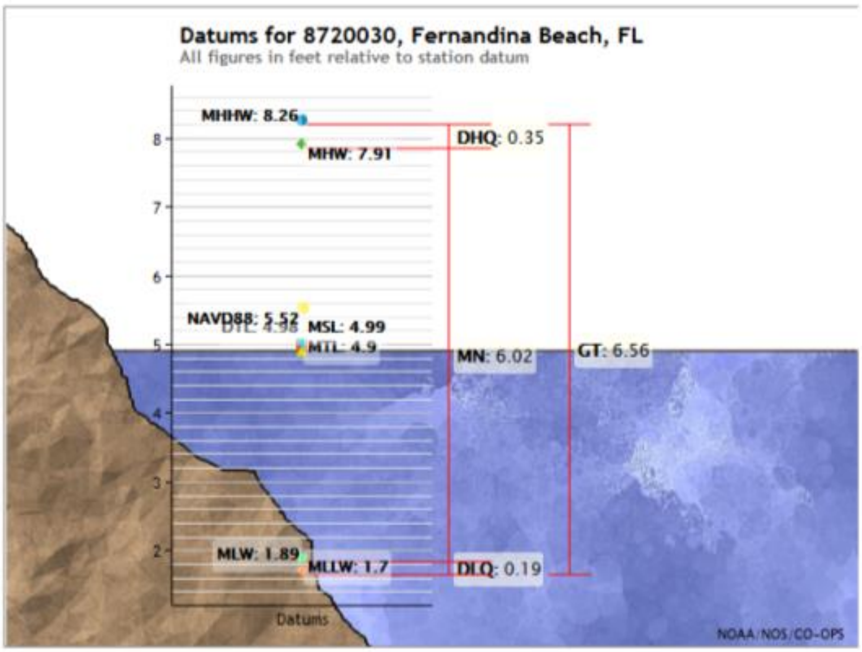


Figure 4.2: Tidal Datums for Fernandina Beach, FL. Datums referred to in this report include Mean Higher High Water (MHHW), North American Vertical Datum of 1988 (NAVD88), Mean Sea Level (MSL), and Mean Lower Low Water (MLLW). The difference between MHHW and MLLW, or the average highest high tide and average lowest low tide each day, is referred to as the Great Diurnal Range (GT). Image adapted from https://tidesandcurrents.noaa.gov/datums.html?id=8720030.

Sea-Level Rise and Flood Vulnerability Thresholds

Current technical guidance from NOAA defines four scenarios of sea-level rise for use in local planning (see Table 4.2).[22] It is important to note that all future sea-level rise scenarios, as developed by NOAA or other federal agencies such as the United States Army Corps of Engineers, are each based upon a different set of technical assumptions. At this time, it is impossible to know for sure which scenario will most closely match actual conditions that transpire over the coming decades. Instead, it is generally recommended to use a risk-based approach for scenario-building. Under such as risk-based approach, higher tolerance for risk is equated to use of a lower sea-level rise scenario, while lower tolerance for risk entails use of a higher sea-level rise scenario. [23]

The Low scenario assumes that future global warming and climate change will be minimal through 2100. For the City of St. Marys, this scenario would entail a straight continuation of the linear trend of sea-level rise already observed at Fernandina Beach since the installation of the tide gauge in 1897. Use of the Low scenario is only recommended for low value infrastructure that can be readily moved, may be easily replaced, and would not be cause for much societal concern if flooded. It could be appropriate to use the Low sea-level rise scenario when siting a low-cost storage building that contains easily replaceable materials and has an expected life-cycle of less than 25-years.

The Intermediate Low scenario assumes some amplification of sea-level rise in the twenty-first century due to thermal expansion of oceans and continued ice melt in Greenland, Antarctica, and mountain glaciers. Empirical support for this amplified sea-level support is suggested by the higher rate (0.126 in/yr) of sea-level rise recorded since 1992 by satellite altimetry as compared to the rate (0.067 in/yr) calculated by integration of the global tide gauge data record before 1992.[24] The Intermediate Low scenario is the minimum rate of sea-level rise recommended for most regular planning purposes.

The Intermediate High scenario assumes an increasing rate of sea-level rise beyond that observed by historical satellite altimetry, primarily due to an increased rate of ice sheet melt in Greenland and Antarctica due to global warming and climate change associated with growing atmospheric concentrations of greenhouse gases. The Intermediate High scenario is generally recommended for higher value infrastructure, such as a wastewater treatment facility, that would be expensive to relocate and would cause serious social concern if flooded before 2100.

The High scenario assumes the onset of catastrophic ice sheet melt in Greenland and Antarctica that prompts global sea-level rise rates similar to those that occurred approximately 13,000 years ago at the end of the last Ice Age. The High scenario is recommended when planning for infrastructure that has very little risk tolerance and would cause extreme societal disruption if flooded. Nuclear power plants and hazardous chemical facilities are examples of such low-risk tolerance infrastructure.[25]

Many sea-level rise vulnerability assessments utilize projected changes in the mean higher high water (MHHW) level as the threshold for determining future vulnerability to flood inundation.[26] A straightforward interpretation of this threshold is that, unless protective measures are taken, areas below MHHW will be vulnerable to tidal flooding on an almost daily basis. It is generally assumed that daily inundation from saltwater would make maintenance of most human development, such as roads and buildings, difficult or even impossible. As shown in Figure 4.2, the 1992 MHHW datum is 2.74 feet higher than NAVD88 and 3.29 feet higher than 1992 Mean Sea Level (MSL) at the Fernandina Beach tide gauge. A summary of projected changes in MHHW, as referenced to NAVD88, at Fernandina Beach under the different NOAA sea-level rise scenarios is provided in Table 4.3.

It is, however, increasingly recognized that stresses to human development due to sea-level rise occur well before an area is flooded on an almost daily basis. For example, spring tides that produce high tides substantially higher than MHHW occur naturally each month during the full moon and new moon cycles. The highest spring tides of the year, which generally occur during full and new moon cycles in the fall months at Fernandina Beach, are colloquially called "king tides." Such king tides are highly predictable and are naturally associated with oceanographic and astronomical cycles, especially the positions of the moon and sun relative to earth. Weather factors, such as strong on-shore winds and storm conditions, also regularly result in high tides that substantially exceed MHHW.

The term "nuisance flooding" is often used to describe the moderate flooding conditions that can occur in localized areas during king tide or storm tide cycles. At Fernandina Beach, the nuisance flooding threshold is defined as 1.94 feet above MHHW, which translates into 4.68 feet above NAVD88.[27] As noted in Chapter 2, the nuisance flooding threshold was exceeded during seven tide cycles at Fernandina Beach in 2015. For the purpose of this report, the current nuisance tide level is used as the elevation threshold for assessing current and future vulnerability to king tides. Table 4.4 provides a summary of projected changes in the king tide level, as referenced to NAVD88, at Fernandina Beach under the different sea-level rise scenarios.

The storm surge associated with the passage of Hurricane Matthew in October 2016 produced the highest water levels (4.17 feet above 1992 MHHW, or 6.91' above NAVD88) observed at the Fernandina Beach tide gauge since the direct landfall of a major hurricane at Cumberland Island in 1898. High water mark data collected by the United States Geological Survey following Hurricane Matthew, as shown in and near the City of St. Marys in Figure 4.3, indicate that water levels in the downtown waterfront area of St. Marys were similar to those observed at the Fernandina Beach tide gauge. This storm, which produced substantial damage in low-lying areas of St. Marys, provides a reference for future vulnerability to similar storms that may be amplified by sea-level rise. Table 4.5 summarizes the additive changes in a high water level event similar to Hurricane Matthew under the NOAA sea-level rise scenarios.

Table 4.2: Locally adjusted sea-level rise values for the Fernandina Beach, FL, tide gauge, by NOAA sea-level rise scenario and as referenced to 1992 mean sea level.

Year	Low	Intermediate Low	Intermediate High	High
1992	0	0	0	0
2015	0.15'	0.20'	0.30'	0.42'

2045	0.35’	0.60’	1.15’	1.79’
2065	0.51’	0.96’	2.01’	3.21’
2100	0.72’	1.75’	4.05’	6.67’

Table 4.3: Mean Higher High Water (MHHW) estimates for the Fernandina Beach, FL, tide gauge, by NOAA sea-level rise scenario and as referenced to NAVD88[28]

Year	Low	Intermediate Low	Intermediate High	High
1992	2.74’	2.74’	2.74’	2.74’
2015	2.89’	2.94’	3.04’	3.16’
2045	3.09’	3.34’	3.89’	4.53’
2065	3.25’	3.70’	4.75’	5.95’
2100	3.46’	4.49’	6.79’	9.41’

Table 4.4: King tide heights for St. Marys, GA, by NOAA sea-level rise scenario and as referenced to NAVD88[29]

Year	Low	Intermediate Low	Intermediate High	High
2015	4.68’	4.68’	4.68’	4.68’
2045	4.88’	5.08’	5.53’	6.07’
2065	5.01’	5.44’	6.39’	7.49’
2100	5.25’	6.23’	8.43’	10.95’

Table 4.5: Predictions of water levels at Fernandina Beach during an event similar to that observed during Hurricane Matthew (2016), by NOAA sea-level rise scenario and as referenced to NAVD88[30]

Year	Low	Intermediate Low	Intermediate High	High
2015	6.91’	6.91’	6.91’	6.91’
2045	7.11’	7.31’	7.76’	8.30’
2065	7.24’	7.67’	8.62’	9.72’
2100	7.48’	8.46’	10.66’	13.18’

Figure 4.3: High water marks, in feet referenced to NAVD88, recorded by the United States Geological Survey during Hurricane Matthew, October 7, 2016.[31] By way of comparison, an average daily high tide in St. Marys is approximately 2.74 feet above NAVD88.

