RESILIENT TITUSVILLE

Florida Coastal Management Program

NOAA — National Oceanic and Atmospheric Administration — U.S. Department of Commerce

Florida Department of Environmental Protection

East Central Florida Regional Planning Council — Est. 1962

Titusville, Florida — Founded 1867

Prepared by the East Central Florida Regional Planning Council and the City of Titusville
May 2019

RESILIENT TITUSVILLE

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DISCLAIMER

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I. Background

Located on the intracoastal waterway on the east coast of Florida, the City of Titusville is vulnerable to a wide array of natural hazards that threaten the long-term economic and functional viability of the community. Because of this, 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 Titusville with a grant to determine vulnerabilities facing the community and develop a plan to enhance the City's short-and-long-term resiliency to climate-related hazards. As part of this process, the following analyses and outreach steps were completed:

- Vulnerability Analysis: This report identifies the economic and functional vulnerabilities posed to the City from four natural hazards, including storm surge, flooding, sea level rise and nuisance flooding. Water quality and the combined effects of surge and sea level rise were also analyzed.
- Public Workshops and Strategy Development: The project team worked with members of the community to identify additional vulnerabilities, collect information on past storm events, identify potential strategies for mitigating vulnerabilities, and develop a final set of resiliency themes to guide the City's actions and priorities moving forward. Two public meetings were held and a survey was developed to complete this portion of the report.
- Identification of Resiliency Themes: Following the completion of the vulnerability analysis and public outreach process, the project team developed 'resiliency themes' to be adopted by the City in order to address the identified vulnerabilities.
- Resiliency Plan and Strategy Development: Using the 'resiliency themes' developed, the project team created a Resiliency Plan and developed a listing of draft actions and programs for the City to consider implementing in order to make Titusville a more resilient City. Wherever possible, the project team worked with the City to include the work developed in previous studies and reports such as the East Central Florida Regional Resiliency Action Plan and the Titusville Vision Plan.

Goals and Impetus of this Resiliency Plan

The over-arching goal of this resiliency plan is to identify coastal vulnerabilities specific to the City of Titusville and provide recommendations to mitigate the effects of sea level rise.

Currently, the east coast of Titusville is experiencing periodic nuisance flooding through the confluence of prolonged rain and annual high tide events. This inundation is encroaching on critical infrastructure found along the shoreline and, if not addressed, can be detrimental to the future development of the city.

Sea level rise projections from NOAA and the U.S Army Corps of Engineers suggests that by 2070, sea levels will have risen more than 4 feet in central Florida, which is enough to permanently inundate part of downtown Titusville, the Parrish Medical Center, and the northeastern section of the City encompassing the Chain of Lakes Park and the marina. This will be the initial tipping point where impacts to critical city infrastructure will occur, such as storm water drain backup along with street and property inundation. Coastal habitats protecting the shoreline will also be affected, which can cause erosion, salt water intrusion, and the degradation of marine ecosystems vital to the region's economy. If the sea level rise trend follows its course, downtown Titusville and the coastal shoreline will be significantly affected, causing permanent damage. *These vulnerabilities must be addressed in a comprehensive way.*

Legal Connection: Florida's 'Peril of Flood' Legislation

The City of Titusville is completing this resiliency study in response to Senate Bill 1094, newly enacted state legislation passed in 2015 to standardize how coastal cities 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 portion of the Comprehensive Plan is meant to address how to eliminate inappropriate and unsafe development in coastal areas. Data and maps developed as part of this study will be incorporated into the City of Titusville's Coastal element in order to fulfill this state requirement.

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 ecosystem will build capacity and establish a shared mission and goals uniting our 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, which gathered stakeholders in Brevard and Volusia County to identify common data sets and to determine how jurisdictions and agencies can work together to address climate-related vulnerabilities.

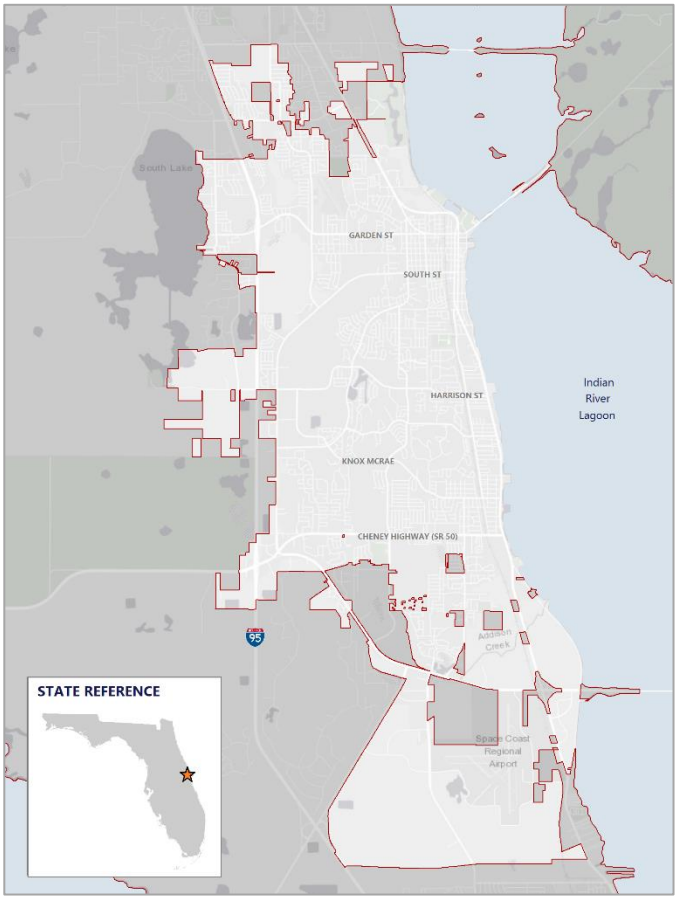
This report builds off of the work developed as part of the Resiliency Action Plan and the Regional Resiliency Collaborative in a number of ways, including the use of the "high curve" Army Corps of Engineers and NOAA sea level rise data as recommended by the plan's Sea Level Rise Committee. Additionally, many of the recommendations developed as part of this report were taken from action items originally identified in the Regional Resiliency Action Plan.

II. City Overview

Location

Home to approximately 46,413 individuals, Titusville is located on the east coast of Brevard County bordering the Indian River lagoon. Adjacent to the city is Merritt Island and the Kennedy Space Center, both of which contribute to the economic prosperity of the region. Please reference the map on this page to view the City boundary and location within the state of Florida.

Map 1: Citywide Map



Population Growth Rate & Projections

The population of Titusville is projected to increase by approximately 7,086 by the year 2040. It is critical that the City accommodates this future population growth while not allowing new units within natural hazard zones.

2000: 40,936 (2000 US Census)
2010: 43,761 (2010 US Census)
2017: 46,413 (US Census Estimates)
2040: 53,499 (+7,086) (BEBR)

Land Use & Build Out Information

Titusville is at high risk of flooding during heavy rain events due to its proximity to the Indian River Lagoon. The downtown is located in the northeastern portion of the city limits where Garden Street and US 1 intersect. This area of the City is fairly dense, with multi-story buildings and minimum development setbacks. The central and western portions of the City primarily consist of residential development of varying intensities. Street networks within these neighborhoods also vary, as some feature cul-de-sacs and some feature more of a grid street network. Conservation lands can be found throughout the City.

Cheney Highway, which runs through the south-central portion of the City, is primarily flanked by commercial land uses and serves as a primary retail connector within the City. Similarly, US1, which runs parallel to the Indian River Lagoon, is primarily flanked by commercial uses that are designated as mixed-use areas in the City's future land use map. Garden Street, near downtown, is a third retail corridor.

The southern portion of the City primarily consists of industrial development and includes the Space Coast Regional Airport. Additional industrial development is located in the southwestern portion of the City along South Street (SR 405).

Existing Studies and Reports

This section includes existing studies and report that closely align with Titusville's resiliency efforts. These reports were reviewed by the project team and informed the development of this report.

Titusville Comprehensive Plan – Coastal Element

The "Coastal" element of the City's Comprehensive Plan focuses on preserving, restoring, and enhancing coastal resources for public use and future ecological benefit. The objectives are to maintain and upgrade the quality of surrounding bodies of water such as the Indian River Lagoon, to protect the basic functions served by vital ecological features, to assure maximum retention of the recreational values of the coastal areas, and to encourage the expansion of existing marina facilities while discouraging their location in inappropriate areas. The aim is to provide public safety in coastal areas that are most vulnerable to chronic stressors and natural disasters. This will be accomplished through the regulation of development of public infrastructure in the coastal zone. Statistics from this report will be included in the "Coastal" element of the City's Comprehensive Plan following final adoption of the plan by the City.

Titusville Vision Plan and 2040 Draft Comprehensive Plan

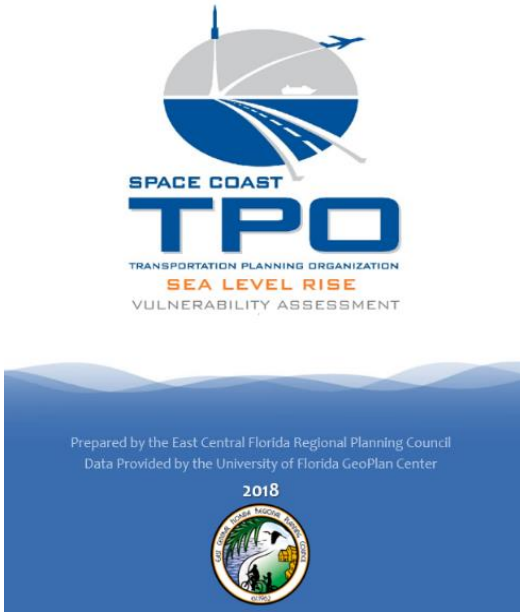
This visioning project focuses on preserving and enhancing the City's waterfront while maximizing connectivity and promoting economic vitality through the redevelopment of the downtown Titusville area. The plan proposes three main areas of focus for the 2040 Comprehensive Plan, including 1) Downtown; 2) the Waterfront; and 3) Commercial Gateways.

The first priority of the Vision Plan is to preserve and improve the waterfront by increasing access to its amenities. Emphasis has also been placed on re-imagining Downtown Titusville through new design concepts and redevelopment. Third, commercial gateways are prioritized as an important element in improving connectivity, as the City wishes to create a 'good first impression' for visitors by redeveloping parcels adjacent to major roadways leading into town. Information compiled during the planning process of this report is utilized in the 2040 Draft Comprehensive Plan.

East Central Regional Resiliency Action Plan

As mentioned in Section 2 ("Background") the ECFRPC was awarded a Florida Department of Environmental Protection (FDEP) Grant in 2017 to work with stakeholders in Brevard and Volusia Counties to develop a Regional Resiliency Action Plan (RRAP). A steering committee comprised of federal, state, regional and local agencies and communities was established to oversee the development of the plan, engage stakeholders and develop a regional approach to sea level rise planning.

The goal of the Regional Resilience Action Plan is to increase the ability of local and regional stakeholders to implement resilience and climate adaptation strategies across disciplines. The action plan incorporates a five-year planning horizon based around four main focus areas derived from the 100 Resilient Cities pioneered by the Rockefeller Foundation: Leadership and Strategy, Economic and Society, Infrastructure and Environment, and Health and Wellbeing. The RRAP provides actions for various levels of government from local to federal, as well as for partnerships across agencies, not-for-profits, the business sector and other stakeholders. *The report also identified all existing sea level rise projections from the U.S. Army Corps of Engineers and NOAA and recommended that communities focus on the low, intermediate and high projection curves from both sources. This report provides an in-depth analysis of the effects of the high curve. Low and intermediate cure maps are located in Appendix III.*



Space Coast Transportation Planning Organization Sea Level Rise Vulnerability Assessment

The Space Coast TPO Sea Level Rise Vulnerability Assessment addressed assets that contribute to transportation functionality within the County, including roadways, railroads, airports, transit and other critical facilities deemed important for countywide transportation and evacuation events. The study utilized sea level rise data provided by the University of Florida GeoPlan Center and planning horizons (2040, 2070 and 2100) as well as inundation projection rate curves (low, intermediate and high) from the U.S. Army Corps of Engineers (USACE). The approach of this study was developed to maintain regional consistency based on other assessments conducted for the City of Satellite Beach and the River to Sea TPO (Volusia County) and utilized the best available data.

Overview of Regulation and Zoning Actions

Adaptation Action Areas

In addition to Senate Bill 1094, an Adaptation Action Areas state statute was established in 2011 and pertains to the "Coastal" element of a local government's Comprehensive Plan. Adaptation Action Areas can be described as areas that experience coastal flooding due to extreme high tides and storm surge, and that are vulnerable to the related impacts of rising sea levels for the purpose of prioritizing funding for infrastructure needs and adaptation planning.

By 2020, the City's Comprehensive Plan will designate future Adaptation Action Areas with assistance from this report. As part of this, land development regulations and zoning (or future land use) classifications may be amended in order to further protect life and infrastructure.

The City has not identified any additional zoning or land development regulation-based issues to be addressed within this report as of the time of its completion. Please refer to the recommendations portion of this report for more information pertaining to zoning, regulations and Adaptation Action Areas.

Land Ownership Overview

The size of parcels within the City is highly variable. Just over six in ten (60.9%) of the City's parcels are less than one quarter-acre in size. Primarily private residential and commercial uses, 89.2% of these parcels are developed while 10.8% are currently undeveloped.

Moving up in size, 18.3% of parcels in the City are between 0.25 and 0.50 acres in size, with 89.8% of these parcels currently developed. Overall, 79.2% of the City's parcels are less than 0.5 acres in size and account for 13.3% of the total incorporated area. The vast majority of property is privately owned.

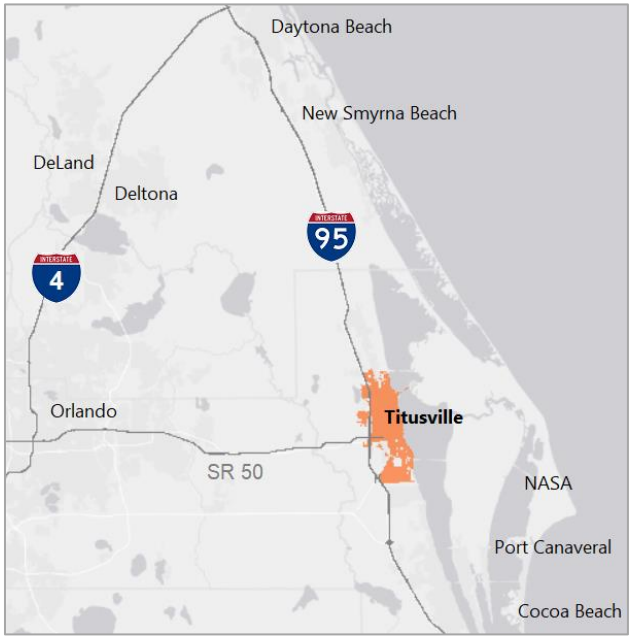
The average parcel size within the City is 1.24 acres, and the positive skew is a result of a high number of large parcels. The analysis showed that 45 of the City's more than 22,000 parcels are more than 50 acres in size and account for 20.2% of the land area of the City. These parcels are generally located away from the Indian River Lagoon with the exception of the municipal marina, Parrish Medical Center, Eastern Florida State College and a large undeveloped property to the south of NASA Causeway that may require additional development regulations in the future.

Parcels located away from the lagoon that exceed 50 acres in size are primarily classified as assorted residential uses and conservation with the exception of the industrial parcels located in close proximity to the Space Coast Regional Airport. Approximately two-thirds of the City's parcels over 50 acres in size are undeveloped as of 2018.

Local and Regional Connectivity Overview

Titusville is located between New Smyrna Beach to the north and Cocoa to the south. There are vast expanses of conservation land to the west, which include the St Johns National Wildlife Refuge, Salt Lake Wildlife Management Area, and Charles H. Bronson State Forest, to name a few. As one of the larger cities near Port Canaveral and the Cape Canaveral Air Force Station, Titusville offers amenities and services that attract visitors and employs many individuals in the space industry and U.S. Air Force. The City of Orlando is accessible via State Road 50 (Cheney Highway).

Map 2: Sub-Regional Context



Hurricane Evacuation Routes

Residents who live north of Garden Street to north of the county line are encouraged to evacuate west on SR 46 to I-95, or continue west on SR 46. Individuals residing South of Garden Street to SR 50 are encouraged to evacuate via I-95 or west on SR 50. Residents of North Merritt Island, Port St. John & South Titusville are recommended to evacuate west on SR 405 to SR 50 west or I-95.

III. Vulnerability Analysis

Section III, "Vulnerability Analysis", provides detailed summaries of vulnerabilities to critical facilities, parcels and roadways. As part of the analysis, vulnerabilities to storm surge, sea level rise, nuisance flooding, the FEMA flood zones, surge plus sea level rise, and water quality are reviewed.

Overview of Hazards

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.

100-Year FEMA Flood Zone

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

Nuisance "High Tide" Flooding

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

Surge + Sea Level Rise

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

Water Quality

The quality of the Indian River Lagoon, surficial aquifers, and other water bodies are highly valued by residents.

Overview of Impacts to Property | All Natural Hazards

Titusville's private and publicly-owned property is at risk to a diverse range of natural hazards, with figures exceeding one hundred million dollars of exposure for all five of the hazards covered in this report.

Approximately a half-billion dollars' worth of property in the City, including 2,377 buildings, are located in the 100-year flood zone. The vast majority of these buildings are located in the "AE" zone. Nuisance flooding is also projected to impact property, as nearly one-quarter of a billion dollars' worth of property value is located in this zone. Vulnerable properties to nuisance flooding are generally along the coast.

Property in the City is also susceptible to sea level rise. By 2040, NOAA projections show that almost a quarter-billion dollars in property value will be exposed to sea level rise. This primarily consists of properties located adjacent to the Indian River Lagoon and coastal properties in the downtown area.

Properties along and near the lagoon are also vulnerable to storm surge. Approximately one-quarter-billion dollars in property value is susceptible to the Category 1, 2, and 3 surge zones, and just over three-quarters of a billion in property value is susceptible to Category 5.

Table 1: Overview of Impacts to Property

Hazard Zone	Acreage of Parcels in Zone	Parcels with Buildings in Zone	Total Property Value	Undeveloped Acres in Zone
All 100 Year Flood Zones	7,344	1,191	$504,069,380	4,807
Zone A	3,468	242	$72,029,320	2,294
Zone AE	3,876	949	$432,040,060	2,513
500 Year Flood Zone	7,555	1,431	$541,950,560	4,903
Sea Level Rise - 2040 (ACOE)	0	0	0	0
Sea Level Rise - 2060 (ACOE)	691	14	$156,936,000	397
Sea Level Rise - 2080 (ACOE)	997	83	$202,505,380	528
Sea Level Rise - 2100 (ACOE)	1,390	192	$274,578,720	808
Sea Level Rise - 2040 (NOAA	916	122	$236,620,700	522
Sea Level Rise - 2060 (NOAA)	929	138	$246,135,940	525
Sea Level Rise - 2080 (NOAA)	1,260	236	$246,472,274	641
Sea Level Rise - 2100 (NOAA)	1,636	325	$295,165,444	893
Nuisance Flooding Zone	1,370	124	$246,820,940	755
Storm Surge - Category 1	910	125	$225,344,160	518
Storm Surge - Category 2	918	136	$228,404,460	522
Storm Surge - Category 3	1,135	156	$261,109,780	602
Storm Surge - Category 4	2,580	1,187	$487,382,940	1,167
Storm Surge - Category 5	4,479	3,139	$768,835,190	1,669
Cat. 3 + NOAA High (2050)	1,314	243	$289,606,570	692
Cat. 3 + NOAA High (2070)	1,677	344	$336,157,590	941
Cat. 3 + NOAA High (2100)	3,444	1,319	$532,582,480	1306

*Acres in zone equals the total acreage of the parcels located within the hazard zone

Overview of Impacts to Critical Facilities | All Natural Hazards

The map and table on the following two pages depict the vulnerabilities that the City's critical facilities face currently and into the future. Fifty-seven critical facilities are vulnerable to at least one hazard zone. Critical facilities that do not face a threat from the five hazards analyzed in this report are not included in the chart or table on the following two pages.

The critical facilities analysis in this report details the risk posed to government operations such as governmental facilities, police and fire stations that are critical to life, safety, health and the continuity of operations city-wide following storm events. Also analyzed are the City's hospitals, which are critical to life and safety and require electricity, water and sewer to function properly. Schools, assisted living facilities and daycares are also included in the analysis due to the vulnerabilities faced by elderly and young populations during natural hazards. Other facility types in this analysis include HazMat facilities, recreational facilities, community centers and utilities. Lift stations, wastewater treatment plants and stormwater outfalls are analyzed separately in this vulnerability analysis.

The most at-risk critical facilities within the City are generally located in the downtown area or in close proximity to the Indian River Lagoon. Facilities such as Eastern Florida State College, the Parrish Medical Center (pictured) and the Osprey Water Reclamation Facility are vital to the City and are located in multiple hazard zones. A number of privately-owned facilities are also located within multiple hazard zones, including Aerospace Interconnect Systems, Eckler Industries, Southeast Power Corp and Vectorworks International.


Parrish Medical Center

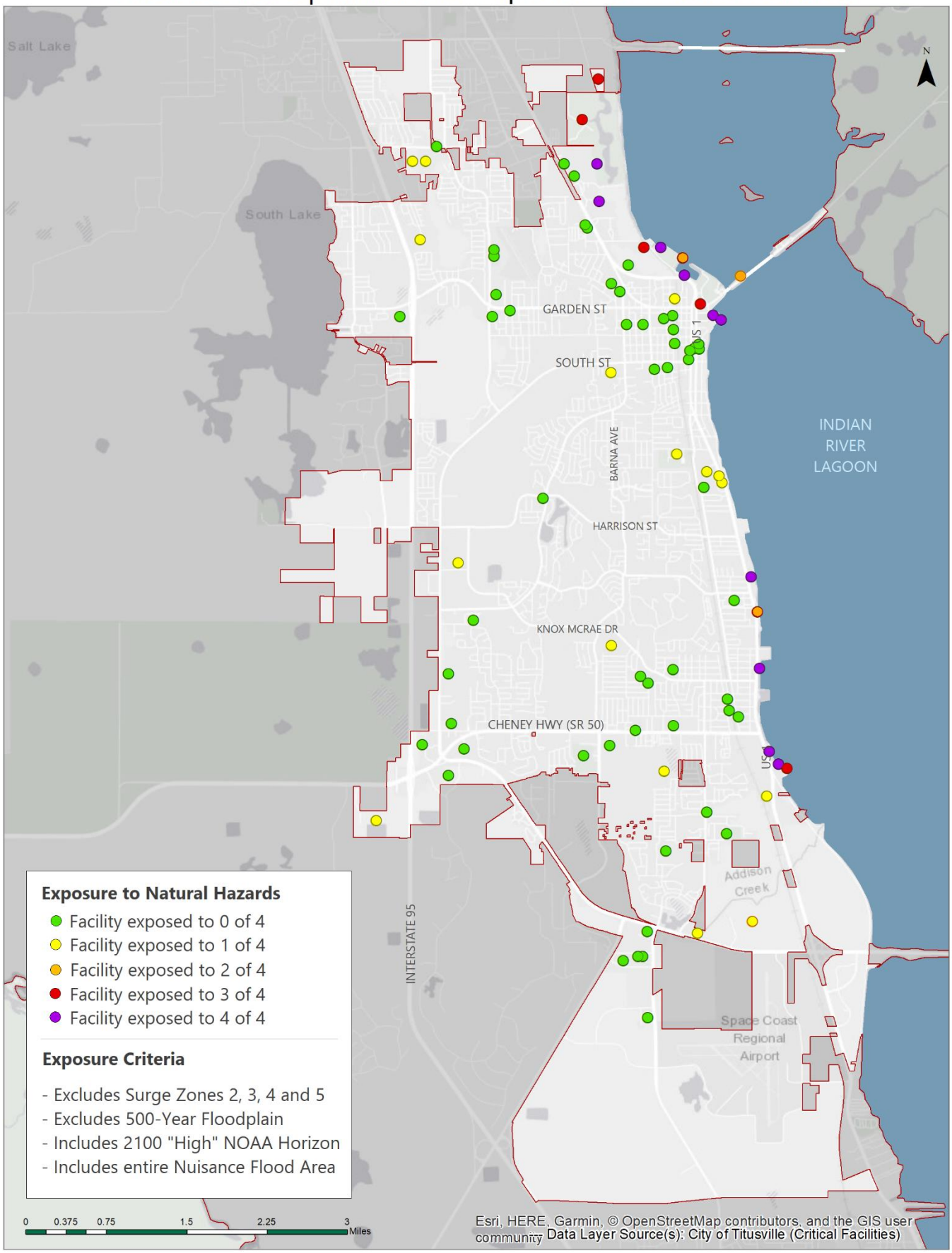
The "Overview of Exposure to Community Features" section of each of the five-individual hazard-specific analyses in this report includes additional information and inset maps concerning the risks posed to individual facilities. Please refer to those sections for a more in-depth look at these facilities.

Eastern Florida State College (Picture Provided by EFS

Table 2: Overview of Impacts to Critical Facilities

Facility	Facility Type	Storm Surge Zone	USACE SLR Horizon	NOAA SLR Horizon	Flood Zone	Nuisance Flood Area
Aerospace Interconnect Systems	HazMat Facility	Category 3	2100	2060	Zone AE	No
American Legion Post #1	Community Center	Category 5	None	None	None	No
Andrew Jackson Middle School	School	None	None	None	Zone AE	No
Apollo Elementary School	School (Shelter)	None	None	None	Zone AE	No
Astronaut High School	School	None	None	None	Zone AE	No
Bellsouth 33670	HazMat Facility	Category 4	None	None	None	No
Blanton Park	Recreation	Category 5	None	None	None	No
Blue Heron Water Reclamation Facility	Utility & HazMat	None	None	None	None	Yes
Boat Ramp 1	Recreation	Category 4	2100	2040	Zone AE	Yes
Boat Ramp 2	Recreation	Category 2	2080	2060	Zone AE	No
Brev. EMS St. #23 & Sr Center & Ag. Ext	Fire Service & Comm. Center	Category 5	None	None	Zone AE	No
Brevard Schools - North Area Maintenance	HazMat Facility	Category 5	None	None	None	No
Campbell Comm. Center & Isaac Campbell Park	Comm. Center & Recreation	Category 5	None	None	None	No
CEMEX	HazMat Facility	Category 4	None	None	None	No
Chain of Lakes Park	Recreation	Category 3	2080	2080	Zone AE	Yes
Chamber of Commerce & Economic Dev't. Dept.	Government	Category 4	None	2100	None	No
Dicerandra Scrub Sanctuary	Recreation	None	None	None	Zone A	No
DRAA Field Stormwater Park	Recreation	Category 5	None	None	None	No
Eastern Florida State College	School	Category 1	2060	2040	Zone AE	Yes
Eckler Industries	HazMat Facility	Category 4	None	2100	None	No
Enchanted Forest Sanctuary	Recreation	Category 5	None	None	Zone A	No
Gibson Complex Field	Recreation	Category 5	None	None	None	No
Harry T. Moore Social Services Center	Government	Category 5	None	None	None	No
Indian River Lodge	Community Center	Category 2	2080	2080	Zone AE	Yes
James Madison Middle School	School	None	None	None	Zone AE	No
Kennedy Point Park	Recreation	Category 1	2100	2040	Zone AE	Yes
Kennedy Point Yacht Club	HazMat Facility	Category 1	2100	2040	Zone AE	Yes
Level 3 Communications Titusville Hut	HazMat Facility	Category 4	None	None	None	No
MCI - TSVLFL	HazMat Facility	Category 4	None	2100	None	No
North Brevard Charities	Community Center	Category 5	None	None	None	No
North Brevard Shrine Club	Community Center	Category 4	None	None	None	No
Oak Park Elementary School	School	None	None	None	Zone AE	No
Osprey Water Reclamation Facility	Utility & HazMat	Category 3	2080	2080	Zone AE	Yes
Parrish Medical Center	Hospital & HazMat Facility	Category 1	2060	2040	Zone AE	Yes
Police Substation	Gov't & Law Enforcement	Category 4	None	None	None	No
Qwest Titusville Regen	HazMat Facility	Category 4	None	None	None	No
Rotary Water Front Park	Recreation	Category 1	2060	2040	Zone AE	Yes
Sears Auto Center 6265	HazMat Facility	Category 4	None	None	None	No
Southeast Power Corp	HazMat Facility	Category 3	2080	2080	Zone AE	Yes
Space View Park	Recreation	Category 2	2080	2040	Zone AE	Yes
Support Construction	HazMat Facility	500 year	None	None	None	No
Titusville Area Chamber of Commerce	Community Center	Category 4	None	2100	None	No
Titusville City Hall, Fire Administration	Government	Category 4	None	None	None	No
Titusville Fire Station #11	Fire Service	Category 4	None	None	None	No
Titusville Fire Station (Proposed)	Fire Service	Category 5	None	None	Zone A	No
Titusville High School	School	Category 4	None	2100	None	No
Titusville Housing Authority	Government	Category 4	None	None	None	No
Titusville Municipal Marina & Park	Government & Recreation	Category 1	2060	2040	Zone AE	Yes
Titusville Public Library	Government	Category 4	None	None	None	No
United Way	Community Center	Category 4	None	None	None	No
Vectorworks International	HazMat Facility	Category 1	2080	2040	Zone AE	Yes
Veterans Memorial Park	Recreation	Category 1	2100	2040	Zone AE	Yes
Watkins Oil	HazMat Facility	Category 4	None	None	None	No
William J Manzo Memorial Park	Recreation	Category 1	2080	2040	Zone AE	Yes
YMCA	Community Center	500 year	None	None	None	No

Critical Facilities | Cumulative Exposure to Natural Hazards



Overview of Impacts to the Transportation Network | All Natural Hazards

Roadways are susceptible to multiple forms of degradation as a result of natural hazards, including cracking over long periods of time as a result of the deterioration of surrounding lands due to flooding, impacts to road substrate or washing away in quick order as a result of storm surge and wave action. Inundation of roadways over multiple days, even if only a few inches, can put the integrity of roadways at risk and increase accessibility issues.

The table below summarizes the impacts the five hazards covered in this report are projected to have on roadways in the City, subdivided by FDOT classification. While no interstates or expressways are at risk, other principal arterial roadways are at risk from sea level rise (up to 3.10 miles by the year 2100), the 100-year flood zone (0.46 miles) and the nuisance flooding zone (1.51 miles). Impairment to these critical roadways can have potentially drastic effects on traffic flow and accessibility to homes and businesses, especially in areas without a grid network.

A number of minor arterial and minor/major collector roadways are also at risk, primarily to sea level rise, nuisance flooding and the 100-year flood. While these roadways are not as critical as principal arterial roadways, their disruption can affect day to day activities and emergency response times.

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 due to the degradation of lands underneath and adjacent to roadways. 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.

Table 3: Overview of Impacts to the Transportation Network

	Miles of Projected Roadway Inundation by Hazard										
Roadway Classification *(FDOT)*	Coastal High Haz. Zone *(Miles)*	NOAA SLR Year 2040 *(Miles)*	NOAA SLR Year 2060 *(Miles)*	NOAA SLR Year 2080 *(Miles)*	NOAA SLR Year 2100 *(Miles)*	ACOE SLR Year 2040 *(Miles)*	ACOE SLR Year 2060 *(Miles)*	ACOE SLR Year 2080 *(Miles)*	ACOE SLR Year 2100 *(Miles)*	100 Year Flood *(Miles)*	Nuisance Flood *(Miles)*
Principal Arterial Interstate - Rural & Urban	0	0	0	0	0	0	0	0	0	0	0
Principal Arterial Expressway - Rural & Urban	0	0	0	0	0	0	0	0	0	0	0
Principal Arterial Other - Rural & Urban	**0.02**	**0.40**	**0.45**	**1.38**	**3.10**	0	0	0	**0.79**	**0.46**	**0.02**
Minor Arterial Rural & Urban	0	0	0	**0.07**	**0.08**	0	0	0	**0.05**	**0.10**	0
Major Collector Rural & Urban	0	0	0	0	**0.03**	0	0	0	0	**1.15**	0
Minor Collector Rural & Urban	0	0	0	0	0	0	0	0	0	**0.37**	0
Local - Major Roads	**0.002**	**0.02**	**0.03**	**0.80**	**1.38**	0	0	0	**0.49**	**0.28**	**0.002**
Local - Minor Roads	**0.04**	0	**0.12**	**2.12**	**4.41**	0	0	**0.38**	**1.56**	**5.65**	**0.001**
All Evacuation Routes	0	0	0	**0.76**	**1.75**	0	0	0	**0.41**	**0.00**	0

**The "High" Sea Level Rise Curve was utilized for Army Corps of Engineers and NOAA data*

Hazard-Specific Vulnerability | Storm Surge

This portion of the report focuses on the vulnerabilities to critical facilities, parcels and roadways from storm surge. In-depth vulnerability statistics are provided to determine risk from a land use, financial and transportation perspective.

Hazard Overview

Storm surge occurs as a result of tropical systems such as hurricanes and tropical storms and primarily affects coastal areas and barrier islands. According to NOAA, storm surge is "the abnormal rise in seawater level during a storm" and "is caused primarily by a storm's winds pushing water onshore"[1]. This rise in water often occurs rapidly and presents immediate danger to life and property. Storm surge can occur on inland waterbodies such as the Indian River Lagoon, which increases the Titusville risk profile although not to the degree of barrier island communities.

Past Impacts and Hazard Frequency in Titusville

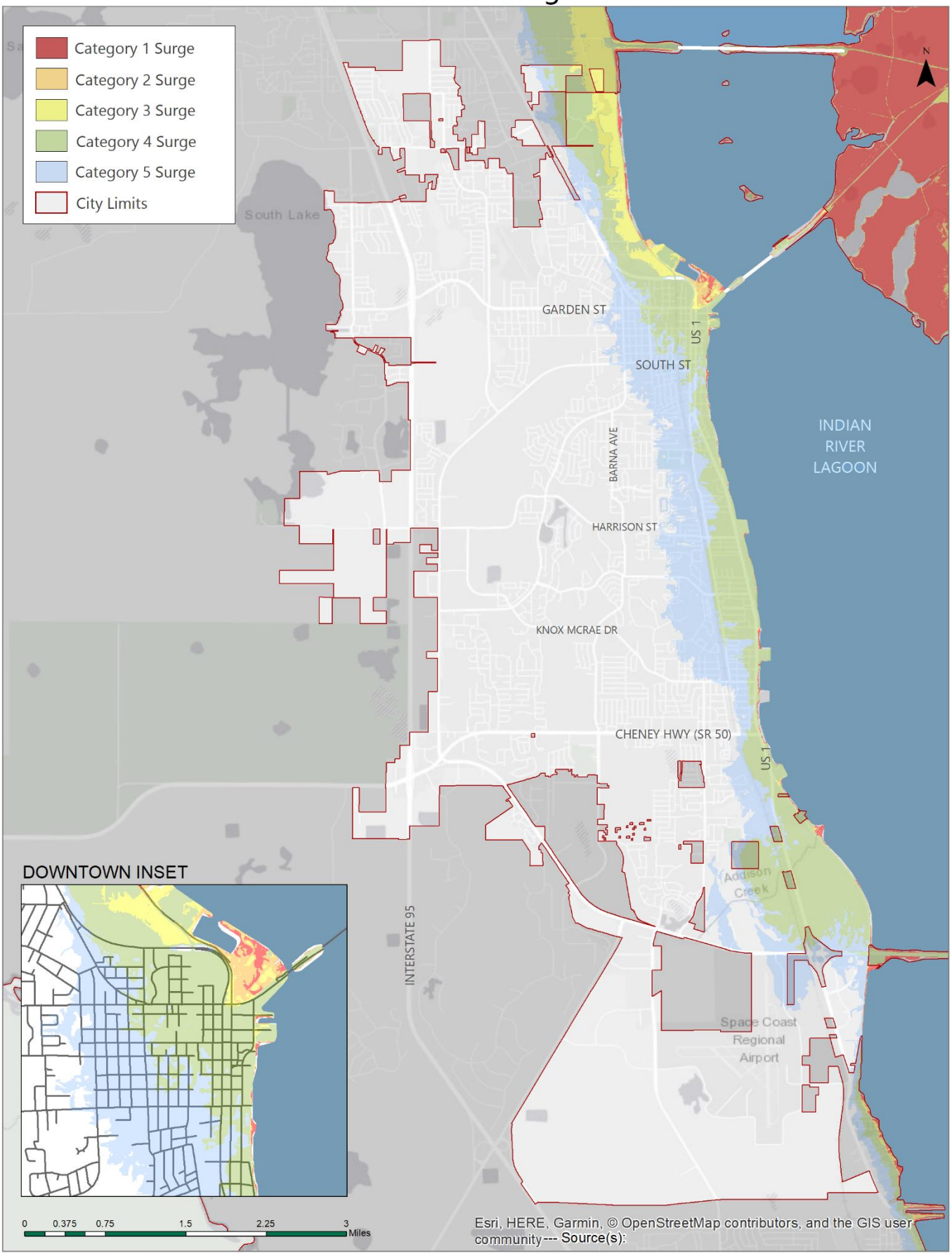
While the Central Florida coastline rarely experiences direct hurricane hits, passing and outgoing storms have historically impacted the lagoon coastline. Storm surge has occurred in Titusville intermittently over the past half-century, with six low to moderate storm surge events occurring since the year 2000. These include Hurricane Frances, 2004; Hurricane Jeanne, 2004; Hurricane Charley, 2004; Hurricane Fay, 2008; Hurricane Matthew, 2016; and Hurricane Irma, 2017. Storm surge effects from storms greater than a Category 1 hurricane were not experienced in Titusville as part of any of the aforementioned storm systems, and a direct hit on Central Florida is rare.

Types of Infrastructure at Risk

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.

Mitigating the effects of storm surge before an occurrence can be costly, but can save dollars over the long-term. It is important for local jurisdictions to locate electric substations and main sewer systems away from coastlines whenever possible, and to ensure that major roadways are mitigated during routine FDOT or County improvements to obtain the biggest return on investment. It is critical to note that while roadways themselves may not be affected, the ground underneath may be.

Hurricane Storm Surge Zones



The impacts of storm surge are primarily focused along the Indian River Lagoon coastline and, depending on the category of the storm, can breach up to approximately one mile inland. The City of Titusville is built out along the lagoon, which heightens its risk profile.

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

As seen in the table below, even a Category 1 surge would likely have severe impacts on properties located adjacent to the lagoon. Under this scenario, more than 25 acres of mixed-use land, 6 acres of residential land and approximately 1.5 acres of industrial land would be impacted. Additionally, 2.56 acres of recreational facilities are projected to be inundated under a Category 1 surge.

Category 2 and 3 storm surge models project minimal additional impacts to areas south of the downtown corridor relative to the impact of Category 1 storm surge. In these southern coastal areas, inundation is projected to remain adjacent to the lagoon without infringing inland.

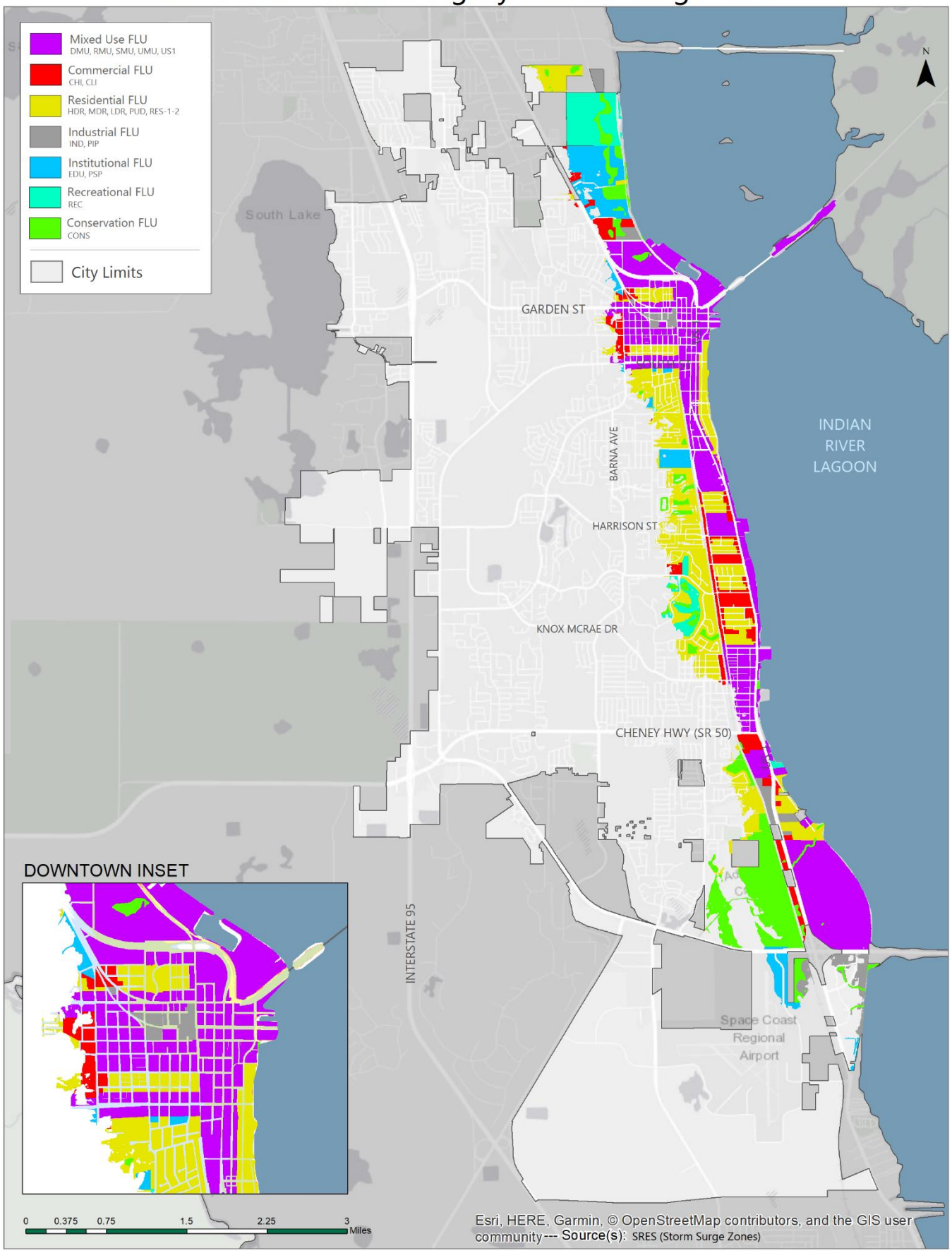
This is not the case in the downtown core and areas to the north, however, as the risk profile more than doubles from an acreage perspective under Category 2 and 3 storm surge models. The downtown core is located on low-lying land and features a range of active uses including mixed use, institutional, commercial and recreational. Inundation and damage from surge to this area would likely temporarily curb economic activity and government activities.

