RESILIENT JACKSONVILLE
VULNERABILITY ASSESSMENT

Prepared for the City of Jacksonville
by Fernleaf & The Water Institute
October 2023

VULNERABILITY ASSESSMENT TEAM

The Resilient Jacksonville Vulnerability Assessment Team was assembled in May 2022. The team includes Jacksonville's Chief Resilience Officer, Anne Coglianese, who served as the coordinating lead for the assessment process. A core team of staff from the City of Jacksonville was assembled to participate in workshops and provide input to guide the process. A team of consultants, led by Fernleaf and The Water Institute, provided facilitation of the assessment process, as well as scientific analysis and technical support for the development of this report. Additional assessment support was provided by SCAPE Landscape Architecture, Halff Associates, and Acuity Design Group.

ACKNOWLEDGEMENTS

The assessment team would like to thank Jacksonville city staff for their willingness to provide data to support resilience throughout the city. The City of Jacksonville is an emerging leader in city resilience planning, and this is a direct result of city staff's commitment to interagency collaboration and scientific integrity. In particular, we would like to thank the City of Jacksonville IT Department for providing the parcel data used for this assessment. We would also like to express thanks to the University of North Florida and the team at CAPA Strategies for making data from the 2022 Heat Watch Survey available, as well as CDM Smith for providing data from the Jacksonville Master Stormwater Management Plan and the Flood Risk Assessment for High Priority Assets.

DISCLAIMER

This assessment uses the best available data for hazards and assets at the time these analyses were performed (June 2023). Results communicated throughout this report are based on data with differing levels of uncertainty and assumptions and should be interpreted as measures of relative risk throughout different areas of Jacksonville.

Analysis results presented in this report are meant to inform questions around the vulnerability of assets. Users of maps, graphics, and other data included in this assessment are solely responsible for interpretations and inferences made from these products, the use of which acknowledges and accepts this disclaimer.

Analysis: June 2023
Report authored: October 2023

Suggested Citation:

Fernleaf and The Water Institute (2023). Resilient Jacksonville Vulnerability Assessment Report. Final report prepared for the City of Jacksonville. Jacksonville, Florida. 100p + appendices.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

KEY TERMINOLOGY

Below are some key terms that you will see throughout this report.

Acute Shocks – Sudden, extreme events that threaten a community. Also referred to as hazards throughout this assessment.

Adaptive Capacity – The ability of an asset to adjust or cope in response to hazards.

Annual Exceedance Probability (AEP) – The probability for which a hazard of a given severity is likely to occur or be exceeded in any given year.

Assets – The specific property classes, services, people/socioeconomics, and infrastructure located throughout the city and its communities.

Census Tract – A geographic unit with a comparable population level utilized by the U.S. Census Bureau for data collection and assessment.

Chronic Stressor – Long-term condition, event, or trend that can exacerbate hazards that can weaken the fabric of a community over time. Stressors can be either climate or non-climate related.

City Resilience – The ability of city systems to adapt and thrive in the face of acute shocks and chronic stressors.

Climate Change – A change in typical climate conditions, such as an increase in the average temperature for a region or change in how much annual rainfall a particular location will receive.

Climate Threats – Major hazards or chronic stressors that are directly influenced by climate change and negatively impact community assets.

Exposure – The presence of assets in harm's way.

Extreme Heat Event – A series of days where the weather is hotter and/or more humid than average for an area and time of year, leading to potentially hazardous conditions.

Heat Index – A measure of how hot a human body feels when relative humidity is factored in along with air temperature.

High Winds – Sustained, strong winds. Tropical systems are the biggest threat for sustained high winds in southeast Florida.

Relative Humidity – A ratio, expressed in percent, of the amount of atmospheric moisture present relative to the amount that would be present if the air were saturated.

Risk – The probability (likelihood) and the consequence, or negative outcome, of a hazard occurring.

Sensitivity – The range or magnitude of how much an asset may be harmed by a threat.

Vulnerability – The output of an analysis of the intersection of various asset characteristics used to indicate levels of sensitivity, potential impact, and adaptive capacity.

KEY HIGHLIGHTS

- Based on the total number of assets, the highest level of vulnerability citywide in Jacksonville are to hazards of floodplain inundation, coastal storm surge, and high winds.
- Nearly 20,000 residential properties in Jacksonville are currently vulnerable to coastal, riverine or stormwater flooding. This is predicted to increase to close to 22,500 by 2070.
- More than a third (37%) of flood-prone residential properties in the city have buildings that were either built before any floodplain requirements were in place or built outside the recognized floodplain where elevation requirements do not apply.
- While properties are prone to flooding throughout the city, some areas have much higher levels of vulnerability and risk; this is especially true for residential properties in the Coastal Communities Development Type and commercial and industrial properties Downtown.
- Approximately 28% of major roads and 22% of minor roads (measured in lane miles) within Jacksonville have the potential to become inaccessible to emergency response in flood events. 7% of these roads are maintained by the City of Jacksonville.
- A large number of vacant properties are vulnerable to current or future flooding under different scenarios; however, vacant properties remain in several areas of the city that may be more resilient to flooding in the future and could be considered for resilient infill opportunities.
- Vulnerability to extreme heat occurs in areas throughout Jacksonville except for in the Rural Mosaic Development Type. These vulnerabilities may be exacerbated by social factors such as access to transportation and cooling centers. Protecting lands in the Rural Mosaic could help Jacksonville be more resilient to extreme heat in the future.
- About 1% of residential properties in Jacksonville are highly vulnerable to wildfire, which includes more than 4,400 properties. The most vulnerable areas are concentrated on the outskirts of the city, where homes are in closer proximity to wildland areas and potential wildfire fuel.
- About 60% of residential properties in Jacksonville are highly vulnerable to high winds. These properties are found predominantly in the Contemporary and Post-War suburbs.
- Social vulnerability is an important consideration for all climate threats. Many areas of Jacksonville that are most vulnerable to the climate threats assessed are also vulnerable to social stressors.