Roads Vulnerability

A series of analyses were performed in ArcGIS 10.2.2 to determine tidal flooding vulnerability for roads in the City of St. Marys in the years 2015 (current condition), 2045 (30-year horizon), 2065 (50-year horizon), and 2100 (end-of-century). The base case for all years in this analysis was king tide flooding under the Intermediate High sea-level rise scenario. An assessment of road miles vulnerable to possible inundation (i.e., below future MHHW) at the year 2100 under the High sea-level rise scenario was also performed.[32]

The first step of the analysis was to clip the digital elevation model (CamdenDEM.tif) to the geographic extent of the City of St. Marys (St_Marys.shp). Cells in the clipped digital elevation model (StMrysDEM.tif) with elevation values below the respective elevation threshold for each flood scenario (Table 4.3 for 2100 MHHW; Table 4.4 for king tide values) were selected and transformed into a series of simplified polygon shapefiles. These shapefiles were then used to clip the roads polyline feature class (from Roads.mdb) for each flood scenario. Using this procedure, all polyline road extents within the output datasets were thus identified, through geographic coincidence with values in the digital elevation model that are below the defined flood threshold, as vulnerable to tidal flooding for the given sea-level rise scenario.

Table 4.6 provides a summary of the road miles vulnerable to tidal flooding under each scenario. Figure 4.4 provides a map visualization of the roads vulnerability assessment. The road that shows the most current and future vulnerability to king tide flooding is St. Marys St. along the historic downtown waterfront. A close-up of the roads vulnerability analysis for downtown St. Marys is shown in Figure 4.5.

Table 4.6: Road miles (and percentage of original road miles) identified as vulnerable to tidal flooding in the City of St. Marys with king tide conditions assessments under the NOAA Intermediate High sea-level rise scenario for each given year.

Total Road Miles	2015 King Tide	2045 King Tide	2065 King Tide	2100 King Tide
162.2	1.0 (0.6%)	2.7 (1.7%)	7.2 (4.4%)	24.0 (14.8%)

Figure 4.4: Vulnerability of current road segments in City of St. Marys, GA, to current and future king tides with Intermediate High sea-level rise

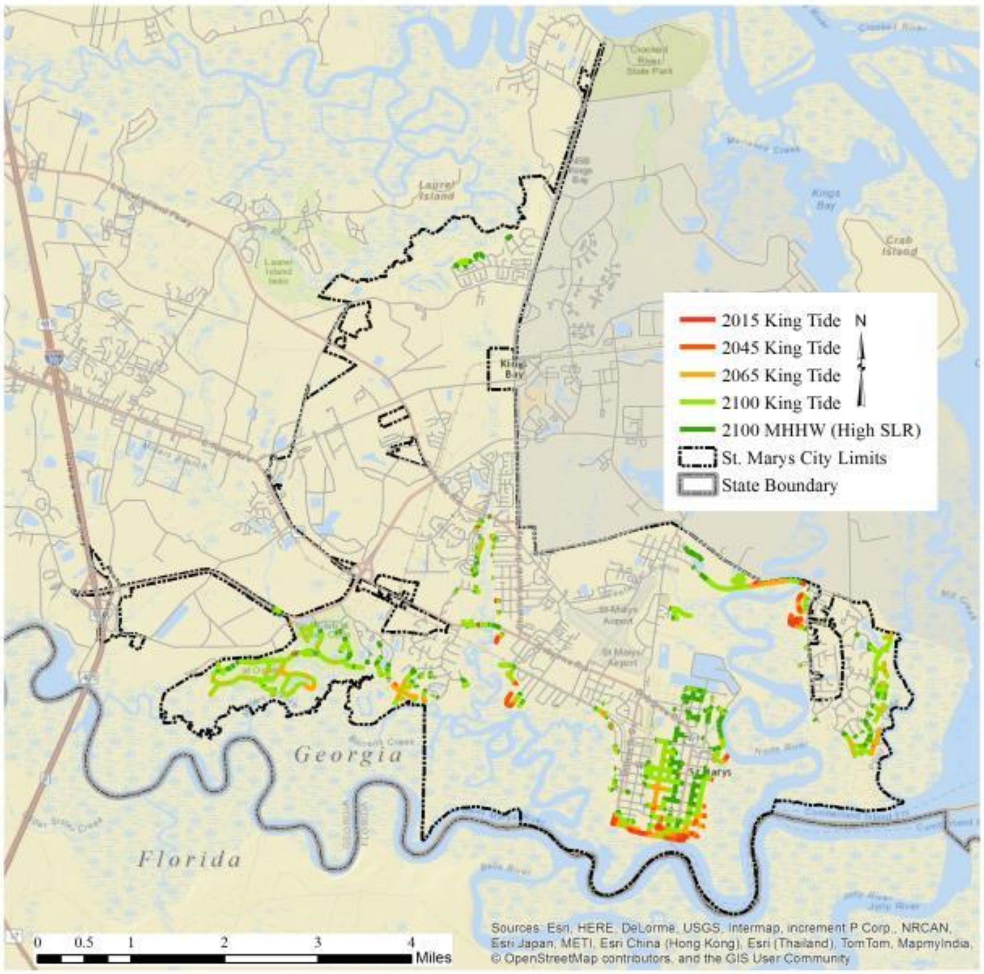


Figure 4.5: Close up of road segment vulnerability in downtown St. Marys, GA, to current and future king tides with Intermediate High sea-level rise

Public Facilities

A flood vulnerability analysis was performed for police stations, fire stations, schools, and wastewater treatment facilities located within the City of St. Marys, as well as for buildings on parcels owned by the City of St. Marys. Most of this analysis was performed through a Zonal Statistics operation in ArcGIS 10.2.2 that extracted minimum ground elevation values, as obtained from the LIDAR-based DEM, within building footprint polygons associated with the given structures. For facilities in which building footprint polygons were not available at the time of the analysis, elevation values were extracted from point locations provided by the City of St. Marys (and verified through aerial photography).[33] The designated FEMA 100-year flood height, also known as the base flood elevation, at the site of each building was determined using a spatial join procedure.

The results of this analysis, as summarized in Table 4.7, indicate that the St. Marys Submarine Museum – located along the historic downtown waterfront – is the only listed public facility that shows a ground elevation lower than the currently designated 100-year base flood elevation. The Submarine Museum site also shows potential vulnerability to king tide flooding by 2045 under an Intermediate High sea-level rise scenario. All other listed public facilities are either located outside of the 100-year floodplain or show ground elevations somewhat higher than the designated base flood elevation for the particular site. Three publicly owned facilities – City Hall, the Liberty Tree Water Plant Site, and the St. Marys Women's Club – show potential vulnerability to a Matthew-sized flood event at 2100 under the Intermediate High sea-level rise scenario.

Table 4.7: Estimated ground elevation of buildings, 100-year FEMA base flood elevation (in feet above NAVD88), and sea-level rise (SLR) flood risk for given publicly-owned buildings within the City of St. Marys. A value of N/A for the base flood elevation means that the facility was not located in the 100-year floodplain at the time of this study. A value of N/A for the flood risk, SLR scenario column means that the facility would not be vulnerable to a Matthew-sized storm surge at the highest sea-level rise scenario by 2100.

