RESILIENT ROCKLEDGE

2019

STORM SURGE | FLOODING | SEA LEVEL RISE |

SEA LEVEL RISE + SURGE

This report was prepared for the City of Rockledge, the Florida Department of Environmental Protection and the National Oceanic and Atmospheric Administration by the East Central Florida Regional Planning Council.

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Executive Summary

In 2018, the Florida Department of Environmental Protection's Florida Coastal Management Program (FCMP) and the National Oceanic and Atmospheric Administration (NOAA) awarded the City of Rockledge grant to assess natural current and future vulnerabilities in the City. The grant funding also provided the opportunity to develop strategies and policies to enhance the City's short-and-long-term resiliency to climate-related hazards and comply with "Peril of Flood" legislation put forth by Senate Bill 1094 and consider the designation of Adaptation Action Areas (AAAs) within the City. Vulnerabilities addressed through this project and assessment include flooding, sea level rise, storm surge, and storm surge combined with sea level rise.

The over-arching goal of this report is to identify coastal vulnerabilities specific to the City of Rockledge and provide recommendations to mitigate the effects of flooding, sea level rise and storm surge.

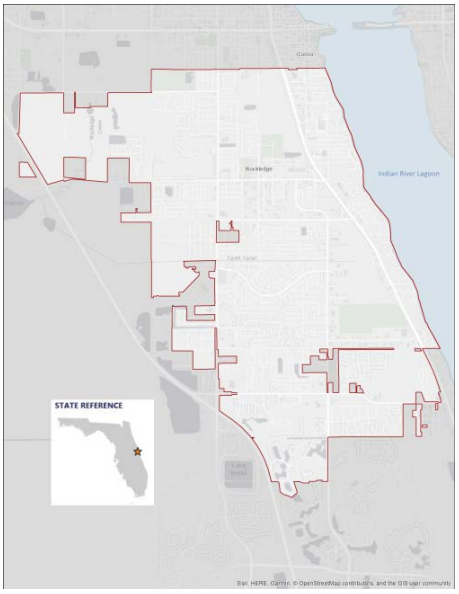
Between January 2018 through June 2019, City staff, along with staff from the East Central Florida Regional Planning Council worked together with the community to fulfill the project goals:

- Vulnerability Analysis: Identify the social, economic and functional vulnerabilities posed to the City from four natural hazards: storm surge, flooding, sea level rise and nuisance flooding. The combined impacts of sea level rise and storm surge were also analyzed.
- Public Engagement: Engage the community to identify additional vulnerabilities and potential strategies for mitigating vulnerabilities, and facilitate discussion concerning future development strategies and opportunities within the City.
- Strategy and Policy Development: Develop strategies for the City to assess based on public input and best practices and integrate strategies into the formulation of comprehensive plan policies for compliance with SB 1094 (Peril of Flood) and enhance resilience in the City.
- Stormwater Assessment: Conduct an assessment of the City's stormwater system as well as provide technical guidance and planning for considerations about the future conditions.

This document provides methodology, data and analysis concerning the vulnerabilities to the City, the process, opportunities and findings from the public engagement activities, strategies to be considered by the City for implementation and inclusion into the comprehensive plan and other City plans and documents, and finally, the stormwater assessment which assessed the impacts of hazards on the stormwater system and developed recommendations to mitigation of impacts.

Background

Coastal communities across Florida are beginning to encounter increasing flooding and surge impacts which pose risks to community assets, local and regional economics, and the health and welfare of residents. Increased frequency and duration of flooding, along with a greater prevalence, can occur as a result of sea level rise, which can have impacts on vital infrastructure. This can result in malfunctioning drainage systems, insufficient stormwater storage, loss of access to facilities and economic losses to properties and the overall community and region (1-SCTPO Vulnerability Assessment[1]). Taking a hard look at current and future vulnerabilities, developing strategies across disciplines to mitigate, adapt or retreat from the impacts and implementing policies and programs aimed towards resilience and sustainability is not only what the City should do to become a resilient city but it is also required by state statue through Senate Bill 1094. Additionally, federal agencies such as the Federal Highway Administration, Housing and Urban Development (HUD) and Federal Emergency Management Admiration (FEMA) are now tying resilience, future conditions from sea level rise and flood impacts to funding programs, making it more important for local jurisdictions and regional and state agencies to assess, plan and implement for the future of coastal communities.



The City of Rockledge, a community along the coast the Indian River Lagoon in Brevard County, Florida, is located south of Cocoa. It is the oldest incorporated municipality in Brevard County. The City faces impacts from sea level rise, storm surge and coastal flooding on the east facing the Indian River Lagoon. US Route 1, a major thoroughfare and evacuation route runs north-south through Rockledge. Interstate 95, another major connector and evacuation route lies on the west of the City. The City is approximately 13.4 square miles with an elevation of 23 feet above sea level. As a coastal community with a higher elevation, the City has a unique chance to use resiliency as an opportunity for redevelopment, infrastructure reinforcement, updating stormwater systems, focusing on water quality and other strategies that will benefit the City and its neighbors long-term.

In 2018, the Florida Department of Environmental Protection's Florida Coastal Management Program (FCMP) and the National Oceanic and Atmospheric Administration (NOAA) awarded the City of Rockledge with a grant to assess natural current and future vulnerabilities facing the City. The grant funding also provided the opportunity to develop strategies and policies to enhance the City's short-and-long-term resiliency to climate-related hazards and comply with "Peril of Flood" legislation put forth by Senate Bill 1094 and consider the designation of AAAs within the City. Vulnerabilities addressed through this project and assessment include flooding, sea level rise, storm surge, and storm surge

[1] Space Coast TPO Sea Level Rise Vulnerability Assessment 2018 https://spacecoasttpo.com/wp-content/uploads/2018/03/Space-Coast-TPO-Sea-Level-Rise-Analysis.pdf

combined with sea level rise. The following report encompasses the various aspects of the project process, vulnerability analysis findings, engagement activities and feedback, and recommendations for the City.

Project Goals

The over-arching goal of this resiliency plan is to identify coastal vulnerabilities specific to the City of Rockledge, provide recommendations, and develop policies to mitigate the effects of flooding, sea level rise and storm surge.

Between January 2019 and June 2019, City staff, along with staff from the East Central Florida Regional Planning Council worked together with the community to fulfill the project goals:

- Vulnerability Analysis: Identify the social, economic and functional vulnerabilities posed to the City from four natural hazards: storm surge, flooding, sea level rise and shallow coastal flooding. The combined impacts of sea level rise and storm surge were also analyzed.
- Public Engagement: Engage the community to identify additional vulnerabilities and potential strategies for mitigating vulnerabilities, and facilitate discussion concerning future development strategies and opportunities within the City.
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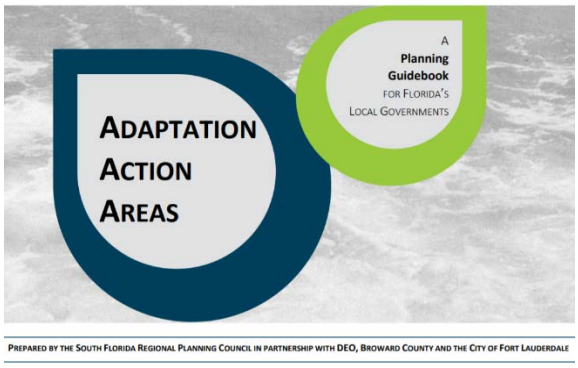
Legislative Connection

Florida's 'Peril of Flood' Legislation

Image Credit 1: Water Symposium of Florida Inc.

Senate Bill 1094, newly enacted state legislation passed in 2015, is aimed to standardize how coastal communities address climate-related vulnerabilities. The law requires coastal local governments in the state of Florida to include a 'peril of flood' component within the Coastal Element of their Comprehensive Plans. The Coastal Element guides communities in the management of coastal resources and eliminates inappropriate and unsafe development in coastal areas in order to protect the health and safety of its residents and visitors. Data and maps developed as part of this study will be incorporated into the City of Rockledge's Coastal Element in order to fulfill this state requirement.

Adaptation Action Areas



In addition to Senate Bill 1094, House Bill 7207 was passed in 2011 in the Community Planning Act and included the "Adaptation Action Area" (AAA) designation for coastal communities. This optional designation is for *"areas that experience coastal flooding and are vulnerable to the related impacts of rising sea levels for the purpose of prioritizing funding for infrastructure needs and adaptation planning for the purpose of prioritizing funding for infrastructure needs and adaptation planning."* (DEP AAA Planning Guide, 2014[2])

Regional Initiatives and Collaboration

On September 19, 2018, the East Central Florida Regional Planning Council unanimously adopted a resolution to develop a process and framework for a regional resilience collaborative in east Central Florida. To date, two committees have been formed; a Council Sub-Committee and a Steering Committee. The steering committee is made of up various disciplines across the region with the knowledge that the interaction of our locals will further enhance the creativity of resilience strategies. This regional collaborative will help build capacity and establish a shared mission and goals uniting knowledge, lessons learned, and future endeavors.

The premise of the Regional Resiliency Collaborative was the completion of the East Central Florida Regional Resiliency Action Plan (ECF RRAP), which gathered stakeholders in Brevard and Volusia County to identify opportunities and gaps in planning for resilience and to facilitate discussion on collaborative and local actions over a five-year timeframe to address climate-related vulnerabilities and strategies.

This report builds from the work developed as part of the Resiliency Action Plan and the Regional Resiliency Collaborative in a number of ways, including the use of the RRAPs Regional Approach to Sea Level Rise recommendation. Additionally, some of the recommendations included as part of this report are local government action items deemed relative to the City of Rockledge originally identified in the Regional Resiliency Action Plan.

> *"Coming together is a beginning; keeping together is progress; working together is success."*
> *– Henry Ford*

[2] Florida Department of Environmental Protection Adaptation Action Area Planning Guidebook https://floridadep.gov/files/aaa-planning-guidepdf-1

Socio-Economic Profile

According to the latest Census Data, the City's population is 26,497 and is expected to increase to 28,507 by the year 2020. Nearly 22% of the population is over the age of 65, while 30% are between 44 and 64, indicating a continued trend toward an older population over the next 30 years. The median age is 46.6 years. The median household income in Rockledge is $61,686 with 10.41% of households living below poverty. 9.39% of renters pay over 30% of their income on gross rent (cost burdened), with 4.31% of housing units spending over 50% on gross rent (severely cost burden). Approximately 1,107 households of 10,631 in the City are living below the poverty line. This is important in terms of social vulnerability because these families may not have the available funds to properly prepare for or recover from hazards such hurricanes nor the ability to make improvements to the home or property to mitigate damage or flooding. These households may also be dependent on income from jobs that, after a disaster, may be closed for a period of time, thus stressing the financial wellbeing of the household.

COST BURDENED – THOSE WHO PAY MORE THAN 30% OF THEIR INCOME FOR HOUSING.

SEVERLY COST BURDENED – THOSE WHO PAY MORE THAN 50% OF THEIR INCOME FOR HOUSING.

(HUD)

Table 1: Socio-Economic Summary of Rockledge

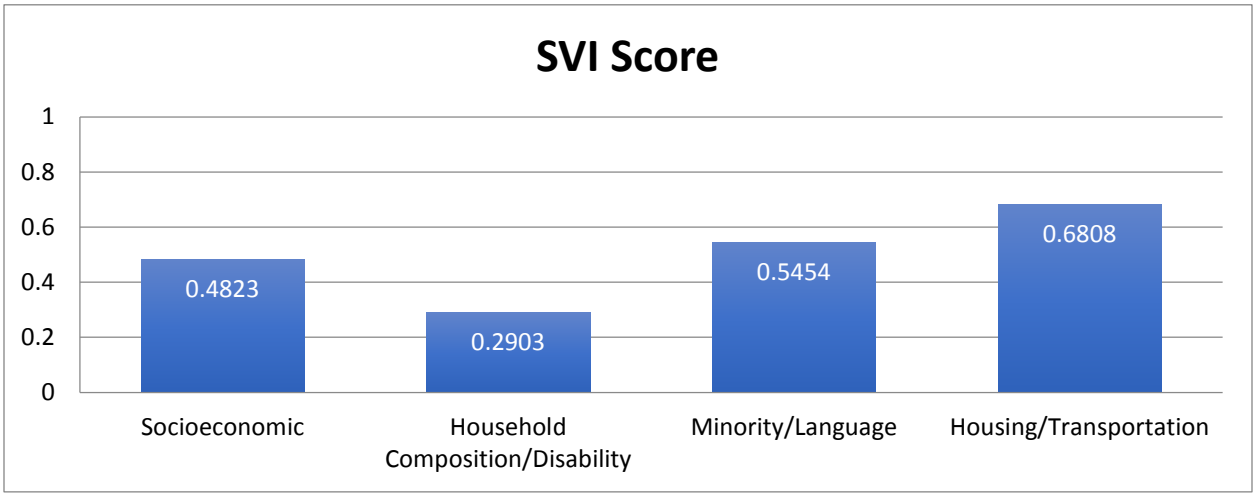
Current Total Population (ACS 2013-2017):	**26,497**
Change in Population (Census 2000-2010)	+4,291
Expected Population (Shimberg Center 2040)	33,245
[5]Median Home Value (ACS 2013-2017)	$162,000
Median Household Income (ACS 2013-2017)	$61,686

Families Below Poverty Level (ACS 2013-2017)	496
People Below Poverty Level (ACS 2013-2017)	2,570 (9.69%)
Population Age 65 and Over (ACS 2013-2017)	5,759 (21.73%)
[3]Individuals who speak English less than Very Well (ACS 2013-2017)	711 (2.68%)
[4]Total Persons Unemployed (ACS 2013-2017)	992
Average Unemployment Rate (ACS 2013-2017)	7.53
Occupied Household with No Vehicle (ACS 2013-2017)	372

[3] Individuals age 5 and older who speak a language other than English at home and who speak English less than very well.
[4] The Census Bureau defines the civilian unemployed population as "civilians 16 years old and over are classified as unemployed if they (1) were neither "at work" nor "with a job but not at work" during the reference week, and (2) were actively looking for work during the last 4 weeks, and (3) were available to accept a job.
[5] The Census Bureau defines value as the "estimate of how much the property (house and lot, mobile home and lot, or condominium unit) would sell for if it were for sale. For vacant units, value was the price asked for the property"

Social vulnerability is "how resilient a community is when confronted by external stresses on human health". Stresses can include natural disasters, disease outbreak and human disturbance and can cause economic loss and human health impacts. The Center for Disease Control utilizes census data to identify census tracts that may need support in the preparation of hazards (Center for Disease Control, 2019[6]).

Figure 1: Social Vulnerability Index Score 2016

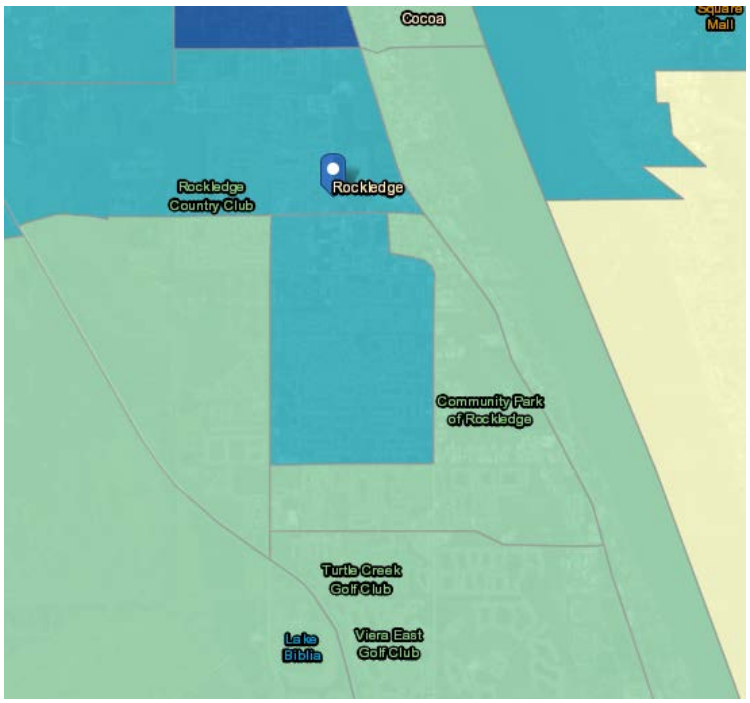


Source: CDC SVI, 2016

The Social Vulnerability Index is based on 14 social factors including vehicle access, poverty, demographics, housing and others and grouped into four themes:

- Housing/Transportation
- Minority/Language
- Household Composition/Disability
- Socioeconomic

The figure illustrates Rockledge's Social Vulnerability Index by census tract. The highest SVI score is found in Census Tract 631.05 with a 2016 Overall SVI score of 0.5279 which indicates a moderate to high level of vulnerability. Figure 1 illustrates the scoring in each of the four themes in this census tract with Housing/Transportation being the highest.