1.0 INTRODUCTION

The City of Jacksonville, Florida has developed a comprehensive city resilience strategy to guide policies, projects, and programs that will help Jacksonville prepare for, adapt to, and quickly rebound from acute shocks and chronic stressors. To develop a science-based resilience strategy, a detailed understanding of the city's vulnerability to multiple climate threats now and in the future was needed. This Vulnerability Assessment was conducted to provide a tool grounded in recent science to inform the development of the *Resilient Jacksonville* Strategy. Its goal is to provide decision makers in Jacksonville with the science-based risk and vulnerability data needed to identify and prioritize resilience actions for the *Resilient Jacksonville* and to inform future planning and project implementation efforts.

1.1 WHAT IS A VULNERABILITY ASSESSMENT?

A vulnerability assessment is a structured process that identifies the ways in which an organization, community, or city is susceptible to harm from existing or potential hazards. Vulnerability assessments evaluate three main components: 1) exposure; 2) potential impact; and 3) adaptive capacity, where both physical and socioeconomic dimensions are considered.

The purpose of this vulnerability assessment is to examine the ways in which Jacksonville's core community assets and populations may be impacted by climate threats under current and future conditions. To ensure that Jacksonville's City leadership and residents have access to the most current and robust analysis of the city's susceptibility to different hazards, this report analyzes outputs from several assessments of vulnerability and key hazards including flooding, heat, wildfire, and high winds. The comprehensive, multi-threat assessment of vulnerability presented in this report aims to assist Jacksonville's decision makers in addressing critical questions related to climate change and help to ensure that investments and decisions are data-driven and equitable as the city prepares for today's risks and proactively adapts for the future.

1.2 UNDERSTANDING CLIMATE CHANGE IMPACTS

Climate is referred to as the usual weather conditions expected for a particular location. Climate change is the change in those usual weather conditions, such as the average temperature for the region, or how much annual rainfall a particular location will receive. Earth's climate is now changing faster than at any point in the history of modern civilization, resulting in widespread and growing impacts (Jay et al., 2018).

According to the Intergovernmental Panel on Climate Change (IPCC), observed climate change has caused adverse impacts on human health, livelihoods, and key infrastructure in urban areas (IPCC, 2023). As communities across the United States continue to experience increasingly severe and frequent weather events resulting from climate change, local governments are recognizing the importance of strengthening resilience to these threats. Changes in climate will result in existing hazards becoming more severe and/or frequent (IPCC, 2023). In sections 1.1–1.3, we highlight how key climate indicators are changing and discuss the potential implications of continued changes to these indicators for the City of Jacksonville.

Temperature

In the southeastern United States, observations over the past 100 years have shown uneven warming temperatures, with an upward trend becoming increasingly apparent (NOAA, 2023). Figure 1 shows the percent change in the minimum temperatures observed (i.e., overnight lows) across the southeast in recent decades. In 2020, minimum temperatures in the southeast were warmer in nearly all areas than the long-term averages from the previous three decades.