FACILITY NAME	BUILDING ELEVATION	BASE FLOOD ELEVATION	FLOOD RISK, SLR SCENARIO
ST MARYS SUBMARINE MUSEUM	5.2	11.0	King Tide, 2045 Intermediate High
CITY HALL	9.5	N/A	Matthew, 2100 Intermediate High
LIBERTY TREE WATER PLANT SITE	9.5	N/A	Matthew, 2100 Intermediate High
ST MARYS WOMEN'S CLUB	9.6	N/A	Matthew, 2100 Intermediate High
ST MARYS ELEMENTARY SCHOOL	10.7	9.0	Matthew, 2100 High
ORANGE HALL	11.0	N/A	Matthew, 2100

			High
ST MARYS COLERAIN FIRE STATION	11.6	N/A	Matthew, 2100 High
POINT PETER WASTEWATER TREATMENT PLANT	11.6	10.0	Matthew, 2100 High
CITY LIBRARY	12.3	N/A	Matthew, 2100 High
SCRUBBY BLUFF WASTEWATER TREATMENT PLANT	14.0	N/A	N/A
MARY LEE CLARK ELEMENTARY SCHOOL	15.1	N/A	N/A
SUGARMILL ELEMENTARY SCHOOL	17.2	N/A	N/A
INDUSTRIAL PARK S-2	18.2	N/A	N/A
ST MARYS DANDY FIRE STATION	18.4	N/A	N/A
AIRPORT	19.9	N/A	N/A
ST MARYS POLICE HEADQUARTERS	20.0	N/A	N/A
ST MARYS MIDDLE SCHOOL	21.8	N/A	N/A
CAMDEN COUNTY MUSH BLUFF FIRE STATION	27.6	N/A	N/A

Flood Vulnerability Assessment for All Structures

A comprehensive 50-year flood damage assessment, including increased future vulnerability due to sea-level rise scenarios, was conducted for all buildings in St. Marys that fall within the designated FEMA floodplain. This includes the standard 100-year floodplain that comprises the special flood hazard area, as well as those areas outside of the special flood hazard area that are designated as within the 500-year floodplain. The 100-year floodplain is also known as the "1% floodplain," as it is estimated that there is at least a 1% chance (i.e., 1 flood per 100 years) of a flood impacting all areas within this floodplain in any given year.

The property vulnerability analysis was performed using a customized adaptation of sea-level rise vulnerability assessment and monetization methods developed for NOAA by the Eastern Research Group, Inc.[34] ArcGIS 10.2.2 was used to derive ground elevation statistics for all building footprint polygons (n = 6,436) within the City of St. Marys, as defined by the available building footprint layer obtained from the Coastal Regional Commission of Georgia. The underlying ground elevation data were obtained from the Coastal Georgia LIDAR digital elevation model. Floodplain categorizations and associated base flood elevation definitions from the current digital flood insurance rate map (DFIRM) were then attached to each building footprint using a spatial join procedure. Building values were estimated using a spatial join procedure in which appraised parcel values from Camden County were appended to associated buildings.[35]

Of the 6,436 original building footprints within the City of St. Marys, a total of 1,204 were located wholly or partially within the designated 100-year floodplain boundary. This included 1,199 within AE zones, which are designated as having at least a 1% annual risk of a still water flood event. The other 5 buildings were located within VE zones, which are designated as having at least a 1% annual risk of wave action damage in addition to still water flooding. Most buildings that have a federally backed mortgage and are located within either an AE or VE zone are required to have flood insurance. An additional 1,897 buildings were located within the 500-year floodplain, which is used to designate areas with at least 0.2% annual flooding risk. Buildings located within the 500-year floodplain, but outside of the 100-year floodplain, have no mandatory flood insurance requirement, although purchase of flood insurance is still recommended due to the possibility of catastrophic flood events.

For all areas within the 100-year floodplain, future flood height risk was calculated at decadal intervals (i.e., 2015, 2025, 2035, 2045, 2055, and 2065) by adding the NOAA Low, Intermediate-Low, and Intermediate-High sea-level rise scenario values to the 100-year base flood elevation from a 2015 baseline. A similar calculation was performed to add sea-level rise onto the 10-year (10%), 50-year (2%), and 500-year (0.2%) flood heights. For areas only within the 500-year floodplain, sea-level rise was added onto the defined 500-year flood height. The original flood heights for the 100-year flood event were defined for each special flood hazard area polygon within the DFIRM shapefile. All 10-year, 50-year, and 500-year flood event heights were derived from the Camden County Flood Insurance Study.[36]

Flood heights affecting each particular building were obtained by subtraction of the high water elevation for a given flood event from the minimum ground elevation associated with a given building footprint. Dollar-based damages to individual buildings were then assessed through application of a generic depth-damage relationship, as adapted from the United States Army Corps of Engineers (Table 4.8),[37] to the annualized probability of the given flood height event.

Table 4.8: Depth Damage Relationship Applied for Flood Events in the City of St. Marys

FLOOD DEPTH (FEET)	DAMAGE (% OF ASSESSED VALUE)
0	0%
1	2.5%
2	13.4%
3	23.3%
4	32.1%
5	40.1%
6	47.1%
7	53.2%

8	58.6%
9	63.2%
10	67.2%

Table 4.9 provides a summary for the baseline of expected dollar damages, as summed across the City of St. Marys, if the area was impacted by a 10-year, 50-year, 100-year, or 500-year flood event. The 2015 damage values are based upon an assumption of the current base flood elevation (i.e., no attributed sea-level rise). The initial assessed value for buildings in the City of St. Marys was $1.8 billion.

Table 4.9: Estimated property damages in the City of St. Marys, by given flood event at year 2015 baseline

Year	10-Year (10%)	50-Year (2%)	100-Year (1%)	500-Year (0.2%)
2015	$146,570	$14,460,900	$27,977,200	$110,895,500

Dollar damage values for the given flood events at subsequent decadal increments were then calculated for each sea-level rise scenario through the 2065 planning horizon. The results for 2045 (30-year planning horizon) are presented in Table 4.10. The 2065 results (50-year planning horizon) are in Table 4.11.

Table 4.10: Estimated property flood damages to current structures in the City of St. Marys in 2045, by sea-level rise scenario and by 2015 assessed value

Scenario	10-Year (10%)	50-Year (2%)	100-Year (1%)	500-Year (0.2%)
Low	$248,435	$16,809,742	$18,529,422	$119,322,878
Int-Low	$615,711	20,876,869	$36,213,482	$133,501,939
Int-High	$2,193,537	$32,505,526	$49,081,770	$165,957,380

Table 4.11: Estimated property flood damages to current structures in the City of St. Marys in 2065, by sea-level rise scenario and by 2015 assessed value

Scenario	10-Year (10%)	50-Year (2%)	100-Year (1%)	500-Year (0.2%)
Low	$317,614	$16,021,642	$28,468,782	$125,076,703
Int-Low	$1,397,458	$24,634,483	$39,100,935	$156,493,545
Int-High	$8,905,013	$60,799,055	$77,402,095	$231,404,195

It is important to be clear that the single event calculations (Tables 4.9-4.11) provide damage estimates for an actual occurrence of the given flood event. However, the risk of flood events is generally assessed through an annual probability of occurrence. Because a 100-year flood event has the equivalent of a 1% chance of occurring in a given year, the annualized damages for the 100-year event are assessed at 1% of what is calculated by the single-event approach. Similarly, a 10-year event is annually assessed at 10% of the single event damage estimate, the 50-year event is assessed at 2% and the 500-year event is assessed at 0.2%

It is also generally accepted that damages from future flood events should be "discounted" according to a "net present value" (NPV) time function. This is based upon the assumption that individuals and societies are willing to pay more to avoid damages that will occur in the near future, with less willingness to pay to avoid future damages.[38] A discount rate of 3.3% was chosen for this project in collaboration with City of St. Marys public officials and stakeholders.

Integration of the probabilistic storm damages, along with application of the 3.3% annualized discount rate,[39] was used to produce a NPV-equivalent flood vulnerability assessment for the City of St. Marys.[40] This assessment cumulatively covers flood risk, as adjusted to increased water heights for flood events due to sea-level rise and discounted property values, for the 50-year period from 2015 to 2065. The results of this NPV assessment are summarized in Table 4.12.

Table 4.12: 50-year net present value (NPV) flood vulnerability assessment for the City of St. Marys, by NOAA sea-level rise scenario.[41] The total assessed value of properties in the City was $1.8 billion.

Low	Intermediate-Low	Intermediate-High
$24,235,800	$28,427,100	$41,218,300

Adaptation Options for Avoidance of Flood Damages

Option 1: Hard Barrier (Not Recommended)

A common infrastructure option for avoiding private property flood losses associated with coastal flooding risk is construction of a hardened physical barrier, such as an enhanced sea wall, levee, and/or dyke. The clear advantage of such a barrier is that, in certain circumstances, damages from flood waters within the built environment can be entirely avoided. For this reason, some large municipalities, such as New York City, are currently pursuing hardened barriers as a primary flood resilience strategy.[42]

Construction of a traditional physical barrier option in the City of St. Marys, however, is inherently problematized by the lengthy linear extent (~21 miles) of the exposed waterfront and marshfront shorelines that are adjacent to structures within the City's delineated floodplain. The construction cost of an engineered sea wall of sufficient height and strength to prevent a surge-associated flood loss along the full 21 miles of developed coastal extent is conservatively estimated at $127.5 million.[43] Such a construction cost is several times higher than the potential 50-year avoided NPV loss of $41.2 million under the Intermediate-High sea-level rise scenario (Table 4.12).

This relatively small potential benefit relative to the construction cost expenditure makes the hard barrier option unattractive to pursue from even a very limited benefit-cost perspective. Other societal costs from a large sea wall – such as reduced waterfront aesthetics, increased erosion and habitat destruction in coastal marshlands, and long-term capital maintenance expenditures[44] – further argue against municipal-scale pursuit of a large-scale, publicly funded hard barrier within the City of St. Marys at this time.