The map on the following page depicts (by color) the land uses projected to be inundated under the Category 5 storm surge zone, which extends more than one mile inland in some locations. With the exception of the conservation lands near the Space Coast Regional Airport, most of the vulnerable land is designated for active uses under the City's future land use map. Since Category 3, 4 and 5 storms are extremely rare in this portion of the state of Florida, it is recommended that the City focus on the Category 1 (coastal high hazard zone) and Category 2 storm surge zones when making land use determinations.

Table 4: Storm Surge Land Use Exposure

	Commercial Low/High Intensity	Mixed Use UMU, SMU, RMU, DMU	U.S. 1 Corridor	High Density Residential	Medium Density Residential	Low Density Residential	Very Low Density Residential RES1 & RES2	P.U.D.	Industrial & Planned Industrial Park	Public/ Semi-Public & Education	Recreation
Surge Zone	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
Category 1	0	25.73	0	0.51	2.40	3.50	0	0	1.49	0	2.56
Category 2	0	55.32	0	0.86	3.21	4.21	0	0	1.94	0	2.70
Category 3	5.88	95.88	0	1.19	3.82	6.58	0	0.81	26.61	23.49	48.54
Category 4	147.71	776.39	26.05	23.78	92.66	79.51	0	25.94	58.97	92.82	138.50
Category 5	220.23	991.47	87.93	117.10	278.97	162.31	0	197.46	134.09	232.71	184.99

Land Uses within Category 5 Storm Surge Zone



Storm surge can potentially have wide-ranging financial impacts on the City depending on the strength of the storm and wind direction. In general, the north and northeast portions of hurricanes generate the onshore winds necessary to push water inland[2].

Category 1, 2 and 3 hurricanes are projected to impact similar areas, primarily on the east of US Highway 1. Approximately a quarter-billion dollars' worth of property value, including between 125 and 882 residential units are located in the surge zone of these storms. Surge inundation for Category 1, 2 and 3 storm "bulbs out" from the coast in only a few areas. These areas include 1) where Addison Creek meets the lagoon south of State Road 50, where projected impacts are minimal, and 2) to the north of Garden Street and through to the northern City boundary. This second area, which includes the northern portion of downtown, Eastern Florida State College and the Parrish Medical Center, accounts for a large portion of the potential financial exposure to storm surge. The effects of Category 1, 2, or 3 storms are otherwise projected to only inundate properties adjacent to the lagoon.

A Category 4 storm coupled with onshore winds would be catastrophic, as the storm surge inundation zone is projected to cross west of US Highway 1 throughout the City. In addition, the financial exposure experienced would nearly double (relative to a Category 3 storm) from approximately one-quarter-billion to just under one-half-billion.

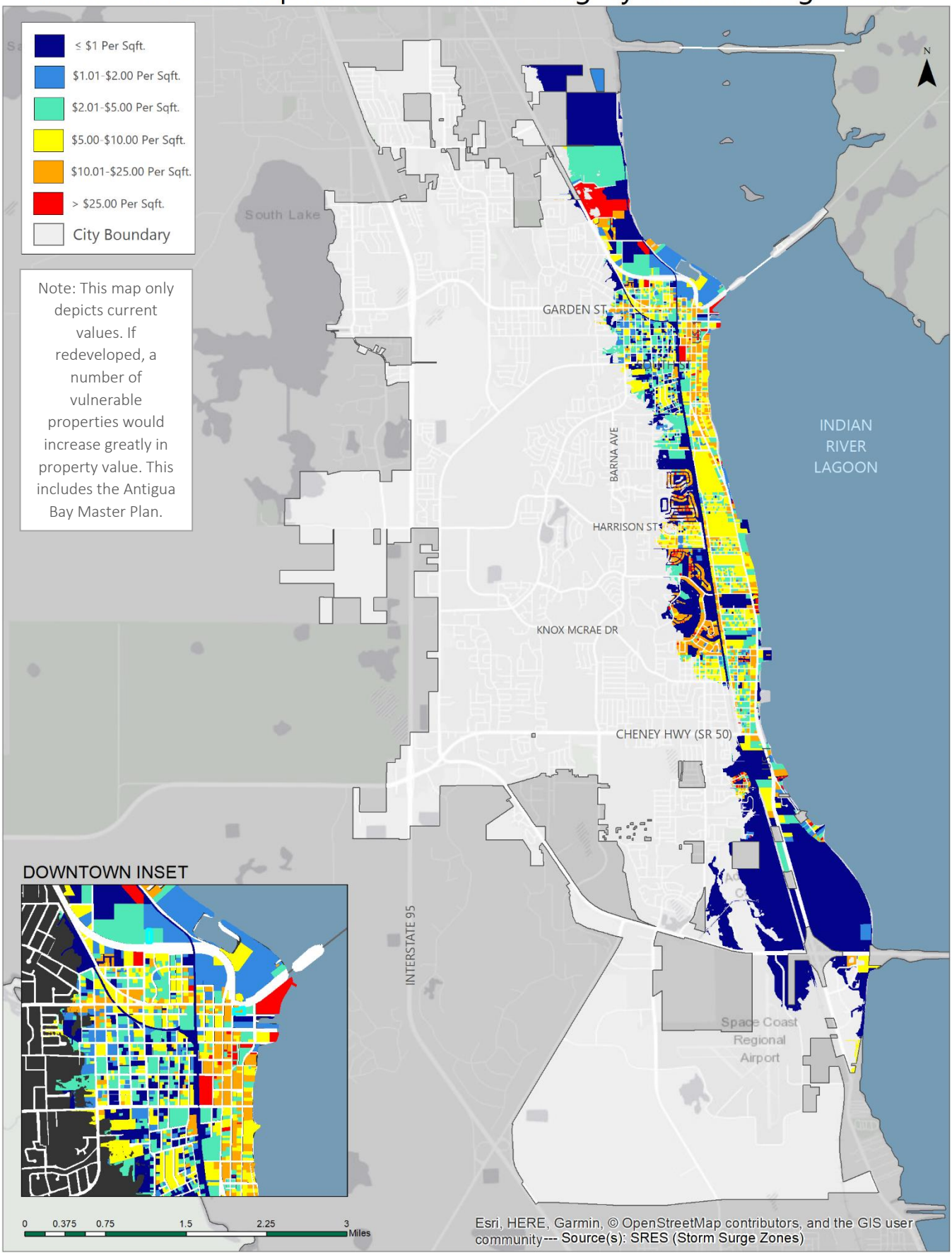
A large portion of the downtown area would be affected by a Category 4 Storm. The effects of a Category 5 storm with onshore winds could also be devastating to the City. In such a scenario, storm surge is projected to inundate the entire downtown area and large swaths of the City. The inundation zone infringes up to one-mile inland under current projections and is estimated to expose more than three-quarter-billion dollars in property value and just under 5,000 residential units.

The age of the building stock in surge zones may increase the City's primary vulnerability to storm surge due to old building standards and potential for a lower first floor elevation. It is recommended that the City educate property owners on strategies geared to improve the resilience of structures.

Table 5: Storm Surge Financial Exposure

						Built Pre-1968	Built 1968-2001	Built 2002 - 2018
Surge Zone	# Parcels in Zone	Number of Buildings	Land Value	Assessed Value	Taxable Value	# Buildings Total Value	# Buildings Total Value	# Buildings Total Value
Category 1	204	125	$39,329,550	$225,344,160	$112,809,453	62 $24,386,910	44 $42,751,710	19 $143,334,410
Category 2	217	136	$40,208,290	$228,404,460	$115,288,393	65 $25,031,500	48 $44,057,700	23 $144,443,120
Category 3	246	156	$41,624,570	$261,109,780	$135,293,233	70 $26,447,210	58 $60,716,070	28 $150,530,140
Category 4	1,648	1,142	$81,316,990	$487,382,940	$294,565,508	664 $108,518,300	87 $165,844,790	391 $175,622,480
Category 5	4,117	3,094	$134,493,870	$768,835,190	$476,474,613	1,413 $166,275,260	729 $284,384,510	952 $272,825,130

Parcel Value Per Square Foot Within Category 5 Storm Surge Zone



As shown in the image on this page, storm surge can severely impact roadways through the force of wave action, completely degrading the lands surrounding and underneath the paved surface. Failure of roadways can lead to a delay in critical services, delayed recovery time, and can cut off entire neighborhoods where alternative access points do not exist.

Effects to the City's transportation network are fairly minimal under the Category 1, 2 and 3 storm surge models, with 2.00 miles of inundation projected along the City's major roadways. This figure jumps to 28.30 miles (not including minor local roadways) when the Category 4 storm surge models are utilized.

Under the Category 3 storm surge models, the effects are primarily constrained to the downtown corridor. In this area, Marina Road (0.55 miles), US1/South Washington Avenue (0.24 miles), Broad Street (0.02 miles) and Garden Street/SR 406 (0.03 miles) are the primary connectors that would be the most at risk. This is in addition to the Max Brewer Memorial Parkway, which is vulnerable but raised considerably above the roadway shoulders.

As discussed previously, the Category 4 storm surge models are a 'tipping point' from a vulnerability perspective, as projected inundation crosses the US1 corridor from the downtown area south to the State Road 50 (Cheney Highway) corridor. Such a storm would likely disrupt immediate access to services such as fire, police and EMS and would pose a significant threat to human life.

An analysis of post-Category 4 storm connectivity showed that the downtown area as well as the area to the east of Hopkins Avenue, south of Beverly Street and north of Olmstead Drive could be completely cut off from the rest of the City until the surge subsides. A slow-moving hurricane would likely be the worst-case scenario for these areas, especially if coupled with an onshore wind.

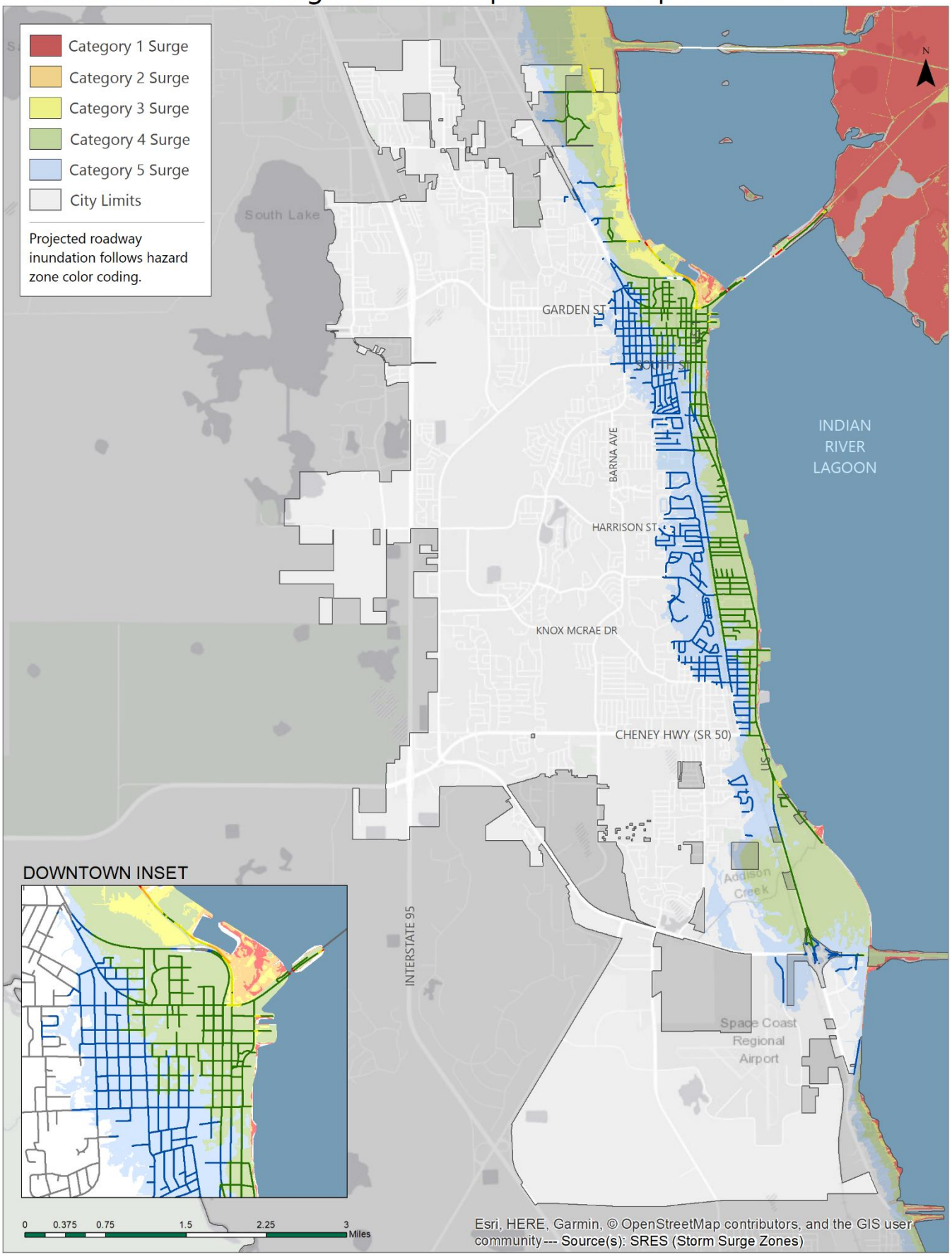
Minor local roadways with projected inundation under the Category 1, 2 and 3 storm surge models (and not listed on the table on the following page) each have less than potentially one quarter mile of impacted surface and include Hammock Road, Buffalo Road, Oak Grove Road, Riveredge Drive and Jay Jay Road.

The table and map on the following two pages depict the risk posed to major roadways within the City by hurricane category.

Table 6: Storm Surge Transportation Exposure

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
Blanton Street	0 miles	0 miles	0 miles	0.12 miles	0.24 miles
Broad Street	0 miles	0 miles	0.02 miles	0.34 miles	0.34 miles
Brown Avenue	0 miles	0 miles	0 miles	0.09 miles	0.51 miles
Canaveral Avenue	0 miles	0 miles	0 miles	0.28 miles	0.38 miles
Cheney Highway (SR50)	0 miles	0 miles	0 miles	0.13 miles	0.18 miles
Columbia Boulevard *	0 miles	0 miles	0 miles	0.03 miles	0.38 miles
Country Club Drive	0 miles	0 miles	0 miles	0.33 miles	0.87 miles
Crofton Avenue	0 miles	0 miles	0 miles	0.07 miles	0.07 miles
De Leon Avenue	0 miles	0 miles	0 miles	0.26 miles	0.26 miles
Deleon Avenue	0 miles	0 miles	0 miles	0.15 miles	1.06 miles
Dixie Avenue	0 miles	0 miles	0 miles	0 miles	0.18 miles
Dummitt Avenue	0 miles	0 miles	0 miles	0.16 miles	0.32 miles
Einig Avenue	0 miles	0 miles	0 miles	0.11 miles	0.11 miles
Fisher Avenue	0 miles	0 miles	0 miles	0.11 miles	0.11 miles
Garden Street *	0 miles	0 miles	0.03 miles	0.52 miles	0.8 miles
Grannis Avenue	0 miles	0 miles	0 miles	0 miles	0.51 miles
Harrison Street	0 miles	0 miles	0 miles	0.24 miles	0.75 miles
Indian River Avenue	0 miles	0 miles	0 miles	1.18 miles	1.18 miles
Julia Court	0 miles	0 miles	0 miles	0.21 miles	0.21 miles
Knox McRae Drive	0 miles	0 miles	0 miles	0.09 miles	0.4 miles
Lemon Avenue	0 miles	0 miles	0 miles	0.19 miles	0.19 miles
Loudon Avenue	0 miles	0 miles	0 miles	0.06 miles	0.07 miles
Maiden Lane	0 miles	0 miles	0 miles	0.05 miles	0.05 miles
Main Street	0 miles	0 miles	0 miles	0.52 miles	0.79 miles
Marina Road	0.04 miles	0.26 miles	0.55 miles	0.63 miles	0.63 miles
Mariners Way	0 miles	0 miles	0 miles	0.07 miles	0.07 miles
Max Brewer Memorial Parkway	0.02 miles	0.03 miles	0.14 miles	1.30 miles	1.30 miles
Mount Vernon Avenue	0 miles	0 miles	0 miles	0.55 miles	0.79 miles
Nevins Court	0 miles	0 miles	0 miles	0.14 miles	0.14 miles
Norwood Avenue	0 miles	0 miles	0 miles	0.08 miles	0.56 miles
Orange Street	0 miles	0 miles	0.02 miles	0.6 miles	0.68 miles
Palm Avenue	0 miles	0 miles	0 miles	0.51 miles	0.51 miles
Palmetto Street	0 miles	0 miles	0 miles	0.28 miles	0.63 miles
Pine Street	0 miles	0 miles	0 miles	0.32 miles	0.70 miles
Raney Road	0 miles	0 miles	0 miles	0 miles	0.45 miles
Riverview Place	0 miles	0 miles	0 miles	0.09 miles	0.09 miles
Robbins Avenue	0 miles	0 miles	0 miles	0 miles	0.46 miles
Roderick A Harris Sr Avenue	0 miles	0 miles	0 miles	0.16 miles	0.28 miles
Savannah Blvd	0 miles	0 miles	0 miles	0 miles	0.19 miles
South Hopkins Avenue	0 miles	0 miles	0 miles	2.07 miles	4.17 miles
South Park Avenue	0 miles	0 miles	0 miles	0 miles	0.60 miles
South Street	0 miles	0 miles	0 miles	0.13 miles	0.79 miles
South Washington Avenue (US1) *	0 miles	0 miles	0.24 miles	6.13 miles	7.38 miles
Stephen House Way	0 miles	0 miles	0 miles	0.03 miles	0.03 miles
Tropic Street	0 miles	0 miles	0 miles	0.18 miles	0.56 miles
Truman Scarborough Way	0 miles	0 miles	0 miles	0.16 miles	0.27 miles
Wager Avenue	0 miles	0 miles	0 miles	0.19 miles	0.25 miles
Wilson Avenue	0 miles	0 miles	0 miles	0.09 miles	0.09 miles

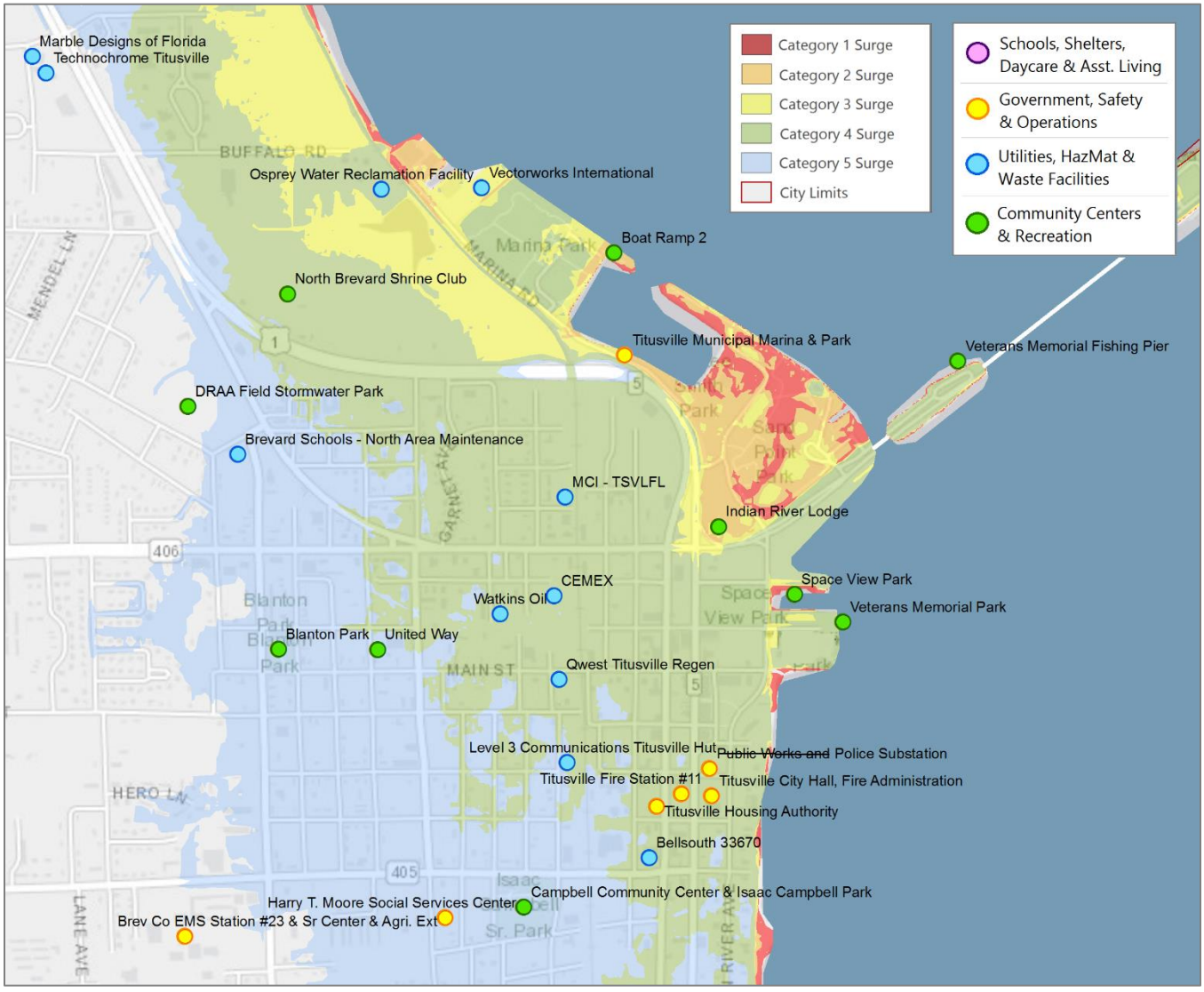
Hurricane Storm Surge Zones - Impact to Transportation Network



Community features such as parks, piers, clubhouses, boat ramps and neighborhoods are essential to any city, including Titusville. Storm surge will almost certainly affect multiple features in the community on Titusville's coastline at some point in the future. The City's downtown and coastline area are the primary tourist attractions and also serve as the location for many critical facilities. Most of downtown will be affected by a Category 4 surge, thus the community features in this zone will be impacted greatly in such a scenario. Storms lesser in intensity than a Category 4 would affect far less facilities as the map on this page depicts.

Facilities including Veteran's Memorial Fishing Pier, Indian River Lodge, Veteran's Memorial Park, Space View Park, and Boat Ramp 2 will be affected by at least a Category 2 storm surge. These facilities are also located within the sea level rise and nuisance flooding hazard zones, increasing their overall risk. It is recommended that the City consider plans to transitioning areas of at-risk parks into eco-tourism amenities or green stormwater amenities as some areas of parks become unusable.

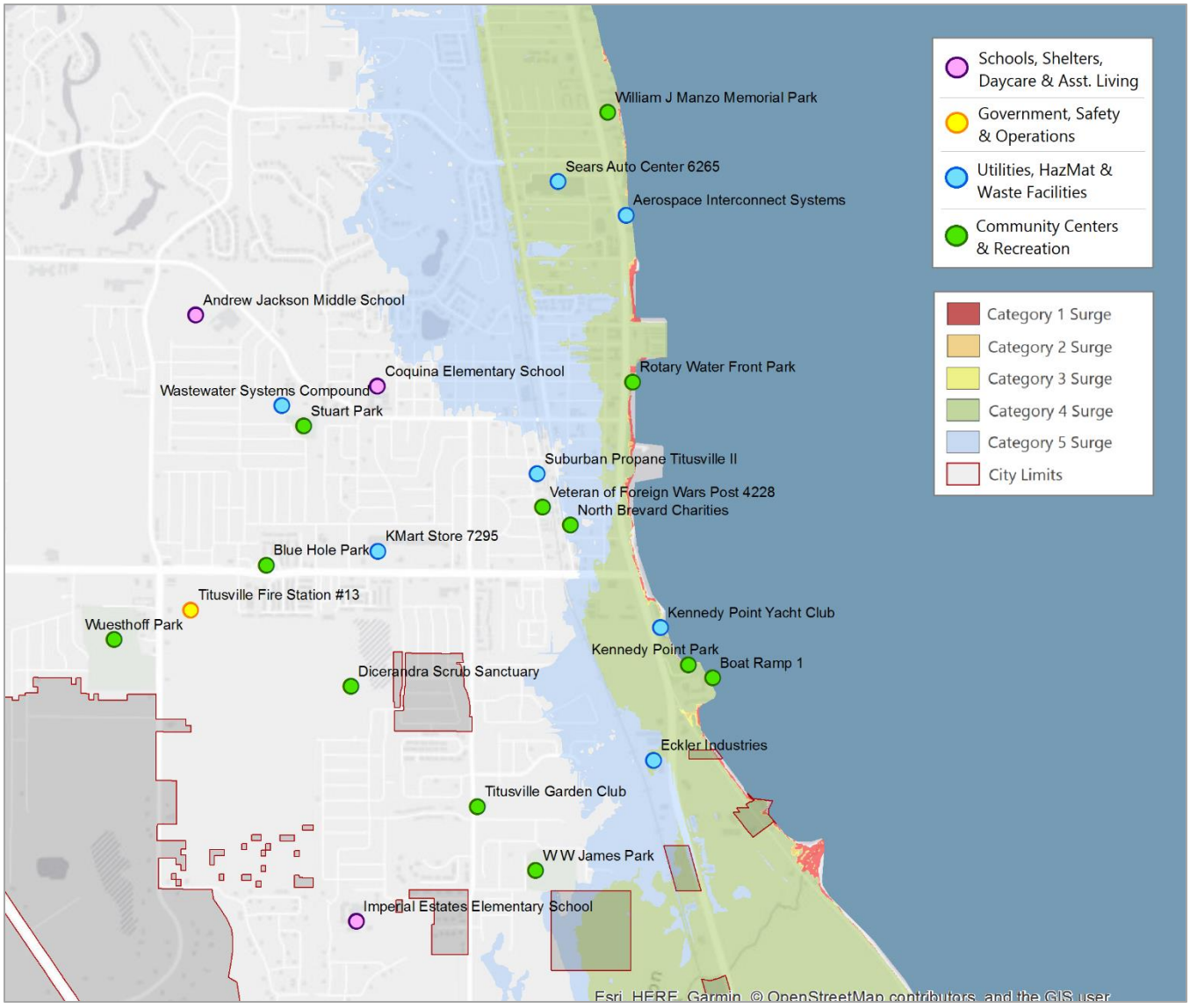
Map 8: Storm Surge Zoom-In Map 1 of 2



The southern portion of the City has fewer community features that will be affected by storm surge as seen on the map below. However, William J Manzo Memorial Park and Kennedy Point Park are in the Category 1 storm surge zone and there are still several other facilities that will be impacted.

Slower and larger but weaker hurricanes (e.g., Category 3 storms such as Katrina) cause much higher storm surge and flooding (even to inland areas) when compared to faster and small but more intense hurricanes (e.g., Hurricane Charley in 2004)[3]. Given that many of Titusville's community centers and recreational areas are in these storm surge zones, they will be inundated and battering waves and wind can potentially damage buildings on these sites. It is recommended that the City harden or relocate critical facilities that are susceptible to the Category 1 storm surge zone (also known as the coastal high hazard zone). The City should also consider providing educational materials to owners of privately-owned facilities located along the lagoon (such as Aerospace Interconnect Systems) concerning mitigation.

Map 9: Storm Surge Zoom-In Map 2 of 2




Erosion
1: Severe Erosion (scarp > 30 cm)
2: Moderate Erosion (scarp 8-30 cm)
3: Little to No Erosion (scarp < 8 cm)
Brevard County Natural Resources Erosion Map
This map depicts the level of coastal erosion that has impacted Titusville's lagoon coastline. Erosion is a common symptom of storm surge and is included within the storm surge vulnerability analysis.
Map by Brevard County Natural Resources
Golf Club
Chain of Lakes Park
Dairy Rd
Old Dixie Hwy
N Washington Ave
N Singleton Ave
Arthur Dunn Airpark
Garden St
406
Main St
Tropic St
Titusville
Hillcrest Ave
South St
Deleon Ave S
Harrison St
S Park Ave
S Hopkins Ave
S Washington Ave
Country Club Dr
La Cita Golf & Country Club
Knox McRae Dr
Barna Ave
Cheney Hwy
50
1
Columbia Blvd

Hazard-Specific Vulnerability | Sea Level Rise

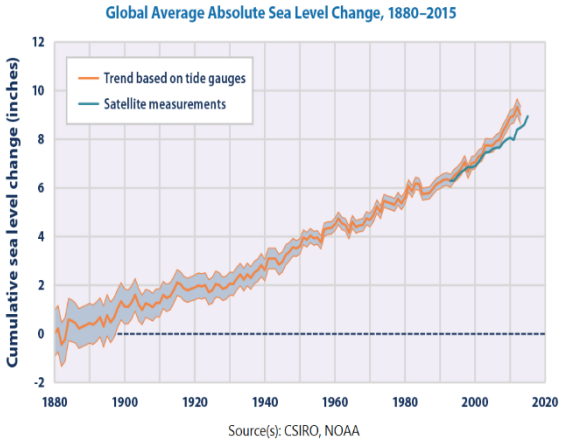
This portion of the report focuses on the impacts to critical facilities, parcels and roadways from sea level rise. In-depth vulnerability statistics are provided to determine risk from a land use, financial and transportation perspective. *Appendix II provides technical NOAA and US Army Corps of Engineers technical reports that analyze the probabilities associated with the sea level rise curves analyzed in this report. Additional maps and tables are also available in Appendix III and IV that show alternative impacts. It is recommended that the City continue to monitor projections and associated probabilities continuously.*

Hazard Overview

Sea level rise is a long-term natural hazard that is occurring as a result of rising global temperatures and local subsidence[4,5]. As global temperatures rise water temperatures also rise, resulting in thermal expansion of water molecules and a greater volume of water on Earth[6]. Sea level rise is already affecting communities in southeast Florida on a high-frequency basis and is often magnified by high tide and king tide events[4]. As the maps in this report show, sea level rise can have impacts on inland water systems such as the Indian River Lagoon and the St. Johns River, so risk is not exclusive to ocean-front and barrier island communities. Areas low in elevation and in close proximity to water bodies that are hydrologically-connected to the Atlantic Ocean are particularly vulnerable to sea level rise. In this report, the project team utilized sea level rise projections from the U.S. Army Corps of Engineers and NOAA.

Impacts and Frequency in Titusville

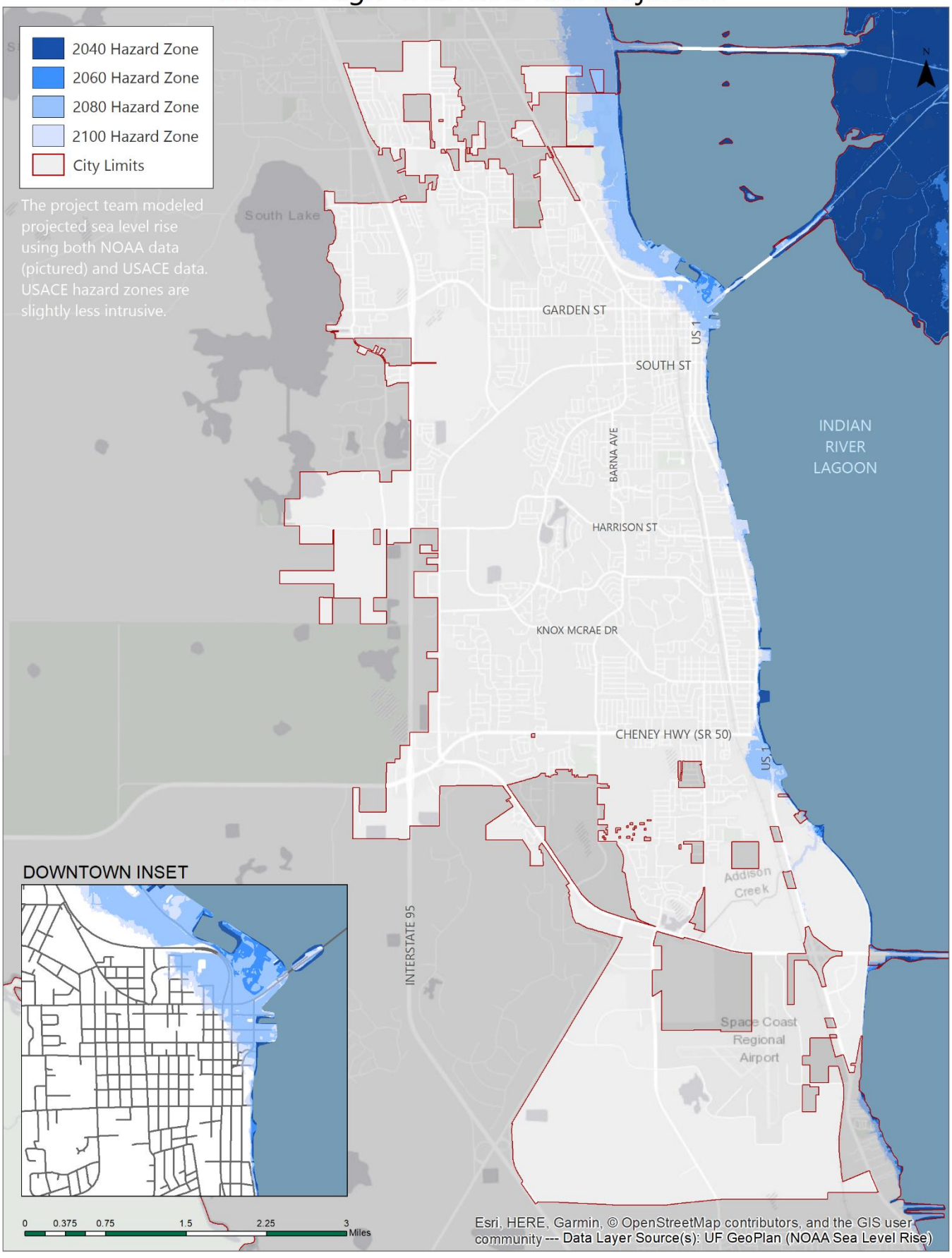
Sea level rise is a long-term stressor that is currently impacting Titusville and is projected to increase indefinitely into the future. As a result of rising seas, normal rain events can cause coastal nuisance flooding (especially when paired with a king tide event) and the frequency of flooding events can increase[7]. It is projected that sea level rise may lead to daily flooding during normal rain events in some areas[7]. Moreover, the effects of storm surge can be exacerbated when paired with sea level rise over the long term.



Types of Infrastructure at Risk

While the total impacts of sea level rise remain unclear, stormwater outfalls, drinking water wells and roadways are among the most at-risk infrastructure systems over the long-term[4]. Stormwater outfalls and drinking water wells are at risk of saltwater intrusion, which over the long-term can degrade the interior lining of these facilities[4]. Due to sea level rise and the elevation of outfalls, the City could potentially see sunny day flooding in streets due to stormwater pipe back up long before the sea levels begin to "breach" the coastline. Additionally, sea level rise can have drastic impacts on roadways and the ground supporting them, which may contribute to roadway degradation before sea levels meet the surface of the roadway. It is recommended that the City continue to monitor endangered outfalls; keep drinking water wells away from the Indian River Lagoon; and monitor roadway systems in the decades prior to the "horizon years" for roadways as determined as part of this section of the report.

NOAA "High" Sea Level Rise Projection



Sea level rise is projected to have varying impacts depending on the curve, data source, and time horizon analyzed. For the purposes of this text analysis, the NOAA "High Curve" will be highlighted to show maximum modeled inundation.

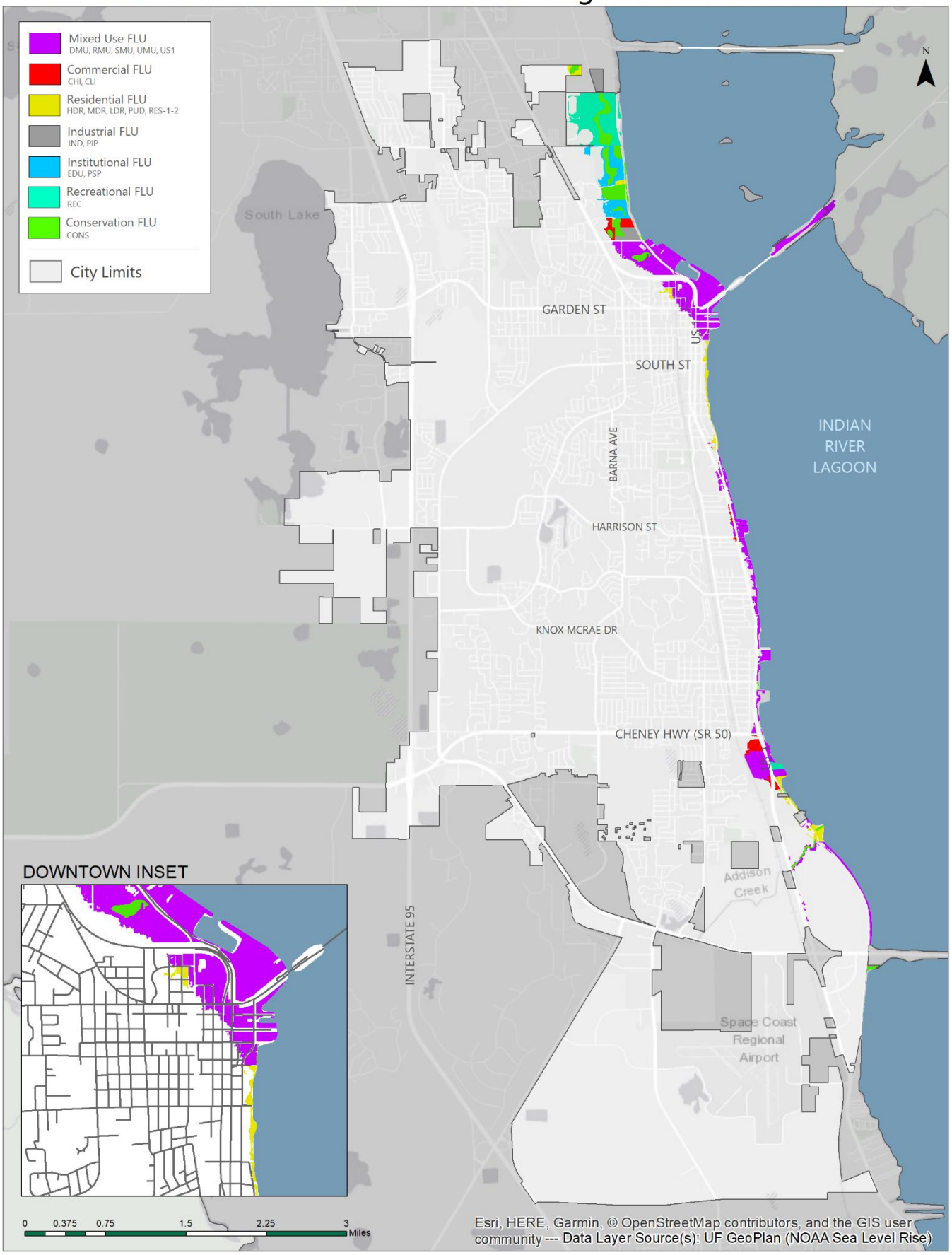
The projected inundation areas, as a result of sea level rise by the year 2100, are generally located along the Indian River Lagoon. In addition to lagoon-adjacent properties, there are four primary areas of projected *inland inundation* including 1) the downtown; 2) the area to the north of downtown (in the vicinity of the Parrish Medical Center); 3) the area to the south of State Road 50; and 4) along Addison Creek. Inundation areas are otherwise adjacent to the lagoon. The table below summarizes projected inundation by land use.

In the downtown area, exposure is projected to infringe on properties with mixed-use future land use varieties (US1, UMU, RMU, SMU and DMU). Since the Titusville Visioning Plan focuses on this area's long-term redevelopment into a mixed-use corridor, it is recommended that the City align the visioning report's findings with strategies geared to protect (and mitigate) high intensity buildings while 'retreating' in areas with the highest projected inundation. Aligning ecological and recreational opportunities – primarily along the lagoon – with 'retreating' strategies could reduce financial risk while enhancing economic development. This, coupled with the utilization of the highest densities outside of the hazard zone, will assist in saving dollars spent on property restoration over the long term. Additionally, infrastructure along the lagoon such as berms (pictured on this page) could protect property while enhancing the visual aesthetic of the area. To the north of downtown, risk of sea level rise inundation is focused primarily on recreational and institutional uses.