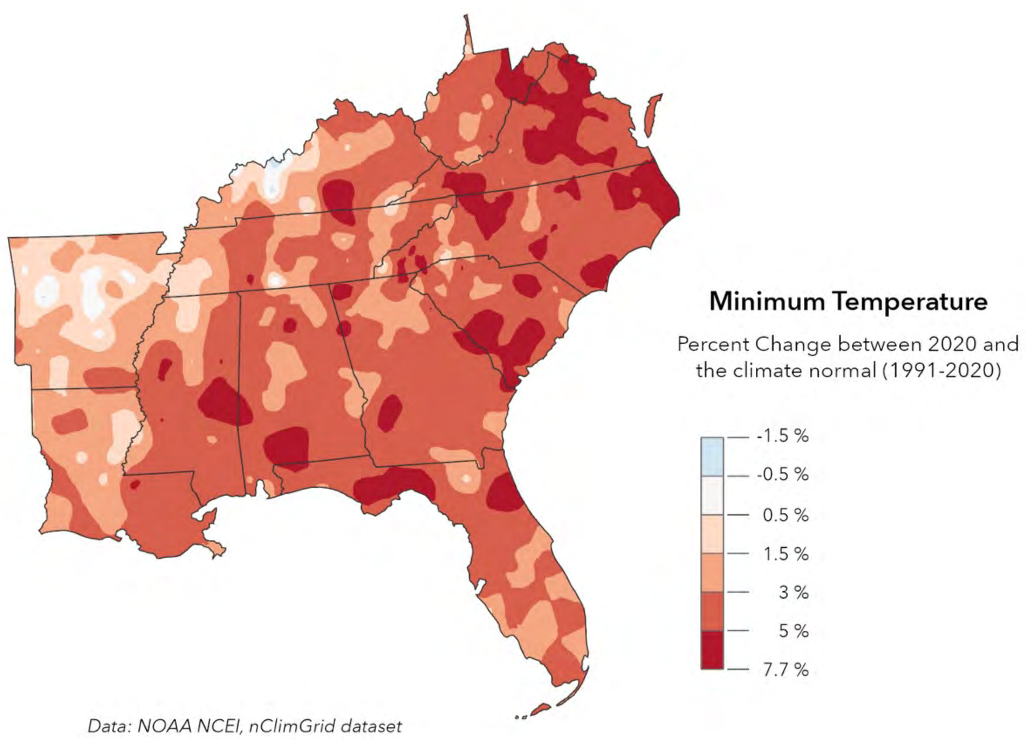


FIGURE 1. AVERAGE MINIMUM TEMPERATURE IN THE SOUTHEAST UNITED STATES IN 2020 COMPARED TO 1991–2020. VISUALIZATION BY JORY FLEMING, BASED ON NOAA NATIONAL CENTER FOR ENVIRONMENTAL INFORMATION NCLIMGRID DATASET (NOAA, 2023).

Climate models that represent our understanding of historical and current climate predictions are often used to predict how the climate will continue to change under future conditions. Today, the largest uncertainty in projecting future climate conditions is the level of greenhouse gas emissions going forward (Jay et al., 2018). With substantial and sustained reductions in greenhouse gas emissions, the global annual average temperature increase could be limited to less than 4°F. However, without significant greenhouse gas mitigation, this increase could be as high as 9°F by the end of this century (Jay et al., 2018).

Regardless of the climate change emissions scenario applied, Jacksonville is predicted to continue to experience increasing temperatures over the next century. Figure 2 provides projections of the rise in the number of very hot days in Duval County based on a climate emissions scenario that anticipates “slow action” on the reduction of global greenhouse gas emissions. These projections were performed using a dataset developed by the Union of Concerned Scientists using downscaled multi-model data (Union of Concerned Scientists, 2019). The heat index is a measure of how hot a human body feels when relative humidity is factored in along with air temperature by combining temperature and relative humidity. By mid-century, the number of days per year in Jacksonville with a heat index above 90°F is projected to rise by 40%. An even more pronounced increase is projected for the number of days with heat index above 100°F, where a 300% increase is projected.

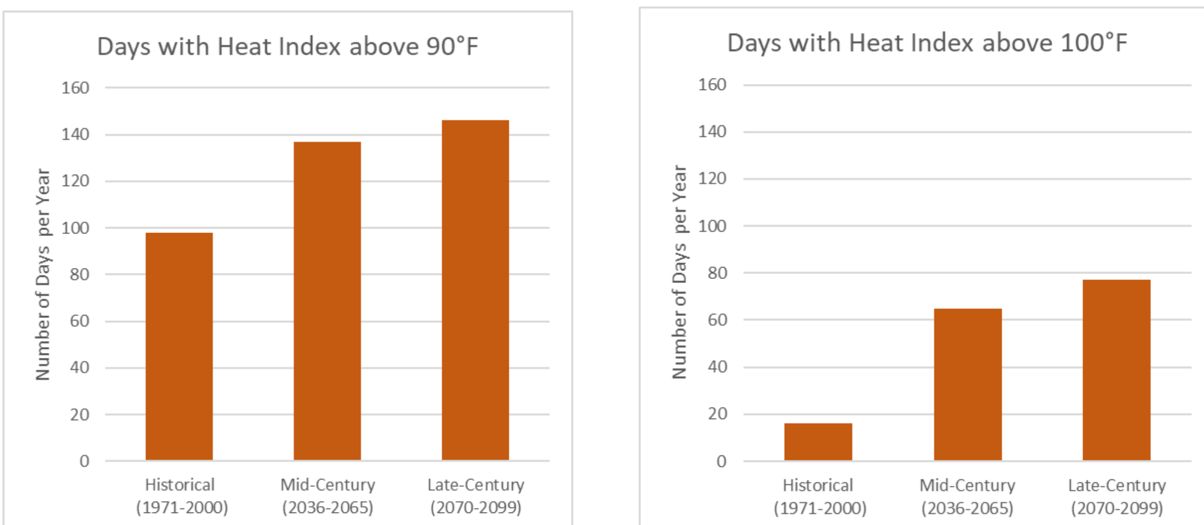


FIGURE 2. PROJECTED DAYS WITH HEAT INDEX ABOVE 90°F AND 100°F BY 2050 (UNION OF CONCERNED SCIENTISTS, 2019).

Rising temperatures pose a number of threats to human health and quality of life. Summertime high temperatures are linked directly to an increased risk of illness and death, particularly among older adults, pregnant women, and children (Jay et al., 2018). Cities and other highly developed areas are especially prone to the health risks from increasing temperatures as the combination of a warming climate and dense concentrations of pavement and buildings can cause “Urban Heat Islands” (see Figure 3), an effect that occurs when natural land cover is replaced with heat-retaining surfaces (EPA, 2022). In addition to the threats to human health, rising temperatures also are predicted to result in increased storm intensities, more frequent high wind events, and increased likelihood of wildfires (Jay et al., 2018).