Option 2: Individual Property Adaptation (Recommended and Adopted)

On January 6, 2014, the St. Marys City Council unanimously passed an amendment to Section 54 of the City's Code of Ordinances for the purpose of flood hazard reduction. Among numerous other provisions, Section 54.6 of the ordinance specifically requires that newly constructed and substantially improved residential structures must be "elevated now lower than two feet above the base flood elevation," while newly constructed or substantially improved nonresidential structures "must be designed to be watertight to one foot above the base flood elevation."

These requirements exceed the National Flood Insurance Program's minimum standard, which is for new and substantially improved structures to simply be above the 100-year base flood elevation. The requirement would notably put all newly constructed or substantially improved residential structures in the City of St. Marys above the 100-year flood height with up to 2-feet of sea-level rise, which is very near the NOAA Intermediate-High sea-level rise scenario for 2065 (2.01'). These flood hazard construction standards will result in drastically reduced potential flood damages within the City over time, including under a scenario that assumes substantially accelerated sea-level rise over the next 50-years.

Costs of elevating new structures – as well as elevating existing structures – are highly dependent on the size, design, and foundation type of the structure. However, a simple comparison of avoided damages per structure in the regulatory floodplain indicates that an average flood-proofing investment of between $20,129 (Low sea-level rise) and $34,234 (Intermediate-High sea-level rise) per structure would be likely to provide a positive benefit-cost return in terms of avoided property loss over the 50-year planning horizon.[45] Additional benefits such as lowered flood insurance rates and substantially reduced time of resident displacement, while not formally accounted in this analysis, can be expected to increase the benefits associated with individual property adaptation measures that follow guidelines established by the City's flood hazard ordinance.[46]

Stormwater Vulnerability Assessment

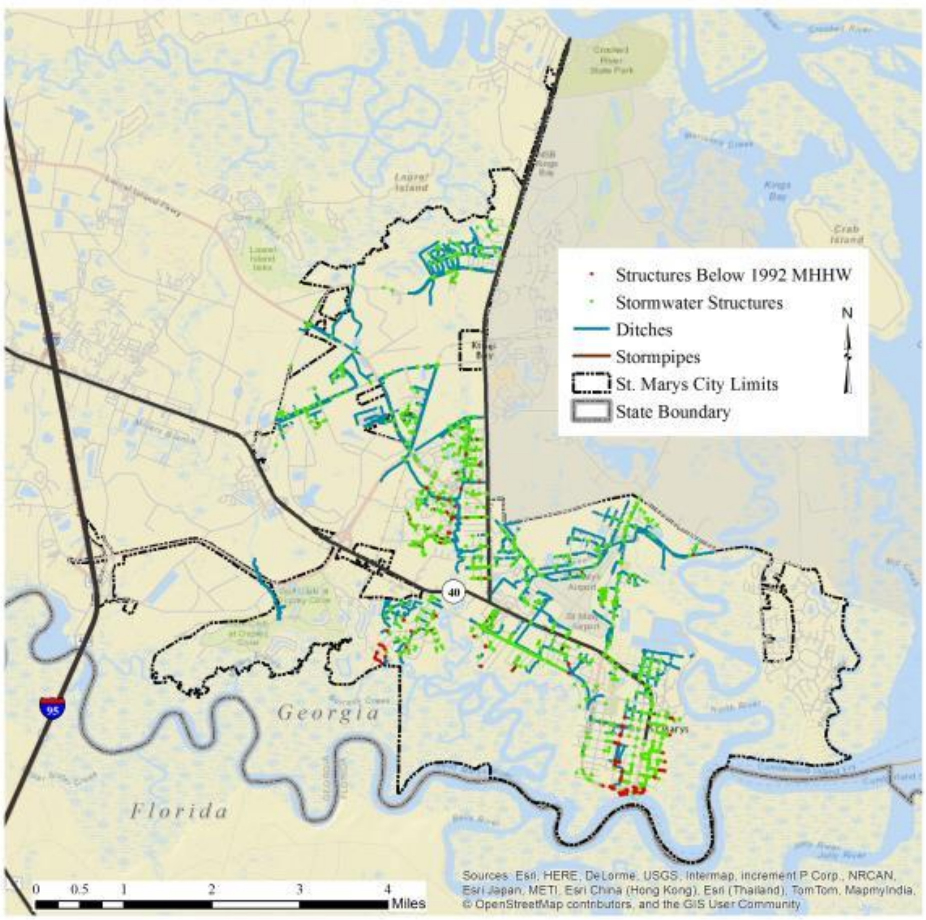
Discussions with stakeholders and public officials within the City of St. Marys indicated some concerns about the current functioning of the City's stormwater drainage system, particularly within the downtown historic district. A number of stakeholders gave specific reports of somewhat frequent flooding in low-lying streets and yards in the downtown area, and further noted that these flood events generally occur when heavy rainfalls happen to coincide with high tide cycles. Observations and knowledge that significant portions of the stormwater system in the historic downtown and other areas of the City discharge directly into tidal waterways, combined with apparent linkages between tide stage and rainfall flooding, raised additional concern that current stormwater issues could be substantially worsened by future sea-level rise.

During the data gathering phase of this project, the City of St. Marys supplied a comprehensive set of geographic information system (GIS) files that together provide a high level of detail about the City's stormwater infrastructure. Geographic information provided by these files include point locations for stormwater infalls and outfalls, linear extents for underground pipes, linear extents for drainage ditches, and polygon extent of retention and detention facilities. Importantly, the attribute information for infall and outfall points also includes specific elevation readings for belowground infrastructure (often referred to as invert elevation). Additional attribute information such as pipe shape, diameter, and construction material was also available for most underground stormwater pipes.

A range of current and future tide range scenarios, as based upon the Fernandina Beach tide gauge, were compared against the known invert elevations for stormwater infalls and outfalls in the City of St. Marys. This City-wide analysis was used to identify the current and future extent of underground stormwater infrastructure that is likely being penetrated by tidewater, thus reducing drainage capacity during rainfall. The City of St. Marys stormwater database contains a total of 1,923 structures with defined bottom elevations, as referenced to NAVD88. The structures include 1,280 stormwater inlet and access points such as box culverts, catch basins, curb inlets, grated drop inlets, junction boxes, manhole accesses, and swale inlets. The other 643 structures are pipe outfalls that lead into ditches, retention ponds, swales, and receiving waters.

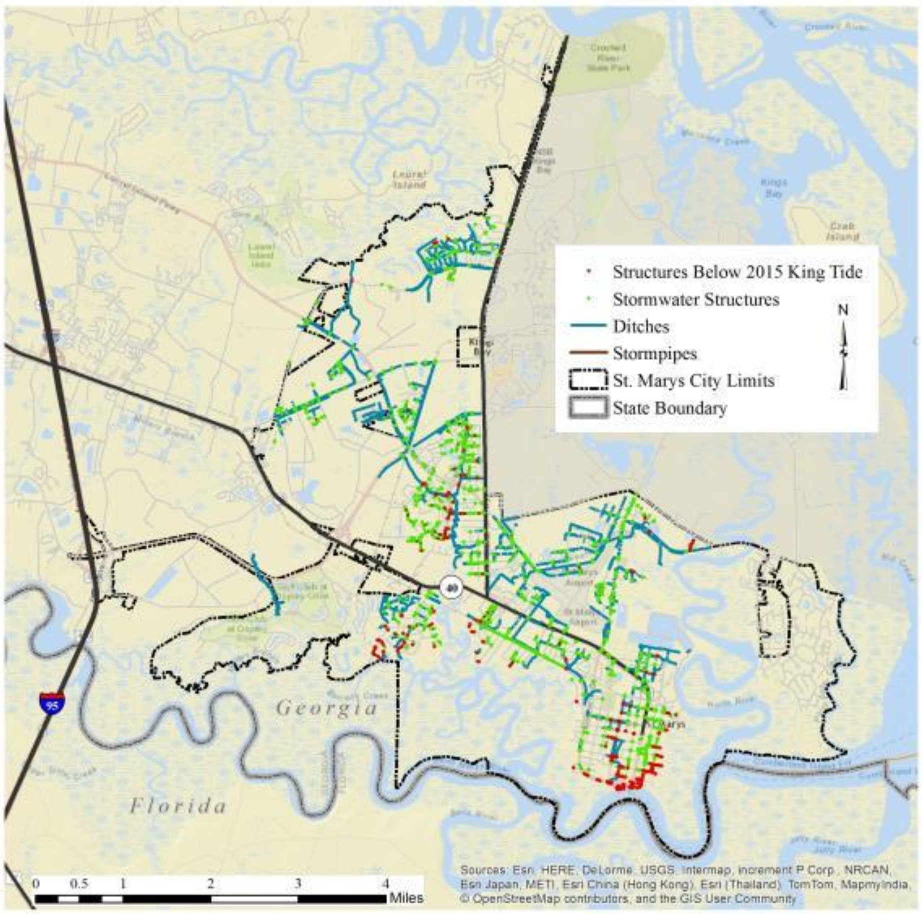
The baseline tidal penetration assessment is for structures with bottom elevations below the 1992 MHHW level, or 2.76' above NAVD88. A total of 148 stormwater structures, including 83 inlets and 65 outfalls, within St. Marys were identified as below this MHHW elevation. A large percentage of structures below 1992 MHHW are located in the City's historic downtown waterfront area and are associated with outfalls that connect directly to the tidally influenced St. Marys River (Figure 4.6). Areas served by these structures can be expected to experience minor to moderate street and yard flooding during heavy rainfall that co-occurs with an average daily high tide.