[6] Center for Disease Control Social Vulnerability Index Interactive Map https://svi.cdc.gov/map.html

Vulnerability Assessment

As the goal of the vulnerability analysis and subsequent policy actions are based upon specific hazards, the methodology section of this report highlights the base data utilized and the general methods of analysis. The areas of vulnerabilities assessed for this report include: sea level rise, shallow coastal flooding, storm surge, and designated flood areas. Modeling by the Tampa Bay Regional Planning Council also assessed storm surge with the effects of sea level rise.

Shallow Coastal Flooding

NOAA's Coastal Flood Exposure Mapper provides data to visualize the potential scale and extent, not exact location, of inundation of low-lying coastal areas susceptible to flooding during extreme high tides, otherwise referred to as shallow coastal flooding or nuisance flooding. According to NOAA, extreme high tides occur a few times per year when the sun, moon, and earth align, or during storm events. Flood levels can increase due to rainfall or wind. Since the 1960's, the occurrences of high tide flooding (exceeding local thresholds for minor impacts to infrastructure) have increased 5- to 10-fold in several U.S. coastal cities. Shallow coastal flooding can affect day-to-day activities; put a strain on infrastructure and sewer systems, and cause some minor property damage depending on its extent.

The coastal flood data utilized in this vulnerability was obtained from NOAA's Coastal Flood Exposure Mapper. The flood thresholds are derived national flood thresholds from NOAA Technical Report NOS CO-OPS 086: Patterns and Projections of High Tide Flooding along the U.S. Coastline Using a Common Impact Threshold (Sweet et al.). [7]NOAA is utilizing this data to replace the flood thresholds previously used in the tool from the National Weather Service (NWS) which take into account local flood risk and are used to issue NWS coastal flood watches, warnings, and advisories.

Figure 2: Coastal Flood Frequency Changes with Sea Level Rise

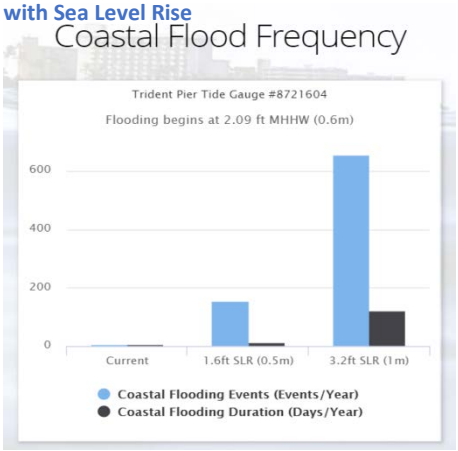
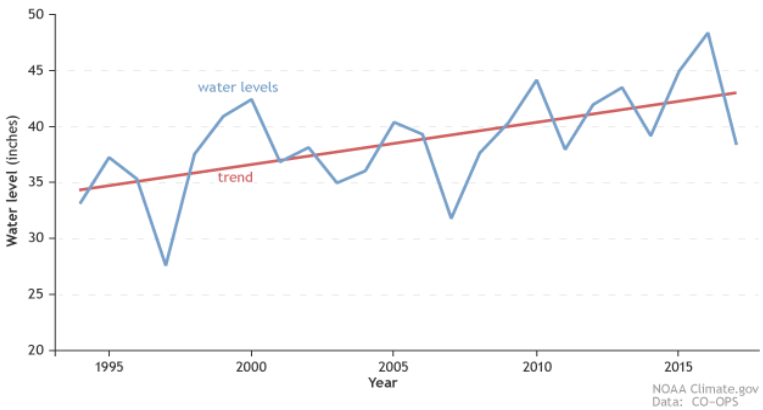


Figure 3: Maximum Daily Water Levels During the Highest Tide of the Year



[7] NOAA Technical Report NOS CO-OPS 086: Patterns And Projections of High Tide Flooding Along The U.S. Coastline Using a Common Impact Threshold, 2018. https://tidesandcurrents.noaa.gov/publications/techrpt86_PaP_of_HTFlooding.pdf

Trident Pier (Brevard County) is the Station relative to Brevard County. The NOAA NOS CO-OPS 086 report indicates the derived threshold for this area for minor flooding (high tide flooding) is 0.55 meters (1.8 ft) above the Mean Higher High Water (MHHW). Due to the topography of Brevard County, these impacts can be realized on both sides of the Indian River Lagoon as well as along the beach side. Wind speed and direction, as well as storms, can make these conditions even worse. NOAA estimates that as sea level rises by 2050 flooding frequency may increase upwards of 85 days/year in the Southeast Atlantic with 364 days by 2100 under the Intermediate scenario. The figures below from NOAA show the historical yearly flood events at Trident Pier and the trend of rising water levels during the highest tide of the year since 1994.

Figure 4: Shallow Coastal Flooding Areas

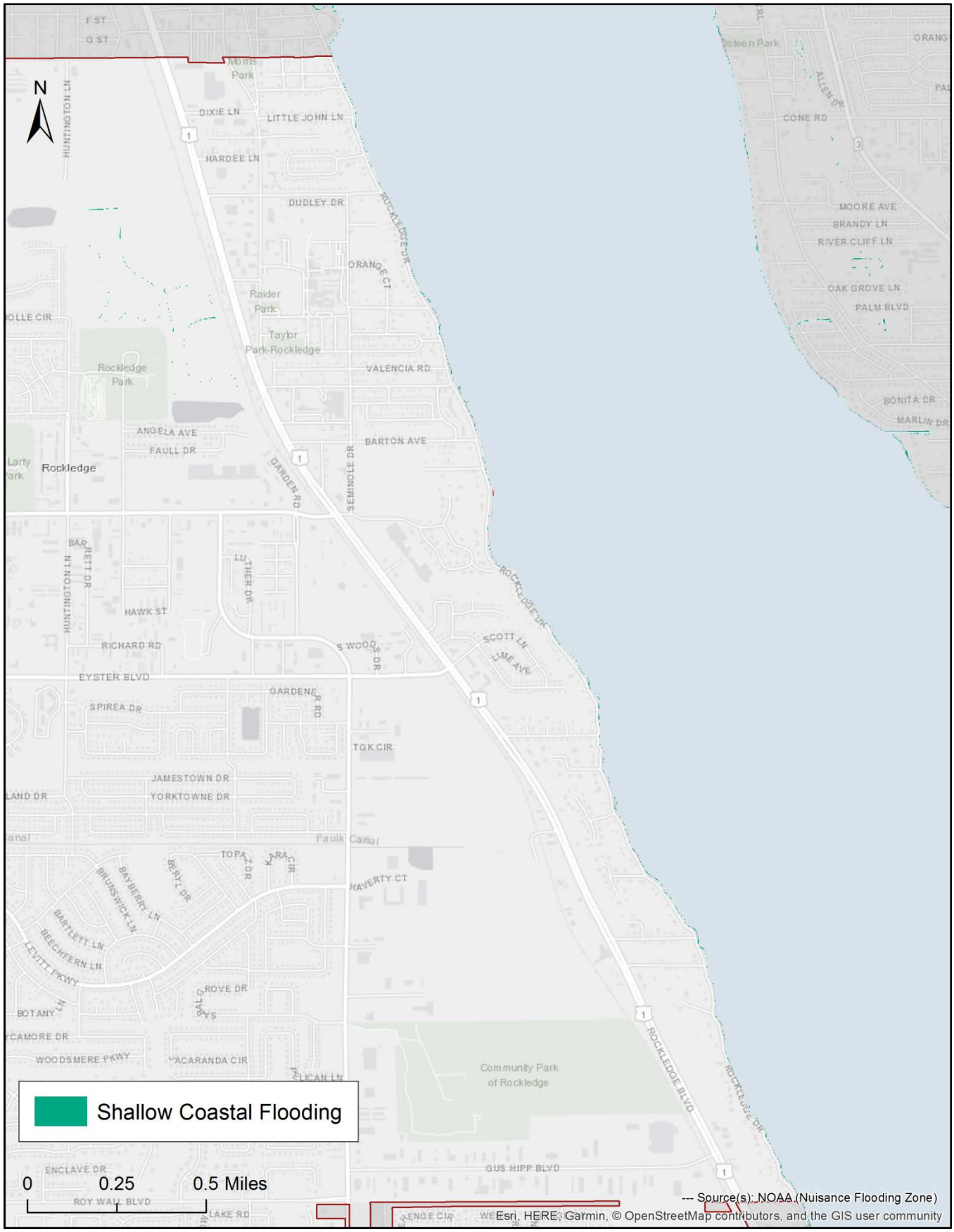
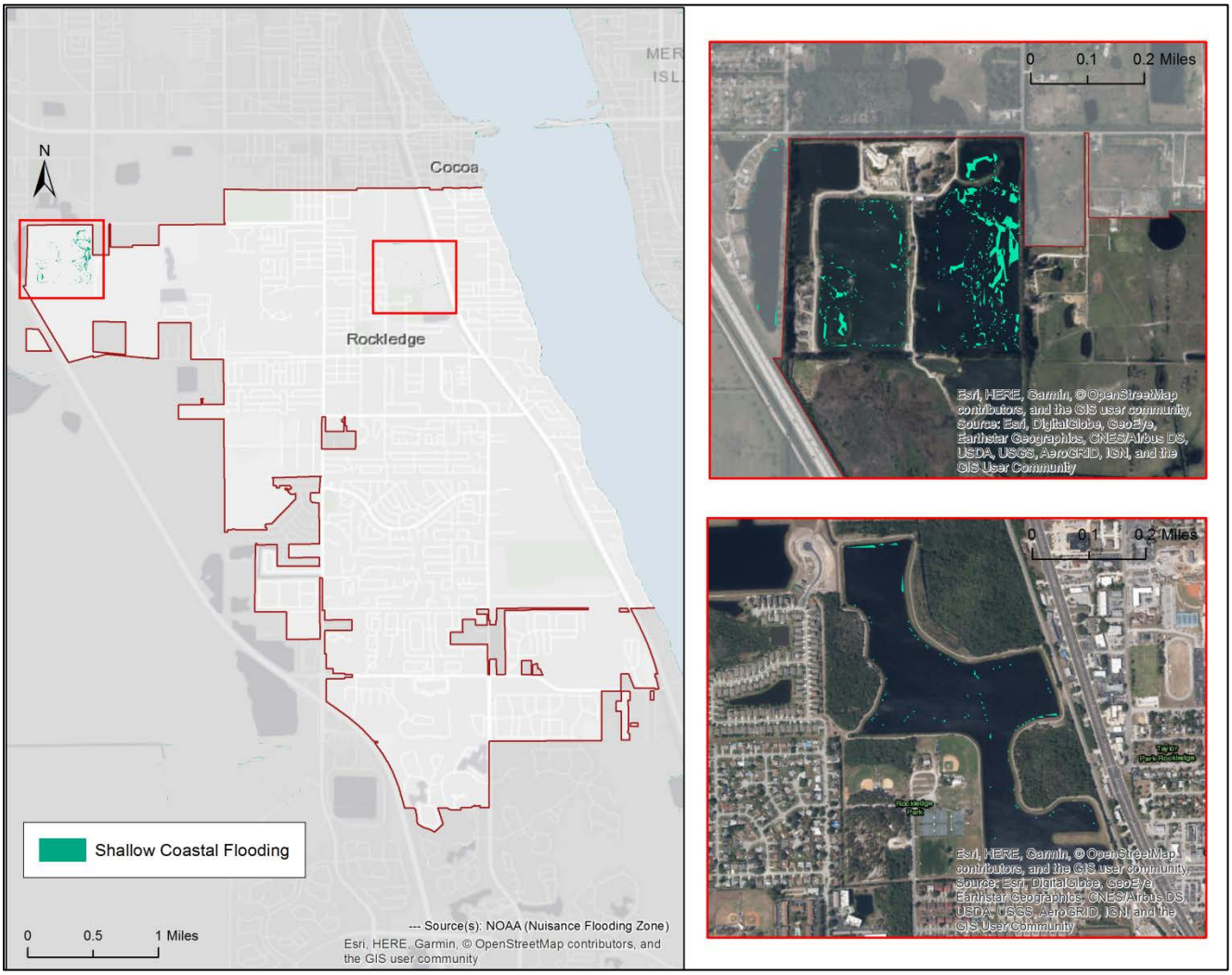
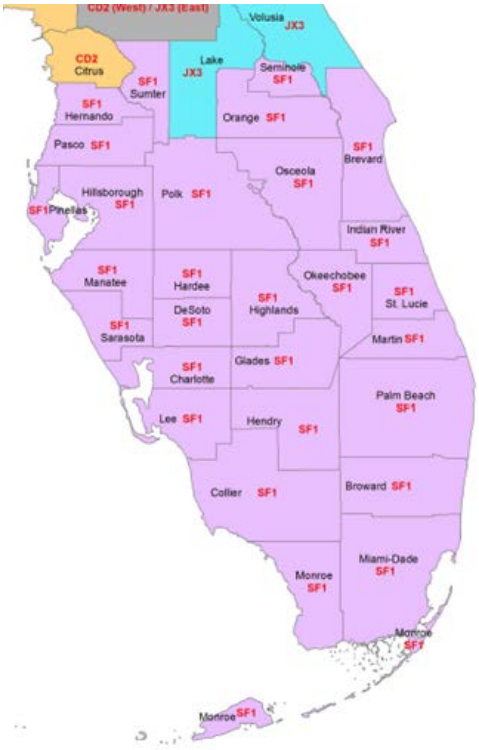


Figure 5: Shallow Coastal Flooding Areas

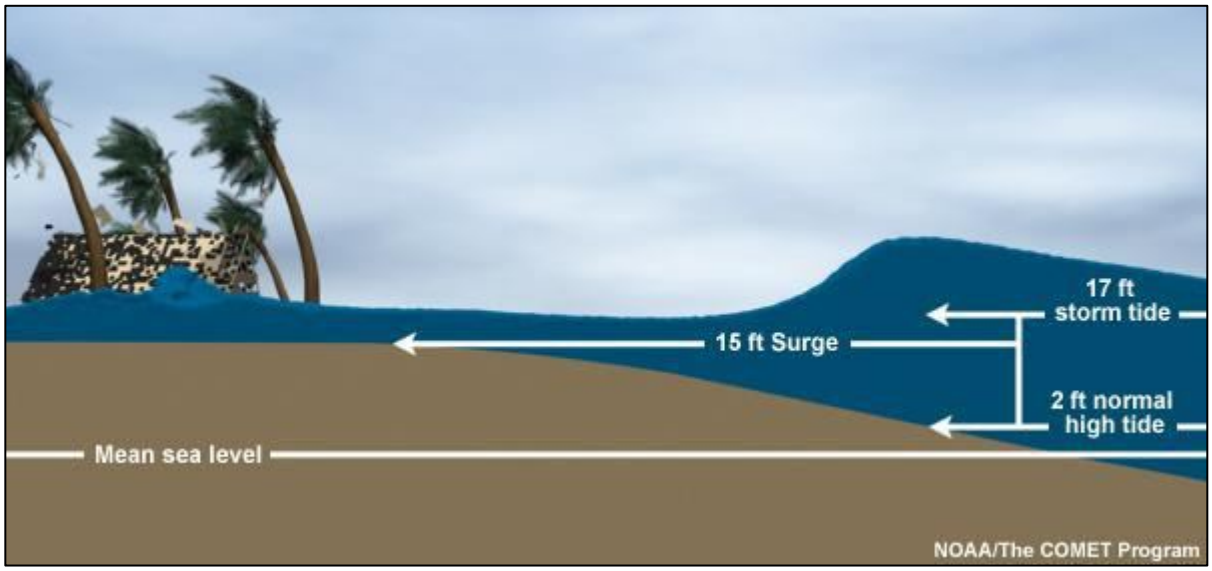


These two inland areas highlighted in the map above show low-lying areas in the City. These areas have water in them already either in the form of a low-lying wetland or body of water. Given that these areas were identified in our analysis, water may rise out of these spots in the City further than current extent due to shallow coastal flooding. Further analysis would be beneficial to understand the potential impacts that increased inundation could cause in these part of the City.