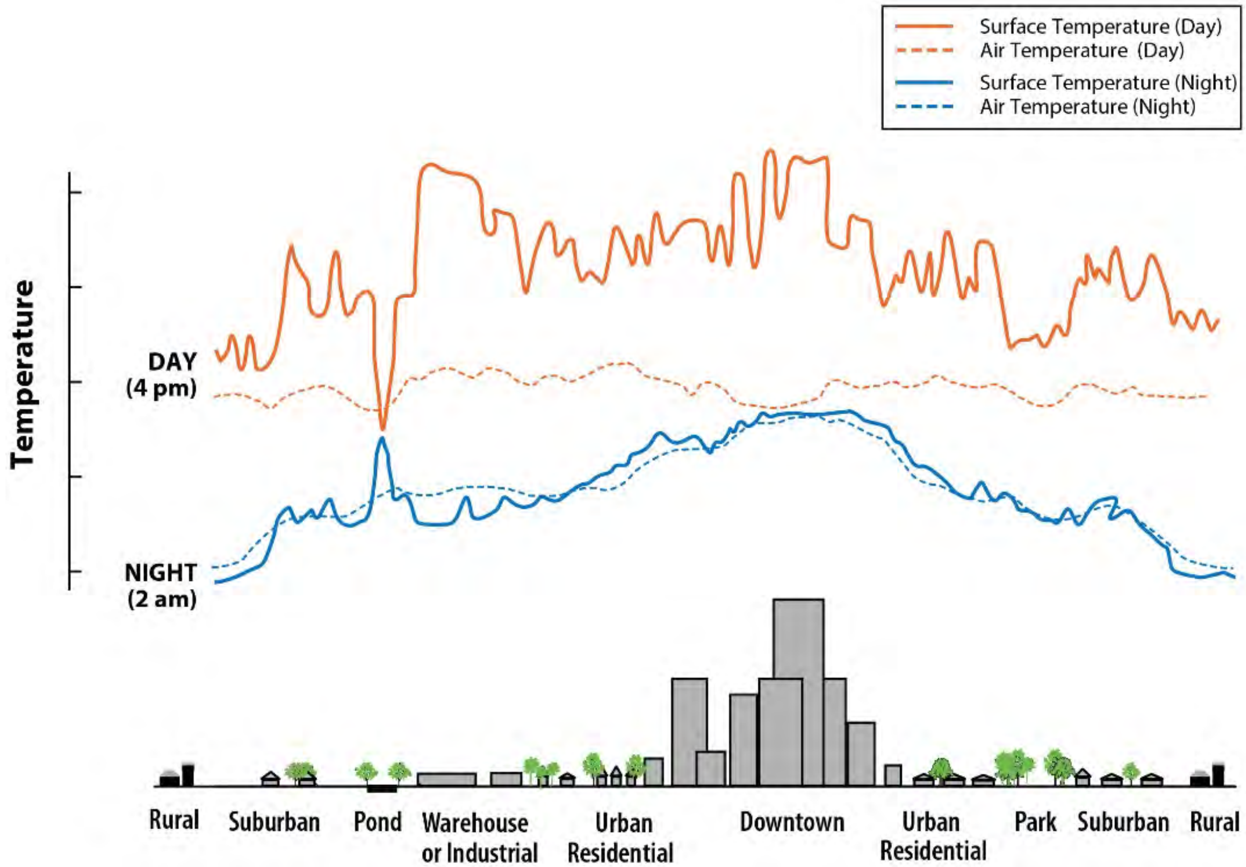


FIGURE 3. U.S. ENVIRONMENTAL PROTECTION AGENCY HEAT ISLAND EFFECT DIAGRAM DEPICTING ELEVATED TEMPERATURES IN AREAS WITH DENSE CONCENTRATIONS OF PAVEMENT AND BUILDINGS (EPA, 2022).

On June 18th, 2022, the University of North Florida (UNF) and the City of Jacksonville partnered to conduct a field campaign as part of the CAPA Heat Watch Program, which collected local heat data and captured the ways in which urban heat varies across the City of Jacksonville. UNF and a team of volunteers collected point temperatures and heat index data across the city and found that the distribution of heat across Jacksonville can vary significantly based on land use. The data from this assessment was then compiled by researchers at CAPA Strategies and turned into temperature maps for Jacksonville's Chief Resilience Officer (CAPA Strategies, 2022). As shown in Figure 4, a difference of 11.8°F was observed during the study across the warmest and coolest parts of the city (CAPA Strategies, 2022). In addition to Downtown, where the highest temperatures were recorded, many of warmest areas of the city were observed in some of the more socially vulnerable communities, including Eastside and New Town. There were also several other commercially developed areas, such as Regency and Southpoint, that recorded much warmer temperatures than the surrounding areas. These results highlight the elevated risk that increasing temperatures may pose to certain communities within Jacksonville.

In addition to the threats to human health, rising temperatures are also predicted to result in increased storm intensities, more frequent high wind events, and increased likelihood of wildfires (Jay et al., 2018).