Table 7: Sea Level Rise Land Use Exposure (High Curves)

	Commercial Low/High Intensity	Mixed Use UMU, SMU, RMU, DMU	U.S. 1 Corridor	High Density Residential	Medium Density Residential	Low Density Residential	Very Low Density Residential RES1 & RES2	P.U.D.	Industrial & Planned Industrial Park	Public/ Semi-Public & Education	Recreation
Horizon Year	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
2040 *ACOE Curve*	0	**0.41**	0	0	0	0	0	0	0	0	0
2060 *ACOE Curve*	0	**6.08**	0	0	**0.25**	**1.74**	0	0	**0.18**	**1.19**	**1.76**
2080 *ACOE Curve*	**4.87**	**63.64**	0	**0.60**	**1.87**	**5.88**	0	**0.19**	**22.00**	**15.74**	**36.66**
2100 *ACOE Curve*	**11.33**	**162.09**	**0.08**	**2.72**	**3.21**	**7.38**	0	**1.38**	**26.93**	**28.92**	**55.73**
2040 *NOAA Curve*	0	**25.72**	0	**0.25**	**3.26**	**1.50**	0	0	**0.27**	0	**2.94**
2060 *NOAA Curve*	0	**52.25**	0	**0.44**	**4.87**	**3.74**	0	0	**0.86**	0	**3.59**
2080 *NOAA Curve*	**13.76**	**208.81**	**0.52**	**3.75**	**7.51**	**7.41**	0	**2.82**	**27.96**	**38.34**	**66.02**
2100 *NOAA Curve*	**25.66**	**286.31**	**1.43**	**5.08**	**13.51**	**10.31**	0	**5.06**	**28.64**	**51.40**	**98.55**

Generalized Land Uses within NOAA "High" Year 2100 SLR Zone



Financial exposure to sea level rise is primarily focused on lagoon-adjacent properties in the 2060- and 2080-time frames. The areas projected to be inundated by these time horizons closely match the areas projected to be inundated by the Category 1, 2 and 3 storm surge zones, encompassing properties worth nearly a quarter-billion dollars. Since these lagoon-adjacent properties are projected to be exposed to numerous hazards (and the loss of these properties could reduce the City's annual tax base by approximately $2,500,000), the City should consider completing a cost-benefit and feasibility analysis to mitigate these properties.

The "Parcel Value Per Square Foot within the NOAA High Year 2100 Zone" map on the next page color codes the value, per square foot, of the properties located within the year 2100 NOAA "high" hazard zone. These figures vary widely by area. In the area to the north of downtown, property values are primarily low with the exception of the Parrish Medical Center property, which exceeds $25.00 per square foot of parcel area. In the downtown, property values are highest inland. Financial exposure adjacent to the lagoon is primarily focused on properties between the Max Brewer Memorial Parkway and Addison Creek. South of Addison Creek, lagoon-adjacent impacts are projected to be minimal. It is recommended that the City refrain from developing in darkest blue areas of the property value exposure map on the following page of this report in order to reduce marginal increases in financial exposure to sea level rise.

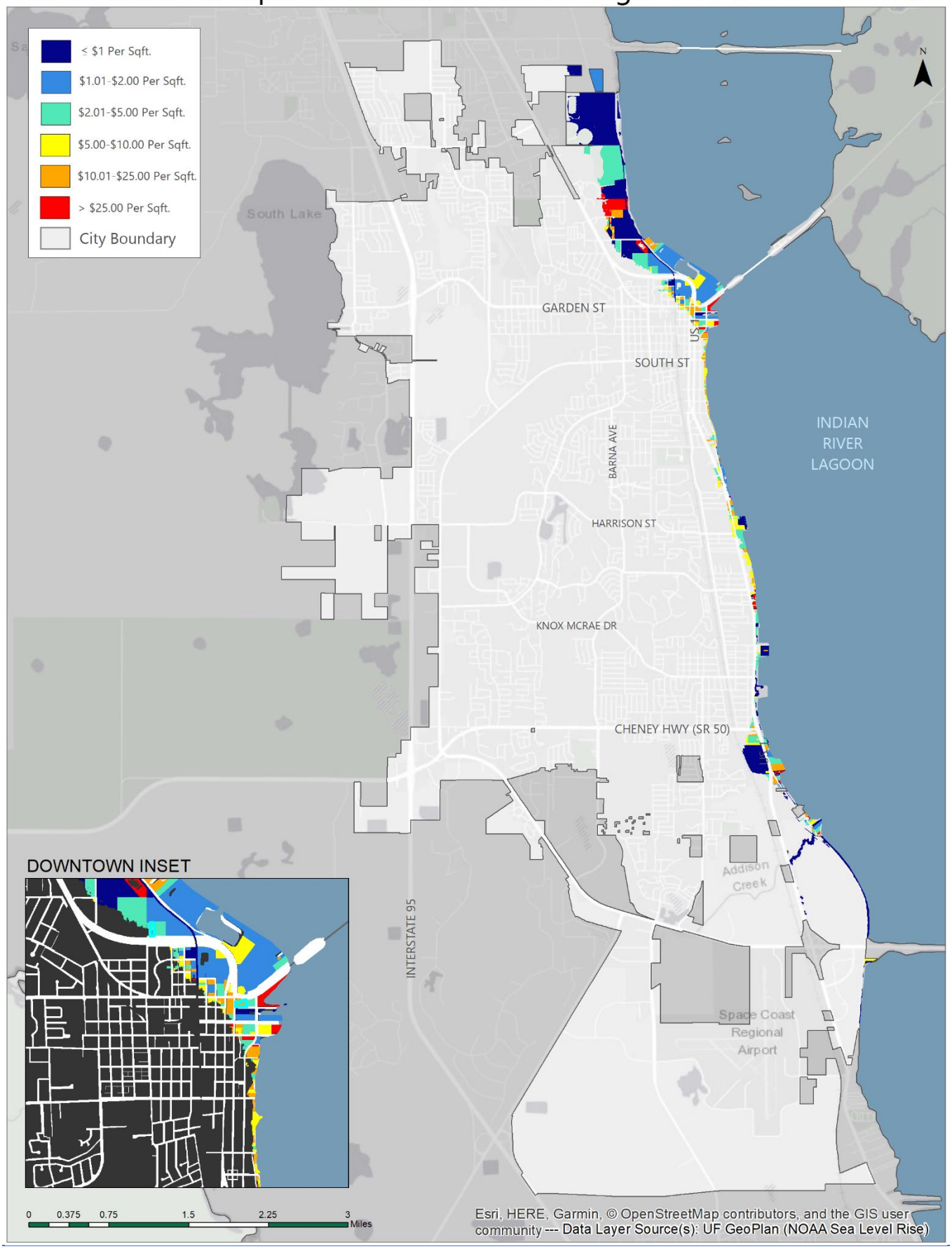
The Municipal Marina, located in the downtown corridor to the north of the Max Brewer Memorial Parkway, is projected to be inundated as soon as the year 2040 horizon. This area could be mitigated by raising the marina docks and transitioning the park space into 'ecological retreat' parks with pathways.

Table 8: Sea Level Rise Financial Exposure (High Curves)

				Built Pre-1968	Built 1968-2001	Built 2002 - 2018
Horizon Year	# Parcels in Zone	Total Number of Buildings	Value of Parcels in Zone	Buildings Total Value	Buildings Total Value	Buildings Total Value
2040 *ACOE Curve*	0	0	0	0	0	0
2060 *ACOE Curve*	37	14	$156,936,000	4 $5,752,110	5 $16,924,560	5 $125,397,450
2080 *ACOE Curve*	139	83	$202,505,380	34 $13,095,500	29 $33,957,780	20 $135,364,980
2100 *ACOE Curve*	284	192	$274,578,720	73 $25,836,510	89 $67,564,700	30 $153,439,600
2040 *NOAA Curve*	198	122	$236,620,700	61 $24,091,180	42 $54,498,600	19 $143,236,274
2060 *NOAA Curve*	223	138	$246,135,940	66 $25,553,740	46 $60,770,270	26 $145,136,714
2080 *NOAA Curve*	348	236	$288,177,640	102 $33,013,690	100 $75,355,610	34 $151,859,734
2100 *NOAA Curve*	477	325	$336,870,810	145 $38,620,570	140 $102,239,160	40 $161,420,464

**The "High" Sea Level Rise Curve was utilized for Army Corps of Engineers and NOAA data*

Parcel Value Per Square Foot within NOAA "High" Year 2100 SLR Zone



Sea level rise is projected to have varying impacts depending on the curve, data source, and time horizon analyzed. The NOAA "High Curve" is utilized in this report to gauge the worst-case modeled scenario. It is also important to note that roadways are likely susceptible to the effects of sea level rise prior to the "horizon year" due to the degradation of surrounding lands underneath the roadway. This "sub-base" area can fail at varying times prior to the horizon year. It is thus recommended that sub-base areas be analyzed on a one-by-one basis for the roadways listed below.

Overall, with the exception of the Max Brewer Memorial Parkway (which may experience sea level rise inundation in the 2040- and 2060-time horizons) and Marina Road, no major roadways within the City are projected to be inundated until the 2080- and 2100-time horizons. This provides ample time for sub-base areas to be examined and strategies to be reviewed on a cost-benefit basis while the City works with FDOT and the Space Coast TPO on reviewing the Max Brewer Memorial Parkway.

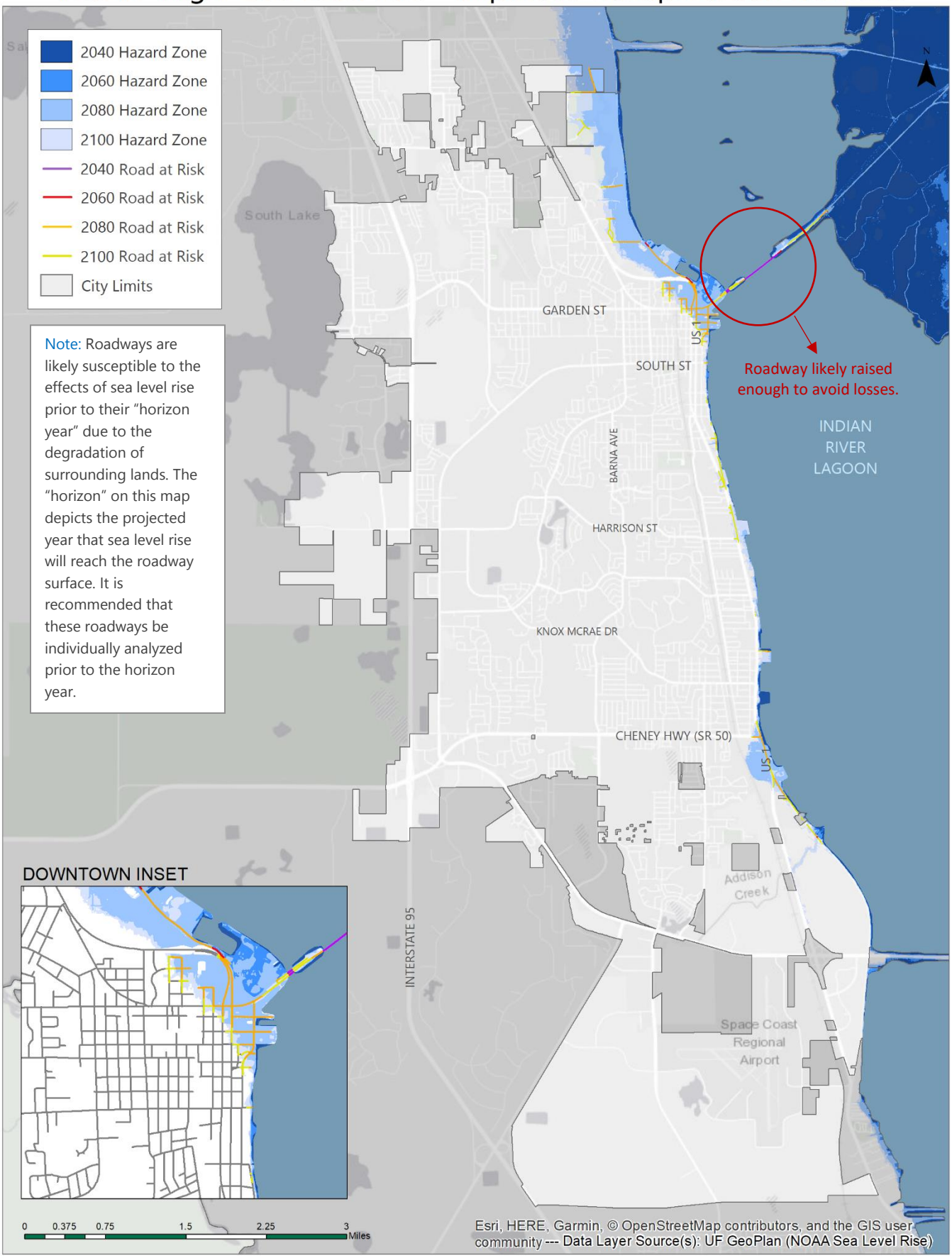
The downtown area is where the vast majority of projected inundation is projected to occur. Major roadways such as Garden Street, South Hopkins Avenue and South Washington Avenue are among the most-at-risk, although not until the 2080- and 2100-time horizons. It is recommended that the FDOT, in coordination with the City, review the feasibility of mitigating these roadways, which could include raising vulnerable sections of the aforementioned roadways prior to the horizon year of 2080. Outside of the downtown area, inundation is projected along numerous portions of the US Highway 1 Corridor (listed as South Washington Avenue in the table below). Inundation to this primary north-south connector is projected to occur to the north of its intersection with Harrison Street and to the north and south of its intersection with Cheney Highway (State Road 50). An analysis of this roadway is critical.

Table 9: Sea Level Rise Transportation Exposure

Road Name Classification	ACOE 2040 Projected Inundation	ACOE 2060 Projected Inundation	ACOE 2080 Projected Inundation	ACOE 2100 Projected Inundation	NOAA 2040 Projected Inundation	NOAA 2060 Projected Inundation	NOAA 2080 Projected Inundation	NOAA 2100 Projected Inundation
Broad Street	0 miles	0 miles	0 miles	0.13 miles	0 miles	0 miles	0.19 miles	0.22 miles
Cheney Highway (SR50)	0 miles	0 miles	0 miles	0 miles	0 miles	0 miles	0.07 miles	0.08 miles
Garden Street *	0 miles	0 miles	0 miles	0.06 miles	0 miles	0 miles	0.09 miles	0.14 miles
Harrison Street	0 miles	0 miles	0 miles	0 miles	0 miles	0 miles	0 miles	0.03 miles
Indian River Avenue	0 miles	0 miles	0 miles	0.13 miles	0 miles	0 miles	0.28 miles	0.38 miles
Julia Street	0 miles	0 miles	0 miles	0 miles	0 miles	0 miles	0 miles	0.01 miles
Main Street	0 miles	0 miles	0 miles	0.03 miles	0 miles	0 miles	0.07 miles	0.1 miles
Marina Road	0 miles	0 miles	0.29 miles	0.63 miles	0 miles	0.12 miles	0.63 miles	0.63 miles
Mariners Way	0 miles	0 miles	0 miles	0 miles	0 miles	0 miles	0 miles	0.01 miles
Max Brewer Memorial Parkway	0 miles	0 miles	0 miles	0.29 miles	0.42 miles	0.48 miles	0.48 miles	1.19 miles
Nevins Court	0 miles	0 miles	0 miles	0.02 miles	0 miles	0 miles	0.03 miles	0.12 miles
Orange Street	0 miles	0 miles	0 miles	0.17 miles	0 miles	0 miles	0.2 miles	0.2 miles
Riverview Place	0 miles	0 miles	0 miles	0 miles	0 miles	0 miles	< 0.01 miles	0.05 miles
South Hopkins Avenue	0 miles	0 miles	0 miles	0.09 miles	0 miles	0 miles	0.3 miles	0.35 miles
South Washington Avenue (US1) *	0 miles	0 miles	0 miles	0.35 miles	0 miles	0 miles	0.67 miles	1.61 miles

* Notes Evacuation Routes

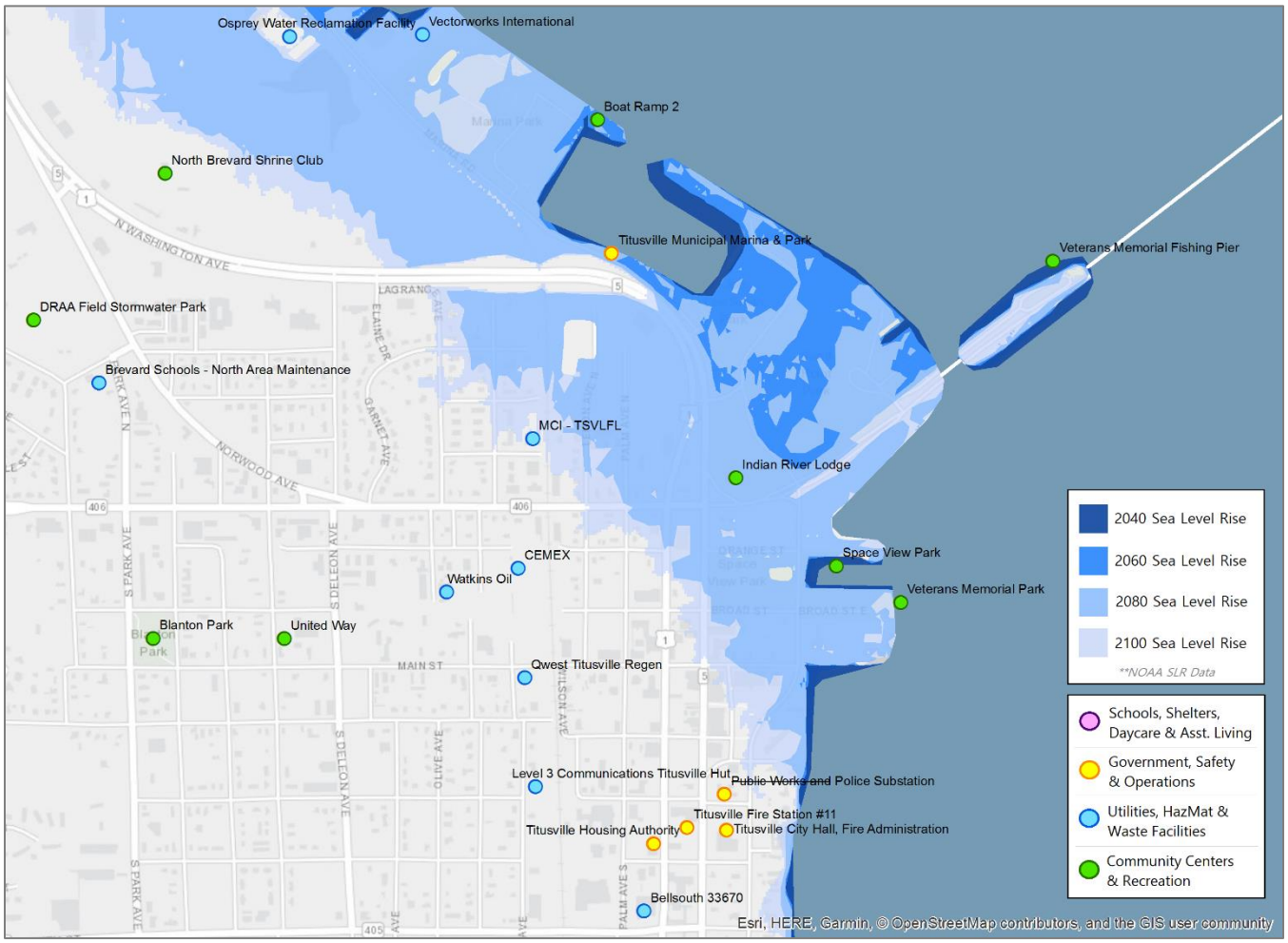
NOAA "High" Sea Level Rise - Impact to Transportation Network



Sea level rise is projected to have varying impacts depending on the curve, data source, and time horizon analyzed. Thus, for the purposes of this analysis, the NOAA "High Curve" for will be utilized. Sea level rise will affect community features in Titusville, necessitating the mitigation of these features or relocation to alternate areas of the City.

As seen in the image below, the downtown Titusville area is the portion of the City most affected by increasing sea levels. Facilities as Boat Ramp 2, Veteran's Memorial Fishing Pier, Space View Park, and Veteran's Memorial Park are projected to be affected by the NOAA high rate of sea level rise by 2040. All of the non-recreational facilities impacted at by sea level rise in this area would benefit from planning for relocation of the facilities or other methods of mitigation, with an importance placed on those impacted at the year 2040. Affected recreational facilities could potentially be retrofitted into stormwater parks. It will need to be determined if some of these facilities can withstand inundation during higher than average tides. Additionally, as with all facilities, site level analysis and elevation data should be assessed to determine the extent of inundation at the sites. The sea level rise hazard zone primarily focuses along the northern portion of the downtown and away from critical administrative buildings such as City Hall, the Titusville Housing Authority, Fire Administration, the Police Substation and two communications centers.

Map 15: Sea Level Rise Zoom-In Map 1 of 2

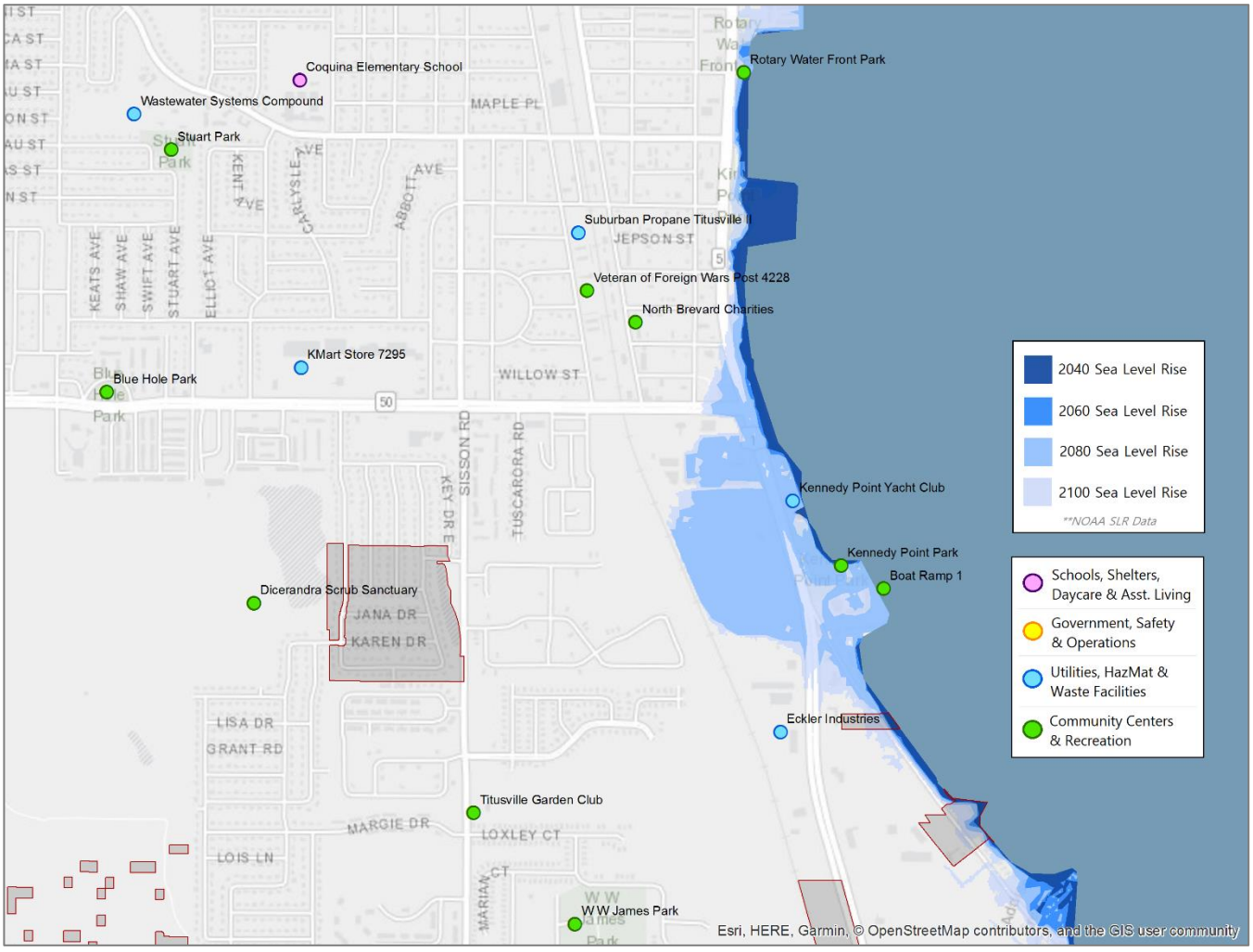


In the southern portion of the City, there are four community facilities that are projected to be impacted by sea level rise before the year 2100. These facilities are Kennedy Point Park, Kennedy Point Yacht Club, Boat Ramp 1, and Rotary Water Front Park. While these facilities do not serve an administrative or first-response-purposes, they are vital to the local economy.

Although there are not a large number of facilities impacted by projected sea level rise in this location, the ones that are impacted will most likely require mitigation if the owners decide to keep them over the long-term. Without some type of remediation, such as raising boat ramp structures, creating floating structures or adapting greenspaces into stormwater parks, there could potentially be less community interaction and tourism in the area. A cost-benefit analysis for mitigating these facilities is recommended.

It is important to note that the portion of projected inundation that cuts inland to the south of State Road 50 encompasses the western portion of Kennedy Point Park. This land could potentially function as a stormwater park in the future, as retrofitting the park to serve this purpose would not require the removal of active park spaces such as ball fields or basketball courts.

Map 16: Sea Level Rise Zoom-In Map 2 of 2



Hazard-Specific Vulnerability | 100-Year FEMA Flood Zone

This portion of the report focuses on the effects to critical facilities, parcels and roadways from the 100-year flood zone. In-depth vulnerability statistics are provided to determine risk from a land use, financial and transportation perspective.

Hazard Overview

The Federal Emergency Management Agency (FEMA) provides digital flood insurance rate maps (DFIRM) maps depicting 100-year flood hazard zones in order to determine which properties require the purchase of flood insurance. The 100-year flood zone (also referred to as the Special Flood Hazard Area) is defined as areas with a 1% annual chance of flooding[8]. Flood zones can include areas susceptible to sitting water (ponding), areas susceptible to sheet flow on sloping terrain, and areas susceptible to flooding as a result of velocity wave action[9]. All three of these scenarios are analyzed as part of this vulnerability analysis.

Past Impacts and Hazard Frequency in Titusville

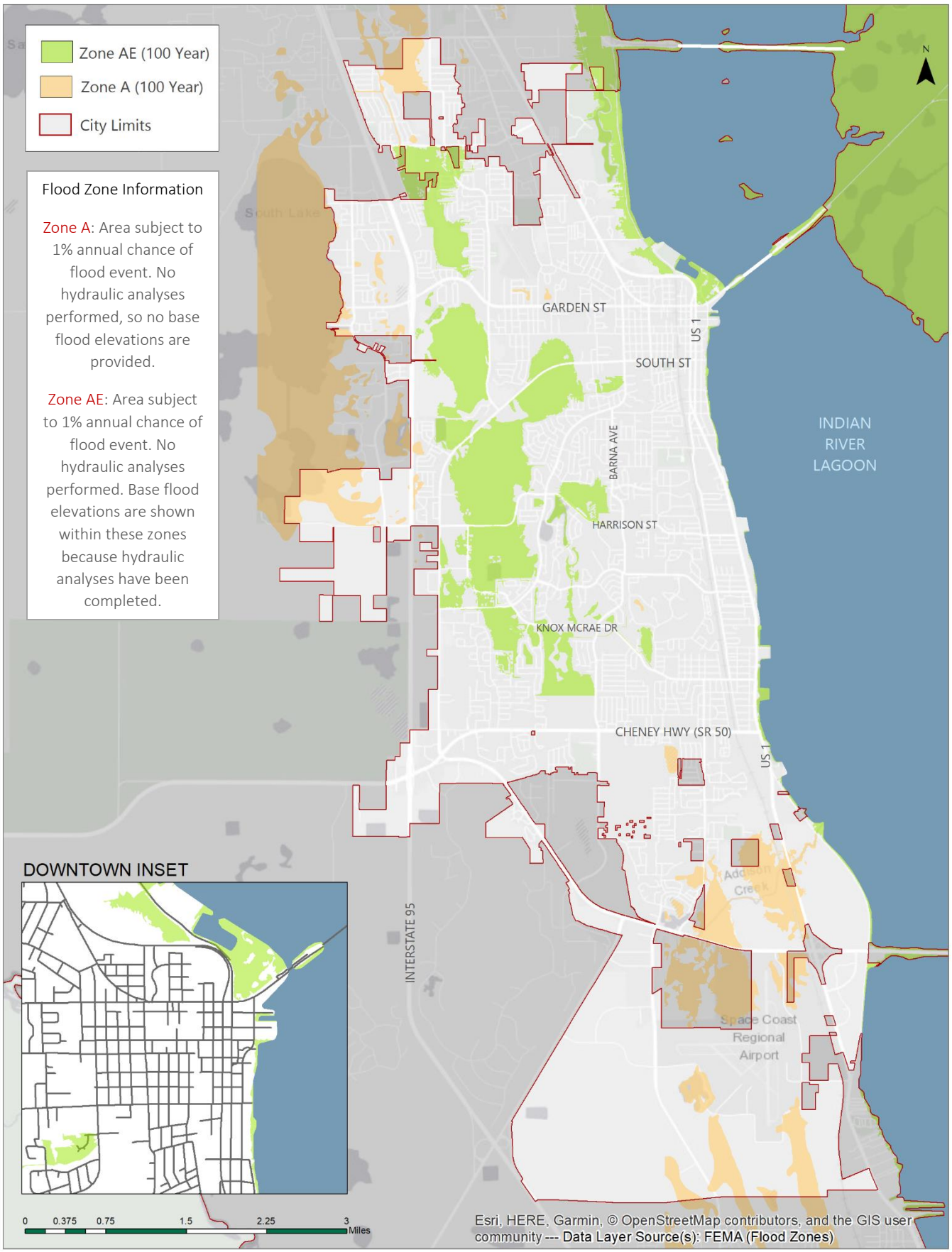
The City of Titusville has areas that are exposed to two different 100-year flood zones – "A" and "AE" – in addition to the 500-year floodplain. The 100-year flood zone is described by FEMA, as a flood having a 1% chance of being equaled or exceeded in any given year. The following image, provided by the City of Titusville, depicts flooding in one of the City's residential areas. Only the 100-year floodplain is analyzed as part of this report.

Types of Infrastructure at Risk

Buildings are among the most at-risk infrastructure to flooding and often make up a large portion of the costs associated with flooding events[10]. Additionally, the failure of stormwater infrastructure can cause additional ponding on streets when overtaxed infrastructure that cannot displace the excess water as a result of backflow[4]. Utilities such as electric plants and substations can also be temporarily or permanently damaged by floods.

From a mitigation perspective, it is critical that the City remove or raise critical facility structures (buildings), water treatment plants and electrical substations that are located within the 100-year floodplain. Concurrently, the City should consider the past impacts of flooding on stormwater infrastructure and focus funding for mitigation in those areas.

FEMA 100-Year Flood Zone



Perhaps the greatest mitigation strategy for flooding is to avoid development in the floodplain altogether, and from this perspective the City is in a safe position with a relatively low risk profile. Approximately 1,829 acres of "conservation" lands are located within the 100-year floodplain, which represents 64.3% of the entire land area of the 100-year floodplain within the City. These areas can be viewed (in bright green on the map on the following page. It is recommended that the City ensure these conservation lands remain in perpetuity and follow the framework laid out in the Future Land Use Map and Wetland Overlay.

One potentially-susceptible area to future development in the 100-year floodplain is the area surrounding Apollo Elementary School. These lands are currently classified as residential in the City's future land use map but are currently undeveloped. Thus, it is recommended that the City consider purchase of the property for conservation/stormwater mitigation or working with the developer to design a subdivision with clustered residences on higher ground and substantial stormwater retention areas. The mixed use-classified land adjacent to the Max Brewer Memorial Parkway (including the Municipal Marina and Sand Point Park) is susceptible to flooding in addition to all of the other hazards analyzed in this report. It is thus recommended that the City incorporate strategies in this location that take into account the varying impacts from flooding, sea level rise and storm surge in a comprehensive manner.

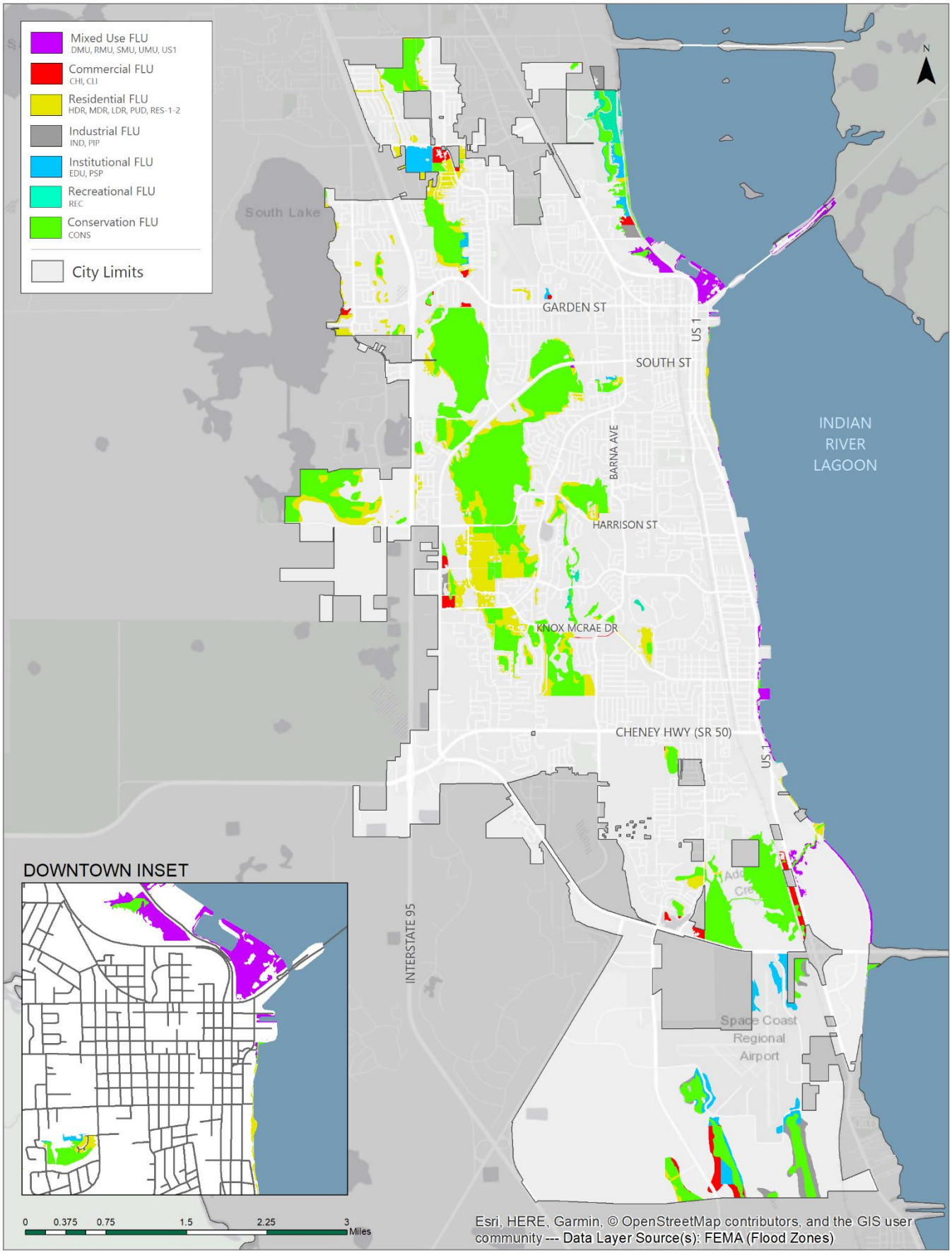
Along the west side of US Highway 1 and to the south of State Road 50 (Cheney Highway), a number of low-and-high-intensity commercially-designated parcels are located within the 100-year floodplain. Also, in this area, numerous parcels adjacent to Addison Creek have mixed use future land use classifications and are located in the 100-year floodplain. These parcels are currently undeveloped and it is recommended that the city assess codes and policies to minimize the development allowed to occur in the 100-year floodplain.

Overall, the low density residential future land use encompasses the most land area in the floodplain other than conservation lands, with over 300 exposed acres. Most of this land is undeveloped. Public (institutional) uses make up approximately 144 acres of the 100-year floodplain; very low density uses account for 115 acres; mixed uses account for 99 acres; commercial uses account for 86 acres; industrial uses account for 82 acres, and high-density residential uses account for 79 acres of the 100-year floodplain. It is recommended that all undeveloped, non-conservation lands within the 100-year floodplain be downzoned or utilize clustered residences on high ground with adjacent retention ponds in order to minimize long term risk to life and property. The table below summarizes the acreage (by land use) within each of the City's floodplains.

Table 10: 100-Year Flood Land Use Exposure

	Commercial Low/High Intensity	Mixed Use UMU, SMU, RMU, DMU	U.S. 1 Corridor	High Density Residential	Medium Density Residential	Low Density Residential	Very Low Density Residential RES1 & RES2	P.U.D.	Industrial & Planned Industrial Park	Public/ Semi-Public & Education	Recreation
Flood Zone	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
Zone A *(100 Year)*	**53.98**	**11.23**	0	**10.59**	**6.00**	**46.47**	**59.29**	**6.37**	**53.78**	**80.51**	**2.53**
Zone AE *(100 Year)*	**31.83**	**88.15**	0	**68.12**	**36.27**	**266.32**	**55.58**	**1.00**	**28.82**	**63.23**	**47.50**

Generalized Land Uses within FEMA 100-Year Flood Zone



As discussed previously, the disproportionately-undeveloped nature of the lands within the 100-year floodplain lower the City of Titusville's financial risk profile to flooding. Approximately 99.1% of the land area of the 100-year floodplain within the City is valued at under $1 per square foot.

There are, however, some highly valued parcels located within the 100-year floodplain. To the north of the downtown area, the Parrish Medical Center is located within the floodplain and exceeds $25.00 per square foot of parcel area. Sea Cat Boats, a boat retailer, is another valuable parcel located in this area.

In the north-northeast portion of the City (to the east of Interstate-95 and south of Dairy Road), a number of highly valued residential parcels are located within the 100-year floodplain. These homes are primarily located within the Titus Woods subdivision.

In the central portion of the City, homes are located within the 100-year floodplain in Baker's subdivision, the Hidden Oaks of Titusville, Hickory Lake and Walnut Hills neighborhoods. Inundation in these areas is projected to primarily affect backyards and is focused along the outside periphery of retention ponds, so the risk posed to actual structures is minimal in these locations.

Overall, nearly one-half billion dollars of property value is located within the 100-year floodplain. This land, however, averages just $3,375 per acre and 1,191 buildings when taking into account the "entire" parcel and not just the exposed portions of parcels. The table below summarizes the financial exposure to the 100-year floodplain as delineated by FEMA, while the map on the following page depicts the parcel value (per square foot) within the 100-year floodplain.

FEMA Flood Zone Definitions

Flood Zone A
Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. Because detailed analyses are not performed for such areas; no depths or base flood elevations are shown within these zones.

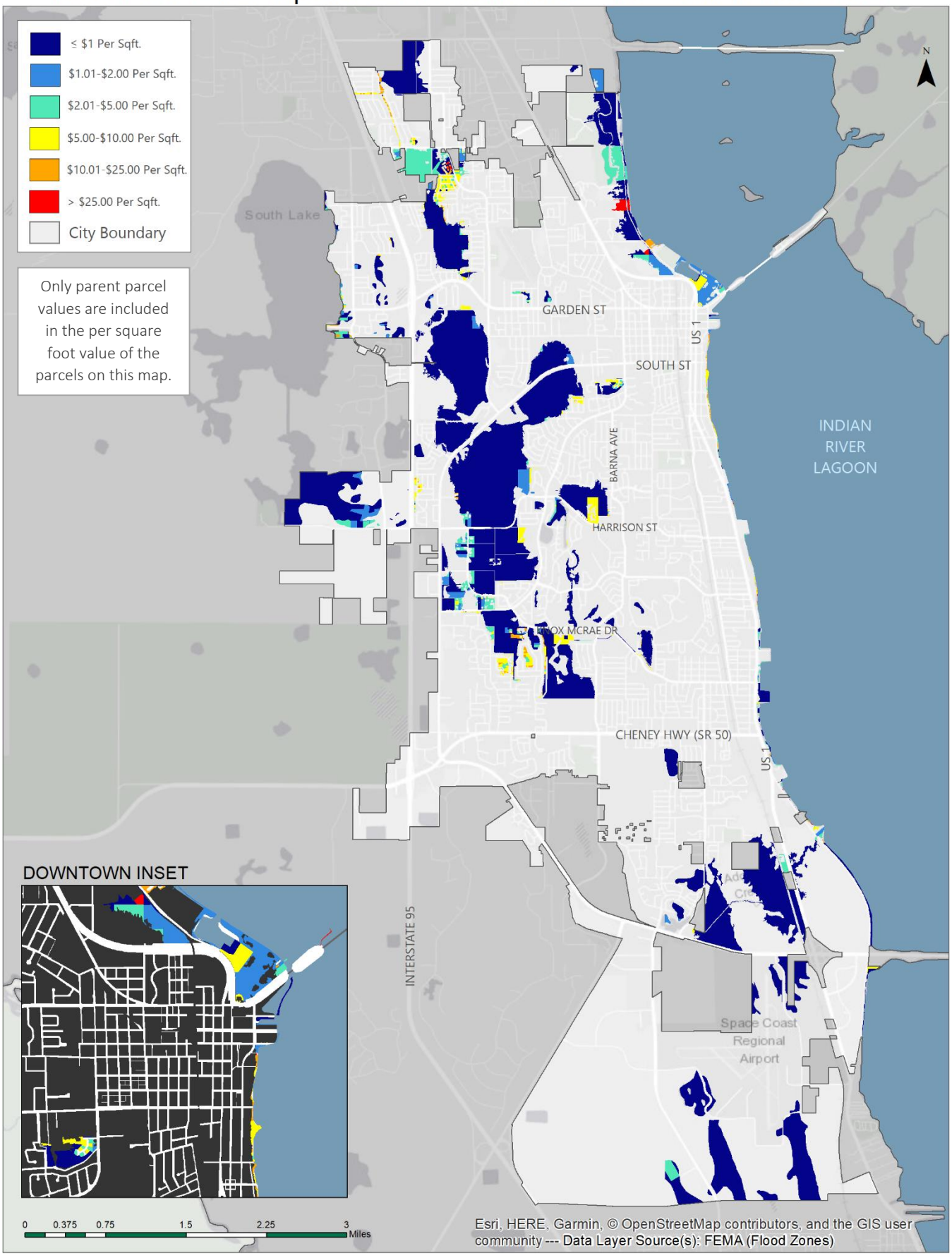
Flood Zone AE
The base floodplain where base flood elevations are provided. AE Zones are now used on new format FIRMs instead of A1-A30 Zones.