Storm Surge



A Sea, Lake, and Overland Surges from Hurricanes (SLOSH) Basin is a geographical region with known values of land topography and ocean bathymetry. These set basins are used to simulate various hurricane tracks to estimate storm surge inundation in an actual event and/or a worst-case scenario. In 2017, the South Florida Super Basin became operational, spanning from the Tampa Bay region, south through the Florida Keys, and north up through Rockledge. Having a larger basin more accurately depicts a surge created by a storm traversing a region, such as a storm that follows a coastline for an extended period of time (i.e. Hurricane Dennis in 2005 and Hurricane Matthew in 2016). Having higher resolution and updated elevation data is one of the major reasons for publishing an update to a basin as it improves the accuracy of the model's storm surge prediction. Higher resolution LiDAR data will result in higher grid size resolution improving surge representation. In addition, it highlights any physical changes made to the coast from recent storms. In 2017, the state of Florida conducted a new SLOSH Super Basin Model to update storm surge data for Brevard County, along with counties to the south. This new data provides a more accurate analysis and includes smaller grid sizes to process the slosh model. This data was used in this assessment.



Source: Onslow County, NC

Table 2: Potential Storm Tide Heights by County

Potential Storm Tide Heights by County*
(In feet above NAVD88)

*Storm Strength	Brevard	Volusia
Category 1	5.7	5.7
Category 2	9.6	9.5
Category 3	15.8	14.3
Category 4	20.8	22.8
Category 5	25.9	25

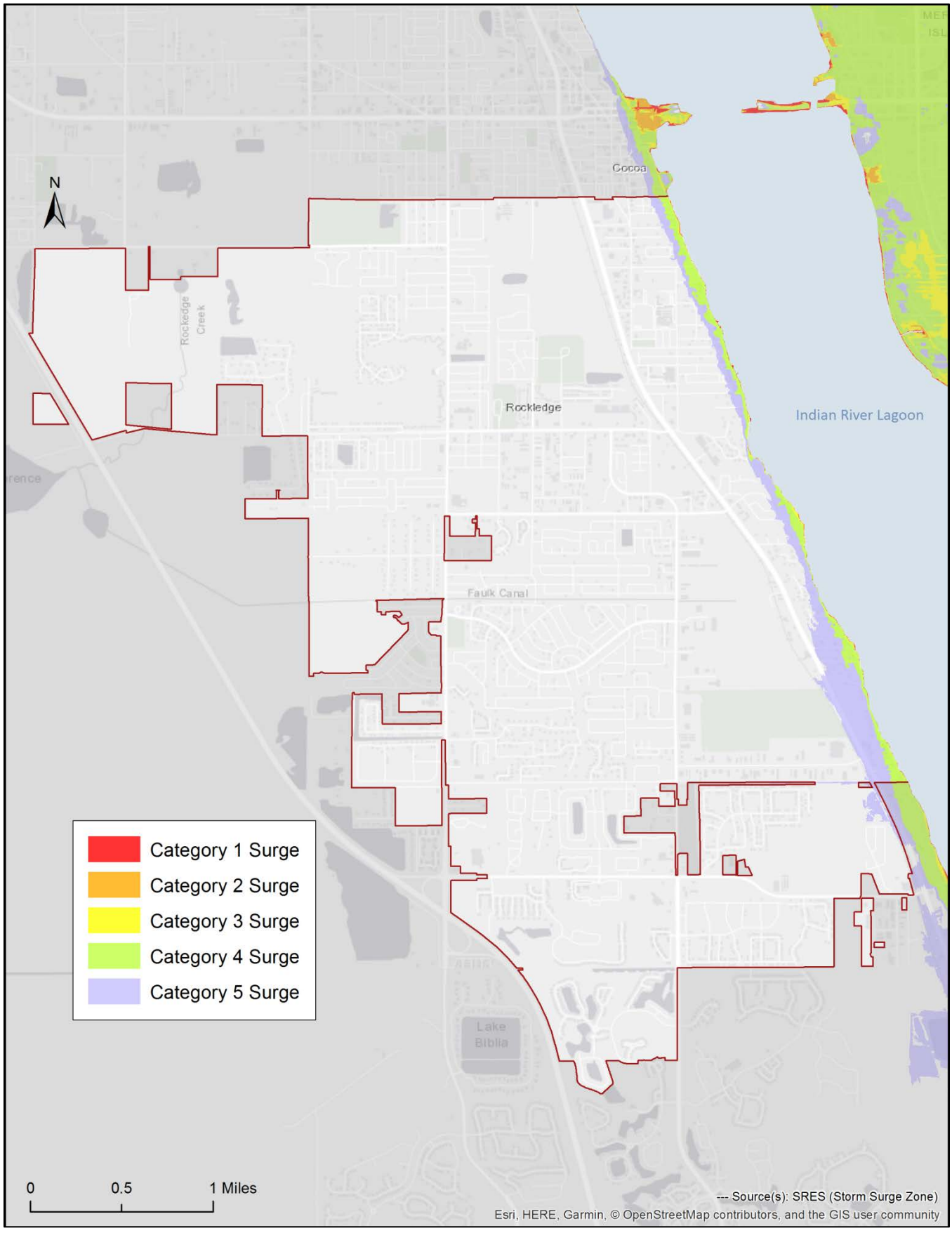
** Based upon the category of storm on the Saffir-Simpson Hurricane Scale*
*** Surge heights represent the maximum values from selected SLOSH MOMs*
Source: ECFRPC SRES 2010

Storm surge can expose and degrade underground utilities and water mains (see picture), destroy electrical equipment, wash away seawalls and revetment systems, and can destroy entire portions of roadways and sidewalks. Coastal erosion, a side effect of storm surge, can deteriorate the foundations of critical facilities located adjacent to water bodies, requiring costly improvements.

Storm Surge in Brevard County from Hurricane Irma

Source: Florida Today

Figure 6: Storm Surge Areas in Rockledge



Sea Level Rise

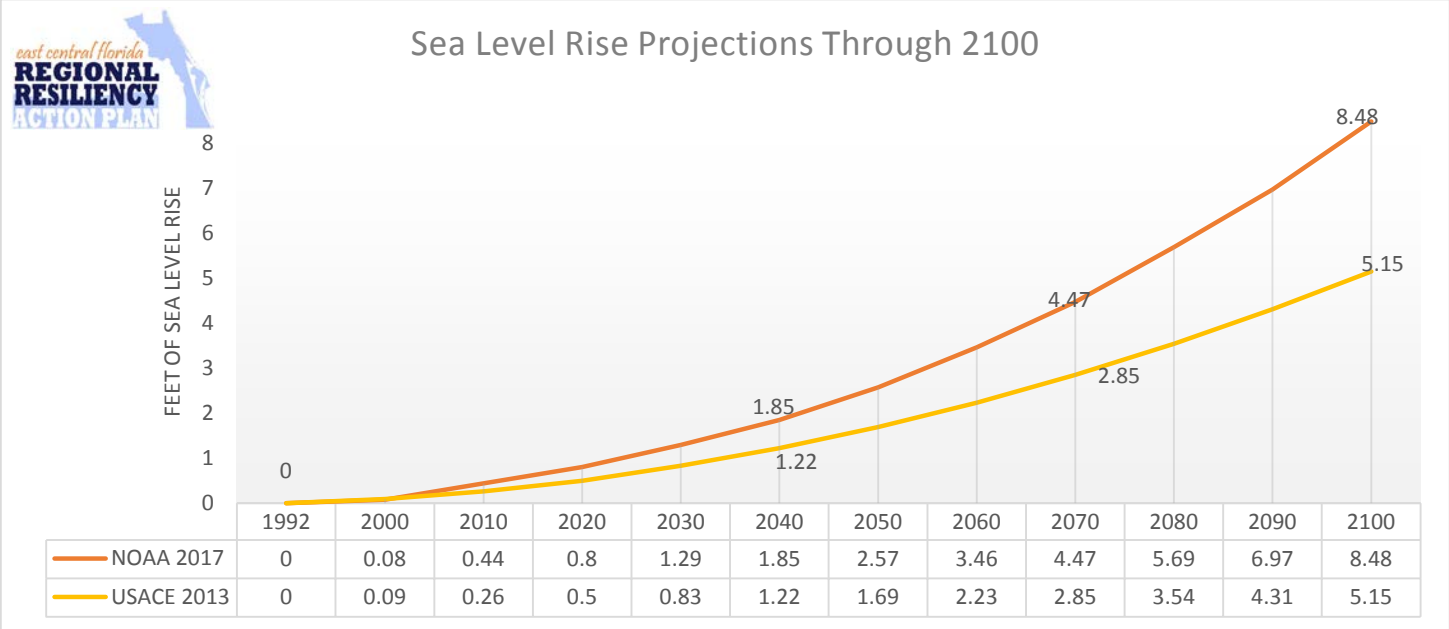
A regional, coordinated approach to planning for sea level rise is important as agencies and communities identify potential risks to infrastructure, plan for future land uses, and determine appropriate mitigation and adaptation measures to minimize the risks of future flooding and inundation. As part of the East Central Florida Regional Resiliency Action Plan, the Planning for Sea Level Rise Sub-Committee, comprised of federal, regional and local experts, academia and planners across sectors, developed a regional planning approach to sea level rise. The purpose of this approach is to provide local governments and regional agencies with a coordinated and vetted method to planning for sea level rise. The recommendation is as follows - *No one projection rate curve should be used for planning purposes across all projects and programs. Instead, a range of rise should be considered based upon the vulnerability, allowable risk, project service life and the forecast project "in-service" date of a facility or development. The range should include a minimum rise of 5.15 feet by 2100 (2013 USACE High) with an upper range of 8.48 feet by 2100 (2017 NOAA High). Short-term planning should consider impacts out to 2040 (20-year planning horizon), medium-term planning should consider impacts out to 2070 (50-year planning horizon), and long-term planning should extend out to 2100 (80-year planning horizon).*

The two projection rate curves are derived from National Oceanographic and Atmospheric Administration (NOAA) 2017 and the US Army Corps of Engineers (USACE) 2013. The Sea Level Scenario Sketch Planning Tool was developed by the University of Florida GeoPlan Center for the Florida Department of Transportation (FDOT) to determine future sea level rise inundation areas utilizing U.S. Army Corps of Engineers (USACE). The USACE data was obtained by download from the GeoPlan Center. This analysis used the "modified bathtub model that applies a hydrologic connectivity filter to remove isolated inundated areas not connect to a major waterway". The resulting inundation files represent the specific projection rate curve mapped on top of MHHW. Unfortunately, the USACE data from the GeoPlan Center does not include the year 2030, therefore, assessment of the USACE data begins for the year 2050. More details concerning the methodology utilized by the University of Florida can be found at the following link: *https://sls.geoplan.ufl.edu/documents-links/*.

As the GeoPlan Center currently only has NOAA 2012 data, the 2017 update data was downloaded from NOAA's Digital Coast Sea Level Rise Viewer which depicts the potential inundation of coastal areas resulting from a 1- 10-foot rise in sea level above current Mean Higher High Water (MHHW) conditions. The data was produced using a modified bathtub approach that accounts for local and regional tidal variability and hydrological connectivity. Two source datasets are used to create the final inundation data: Digital Elevation Model (DEM) of the area and a tidal surface model that represents spatial tidal variability. Again, this data does not account for erosion, subsidence or any other future changes in an area's hydrodynamics. A detailed methodology for producing these data can be found via the following url: *http://www.csc.noaa.gov/slr/viewer/assets/pdfs/Inundation_Methods.pdf*

Data utilized in the analysis illustrates inundation as it would appear during the MHHW (excluding wind driven tides) in accordance with the amount of sea level rise portrayed.

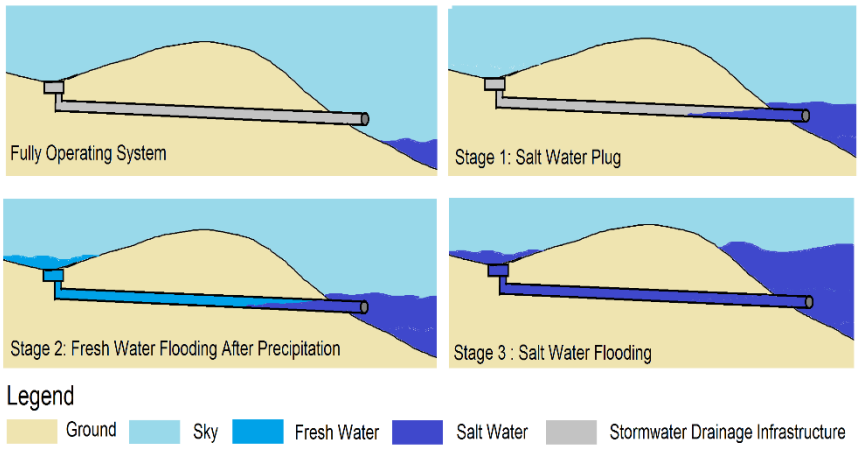
Figure 7: ECF Regional Resilience Action Plan Regional Approach to Sea Level Rise Planning



	1992	2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100
NOAA 2017	0	0.08	0.44	0.8	1.29	1.85	2.57	3.46	4.47	5.69	6.97	8.48
USACE 2013	0	0.09	0.26	0.5	0.83	1.22	1.69	2.23	2.85	3.54	4.31	5.15

For the purpose of assessing sea level rise vulnerabilities on the City, the regional approach was used as the parameters of the assessment. The planning horizons for the City of Rockledge include 2040, 2060, 2080 and 2100. The maps on the following page illustrate the potential areas of impact based upon the NOAA and the USACE projection rate curves for the specific planning horizons. It is important to note that these maps show areas that will be inundated during MHHW, but effects may be seen prior to inundation through increased erosion and wave action, as well as failure of the stormwater systems.