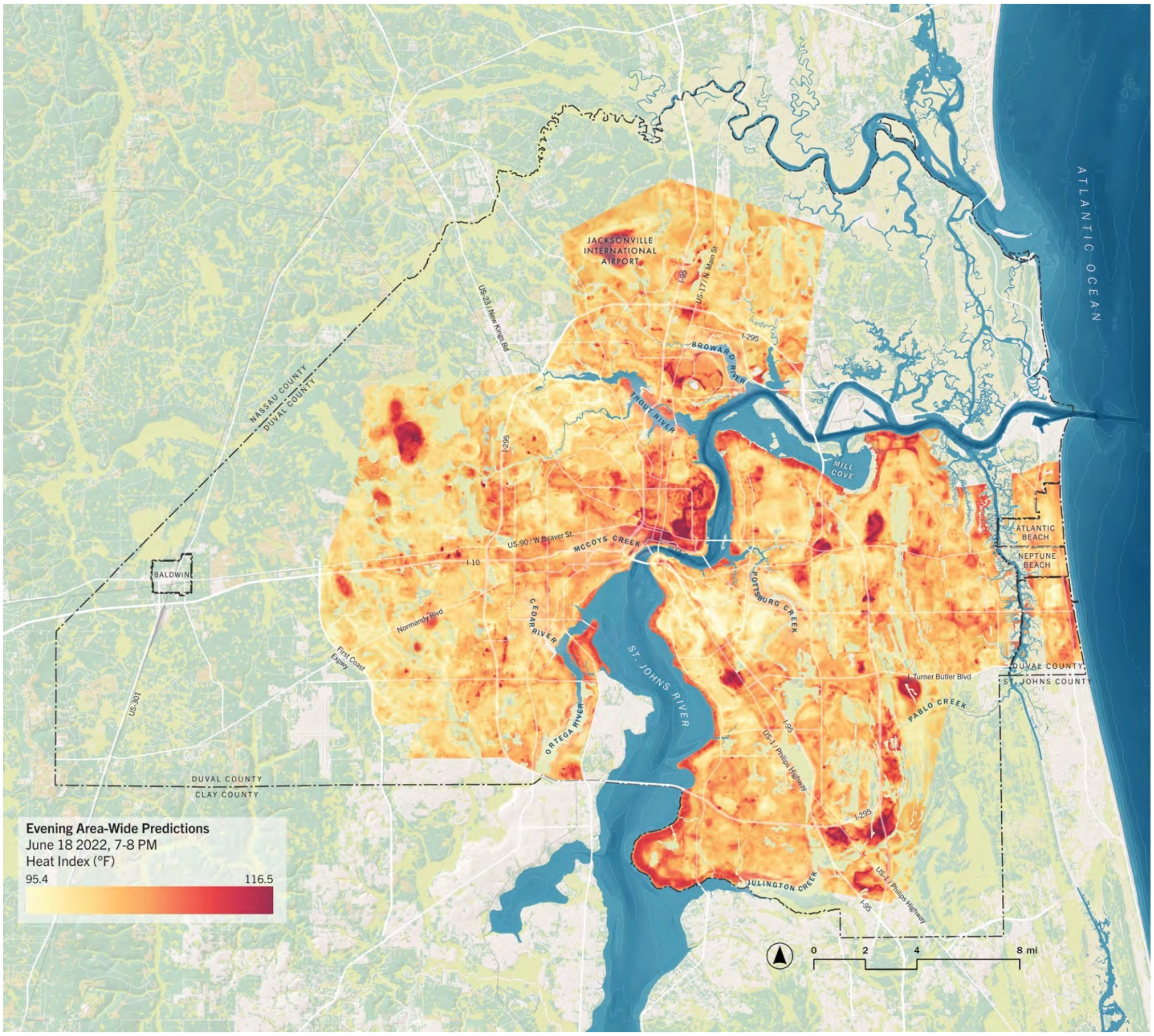


FIGURE 4. HEAT INDEX VALUES ACROSS JACKSONVILLE DURING EVENING TEMPERATURES FOR JUNE 18, 2022. (CAPA STRATEGIES, 2022)

Sea Level Rise

Warming temperatures worldwide are causing land and glacial ice to melt and ocean water to expand as it warms. Globally, the average sea level has risen about 8–9 inches since 1880, with 3 inches of that rise occurring since 1990 (Carter et al., 2018). Jacksonville, as a coastal city, is particularly vulnerable to sea level rise. Based on historical data, Mayport has observed a relative sea level rise increase of 2.83 millimeters/year (+/- 0.25) from 1928 to 2022, which is equivalent to a change of 0.93 feet over roughly the last century (NOAA, 2022, Figure 5).

Over the next century, Jacksonville will experience more coastal flooding due to sea level rise and from stronger coastal storms. The short-term impacts of sea level rise include increased risk of high tide flooding and storm surge. In 2021, Mayport experienced four high tide flood days. By 2050, this number is anticipated to increase to 40–60 high tide flooding days (NOAA, 2022).