Figure 4.6: Stormwater structures with underground elevation less than current mean higher high water (MHHW) datum (2.76’ above NAVD88), City of St. Marys, GA.



A second tidal penetration assessment identified structures with bottom elevations below the 2015 king tide level, or 4.68’ above NAVD88. A total of 334 stormwater structures, including 184 inlets and 150 outfalls, were identified as below this king tide elevation. Many of these structures are also located in the City’s historic downtown waterfront area and associated with outfalls into the St. Marys River (Figure 4.7). However, neighborhoods that are drained by outfalls into Dark Entry Creek, including to the south of State Road 40 and just south of Colerain Dr., also show potential impacts from current king tides. Areas served by these structures can be expected to experience moderate to severe street and yard flooding during heavy rainfall that co-occurs with very high tides.

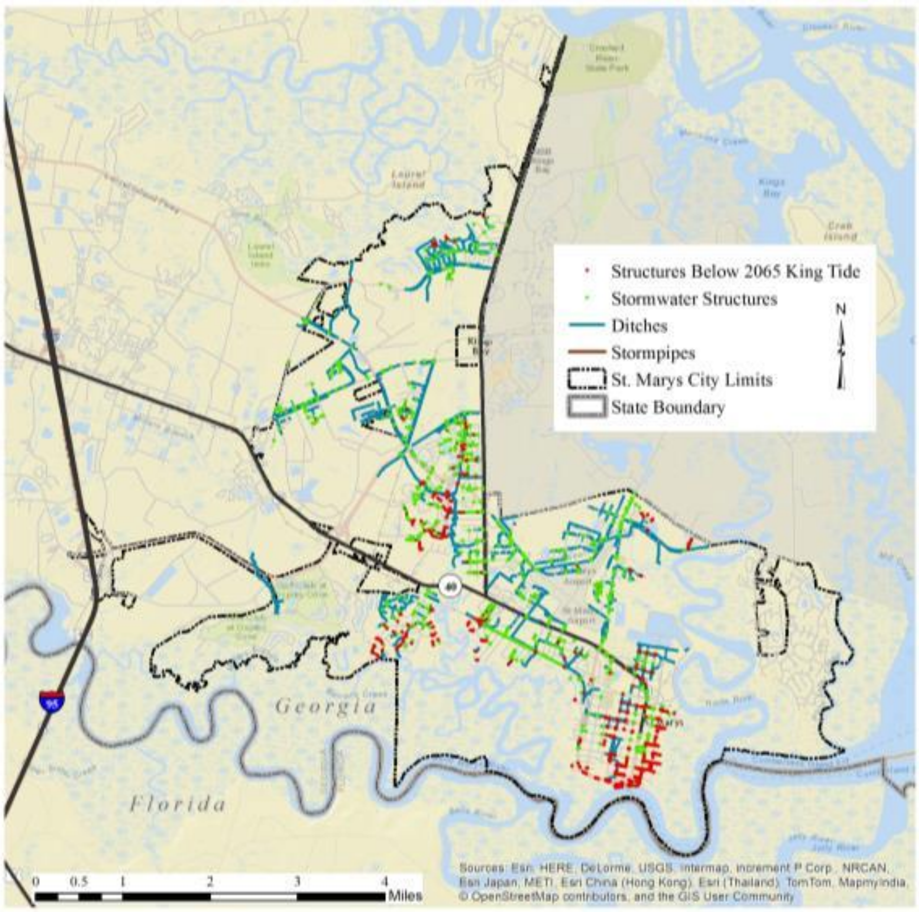
Figure 4.7: Stormwater structures with underground elevation less than 2015 king tide height (4.68' above NAVD88), City of St. Marys, GA.



A third tidal penetration assessment identified structures vulnerable to 2065 king tide with Intermediate-High sea-level rise. The 2065 king tide under this scenario is 6.39' above

NAVD88, or approximately 1.71’ higher than a 2015 king tide. A total of 621 stormwater structures, including 358 inlets and 263 outfalls, were identified as below this elevation. Most of the City’s downtown drainage into the St. Marys River and many areas that drain directly into Dark Entry Creek show substantial impacts from annual king tides under this scenario. If this scenario does occur, the areas served by these structures could be expected to experience severe street and yard flooding, with some potential for minor flooding of low-lying structures, during heavy rainfall events that co-occur with very high tides.

Figure 4.8: Stormwater structures with underground elevation less than 2065 king tide height with Intermediate High sea-level rise (6.39’ above NAVD88), City of St. Marys, GA.



Suggestions for Stormwater Adaptation

The results of this stormwater infrastructure assessment provide some objective confirmation of stakeholder observations about street-flooding issues in St. Marys, particularly within the City's historic downtown waterfront area. This is not surprising, as stresses and failures within municipal stormwater drainage systems are increasingly recognized as among the most chronic, complicated, and visible early consequences of sea-level rise across the country and throughout the world.[47]

In 2016, faculty from the University of Georgia's Carl Vinson Institute of Government (Vinson Institute) worked with the City of St. Mary to develop the *Downtown St. Mary Strategic Plan and Vision* report, which outlines several steps that the City should consider for the purpose of reducing street flooding in the downtown area. [48]

The following provides a summary of key recommendations contained in the Vinson Institute report:

1) Increased use and construction of "rain garden" bioswales that redirect stormwater from impervious streets and pipe infrastructure into vegetated greenspace areas. Vegetated areas will tend to slow down and reduce the volume of runoff that eventually enters into stormwater drainage systems, thus alleviating downstream flooding issues.

2) Direct stormwater from building rooftops into bioswales, vegetated greenspace, or capture and reuse devices (e.g., rain barrels and cisterns), rather than into impervious surfaces (e.g., driveways and parking lots) that feed into street drainage systems. These practices also reduce the volume of runoff that enters into the stormwater drainage systems, which alleviates downstream flooding.

3) Increase the tree canopy within developed areas of the City, including along streets. In addition to the beauty and water quality benefits associated with tree cover, the interception of rainfall by tree leaves is known to reduce the volume of that enters into stormwater systems.

4) Conservation of undeveloped, low-lying properties along waterfront and marshfront areas of the City. Maintenance of low-lying areas as open space gives an opportunity for more sustainable stormwater management in the near-term, while also helping to alleviate long-term risks to property and people from increased tidal flooding.[49]

While the above green infrastructure recommendations were developed specifically for the downtown area of St. Marys, the same principles and practices for runoff reduction can also be used in other areas of the City to help alleviate current and future stormwater flooding. However, it is likely that improved stormwater drainage, particularly under a condition of accelerated sea-level rise, would require pursuit of strategic and, in comes cases, substantial upgrades to the City's existing hard, "gray" stormwater infrastructure. The following are three of the most common gray stormwater upgrades currently being pursued by coastal communities for the purpose of reducing stormwater and tidal flooding problems:

1) Installation of backflow preventers on low-lying outfalls subject to tidal inundations. Backflow prevention devices include a variety of flap gates, check valves, and slide gates that are designed to keep tide water from entering into stormwater systems during high tide events. These devices are generally among the lowest cost upgrades for making a stormwater system more resistant to tidal flooding. However, backflow preventers do require periodic maintenance to ensure that they continue to function properly.[50] It is also important to note that while penetration of tidal water into stormwater systems is greatly lessened through use of backflow preventers, drainage of runoff during rainfall events will still be constrained by high tide events that submerge pipe outfalls.[51]

2) Replacement of degraded and undersized underground pipes. The maximum discharge rate for a stormwater pipe system is controlled by factors that include the slope of the system, construction material, condition of pipes, and pipe diameter. Many urban stormwater systems, particularly those built decades ago, are characterized by undersized drainage pipes that are insufficient for handling large volumes of stormwater. These older drainage systems are very often also degraded by cracks, obstructions, and sedimentation, all of which further reduce drainage potential. Notably, much of the City's most vulnerable stormwater infrastructure is located in the historic downtown of St. Marys and was originally built in the early to mid-20th century. As the City moves to implement renovations within the historic downtown and waterfront, it is highly recommended that potential upgrades to the stormwater pipe infrastructure be included as a core scope within these projects.