Figure 8: Stages of Stormwater Infrastructure Failure Due to Sea Level Rise



Source: Stetson University

Figure 9: USACE Sea Level Rise High Curve Projections

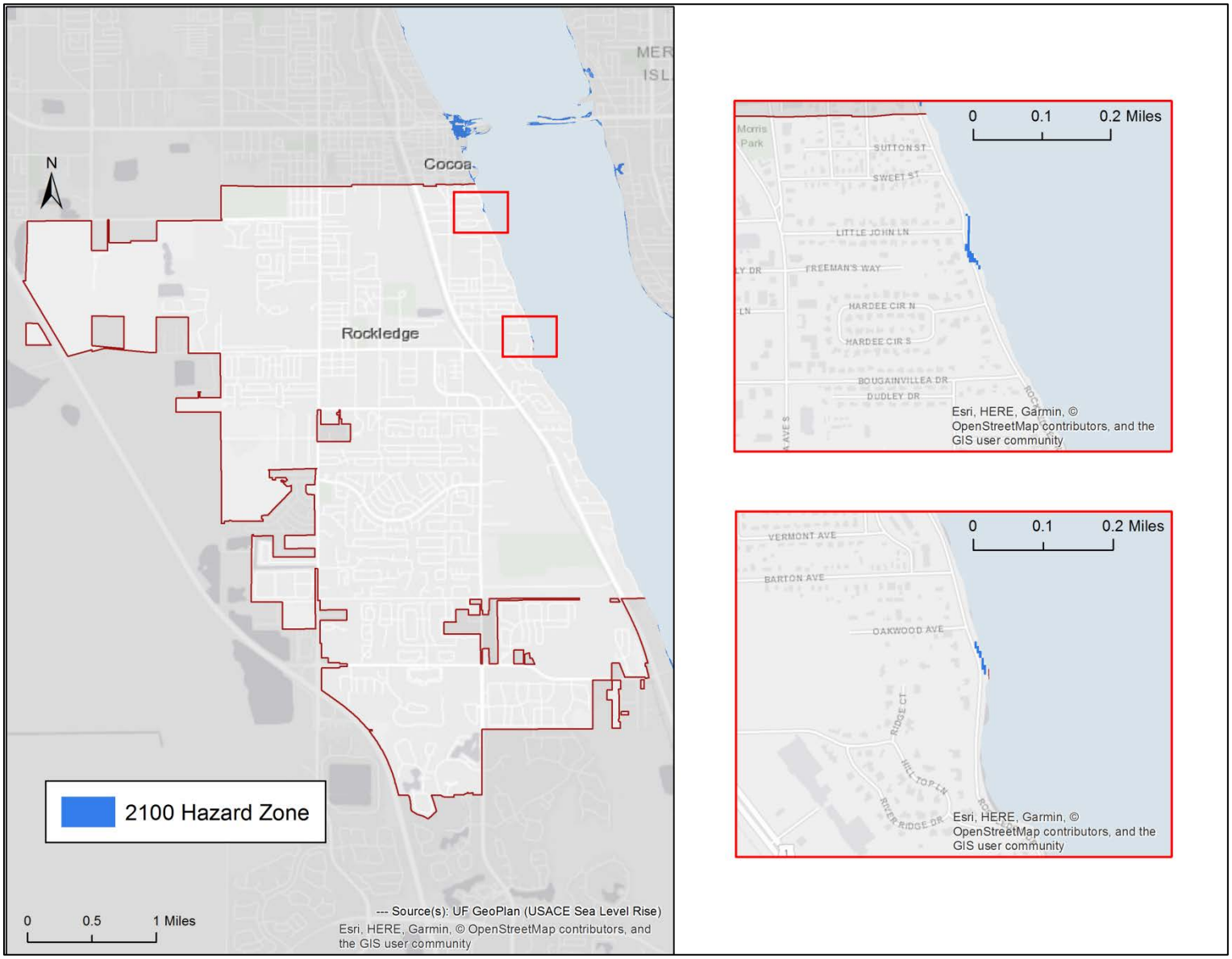
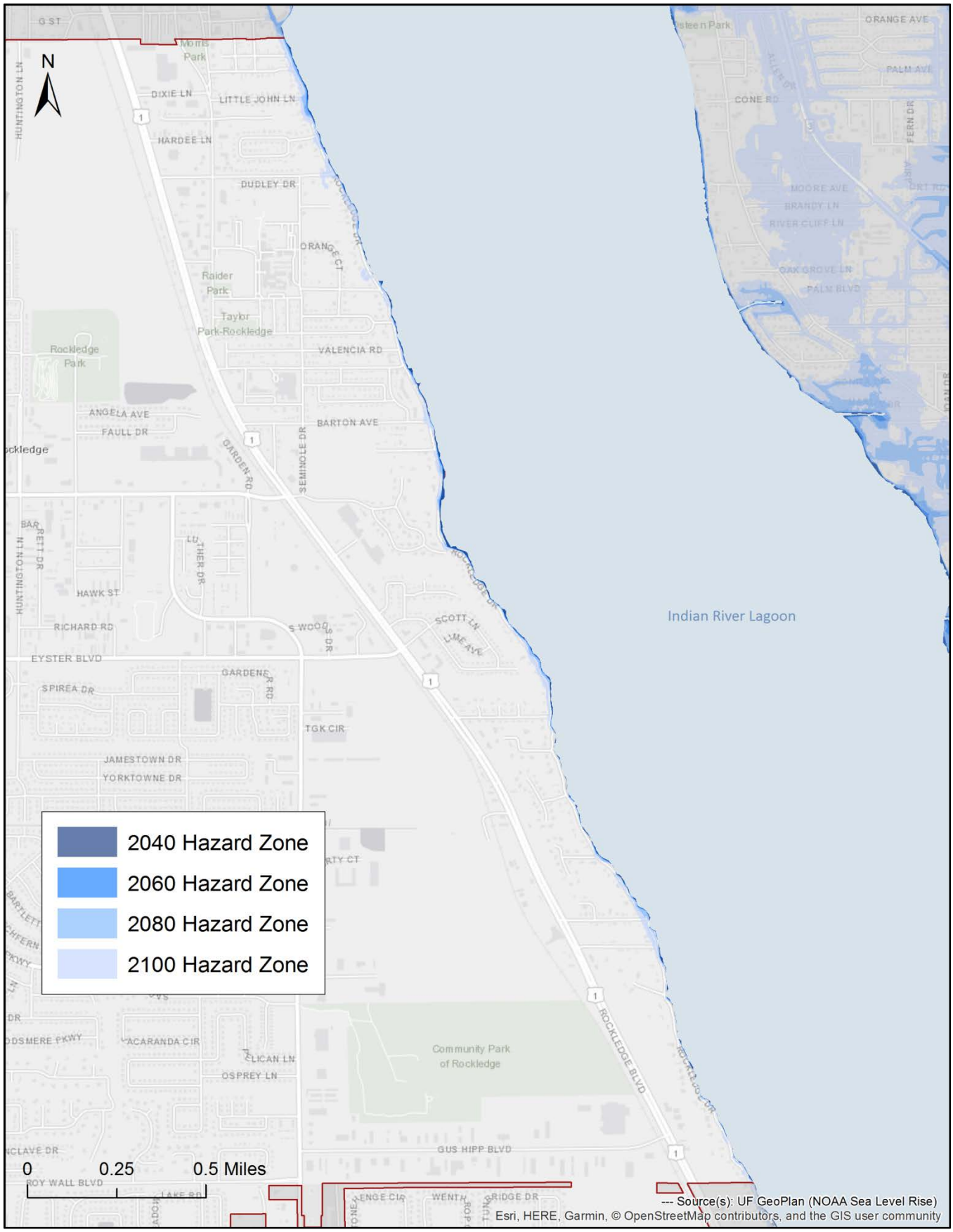


Figure 10: NOAA Sea Level Rise High Curve Projections



Storm Surge with Sea Level Rise

The Tampa Bay Regional Planning Council developed an ArcGIS Add-In Tool to model how future sea level rise conditions effect surge based on new National Hurricane Center (NHC) Sea, Lake, and Overland Surges from Hurricanes (SLOSH) "super basins" that provide greater resolution of data for storm surge modeling. The model uses the latest South Florida Super Basin SLOSH data for Brevard County. The model allows users to analyze certain levels of sea level rise (ex: 4 feet) dependent on what Horizon SLR curve they choose. The model is agnostic and all that is required is to choose the future surface rise. The model is referenced to NOAA tidal gauges for tidal variability. The model uses the future sea surface determined by project designers; however instead of being referenced to Mean Higher High Water (MHHW), the SLR was referenced against Mean Sea Level (MSL). SLOSH basin data is referenced to high tide, so using MHHW and surge together would be like "double-dipping". The data the model uses comprises a Digital Elevation Model (DEM), SLOSH Basin, Sea Layer with hydrologic connectivity, and NOAA tidal gauges. It is important to see the effect sea level rise has on coastal and tropical storms. Sea level rise in the near term is not dramatic when viewed on its own. However, coastal storm run-up and storm surge can be pushed past a tipping point when sea levels are higher than today. A Category 1 storm could become a Category 2 or perhaps a Category 3 storm by today's standards. The horizon years 2050, 2070, and 2100 provide outlooks between the sea level rise outlook years in this analysis, which can provide extra insight about the City's vulnerability.

Figure 11: Flood Assessment Tool Beta Version

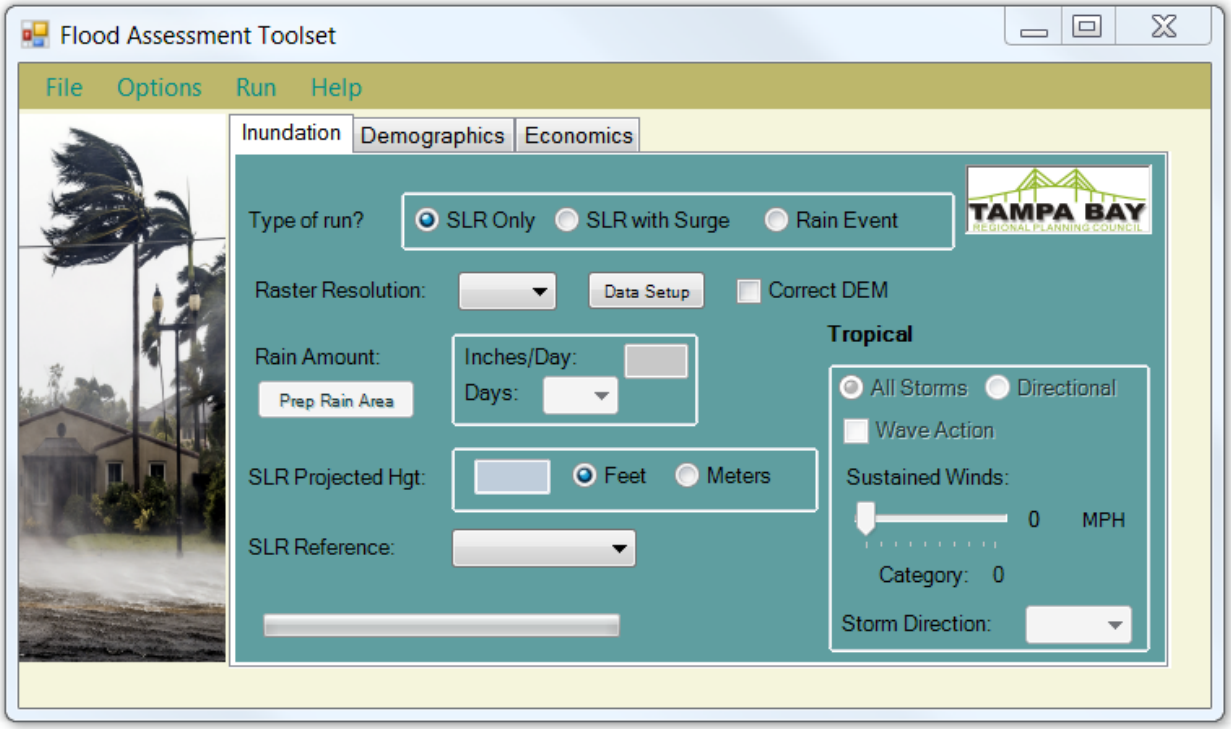
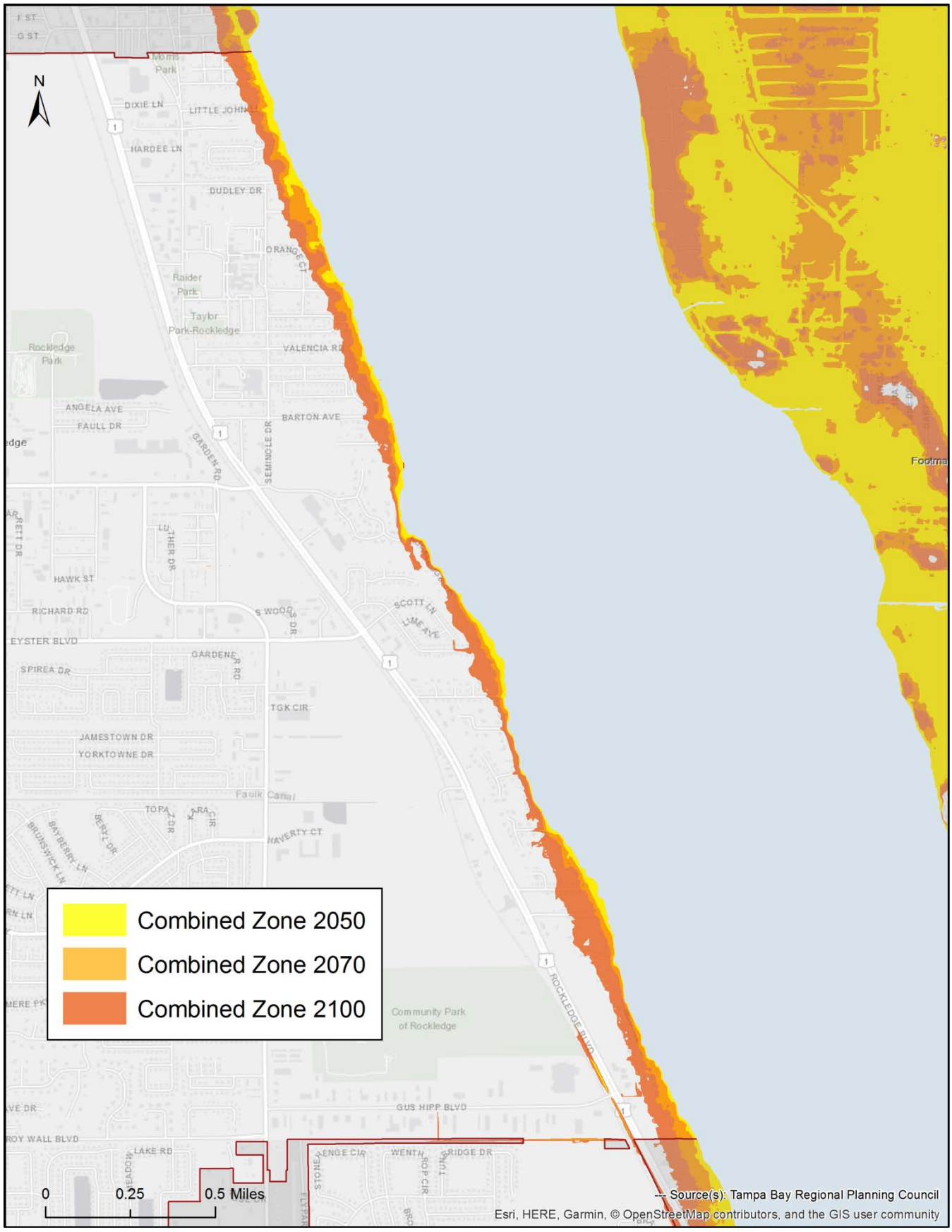


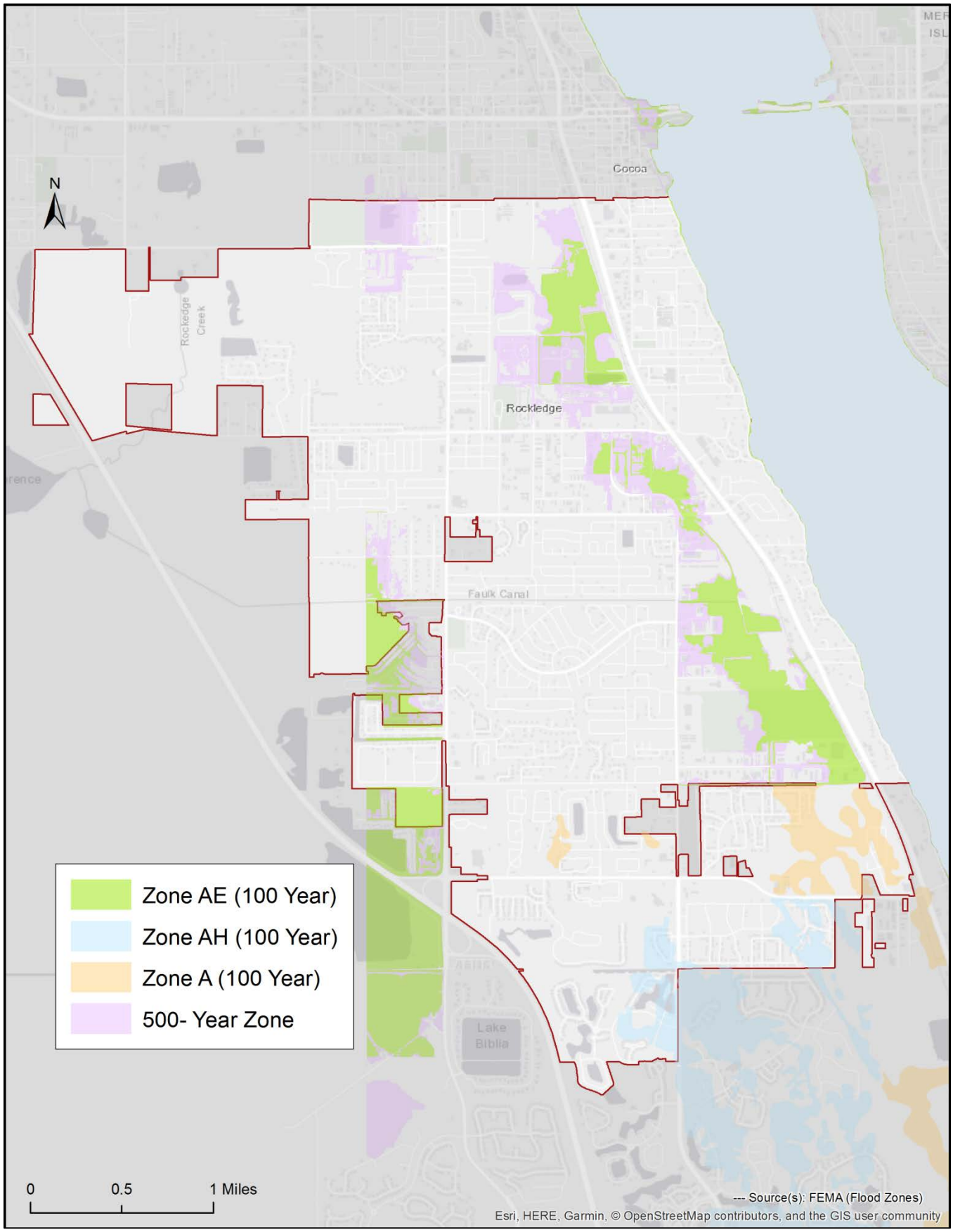
Figure 12: Combined Storm Surge and Sea Level Rise



Designated Flood Areas

The FEMA Digital Flood Insurance Rate Maps (DFRIM) from 2014 were used to conduct the assessment of assets located in the 100-year (1% annual chance of occurring) and 500-year (0.2% annual chance of occurring) flood zones as well as the VE (Coastal areas with a 1% chance or greater of flooding and additional hazard associated with storm waves) zone. DFIRMS data indicates flood risk information derived from Flood Insurance Studies (FISs), previously published Flood Insurance Rate Maps (FIRMs), flood hazard analyses performed in support of the FISs and FIRMs, and new mapping data, where available. According to FEMA, over time as various conditions change from construction and development, as environmental and watershed conditions change, flood risks also change. For this reason, FEMA has been in an effort to conduct a RiskMAP Coastal Restudy for Brevard County which includes revised DFRIMS. As of the time of this analysis, the study and revised DFIRMS have yet to be reviewed and adopted (October 2018). It is recommended that after the DFIRMS are adopted, an analysis should include areas added to the flood zones. The City of Rockledge's 100-year flood zones are generally located along the eastern center of the City on the western side of Rockledge Blvd. The 500-year zone as indicated by the purple encompasses a larger swath around the same area as the 100-year floodplain. This is the City's largest vulnerability.