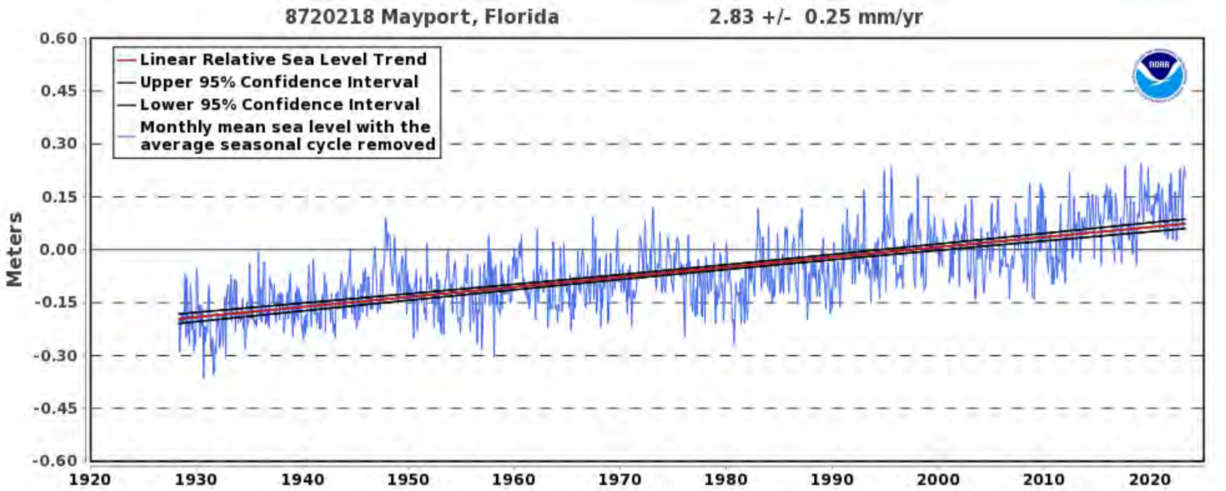


FIGURE 5. RELATIVE SEA LEVEL TREND FOR MAYPORT, FL, BASED ON MONTHLY MEAN SEA LEVEL DATA FROM 1928–2022 (NOAA TIDES AND CURRENT, MAYPORT, FL).

Precipitation

Findings from the Fourth National Climate Assessment suggest that compared to the historic average for the southeast United States, there is an expected 1.5–2x increase in extreme precipitation events by 2070 (Terando et al., 2018). Because of this, Jacksonville will experience more inland flooding due to more intense rainfall events and the associated stormwater runoff.

While Jacksonville is predicted to have an increase in extreme precipitation events, rising temperatures, increased evapotranspiration, and changing rainfall patterns due to climate change are also predicted to result in more frequent drought conditions (IPCC, 2023). Drought and increasing temperatures could pose threats to Jacksonville's agricultural and timber producers through reduced freshwater supplies and increased risk of wildfires.

1.3 CLIMATE THREATS CONSIDERED

Vulnerability to hazards is driven by the relationships between climate and non-climate stressors. As an example, rainfall alone is not a threat; however, an extreme rainfall event is considered a threat that can cause increased flooding if enough precipitation falls within a certain amount of time, or in an area with significant impervious surface cover (a non-climate stressor). Non-climate stressors are conditions that contribute to the occurrence of a threat and can exacerbate its impacts. For example, urbanization and large swaths of impervious surface are non-climate stressors and are known to increase runoff, erosion, and flooding, and aggravate Urban Heat Island effects.

This assessment focuses on Jacksonville's vulnerability resulting from four specific climate threats: flooding, extreme heat, high winds, and wildfires. These threats were identified by the resilience planning team as most likely to negatively impact the city under present and possible future conditions. More detailed definitions of each of these threats are provided below.

Flooding

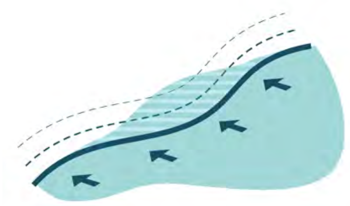
When Hurricane Irma hit Jacksonville as a tropical storm on September 11, 2017, storm surge and runoff from torrential rains pushed the St. Johns River to record-breaking heights (Cangialosi et al., 2021). This resulted in the worst flooding observed in Jacksonville's 250-year history and demonstrated the city's vulnerability to multiple types of flooding.

Coastal Flooding

Coastal flooding refers to flooding that occurs due to inundation from the ocean. There are two types of coastal flood risks in Jacksonville: high tide flooding and coastal storm flooding. Because the lower St. Johns River is a broad and shallow tidal estuary influenced by salt water and tides as far as 100 miles upriver (Durako et al., 1988), coastal flood threats to the city extend far inland from the Atlantic coastline.

High Tide Flooding

High tide flooding involves flooding of low-lying coastal areas by high tides. This can occur during normal high tides or extreme high tide events (e.g., "king" tides or spring high tides). As sea levels rise, the time periods when tidal flooding occurs will increase in frequency and duration. Over time, this may be exacerbated by losses of natural barriers (Sweet et al., 2018).



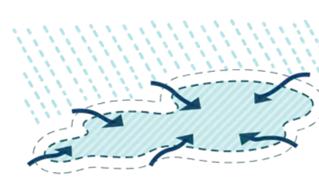
Coastal Storm Flooding

Coastal storm flooding is flooding driven by coastal storms like hurricanes. It includes the effects of both storm surge and high waves. Higher sea levels due to climate change will raise the elevation of storm surge and waves and cause them to travel farther inland than in the past, impacting more coastal properties (Reidmiller et al., 2018; Terando et al., 2018).

Rain-induced Flooding

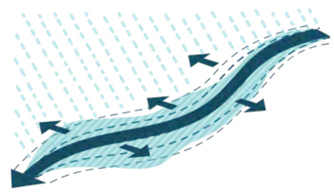
Rain-induced flooding is freshwater flooding that occurs as a result of heavy precipitation events. The types of rain-induced flooding that can occur in Jacksonville are stormwater flooding and riverine flooding.