500 Year Flood Zone
Area of minimal flood hazard, with a 0.2% (or 1 in 500) annual chance of flooding.

Table 11: 100-Year Flood Financial Exposure

						Built Pre-1968	Built 1968-2001	Built 2002 - 2018
Flood Zone	# Parcels in Zone	Number of Buildings	Land Value	Assessed Value	Taxable Value	# Buildings Total Value	# Buildings Total Value	# Buildings Total Value
Zone A *(100 Year)*	341	242	$30,134,830	$72,029,320	$39,483,670	24 $1,545,810	163 $35,944,850	55 $17,688,110
Zone AE *(100 Year)*	1,576	1,191	$70,633,990	$432,040,060	$232,268,241	330 $47,692,000	626 $170,393,720	235 $183,711,060

Parcel Value Per Square Foot within FEMA 100-Year Flood Zones



Transportation Network Exposure | 100-Year FEMA Flood Zone

Transportation exposure to the floodplain throughout the City is lower than the exposure to other natural hazards, as much of the floodplain is undeveloped.

In the downtown area, Marina Road is the sole main roadway projected to be inundated in a 100-year flood event, as the 100-year floodplain is primarily restricted to areas adjacent to the lagoon. Inundation during a 500-year rain event as modeled by FEMA is projected at the intersection of Garden Street and US Highway 1, which would disrupt traffic flow greatly in the downtown area. Efforts to raise this intersection or improve drainage should be reviewed for cost-effectiveness in this area.

In the west-central portion of the City, portions of streets in the Fox Lake Manor, Oakdale, Whispering Oaks and Whispering Hills Golf Estates neighborhoods are projected to be inundated under 100-year flood conditions. Additionally, a 0.44 mile stretch of Harrison Street is projected to be inundated under 100-year flooding conditions in this location.

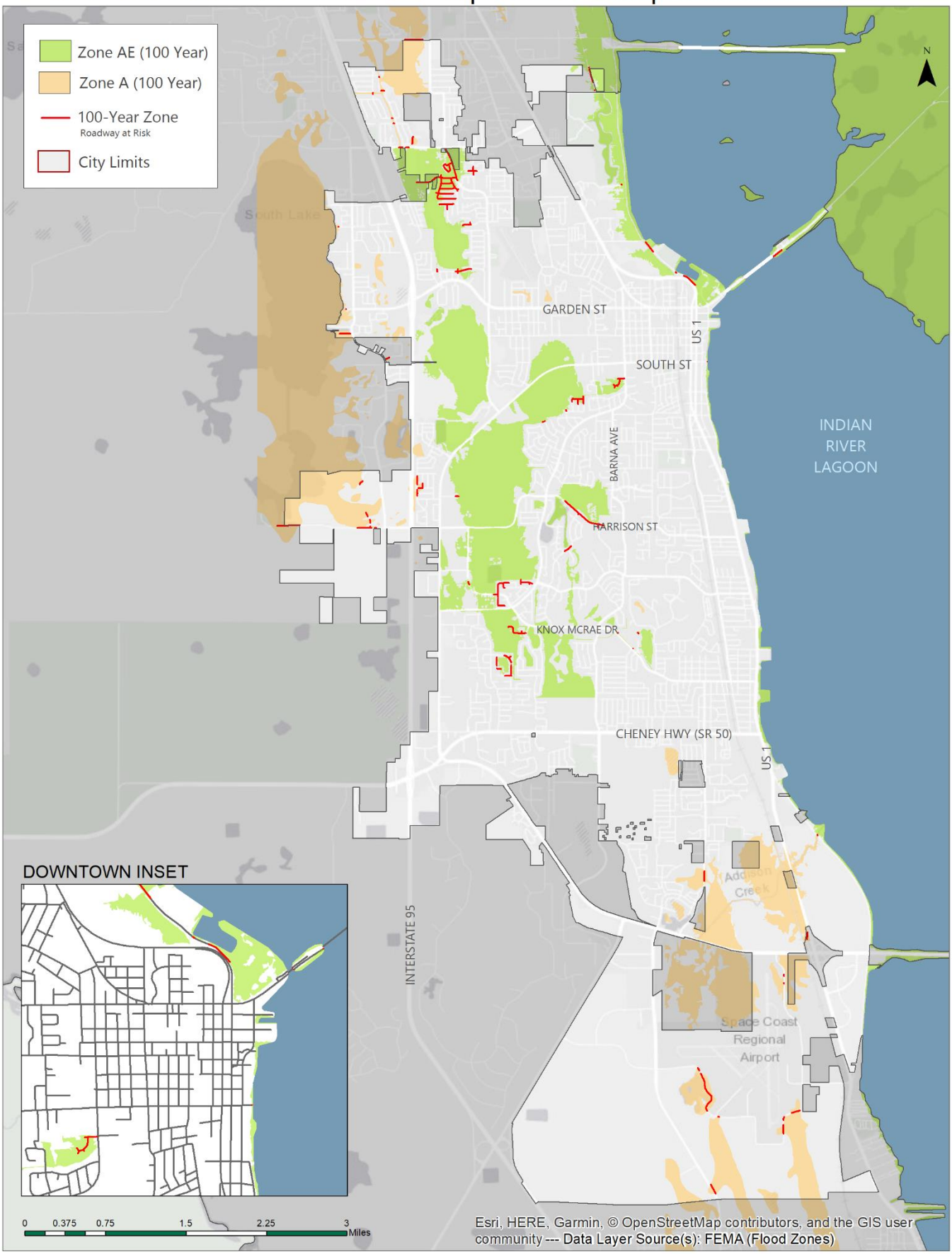
Minor local roadways with projected inundation under the 100-year flood (and not listed on the table below) are numerous. The minor local roadways with the highest inundation levels include Perimeter Road (0.65 miles), Parkland Street (0.38 miles), Crescent Drive (0.24 miles), Susanna Lane (0.21 miles), Hemlock Lane, (0.20 miles), Tomoka Avenue (0.20 miles), Melody Lane (0.17 miles), Heather Drive (0.16 miles), Carnegie Street (0.15 miles), Heider Road (0.14 miles), Alexander Drive (0.13 miles), Cornwall Drive (0.13 miles), Hickory Lake Court (0.12 miles) and Morbeca Street (0.10 miles).

Table 12: 100-Year Flood Transportation Exposure

Road Name Classification	100-Year Flood Zones A, AE, AH, AO, VE – Number of Miles	VE Flood Zone Number of Miles
Dairy Road	0.07 miles	0
Elder Street	0.14 miles	0
Fox Lake Road	0.37 miles	0
Garden Street *	0	0
Grissom Parkway	0.10 miles	0
Harrison Street	0.44 miles	0
Knox McRae Drive	0.06 miles	0
Marina Road	0.26 miles	0
Max Brewer Memorial Parkway	0.49 miles	0
Parrish Road	0.17 miles	0
Royal Oak Drive	0.09 miles	0
Singleton Avenue	0.32 miles	0
Sisson Road	0.1 miles	0
South Hopkins Ave	0	0
South Washington Ave (US1) *	0	0

* Notes Evacuation Routes

100-Year FEMA Flood Zone - Impacts to Transportation Network



Overview of Exposure to Community Features | 100-Year FEMA Flood Zone

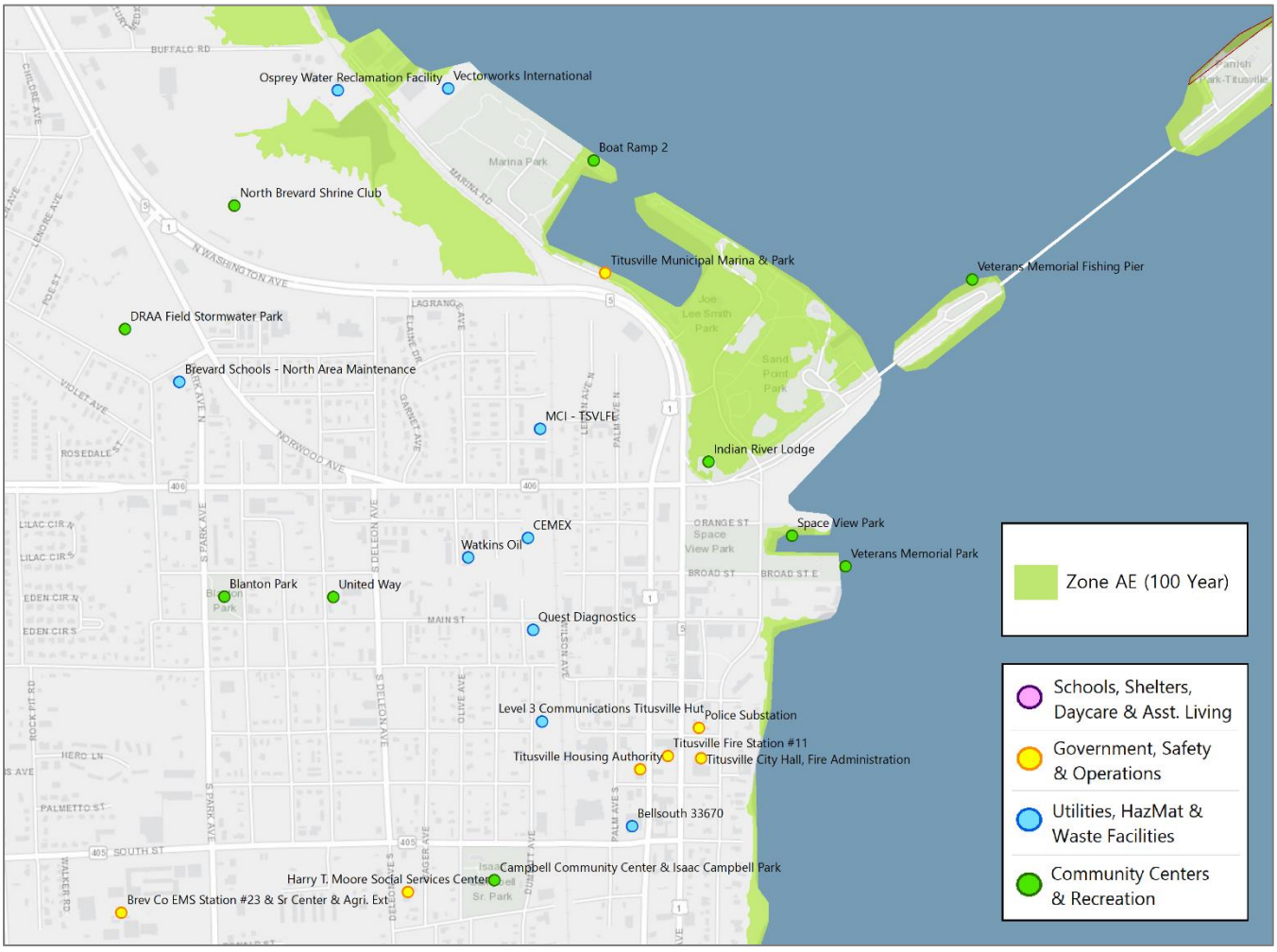
Although more of the City has the potential for impact from 100-year flood events, the downtown area and the southern portion of the City on the lagoon side will have the most vulnerable community features of any area in the City.

Boat Ramp 2, Veteran's Memorial Fishing Pier, Space View Park, Indian River Lodge, and Veteran's Memorial Park are located in the 100- year floodplain. The threat to these downtown community facilities would result in flooding, standing water, destruction of infrastructure on the facility sites, threat of electrocution during prolonged rain events and other hazards.

It will be critical to follow any changes over time to the FEMA flood maps, as a number of facilities are in close proximity to the 100-year floodplain in the downtown area.

It is recommended that the City raise, adapt or relocate critical facilities that are located within the 100-year floodplain after completing a cost-benefit analysis.

Map 21: 100-Year Flood Zoom-In Map 1 of 2



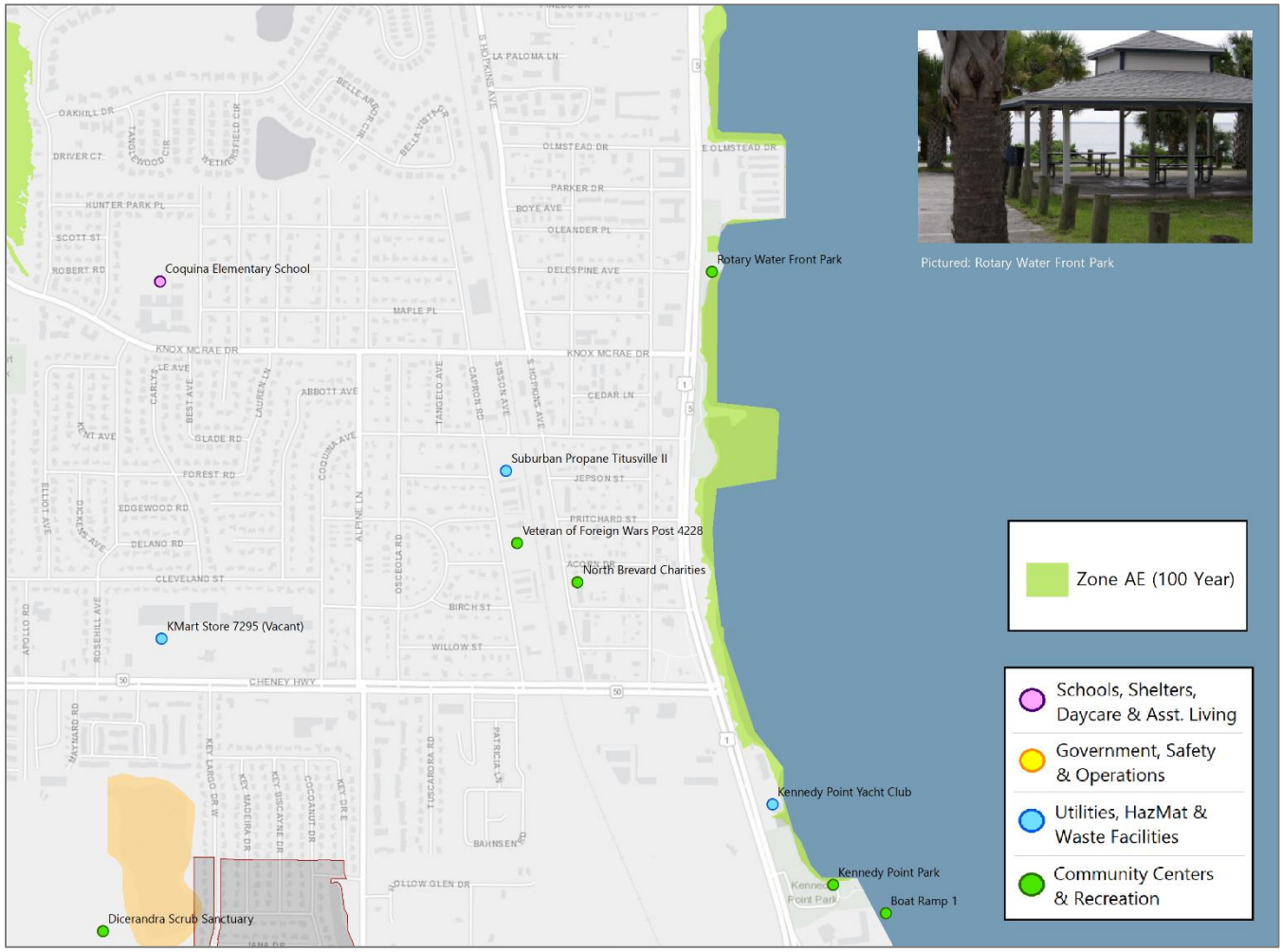
Overview of Exposure to Community Features | 100-Year FEMA Flood Zone

The southeastern portion of the City also has a number of community facilities that will be impacted by 100-year flood events, including Boat Ramp 1, Kennedy Point Park, Kennedy Point Yacht Club and Rotary Water Front Park.

These facilities are also susceptible to nuisance flooding, storm surge and sea level rise, which greatly increases their overall risk profile. Unlike sea level rise and nuisance flooding, however, the 100-year floodplain does not jet inland in this portion of the City. Thus, in the event of a high tide, these maps may not be as reflective of actual flooded areas as the nuisance flooding maps. The nuisance flooding maps can be viewed on the following ten pages of this report.

While not pictured in this section of the report, the YMCA in the southwest portion of the City is located just outside of the 100-year floodplain. Given this is the only YMCA in the City and is located with surrounding 100-year floodplain areas, flood proofing may be a necessity.

Map 22: 100-Year Flood Zoom-In Map 2 of 2



Hazard-Specific Vulnerability | Nuisance "High Tide" Flooding

This portion of the report focuses on the effects to critical facilities, parcels and roadways from nuisance flooding. In-depth vulnerability statistics are provided to determine risk from a land use, financial and transportation perspective.

Hazard Overview

Nuisance flooding is "minor, recurrent flooding that takes place at high tide" and "occurs when the ocean has reached the brim locally" according to NOAA[11]. Like other hazards analyzed in this report, nuisance flooding is tied to the presence of other natural hazards such as sea level rise[11]. While not immediately life threatening, nuisance flooding is just that – a nuisance – and the costs over the long term may rise.

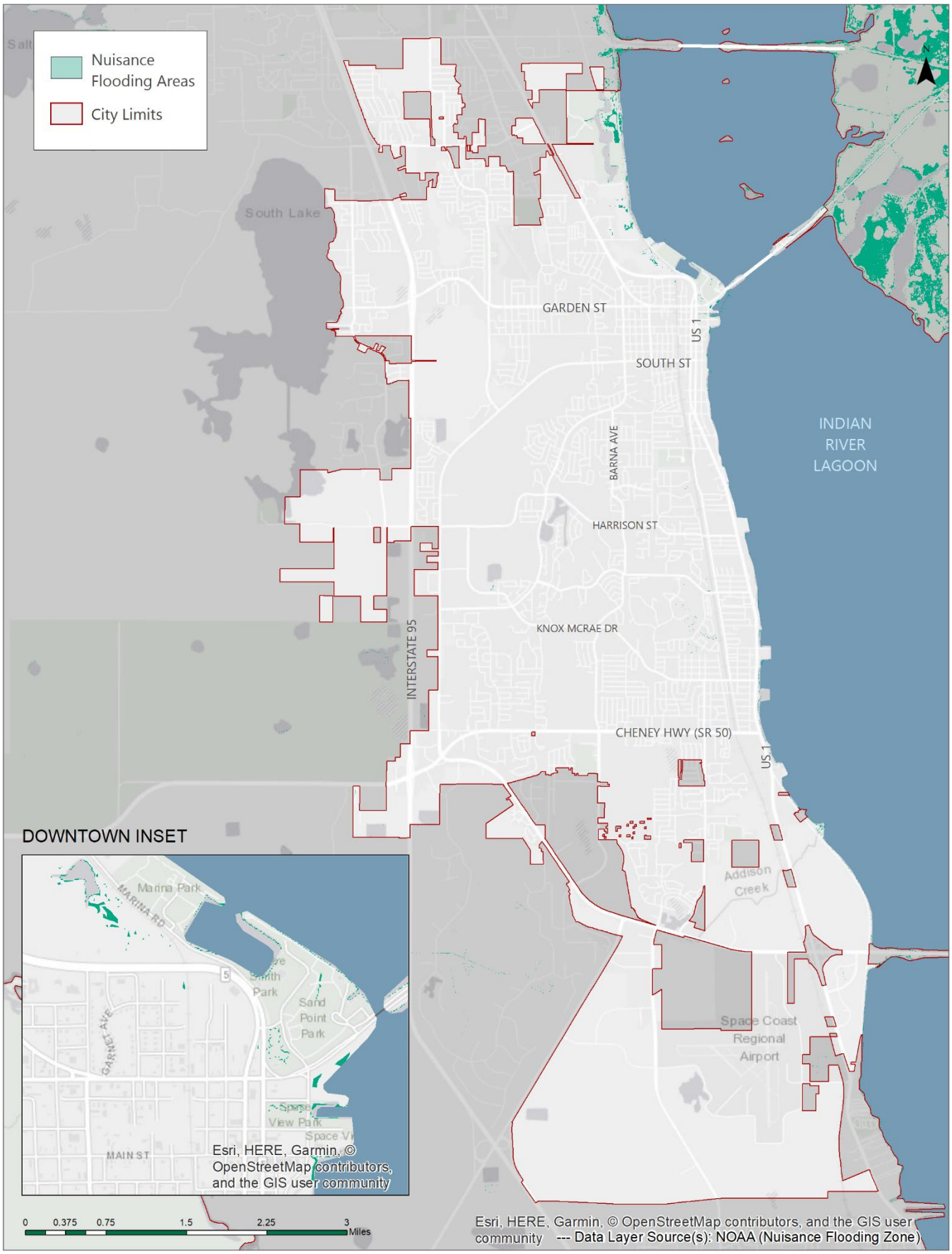
Past Impacts and Hazard Frequency in Titusville

Nuisance flooding is expected to increase in frequency and duration over time as sea levels rise[12]. The frequency of nuisance flooding depends on the season (Florida's "wet months" primarily fall within the summer and fall) with most occurring during the fall in the southeastern United States[12]. While there is variability by location, the data shows that "multi-month" events occur in some coastal communities[12]. The map on this page, provided by NOAA, depicts annual nuisance flooding days in select locations. It is recommended that the City and Brevard County Emergency Management develop a process of documenting the exact frequency and duration of these events so that location-specific data is available.

Types of Infrastructure at Risk

Similar to flooding in general, infrastructure such as buildings, water treatment plants, electrical substations and stormwater infrastructure (such as outfalls) are susceptible to the effects of nuisance flooding. Nuisance flooding typically affects infrastructure near large water bodies, while 100-year flood events can impact inland areas that are not in close proximity to large water bodies.

Source: NOAA


Nuisance Flooding Areas
City Limits
South Lake
GARDEN ST
US 1
SOUTH ST
BARNA AVE
INDIAN RIVER LAGOON
HARRISON ST
KNOX MCRAE DR
INTERSTATE 95
CHENEY HWY (SR 50)
US 1
Addison Creek
Space Coast Regional Airport
DOWNTOWN INSET
Marina Park
MARINA RD
Park
Sand Point Park
GARNET AVE
View Park
MAIN ST
Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community
0 0.375 0.75 1.5 2.25 3 Miles
Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community --- Data Layer Source(s): NOAA (Nuisance Flooding Zone)

Nuisance flooding impacts a wide range of land uses within the City. As shown in the chart below, over 22 acres of non-conservation lands are projected to experience this increasing flooding hazard. Since the nuisance flooding hazard zone is generally located adjacent to the lagoon, a large percentage of the affected lands are currently developed.

Of the exposed land, approximately 11.6 acres (52%) is designated as recreational uses. This includes Kennedy Point Park to the south of State Road 50 as well as Chain of Lakes Park at the City's northern boundary. As discussed in other portions of this analysis, repurposing these parks into water-absorbing eco-tourism areas could be beneficial over the long term. The image on this page 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.

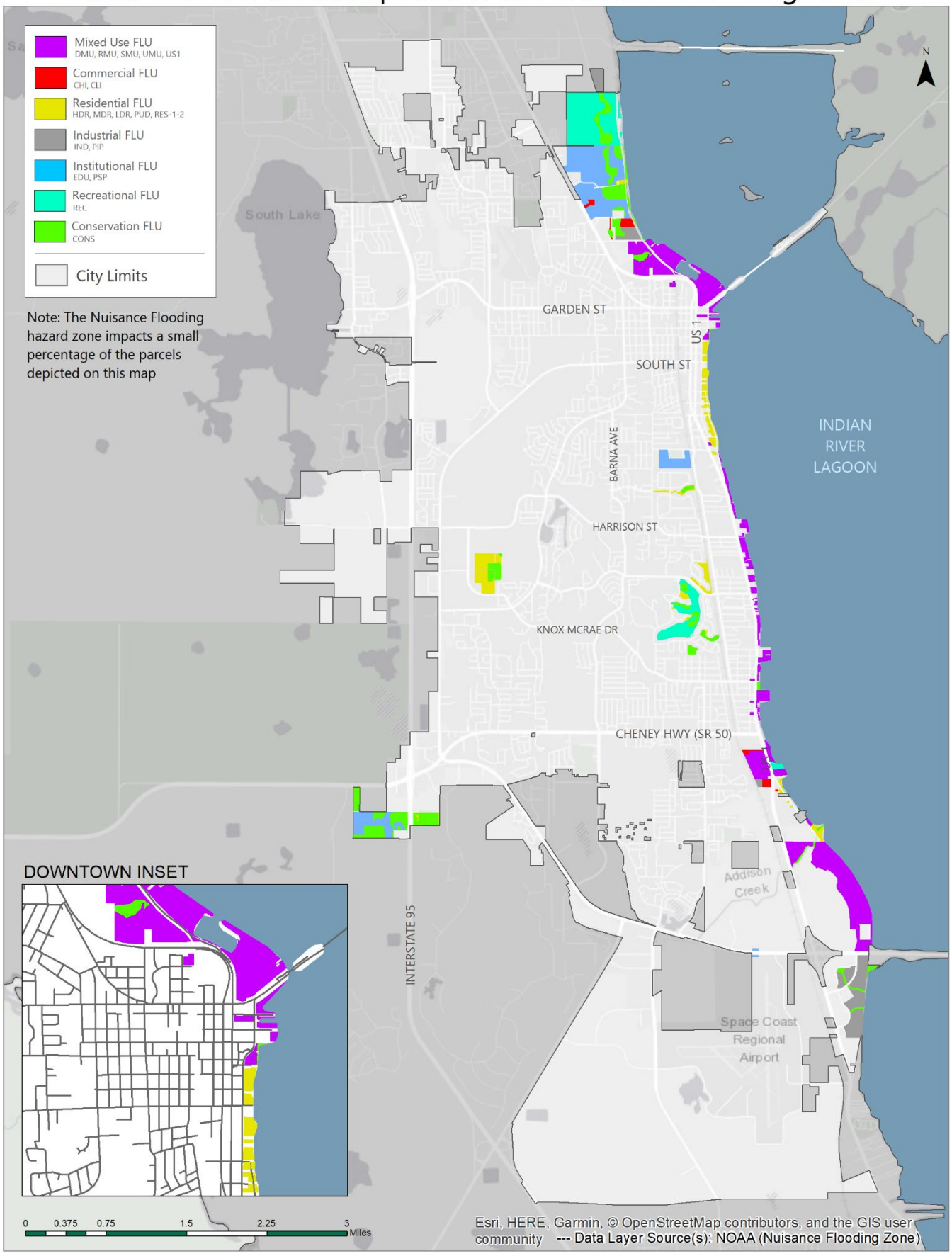
Important institutional lands are also exposed to the nuisance flooding hazard zone. These institutions, the Parrish Medical Center and Eastern Florida State College, are also susceptible to storm surge and sea level rise, so a comprehensive approach to dealing with these hazards is prudent. One good strategy for dealing with periodic flooding is to design outdoor campus or design meeting areas in a flexible, dual-use manner. Similar to Fourth Ward Park in the image above, certain areas can be delineated as 'retreat' portions of the landscape, while raised walkways or common areas are intertwined on higher ground. This would likely mitigate to flooding while boosting the overall aesthetics of these institutions.

A large degree of exposure (29%) to the nuisance flooding hazard is on lands with mixed use future land use classifications along the lagoon shoreline and in the downtown area. Some of this 'mixed use' land in the downtown area function as recreational activity centers (Sand Point Park and the marina), while other portions are developed. It is recommended that any future development in the portion of the downtown core near the Garden Street and US Highway 1 intersection be raised to mitigate for the effects of nuisance flooding and implement the practice of 'low impact development'. Improvements to drainage (swales, etc.) could also reduce the amount of runoff affecting private property.

Table 13: Nuisance Flooding Land Use Exposure

	Commercial Low/High Intensity	Mixed Use UMU, SMU, RMU, DMU	U.S. 1 Corridor	High Density Residential	Medium Density Residential	Low Density Residential	Very Low Density Residential RES1 & RES2	P.U.D.	Industrial & Planned Industrial Park	Public/ Semi-Public & Education	Recreation
Zone	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
Nuisance Flooding Area	**0.49**	**6.42**	0	**0.09**	**0.58**	**0.93**	0	**0.14**	**1.18**	**0.90**	**11.57**

Land Uses of Parcels Exposed to the Nuisance Flooding Area



From a financial perspective, nuisance flooding can have a severe impact on affected properties due to the close proximity of the hazard zone to the coastline and the potential for duplicative (repetitive) losses to one property. The latter point – high frequency of losses – severely heightens this hazard's impact. Additionally, nuisance flooding can disrupt business access, increasing economic losses in these areas during flood events.

The map on the next page depicts modeled exposure areas color coded by value per square foot. While this map shows that a majority of the exposed land is less than one dollar per square foot in value, it is important to note that the vast majority of exposed financial value is located on small parcels located adjacent to the lagoon. The financial exposure is difficult to discern at such a large scale.

The highest-value-clusters of lagoon-adjacent properties exposed to this hazard are located in three areas. The first area is located between Garden Street and Grace Street and includes 64 properties worth a combined $17.5 million. The second area of high financial exposure is located between Lado Lane and Narvaez Drive, where $25 million dollars' worth of property is exposed. The third area, just to the south of Kennedy Point Park, includes a small number of properties worth approximately $10 million dollars.

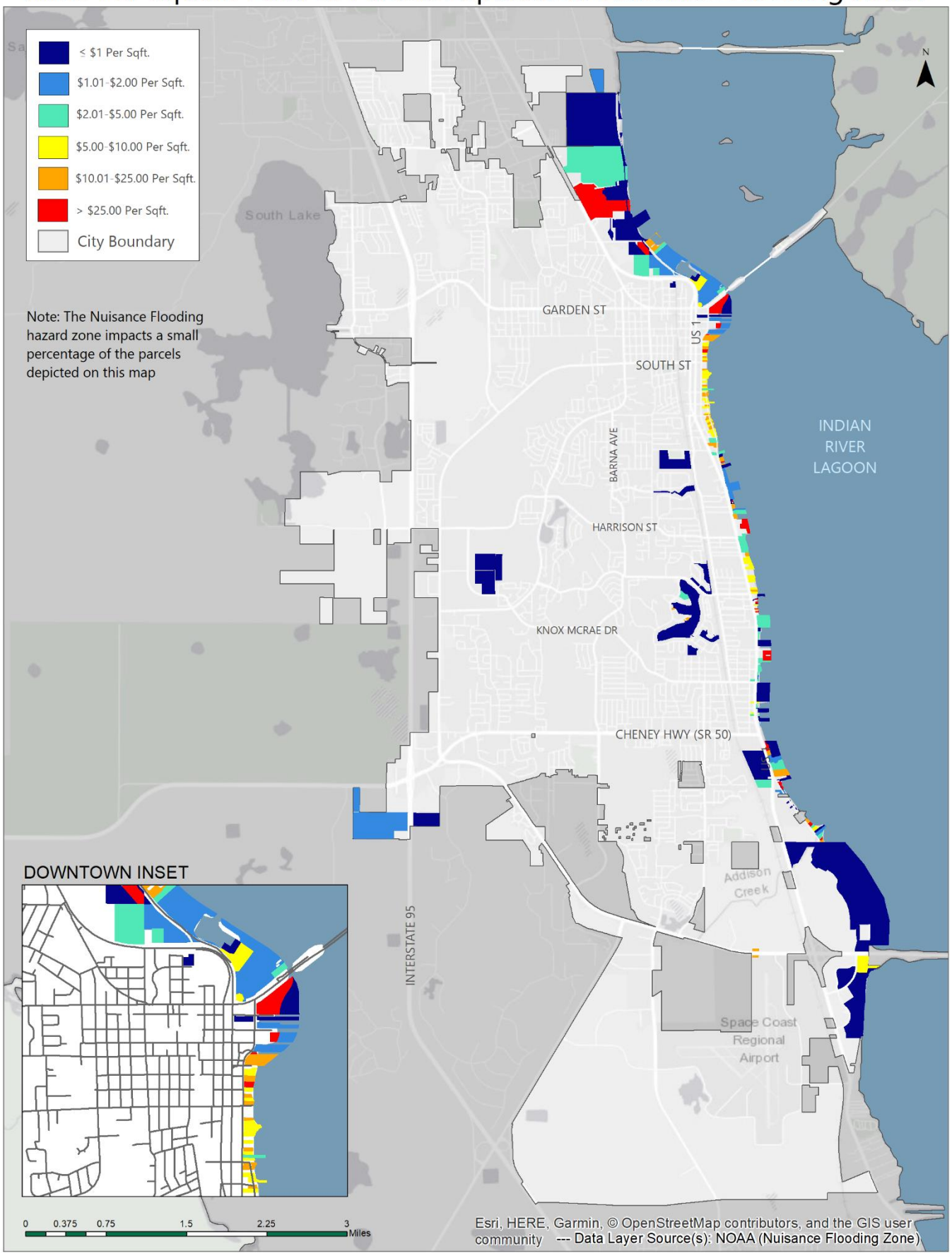
The City should consider educating private property owners on the mitigation techniques that can be performed such as flood-proofing.

The Parrish Medical Center makes up more than $72 million of the approximately $247 million dollars in assessed value (29%) exposed to the nuisance flooding hazard zone. A large portion of this land is undeveloped, although the Vista Manor property to the south is also exposed. It is recommended that all medical activities to the east of the primary medical center be moved to a less-flood-susceptible area, and that the land to the east of the hospital remain undeveloped indefinitely.

From a build year perspective, the vast majority of exposed buildings were built after 1968, when flood insurance was first required from property owners in flood-prone areas. A total of 104 of the 265 buildings in the hazard zone (39%) were built before this critical date. Furthermore, 161 exposed buildings (61% of those in the hazard zone) 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.

						Built Pre-1968	Built 1968-2001	Built 2002 - 2018
Zone	# Parcels in Zone	Parcels w/ Buildings	Land Value	Assessed Value	Taxable Value	# Buildings Total Value	# Buildings Total Value	# Buildings Total Value
Nuisance Flooding Area	209	124	$40,149,780	$246,820,940	$117,764,243	60 $24,545,410	43 $59,274,680	21 $135,361,000

Value Per Square Foot of Parcels Exposed to Nuisance Flooding Areas



Transportation Network Exposure | Nuisance "High Tide" Flooding

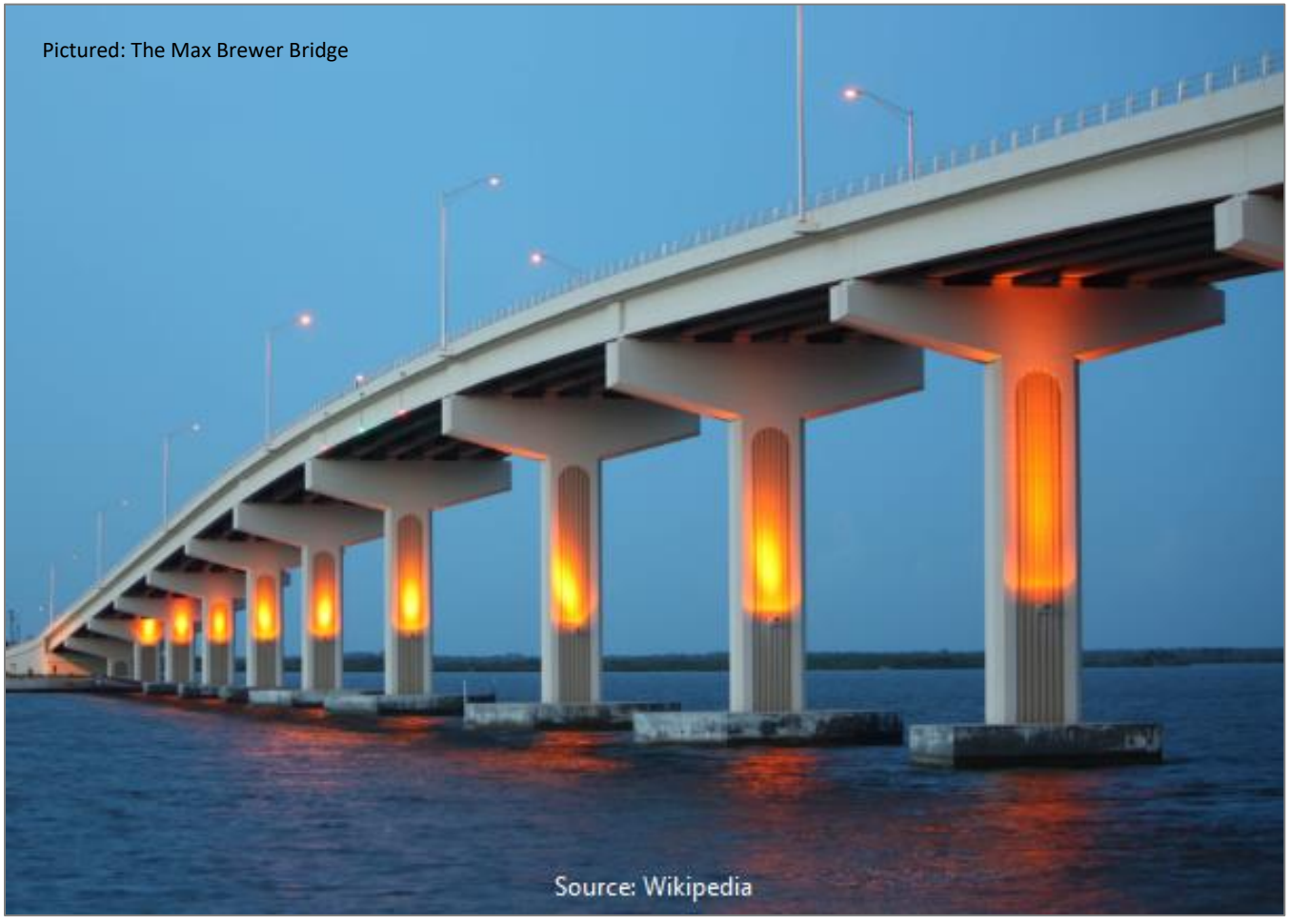
Impacts to the City's transportation network from the effects of nuisance flooding occurs primarily adjacent to the lagoon and is very minimal overall.

In the downtown area, roads that were previously modeled to be impact by this hazard included Garden Street (SR 406), South Washington Avenue (US Highway 1), Broad Street, South Hopkins Avenue, Main Street Orange Street, Nevins Court and Indian River Avenue, but this is not the case per the most up-to-date model from NOAA. However, portions of the right of way of the Max Brewer Memorial Parkway are at risk. It is recommended that City staff document roadway segments that flood during higher-than-average tide events.