Figure 13: 100- and 500-Year Flood Zones



Findings

The findings section of this report provides an overview, maps and tables of potential impacts to critical facilities, transportation infrastructure and takes a look at vulnerable land uses and their values. The five hazards addressed include 1) Shallow Coastal Flooding Areas 2) Storm Surge; 3) Sea Level Rise; 4) Future Storm Surge with Sea Level Rise and 5) FEMA 100-and-500-Year Flood Zones

Shallow Coastal Flooding

Shallow coastal flooding areas are areas that flood frequently during higher than average tide events.

Storm Surge

Storm surge occurs when hurricanes and tropical storms raise water levels in coastal areas which is pushed on shore.

Sea Level Rise

Sea level rise is occurring at an alarming pace along Florida's east coast. This is a long-term hazard.

Surge + Sea Level Rise

Referred to as the "Combined Hazard Zone", this includes the long-term effects of surge plus sea level rise.

100-Year Flood

The 100-year flood zone depicts areas that have a 1% annual chance of flooding. FEMA provides this data.

1. Transportation Impacts

Roadways are susceptible to degradation across multiple fronts as a result of natural hazards, including cracking over long periods of time from the deterioration of surrounding lands or substrate due to flooding, storm surge and wave action. As a result, roadways are likely susceptible to the effects of sea level rise prior to the "horizon year" of inundation of the *roadway surface* provided in the table below. This may heighten the risk profile of roadways to a greater degree than what is shown under the sea level rise and combined hazard zone analyses in this report and below. Additionally, as roadways were not designed to be inundated, especially with salt water, even only a few inches of flood water for multiple days can put the integrity of roadways at risk and increase accessibility issues throughout the community, thus impacting everyday activities and the economic vitality of the area. Impacts should not only just be considered to the roadway itself but also the utilities that are associated with the roadway in its right of way or underground.

The table below summarizes the impacts to roadways within the City of Rockledge by hazard and subdivided by FDOT classification, thus indicating the potential responsible agency. Local roadways, which fall under the purview of the City, are expected to experience the greatest amount of inundation from hazards and thus have all been called out for this analysis. While these roadways do not have the capacity of larger roadways, disruption to these routes from flooding can affect day to day activities and emergency response times and cut off entire sections of the City. Impacts along large roadways are not considered extensive in terms of mileage. The Coastal High Hazard Area (CHHA) is defined as the area below the elevation of the Category 1 storm surge line. While few roadway segments are located in the CHHA, the City begins to see more impacts to local roadways with a Category 4 surge. As evident in Table 4, as sea level rises, the extent and depth of storm surge is expected to increase, thus potentially changing the areas classified as the CHHA and other surge zones and impacting more roadways. These will be described later in this section.

Table 3: Overview of Impacts to the Transportation Network

Roadway Classification *(FDOT)*	Storm Surge CHHZ *(Miles)*	NOAA SLR Year 2040 *(Miles)*	NOAA SLR Year 2060 *(Miles)*	NOAA SLR Year 2080 *(Miles)*	NOAA SLR Year 2100 *(Miles)*	USACE SLR Year 2100 *(Miles)*	100 Year Flood Zone *(Miles)*	Shallow Coastal Flood Area *(Miles)*	Combined CHHZ *(Miles)*
Principal Arterial Interstate - Rural & Urban	0	0	0	0	0	0	0.06	0	0
Principal Arterial Other - Rural & Urban	0	0	0	0	0	0	0.03	0	0
Minor Arterial Rural & Urban	0	0	0	0	0	0	0.13	0	0
Major Collector Rural & Urban	0	0	0	0	0	0	0.17	0	0
Local Roads	> 0.01	0.03	0.04	0.18	1.6	0.22	4.82	0.26	10.13
All Evacuation Routes	0	0	0	0	0	0	0	0	0

Storm Surge

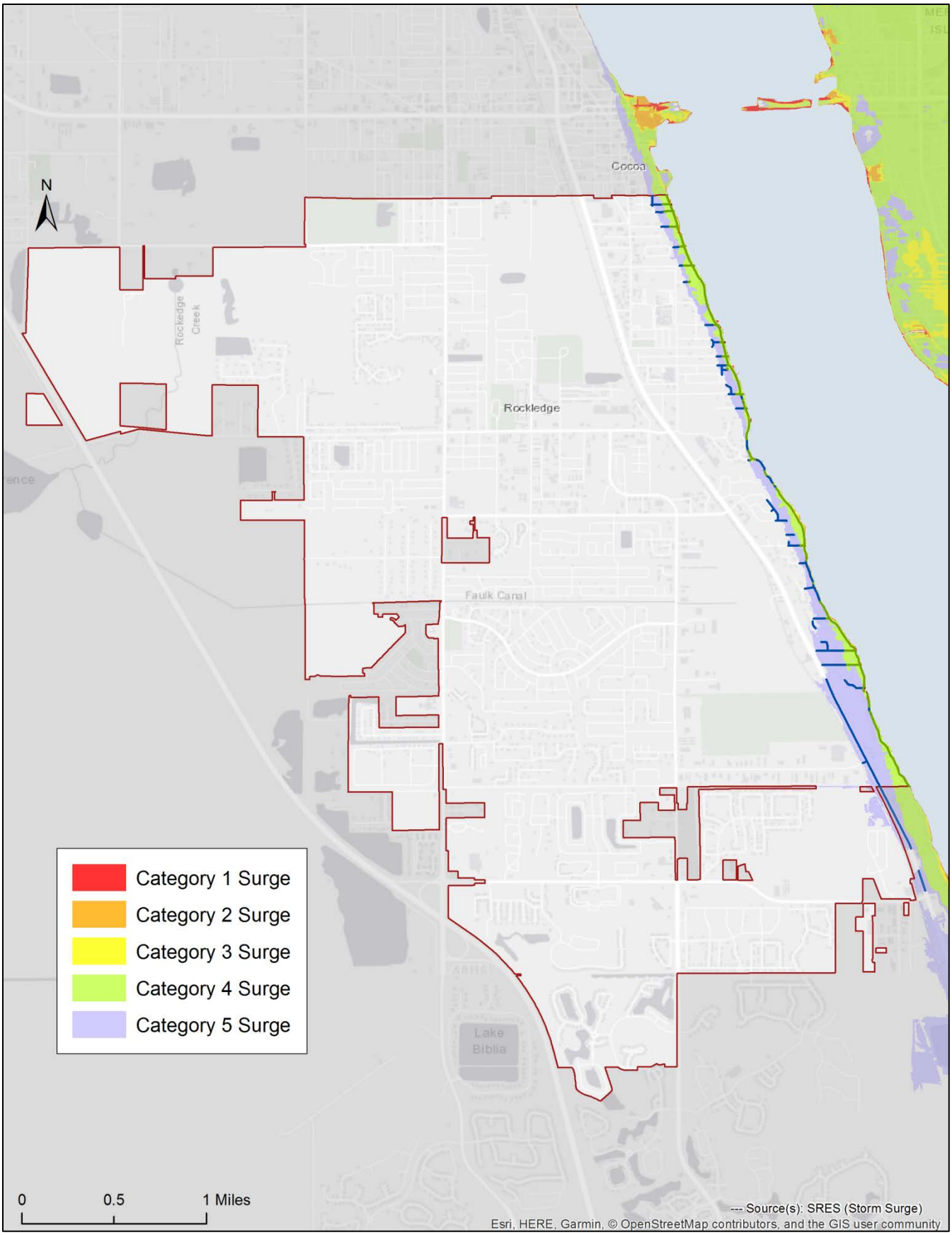
Table 4: Miles of Roadways Per Surge Zone

Indicates FDOT roads and major local roads

Road Name Classification	Cat. 1 Surge Projected Inundation	Cat. 2 Surge Projected Inundation	Cat. 3 Surge Projected Inundation	Cat. 4 Surge Projected Inundation	Cat. 5 Surge Projected Inundation
Alexander St Local Roadway	0	0	0	0	0.05 (2)
Barton Ave Local Roadway	0	0	> 0.01	0.04 (3)	0.08 (5)
Bayshore Ct Local Roadway	0	0	0	> 0.01	0.12 (9)
Bouganvilla Dr Local Roadway	0	0	0	0.06 (2)	0.08 (3)
Burlington Ave Local Roadway	0	0	0	0	> 0.01
Fernwood Dr Local Roadway	> 0.01	> 0.01	> 0.01	0.03 (3)	0.11 (6)
Floridelphia Ave Local Roadway	0	> 0.01	> 0.01 (2)	0.08 (4)	0.21 (5)
Hardee Dr Local Roadway	0	0	> 0.01	0.03 (3)	0.07 (6)
Knollwood Dr Local Roadway	0	0	0	0	0.06 (3)
Lime Ave Local Roadway	0	0	0	0	0.02
Little John Lane Local Roadway	0	0	> 0.01	0.05 (3)	0.1 (4)
Loch Ness Dr Local Roadway	0	0	0	0.01 (2)	0.04 (3)
Magruder Ave Local Roadway	0	0	0	0.06	0.21 (3)
Magruder Ter Local Roadway	0	0	0	0	0.08
Oakwood Ave Local Roadway	0	0	0	0.01 (2)	0.06 (3)
Orange Ave Local Roadway	0	0	0	0.02 (2)	0.07 (4)
Park Ave Local Roadway	0	0	0	0.03 (2)	0.1 (5)
Park Pl Local Roadway	0	0	0	0	0.02
Renee Ct Local Roadway	0	0	0	0	0.04
River Groves Dr Local Roadway	0	0	0	0	0.05

Road Name Classification	Cat. 1 Surge Projected Inundation	Cat. 2 Surge Projected Inundation	Cat. 3 Surge Projected Inundation	Cat. 4 Surge Projected Inundation	Cat. 5 Surge Projected Inundation
River Ridge Dr Local Roadway	0	0	0	0.02 (2)	0.03 (4)
Riverside Dr Local Roadway	0	0	0	> 0.01	> 0.01
Rockledge Ave Local Roadway	0	0	0	0.02 (2)	0.07 (3)
Rockledge Ct Local Roadway	0	0	0	> 0.01	0.04 (2)
Rockledge Dr Local Roadway	> 0.01	0.01 (3)	0.04 (8)	3.05 (73)	3.59 (102)
Roy Wall Blvd/ Gus Hipp Blvd Major Collector	0	0	0	0	0.02
Scott Lane Local Roadway	0	0	0	0	0.13 (4)
Shares Dr Local Roadway	0	0	0	0	0.12 (4)
SR-5/ SR-500 to SR-50 Principal Arterial- Other	0	0	0	0	1.14
Summer Pl Local Roadway	0	0	0	0	0.04
Sutton St Local Roadway	> 0.01	> 0.01	> 0.01 (2)	0.05 (4)	0.11 (6)
Sweet St Local Roadway	0	0	0	0.05 (2)	0.09 (3)
Un-named Rd	0	0	0	0	0.04
Valencia Rd Local Roadway	0	0	0	0.04 (2)	0.07 (3)
Wincove Lane Local Roadway	0	0	0	0.02	0.09 (2)

Figure 14: Roadways in Cat 1-5 Storm Surge Areas



Sea Level Rise

Table 5: Roadways Vulnerable to Sea Level Rise by Mile

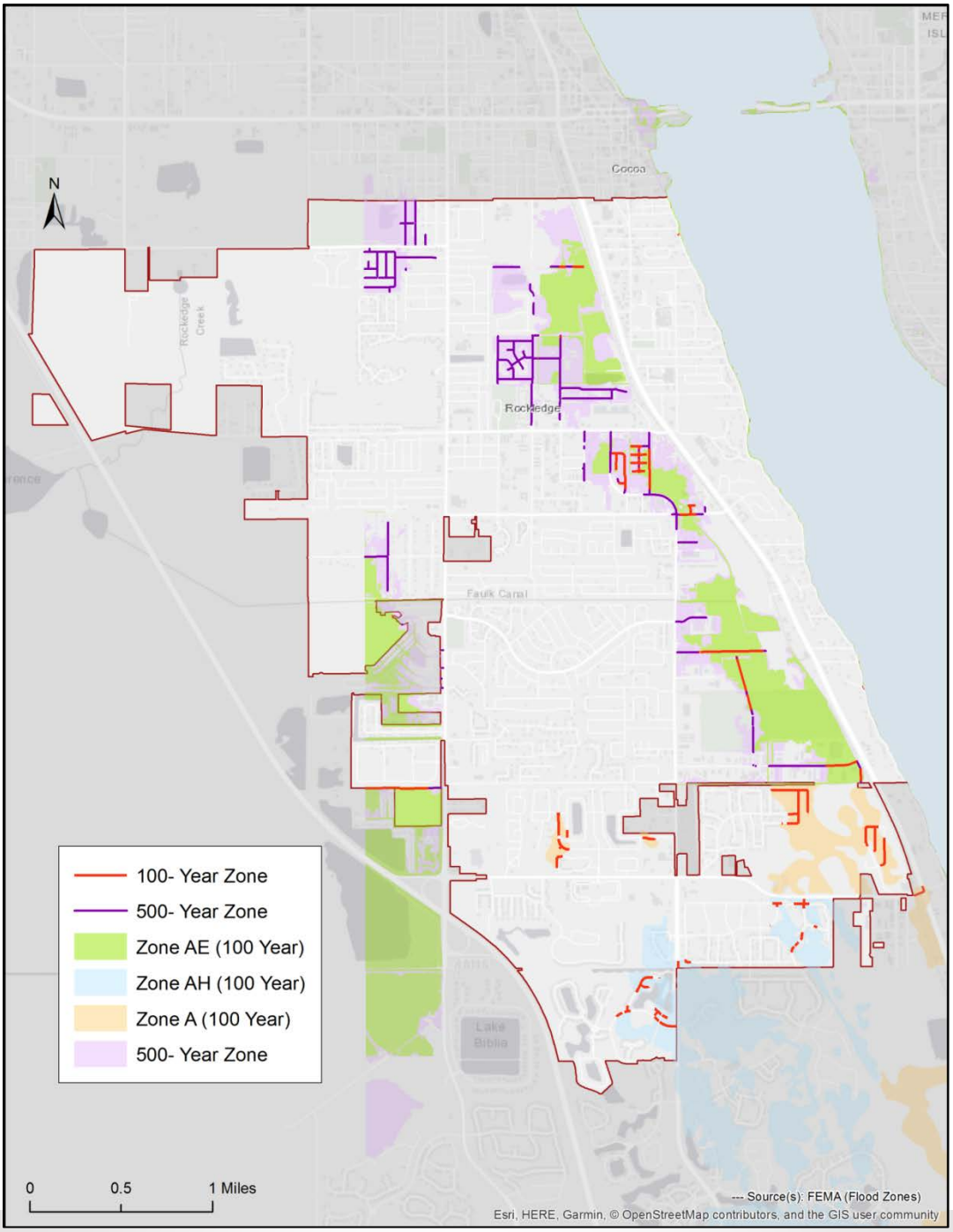
Road Name Classification	USACE 2040 Projected Inundation	USACE 2060 Projected Inundation	USACE 2080 Projected Inundation	USACE 2100 Projected Inundation	NOAA 2040 Projected Inundation	NOAA 2060 Projected Inundation	NOAA 2080 Projected Inundation	NOAA 2100 Projected Inundation
Rockledge Dr Local Roadway	0	0	0	0.22 (2)	0.02	0.02	0.14 (8)	1.39 (43)
Fernwood Dr Local Roadway	0	0	0	0	> 0.01	> 0.01	> 0.01	> 0.01
Floridelphia Ave Local Roadway	0	0	0	0	> 0.01	0.01	> 0.01	0.01 (2)
Oakwood Ave Local Roadway	0	0	0	0	> 0.01	> 0.01	> 0.01	0.01
Sutton St Local Roadway	0	0	0	0	0	> 0.01	> 0.01	0.02 (2)
Barton Ave Local Roadway	0	0	0	0	0	0	> 0.01	0.01
Bouganvilla Dr Local Roadway	0	0	0	0	0	0	> 0.01	0.04 (2)
Hardee Dr Local Roadway	0	0	0	0	0	0	> 0.01	0.01 (2)
Little John Lane Local Roadway	0	0	0	0	0	0	0.01	0.02 (2)
River Ridge Dr Local Roadway	0	0	0	0	0	0	> 0.01	0.01
Rockledge Ave Local Roadway	0	0	0	0	0	0	> 0.01	> 0.01
Sweet St Local Roadway	0	0	0	0	0	0	> 0.01	0.02 (2)
Valenica Rd Local Roadway	0	0	0	0	0	0	> 0.01	> 0.01
Magruder Ave Local Roadway	0	0	0	0	0	0	0	0.02
Park Ave Local Roadway	0	0	0	0	0	0	0	> 0.01
Riverside Dr Local Roadway	0	0	0	0	0	0	0	> 0.01
Wincove Lane Local Roadway	0	0	0	0	0	0	0	> 0.01