Stormwater (Pluvial) Flooding



Stormwater flooding, also known as pluvial flooding, is flooding due to rainwater piling up in areas with poor drainage. This often happens during heavy rainfall events when drains and pipes cannot keep up with the amount of falling rain. As warmer air can result in an increase in atmospheric water vapor, extreme precipitation events are expected to increase. In the southeast and across the United States, an increasing trend in the frequency and intensity of heavy rain events is already being observed (Reidmiller et al., 2018; Terando et al., 2018).

Riverine (Fluvial) Flooding



Riverine flooding, also known as fluvial flooding, is when water in rivers, creeks, canals, or swales overtops the banks. This can happen due to local heavy rainfall. It can also result from rainfall upstream, even when it has not rained where the flooding occurs.

Compound Flooding

Compound flooding is when different types of flooding occur at the same time. An example of compound flooding is when heavy rain falls during a coastal storm, resulting in flooding from both the coastal storm surge as well as from riverine or stormwater flooding. Many places along the St. Johns River and its tributaries are vulnerable to this kind of flooding; however, this type of flooding is the most difficult to predict in Jacksonville due to the complexity of predicting for flooding from multiple sources of water. Note: As modeled predictions for compound flooding in Jacksonville are not currently available, this Vulnerability Assessment does not evaluate vulnerability to compound flooding. However, recognizing this gap, the City is beginning efforts to model compound flooding in Jacksonville that incorporate groundbreaking scientific methods. These new estimates will further support assessment of flood vulnerability in Jacksonville.

Extreme Heat

Extreme heat events are periods of time in which temperatures are much hotter and/or more humid than average (CDC, 2017). Extreme heat events have always occurred, but changes in climate have made extreme heat events more common, more severe, and longer-lasting (EPA, 2016).

Extreme heat events are quickly becoming one of the deadliest weather-related events in the country, with more than 600 people killed in the United States by extreme heat every year (Berko et al., 2014). However, not everyone is affected by heat equally. Research shows that children under 5 and adults over 65 years of age, people who are pregnant, and those who have chronic lung, heart, and kidney conditions have higher sensitivity to extreme heat. Often, extreme heat events involve nighttime temperatures that stay too warm and don’t allow human bodies to cool down (EPA, 2016). This prevents recovery from daytime heat and can lead to increased health risks. In addition, outdoor workers, those living in mobile homes or individuals who are unhoused, renters in substandard housing, and student athletes are likely to have increased exposure or decreased adaptive capacity to extreme heat. Together these are also often referred to as “high-risk” groups in the context of public health impacts of extreme heat.

High Winds

High winds are defined as sustained, strong winds most often associated with tropical storm systems. High winds can damage or destroy property, cause extensive power outages or other utility disruptions, and threaten health and safety due to windblown debris. Jacksonville experienced the damage high winds can cause when Hurricane Irma’s 85(+) mph wind gusts damaged trees, roofs, and powerlines (Cangialosi et al., 2021). The high wind threat from storms like Irma is likely to increase in the next century as most forecasting models show that climate change may increase hurricane wind intensity. This change is likely due to warmer ocean temperatures and more moisture in the air, which can fuel hurricanes (Colbert, 2022).

Wildfires

Wildfires are defined as unplanned fires that burn in natural or wildland areas. Wildfires can cause damage to important natural resources as well as surrounding communities located in the wildland urban interface (Southern Group of State Foresters, 2023*).* As the climate warms, increases in wildfire frequency and area burned are anticipated and are expected to drive up the costs associated with health effects, fire suppression, and loss of homes and infrastructure (Reidmiller et al., 2018). Reports published by the IPCC support these projections, explaining that rising temperatures and increases in the duration and intensity of drought are expected to increase wildfire occurrence and reduce the effectiveness of prescribed fire. Although the western United States experiences the greatest total area burned by wildfire, the southeast has the largest area burned by prescribed fire and the highest number of wildfires. Furthermore, rapid urban expansion taking place near managed forests leads to reduced opportunities to use prescribed fire, which could impact native species and has the potential to increase wildfire occurrence and impacts to the economy and public health (Terando et al., 2018).

Climate Threat Datasets

This assessment was conducted using the best available existing datasets for Jacksonville. Table 1 lists the climate threat data sources used for this Vulnerability Assessment report. A more detailed description of the flood datasets used and the methodologies to aggregate them is provided in Appendix A: Flood Risk Data & Terminology.

TABLE 1. CLIMATE THREAT DATA SOURCES USED FOR THE RESILIENT JACKSONVILLE VULNERABILITY ASSESSMENT.