3) Development of enhanced stormwater storage capacity in newly constructed retention and detention basins, particularly in more elevated areas. Over time, it is expected that sea-level rise will also cause a rise in water tables along the coastal zone, thereby reducing the rate of potential stormwater infiltration into increasingly saturated soils. Concerns about such issues have led some U.S. and European municipalities to consider "over-design" standards for new stormwater facilities in upland areas well above the water table. The primary idea behind such an over-design standard is that the excess storage capacity in these new facilities may be needed as a safety factor to ensure that very little runoff escapes into lower-lying coastal areas that are most vulnerable to flooding.[52] Over the long-term, such

facilities could also potentially be used as storage locations for excess water pumped from low-lying areas during rainfall events that co-occur with high tides.

The identification and design of particular projects to implement these suggested stormwater adaptation strategies will require engineering assessments and associated municipal resources that reach beyond the scope of this flood resiliency assessment. It is, however, suggested that the City of St. Marys begin considering a municipal stormwater utility fee structure for the purpose of generating funds dedicated to the maintenance and upgrade of the local drainage system. The University of Georgia has developed several publications and has other resources available for communities interested in studying the feasibility and appropriateness of a local stormwater utility.[53]

Chapter 5: Community Rating System

The Community Rating System (CRS) is a voluntary Federal Emergency Management Agency (FEMA) program that rewards communities for exceeding minimum floodplain management standards, thereby improving public safety and the economic stability of the community. It can be an efficient and cost-effective way for local governments to address the rising costs of flood insurance in the community, while simultaneously building resilience, minimizing damage to people and property and speeding up the recovery process.

Local communities gain points in the CRS program by improving their preparation and response to flooding issues through developing and documenting public information activities, improved mapping capacity, adoption of enhanced floodplain regulations, implementation of flood damage reduction mechanisms, and enhanced warning and response procedures. The CRS has three goals: 1) reduce and avoid flood damage to insurable properties, 2) strengthen and support the insurable aspects of the National Flood Insurance Program, and 3) foster comprehensive floodplain management.

When the St. Marys Flood Resiliency Project began in 2013, the City of St. Marys was not a participant in the CRS. Any community that does not participate is automatically classified as a 10 on the CRS scale, earning zero reductions in flood insurance premiums for policyholders. One of the core goals of the St. Mary's Flood Resiliency Project was to assist the City in joining the CRS program.

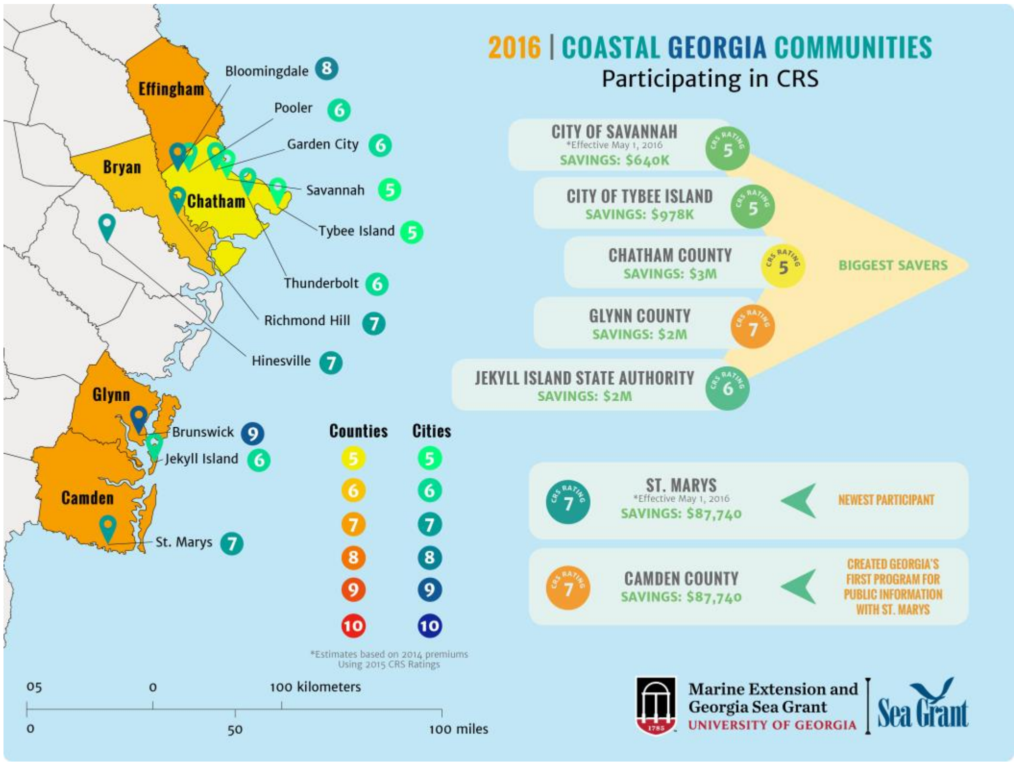
RISING COST OF FLOOD INSURANCE

Flooding has been, and continues to be, a serious risk in the United States—so serious that most insurance companies have specifically excluded flood damage from homeowners insurance. To address the need, in 1968 the U.S. Congress established the National Flood Insurance Program (NFIP). It enabled property owners in participating communities to purchase flood insurance, if the community had adopted floodplain management ordinances and minimum standards for new construction. However, owners of existing homes and businesses did not have to rebuild to the higher standards, and many received subsidized rates that did not reflect their property's true risk.

Fortuitously, the timing of the St. Marys Flood Resiliency Project coincided with drastic changes that were taking place in flood insurance policy at the national level. Due to unprecedented insurance claims made to FEMA during the aftermath of Hurricane Katrina and Super Storm Sandy, the NFIP was billions of dollars in debt and Congress sought to take action to ensure the solvency of the flood insurance program. The Biggert-Waters Flood Insurance Reform Act of 2012 was passed by Congress and signed into law by the President. The consequences of suddenly imposing actuarial flooding insurance rates within the very next policy cycle led to some residents facing mandatory insurance costs that exceeded their mortgages, compromised their ability to sell their property and exacerbated foreclosures. This produced an outcry from coastal residents affected by the policy changes and a demand from lawmakers for a deeper understanding of flooding issues.

In response, in March of 2013, Georgia Sea Grant conducted its first Community Rating System workshop in Brunswick in partnership with the Georgia Environmental Protection Division Flood Plain Unit, the FEMA insurance and elevation certificate specialist, the FEMA outreach specialist, the Insurance Services Office agent and the Department of Natural Resources Coastal Hazards specialist. Over 50 people representing 17 coastal communities attended this workshop. A post-workshop evaluation identified CRS as the program which could offset increasing insurance costs, and indicated a strong need for coastal CRS training and outreach.

In the fall of 2013, then Congressman Jack Kingston reached out to Georgia Sea Grant staff in search of guidance and education on the issue of flooding vulnerability and economic consequences. Over the next several months, Georgia Sea Grant staff worked closely with the Congressman's office, informing him and his staff about coastal flooding and vulnerability. In 2014, the Homeowner Flood Insurance Affordability Act became law, thus modifying and repealing certain provisions in the previous legislation, including a gradual increase in premiums over a five-year period. Even with the implementation of this act, coastal residents have seen increased premiums, higher policy fees and added mandatory surcharges.



CRS in Coastal Georgia

As of October 1, 2016, 16 cities and counties in coastal Georgia were active CRS participants. Due in part to the efforts of Georgia Sea Grant and its partners, several participating communities in coastal Georgia have improved their scores since 2014, resulting in additional savings for property owners.

CRS in St. Marys

One of the most significant achievements of this project has been the successful entry of St. Mary's into the CRS at a rating of seven, thus resulting in a 15% reduction in flood insurance premiums for residents in the special flood hazard area. Not only has the City been rewarded for requiring higher minimum standards for flood preparedness, citizens have saved over $87,000 in annual flood insurance premiums.

EARNING CRS POINTS IN ST. MARYS

- Georgia Sea Grant collaborated with the City of St Marys staff, and Georgia DNR to document and calculate the amount of **open space** within the city boundaries. Points are awarded for the amount of open space areas that are preserved, or in the process of becoming preserved, to their natural state.
- The City is requiring that all new construction have **two feet of freeboard**. Freeboard is elevating the lowest floor of a building, in this case houses, by a set additional height above the National Flood Insurance Program's minimum height requirements. This will further protect homes from damage due to flooding events.
- Georgia Sea Grant assisted in establishing a flood reference section in the St. Marys and Camden County public libraries. Making required FEMA materials on flood protection and other locally pertinent materials available at public libraries not only helps communities earn CRS credit, but also helps to ensure public safety, minimize property damage and assist recovery efforts related to flooding.

Georgia Sea Grant also helped by creating maps and diagrams detailing how sea-level rise might impact the city. It additionally assisted in educating residents about their flood risk, through hosting public Town Hall meetings and other outreach opportunities. Georgia Sea Grant's efforts led to further research in downtown St. Marys to plan for how the historic district might adapt to current and future flooding.

Pull-out Quote:

> ***"If your community is considering entering into the CRS Program, the Sea Grant staff can provide the knowledge and experience to assist your community in the CRS application. Their assistance was invaluable."***
>
> ***- Michele Wood, St. Marys Floodplain Manager***

CRS TRAINING

As previously mentioned, Georgia Sea Grant and its partners provided diverse educational opportunities for local decision-makers and community members throughout the project cycle, using the latest research and on-the-ground observations. The organizations also provided intensive trainings on CRS, offering technical expertise and guidance to increase understanding and participation in the National Flood Insurance Program (NFIP) among local governments on the coast.