When analyzing impacts to roadways affected by sea level rise, using both the USACE and the NOAA High curves, some impact will begin to affect a large portion of local roadways on the lagoon coast of the City. As no major roads are anticipated to be inundated in either scenario, the City has time to assess strategies that take into account risk, return on investment and their overall long-term resilience when addressing vulnerabilities to local roads. It should be noted however, that just because the roadway will not be impacted during high tides as sea levels rise, as stated earlier, the integrity of the roadway may be compromised as flooding, erosion and inundation may impact surrounding land and much of the western roadways are considered vulnerable to shallow coastal flooding. By 2100, when considering all roadways impacted in the City under both USACE and NOAA, approximately 2 miles of road is inundated with Rockledge Drive experiencing the most impact.

This image shows how erosion and flooding can begin to impair the integrity of roadways long before inundation occurs and also cause damage the underground utilities.

100 - and 500-Year Flood Zones

Figure 15: Roadways Located in the 100- and 500- Year Flood Zones



Less than 1 mile of major roadways are located in the 100-Year Floodplain, however, as depicted on the map, the most vulnerable roadways to the 100-Year flood are local roads along the western side of Rockledge Blvd. 5.21 miles of total roadway are vulnerable to a 100-year flood, approximately 5 miles of which are local, residential roadways. The flooding of these roads during a storm would ultimately cut off access to and from these sections of the City. As some of these roadways are also vulnerable to surge and sea level rise, creative stormwater mitigation techniques may be a valuable strategy in this area from increasing permeability and retention on site to acquiring property for water detention that could become part of a hybrid green/gray stormwater system.

2. Land Use Impacts

Rockledge's private and publicly-owned property has some risk to a diverse range of natural hazards. The table below illustrates the number of acres of land in each hazard zone, the number of building, property value and the number of undeveloped acres. Some items to note:

- In both sea level rise curves, comparatively speaking they are the least impactful of the hazards.
- The Flood Zone areas in the City including the 500- Year zone have the largest impact acreage wise on the City
- Given the status of the City as a coastal community, the level of impact from hazards can be mitigated and there are opportunities as a community to create a vibrant community and future regardless of vulnerabilities.

Table 6: Hazard Overview by Acres, Building, and Value

Hazard Zone	Acres in Zone	Buildings in Zone	Total Property Value	Undeveloped Acres in Zone
All 100 Year Flood Zones	1618.44	789	235,795,970	884.99
Zone A	223.14	240	49,281,900	125.26
Zone AE	1118.85	352	124,409,830	702.03
Zone AH	276.45	197	62,104,240	57.7
500 Year Flood Zone	2030.69	1379	330,232,920	1019.01
Sea Level Rise - 2100 (USACE)	0.78	7	3,198,920	0.09
Sea Level Rise - 2040 (NOAA)	22.3	99	48,674,470	8.01
Sea Level Rise - 2060 (NOAA)	23.53	111	53,108,030	15.25
Sea Level Rise - 2080 (NOAA)	28.52	122	57,058,770	32.09
Sea Level Rise - 2100 (NOAA)	58.92	124	62,039,100	62.09
Shallow Coastal Flooding Zone	451.16	91	46,317,160	370.61
Combined Zone - Cat. 3 (2050)	59.35	133	64,790,330	16.4
Combined Zone - Cat. 3 (2070)	443.36	147	70,207,320	364.39
Combined Zone - Cat. 3 (2100)	862.98	241	95,325,430	644.73
Storm Surge - Category 1	19.28	84	42,940,720	7.29
Storm Surge - Category 2	21.31	98	48,345,120	7.39
Storm Surge - Category 3	24.9	117	55,552,660	7.39
Storm Surge - Category 4	114.57	166	68,115,910	23.56
Storm Surge - Category 5	319.54	310	94,449,790	162.2

Shallow Coastal Flooding

Shallow coastal flooding impacts each land use within the City with nearly 382 acres of developable lands projected to experience this increasing flooding hazard. As the shallow coastal flooding hazard zone is generally located along the lagoon edge and a few low lying areas in the north inland portion, almost all of affected lands are currently zoned Residential. The City should work with property owners in the affected areas with roadway impacts along the water front for an open flood mitigation dialogue. Any more inland areas affected by this flooding could be converted or used as a stormwater park that has the potential to serve as a mitigation area with opportunity for recreational use too.

The image shows "Fourth Ward Park" in Atlanta, Georgia, a great example of this park concept. In this park, walkways traverse through stormwater ponds and native plants are used to absorb rainwater without diverting it into drains.

Table 7: Land-Use by Acres in Shallow Coastal Flood Areas

	Commercial	Low Density Residential	Med. Density Residential	Residential/Public Mixed
Zone	Acres	Acres	Acres	Acres
Shallow Coastal Flooding Area	0.01	6.93	0.06	0.44

Shallow coastal flooding is expected to impact the lagoon side of the City and a few low-lying areas in the more north and inland portions. This area along the lagoon may experience more erosion as a result of shallow coastal flooding, in addition to storm surge and rising seas.

The area of the City located in the shallow coastal flood zone is similar in extent to the area vulnerable to the NOAA sea level rise scenario through 2080, and also includes exposure to multiple hazards, including Category 1-5 storm surge and the AE flood zone thus making this general area the most vulnerable to flooding both in the short and the long term. Access to many of these properties in these hazard areas, mainly along Rockledge Drive, will remain an issue that may require some short to mid-term flood mitigation strategies and the City will need to delve into how to work with these properties as hazards become more severe in the future. From a financial perspective, shallow coastal flooding can have a severe impact on affected properties due to accessibility and the need to mitigate structures or property. In Figure 16, the entire parcel of the affected area is shown, but this does not mean that the building on that parcel is affected by the hazard zone. The low-lying areas inland impacted by the shallow coastal flooding will require further assessment to understand the impact.

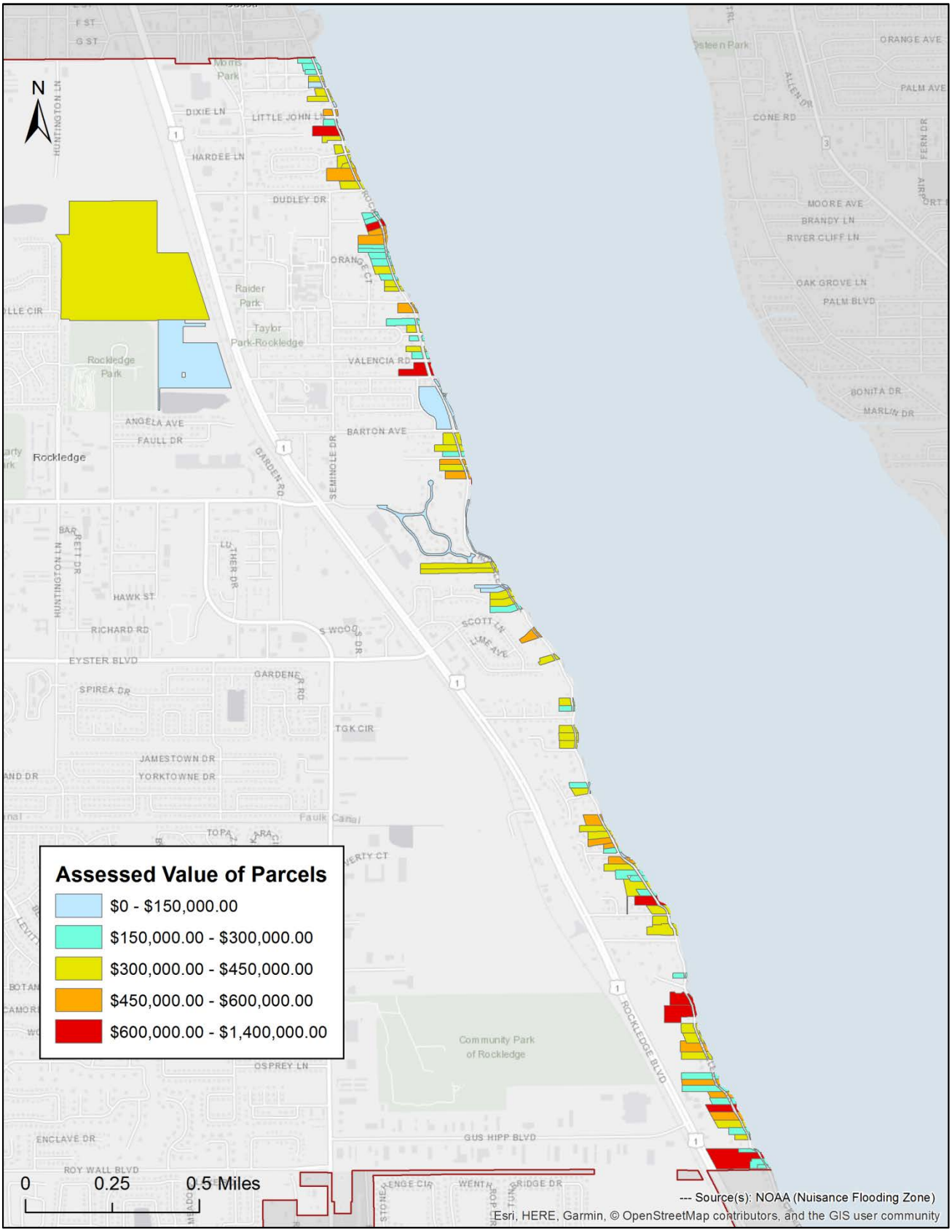
The highest-value-clusters of lagoon-adjacent properties exposed to shallow coastal flooding include 108 parcels - 91 buildings - worth a combined $46.3 million. The map on the following page illustrates the areas of greatest financial exposure are located by assessed value. The highest valued parcel affected is Rockledge Presbyterian Church followed by a single- family residence.

From a build year perspective, the vast majority of buildings were built before 1968, aka before when flood insurance was first required from property owners on properties in the zone. A total of 58 of the 91 buildings in the hazard zone (63.7%) were built before this critical date. Furthermore, only 4 buildings (4.4% of those in the hazard zone) on vulnerable properties were built after the modern Florida Building Code went into effect. The table below depicts these building figures and the associated financial exposure by build year.

Table 8: Shallow Coastal Flood Impacts by Financial Exposure

						Built Pre-1968	Built 1968-2001	Built 2002 - 2018
Zone	# Parcels in Zone (% of All Parcels)	Number of Buildings	Land Value	Assessed Value	Taxable Value	# Buildings Total Value	# Buildings Total Value	# Buildings Total Value
Shallow Coastal Flooding Area	108	91	$31,463,010	$46,317,160	$36,757,026	58 $19,553,410	29 $21,706,660	4 $2,552,390

Figure 16: Shallow Coastal Flood Assessed Property Value



Storm Surge

The City sees a higher impact from storm surge starting at the Category 4 tipping point. Residential land uses begin more intense impact at Category 4 and even more at Category 5 with 3.6% of the City's parcels vulnerable. Fortunately, not even 1% of parcels are in the Coastal High Hazard Area (Cat 1), which are the most vulnerable to surge. The City should work with property owners affected by storm surge to have an open dialogue about storm effects and how to properly prepare and mitigate damage for those affected areas. The majority of the housing stock was built pre 1968 which has the potential for greater damage from flood and wind due to older building standards. As homes are rebuilt either because of reinvestment or damage, they will need to be built at the current standards. The City, in the areas most vulnerable to flooding from surge, shallow coastal flooding and sea level rise, may wish to require standards that will facilitate the raising of the first living floor well above flood levels or above the determined elevation above the crown of the road to minimize flood impacts.

Table 9: Storm Surge Exposure by Future Land Use Classification by Acres

	Commercial	Low Density Residential	Med. Density Residential	Industrial	Recreational Public Passive
Storm Surge Zone	Acres	Acres	Acres	Acres	Acres
Category 1	1.09	11.26	6.93	0	0
Category 2	1.09	12.42	7.8	0	0
Category 3	1.31	14.79	8.8	0	0
Category 4	7.85	51.43	55.29	0	0
Category 5	16.78	56.82	152.93	7.64	85.37

Table 10: Surge Impacts by Financial Exposure

						Built Pre-1968	Built 1968-2001	Built 2002 - 2018
Storm Surge Zone	# Parcels in Zone (% of All Parcels)	Number of Buildings	Land Value	Assessed Value	Taxable Value	# Buildings Total Value	# Buildings Total Value	# Buildings Total Value
Category 1	95 (0.88%)	84	$28,537,080	$42,940,720	$33,701,716	55 19,259,470	26 20,525,070	3 $1,876,690
Category 2	110 (1.01%)	98	$32,827,020	$48,345,120	$38,455,616	63 21,664,900	31 22,848,340	4 2,552,390
Category 3	129 (1.19%)	117	$38,788,110	$55,552,660	$44,958,156	78 27,071,570	34 24,085,030	5 3,116,570
Category 4	199 (1.84%)	166	$47,217,620	$68,115,910	$54,985,706	115 33,659,380	43 27,519,520	8 3,901,150
Category 5	390 (3.6%)	310	$57,336,770	$94,449,790	$76,093,266	207 42,882,890	78 36,139,640	25 9,814,890

Sea Level Rise

Property in the City is also susceptible to sea level rise. By 2040, the NOAA projection shows very little inundation along the lagoon side of the City. By 2060, the NOAA projection exposure increases inundation to all along the coast of the City affecting the Rockledge Drive area. With exposures under the NOAA High Curve, 124 properties in 2100 are vulnerable to inundation at this point. Using the lower boundary, USACE, land use exposure is primarily limited 7 properties impacted and only 0.78 acres. As stated earlier in the report, it is important to recognize that while some buildings or parcels may be at an elevation that keeps them from inundation, access to these areas may be impacted by flooding in its vicinity. This is particularly important for the few properties along Rockledge Drive up and down the City's lagoon coast.