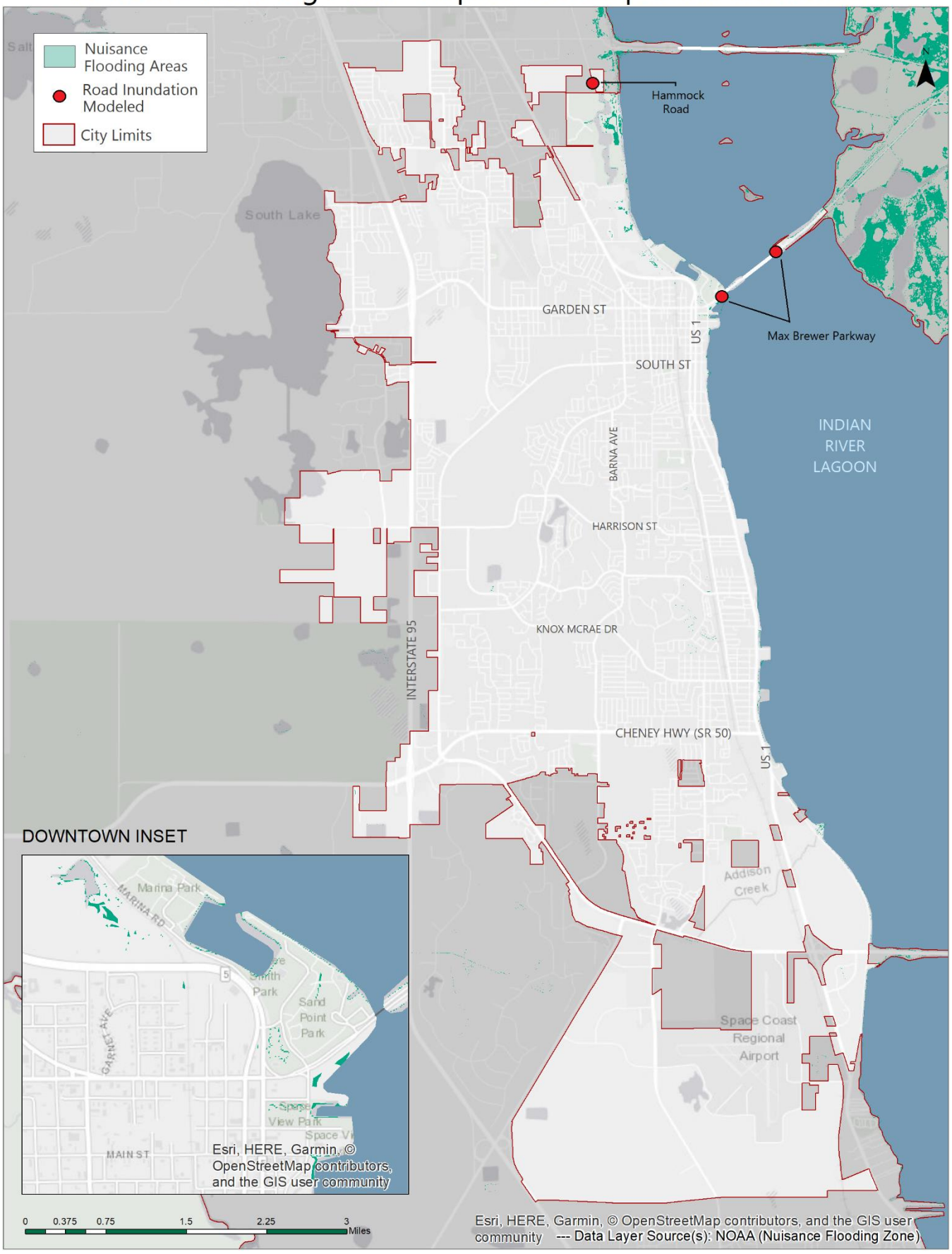
Table 15: Nuisance Flooding Transportation Exposure

Road Name Classification	Nuisance Flooding Area Projected Inundation	Evacuation Route
Hammock Road	.001 miles	No
Max Brewer Memorial Parkway	.02 miles	No

*The elevation of the Max Brewer Memorial Parkway should be reviewed by FDOT and the City



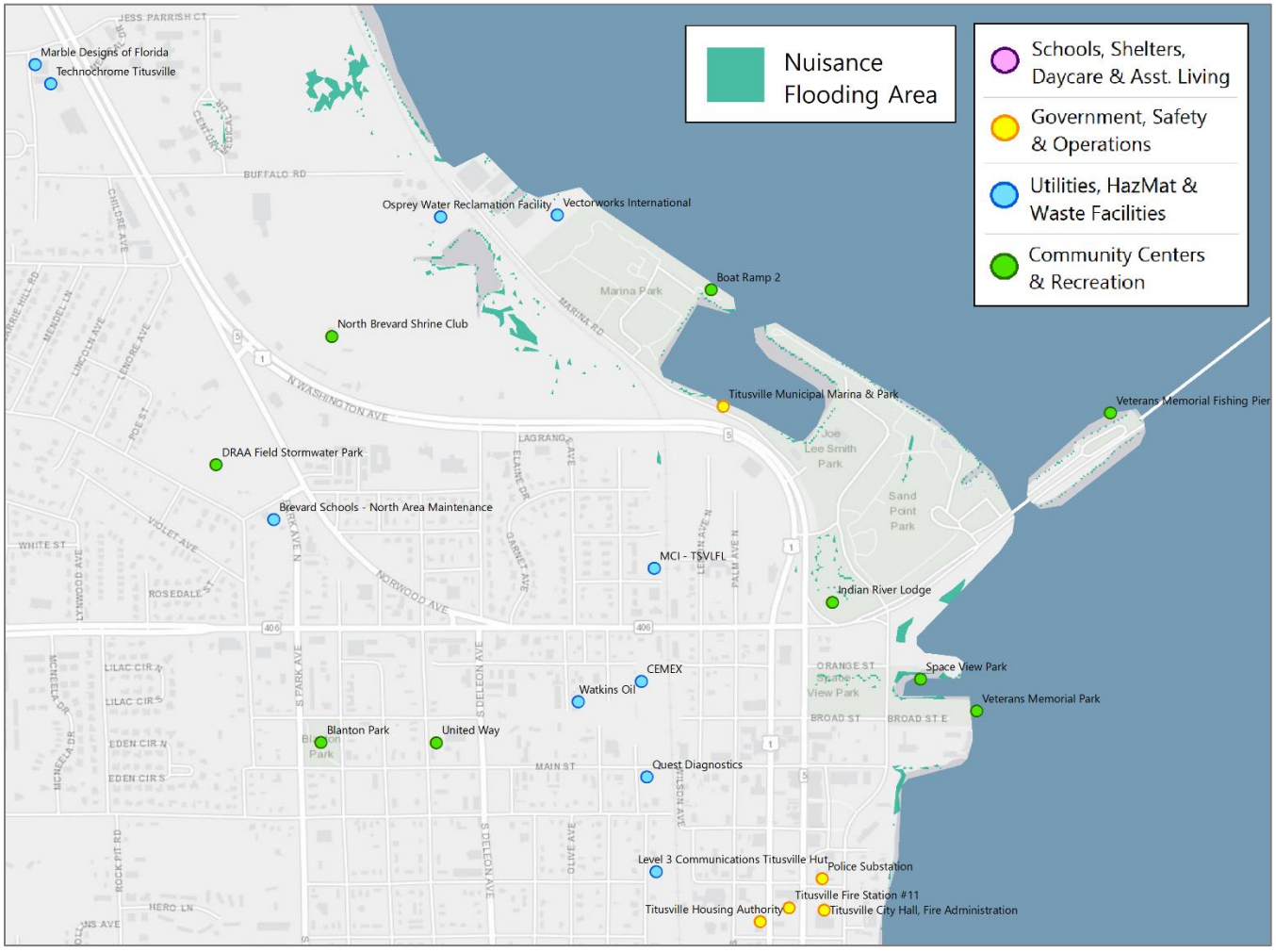
Nuisance Flooding Zone - Impact to Transportation Network



The nuisance flooding hazard zone is generally smaller in size than both the 100-year and the 500-year floodplains, and thus, less facilities are at risk. Areas with nuisance flooding are susceptible to saltwater intrusion and while currently they may only experience one to three flooding events during the fall, this flooding will be exacerbated in frequency over the long term.

The nuisance flooding hazard zone is generally located near or adjacent to the Indian River Lagoon, and the acreage of the zone is small and scattered. In the downtown area, Veteran's Memorial Fishing Pier, Indian River Lodge, Space View Park, Veteran's Memorial Park and Vectorworks International are currently in areas susceptible to periodic nuisance flooding. Strategies to retrofit or mitigate the recreational facilities within the nuisance flooding zone have been addressed extensively previously in this analysis due to the fact that these facilities are also susceptible to sea level rise, storm surge and the 100-year flood zone. Of particular concern from a nuisance flooding perspective is the vulnerability of Vectorworks International, which stores hazardous materials on site. The City should consider providing educational materials concerning flood proofing to the owners of these businesses to alleviate health-related externalities posed by potential impacts to these facilities.

Map 27: Nuisance Flooding Zoom-In Map 1 of 2

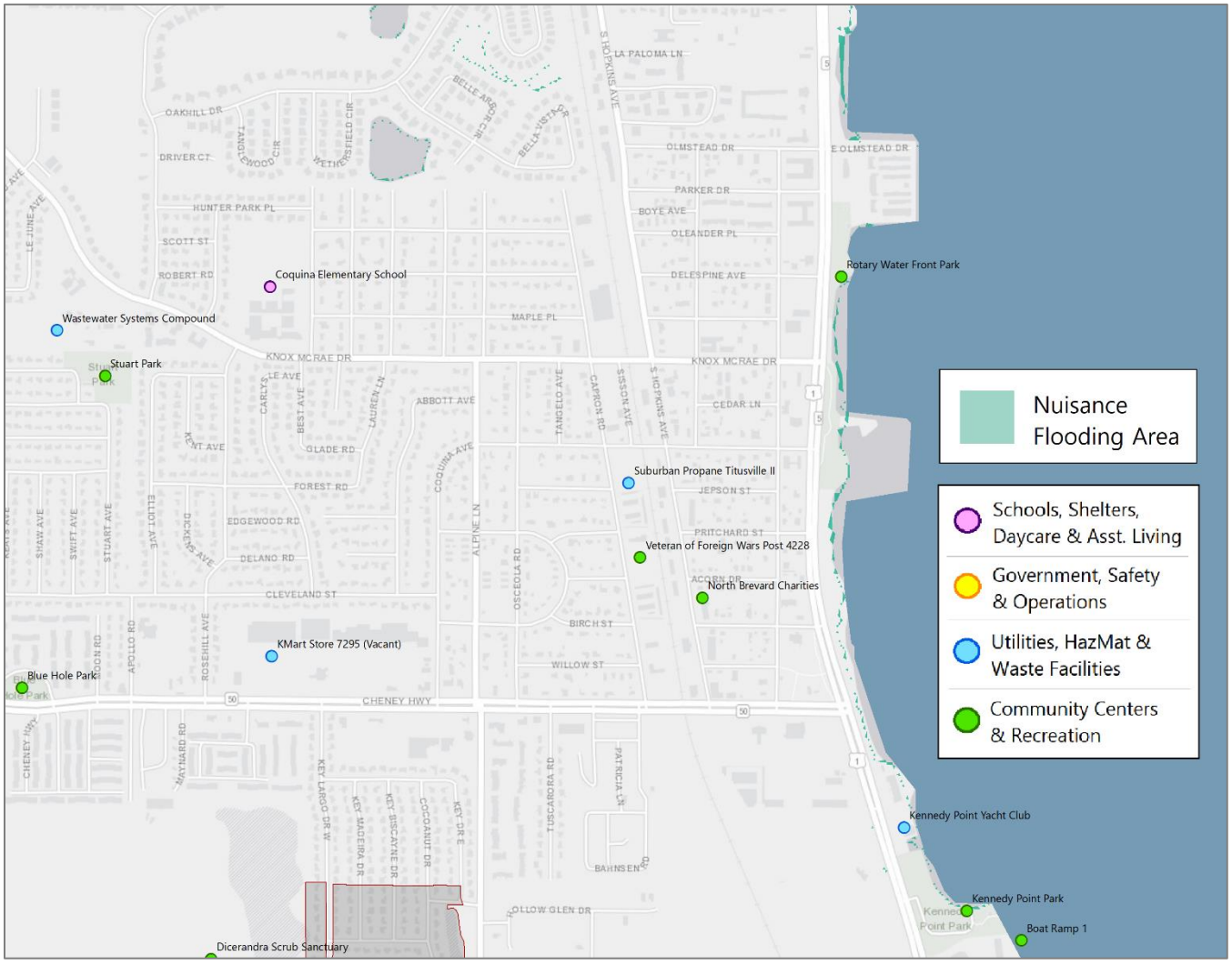


Critical facilities in the southern portion of the City that are currently affected by nuisance flooding are William J Manzo Memorial Park, Rotary Water Front Park, Kennedy Point Park, and Boat Ramp 1. All of these facilities are located adjacent to the lagoon.

The City should survey portions of recreational facilities that typically flood first during rain events and consider designing interim stormwater features in these locations. This strategy would begin the process of retrofitting recreational facilities on an incremental, low-cost basis. This strategy is covered within the "Themes and Strategies" portion of this report.

Not pictured in these maps is Chain of Lakes Park, which is also modeled to be impacted by periodic nuisance flooding. It is recommended that the City monitor the shape and size of this hazard zone over time, as NOAA periodically updates the extent of the zone with new information.

Map 28: Nuisance Flooding Zoom-In Map 2 of 2



Hazard-Specific Vulnerability | Combined Hazard Zone

The effects of the combined hazard zone are expected to be drastic for critical facilities, parcels and roadways within the City. In-depth vulnerability statistics are provided to determine risk from a land use, financial and transportation perspective to this hazard. The year 2100, Category 3 Combined Hazard Zone map can be viewed on the next page of this report.

Hazard Overview

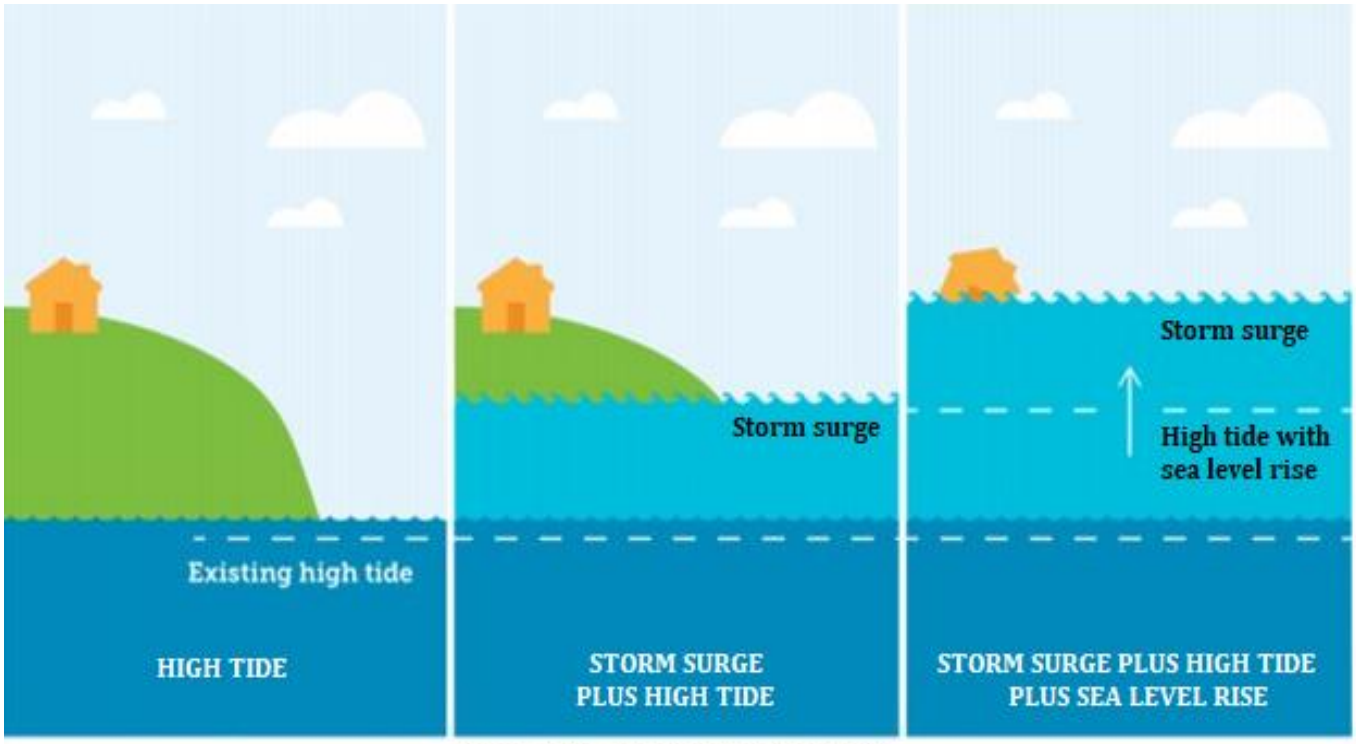
For the purposes of this report, the "Combined Hazard Zone" is defined as the cumulative long-term effects of sea level rise in addition to (or on top of) storm surge. According to researchers, sea level rise will "amplify" the effects of storm surge over the long term[13].

Hazard Frequency in Titusville

The combined hazard zone is a forward-looking risk scenario and data does not currently exist showing the relative increase that historic sea level rise has had on observed storm surge levels. In general, the frequency of storm surge will not increase over time as a result of sea level rise, but the severity of storm surge (and hurricanes, in general) will.

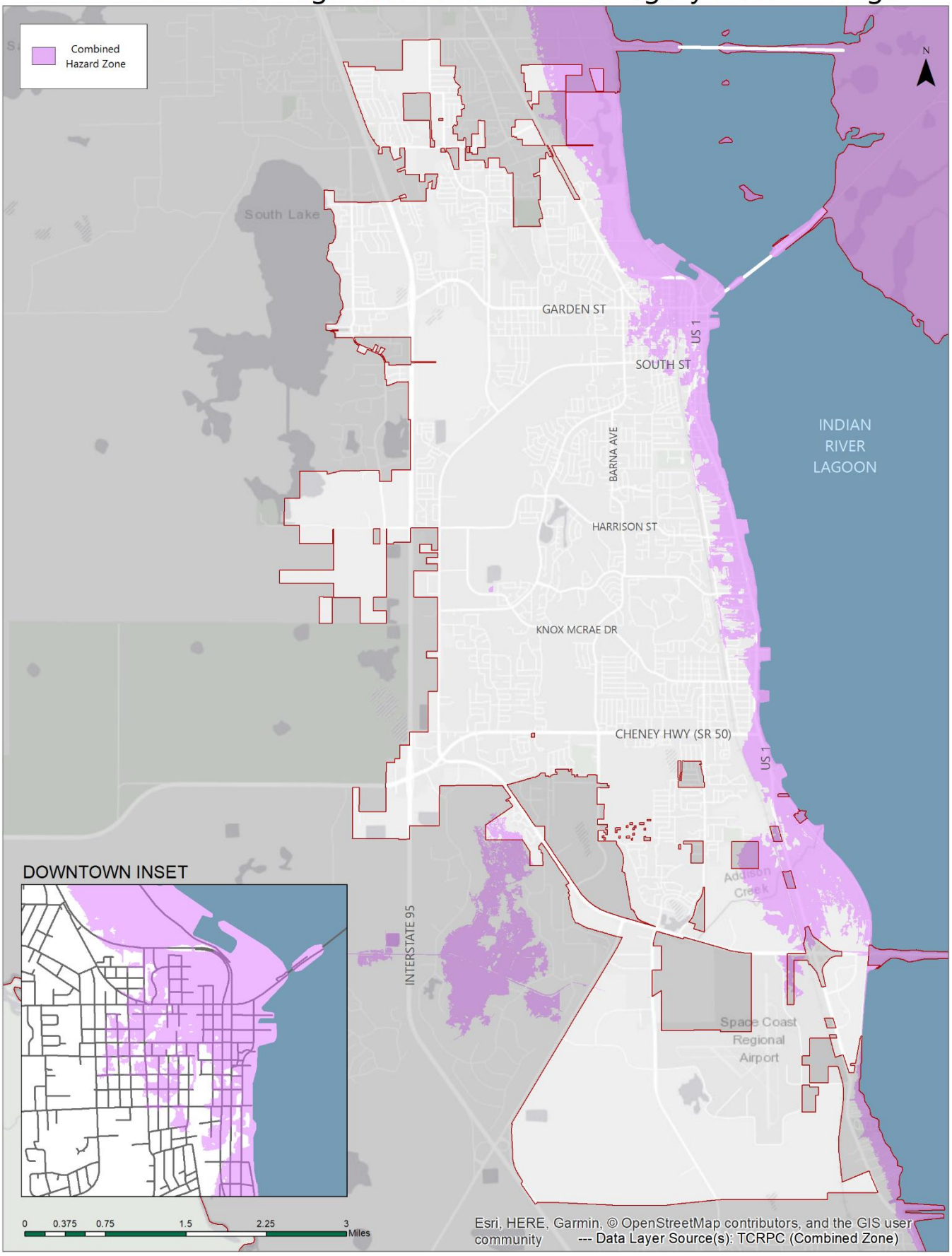
Types of Infrastructure at Risk

Similar to storm surge and sea level rise, a vast array of infrastructure is at risk as a result of the combined hazard of sea level rise on top of storm surge. This includes buildings, underground infrastructure, stormwater infrastructure, sea walls, electrical substations and water treatment plants.



Source: Climate Commission 2013

NOAA Year 2100 "High" Sea Level Rise + Category 3 Storm Surge



The risk posed to the City's property from the effects of the combined hazard zone is included in the two tables on this page.

The projected extent of this hazard zone should be monitored over time by City staff while the City also monitors NOAA and U.S. Army Corps of Engineers sea level rise projections.

Table 16: Combined Hazard Zone Land Use Exposure

	Commercial Low/High Intensity	Mixed Use UMU, SMU, RMU, DMU	U.S. 1 Corridor	High Density Residential	Medium Density Residential	Low Density Residential	Very Low Density Residential RES1 & RES2	P.U.D.	Industrial & Planned Industrial Park	Public/ Semi-Public & Education	Recreation
Zone	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
Category 3 *Year 2050*	13.9	229.9	0.5	3.7	7.8	8.1	0.0	3.3	28.2	35.7	71.0
Category 3 *Year 2070*	26.5	306.0	1.5	5.5	16.1	11.3	0.0	6.1	29.5	53.6	105.4
Category 3 *Year 2100*	123.3	749.5	18.5	22.0	93.5	52.4	0.0	32.0	62.4	101.0	138.9

Table 17: Combined Hazard Zone Financial Exposure

						Built Pre-1968	Built 1968-2001	Built 2002 - 2018
Zone	# Parcels in Zone	Number of Buildings	Land Value	Assessed Value	Taxable Value	# Buildings Total Value	# Buildings Total Value	# Buildings Total Value
Category 3 *Year 2050*	358	243	$45,937,610	$289,606,570	$160,547,263	103 $33,365,270	107 $47,477,540	33 $87,910,060
Category 3 *Year 2070*	494	344	$56,141,730	$336,157,590	$191,457,193	160 $39,914,760	144 $70,295,440	40 $98,410,790
Category 3 *Year 2100*	1662	1319	$86,513,050	$532,582,480	$321,075,738	862 $107,270,960	393 $160,369,560	64 $124,769,090

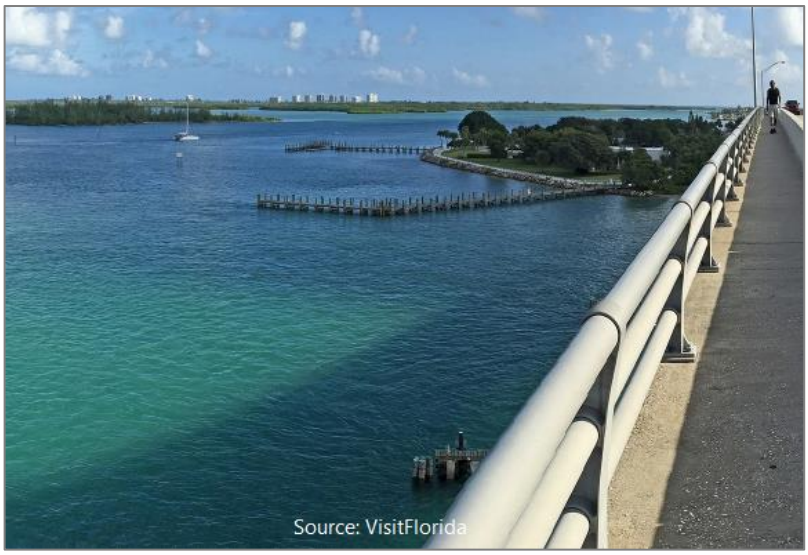
Hazard-Specific Vulnerability | Water Quality

The deterioration of water quality can be a serious vulnerability for a community from a life, safety and health perspective, as well as from an economic development perspective. Water quality was named the number one vulnerability by residents as part of the MetroQuest survey that is discussed in the next portion of this report.

Protecting the Lagoon

The Indian River Lagoon is a primary economic development generator for the City of Titusville, and keeping the waterway clean is vital from an economic and health perspective. Runoff from residential backyards and businesses add nitrogen and phosphorous-laden chemicals to the water, reducing water clarity and threatening critical ecosystems. In addition, stormwater outfalls that drain into the lagoon can be a source of pollutants.

As discussed in the Resiliency Themes and Strategies portion of this report, the City should consider strategies to limit the amount of pollutants that enter the lagoon such as lagoon friendly yards, living shorelines and other green infrastructure. These strategies can be directly invested in by the City on lagoon-adjacent publicly-owned properties, while the City can also provide educational materials to residents in order to increase lagoon-friendly practices on private property.



Pictured: The Indian River Lagoon

Saltwater Intrusion into Water Systems

Saltwater intrusion is a term to describe when salt water intrudes on fresh water bodies or stormwater infrastructure such as pipes, pumping wells and outfalls. When intrusion occurs into fresh water bodies, public drinking water may be compromised and freshwater ecosystems can suffer. On the other hand, saltwater intrusion into stormwater infrastructure can deteriorate pipes, causing premature aging and potential clogging over the long term. The overall capacity of the City's stormwater system can also be compromised.

As sea levels are projected to rise, saltwater intrusion is expected to increase in frequency. As discussed later in this report in the Resiliency Plan section, it is recommended that the City assess the elevations of all stormwater outfalls along the Indian River Lagoon while identifying system capacity vulnerabilities that may arise as a result of long-term sea level rise.

Lift Station and Wastewater Facility Impacts | All Hazards

Wastewater treatment facilities and lift stations are susceptible to a number of natural hazards, including groundwater flooding, sea level rise and storm surge[14]. These facilities are susceptible to corrosion and, if affected, can restrict wastewater treatment access to large segments of the population[14]. The table below and the map on the next page depict the risk posed to these facilities throughout the City.

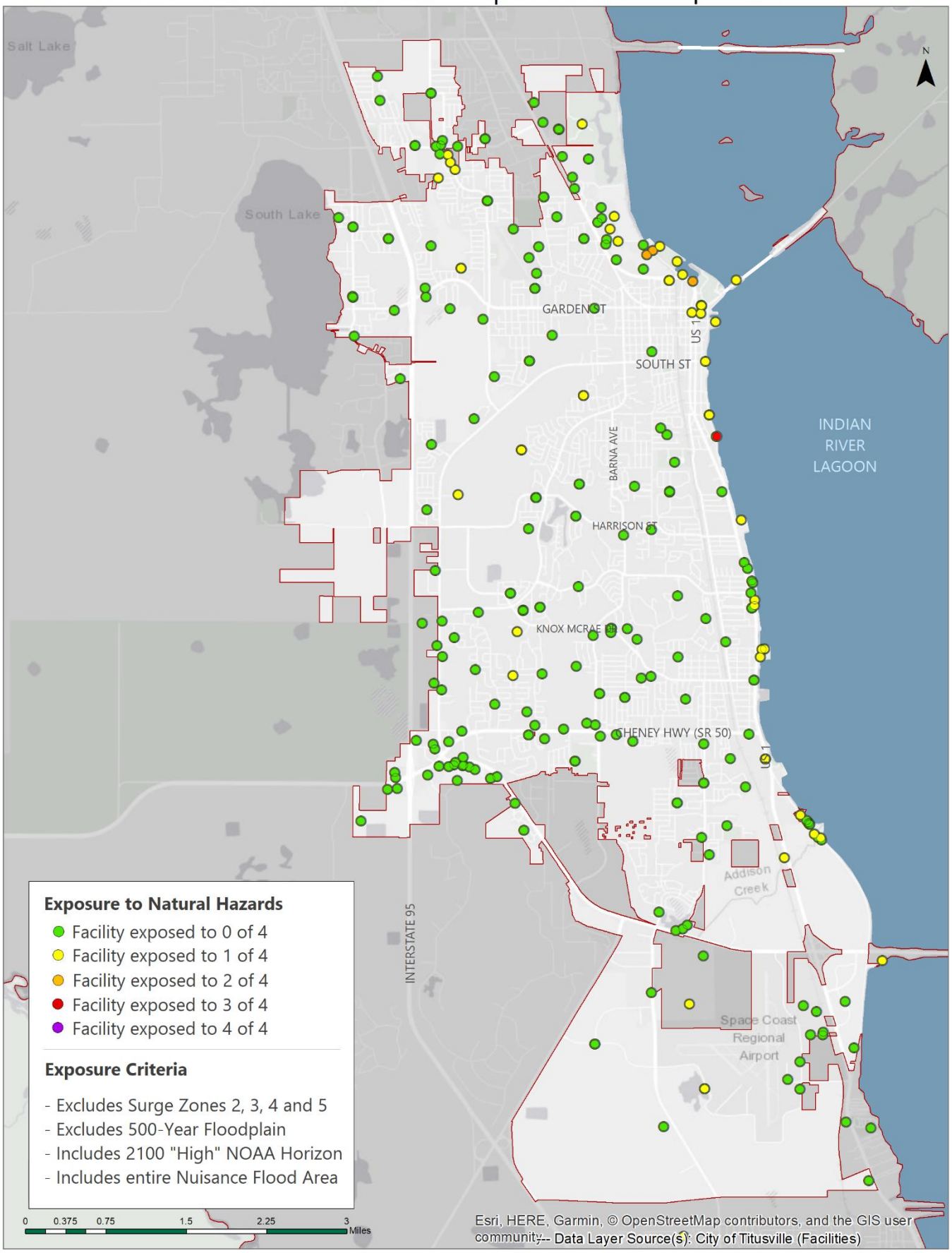
Table 18: Impacts to Lift Stations and Wastewater Facilities

Station ID	Surge Zone	ACOE SLR Horizon	NOAA SLR Horizon	Flood Zone	Nuisance Flood
JC	Cat. 5	None	None	None	No
JC 1	Cat. 4	None	2100	None	No
JC 3	Cat. 4	2100	2080	None	No
LS 13	None	None	None	Zone AE	No
LS 14	Cat. 4	None	2080	None	No
LS 15	Cat. 4	2100	2080	None	No
LS 18	Cat. 3	2100	2080	500 Year	No
LS 23	Cat. 5	None	None	None	No
LS 25	Cat. 4	None	2100	None	No
LS 28	None	None	None	Zone AE	No
LS 29	Cat. 4	None	2100	None	No
LS 3	None	None	None	Zone AE	No
LS 30	Cat. 5	None	None	None	No
LS 31	Cat. 1	None	2060	Zone AE	No
LS 32	None	None	None	Zone AE	No
LS 34	Cat. 4	None	None	None	No
LS 44	Cat. 4	None	None	None	No
LS 46	Cat. 5	None	None	None	No
LS 48	None	None	None	500 Year	No
LS 50	Cat. 4	None	None	None	No
LS 56	Cat. 4	2100	2080	None	No
LS 65	None	None	None	Zone A	No
LS 67	Cat. 5	None	None	None	No
LS 7	Cat. 4	None	None	None	No
LS 71	Cat. 3	2100	2080	500 Year	No
LS 77	None	None	None	Zone AE	No
LS 79	None	None	None	500 Year	No
LS 81	None	None	None	Zone A	No
LS 82	Cat. 4	None	2100	None	No
LS 83	Cat. 5	None	None	None	No
LS 91	None	None	None	Zone AE	No
LS 97	Cat. 4	2100	2080	None	No
P103	Cat. 4	None	None	None	No
P104	Cat. 4	None	None	None	No
P105	Cat. 3	2100	2080	500 Year	No
P106	Cat. 5	None	None	None	No
P107	Cat. 5	None	None	None	No
P108	Cat. 4	None	2100	None	No
P109	Cat. 4	None	2080	None	No
P112	None	None	None	Zone AE	No
P113	None	None	None	Zone AE	No
P114	None	None	None	Zone AE	No
P116	None	None	None	Zone AE	No
P118	None	None	None	500 Year	No
P122	Cat. 4	None	None	None	No
P127	Cat. 4	None	None	None	No
P131	Cat. 4	None	2100	None	No
P132	Cat. 4	None	2080	None	No

Station ID	Surge Zone	ACOE SLR Horizon	NOAA SLR Horizon	Flood Zone	Nuisance Flood
P136	Cat. 4	None	2100	None	No
P147	Cat. 4	None	None	None	No
P151	Cat. 2	2080	2080	Zone AE	No
P152	None	None	None	Zone A	No
P153	Cat. 4	None	2100	None	No
P155	Cat. 4	None	None	None	No
P156	Cat. 4	None	None	Zone A	No
P157	Cat. 5	None	None	None	No
P160	Cat. 4	None	2100	None	No
P165	Cat. 3	2100	2080	Zone AE	No
P168	Cat. 4	None	None	None	No
P172	Cat. 4	None	None	None	No
P175	Cat. 4	None	2100	None	No
P176	Cat. 4	None	None	None	No
P177	Cat. 4	None	None	None	No
P178	Cat. 4	None	None	None	No
P179	Cat. 5	None	None	None	No
P180	Cat. 4	None	2100	None	No
P185	Cat. 4	None	2100	None	No
P187	Cat. 3	2100	2080	500 Year	No
P188	Cat. 4	None	None	None	No
P190	Cat. 4	None	None	None	No
P191	Cat. 4	None	2100	None	No
P194	Cat. 4	None	None	None	No
P195	Cat. 2	2080	2060	Zone AE	No
P197	Cat. 5	None	None	None	No
P198	Cat. 5	None	None	None	No
P199	Cat. 4	None	None	None	No
P201	None	None	None	500 Year	No
P202	None	None	None	500 Year	No
P203	Cat. 4	None	2100	None	No
P204	Cat. 5	None	None	None	No
P205	Cat. 4	None	None	None	No
P207	Cat. 5	None	None	None	No
P215	Cat. 4	None	None	None	No
P218	Cat. 3	2080	2080	Zone AE	No
WW 13	None	None	None	Zone AE	No
WW 15	Cat. 4	2100	2080	None	No
WW 18	Cat. 3	2100	2080	500 Year	No
WW 28	None	None	None	Zone AE	No
WW 29	Cat. 4	None	2100	None	No
WW 31	Cat. 4	None	2080	None	No
WW 32A	None	None	None	Zone AE	No
WW 44	Cat. 4	None	None	None	No
WW 50	Cat. 4	None	None	None	No
WW 56	Cat. 4	2100	2080	None	No
WW 65	None	None	None	Zone A	No
WW204	Cat. 5	None	None	None	No

LS = Lift Station ---- WW = Wastewater Treatment ---- JC = Junction Chamber ---- WW204 = Wet Well

Lift Stations & Wastewater Facilities | Cumulative Exposure to Hazards



Stormwater Outfall Impacts | All Hazards

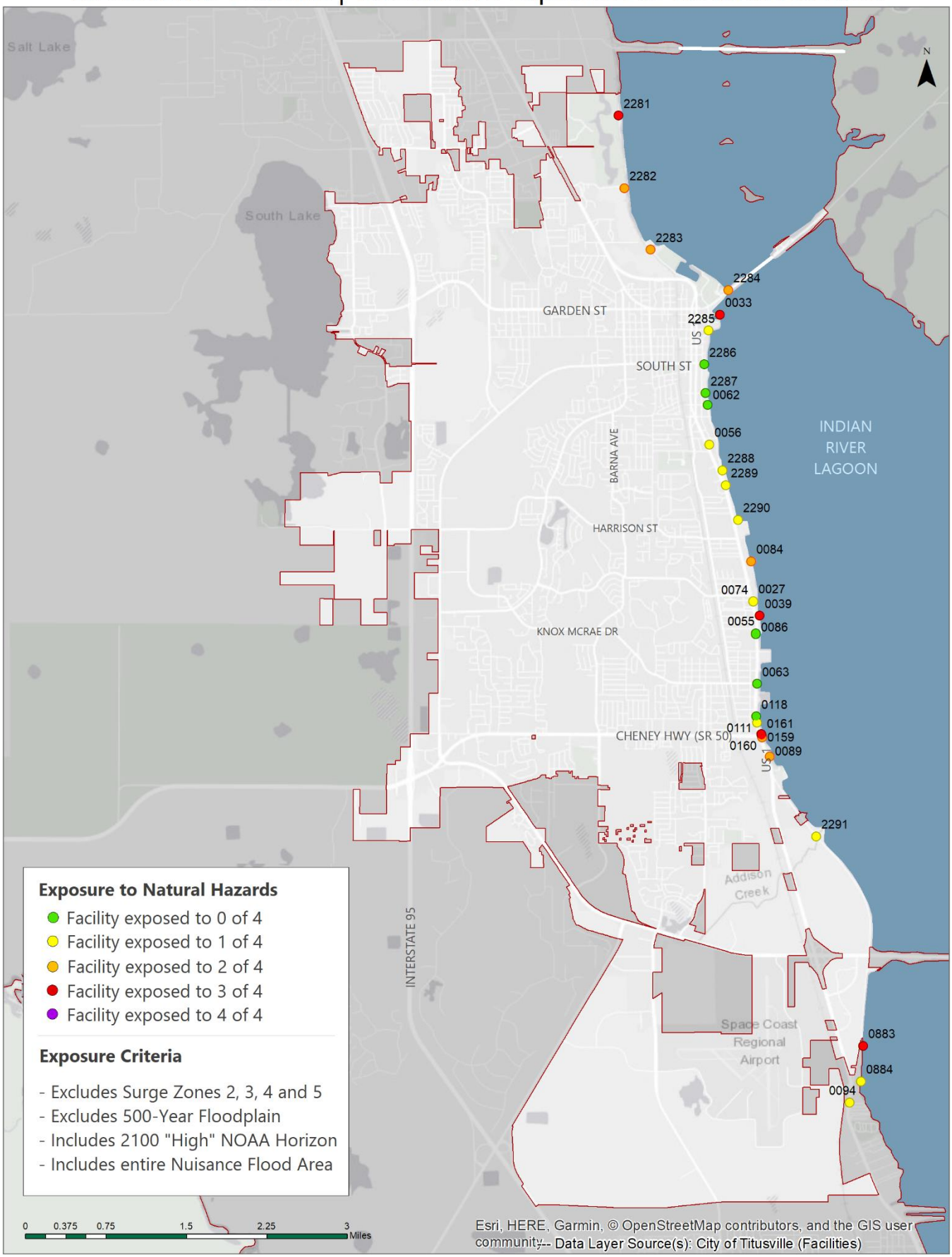
Stormwater infrastructure is critical to flood management, and the natural hazards addressed in this report can cripple its ability to function effectively. Storm surge can damage outfalls in short periods of time, while sea level rise and nuisance flooding can lead to long term corrosion of outfalls due to saltwater intrusion[15]. It is recommended that the City perform a more in-depth study of the elevation of these structures above mean sea level and consider raising the most at-risk outfalls.

The table below shows the stormwater outfalls identified as part of a 2016 East Central Florida Regional Planning Council study of the Indian River Lagoon. The map ID in the chart below corresponds to the map ID labels on the following page.

Table 19: Impacts to Stormwater Outfalls

Map ID	Maintaining Agency	Storm Surge Zone	ACOE SLR Horizon	NOAA SLR Horizon	Flood Zone	Nuisance Flood Area
0033	FDOT	Category 1	2100	2060	Zone AE	No
0039	FDOT	Category 2	None	2060	Zone AE	Yes
0084	FDOT	None	None	2040	Zone AE	No
0089	FDOT	None	2100	2060	Zone AE	No
0159	FDOT	Category 2	2080	2080	Zone AE	No
0160	FDOT	Category 1	2080	2060	Zone AE	No
0161	FDOT	Category 1	2080	2060	Zone AE	No
0883	Private	Category 1	2100	2060	Zone AE	No
2281	Brevard County	Category 1	2080	2040	Zone AE	No
2282	City of Titusville	Category 3	2080	2080	Zone AE	No
2283	City of Titusville	Category 2	2080	2080	Zone AE	No
2284	City of Titusville	None	None	2040	Zone AE	No
0027	FDOT	Category 4	None	2080	None	No
0055	FDOT	Category 4	None	None	None	No
0056	FDOT	Category 4	None	2080	None	No
0062	FDOT	Category 4	None	None	None	No
0063	FDOT	Category 4	None	None	None	No
0074	FDOT	Category 4	None	2100	None	No
0086	FDOT	Category 4	None	None	None	No
0094	FDOT	Category 5	2040	2040	None	No
0111	FDOT	Category 4	None	2100	None	No
0118	FDOT	Category 4	None	None	None	No
0884	Private	Category 4	None	2080	None	No
2286	City of Titusville	Category 4	None	None	None	No
2287	City of Titusville	Category 4	None	None	None	No
2288	City of Titusville	Category 4	None	2100	None	No
2289	FDOT	Category 4	None	2100	None	No
2290	FDOT	Category 4	None	2060	None	No
2291	Brevard County	Category 4	None	2100	None	No
2285	City of Titusville	Category 3	2100	2080	500 Year	No

Stormwater Outfalls | Cumulative Exposure to Natural Hazards



Impacts to S.C.A.T Bus Stops

Space Coast Area Transit (S.C.A.T) operates throughout the City of Titusville and eleven bus stop locations are currently situated in hazard zones. Mitigating impacts to bus stops can include moving the stop (benches, trash receptacles and cover) to a more secure location. The table below summarizes the modeled impacts to the City's vulnerable bus stops, many of which are located along US Highway 1.

Table 20: Impacts to Bus Stops

Bus Stop Location	Coastal High Haz. Zone (Cat 1)	NOAA SLR Horizon	USACE SLR Horizon	Nuisance Flood Area	FEMA Flood Zone
Indian River Ave. at Julia St.	No Exposure	2100	None	No	None
Indian River Ave., North of Main St.	No Exposure	2080	2100	No	None
S. Hopkins Ave., North of Orange St.	No Exposure	2080	None	No	None
US1, North of Columbia Blvd.	No Exposure	None	None	No	Zone A
US1, North of Garden St.	No Exposure	2080	2100	No	None
US1, South of Jackson St. (East Side)	No Exposure	2100	None	No	None
US1, South of Jackson St. (West Side)	No Exposure	2100	None	No	None
US1, South of Riverside Dr. (East Side)	No Exposure	2100	None	No	None
US1, South of Riverside Dr. (West Side)	No Exposure	2080	None	No	None
US1, South of SR 50 (East Side)	No Exposure	2080	2100	No	None
US1, South of SR 50 (West Side)	No Exposure	2080	2100	No	None

Impacts to the F.E.C Railroad Network

The Florida East Coast Railway runs for 9.72 miles through the City of Titusville and is susceptible to the impacts of multiple hazards covered in this report. The most at-risk portion of the railway is located in and to the north of the downtown area. Here, the railway comes into close proximity of the lagoon and is highly susceptible to multiple hazards, including storm surge, sea level rise and the 100-year flood. At this time, the railway is raised enough to avoid the Category 3, 4, and 5 surge zones and the railway surface is not projected to be impacted by sea level rise before the year 2080. The table below depicts the risk posed to the railroad network to storm surge, nuisance flooding, the 100-and-500-year flood zones and the USACE and NOAA sea level rise curves. Additional information regarding potential impacts from sea level rise can be found in the Space Coast TPO Sea Level Rise Vulnerability Assessment.