- **National Flood Insurance Program's Community Rating System Workshop: A Step-by-Step Guide for Coastal Governments** - *March 1, 2013 in Brunswick, Georgia*
  Over 30 coastal government officials, staff and other interested parties gathered to learn more about the CRS program and its benefits to communities.
- **Preliminary Release of the New Coastal Floodplain Maps** – *August 19, 2015 in Brunswick, Georgia*
  FEMA and state floodplain managers presented engineering and mapping data to 60 officials from Glynn, McIntosh Camden and Long Counties, outlining the timeframe in which the new flood maps will be released to the public. Representatives from Senator Johnny Isakson's office and Congressman Buddy Carter's office were also present.
- **Beyond the Why and Getting to How: Earning CRS Credits for Open Space, Regulatory Standards and Voluntary Property Acquisition Programs** – *August 28, 2014 in Savannah, Georgia*
  Georgia Sea Grant partnered with the UGA Carl Vinson Institute of Government to host a flooding policy and planning workshop for over 200 people, focused on best practices and tips for success in joining or complying with the CRS program.
- **FEMA Elevation Certificate Workshop –** *September 17, 2015 in Brunswick, Georgia*
  This training was conducted for surveyors, engineers, floodplain administrators and municipal and county officials.
- **FEMA Floodplain Managers Training** – *December 7-11, 2015 in Brunswick, Georgia*
  FEMA's training on managing floodplain development usually occurs in Maryland; however, Georgia Sea Grant helped offer this course at its UGA Marine Extension facility in Brunswick, allowing twenty local government staff from across the state to more accessibly acquire their Floodplain Management Certification.

NETWORK BUILDING

The project team also helped build a coalition of coastal communities to tackle the challenges of flooding, so that cities and counties with greater experience and capacity can assist smaller or more rural communities. This included organizing forums where scientists, practitioners and local government staff could share lessons learned with one another, as well as challenges and opportunities for earning points in CRS.

Throughout the project period, Georgia Sea Grant helped establish the following learning networks:

- The **Coastal Georgia CRS Users Group** expanded to include Camden County and St. Marys by offering to rotate the location of its meeting among the participating communities.
- One benefit of this strengthened support between floodplain managers is a new collaboration between Camden County and St Marys to create **the state's first Program for Public Information (PPI)**, an outreach collaboration to increase awareness of flooding and coastal hazards.
- The **Georgia Coastal Hazards Community of Practice** provides opportunities to share activities best management practices for coastal climate-related projects and FEMA's Community Rating System.

COMMUNITY FLOOD INFORMATION LIBRARY

To ensure public safety, minimize property damage and assist recovery efforts related to flooding, FEMA recommends that all communities close to flood-prone rivers and coasts make information about floods and flood insurance available to their citizens. Not only is this information invaluable for public safety, but making these materials available at the public library can help communities earn credit and reduce the cost of flood insurance under the Federal Emergency Management Agency (FEMA) Community Rating System.

FEMA requires a group of nine publications to be available at the local library for a community to receive CRS credit under the Flood Protection Library (LIB) element. FEMA also provides credit for making information specifically related to floods and flood plains in the local area available to the public. These are credited under the Locally Pertinent Documents (LPD) element. Listed below are the required FEMA materials, followed by a list of Locally Pertinent Documents with examples for coastal Georgia. These materials have been provided by public libraries in the City of St. Marys and Camden County and are located within their flood information sections.

FEMA provides hard copies of many of their documents to community libraries free of charge. Information on preparing for floods, flood insurance and flood recovery also can be found by following the links below.

FEMA Required Materials:

1. Community Rating System Coordinator's Manual
2. Above the Flood: Elevating Your Flood Prone House, FEMA-347 (2000)
3. Answers to Questions About the National Flood Insurance Program, F-084 (2011)
4. Coastal Construction Manual, FEMA-P-55, (2011)
5. Elevated Residential Structures, FEMA-54 (1984)
6. Protecting Manufactured Homes from Floods and Other Hazards, FEMA P-85 (2009)

7. Mitigation of Flood and Erosion Damage to Residential Buildings in Coastal Areas, FEMA-257 (1994)
8. Protecting Building Utilities From Flood Damage, FEMA-P-348 (1999)
9. Protecting Floodplain Resources, FEMA-268 (1996)
10. Reducing Damage from Localized Flooding, FEMA 511 (2005)

Locally Pertinent Documents:

1. Community Handbook on Floodplain Management
2. Georgia Floodplain Management
3. Community Floodplain Management Ordinance
4. Environmental Organization's Guide to Habitat
5. Community FIRM
6. Army Corps of Engineers Reconnaissance Report
7. Community Flood Insurance Study
8. County's Floodplain Management or Hazard Mitigation Plan
9. Local Resource Management Plans Related to Floodplains

References:

[1] Hauer, M. E., J. M. Evans, and D. R. Mishra. 2016. Millions projected to be at risk from sea-level rise in the continental United States. Nature Climate Change DOI:10:10.1038/nclimate2961.

[2] Nicholls, R.J. 2011. Planning for the impacts of sea level rise. Oceanography 24:142-155.
Hinkell, J., D. Lincke, A.T. Vafeidas, M. Perrette, R.J. Nicholls, R.S.J. Tol, B. Marzeon, X. Fettweis, C. Ionescu, and A. Levermann. 2014. Coastal flood damage and adaptation costs under 21st century sea-level rise. PNAS 111:3292-3297.

[3] Evans, J. M., J. Gambill, R .J. McDowell, P. W. Prichard, and C. S. Hopkinson. 2016. Tybee Island Sea-Level Rise Adaptation Plan. Athens: Georgia Sea Grant. DOI: 10.13140/RG.2.1.3825.9604/1.

[4] FEMA. 2007. Flood Insurance Study, Camden County, Georgia and Incorporated Areas. Flood Insurance Study Number 13039CV000A. Federal Emergency Management Agency. http://www.georgiadfirm.com/pdf/panels/13039cv000a.pdf.

[5] NOAA, National Coastal Population Report, Population Trends from 1970 to 2020, 7 (2012). http://oceanservice.noaa.gov/facts/coastal-population-report.pdf

[6] U.S. Census Bureau, Population Estimates Program (PEP), Updated annually. http://www.census.gov/popest/. U.S. Census Bureau, 2010 Census of Population, P94-171 Redistricting Data File. Updated every 10 years. http://factfinder.census.gov

[7] Census Viewer. http://censusviewer.com/city/GA/Saint%20Marys

[8] Hauer, M., J. Evans, and C. Alexander. 2015. Sea-level rise and sub-county population projections in coastal Georgia. Population & Environment 37:44-62.

[9] GEMA. 2015. The Official Georgia Hurricane Guide. Atlanta: Georgia Emergency Management Agency. http://www.weather.gov/media/chs/misc/GAHurricaneGuide.pdf.

[10] Carter, L. M., J. W. Jones, L. Berry, V. Burkett, J. F. Murley, J. Obeysekera, P. J. Schramm, and D. Wear. 2014. Ch. 17: Southeast and the Caribbean. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 396-417.

[11] Supra note 9.

[12] Pavey, R. 2010. Georgia rarely gets hit by hurricanes: here's why. The Augusta Chronicle. September 1. http://chronicle.augusta.com/content/blog-post/rob-pavey/2010-09-01/georgia-rarely-gets-hit-hurricanes-here-s-why.

[13] Fraser, W. J. 2006. *Lowcountry Hurricanes: Three Centuries of Storms at Sea and Ashore*. Athens: University of Georgia Press.

[14] Kiage, L. M., D. Deocampo, T. A. Mccloskey, T. A. Bianchette, and M. Hursey. 2011. A 1900-year Paleohurricane Record from Wassaw Island, Georgia, USA. Journal of Quarternary Science 26:714-722.

[15] NOAA. 2016. Fernandina Beach, FL – Station ID: 8720030. http://co-ops.nos.noaa.gov/stationhome.html?id=8720030.

[16] Parris, A., P. Bromirski, V. Burkett, D. Cayan, M. Culver, J. Hall, R. Horton, K. Knuuti, R. Moss, J. Obeysekera, A. Sallenger, and J. Weiss. 2012. Global Sea Level Rise Scenarios for the US National Climate Assessment. NOAA Tech Memo OAR CPO-1. 37 pp.

[17] Supra note 8.

[18] Sweet, W.V. and J. J. Marra. 2016. 2015 State of U.S. "Nuisance" Tidal Flooding. https://www.ncdc.noaa.gov/monitoring-content/sotc/national/2016/may/sweet-marra-nuisance-flooding-2015.pdf.