As with the other hazards, residential is the most impacted future land use category. Working with property owners to assess the best methods to mitigate the effects to these residences will be a priority. Increasing the amount of conservation or recreation lands that can help serve as buffers or other types of mitigation and adaptation to sea level rise would be beneficial to potentially diverting water and protecting developed properties along Rockledge Drive. Creating alternative routes from the west to the properties that will see the effects of sea level rise along the coast could alleviate potential access issues as Rockledge Drive becomes impacted.

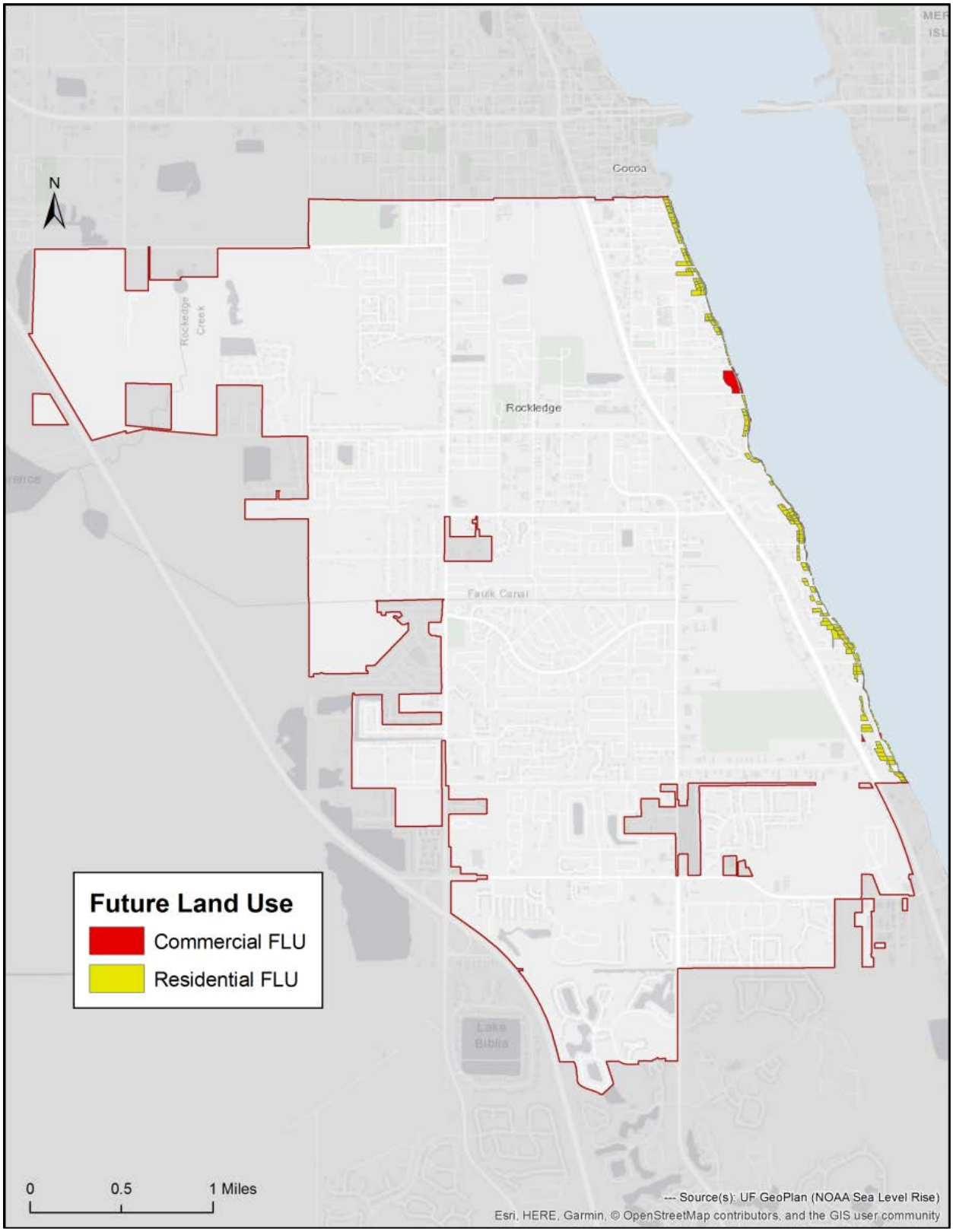
Table 11: Sea Level Rise Exposure by Future Land Use Classification by Acres

	Commercial	Low Density Residential	Med. Density Residential
Horizon Year	Acres	Acres	Acres
2100 *USACE Curve*	0	0.78	0
2040 *NOAA Curve*	1.2	12.82	8.28
2060 *NOAA Curve*	1.3	13.8	8.43
2080 *NOAA Curve*	1.3	17.54	9.68
2100 *NOAA Curve*	5.95	34.3	18.67

Table 12: Sea Level Rise Impacts by Financial Exposure

				Built Pre-1968	Built 1968-2001	Built 2002 - 2018
Horizon Year	# Parcels in Zone (% of All Parcels)	Value of Parcels in Zone	Total Number of Buildings	Buildings Total Value	Buildings Total Value	Buildings Total Value
2100 *USACE Curve*	8 (0.07%)	$3,198,920	7	3 $1,389,100	4 $1,773,870	0 $0
2040 *NOAA Curve*	110 (1.01%)	$48,674,470	99	65 22,428,100	30 22,138,630	4 2,440,870
2060 *NOAA Curve*	123 (1.13%)	$53,108,030	111	75 $25,731,650	31 $22,592,940	5 $3,116,570
2080 *NOAA Curve*	137 (1.26%)	$57,058,770	122	84 $29,146,070	33 $23,129,060	5 $3,116,570
2100 *NOAA Curve*	153 (1.41%)	$62,039,100	124	96 $30,563,670	39 $26,321,370	5 $3,116,570

Figure 17: NOAA 2100 Sea Level Rise Impacts by Future Land-Use Category



100- and 500-Year Flood Zones

A large amount of the City is affected by the 100- Year flood zones totaling at about 1,618 acres. The AE zone has the largest number of acreage and the greatest number of parcels and buildings affected, but there is also significant effects in Zone A and Zone AH. Approximately 51% of buildings in the 100-year flood zone were built prior to 2002, when new building codes were implemented, while approximately 75% of vulnerable homes in the 500-year floodplain were built prior to 2002. As flooding and storms becomes more frequent in the City, these buildings will most likely need to be retrofitted, mitigated or rebuilt to the new standards. Residential comprises 25.5% of vulnerable parcels in the 100-year flood zone and 28.6% in the 500-year flood zone.

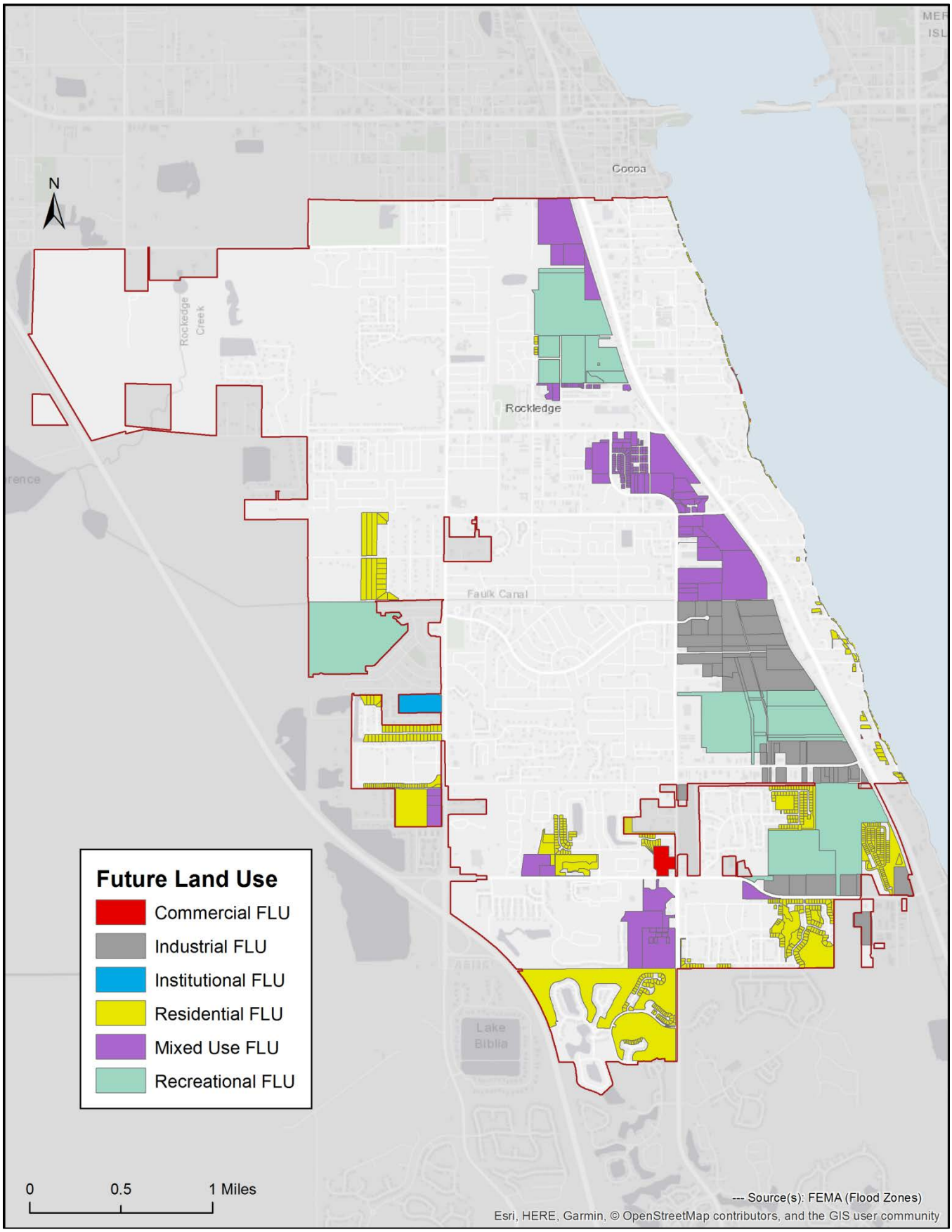
Table 13: 100-and 500-Year Flood Plain Exposure by Future Land Use Classification by Acres

	Commercial	Low Density Residential	Med. Density Residential	Industrial	Institutional	Redevelopment Mixed Use	Mixed Use Planning District 5	Mixed Use Planning District 7	Recreational Public Active	Recreational Public Passive	Recreational Public Mixed
Flood Zone	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
Zone A *(100 Year)*	9.73	28.08	74.46	44.23	0	0	0	12.68	0	53.96	0
Zone AE *(100 Year)*	1.31	72.93	37.91	233.09	15.17	103.58	160.25	10.87	180.57	196.6	106.57
Zone AH *(100 Year)*	0	0	199.3	9.38	0	0	0	67.77	0	0	0
500 Year *(Includes 100 Year)*	11.04	135.81	445.02	326.91	15.17	223.97	186.82	91.32	200.48	250.56	143.59

Table 14: 100- & 500-Year Flood Plain Impacts by Financial Exposure

						Built Pre-1968	Built 1968-2001	Built 2002 - 2018
Flood Zone	# Parcels in Zone (% of All Parcels)	Number of Buildings	Land Value	Assessed Value	Taxable Value	# Buildings Total Value	# Buildings Total Value	# Buildings Total Value
Zone A *(100 Year)*	260 (2.4%)	240	11,235,020	49,281,900	39,426,752	0 0	61 13,662,830	179 36,966,810
Zone AE *(100 Year)*	537 (5%)	352	52,835,870	124,409,830	92,256,657	70 23,646,370	218 71,555,920	64 18,763,910
Zone AH *(100 Year)*	219 (2.02%)	197	8,253,910	62,104,240	49,418,746	0 0	54 16,829,300	143 45,143,530
500 Year *(Includes 100 Year)*	1,674 (15.44%)	1,379	90,334,720	330,232,920	250,342,783	194 31,979,820	448 165,743,880	215 119,993,720

Figure 18: Future Land Use in the 100-Year Flood Zones



Storm Surge and Sea Level Rise

As sea levels rise, storm surge from hurricanes can be expected to become higher and impact a greater extent of the City. This analysis explored the impact that rising seas would have on a Category 3 storm surge using the USACE High and NOAA 2017 High projection rate curves for 2050, 2070, and 2100. The year 2050 was utilized as the planning horizon for this analysis (instead of 2040) due to the differential in the curves and increase of sea level at this horizon. The GIS add-in tool will be available for further analysis upon completion of this report and it would be advantageous for the City or County to conduct further assessment of varying sea level increases with each storm surge category, especially the Category 1 surge zone which constitutes the Coastal High Hazard Area.

Current Category 3 storm surge impacts approximately 24.9 acres of the City. As sea level rises to 8.5 feet, the extent of impact grows upward affecting 863 acres by 2100 under NOAA High. In thinking more short term, by 2050, sea level is expected to rise approximately 1.7-2.5 feet. Analysis shows that a rise of 4.5 feet, estimated occur between 2070 (NOAA High) and 2090 (USACE High), will ultimately be the point in which a current Category 4 zone will become the new Category 3 zone. It is expected that by 2050 surge heights could reach between 44.91 and 45.76 feet and 46.03 feet and 47.64 feet by 2070. The City should assess the depth of surge (in the database provided as part of this project) at various critical facilities and determine appropriate measures for elevating or hardening the most vulnerable structures while considering the remaining functional life span of the facility.

The tables below illustrate the changes of impacts from a Category 3 surge as sea levels rise.

Table 15: Combined Storm Surge and Sea Level Rise Exposure by Future Land Use Classification by Acres

	Commercial	Low Density Residential	Med. Density Residential	Industrial	Recreational Public Passive	Redevelopment Mixed Use	Mixed Use Planning District 5	Recreational Public Active	Recreational Public Mixed
Zone	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
2017 Category 3	0.22	2.37	8.8	0	0	0	0	0	0
Category 3 *Year 2050*	5.96	32.28	17.16	0.53	0	0	3.42	0	0
Category 3 *Year 2070*	6.37	306.64	41.03	0.53	85.37	0	3.42	0	0
Category 3 *Year 2100*	9.7	318.54	119.7	73.58	85.37	48.69	81.75	59.4	66.25

Table 16: Combined Storm Surge and Sea Level Impacts by Financial Exposure

						Built Pre-1968	Built 1968-2001	Built 2002 - 2018
Zone	# Parcels in Zone (% of All Parcels)	Number of Buildings	Land Value	Assessed Value	Taxable Value	# Buildings Total Value	# Buildings Total Value	# Buildings Total Value
Category 3 *Year 2050*	153 (1.41%)	133	$43,612,930	$64,790,330	$52,191,426	90 $30,603,720	37 $25,252,460	6 $6,818,370
Category 3 *Year 2070*	178 (1.64%)	147	$47,076,210	$70,207,320	$56,467,506	99 $32,251,820	40 $26,565,120	8 $7,520,070
Category 3 *Year 2100*	323 (2.98%)	241	$55,663,800	$95,325,430	$71,144,986	160 $38,743,560	60 $37,211,680	21 $16,407,790