Table 21: Impacts to Railroads

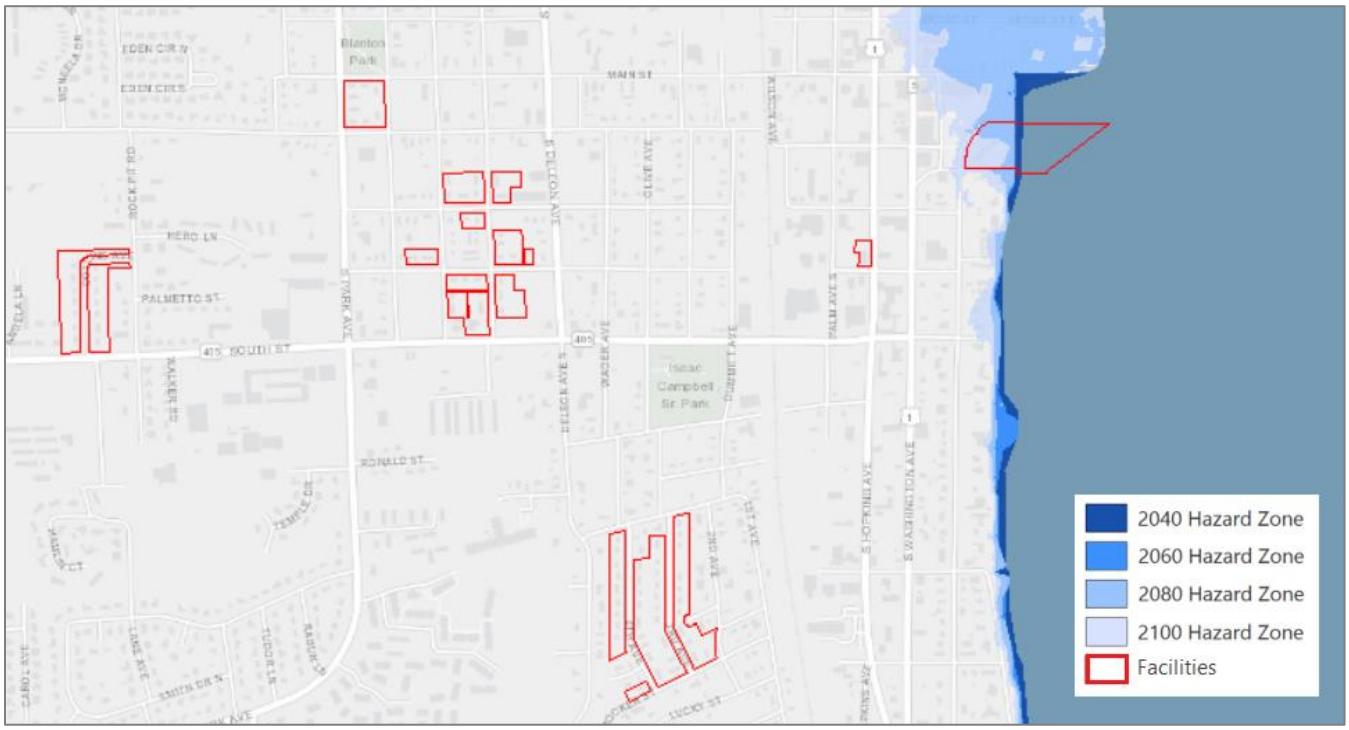
	Cat. 1 Storm Surge	Cat. 2 Storm Surge	Cat. 3 Storm Surge	Cat. 4 Storm Surge	Cat. 5 Storm Surge	Nuisance Flood Area	FEMA 100 Year Flood Zone	FEMA 500 Year Flood Zone
Linear Miles Within Hazard Zone (% total mileage)	None	None	None	2.79 mi. 28.7%	7.42 mi. 76.3%	None	0.03 mi. 0.003%	1.10 mi. 11.3%

	USACE SLR 2040	USACE SLR 2060	USACE SLR 2080	USACE SLR 2100	NOAA SLR 2040	NOAA SLR 2060	NOAA SLR 2080	NOAA SLR 2100
Linear Miles Within Hazard Zone (% total mileage)	None	None	None	0.16 mi. 0.02%	None	None	1.09 mi. 11.2%	1.60 mi. 16.5%

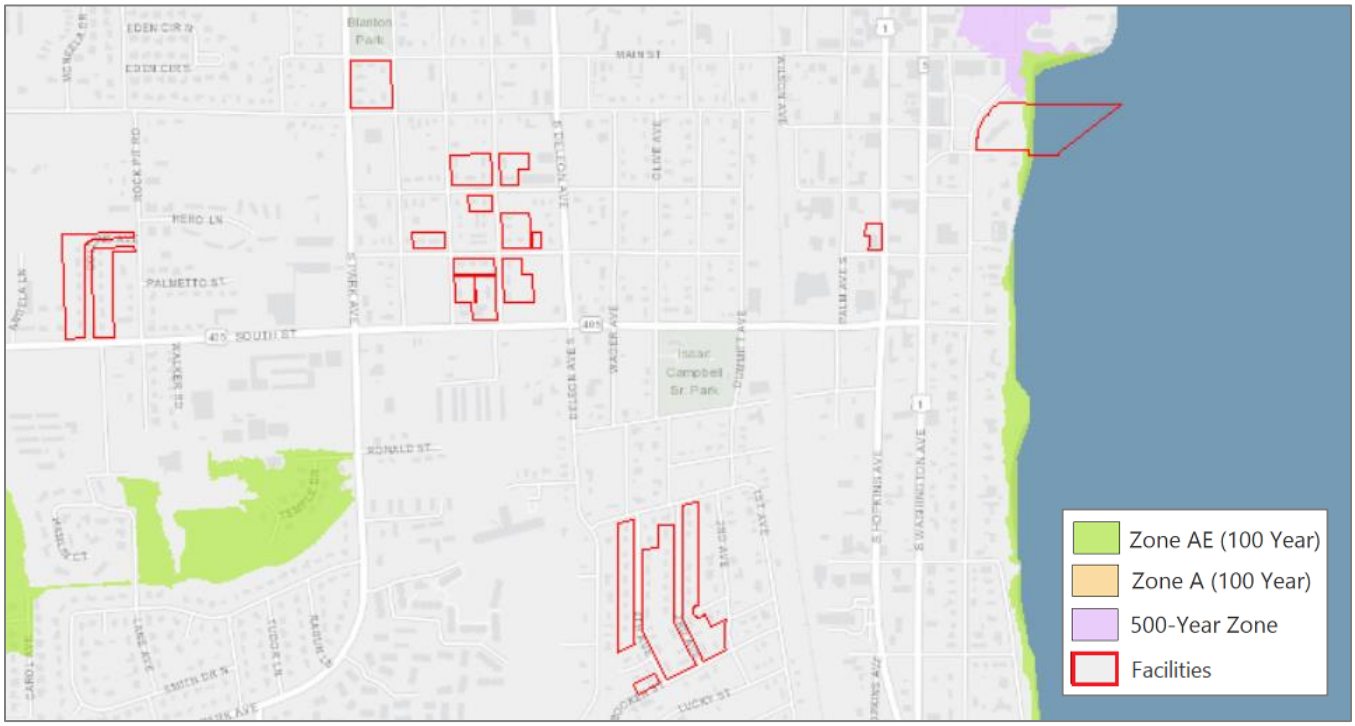
Housing Authority Property Impacts | All Hazards

The Titusville Housing Authority owns a number of properties within the City, and some of these facilities are projected to be impacted by the hazards covered in this report. The map series below depicts these facilities in the context of storm surge, sea level rise, FEMA flood zones and the nuisance flooding area.

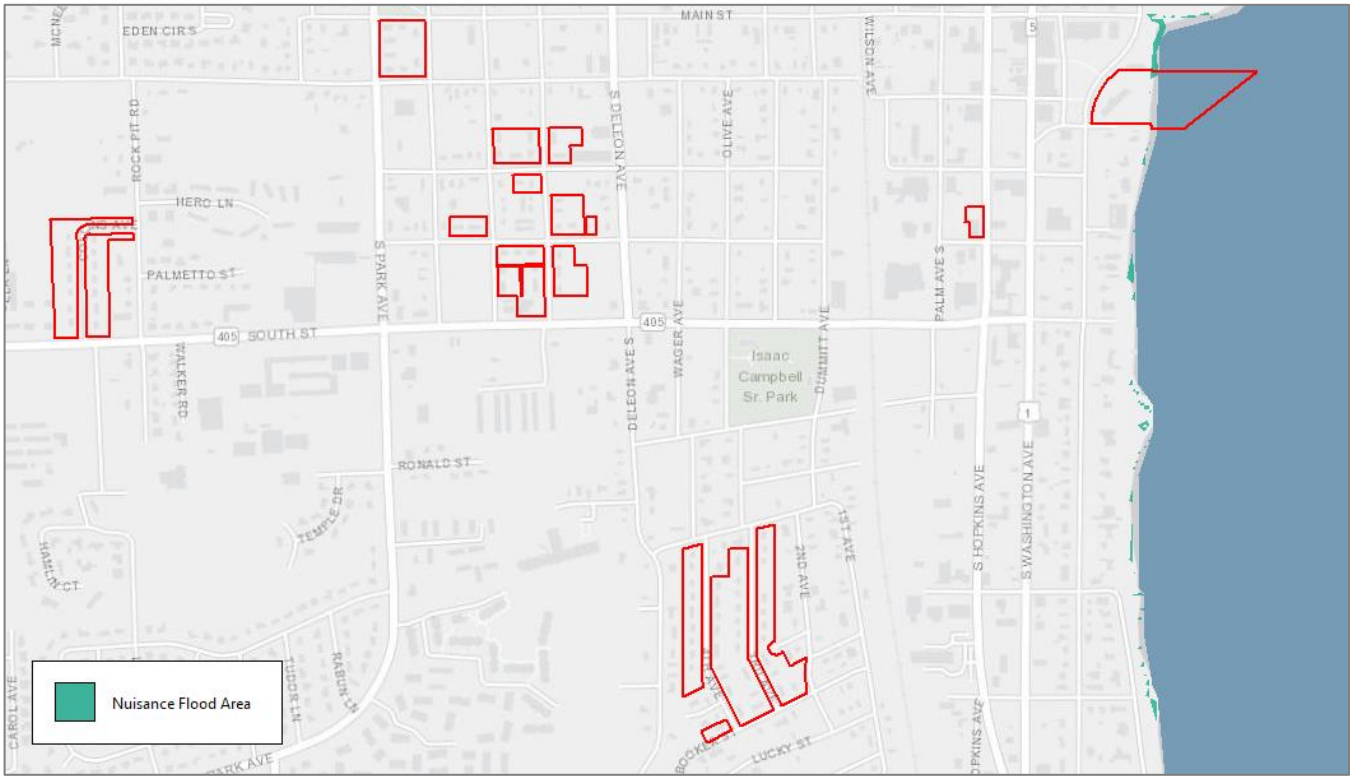
Housing Authority Map Series: Sea Level Rise



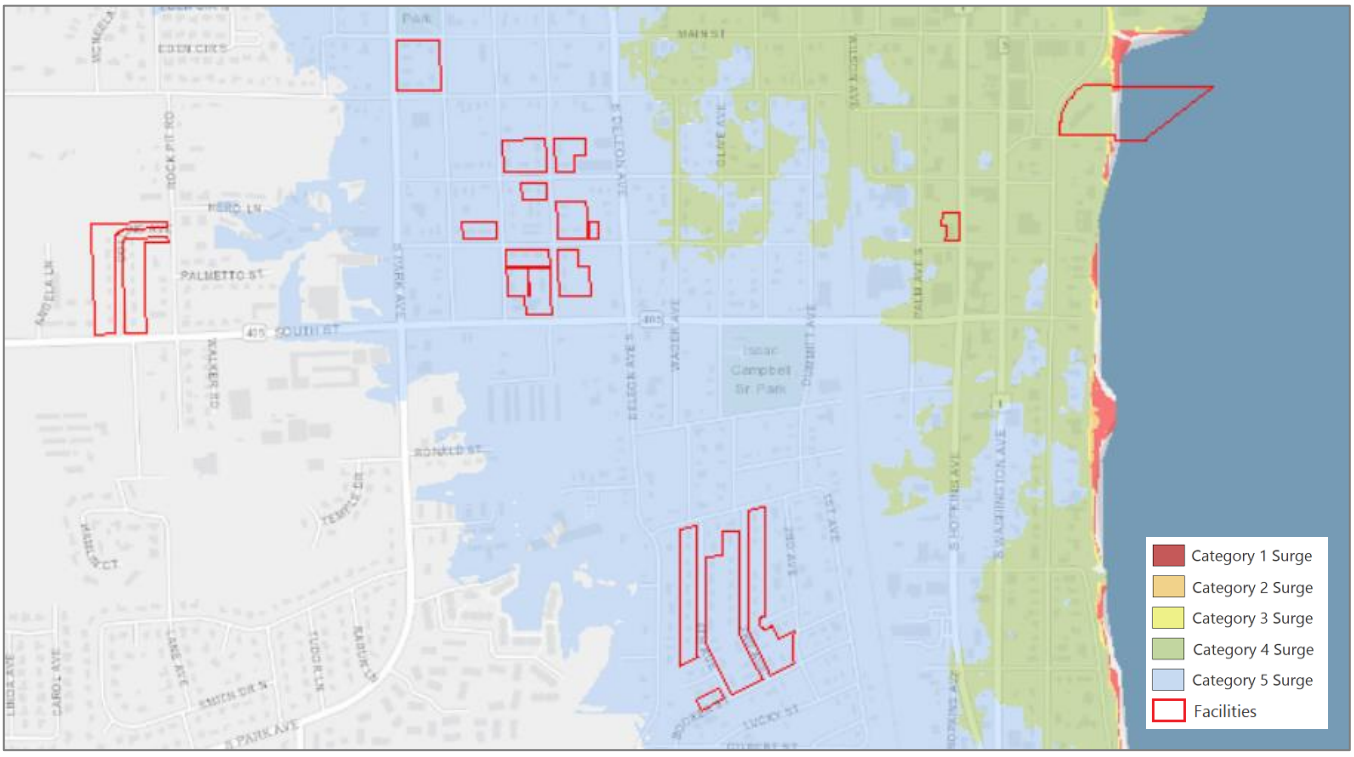
Housing Authority Map Series: FEMA Flood Zones



Housing Authority Map Series: Nuisance Flooding Areas



Housing Authority Map Series: Storm Surge Zones



IV. Public Input

A thorough public input process accompanied the development of this resiliency plan and served to bridge identified vulnerabilities with citizen-driven solutions. As part of this process, two public workshops were held and an online survey was distributed to City residents. This portion of the report summarizes the input received from the public and how it informed the development of the resiliency plan.

Overview of Meetings and Outreach

Public Workshop #1

Date: November 15, 2018

MetroQuest Survey

Dates Open: January 31, 2019 – March 1, 2019

Public Workshop #2

Date: March 28, 2019

Public Workshop #1

The first workshop focused on the identification of vulnerabilities facing the community as well as two map exercises designed to gather location-specific input. These exercises guided the development of the vulnerability analysis, strategies and themes, survey and final resiliency plan.

Public Workshop #1: Development of Vulnerabilities and Strategies

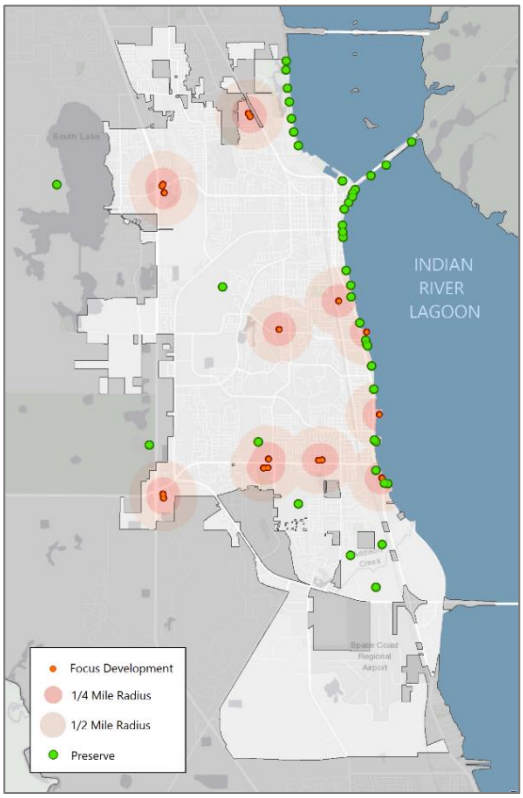
Meeting attendees were asked to identify Titusville's biggest vulnerabilities in order to narrow the focus of the conversation and identify solutions for dealing with these vulnerabilities. The following vulnerabilities and strategies, which have been condensed for the purposes of this report, were developed as part of this first exercise:

Table 22: Workshop #1 Vulnerabilities and Strategies

Vulnerability	Identified Resiliency Strategies
Aging Infrastructure	Educate young residents; Infrastructure replacement plan; Landscaping that encourages absorption
Development Pressures	Density in the core; Preserve greenspaces; Strengthen zoning codes; Infrastructure must keep up
Diminishing Property Value	Facilitate raising of properties; Raise/harden public assets; Obtain climate data with high certainty level
Fiscal Concerns	User fees; Limit incentives to non-green businesses; Use visioning plan for economic development
Hurricanes	Reclaim shoreline; Strengthen codes; Limit outflow into lagoon; Low impact development
Lack of Stormwater Infrastructure	More trees; Underground utilities; Retention areas with wetlands
Polluted Water Ecosystems	Rethink bridge concepts; Septic/fertilizer regulation; Retention; Living shorelines; Xeriscaping
Salt Water Intrusion	Increase outfall capacity; Raise outfalls; Study why wells are failing; Redesign stormwater system
Sea Level Rise	Mangrove buffers; Restrict development; Strong building codes; Find best practices
Traffic & Lack of Transit	Reduce auto-dependence; Better sidewalks; Local trolley system; Pedestrian amenities
Water Quality	Limit pesticides/pollutants in river; Artificial turf; Divert runoff away from river; Sustainable growth

Public Workshop #1, Map Exercise #1
Identification of Future Preservation & Development

This exercise allowed residents to place dots on areas of the City that they would like to see preserved as greenspace or focused on as areas for new development. The map to the right depicts feedback provided by residents.

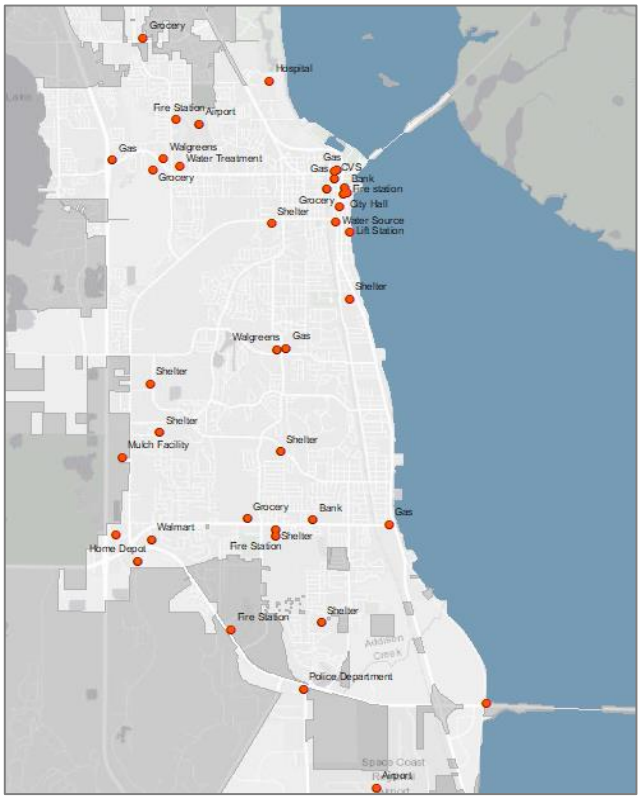


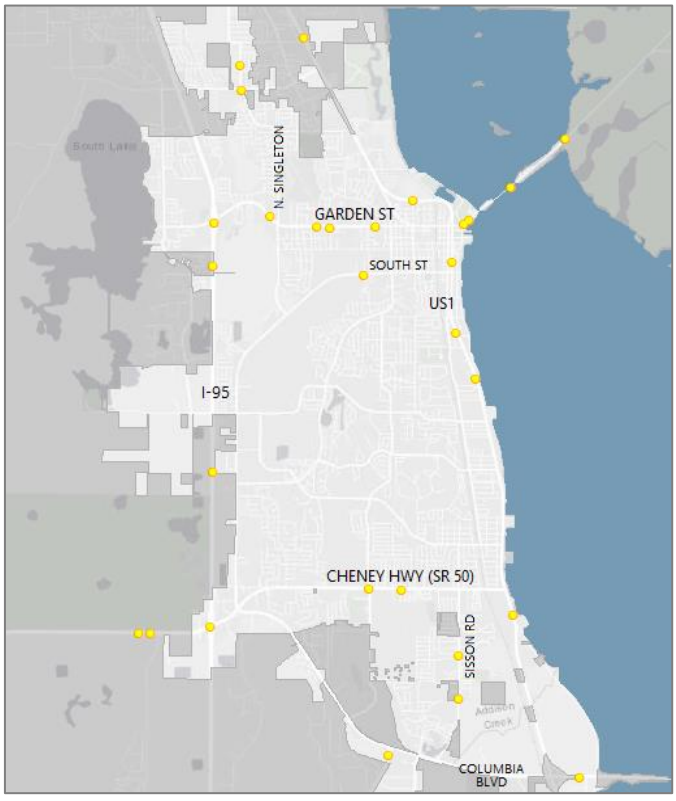
Citizens focused much of their time placing preservation dots along the Indian River Lagoon, as water quality and the impacts of hurricanes are among the City's most identified vulnerabilities. Preservation dots can also be found to the west, signaling a desire for City residents to have a western growth boundary. Additional preservation dots were placed to the north of Space Coast Regional Airport.

Future development dots are somewhat scattered, but there is some consistency. The State Road 50 (Cheney Highway) corridor is a linear connector of many focus areas, while the lagoon coastline is preferred by some. Residents made clear their desire to keep the shoreline "low impact" if developed.

Public Workshop #1, Map Exercise #2 – Critical Businesses and Roadways

The following businesses (left) and roadways (right) were deemed critical after storm events by residents:





MetroQuest Survey

Using the input received from the first Public Workshop, a survey was developed to further clarify and organize the vulnerabilities, strategies and opportunities preferred by residents from a resiliency perspective. A total of 85 survey responses were received. The results of this survey have informed the development of the City's Resiliency Themes and Strategies, which are located in Section V of this report. The results of the survey are below:

Ranked Vulnerabilities

As part of the survey, citizens were asked to rank their top three vulnerabilities from a list of six. The following results were tabulated (with average ranking in parenthesis):

1. Water Quality (1.54) *High score led to the addition of "Water Quality" as the sixth hazard analyzed in this report
2. Aging Infrastructure (1.91)
3. Hurricanes and Storm Surge (1.94)
4. City Improvement Funding (2.13)
5. Flooding (2.32)
6. Sea Level Rise (2.54)

Ranked Strategies

Residents then ranked the top strategies from three resiliency perspectives; protect, adapt and retreat. The following results were tabulated with average 0 through 5 rating in parenthesis:

Protect	Adapt	Retreat
1. Green Infrastructure (4.45)	1. Green Public Areas (4.53)	1. Land Use (4.12)
2. Stormwater Infrastructure (4.30)	2. Green Private Properties (3.92)	2. Land Acquisition (3.89)
3. Gray Infrastructure (3.78)	3. Policy (3.73)	3. Policy (3.43)
4. Property Improvement (3.54)	4. Gray Infrastructure (3.56)	4. Property Relocation (3.16)
		5. Funding Relocation (3.08)

City Opportunities

The final task for residents included prioritizing from a list of seven opportunities that residents would like to see prioritized by the City. The following results were tabulated (with average ranking in parenthesis):

1. Adaptation and Conservation (2.15)
2. Sustainable Development (2.31)
3. Resilience Action Plan (2.50)
4. Stormwater Master Plan (2.52)
5. Elevation Increases (2.57)
6. Funding (2.64)
7. Redevelopment (2.64)

Survey Respondent Information

Age: 32% between 26 – 40; 50% between 41 – 60, 17% between 61 – 80; and 1% over the age of 81.
Average Time Living in Titusville: 32% less than 5 years; 14% between 5 and 10 years; 14% between 11 and 20 years; and 40% more than 21 years.

Public Workshop #2

The second Public Workshop built on the input received in the first Public Workshop and the MetroQuest survey. ECFRPC staff presented the results of the Vulnerability Assessment, the Resiliency Themes and Strategies (detailed in Section V) and shared the results of the MetroQuest survey. The public had the opportunity to take part in an open house and comment on the draft plan.

The open house included four stations that allowed participants to view the plan and maps, learn about and give their opinions on the resiliency strategies covered in Section V, and interact with resiliency and planning professionals from around the County and Region. The stations included:

1. ### Vulnerability Assessment and Map Review

   Participants were able to view the draft version of the Vulnerability Assessment and review large print out maps depicting the City's vulnerabilities to natural hazards. City and ECFRPC planning staff answered questions concerning the plan and took notes on additional information to be added.

Pictured: Residents place dots on their preferred resiliency strategies.

2. ### Resiliency Strategy Review and Discussion

   The "Resiliency Themes and Strategies" covered in Section V of this report were displayed for residents to learn about with planning team members on hand to answer questions. Residents were able to place dots on their preferred strategies, which was provided to the City.

Pictured: Residents learn about living shorelines.

3. ### Living Shorelines Exhibit

   Jane Hart with the Brevard County Natural Resources Department exhibited the County's living shorelines program and provided participants with information on their benefits, uses, and examples of local applications in Brevard County.

4. ### University of Florida IFAS Exhibit

   Holly Abeels with the University of Florida Institute of Food and Agricultural Sciences (IFAS) presented an exhibit detailing native Floridian plant species, best practices for sustainable planning, lawncare and gardening, and other IFAS research projects.

Pictured: UF IFAS Exhibit

V. Resiliency Theme and Strategy Development

The vulnerability assessment and public outreach process crafted the development of four resiliency themes that form the basis of the recommendations in the Resiliency Plan section of this report. Each of these themes have their own set of associated strategies that are analyzed in this section. The four resiliency themes are summarized below:

1. **Adapt & Protect**

   Protecting critical infrastructure in and around hazard zones is critical when facility relocation or other options are not feasible. Adapting to the effects of natural hazards means installing infrastructure and technology that lessen the financial and societal impacts while enhancing overall system functionality. Protecting critical assets can be done in a number of ways, such as through sea walls, raising structures and buffering shorelines, while adapting can be achieved through stormwater parks, bioretention and other strategies.

2. **Retreat**

   Retreating from natural hazards should occur when the long-term costs of development in a hazardous area exceeds the cost of relocation or developing in another area. The vast majority of retreating strategies are land use and policy-based, such as imposing hazard zone setbacks, down zoning, cluster zoning, transfer of development rights and adopting urban service area boundaries. Retreating also includes facility relocation, which is expensive in the short term but cost-saving over the long-term.

3. **Prepare & Recover**

   Preparing and recovering from natural hazards involves pre-planning a community's response in order to lessen the financial and societal impacts. This theme gets to the root of resiliency – the ability to bounce back – and there are a number of options available to communities. Ensuring that local government and local businesses have continuity of operations plans or emergency generators can restore critical services quickly after a storm. On the other end of the spectrum, post-disaster redevelopment planning looks at long-term recovery.

4. **Mobilize & Educate**

   Having an active, involved public is one of the greatest assets a community can have. This resiliency theme largely focuses on gathering stakeholders throughout the community for education programs as well as citizen-led advocacy groups. Educating citizens and elected officials on topics such as property mitigation, preparing for natural hazards, and lagoon-friendly practices can greatly reduce the financial impact of natural hazards.

This section of the report provides information on strategies that can be implemented to reinforce the four resiliency themes outlined above. The resiliency strategies covered generally fit into six categories, including 1) Gray Infrastructure, 2) Green Infrastructure, 3) Property Improvements, 4) Land Use & Policy, 5) Education and 6) Administrative. The table on the next page outlines these strategies.

Resiliency Theme & Strategy Matrix

The following resiliency strategies are analyzed within this section of the report within their respective themes. Costs, uses and case studies were reviewed are part of this analysis.

Theme	Strategy	Project Type
Adapt & Protect	Sea Wall	Gray Infrastructure
	Groins & Breakwaters	Gray Infrastructure
	Levee	Gray Infrastructure
	Tidal Barrier	Gray Infrastructure
	Raising Roadways	Gray Infrastructure
	Water Pump Systems	Gray Infrastructure
	Underground Utilities	Gray Infrastructure
	Install Larger Stormwater Pipes	Gray Infrastructure
	Berms (Revetments)	Green Infrastructure
	Habitat Restoration	Green Infrastructure
	Beach Renourishment	Green Infrastructure
	Living Shorelines	Green Infrastructure
	Low Impact Development	Green Infrastructure
	Green Streets (Bioretention)	Green Infrastructure
	Stormwater Parks	Green Infrastructure
	Down Spouts, Rain Gardens & Harvesting	Green Infrastructure
	Permeable Pavement & Green Parking	Property Improvement
	Raising Structures	Property Improvement
	Flood Proofing	Property Improvement
	Floating Structures	Property Improvement
	Structure Hardening	Property Improvement
	Surface Water Management Regulations	Land Use / Policy
	Parcel Tier Designations	Land Use / Policy
	Groundwater Extraction Regulations	Land Use / Policy
	Lagoon Friendly Yards	Land Use / Policy
	Increase Design Standards/Code	Land Use / Policy
Retreat	Hazard Zone Setbacks	Land Use / Policy
	Rolling Easement	Land Use / Policy
	Down Zoning	Land Use / Policy
	Cluster Zoning	Land Use / Policy
	Land Purchase & Transfer of Dev't Rights	Land Use / Policy
	Urban Service Area Boundaries	Land Use / Policy
	Velocity Zone Standards	Land Use / Policy
	Facility Relocation	Property Improvement
Prepare & Recover	Emergency Generators	Property Improvement
	Solar Power Battery Storage	Property Improvement
	Continuity of Operations Plans	Administrative
	Post-Disaster Redevelopment Plans	Administrative
	Debris Management Plans	Administrative
Mobilize & Educate	Topic: Property Improvement Strategies	Education
	Topic: Vulnerabilities Facing Titusville	Education
	Topic: How to Prepare for Natural Hazards	Education
	Topic: Lagoon-Friendly Practices	Education
	Implement a City-Wide Sustainability Program	Mobilization
	Foster Hands-On Collaboration	Mobilization

Resiliency Theme #1 Overview | Adapt & Protect

Adapting and protecting structures, roadways and infrastructure to future hazard conditions is a complex undertaking that requires both 1) an analysis of vulnerabilities facing the community, and 2) a high level of fiduciary responsibility. This resiliency theme comes with a vast range of potential strategies ranging from green and gray infrastructure, to individual property improvements and policy considerations. These strategies, summarized in the matrix, are analyzed on the next seven pages of this report.

Why Plan to Adapt and Protect?

Planning for changes in sea levels, higher-than-currently-observed storm surge levels, increasing floodplain sizes, nuisance flooding and water quality is a long-term undertaking with time-sensitive priorities. While some natural hazards are affecting the City today and must be dealt with immediately, other hazards are further down the horizon and must be taken in stride. As analyzed in the vulnerability assessment portion of this report, the City of Titusville has upwards of half-a-billion dollars in real estate value exposed to the various natural hazards covered. It is important that strategies to address asset vulnerabilities be determined with a high level of foresight, fiduciary responsibility and citizen input.

The Focused, Synergetic Implementation of Strategies within Adaptation Action Areas

Adaptation Action Areas, also known as "AAA's", are areas of the City that are prioritized for a range of resiliency projects due to the area's high exposure to natural hazards over the short and long term. When reviewing the strategies on the following pages, it is important to keep in mind that a mix of strategies will likely need to be utilized in conjunction within identified areas of the City (such as the downtown area or near the intersection of State Road 50 and US Highway 1). In short, adaptation and protection strategies should be synergetic with one another and geographically-focused in their implementation. The delineation of Adaptation Action Areas is highly recommended.

Strategic Patience: The Relationship Between the Innovation Curve and Cost

The term "strategic patience" in relation to innovation, time and costs is a critically important concept for City staff to consider when making fiduciary commitments to resilience. The general relationship between the innovation curve and cost is impacted by the passage of time; in short, as time goes on, today's technology will become cheaper. When considering the strategies on the following pages and the vulnerability assessment portion of this report, this concept is critical. For example, if a facility is not projected to be impacted by sea level rise until the year 2040, then it would be prudent for the City to invest in mitigation projects later rather than today. When considering adaptation, protection and retreating strategies, this concept is paramount and will have a considerable long-term financial impact.

It Is critical that the City consider return on investment and continually implement policies, plans and funding to ensure funding is available when it is needed.

Seawalls

Type: Gray Infrastructure
Cost: $500 - $2,000 per linear foot[16]

Overview: Seawalls are designed to prevent erosion and flooding on private and public property situated in coastal areas. Virginia Beach, Virginia built a 55-block seawall along public and private properties as a first defense against storm surge and sea level rise. Seawalls last for three to five decades but can deteriorate coastal habitats if not used alongside living shorelines.

Groins & Breakwaters

Type: Gray Infrastructure
Cost: $125 - $200 per foot (Rock); $65 - $100 per foot (Wood)[17]

Overview: These are hard shoreline structures that act as barriers to protect a coast or harbor from strong waves and storm surge. South Beach, Miami has a breakwater barrier to protect the beach from intense water activity coming from the harbor. Breakwaters can also offer recreational opportunities for residents who like to walk along the shore or fish.

Levees

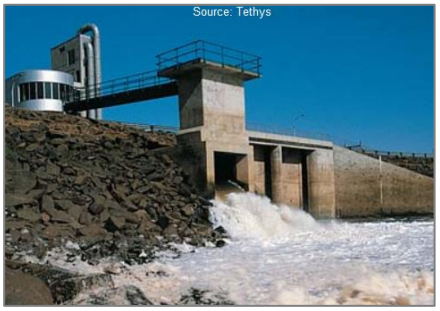
Type: Gray Infrastructure
Cost: $2.5 to $5.0 million per mile[18]

Overview: Levees can be man-made or naturally occurring to regulate water levels and prevent overflow. These structures are typically elongated embankments that are parallel to the flow of water. They lower water levels on adjacent lands by managing the flow of water. The applicability of levees in Titusville would need to be determined by City staff.

Tidal Barrier (Dam)

Type: Gray Infrastructure
Cost: $3.0 to 15.0 million (Tidal Energy Station)[19]

Overview: Dam-like structure that limits high tides and storm surge from traveling upstream, reducing potential overflow of creeks and banks. This infrastructure could be implemented in lagoon-adjacent areas where there are critical facilities in need of protection. The applicability of tidal barriers in Titusville would need to be determined by City staff.



Berms & Revetments

Type: Green Infrastructure

Cost: $18 - $35 per cubic yard (Riprap)[17]

Overview: Berms are raised barriers or shelves that serve as a fortification border between two areas to control erosion and sedimentation. Revetments are slanted structures placed along the coastline to absorb the force of incoming waves. Berms can be aesthetically pleasing if done correctly, as seen in the picture to the right.

Habitat Restoration

Type: Green Infrastructure

Cost: Variable, depending on habitat. Volunteers recommended.

Overview: Restoration of dunes, wetlands and marshlands can improve water quality and the health of ecosystems, provide recreational and philanthropic opportunities, and buffer property from water velocity. Groups such as the Surfrider Foundation volunteer to do this kind of work in other locations around the state of Florida.

Beach/Shoreline Nourishment & Replenishment

Type: Green Infrastructure

Cost: $16 per cubic foot (Panama City Beach case study)[20]

Overview: This strategy lengthens beaches or reduces water depths, may restore natural sand flow where it has been interrupted, and provides erosion protection for a large area over time. This type of project is most useful in areas that are highly susceptible to coastal erosion. The applicability of replenishment depends on the presence of a sand beach.

Living Shorelines

Type: Green Infrastructure

Cost: $1.30 - $4.50 per square foot[17]

Overview: A vegetated shoreline that utilizes local plants with the purpose of dissipating erosive wave energy, filtering out toxins from water draining into the lagoon and supporting coastal marine ecosystems. Many types of living shorelines exist, including salt marshes, mangroves, oyster reefs, and other vegetative systems that utilize robust local species. Often times, a mix of strategies are used. These low-cost systems provide an alternative to seawalls and work best in low-wake zones.

Raising Roadways

Type: Gray Infrastructure

Cost: $3.0 - $7.5 million per mile (Florida Keys case study)[21]

Overview: When transportation infrastructure is susceptible to periodic flooding, cities may resort to raising roadways to prevent further inundation. This ensures that accessibility is maintained during and after a storm event for first responders and those in need of assistance. This strategy has been implemented widely in south Florida.

Raising Structures

Type: Property Improvement

Cost: $3,700 to $6,000 (Home) ranging to $100,000 (Large Building)[22]

Overview: To reduce the probability of inundation and wave action, private and public property owners may choose to raise structures above base flood elevation. This strategy can be implemented through the Hazard Mitigation Grant Program (HMGP) or through private investment. The feasibility of this strategy should be based on a cost-benefit analysis.

Water Pump Systems

Type: Gray Infrastructure

Cost: $237,000 to $587,000 per daily million gallons pumped[23]

Overview: It is essential for cities to have adequate water pumping systems to allow the distribution of clean water and proper disposal of wastewater. Costs are based on the daily volume of water pumped from the service area. Miami Beach has implemented a water pump system, although this strategy may not be financially feasible for all cities to implement in large degrees.

Underground Utilities

Type: Gray Infrastructure

Cost: $3 million per mile[35]

Overview: Moving utilities underground has the benefit of protecting critical assets from the affects of wind, rain, and other hazards while reducing accidental injuries (such as electrocution) and associated repair costs following a natural disaster event. Water table issues also must be assessed before underground utilities are installed.

Install Larger Stormwater Pipes

Type: Gray Infrastructure

Cost: Generally, $88 - $256 per linear foot, up to $547 (case studies)[24]

Overview: This infrastructure, part of a City's stormwater management system, is designed to drain excess rain and ground water from impervious surfaces such as parking lots, sidewalks, public areas and paved streets into canals and receiving water bodies. Installing larger storm water pipes would increase the City's water drainage capacity.

Flood Proofing Structures

Type: Property Improvement

Costs: $4,290 - $8,800 (each flood door)[25]; $80 per foot (insta-dam)

Overview: This strategy includes making foundations, doors, and windows watertight, or changing the use of ground floor facilities to tolerate temporary inundation. Dry floodproofing makes assets waterproof, while wet floodproofing ensures that key materials are water resistant or elevated above the designed flood elevation. Products to flood-proof structures range widely in price, increasing their accessibility.

Floating Structures

Type: Property Improvement

Cost: $350 per square foot per new floating structure[26]

Overview: Structures that are designed to sit upon the water and can incorporate roads, communities, bridges, homes, wetlands, and buildings. As the sea levels increase or decrease, floating structures have the ability to adjust accordingly. Over the long term, this option should become cheaper and more feasible to implement.

Structure Hardening

Type: Property Improvement

Cost: $10 per square ft. (metal roof)[27]; $40 - $55 per square ft. (window)[28]

Overview: Structures can be hardened in a number of ways to mitigate against the impacts of strong winds, rain, tornadoes and other natural disasters. This can include the installation of wind-resistant metal roofing (a material that functions in winds up to 160 mph) and reinforced windows that protect against debris, wind and hail.

Permeable Pavement & Green Parking

Type: Property Improvement
Cost: $10 - $15 per square foot[23]

Overview: Permeable pavement allows rainwater to be treated and absorbed on-site, reducing the load on the City's stormwater system. This is a very prominent feature of low impact development (see below).

Low Impact Development

Type: Green & Gray Infrastructure
Cost: Development savings near 25.0% (Naperville, IL case study)[29]

Overview: Low impact development includes the use of multiple strategies such as bioretention, permeable surfaces, solar, green buildings and other features in masse in a new or existing development. This strategy is becoming more common in coastal real estate development.

Green Streets (Bio-Retention)

Type: Green Infrastructure
Cost: $44 per square ft. of managed impervious area (see source)[30]

Overview: Green streets combine bio-retention, swales, planters and other green features with the elements of complete streets to enhance aesthetics and on-site water retention. Green streets also commonly include bicycle and pedestrian infrastructure that improves safety.

Stormwater Parks

Type: Green Infrastructure
Cost: $7 - $11 per cubic foot[31]

Overview: Stormwater parks use water and natural wetlands as aesthetic features. Parks can function as stormwater parks temporarily, partially flooded during storm events and usable as a community feature when dry. Ward Park in Atlanta (pictured) is an excellent example of this strategy.

Rain Gardens, Down Spouts & Harvesting

Type: Green Infrastructure & Property Improvement
Cost: $3-4 per sq. ft. (residential); $10 - $40 per sq. ft. (commercial)[32]

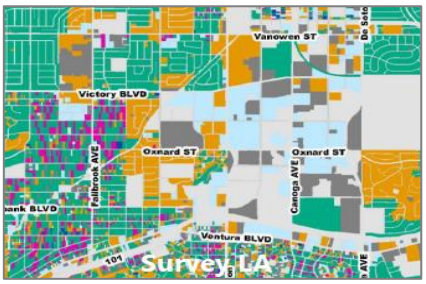
Overview: These three strategies work cohesively to treat water on site. Downspouts ($50) funnel rainwater that hit a structure's roof into rain gardens (prices vary) or barrels ($20) on the building's exterior. This strategy is highly feasible in Titusville, where rain water is plentiful.

Surface Water Management Regulations

Type: Land Use / Policy
Cost: $20 - $70 per square foot[33]

Overview: Regulatory criteria for surface water management systems serving developments are set to provide adequate flood control and remove pollutants from storm runoff. Surface water management systems can contain storm drains, street gutters, weirs, sluice gates, dams, pumps, swales, culverts, drainage wells, French drains, and more.