[19] Ibid

[20] Webler, T., S. Tuler, K. Dow, J. Whitehad, and N. Kettle. 2016. Design and evaluation of a local analytic-deliberative process for climate adaptation planning. The International Journal of Justice and Sustainability 21:166-188.

[21] Federal Emergency Management Agency. Flood Insurance Study Number 13039CV000A. Camden County, Georgia and Incorporated Areas. 2005. http://www.georgiadfirm.com/pdf/panels/13039cv000a.pdf.
We note that the flood heights within the 2005 Flood Insurance Study provided the official basis for the Flood Insurance Rate Map in force in St. Marys and Camden County throughout the duration of this project. We also

note, however, that FEMA has conducted extensive analyses to update the 2005 study, and that preliminary copies of the updated Flood Insurance Rate Map were released for public comment in 2016.

[22] Supra note 14.

[23] See, for example, Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group. 2015. Unified Sea Level Rise Projection for Southeast Florida. http://www.southeastfloridaclimatecompact.org/wp-content/uploads/2015/10/2015-Compact-Unified-Sea-Level-Rise-Projection.pdf.

[24] Nicholls, R.J. and A. Cazenave. 2010. Sea-level rise and its impact on coastal zones. Science 328:1517-1520.

[25] Supra note 16.

[26] See, for example, Hauer et al. (2016), supra note i; Hauer et al. (2015), supra note vii; Strauss, B.H., S. Kulp, and A. Levermann. 2015. Carbon choices determine US cities committed to futures below sea level. Proceeding of the National Academy of Sciences of the United States 112:13508-13513.

[27] Sweet and Marra (2016), see supra note xvii.

[28] Calculated using the United States Army Corps of Engineers Sea-Level Change Curve Calculator, Version 2015.46. http://www.corpsclimate.us/ccaceslcurves.cfm.

[29] All values are calculated based upon a consistent 2015 king tide reference. This requires subtracting the assumed sea level rise between 1992 and 2015 before adding future sea-level rise respectively across all scenarios. The equational form for this correction is:

$KT_{y,S} = KT_{2015} - SLR_{1992\text{-}2015,S} + SLR_{y,S}$; where

$KT_{y,S}$ = King tide in year y under sea level rise scenario S

KT_{2015} = King tide in 2015 (4.68')

$SLR_{1992\text{-}2015,S}$ = Sea level rise from 1992 to 2015 under sea level rise scenario S

$SLR_{y,S}$ = Sea level rise from 1992 to year y under sea level rise scenario S

[30] These additive changes represent a simple addition of sea level rise scenarios, using a 2015 baseline consistent with the king tide water levels in Table 4.2, to the Hurricane Matthew water level. Formal storm surge modeling of a Hurricane Matthew-type event, as based upon higher water levels associated with future sea-level rise, was outside of the scope and resources available for this project and therefore not performed for this analysis.

[31] Data acquired from: https://www.usgs.gov/special-topic/hurricane-matthew

[32] We caution that this analysis is only for general planning purposes and, due to limitations of the underlying elevation and road centerline datasets, is not of engineering or survey quality. Site-level elevation surveys and/or specific flood level observations are required to determine actual flooding vulnerability of identified road segments.

[33] The listed minimum elevations represent ground elevation as extracted from a LIDAR-based digital elevation model, but do not necessarily reflect actual first floor elevation for any building or structure.

[34] Eastern Research Group, Inc. 2013 What will adaptation cost? An economic framework for coastal community infrastructure. NOAA Coastal Services Center. https://coast.noaa.gov/data/digitalcoast/pdf/adaptation-report.pdf.

[35] For parcels with multiple building footprints, the full appraised value was divided equally among the buildings for the purposes of the damage assessment.

[36] Supra note 21.

[37] United States Army Corps of Engineers. 2000. Economic Guidance Memorandum (EGM) 01-03, Generic Depth-Damage Relationships. https://planning.erdc.dren.mil/toolbox/library/EGMs/egm01-03.pdf. All buildings were assessed using the damage curve for one story, no basement structures. The original depth damage curve was adjusted upward by 2 feet based upon the assumption of a 2-foot elevation grade for the first floor of each structure.

[38] Gersonius, B. R. Ashley, A. Pathirana, and C. Zevenbergen. 2012. Climate change uncertainty: Building flexibility into water and flood risk infrastructure. Climatic Change 116:411-423.

[39] This NPV calculation "discounts" future damages based on the following function:

$D_{NPV} = D_t / (1 + N)^t$, where
D_{NPV} = Net Present Value Damage
N = Discount rate (3.3%, or .033)
t = Years since 2015
D_t = Damage calculation for year t, as based on 2015 assessed value

40 Equations and technical demonstration of the applied flood damage assessment method can be found in Chapter 3 of Eastern Research Group, Inc. (2013), supra note xxxiii, as well as Appendix VII of Evans et al. (2016), supra note ii.

41 It is important to note that the NPV flood vulnerability assessment, as summarized in Table 4.12, was conducted with available datasets that do have important limitations. Most notably, information about building-specific characteristics that could greatly mitigate flood damage – such as elevated first floors – was not available in a digital form. Inclusion of such site-specific information, which would require detailed surveys of structures in the floodplain, could potentially result in substantial changes – and likely reductions – in the cumulative damage estimates.

42 Beck, G.T. 2014 New York's new $335 million storm-surge barrier will transform the lower east side. https://nextcity.org/daily/entry/new-yorks-new-335-million-storm-surge-barrier-will-transform-the-lower-east

43 The estimated cost of a sea wall was derived from estimates originally published in Yohe, G., J. Neumann, P. Marshall, and H. Ameden. 1996. The economic cost of greenhouse-induced sea-level rise for developed property in the United States. Climatic Change 32:387-410. The standard estimate by Yohe et al. is $750 per linear foot, with a high end estimate of $4,000 per linear foot. Inflation adjustment from 1996 dollars to 2015 dollars results in a standard estimate of approximately $1,150 per linear, with a high end estimate of approximately $6,050 per linear foot.

44 Eastern Research Group, Inc. (2013), supra note xxxiii.

45 These values per structure are simply calculated as D_{SLR}/n, where
D_{SLR} = Damages by sea level rise scenario, SLR, from Table 4.12
n = Number of structures in regulatory floodplain, which is 1,204

46 Highfield, W.E. and S.D. Brody. 2013. Evaluating the effectiveness of local mitigation activities in reducing flood losses. Natural Hazards Review 14:229-236.

47 Titus, J.G., C.Y. Kuo, M.J. Gibbs, and T.B. Laroche. 1989 Greenhouse effect, sea level rise, and coastal drainage systems. Journal of Water Resources Planning and Management 113:216-225.
King, P.G., A.R. McGregor, and J.D. Whittet. 2016. Can California coastal managers plan for sea-level rise in a cost-effective way? Journal of Environmental Planning and Management 59:98-119.

48 Bivins, D., L.D. Holbrook, S. Pippin, K.M. Messich, T.C. Stancil, C. Stebbins, C. Riker, K DeVivo, and M. Bailey. 2016. Downtown St. Marys Strategic Vision and Plan. Athens: Carl Vinson Institute of Government. http://www.stmarysga.gov/St.%20Marys%20Report%20FINAL.pdf.

49 Runoff reduction and water quality benefits from these green infrastructure practices are described in great detail by: Center for Watershed Protection. 2009. *Coastal Stormwater Supplement to the Georgia Stormwater Manual*. http://documents.atlantaregional.com/gastormwater/Georgia-CSS-Final-Apr-09.pdf.

50 New Haven (CT) City Plan Department. 2010. Natural Hazard Mitigation Plan Update. http://www.cityofnewhaven.com/cityplan/pdfs/PlanningPrograms/Final%20NH-HMP[1]-%20latest%20version.pdf

51 Dent, S. and S. Deslauriers. 2013. Master planning collection systems in a time of uncertainty: Climate change, adaptive management, and defining new levels of service. Proceedings of the Water Environment Federation 15:322-336.

52 Semadeni-Davies, A., C. Hernebring, G. Svensson, and L.G. Gustafsson. 2008. The impacts of climate change and urbanization and drainage in Helsinborg, Sweden: Suburban stormwater. Journal of Hydrology 350:114-125.

Bloetscher, F., B.N. Heimlich, and T. Romah. 2011. Counteracting the effects of sea level rise in Southeast Florida. Journal of Environmental Science and Engineering 5:1507-1525.
Bird, J.M. M. Tobin, T. McGowan, and M. Abbott. 2015. A Research Paper Reviewing Issues and Unintended Consequences related to Raising Minimum Building Finish Floor Elevations. City of Miami Beach, FL.

[53] Smith, J. 2006. Stormwater Utilities in Georgia. University of Georgia School of Law. http://digitalcommons.law.uga.edu/cgi/viewcontent.cgi?article=1013&context=landuse.
Carter, T.L. 2008. Stormwater Utility Handbook: A Step-by-Step Guide to Establishing a Utility in Coastal Georgia.
https://epd.georgia.gov/sites/epd.georgia.gov/files/related_files/site_page/Coastal_Stormwater_Utility_Handbook_2008.pdf,