3. Critical Facility Impacts

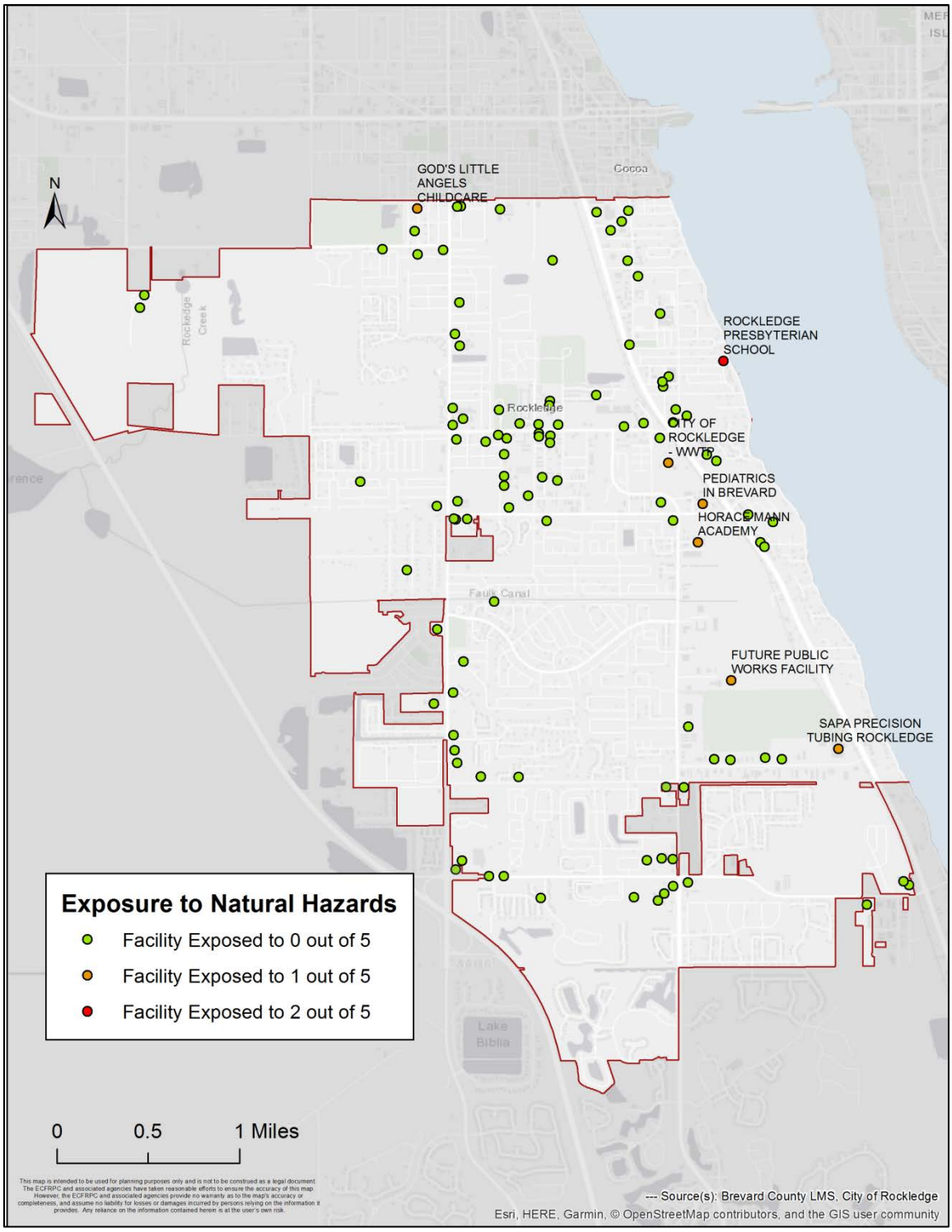
The critical facilities analysis in this report details the risk posed to government operations that are critical to life, safety, health and the continuity of operations city-wide following storm events. Other facility types in this analysis include HazMat facilities, utilities, lift stations, schools and other governmental facilities. As shown in the table below, no facilities are located in the 100-year flood zone. The majority of facilities also are not vulnerable to any hazard. Only 7 out of the total 111 critical facilities are vulnerable to a hazard. The only facility exposed to two hazards is Rockledge Presbyterian Church/School located close to the lagoon on Rockledge Drive in the Category 5 storm surge zone and also in the 2100 Combined Zone. Another facility to note is the Sapa Precision Tubing, which is a hazardous materials facility located in the Zone AE flood zone. The future Public Works Facility was added in the analysis as well. Although it will be located in the 500- year flood zone, this area is minimally impacted. It would be beneficial for the City to begin conversations with these facilities that are impacted and the possible effects the hazards will have. While this analysis displays that there are few critical facilities impacted by hazards, it is important for the City to address the ability of these facilities during and after disasters as well as reassess their vulnerabilities in the future.

Source: Global Spec

Table 17: Critical Facilities by Hazard

Facility	Facility Type	Storm Surge Zone	Flood Zone	Combined Zone
City Of Rockledge - Wwtp	Hazardous Materials Facility		500 Year	
Future Public Works Facility	Local Government Facility		500 Year	
God'S Little Angels Childcare	Day Care		500 Year	
Horace Mann Academy	Public School		500 Year	
Pediatrics In Brevard	Rural Health Clinic		500 Year	
Rockledge Presbyterian School	Day Care	Category 5		2100
Sapa Precision Tubing Rockledge	Hazardous Materials Facility		Zone AE	

Figure 19: Critical Facilities Exposure to Natural Hazards



This map depicts the number of vulnerabilities to which each of the City's critical facilities is exposed. Seven of the 111 critical facilities are impacted by a hazard. As evident on this map and in the table, facilities vulnerable to 1 or 2 hazards are in a flood zone, the combined storm surge and sea level rise zone, or in a storm surge zone. The vast majority of the City's critical facilities are unaffected by a hazard.

General Overview and Policy Discussion

The City of Rockledge was awarded a Florida Department of Environmental Protection (FDEP) grant to assess sea level rise, storm surge and flooding impacts on the City, engage the public and develop strategies and policies aimed to mitigate, adapt and plan for the impacts. The City contracted with the East Central Florida Regional Planning Council (ECFRPC) to develop the vulnerability assessment, engage the public and develop the policies and recommendations.

Components of this Report

A vulnerability assessment was conducted and served as a basis for many of the recommendations from the report. Two public meetings were held and an online survey was developed to provide public input. The City's existing Comprehensive Plan was reviewed and recommendations were made to enhance the City's planning for current and future flood impacts, including sea level rise and hurricane surge. The Coastal Element of the Comprehensive Plan was updated to include draft goals, objectives and policies per the state mandated Peril of Flood legislation for consideration by the City for inclusion in the City's Evaluation and Appraisal Report (EAR). These component parts comprise the tasks that are a part of the FDEP grant deliverables.

Overview

In order to comprehend the physical risks to the infrastructure, residents and businesses of the City over time, a vulnerability assessment was conducted. While the impacts of sea level rise inundation impact Rockledge minimally compared to the other cities, storm surge and flood zones impacts are greater and display potential for flooding along the Indian River Lagoon (IRL) and inland from the St. John's River. While the completed modeling depicts the rising waters from sea level rise and increasing storm surge from sea level rise, it does not account for heavier precipitation events that can have a strong impact on flooding. A warmer climate may portend stronger and more frequent hurricanes as well.

Putting mechanisms in place well ahead of time to mitigate flooding will make the transitions required in the future easier to implement. The goals adopted by the City should include policy approaches that maintain the safety and well-being of the community and preservation of municipal infrastructure while also minimizing the long-term potential legal liabilities and unintended future risks to residents from the perils of flood.

By acting now, the City can get ahead of many future flood impacts which will have an increasing influence over the daily lives of residents and business owners over time. It is important that Rockledge takes a pro-active stance in addressing the mid and long-term future of the City. If the City decides in

the future to be an area for relocation of surrounding areas more susceptible to coastal hazards, planning and visioning should occur in the near future to ensure development is appropriate and resilient.

Impacts to the City will be from the Indian River Lagoon (IRL), St. John's River, and some low-lying areas spread across the area of the City. The City is challenged with maintaining a balance between the current quality of life and the physical realities of increasing hazards from higher water. The City will need to consider the impacts of a reasonable lower level of service than has been provided in the past due to financial capacity of the City to construct large and expensive infrastructure projects to protect from the perils of flood.

Peril of Flood Requirements

The Comprehensive Plan update must include statutory mandated Peril of Flood language. The six components which have been integrated into the comprehensive plan goals, objectives and policies are as follows:

1	Include development and redevelopment principles, strategies, and engineering solutions that reduce the flood risk in coastal areas which results from high-tide events, storm surge, flash floods, stormwater runoff, and the related impacts of sea-level rise.
2	Encourage the use of best practices development and redevelopment principles, strategies, and engineering solutions that will result in the removal of coastal real property from flood zone designations established by the Federal Emergency Management Agency.
3	Identify site development techniques and best practices that may reduce losses due to flooding and claims made under flood insurance policies issued in this state.
4	Be consistent with, or more stringent than, the flood-resistant construction requirements in the Florida Building Code and applicable flood plain management regulations set forth in 44 C.F.R. part 60.
5	Require that any construction activities seaward of the coastal construction control lines established pursuant to s. 161.053 of the Florida Statutes be consistent with Chapter 161 of the Florida Administrative Code.
6	Encourage local governments to participate in the National Flood Insurance Program Community Rating System administered by the Federal Emergency Management Agency to achieve flood insurance premium discounts for their residents.

Rational of Policy Development

Policy recommendations are the result of interaction with the residents, survey results, opinions by experts (Thomas Ruppert, Esq (Florida Sea Grant)) and the vulnerability assessment. The principles that have been discussed as the policy recommendations have been developed include;

1. There will be an increase in flood potential in the City from sea level rise and associated intensification of storms and rain events.
2. The protection of safety and property due to the risk of flooding impacts should be emphasized. This better protects the City in a legal challenge against a taking of property when the regulations to protect property are challenged. The regulations must be based on technical data, such as the information provided in the vulnerability assessment. The regulations can also include environmental regulations such as protection of living shorelines as a strategy to protect human safety and protect property.
3. A statement should be included in ordinances that the City's policy mandates that the local government has a need and responsibility to make challenging decisions that balance the important interests of property rights with the need for the community to responsibly manage its financial resources and protect the lives of residents and first responders. Included should also be a note that the City, unlike private property owners, cannot simply alienate property to relieve itself of its legal duties and responsibilities.
4. Highlight the fact that the comprehensive plan and ordinances are to give residents adequate current and advanced notice of future conditions of potential property impacts due to the perils of flood. This may ensure that investment-backed expectations are actually reasonable in light of changes occurring due to sea level rise and climate change.
5. Ensure that the processes in ordinances respect due process of property owners.
6. Strive to have comprehensive plan language, polices and ordinances work in conjunction to accomplish the City's aims.
7. Include policies and ordinances that minimize the risk of "moral hazard". This is where risk taking behavior is potentially rewarded by allowing those who take the risk of living in hazardous areas having other tax payers incur the higher costs to maintain the infrastructure necessary to service or protect them.
8. Identify the existing and future data required to set policy and to implement desired policies, now and in the future.
9. Redevelopment potential

Incorporating Resilience into the City Plans, Policies and Programs

The strategies presented in this report are based on input from public engagement activities, findings from the vulnerability analysis, review of the coastal element of the comprehensive plan and best practice research.

Through the public engagement process, numerous facilities and utilities were identified as being critical to pre and post-storm preparedness and recovery including lift stations, gas stations, utility lines and stores that provide food, water, ice and other necessary goods. Working with these businesses, and internally, to provide opportunities to minimize risk and speed recovery efforts, would be beneficial. It

will be essential for the City to have an ample supply of gasoline or propane for at least 2 weeks and assess the feasibility of moving utility lines underground or constructing concrete poles for the lines. Solar power may be an option since it will lower the municipal operating expenses year-round, provide power for daylight operations directly from the panels and provide power for batteries to use for night time operations or when overcast. The City is encouraged to also work with Brevard County Emergency Management and surrounding communities in order to educate, prepare, and recover from disasters and to collaboratively incorporate resilience strategies into all plans, policies, and procedures.

The residents of the City voiced concern about various stormwater issues like aging of the infrastructure and impacts of saltwater. In order to address these, the City should begin to develop new and innovative approaches to their stormwater master plan for its next update. It is recommended that the City further assess outfall impacts to the complete stormwater system to determine impacts from elevating lagoon and river waters which can cause stormwater system failure. The City may use the stormwater analysis provided through this report as guidance to create a prioritization process to ensure any flooding including any on the western side is alleviated and occurs out of vulnerable areas. The City of Rockledge should also work with the City of Cocoa who supplies their freshwater on any coordination to ensure infrastructure and supply resilience.

Any stormwater system update should include a hybrid approach to stormwater through the use of both gray and green infrastructure that is aimed to capture water prior to discharge to the river allowing for additional filtration. The plan should also examine strategic locations for using open space for green infrastructure projects. Projects utilizing Low Impact Development (LID) and other green infrastructure like stormwater parks, green parking lots, and bioswales help reduce stormwater run-off and increase natural filtration, thus improving water quality. The City should examine strategic locations for using open space for green infrastructure projects that create amenities for the community while increasing water capture and filtration, beautifying, reducing flood and other positives to LIDs and green infrastructure.

The stormwater master plan should be integrated with the City's conservation element and the parks and recreation plan. Utilizing open space for stormwater use during the wet season or storms while serving the community as an eco-tourism or area of activity for the remainder for the year is a win-win for the community. The City should continue at their current rate of maintenance of the stormwater system, like clearing baffle boxes monthly, while considering new and innovative approaches as well. Hosting experts in the area of this specialty to help identify feasibility and locations for projects would be beneficial. Acquiring properties in the 100-Year flood plain may be advantageous for the City.

The City, to be compliant with state statute, is updating its comprehensive plan to include policies to address sea level rise, flooding and storm surge. This update includes data and analysis derived from the vulnerability analysis that illustrates areas of impact as well as infrastructure and facilities vulnerable to the hazard. A reference should be made to the vulnerability assessment for further information.

The Transportation and Future Land Use elements of the comprehensive plan should be updated to include reference to findings from the vulnerability assessment and include associated policies that

ensure sea level rise, current and future flood risks, and enhanced surge are considered in planning decisions.

Based upon the findings of the vulnerability assessment, it would be advantageous for City staff (planning, stormwater, building official, etc.) to reassess required elevations of properties, especially in the Coastal High Hazard Area (CHHA), the Lagoon Protection Area, and areas vulnerable to sea level rise, flooding and storm surge. Many local governments are updating ordinances to increase the base floor elevation of the lowest floor. Examples include: elevating the lowest habitable floor to 10 feet above BFE in CHHA areas; elevating first floor to a minimum of either 7 feet NGVD or 30 inches above the highest point of any abutting street. The Vulnerability Assessment can guide City officials to address elevation requirements, and the ordinances should be adjusted accordingly. Due to the 100-Year flood plain exposure, it is also recommended that these adjustments also be applicable to development in the 100-Year floodplain, if development is allowed.

The Capital Improvement Element should be updated to include a policy(ies) that requires projects funded by the City to include an assessment of sea level rise, future flood risks, and elevated storm surge to determine acceptable risk and associated costs for adapting or mitigating those risks. The city will need to develop a process and checklist for this assessment so all departments are on the same page concerning approaches for assessment.

Based on resident input from the workshops and the survey, Rockledge is currently developed with little green space area left and there is a strong desire to keep green areas as they are vital to the community. Residents also emphasized green infrastructure implementation where possible as a priority and pointed out already existing infrastructure in the City that could be used for redevelopment if necessary. It would be wise for the City to conduct an underutilization study of areas in the City that could be redeveloped to create more economic vitality without sprawling into undeveloped lands. The City may also develop a historical areas preservation analysis to identify historic areas and landmarks. Then create an ordinance for the protection and preservation of these areas. Any development, redevelopment, rebuilding, or retrofitting should be held to Florida Building Code standards and green infrastructure techniques should be prioritized as deemed feasible. The City should educate the public on programs such as the Florida PACE Funding Agency (PACE) https://www.floridapace.gov and promote the Solar and Energy Loan Fund (SELF) to aid businesses, and homeowners, as well as the City itself, in financing improvements to property to make them more energy efficient and storm resilient. Also, the Florida Green Building Coalition (FBGC) is a resource that helps not only businesses and homeowners build to new standards but also offers a certificate for local governments that “set goals and implements environmental practices that can lead to tangible reductions in operation cost and capital outlays”. FGBC not only leads and promotes sustainability but also provides recommendations to fortify homes for resilience through “disaster mitigation” points.

From the public input and the vulnerability analysis, Rockledge has been identified as a City with less impact from flooding hazards as surrounding area in Brevard County. Thus, the City may become a place for relocation of other surrounding populations that will experience more severe impacts from flooding. It would be beneficial for the City and its residents to create a “Visioning Plan” in order to

contemplate the future possibilities of the City and encapsulate desires of the community as a whole for the future while considering projected impacts from hazards.

Finally, Brevard County has developed a website, “Brevard County Shoreline Public Map,” that is an excellent reference that discusses the importance of living shorelines, types of shorelines, how to design them and how erosion is an issue along much of the Indian River Lagoon. It would behoove the City to work with private property owners on solutions to fortify the shoreline and reduce risk of erosion. See the URL below for the Brevard County website.

https://www.arcgis.com/apps/MapSeries/index.html?appid=c797fc2174e44df79a71304d88c159f3

For other reports that are a part of the Resiliency Plan please visits the project website:
https://www.perilofflood.net/rockledge

Reports include:

Public Engagement Report

Stormwater Assessment Report

Plan Assessment and Strategy Report