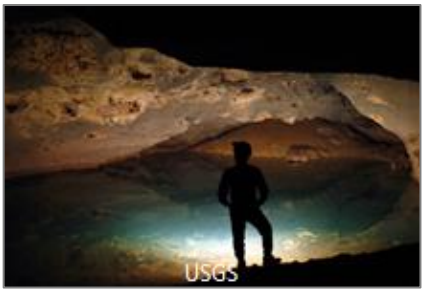
Parcel Tier Designations



Type: Land Use / Policy

Overview: This strategy designates parcels into a tier system to assist with allocating permits to appropriate areas (or properties) from an environmental and planning perspective. Higher tiers are highly-sensitive lands with higher restrictions. This has been done in the Florida Keys and is a variation of an *Adaptation Action Area* class system.

Groundwater Extraction Coordination



Type: Land Use / Policy

Overview: Groundwater is often extracted due to the demand of the resource in certain areas. This can cause long term effects on the quality and availability of water. Coordinating with other agencies on multiple levels of government to reduce groundwater extraction can avoid pollution and prevent land from sinking.

Lagoon Friendly Yards

Type: Land Use / Policy Resource: KeepBrevardBeautiful.org
Cost: See “Living Shorelines”

Overview: These yards minimize pollution through active filtering of rainwater, reduce stormwater runoff, minimize nutrient inputs, restore the ecosystem, and beautify the landscape. These can be implemented individually or through tools such as fertilizer/ yard ordinances.

Increase Design Standards / Building Code

Type: Land Use / Policy

Overview: Cities have design standards and building codes that buildings must abide by. The increase in performance of these standards and codes can aid in the prevention of future building damage and reduce financial exposure to natural hazards. This can include hardening criteria and restrictions on the placement of the building on a lot.

Resiliency Theme #2 Overview | Retreat

The NOAA and USACE sea level rise projections show varying levels of projected inundation within Titusville by the 2040, 2070- and 2100-time frames; thus, the option of retreating away from this hazard zone must be an option for the City to consider. Strategies dealing with retreating are not limited to property relocation or abandonment; some strategies work as proxies to drive future population growth away from hazard zones while others attempt to save a property on an incremental basis as time passes. These strategies are detailed on the following three pages of this report.

When to Retreat: The Importance of the Cost-Benefit Analysis

Retreating a property from a natural hazard zone is a financial decision that must take into account the status quo and a set of feasible alternatives. For example: If the cost of relocating a building exceeds the cost of building or adapting an entirely new facility, then it would be a prudent decision to abandon the facility and retain building materials for reconstruction purposes. On the flip side, if relocation costs do not exceed the cost of a new building, then relocation is a feasible solution. This should not be a reactive decision, especially for critical infrastructure. The City will need to determine the criteria for moving or abandoning facilities in critical areas. Policies and plans should define this criterion.

Retreat by Proxy: Clustering of Density and Urban Places

The act of retreating can be done by proxy. In other words, seemingly unrelated land use decisions (such as cluster zoning and transfer of development rights) can have a direct impact on the proportion of a city's population or infrastructure that are exposed to a particular hazard zone. As discussed earlier in this report, the City of Titusville's population is projected to grow by more than 7,000 over the next 21 years. A feasible retreat-by-proxy solution for the City to undertake would be to maximize the percentage of those 7,000 new residents whose homes and places of work will be located outside of a hazard zone. This would result in a marginal cost decrease per resident from a resiliency-program perspective. This would best be achieved by clustering dense residential and mixed-use corridors away from hazard zones.

Follow the Sea Level Rise Projections

NOAA and the U.S. Army Corps of Engineers routinely refine their hazard data with the latest climate models. It is imperative that the City review any changes in these projections as time goes on, as sea level rise horizon years could potentially vary greatly with more refined data.

Insurance and Land Use Law Matters

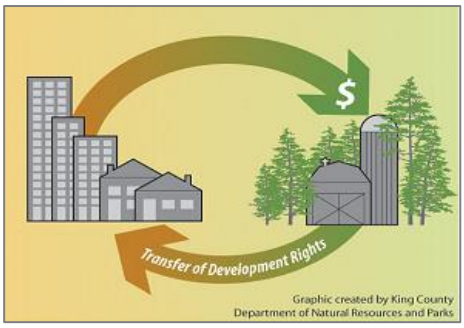
In addition to sea level rise projections, City staff should remain vigilant of new law cases regarding vulnerable properties and the powers that local municipalities do and do not have when dealing with contentious land use and property disputes. The related response of the insurance industry (nationwide) will also have great implications on what will become of inundated property.

Land Purchase & Transfer of Development Rights

Type: Land Use / Policy

Cost: Market Value

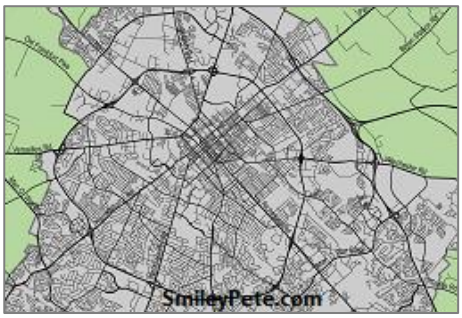
Overview: Transfer of development rights is a market-based tool that allows communities to channel development toward designated growth areas and away from natural areas. Purchasing land may be beneficial to conserve natural land or relocate facilities from at risk areas. This strategy is often used in unison with cluster zoning and down zoning.



Urban Service Area Boundaries

Type: Land Use / Policy

Overview: Urban service area boundaries are created to regulate sprawl and apply land use policies within defined, manageable boundaries. When a City has an urban service boundary, services and infrastructure are not provided outside of the boundary in order to prevent development in sensitive areas and future losses. This allows new development to occur in lower-risk areas.



Down Zoning

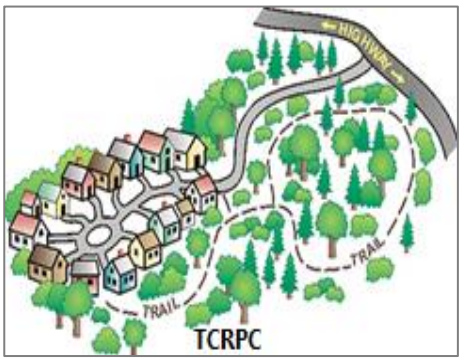
Type: Land Use / Policy

Overview: This process involves rezoning an area to a usage of lower intensity, limiting financial exposure of development in high-risk areas. This can be applied in parts of the city that might be vulnerable to the effects of sea level rise, storm surge and flooding. The Lucas v. South Carolina Coastal Council Supreme Court case somewhat limits its usage, as the total economic value of a property cannot be taken.

Cluster Zoning

Type: Land Use / Policy

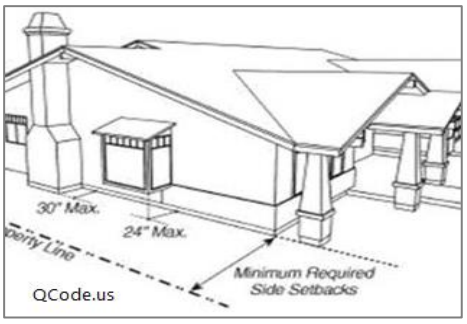
Overview: This type of zoning is used to "cluster" density within well-defined urban centers, leaving room for open spaces elsewhere throughout the City. This strategy is best implemented in areas that are located away from hazard zones and centrally located. In a best-case scenario, cluster zoning creates walkable places that feature residences, jobs, entertainment and parks in a centralized area while preserving critical green spaces on the outskirts of a City.



Hazard Zone Setbacks

Type: Land Use / Policy

Overview: In addition to the coastal construction control line (CCCL), hazard zone setbacks are physical requirements dictating or restricting the placement of a building on a lot. In the context of natural hazards, these setbacks are positioned from the relative location of the hazard zone to the property. These setbacks can assist in limiting the impact of coastal erosion and storm surge.



Velocity Zone Standards

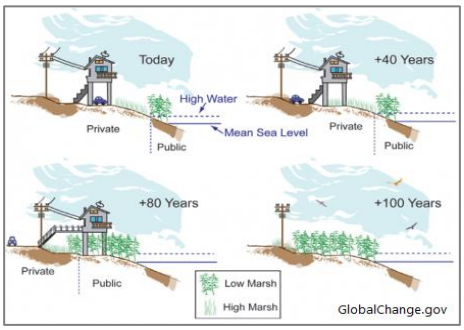
Type: Land Use / Policy

Overview: Velocity zone standards are typically a floodplain management ordinance that mandates a vertical "freeboard" standard in velocity zones. BOCA (Building Officials and Code Administrators) and CABO (Council of American Building Officials) are primary resources that assist cities in the implementation of velocity zone standards. Ocean City, Maryland, has implemented this strategy to protect against storm surge and erosion.

Rolling Easements

Type: Land Use / Policy

Overview: Rollins easements are implemented on privately owned coastal land that is available for public use that maintains its size and migrates inland as the sea level rises. This would be applicable for areas where hardening the shoreline would have negative consequences on coastal resources, and where there is space for the easement to move inland over time. Applicability depends on the physical constraints of a particular site.



Facility Relocation

Type: Property Improvement

Cost: $12 to $16 per square foot of building[34]

Overview: This strategy involves physically moving an asset or facility that is at risk or that has experienced multiple flood losses in the past. In all cases, a cost-benefit analysis should be performed due to the potential alternative feasibility of building an entirely new facility. Relocation often exceeds one million dollars for medium-to-large public facilities, but for individual homes it can be cheaper.

Resiliency Theme #3 Overview | Prepare & Recover

The act of recovering strikes the core of the term "resiliency". Since it is an inevitability that another hurricane, flood event or other natural hazard will impact Titusville, it is critical that the City and its residents are as prepared as possible before such a scenario occurs. This means keeping emergency plans updated and coordinating with higher levels of government and the public before, during and after a storm event. This section of the report outlines strategies that the City can undertake to improve the community's ability to prepare and recover.

Coordination with Brevard County Emergency Management

Brevard County Emergency Management is in charge of all federally-required emergency management plans for unincorporated Brevard County and its jurisdictions. Often times, a lack of coordination in sharing data, resources, information, and other necessities between jurisdictions wastes valuable time, money and resources. It is thus imperative that the City of Titusville retain a high level of correspondence with the County EOC. This includes the detailed maintenance of critical facility listings (stored in ArcGIS), coordination of citywide emergency management plans with countywide emergency management plans, and coordination with the federal government.

Coordination with the State of Florida

Ensuring that the Florida Division of Emergency Management (FDEM) has all of Titusville's critical facilities in GIS format on an annually-updated basis is critical from a data-sharing perspective. In addition, City staff should stay informed on special programs that the state implements following hurricane events. For example: After Hurricane Irma struck Florida in September 2017, the Florida Department of Economic Opportunity created Rebuild Florida to assist families impacted by the storm. Knowledge of programs such as this can vastly improve quality of life for residents following a storm event.

Coordination with the Federal Government (FEMA)

Just as important as coordination between local and county governments is coordination between local governments (including counties) and the federal government. The federal government is in charge of paying local governments for losses incurred during storms, and well-maintained GIS data and records of past losses are central to receiving funds after a storm. The more organized the City or County is leading up to a storm event, the more likely the federal government will be to disperse funding.

Plans Necessary for a Speedy Recovery

In addition to the countywide Local Mitigation Strategy (LMS) and Floodplain Management Plan (FMP) that are updated by the County, three municipal plans could benefit the City of Titusville from a recovery perspective. This includes a Continuity of Operations (COOP) Plan, a Debris Management Plan, and a Post-Disaster Redevelopment Plan (PDRP). These plans are detailed on the following pages of this report.

The Importance of Business & Economic Resiliency: Recovering After a Natural Hazard

According to the Federal Emergency Management Agency's National Flood Insurance Program (NFIP), up to 40% of small businesses never re-open after a natural disaster[36]. This has major economic and social implications for coastal cities with large numbers of "mom and pop" businesses such as Titusville.

Ensuring that business owners are equipped with the knowledge, public resources and storm-resistant materials needed to mitigate the effects of natural disasters before the hazard event can lessen short and intermediate-term financial losses, bolstering a City's economic resiliency. This includes being informed of best management practices by FEMA and Brevard County Emergency Management, ensuring that needed assets are available at quick notice to board up or flood-proof building exteriors, and general rules and expectations for communication between employees prior to the hazard event.

In addition to preparing before a natural hazard event occurs, ensuring continuity of operations after a hazard event can be equally important to the local economy. As described on the next page, Continuity of Operations Plans (also known as COOP Plans) fill this need. COOP plans describe the actions that businesses can take to bring services back as soon as possible after a hazard event, including actions that ensure enough employees are present to work imminently following a storm, or actions that provide reserve resources or assets to assist in cleanup efforts on property.

Within the Resiliency Plan portion of this report, recommendations for educating and providing resources to local business owners are included.

Working with the U.S. Small Business Administration

The U.S. Small Business Administration (SBA) assists business owners in a number of ways and can be a beneficial resource for citizens to utilize. The SBA provides small business owners assistance in dealing with FEMA following storm events, which ensures that short term food, clothing and medicine are provided and long-term claim needs are met[37].

The Small Business Administration also provides low-interest loans for destroyed or damaged assets within declared disaster areas[37]. Ensuring that residents are informed of these resources is a critical piece of the "Prepare and Recover" theme. The Small Business Administration's Emergency Preparedness website can be viewed at this link (or see source #37 in Appendix VII to view the text version of the website link).

Pictured: Dixie Crossroads, a well-known small business in Titusville.

Continuity of Operations Plans

Type: Administrative

Overview: Continuity of Operations Plans outline how a business or governmental body will maintain and restore services in a timely manner following a hazard event. COOP plans are a critical piece to local government organization as they outline how personnel across departments will communicate, where reserve resources and assets can be accessed, and how the population will regain critical services.

Debris Management Plans

Type: Administrative

Overview: These plans are a critical piece to recovering after a disaster due to the nuisance of clogged roadways and potential injury to residents. Ensuring that the City trims trees and has a plan or contractor lined up after a hazard event could determine whether debris is removed quickly or left on the side of the road for months following a storm.

Post-Disaster Redevelopment Plans

Type: Administrative

Overview: According to FEMA, Post-Disaster Redevelopment Plans "facilitate pre-disaster planning in a way that guides long-term recovery efforts (five years or more) following a disaster". In this regard, the PDRP is a long-term continuity plan that prioritizes redevelopment efforts based on the overall feasibility and the potential for future losses in an area.

Emergency Generators

Type: Property Improvement Cost: $200 - $5000

Overview: Emergency generators are a very important piece of standalone-power equipment for facilities such as hospitals, government administration, police and fire headquarters, as well as food and grocery establishments.

Solar Power Battery Storage

Type: Property Improvement Cost: $1,000 - $10,000

Overview: Solar batteries work similar to emergency generators, as they provide a standalone power source when the electrical grid has been compromised. They can be beneficial for public facilities or for private property owners following a loss of power.

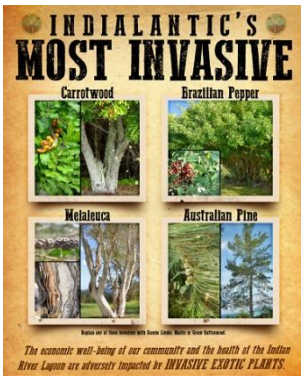
*Structure Hardening, covered under the "Adapt & Protect" theme, can also be considered a temporary strategy for resilience under the "Prepare & Recover" theme. This includes the boarding of windows and reinforcing roofs.

Resiliency Theme #4 Overview | Mobilize & Educate

Mobilizing and educating residents and elected officials can act as an ignition driving the City toward a more resilient future. With increased education and on-the-ground participation, the City of Titusville will be in a position where citizens provide more-informed-feedback for resiliency projects and programs. Moreover, education on an individual level – when scaled cumulatively – can have massive on-the-ground impacts. This section of the report identifies education and mobilization strategies for the City to consider.

Sustainability Programs

Many cities around the central Florida region have begun to implement sustainability programs geared to improve sustainability, resiliency and collaboration within their communities. These programs act as vessels for spreading education and awareness for residents in at-risk coastal cities. Typically approved by elected officials and led by a citizen-driven board, these programs can be critical starting points for cities that aim to achieve high rates of citizen participation and feedback. Sustainability programs also act as a catalyst for the creation of other public advocacy groups through the approval of Sustainability Plans, which prioritize strategies and long-term goals for communities. This report, as well as the City's Visioning Plan, would go hand-in-hand with a citywide Sustainability Plan, as common themes would be drawn upon for action. Three case studies in Brevard County include the City of Satellite Beach Sustainability Board (Facebook page), the Cocoa Beach Sustainability Committee, and the Indialantic Environmental Advisory Task Force, which have fostered healthy conversations among citizens wanting to become involved.



Education Programs & Materials

The process of citizen education comes in many shapes and sizes and is not limited to formal, in-person classes or workshops. In fact, many cities around the state and country have begun to educate in innovative ways. One example of innovation in this regard are the "one page" mail outs that the City of Indialantic disseminates detailing the best water-taking local plants to use for front yards as well as the most invasive plant species for the health of the lagoon (pictured to the left). Education materials like these are inexpensive to produce and are typically well-received by residents.

Other strategies to implement education programs include the use of social media (through the City) and the integration of Florida-specific environmental education in elementary, middle and high schools. One recommendation of this report is for the City to create a "Resilient Titusville" Facebook page. It is important to keep all of these potential educational forms in mind when producing the educational materials recommended on the next page of this report.

Identifying Community Champions

The identification of community champions is a critical piece to spurring on-the-ground mobilization of residents. These citizens, typically "natural leaders" and "early-adopters" of innovative ideas, can be found across a range of age groups and demographics. Identifying a diverse range of these citizens is critical.

Mobilization: Sustainability Programs

Type: Administrative

Overview: Sustainability programs have begun to pop up in cities around the country as a way to ensure sustainable practices in development, infrastructure, information technology, waste management, and other areas. Typically, a sustainability program will begin with the approval of elected officials. While some cities have hired Sustainability Directors, other cities have taken a citizen-driven approach. The first two steps in the process after incorporation is typically to form a citizen-led sustainability board and the development of a sustainability plan.

Mobilization: Enhancing Sustainability Through Hands-On Collaboration

Type: Education

Overview: Through Sustainability Programs, the community can begin to collaborate on issues such as lagoon clean ups, beach restoration, and other hands-on projects that activate community members and develop social capital. These groups provide a forum for residents to not only become involved, but to learn about the threats facing their community and the steps necessary to counteract them. Thus, the education component develops naturally.

Education Topic: Property Improvement Strategies *(Long Term Resiliency)*

Type: Education

Overview: Strategies to improve property have been thoroughly covered in this section of the report and could serve as a great first-step for residents to become informed on what they can do to minimize financial impacts to their property during a natural hazard. As more and more residents become aware of these strategies and implement them in larger numbers, the City will become more resilient without any direct public investment.

Education Topic: How to Prepare for Natural Hazards *(Short Term Resiliency)*

Type: Education

Overview: While property improvement strategies (above) deal with intermediate-to-long range solutions to improve property, there are a number of strategies that residents can implement to reduce their short-term risk to an impending natural hazard. Educating residents on these practices, such as boarding up windows and parking cars in garages, can dramatically reduce the impacts of natural hazards if implemented on a large scale.

Education Topic: Lagoon-Friendly Practices

Type: Education

Overview: Water quality and the health of the lagoon system are among the biggest vulnerabilities facing the community from a residents' perspective. Educating residents on what they can do to reduce impacts to the lagoon, such as limiting the use of pesticides and fertilizer, can greatly improve its health.

Education Topic: Vulnerabilities Facing Titusville

Type: Education

Overview: A general understanding of the natural hazards that face the City of Titusville and what can be done to mitigate their impacts can generate a citizenry that is more informed of where their tax money is being spent. A heightened awareness in this regard will allow for more impactful citizen input on potential solutions.

Resiliency Strategy and Hazards Matrix

The following table, which concludes the Resiliency Themes and Strategies portion of the report, links the strategies analyzed with the natural hazards covered in the Vulnerability Analysis.

Theme	Strategy	Storm Surge	Water Quality	100-Year Flood	Sea Level Rise	Nuisance Flood
Adapt & Protect	Sea Wall					
	Groins & Breakwaters					
	Levee					
	Tidal Barrier					
	Raising Roadways					
	Water Pump Systems					
	Underground Utilities					
	Install Larger Stormwater Pipes					
	Berms (Revetments)					
	Habitat Restoration					
	Beach Renourishment					
	Living Shorelines					
	Low Impact Development					
	Green Streets (Bioretention)					
	Stormwater Parks					
	Down Spouts, Rain Gardens & Harvesting					
	Permeable Pavement & Green Parking					
	Raising Structures					
	Flood Proofing					
	Floating Structures					
	Structure Hardening					
	Surface Water Management Regulations					
	Parcel Tier Designations					
	Groundwater Extraction Regulations					
	Lagoon Friendly Yards					
	Increase Design Standards/Code					
Retreat	Hazard Zone Setbacks					
	Rolling Easement					
	Down Zoning					
	Cluster Zoning					
	Land Purchase & Transfer of Dev't Rights					
	Urban Service Area Boundaries					
	Velocity Zone Standards					
	Facility Relocation					
Prepare & Recover	Emergency Generators					
	Solar Power Battery Storage					
	Continuity of Operations Plans					
	Post-Disaster Redevelopment Plans					
	Debris Management Plans					
Mobilize & Educate	Topic: Property Improvement Strategies					
	Topic: Vulnerabilities Facing Titusville					
	Topic: How to Prepare for Natural Hazards					
	Topic: Lagoon-Friendly Practices					
	City-Wide Sustainability Program					
	Foster Hands-On Collaboration					

VI. Draft Resiliency Plan

This section of the report is a culmination of the information collected as part of the vulnerability assessment, citizen input, resiliency themes and strategy development, and includes recommendations that form the basis of a Draft Resiliency Plan for the City to further develop for adoption. Recommendations are identified by their connections to the four themes developed in this report – Adapt & Protect, Retreat, Recover, and Educate & Mobilize – and priorities as well as the responsible City department(s) are provided with each recommendation.

The East Central Florida Regional Resiliency Action Plan, completed in 2018 by the East Central Florida Regional Planning Council, was used as a baseline for many of the recommendations developed in this section of the report. As a starting point, the Regional Resiliency Action Plan's Goals and Objectives were utilized to organize tasks. The results of the Vulnerability Assessment, MetroQuest Survey and Community Workshops further guided the more location-specific and context-sensitive recommendations included in this section.

Draft Goals and Objectives

Goal #1: Leadership & Strategy | Promote leadership, education, and empowerment to foster resiliency

- Incorporate resiliency into local plans, policies and objectives
- Plan fiscally to implement resilient and sustainable solutions to long term impacts
- Implement strategies to promote adaptive measures that keep people and property safe
- Engage and educate private sector stakeholders, elected officials, and others

Goal #2: Economic & Society | Provide opportunities to foster economic prosperity and social equity

- Protect high value assets from natural hazards
- Educate businesses about access to funding and financial services related to resiliency
- Facilitate and support the efficient recovery of business operations after an event
- Improve social inclusion in decision making processes

Goal #3: Infrastructure & Environment | Encourage responsible development and infrastructure solutions

- Prioritize the use of green infrastructure as a first line of defense
- Promote interconnectivity of natural lands for habitat migration
- Enhance stormwater systems to be more resilient
- Improve water quality in surface water bodies
- Incorporate resiliency into local plans, policies and objectives
- Preserve and adapt the built environment to keep people and property safe
- Improve community mobility while improving vulnerable transportation infrastructure

Goal #4: Health & Well Being |Facilitate opportunities to improve community and environmental health

- Improve the capacity of the City to better respond to hazard events
- Improve capacity of medical facility operations to prepare for and recover from hazards
- Promote sustainable practices in government-owned facilities
- Engage residents and business owners with locally relevant information
- Improve access to resources for the homeless, special needs, elderly and poor

Goal & Objective	Task / Recommendation	Partner(s)	Priority	Corresponding Resiliency Themes			
				Adapt & Protect	Retreat	Prepare & Recover	Educate & Mobilize
Leadership and Strategy Objective #1 Incorporate resiliency into local plans, policies and objectives.	Prioritize the review of all plans, policies and procedures to assess the inclusion of resilience strategies or impediments. This can include the Comprehensive Plan, Land Development Regulations, Capital Improvements Plan, Building Code, and other plans.	All Departments Titusville Environmental Commission	High				
	Implement the findings of the Resilient Titusville 2020 report and the City's Visioning Study into local policies and programs.	Planning Department	Medium				
	Consider creating a Sustainability Officer position to work across City Departments to improve sustainability and resiliency efforts.	All Departments	Medium				
	Create a jurisdiction-wide Resiliency Action Plan through the findings of this report, the Titusville Visioning Plan and through further recommendations of the City's Environmental Commission. Carefully note areas (such as sea level rise) that the City must monitor over time in order to maximize the fiduciary responsibility of all actions.	Planning Department Public Works Department Water Resources Department Titusville Environmental Commission	Medium				

Goal & Objective	Task / Recommendation	Partner(s)	Priority	Corresponding Resiliency Themes			
				Adapt & Protect	Retreat	Prepare & Recover	Educate & Mobilize
Leadership and Strategy Objective #2 Plan fiscally to implement resilient and sustainable solutions to long-term impacts	Assess the City's Capital Improvements Plan to ensure the inclusion of sustainable and resilient projects, such as green infrastructure.	All Departments Titusville Environmental Commission	High				
	Conduct budgeting workshops to determine appropriate ways to build reserves and adjust budgets to include dollars for projects that will protect life, safety and health in future years.	All Departments Public Watershed Management Program	Medium				
	Implement strategies to build reserves incrementally to be proactive in creating sustainable and resilient communities.	All Departments	Medium				
	Conduct a survey of stakeholders to assess priority and funding for the public purchase of vulnerable lands.	All Departments Titusville Environmental Commission	Medium				

Goal & Objective	Task / Recommendation	Partner(s)	Priority	Corresponding Resiliency Themes			
				Adapt & Protect	Retreat	Prepare & Recover	Educate & Mobilize
Leadership and Strategy Objective #3 Implement strategies to promote adaptive measures that keep people and property safe from natural hazards	Conduct an analysis of the City's public shorelines to determine where living shorelines are appropriate. This includes salinity, depth, shoreline type, and wake analyses.	Planning Department Public Works Department	High				
	Conduct a workshop with residents to determine obstacles that they face in improving their property to be more resilient to natural hazards.	Planning Department	High				
	Assess and update the Land Development Code as necessary to allow private land owners to implement native vegetation programs, living shorelines, or other efforts that allow water to be treated on site.	Planning Department SJRWMD UF IFAS Extension Natural Resources Conservation Service	High				
	Research appropriate parking standards for the community, and identify parking lots that can potentially be downsized to include green infrastructure and permeable surfaces as well as strategies to mitigate the heat island effect.	Planning Department	High				
	Streamline the permit process in order to allow private land owners to implement native vegetation programs, living shorelines or other efforts that allow water to be treated on site.	Planning Department	Medium				
	Consider updating parking standards within the City's Land Development Regulations to allow or require additional space to include green infrastructure, permeable surfaces and other strategies that mitigate the heat island effect.	Planning Department	Medium				
	Prioritize publicly-owned parking lots that can be retrofitted to include more permeable surface to reduce stormwater loads and treat water on-site.	Public Works Department Water Resources Department	Medium				

Goal & Objective	Task / Recommendation	Partner(s)	Priority	Corresponding Resiliency Themes			
				Adapt & Protect	Retreat	Prepare & Recover	Educate & Mobilize
Leadership and Strategy Objective #4 Engage and educate private sector stakeholders, elected officials and other members of the community about strategies to increase resilience in the built, natural, and social environment.	Find champions and strong advocates both elected and non-elected to participate in regional initiatives such as the East Central Florida Regional Resilience Collaborative.	All Departments City Commission	Ongoing				
	Conduct new leadership orientation for newly-elected officials, providing educational materials that outline the City's primary vulnerabilities and hazard mitigation strategies.	All Departments ECFRPC Florida Sea Grant UF IFAS Extension	Ongoing				
	Hold a workshop or one-on-one meetings with private sector stakeholders to educate and train them on sustainable practices, such as continuity of operations plans, the importance of emergency generators, and other topics.	Titusville Environmental Commission Planning Department Economic Development Commission UF IFAS Extension	High				
	Create a social media account for the Titusville Environmental Commission.	Titusville Environmental Commission	High				
	Create and mail infographics to educate the public about the economic and environmental benefits associated with the property improvement strategies covered in the City's Resiliency Plan.	UF IFAS Extension	Medium				
	Provide outreach and educational opportunities to residents to learn about the importance of developing away from natural hazard zones.	Planning Department Titusville Environmental Commission UF IFAS Extension	Medium				
	Develop volunteer initiatives based off of the educational opportunities in order to continue learning through hands-on activity. This can include shoreline enhancement projects.	Titusville Environmental Commission Planning Department UF IFAS Extension & Brevard Public Schools Surfrider Foundation	Future				
	Re-evaluate workshops and educational materials to determine gaps and lessons learned.	Titusville Environmental Commission Planning Department	Future				

Goal & Objective	Task / Recommendation	Partner(s)	Priority	Corresponding Resiliency Themes			
				Adapt & Protect	Retreat	Prepare & Recover	Educate & Mobilize
Health and Wellbeing Objective #1 Improve the capacity of the City to better respond to hazard events.	Update evacuation plans to assist areas that are transportation dependent and that will need assistance in evacuation and re-entry.	Emergency Management SCAT Planning Department	Ongoing				
	Identify, within the countywide COOP and transit plans, a listing of priority transit routes for operation after a natural hazard event.	Emergency Management SCAT Planning Department	Ongoing				
	Identify staging areas for fueling trucks pre and post disaster for efficient evacuation and re-entry.	Emergency Management Planning Department	Ongoing				
	Consider mandatory evacuation orders for Hurricanes above a strength level determined by City staff.	Emergency Management Planning Department	Ongoing				
	Assess potable water supplies and infrastructure from natural disaster impacts such as sewage infiltration and saltwater intrusion.	Planning Department Water Resources Department	Ongoing				
	Update plans to include information gathered from Hurricane Irma After Action Reports.	Emergency Management All Departments	High				
	Identify and prioritize critical facilities with generator needs and add this information to the appropriate funding list (i.e. LMS, CIP, etc.).	Emergency Management All Departments	High				
	Investigate the feasibility of and needs associated with alternative energy fleet vehicles for emergency response use.	Public Works Department Emergency Management CERT	Medium				
	Assess food insecurity in vulnerable populations and apply this information during future hazard events.	Emergency Management Department of Health Planning Department	Medium				
	Work with food pantries and other resources to close the gaps identified in food insecurities and vulnerable populations.	Emergency Management Department of Health Planning Department	Future				
	Reassess gaps in response to hazard events and address those gaps in future plans. Coordinate these findings with Brevard County Emergency Management.	All Departments	Future				

Goal & Objective	Task / Recommendation	Partner(s)	Priority	Corresponding Resiliency Themes			
				Adapt & Protect	Retreat	Prepare & Recover	Educate & Mobilize
Health and Wellbeing Objective #2 Improve capacity of medical facility operations to prepare for and recover from natural disasters and future conditions.	Hold training workshops at medical facilities that test response and evacuations from a hazard event.	Emergency Management Medical Facilities Planning Department	Ongoing				
	Further assess vulnerability to medical facilities (hospitals, hospices, dialysis centers, assisted living facilities, nursing homes, etc.), helicopter pads and access points from sea level rise, flooding and storm surge impacts.	Emergency Management Medical Facilities Planning Department	High				
	Develop or update internal operations plans for natural disasters such as strong hurricanes and tornadoes. Educate hospital staff on best practices when necessary.	Emergency Management Medical Facilities Planning Department	Medium				
	Determine mitigation/adaptation strategies for identified vulnerabilities to medical facilities and develop an implementation plan.	Planning Department Medical Facilities	Medium				
	Assess and update future land use and zoning codes to limit or mitigate the placement of medical facilities in vulnerable areas.	Planning Department	Future				

Goal & Objective	Task / Recommendation	Partner(s)	Priority	Corresponding Resiliency Themes			
				Adapt & Protect	Retreat	Prepare & Recover	Educate & Mobilize
Health and Wellbeing Objective #3 Promote sustainable practices in government-owned facilities.	Assess feasibility of a sustainability program within the City and audit existing programs in other Cities as well as incentive programs such as Florida Green Building Coalition and LEED.	Planning Department	High				
	Identify locations for electric charging stations, especially near/at publicly-owned properties and high employment areas.	Planning Department Titusville Environmental Commission	Medium				
	Update local codes and policies to promote sustainable and Low Impact Development practices for government owned facilities.	Planning Department	Medium				
	Develop programs to install community gardens and green roofs on public buildings and on buildings within the community.	Planning Department Public Works Titusville Environmental Commission	Medium				
	Conduct an energy audit within the City and develop strategies to mitigate the effects of the greenhouse gas effect.	Planning Department Titusville Environmental Commission	Medium				
	Work with the school board to maximize the use of green building techniques and sustainable practices to provide hazard mitigation opportunities.	School Board Planning Department	Medium				
	Assess and update future land use and zoning codes to limit or mitigate the placement of government buildings in vulnerable areas.	Planning Department Titusville Environmental Commission	Future				
	Reassess sustainability plan and metrics associated with the implementation of sustainable building practices in government facilities.	Planning Department Public Works Building/Zoning Department Titusville Environmental Commission Water Resources Department	Future				

Goal & Objective	Task / Recommendation	Partner(s)	Priority	Corresponding Resiliency Themes			
				Adapt & Protect	Retreat	Prepare & Recover	Educate & Mobilize
Health and Wellbeing Objective #4 Engage residents and business owners with locally-relevant information	Evaluate existing programs in other jurisdictions and agencies aimed at educating residents and business owners about imminent natural hazards and sustainable practices, such as the City of Orlando Greenworks, FGBC, PACE.	Planning Department Building Department Titusville Environmental Commission	Ongoing				
	Work with volunteers like religious institutions, clubs, schools etc. for beach clean-up, tree planting, bioswale creation, urban farming and other hands-on events.	Titusville Environmental Commission IFAS	Ongoing				
	Conduct in-depth community outreach events outside of the storm season to identify needs and barriers associated with resource accessibility and disaster response.	FEMA Titusville Environmental Commission Emergency Management	Ongoing				
	Develop indicators and begin tracking data to develop a baseline for future assessments.	Planning Department Building/Zoning Department Titusville Environmental Commission	Medium				
	Develop or utilize existing incentives to increase the energy efficiency and resilience of homes and businesses.	Planning Department Building Department Titusville Environmental Commission Chambers of Commerce	Medium				
	Educate and engage the community in improving the tree canopy through plantings on residential properties (Florida Friendly Landscaping / Energy Efficiency).	Planning Departments Titusville Environmental Commission	Future				
	Develop a "Return on Investment" Infographic on various resilient and sustainable strategies for homeowners and businesses.	Planning Department Titusville Environmental Commission	Future				
	Reassess sustainability plan and metrics associated with the implementation of sustainable and resilient programs and incentives in the community.	Planning Department Public Works Department Titusville Environmental Commission	Future				

Goal & Objective	Task / Recommendation	Partner(s)	Priority	Corresponding Resiliency Themes			
				Adapt & Protect	Retreat	Prepare & Recover	Educate & Mobilize
Health and Wellbeing Objective #5 Improve access to resources for the homeless, special needs, elderly, low income, and English-limited residents.	Continue "primary" social media account to relay all disaster-related information.	City Aministration Emergency Management	Ongoing				
	Continue to utilize pre-registration to identify shelters for special needs and seniors within the community.	City Aministration Emergency Management	Ongoing				
	Prioritize and utilize the Idignity Program to ensure residents have essential documents before disasters.	City Aministration Emergency Management	Ongoing				
	Identify areas outside vulnerabilities to encourage/incentivize the development of affordable housing.	Planning Department	Medium				
	Assess plans and policies to encourage development of future affordable housing choices outside of vulnerable areas and with access to transit, jobs, and resources.	Planning Department	Medium				
	Reassess plans and procedures to determine remaining gaps and success of implemented procedures.	All Departments	Future				

Goal & Objective	Task / Recommendation	Partner(s)	Priority	Corresponding Resiliency Themes			
				Adapt & Protect	Retreat	Prepare & Recover	Educate & Mobilize
Economy and Society Objective #1 Protect high-value assets from natural hazards.	Continue to conduct assessments of land use and facilities to determine vulnerabilities to sea level rise, storm surge, coastal erosion and flooding.	Planning Department	High				
	Identify local businesses such as gas stations, food suppliers or others that provide specific services or resources vital for recovery.	Emergency Management Planning Department	High				
	Using vulnerability analysis findings, identify vulnerable areas of economic significance.	Economic Development Agencies Planning Department	Medium				
	Develop and adopt policy language that prohibits the development of high value assets in vulnerable areas or if necessary, are mitigated to the greatest extent possible.	Planning Department Titusville Environmental Commission Water Resources Department Public Works Department	Medium				
	Identify strategies and policies related to resilient rebuilding in identified vulnerable areas such as how to build back better, risk informed construction standards, streamlined processes for post disaster reconstruction, debris removal / pre-identified debris management resources, and a guide regeneration.	Planning Department	Medium				
	Conduct an assessment of policy language and find existing case studies that direct high value assets away from vulnerable areas and test feasibility of those policies locally.	Planning Department Water Resources Department	Medium				
	Develop possible mitigation strategies of at-risk public infrastructure identified as part of the natural hazard vulnerability assessment.	Public Works Department Planning Department Water Resources Department	Medium				
	Conduct a risk-based cost-benefit analysis for mitigation strategies of at-risk structures identified as part of the natural hazard vulnerability assessment. Identify the assets with the highest short-term risk for inundation. Develop a prioritization process to address mitigation/adaptation strategies for vulnerable assets.	Public Works Department Planning Department Water Resources Department	Future				
	Develop a long-term financial plan for loss of or restructure of tax base in highly vulnerable areas.	All Departments Economic Development Agencies	Future				

Goal & Objective	Task / Recommendation	Partner(s)	Priority	Corresponding Resiliency Themes			
				Adapt & Protect	Retreat	Prepare & Recover	Educate & Mobilize
Economy and Society Objective #2 Educate business about access to funding and financing services related to resiliency and sustainability	Research funding and financing services for pre/post post disaster needs and sustainable practices. Determine the role of the City in the implementation of financing mechanisms.	Titusville Environmental Commission Chambers of Commerce	High				
	Conduct a workshop with business owners to determine needs, wants and constraints as related to implementing resilient and sustainable practices.	Titusville Environmental Commission Chambers of Commerce UF IFAS Extension Florida Sea Grant	High				
	Create, update and disseminate an educational infographic for businesses with funding and financing services for pre/post- disaster needs and sustainable practices.	Emergency Management Economic Dev't Commission Chambers of Commerce Planning Department	Medium				
	Determine the feasibility and functionality of a program to help impacted businesses with rent deferment.	City Administration Chambers of Commerce	Medium				
	Reassess efforts and programs to fill identified gaps in service and education.	Titusville Environmental Commission Chambers of Commerce All Departments	Future				

Goal & Objective	Task / Recommendation	Partner(s)	Priority	Corresponding Resiliency Themes			
				Adapt & Protect	Retreat	Prepare & Recover	Educate & Mobilize
Economy and Society Objective #3 Facilitate and support the efficient recovery of business operations after an event	Research available templates for business and employee preparedness plans and create an outreach proposal for businesses to update these templates.	Chambers of Commerce Workforce Agencies Planning Department	High				
	Create a tourism marketing program to implement after a disaster event to bring tourists back by showcasing that the area is "Open for Business". Create PSA's and other materials.	Economic Development Commission Tourism Development Council Planning Department Titusville Environmental Commission	High				
	Identify "point person" in local government to act as a liaison between the business community and the local government for resiliency.	City Administration Economic Development Commission	High				
	Develop a section on the City's website focused on disaster preparedness and include links to business continuity plan and employee disaster plan templates.	Planning Department Chambers of Commerce Emergency Management EOC	Medium				
	Develop a "one-pager" with best practices and links for responding to and preparing for hazard events. Create/update and disseminate an educational infographic for businesses with emergency information to access for post disaster needs.	Emergency Management Planning Department Chambers of Commerce Workforce Agencies	Medium				
	Work with the identified local critical facility businesses to determine resources needed to aid in timely recovery efforts such as generators, mitigation projects, etc.	Emergency Management Planning Department	Medium				
	Reassess efforts and update plans and programs to fill identified gaps.	Chambers of Commerce Planning Department	Future				
	Consider implementing a long-term recovery plan for businesses to retain employees as soon as possible following a storm event.	Chambers of Commerce Planning Department	Future				

Goal & Objective	Task / Recommendation	Partner(s)	Priority	Corresponding Resiliency Themes			
				Adapt & Protect	Retreat	Prepare & Recover	Educate & Mobilize
Economy and Society Objective #4 Improve social inclusion in decision making process	Host community meetings in underserved, low income communities to discuss projects within and just outside the community.	All Departments	Ongoing				
	Partner with local organizations and faith-based organizations to provide feedback concerning needs and opportunities specific to a project or program.	All Departments	Ongoing				
	Conduct health impact assessments when considering projects that may affect underserved, low income communities, and determine benchmark health outcomes.	Planning Department	Ongoing				
	Engage with communities to identify gaps and priorities in the decision making process to improve social inclusion.	Planning Department UF IFAS Extension	High				
	Create an outreach plan to involve all communities in an engaging opportunity to be a part of local decisions.	Planning Department UF IFAS Extension	Medium				
	Implement the outreach plan.	Planning Departments Communications Departments	Future				
	Reassess the gaps that remain in community involvement outcomes.	Communications Department	Future				

Goal & Objective	Task / Recommendation	Partner(s)	Priority	Corresponding Resiliency Themes			
				Adapt & Protect	Retreat	Prepare & Recover	Educate & Mobilize
Infrastructure and Environment Objective #1 Prioritize the use of Green Infrastructure as a first line of defense.	Conduct an audit of coastal areas to identify locations for living shorelines and prioritize areas for implementation on publicly owned land.	Planning Department Public Works Department Water Resources Department	High				
	Where possible, implement "green streets" to mitigate stormwater impacts.	Planning Department	High				
	Create/implement/expand a program or partnership to educate property owners about the benefits of living shorelines and assist with installation.	SJRWMD FDEP Florida Sea Grant	Medium				
	Assess comprehensive plan, LDRs and process applications for barriers to implement green infrastructure and to prioritize natural solutions versus engineered engineering projects.	Planning Department	Medium				
	Develop a Restoration Plan(s) to prioritize the restoration of tidal wetlands, dunes and salt marshes and create living shorelines to soften the impacts of wave-induced erosion in high risk areas. Include indicators to measure success and return on investment.	FDEP SJRWMD	Medium				
	Update comprehensive plans, LDRs and process to address barriers to implement green infrastructure and make it a priority to assess natural solutions as a first step prior to engineering solutions.	Planning Department Public Works Department Water Resources Department	Medium				
	Develop incentives for residents, businesses, and developers to use living shorelines and other green infrastructure techniques as a priority.	Planning Department Water Resources Department	Future				
	Create partnerships with colleges, NGOs, contractors and others to install and maintain green infrastructure.	Planning Department Water Resources Department	Future				
	Analyze funding sources to move projects and programs forward that focus on Green Infrastructure.	Planning Department Water Resources Department	Future				
	Reassess plans, procedures, programs and policies to improve on any lessons learned.	All Departments	Future				

Goal & Objective	Task / Recommendation	Partner(s)	Priority	Corresponding Resiliency Themes			
				Adapt & Protect	Retreat	Prepare & Recover	Educate & Mobilize
Infrastructure and Environment Objective #2 Promote interconnectivity of natural lands for habitat migration.	Work continuously with advocacy groups to inform the public on development strategies that support biodiversity and interconnectivity.	SJRWMD Natural Lands Program FFWCC FDEP 1000 Friends of Florida	Ongoing				
	Assess coastal nesting areas based on future conditions to develop preservation strategies viability of these areas.	SJRWMD Natural Lands Program FFWCC FDEP USACE 1000 Friends of Florida	High				
	Assess undeveloped lands, agricultural lands, natural lands and migrating habitats to determine future priority corridors and properties for acquisition based on future conditions. Utilize the SLAMM model or other models as appropriate.	Natural Lands Program ECFRPC SJRWMD FFWCC FDACS USDA FDEP 1000 Friends of Florida	High				
	Further develop preservation strategies for coastal nests (birds, turtles, etc.) to ensure the ecological and economic viability of the coastline and incorporate into related plans.	SJRWMD Natural Lands Program FFWCC FDEP USACE 1000 Friends of Florida	Medium				
	Conduct survey of stakeholders to assess priority and funding of conservation lands for acquisition and maintenance.	Planning Department Local Government Commission FFWC / FWS	Medium				
	Re-evaluate and update conservation and acquisition plans to implement findings from future corridor assessment and prioritization plan.	FDEP SJRWMD FWC FWS	Future				
	Update the comprehensive plan and other plans/codes with appropriate language to prevent future development from infringing on these priority corridors.	Planning Department	Future				
	Evaluate strategies and alternative analysis for longer term funding for acquisition / management program.	All Departments	Future				

Goal & Objective	Task / Recommendation	Partner(s)	Priority	Corresponding Resiliency Themes			
				Adapt & Protect	Retreat	Prepare & Recover	Educate & Mobilize
Infrastructure and Environment Objective #3 Enhance stormwater systems to be more resilient.	Continue stormwater improvement projects to comply with adopted Basin Management Action Plan (BMAP) for the Indian River Lagoon.	Public Works Department	Ongoing				
	Consider future inundation and nuisance flooding to determine areas of flood impacts to roadway stormwater infrastructure.	Public Works Department	Ongoing				
	Evaluate existing green space for stormwater retention and evaluate findings based on future conditions.	Public Works Department	Medium				
	Develop strategies to prioritize and implement the use of green space in stormwater management.	Planning Department	Medium				
	Assess stormwater system facilities for vulnerabilities to future inundation and erosion including elevations of outfalls into surface water bodies.	Public Works Department	Medium				
	Prioritize areas of critical vulnerable stormwater infrastructure. Review other projects to determine if improvement projects can be addressed simultaneously for a greater cost benefit.	Public Works Department	Medium				
	Develop prioritization process and funding mechanisms for infrastructure projects in Adaptation Action Areas.	Planning Department Public Works Department Water Resources Department	Medium				
	Identify feasible improvements, mitigation or adaptation strategies to address vulnerable stormwater system areas.	Public Works Department	Future				
	Conduct a risk-based cost-benefit analysis for mitigation strategies of stormwater infrastructure identified as part of the natural hazard vulnerability assessment.	Public Works Department	Future				
	Reassess outfall and infrastructure elevation data to determine any gaps in data collection and analysis.	Public Works Department	Future				
	Identify a process or mechanism to determine what infrastructure/areas may not be upgraded or mitigated at a certain time or impact. Reference previous data/information developed on stormwater and cost/benefit analysis in this analysis in order to help create a legal justification of decisions.	Public Works Department	Future				

Goal & Objective	Task / Recommendation	Partner(s)	Priority	Corresponding Resiliency Themes			
				Adapt & Protect	Retreat	Prepare & Recover	Educate & Mobilize
Infrastructure and Environment Objective #4 Improve water quality in surface water bodies.	Continue financial/staff support of programs and projects to improve water quality.	Indian River Lagoon Council Water Resources Department Public Works Department FDEP / SJRWMD	Ongoing				
	Identify and educate communities about best management practices (BMP's) for reducing nutrient loads flowing into surface waters via residential, commercial, industrial and agricultural lands.	Indian River Lagoon Council Water Resources Department Public Works Department FDEP / SJRWMD	Ongoing				
	Identify projects and programs aimed at improving water quality and conduct a gaps analysis.	Water Resources Department Public Works Department	High				
	Review and update projects planned to address current total maximum daily load (TMDL) water quality targets.	Water Resources Department Public Works Department	Medium				
	Evaluate existing fertilizer ordinances and successfulness. Conduct gap analysis to determine a regional approach.	Marine Resource Council Planning Department UF IFAS Extension	Medium				
	Reassess success of programs and policies aimed to improve water quality in surface water bodies.	Planning Department Water Resources Department Public Works Department	Future				
	Investigate financial strategies to continue programs into the future.	All Departments	Future				

Goal & Objective	Task / Recommendation	Partner(s)	Priority	Corresponding Resiliency Themes			
				Adapt & Protect	Retreat	Prepare & Recover	Educate & Mobilize
Infrastructure and Environment Objective #5 Incorporate resiliency into local plans, policies, processes and objectives.	Continue to monitor sea level rise projections over time. Consider installing water monitoring stations to measure sea level rise within the City.	All Departments	High				
	Determine if Adaptation Action Area designation and policies are appropriate for the jurisdiction. If determined appropriate, develop policies and maps to identify the area, purpose and other related policies. Ensure that AAA designations can be removed, if needed.	Planning Department	High				
	Adopt an "Adaptation Action Area" that includes hazard zones agreed upon by City staff.	All Departments	Medium				
	Assess other plans to reference Adaptation Action Areas and incorporate language as appropriate.	Planning Department	Medium				
	Audit Comprehensive plan against other plans (i.e. CRA plans, Downtown Development Plans, Economic Development Plans, LDRs, PDRP) to ensure compatibility of addressing resiliency and future development based on future conditions.	Planning Department Titusville Environmental Commission Public Works Department Water Resources Department	Medium				
	Develop a Sustainability and/or Resiliency Plan if deemed appropriate by stakeholders and previous efforts.	Planning Department Titusville Environmental Commission ECFRPC	Medium				
	Adopt changes in all necessary plans to reduce the volume of nutrient loads and fertilizers from public and private property flowing into the Indian River Lagoon.	Planning Department Titusville Environmental Commission Water Resources Department	Medium				
	Add and adopt policies to Comprehensive Plan, and other plans, that result from the recommendations identified in the Resiliency/Sustainability Plan and comp plan audit.	Planning Department Titusville Environmental Commission Water Resources Department	Medium				
	Update/Enhance/Develop Design Guidelines within Land Development Regulations that protect and buffer structures from the impact of hazards. These guidelines should address sea level rise, storm surge, flooding, wind damage, and the urban heat island effect.	Planning Department Titusville Environmental Commission ECFRPC	Medium				
	Establish policies and practices for area-wide metrics such as net density requirements that cluster development away from high hazard areas.	Planning Department Titusville Environmental Commission	Future				
	Update CIP to implement priority projects identified through vulnerability analysis and appropriate mitigation projects.	Public Works Department	Future				

Goal & Objective	Task / Recommendation	Partner(s)	Priority	Corresponding Resiliency Themes			
				Adapt & Protect	Retreat	Prepare & Recover	Educate & Mobilize
Infrastructure and Environment Objective #6 Preserve and adapt the built environment to keep people and property safe	Develop incentives for developers to build outside vulnerable areas or build in a resilient/sustainable way in vulnerable areas.	Planning Department	Medium				
	Develop incentives to developers that use methods consistent with Low Impact Development (LID) standards, Florida Green Building Coalition, and techniques to reduce the heat island effect.	Planning Department	Medium				
	Provide dedicated funding for annual tree maintenance near power lines to help prevent storm damage and allow access for electricity providers to fix broken power lines in an efficient manner following a natural disaster.	Emergency Management	Medium				
	Research potential strategies addressing undeveloped parcels located within the Adaptation Action Area.	Planning Department	Medium				
	Develop a risk assessment to determine wellfields, groundwater and underground infrastructure at risk to saltwater intrusion.	Water Resources Department	Medium				
	Develop possible mitigation strategies of at-risk public infrastructure identified as part of the natural hazard vulnerability assessment.	Public Works Department Water Resources Department	Medium				
	Develop a prioritization process and funding mechanisms for infrastructure projects in Adaptation Action Areas and incorporate into CIP.	Planning Department Public Works Department Water Resources Department	Medium				
	Conduct a risk-based cost-benefit analysis for mitigation strategies of at-risk public infrastructure identified as part of the natural hazard vulnerability assessment.	Public Works Department Water Resources Department	Future				
	Implement incentives to developers that use methods consistent with Low Impact Development (LID) standards and Florida Green Building Coalition.	Planning Department Building Department	Future				
	Evaluate success of implemented actions and gaps to be addressed.	All Departments	Future				

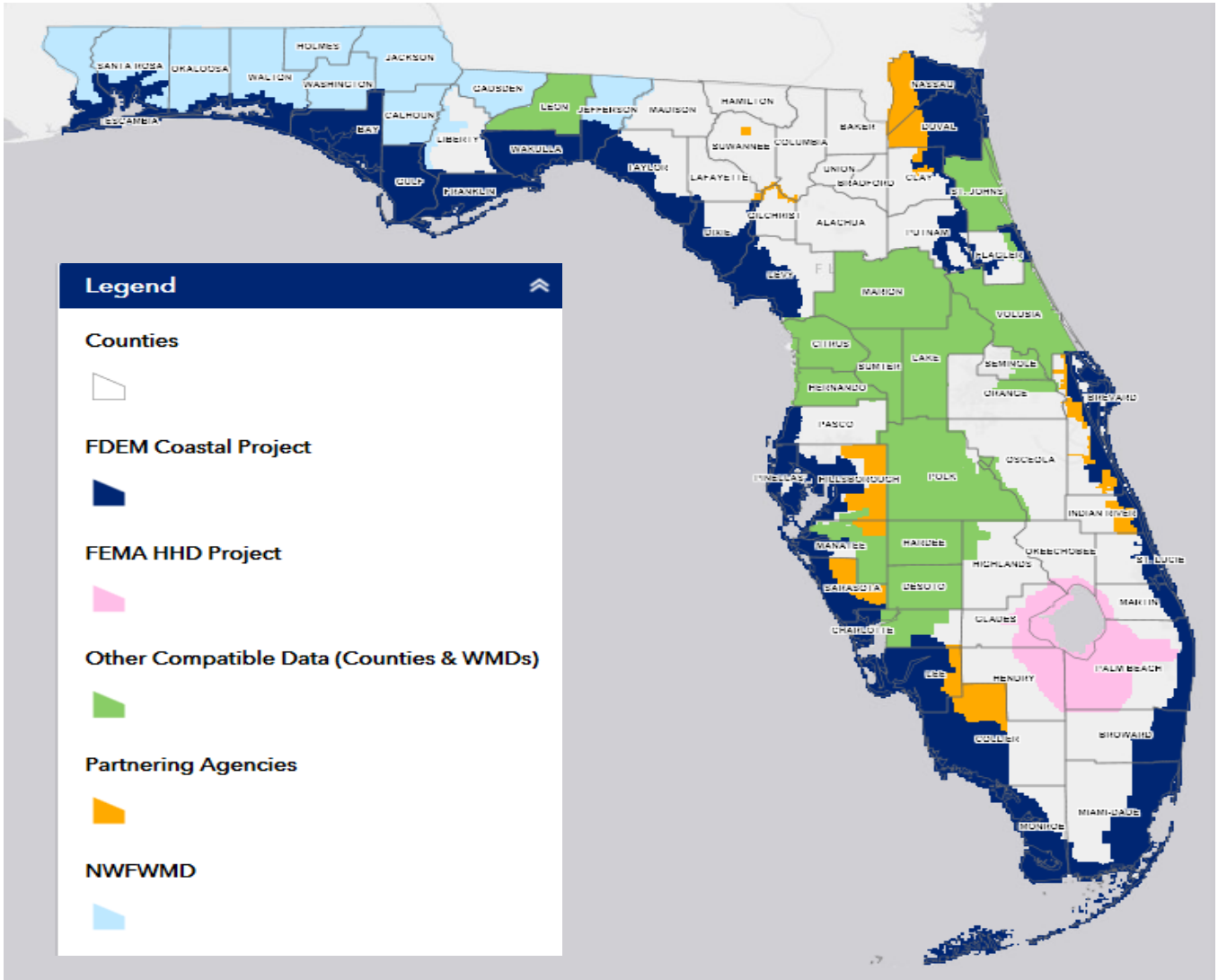
Goal & Objective	Task / Recommendation	Partner(s)	Priority	Corresponding Resiliency Themes			
				Adapt & Protect	Retreat	Prepare & Recover	Educate & Mobilize
Infrastructure and Environment Objective #7 Improve community mobility while improving vulnerable transportation infrastructure.	Update evacuation plans to represent newest data of areas that are transportation dependent that will need assistance in evacuation and re-entry.	Emergency Management Transit Agencies Planning Department	High				
	Prioritize and implement mitigation efforts on trails within the Adaptation Action Area and other vulnerable areas.	FDOT TPO Planning Department Public Works Department	Medium				
	Identify areas where bicycle and pedestrian improvements can be included in transportation projects that mitigate roadways vulnerable to natural hazards	TPO Planning Department Public Works Department	Future				
	Evaluate success of implemented actions and gaps to be addressed.	All Departments	Future				

Appendix I. LIDAR Background and Decision Criteria

LiDAR (Light Detection and Ranging) is the surveying technology that uses light from a pulsed radar to measure variable distances to the earth. These light pulses, combined with other data, are used to generate three-dimensional information about the surface of the earth. This data is then used to create digital elevation models (DEM) for Geographic Information System (GIS) processing. These DEMs are utilized in the processing of sea level rise inundation mapping by the University of Florida Geoplan's Sea Level Scenario Sketch Planning Tool and NOAA's Digital Coast Tools that were utilized for the modeling and assessment of sea level rise impacts in the City of Titusville.

Both NOAA and UF Geoplan utilize the same DEM data developed through the LIDAR and DEM collection and processing efforts conducted by the State of Florida's Department of Emergency Management's (FDEM) Coastal LiDAR project. According to FDEM, efforts between counties, FDEM, and water management districts between 2006 and 2009, collected over 28,000 square miles of LiDAR in Florida. The figure below illustrates the coverage of the LiDAR efforts and the partner agency.

Map 36: LIDAR Coverage



The US Geological Survey 3DEP, the 3D Elevation Program, was developed in response to the growing need for high-quality topographic data. The goal of the program is to collect enhanced, high-quality LiDAR data for the U.S. The USGS 3DEP program has developed specific criteria for this high-quality data. The data must be quality level 2 (QL2) or higher (see chart below) and must have been collected within the last 8 years.

Table 26: USGS 3DEP Data Criteria

Quality Level (QL)	Density (≥ pts/m²)	Precision (RMSE ≤ cm)	Swath Overlap Difference (RMSE ≤ cm)
QL0	8	3	4
QL1	8	6	8
QL2	2	6	8
QL3	0.5	12	16

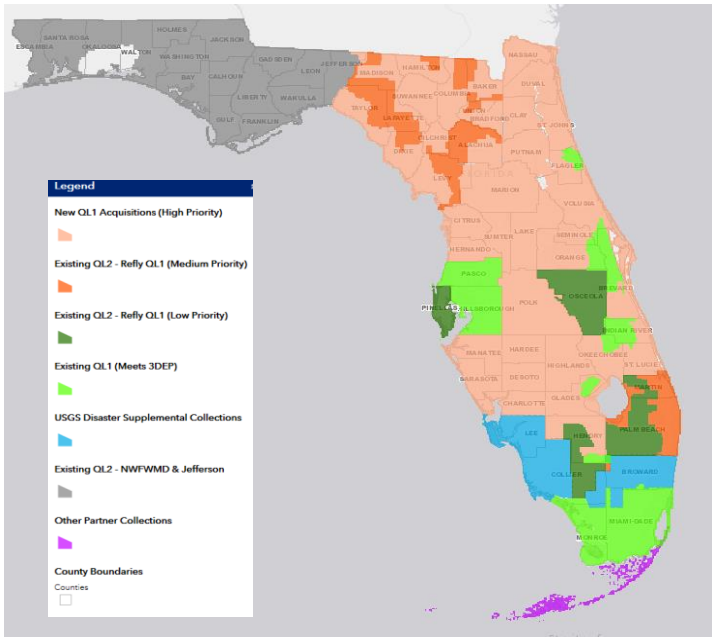
***RMSE stands for "Root Mean Square Error"

According to an assessment of the current Lidar available in Florida by FDEM, only a small portion of the data met a QL 1 or 2. In 2018, the Florida State Legislature approved $15 million to FDEM for "the production of a complete and accurate 3D map of the entire State…" USGS also allocated $7.6 million to Florida for LiDAR acquisition after they received funding for LiDAR acquisition in states affected by Hurricanes Harvey, Irma, and Maria.

The map below, from FDEM, illustrates the priority areas for LiDAR acquisition. As shown below, coastal and southern Brevard County are classified as "High Priority" for new QL1 Acquisition. Information concerning the timeline for data acquisition had not yet been released by FDEM at the time of this report.

Currently, the best data available for sea level rise inundation mapping is that which was developed as a result of the 2009 LiDAR efforts by FDEM and partner agencies and counties. The horizontal accuracy of this data is 1 meter. Both NOAA and UF Geoplan utilize the resultant DEMs for modeling purposes.

Map 37: FDEM LIDAR Acquisition Priority Areas



Below are resources and links for more information concerning LIDAR.

LiDAR Inventory

- This site has information on the status of existing lidar and the parameters of the LiDAR across the United States.
- Link: https://coast.noaa.gov/inventory/

FDEM 2010 LiDAR Report for Brevard County

- Document about the FDEM 2010 LIDAR, break lines and contours for Brevard County including the parameters and processing information.
- Link: https://coast.noaa.gov/htdata/lidar1_z/geoid12a/data/558/supplemental/Survey_Report_for_Brevard_County_FL.pdf

FDEM 2018 State LiDAR Acquisition Project

- Story map about the history of FDEM LiDAR collection and the 2018 LiDAR Acquisition Project
- Link: https://floridadisaster.maps.arcgis.com/apps/MapJournal/index.html?appid=c1a901b51646442db0eff37cbb98219f#

FDEM General LIDAR Site

- Link: https://www.floridadisaster.org/dem/ITM/geographic-information-systems/lidar/

FDEM Coastal LiDAR Mapping Project Data Downloads

- Link: http://fldem.ihrc.fiu.edu/fldemlidar20120119/Default.aspx

Appendix II. Methodology

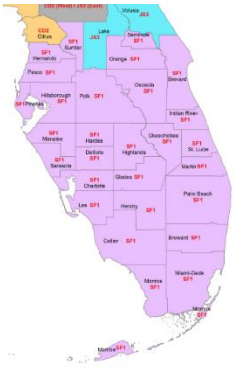
As the goals of the vulnerability analysis and subsequent policy actions are based upon specific hazards, the methodology section of this report highlights the base data utilized and the general methods of analysis. The areas of vulnerabilities assessed for this report include: sea level rise, frequent 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.

Frequent Flooding Data

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 have increased 5- to 10-fold since the 1960s in several U.S. coastal cities. 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. 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.

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 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.

Map 38: South Florida Super Basin (Purple)



Storm Surge Data

A Sea, Lake, 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 (pictured, in purple) became operational, spanning from the Tampa Bay region, south through the Florida Keys, and north up through Cape Canaveral. This basin replaced 6 smaller basins across the region, including the Cape Canaveral Basin which had previously been used as the Brevard and Volusia County SLOSH Basin. 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.

Sea Level Rise Data

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).*

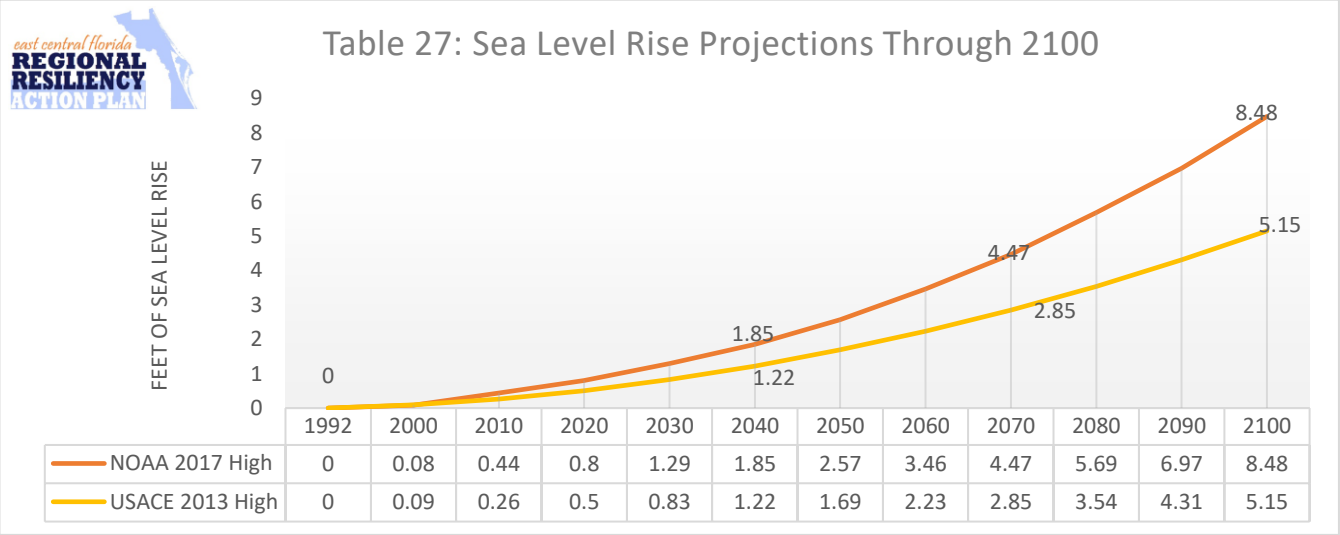
For the purpose of assessing sea level rise vulnerabilities on the City, the regional approach was used as the parameters of the assessment. The planning horizons for the City of Titusville are 2040, 2060, 2080 and 2100.

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 data. The 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 Mean Higher High Water (MHHW).

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/.

The GeoPlan Center currently only has NOAA 2012 data; therefore, the 2017 update data were 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 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: 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 on NOAA's website at the following link: 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 highest high tides (excluding wind driven tides) in accordance with the amount of sea level rise portrayed.



	1992	2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100
NOAA 2017 High	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 High	0	0.09	0.26	0.5	0.83	1.22	1.69	2.23	2.85	3.54	4.31	5.15

Sea Level Rise: NOAA and USACE GIS Data Methodologies

- Link to NOAA Methodology
- Link to USACE Methodology

The probabilities associated with the two sea level rise curves analyzed in this report are based on a set of underlying assumptions about the Earth's climate. Please review the reports above and all technical data provided by the U.S. Army Corps of Engineers and NOAA.

Flood Data

The FEMA Digital Flood Insurance Rate Maps (DFRIM) from 2014 were used to conduct the assessment of assets located in the 100- and 500-year 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 Risk MAP Coastal Resiliency Study 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.

Use of Geographic Information Systems (GIS) to Complete the Vulnerability Assessment

The East Central Florida Regional Planning Council utilized Geographic Information Systems (GIS) to complete the vulnerability assessment in this report.

The following steps were completed:

1) Collected GIS data for 1) critical facilities, 2) roadways and 3) parcels
    a. Quality assured this data with satellite imagery
    b. Parcel files from the County were custom built to include information concerning build year, financial values, addresses, and other data.
2) Imbedded hazard fields into the attribute tables of the three aforementioned GIS files
3) Populated hazard fields
    a. The following priorities were assigned (highest priority hazard zones were queried last in the event that an asset was in multiple hazard zones
        i. Sea Level Rise: Earlier horizons receive higher priority
        ii. Flood Zone Priority: VE, AO, AH, AE, A (due to zone descriptiveness)
        iii. Storm Surge: Category 1, 2, 3, 4 and then 5
    b. Executed a select-by-location function to identify assets in each hazard zone for:
        i. Parcels (Polygon)
        ii. Critical Facilities (Polygon)
    c. Executed the clip function to identify the roadway segments in each hazard zone
        i. Re-calculated geometry for roadways (length, in miles) after the clip function was executed
4) Populated report by querying the completed data tables

The following special circumstances were encountered:

1) Some parcels had an earlier horizon per the USACE dataset than the NOAA dataset, which is not possible because the projections for NOAA are higher. This occurred because of how the layers are drawn over the lagoon. In these circumstances, the horizon for the USACE curve (per asset) was utilized as the horizon for the NOAA curve.
2) NOAA sea level rise values (per time horizon) were rounded to the nearest whole number.
3) It is recommended that the City document the actual height (above mean sea level) for all of the outfalls within the City.
4) The three clipped hazard zone maps for storm surge (financial, land use and transportation overlays) were clipped to the Category 5 zone due to the long-term framework (80 years +) of this plan. While a Category 5 hurricane is a rare occurrence, the maximum extent must be shown due to the time horizon of this plan.

Appendix III. Low and Intermediate Curve Sea Level Rise Maps

The maps on the following two pages depict the modeled "intermediate" sea level rise zones as determined by the U.S. Army Corps of Engineers and the National Oceanographic and Atmospheric Administration. These maps show the following levels of inundation (represented in number of feet to two significant digits) in comparison to the high curve from a 1992 baseline, as measured by the Daytona Beach Shores tidal gauge utilizing Mean Higher High Water MHHW). "Low" sea level rise curve maps are not included in this section due to their minimal projected impacts on the City.

Table 28: USACE and NOAA Sea Level Rise Curve Detail

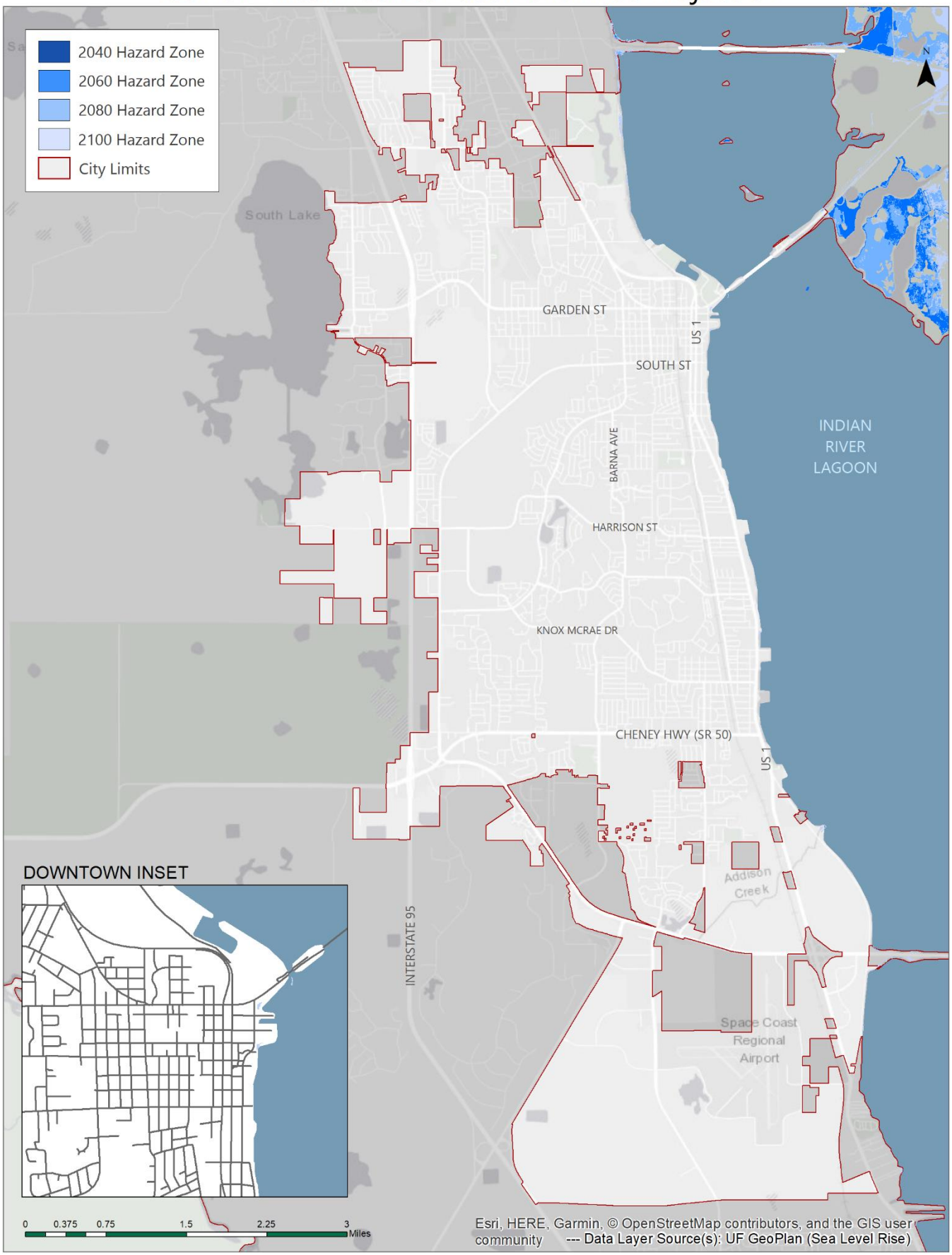
Source & Curve	2040	2060	2080	2100

USACE Low Curve	0.42'	0.58'	0.67'	0.83'
USACE Intermediate Curve	0.58'	0.92'	1.42'	1.92'
USACE High Curve	1.22'	2.23'	3.54'	5.15'

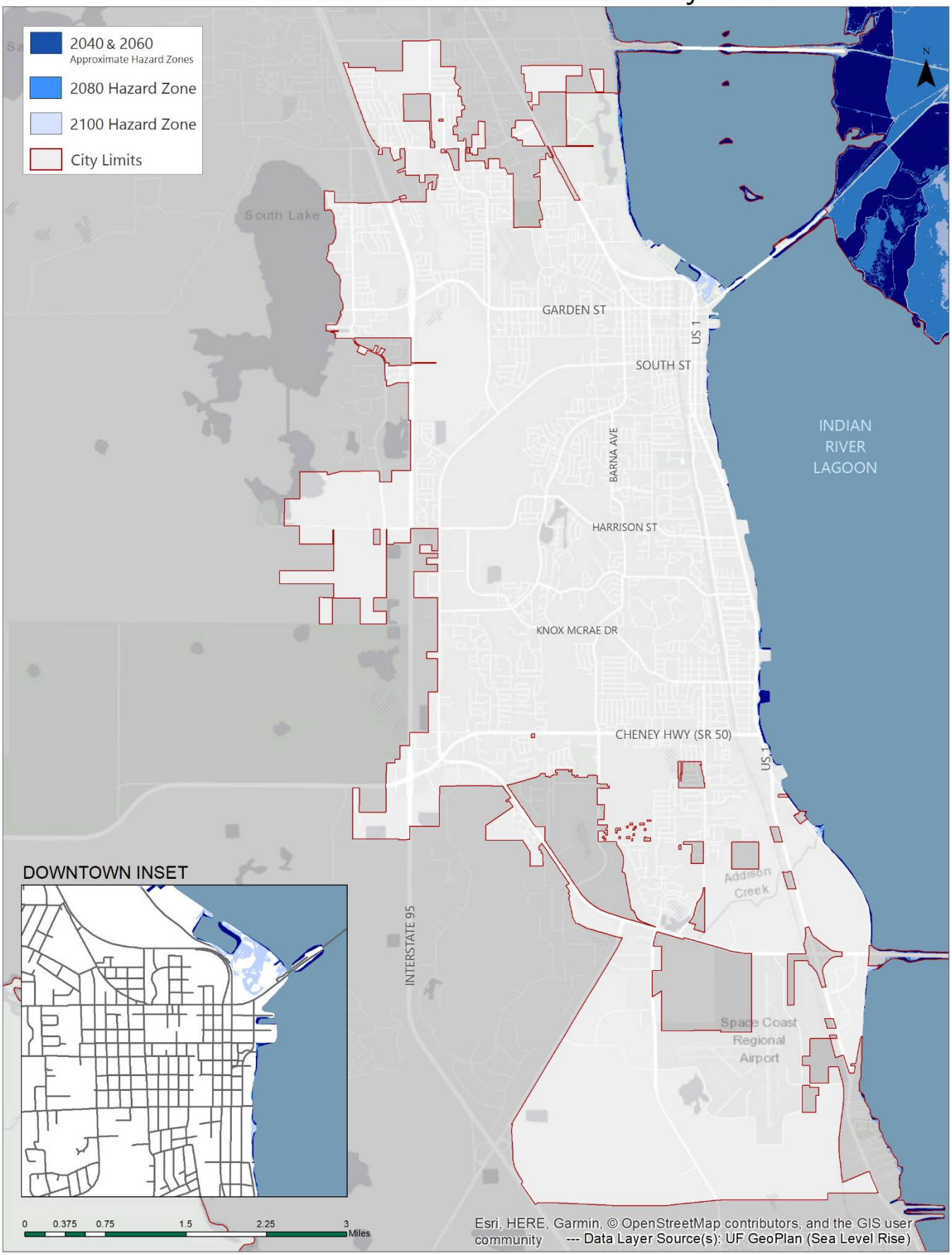
NOAA Low Curve	0.43'	0.62'	0.82'	0.98'
NOAA Intermediate Curve	0.82'	1.48'	2.33'	3.28'
NOAA High Curve	1.85'	3.46'	5.69'	8.48'

The third map within this appendix show the inundation associated with a three-foot nominal increase in sea level rise. This level of sea level rise will be assessed by City staff while staff continues to monitor sea level rise projections and their associated probabilities over the next 5 to 20 years.

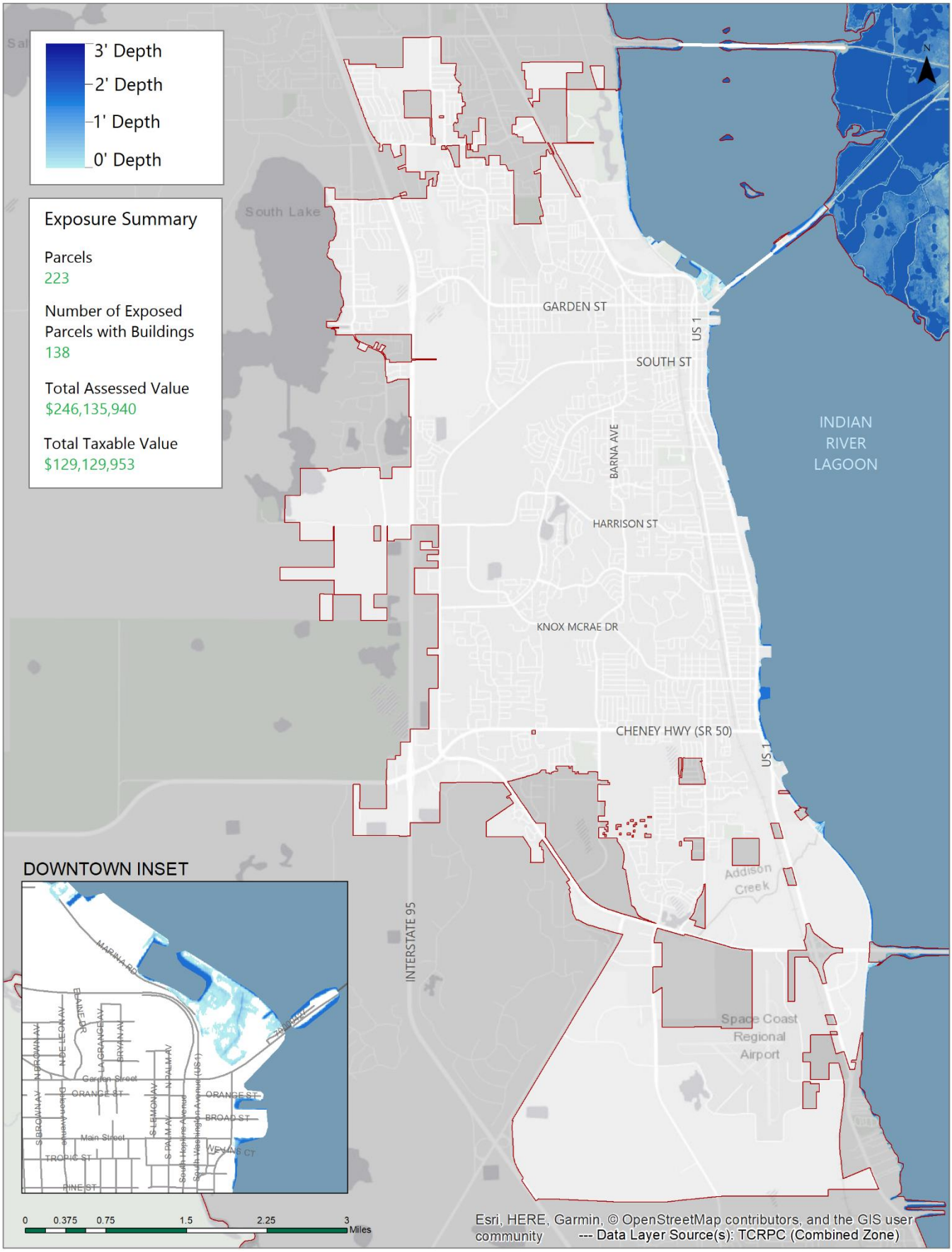
USACE "Intermediate" Sea Level Rise Projection



NOAA "Intermediate" Sea Level Rise Projection



Inundation Extent from Three-Foot Increase in Sea Level Rise



Appendix IV. Facility Exposure to Sea Level Rise by Inundation Level

The following table shows the level of sea level rise (in feet) that would inundate the critical facility parcels covered in this report.

Table 29: Facility Exposure to Sea Level Rise by Inundation Level

Facility	Facility Type	Sea Level Rise Tipping Point (ft)
Aerospace Interconnect Systems	HazMat Facility	3
Banana River Park Debris Staging Area	Waste Facility	5
Boat Ramp 1	Recreation	1
Boat Ramp 2	Recreation	3
Cape Canaveral Comm. Services/Water Reclamation	Transportation Operations	5
Cape Canaveral Fire Department Station #52	Fire Service	6
Chain of Lakes Park	Recreation	4
Cocoa Lift Station #1	Utility	5
Cocoa Lift Station #45	Utility	4
Columbia Electric Substation	Utility	5
Craig Technologies	HazMat Facility	5
Eastern Florida State College	School	1
Indian River Lodge	Community Center	4
Kennedy Point Park	Recreation	1
Kennedy Point Yacht Club	HazMat Facility	1
Lift Station 12 (Patriots Park)	Utility	5
Lift Station 13 (Thurm Boulevard)	Utility	5
Lift Station 14 (Villa Nova - Thurm)	Utility	6
Lift Station 2 (Center Street)	Utility	5
Lift Station 3 (West Central)	Utility	4
Lift Station 5 (Columbia Dr)	Utility	4
Lift Station 7 (Central/Thurm)	Utility	4
Lift Station 8 (Manatee Bay/Thurm)	Utility	5
Lift Station 9 (Banana River Dr)	Utility	3
Manatee Sanctuary Park and Debris Staging Area	Waste Facility	6
Osprey Water Reclamation Facility	Utility and HazMat	5
Parrish Medical Center	Hospital and HazMat Facility	1
Rotary Water Front Park	Recreation	1
Southeast Power Corp	HazMat Facility	4
Space View Park	Recreation	1
Titusville Municipal Marina & Park	Government and Recreation	1
Vectorworks International	HazMat Facility	1
Veterans Memorial Fishing Pier	Recreation	1
Veterans Memorial Park	Recreation	1
William J Manzo Memorial Park	Recreation	1

Appendix V. Shoreline Edge Types in Titusville

Appendix VI. Source Documentation

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Prepare for Emergencies
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Appendix VII. Planning Team Contact Information

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