Climate Threat	Data Source
Current Coastal Storm and Riverine Flooding (FEMA NFHL)	National Flood Hazard Layer (FEMA, 2021)
Current and Future Coastal Storm Flooding (USACE CHS)	USACE South Atlantic Coastal Study Coastal Hazard System Data (USACE, 2021a)
Future Coastal Storm, High Tide, and Riverine Flood 1% Annual-Chance Flood Extent (Future 1% Combined AEP)	USACE South Atlantic Coastal Study Coastal Hazard System Data (USACE, 2021a), City of Jacksonville Master Stormwater Management Plan (City of Jacksonville, 2022) and Flood Risk Assessment for High Priority Assets (CDM Smith & Jacobs, 2022)
Extreme Heat	National Land Cover Database (USGS, 2019) Tree Canopy Cover Dataset (USFS, 2016)
Wildfire	Wildfire Risk to Communities (USDA Forest Service, 2020)
High Winds	Wind-borne Debris Region (American Society of Civil Engineers, 2022)

1.4 SOCIAL STRESSORS CONSIDERED

The assessment recognizes that socially vulnerable populations are disproportionately impacted by climate threats. Therefore, social factors are critical to the methodology and insights of the assessment. Incorporating social vulnerability as a focus of the assessment provides a useful foundation to help inform socially equitable consideration in resilience planning by identifying disproportionate impacts on socially vulnerable populations. This assessment integrates social vulnerability using a data and metric-based approach; however, it should be noted that a data-driven process is only a part of a socially equitable foundation for building resilience, and data has its limitations in what it can help inform. These limitations include gaps in data and reporting and rapidly changing population information (see also Wood et al., 2021).

Social Stressors Datasets

Several socioeconomic metrics and sources of census tract-level information are used in this assessment, including the U.S. Centers for Disease Control and Prevention's overall social vulnerability index (SVI) and its four themes of socioeconomic status: household composition and disability, minority status and language, housing, and transportation (Centers for Disease Control and Prevention, 2020). In addition, socioeconomic metrics from the American Community Survey 5-Year Estimates (United States Census Bureau, 2020), such as household living below the poverty line and median household income, are examined. These socioeconomic metrics and SVI are used to evaluate the co-occurrence of vulnerability to climate threats and social vulnerability. For example, the co-occurrence of high food infrastructure vulnerability with high Supplemental Nutrition Assistance Program (SNAP) participation or high residential property vulnerability with high overall social vulnerability. In addition, socioeconomic metrics are integrated into the rulesets of the vulnerability framework (see 2.1 Process and Methodology).

TABLE 2. SOCIAL STRESSORS DATA USED FOR THE RESILIENT JACKSONVILLE VULNERABILITY ASSESSMENT.

Social Stressor	Data Source
Social Vulnerability	Social Vulnerability Index (Centers for Disease Control and Prevention, 2020)
Poverty	2016-2020 American Community Survey 5-year Estimates (United States Census Bureau, 2020)
Median Household Income	2016-2020 American Community Survey 5-year Estimates (United States Census Bureau, 2020)
Food Insecurity	SNAP Authorized Retailer Locations (U.S. Department of Agriculture, 2022)
Food Insecurity	Food Access Research Atlas (USDA, 2019)

1.5 COMMUNITY ASSETS

This Vulnerability Assessment identifies community assets under four overarching core community asset themes (Homes, Infrastructure and Services, Commercial and Industrial Properties, and Vacant Land) and 10 asset categories that together represent most of the built environment and natural areas in Jacksonville. These themes and categories are described below and provided in Table 3. Core community asset themes and asset categories used for the vulnerability assessment.

Homes

Homes include a variety of asset categories identified as residential, including single, multifamily, condos, and mobile home parks. In addition, this category includes properties identified as nursing homes, retirement homes, assisted housing, group homes, and residential health facilities.

This asset category is represented in this assessment primarily through property parcel and building information. Critical and property use information were used to understand different levels of impact (e.g., multi-residence units vs. single). Assessment of this category evaluated potential for direct impacts from threats and were used to identify vulnerable neighborhood areas.

Infrastructure and Services

Infrastructure and Services include fire and police stations; medical facilities; schools; food supply and distribution; and energy, utility, and communication facilities. To consider the range of assets within this theme, the following asset categories were used:

- Utility and Critical Services
- Other Government-Owned Properties (including public schools and parks)
- Cultural and Community Services
- Road Network (major and minor road segments that provide critical connections to neighborhoods and assets)

With the exception of the Road Network asset category, the asset categories within this theme are represented by parcel datasets in addition to building and property use information. Assessments within this theme consider property and building-level characteristics and the services they provide to the community.

Commercial and Industrial Properties

Commercial Properties include facilities such as retail, lodging properties, food facilities, medical facilities, financial businesses, offices, and parking.

Industrial Properties contain warehouses and manufacturing, processing, and storage facilities.

Assessments within this theme consider property and building-level characteristics and the services they provide to the community.

Open Space and Vacant Land

The Open Space and Vacant Land core community asset theme includes parcels identified as protected (e.g., parks) or working lands (e.g., agriculture or timber), as well as privately and government-owned vacant land. This asset category is represented in this assessment through property parcel data.

TABLE 3. CORE COMMUNITY ASSET THEMES AND ASSET CATEGORIES USED FOR THE VULNERABILITY ASSESSMENT.

Core Community Assets	Asset Categories	Description
Homes	Residential Properties	All types of residential facilities: single, multifamily, condos, mobile home parks, nursing homes, retirement homes, assisted housing, group homes, and residential health facilities (approx. 308,500 parcels)
Infrastructure and Services	Utility and Critical Services	Electric, communication, and water and wastewater utility properties; government-owned critical facilities like fire stations and emergency shelters; privately owned critical assets that provide food, medical and shelter services (approx. 2,400 parcels)
	Other Government-Owned Properties	Government-owned properties not included in the previous category such as city hall, public schools, libraries, parks, and community centers (approx. 6,890 parcels)
	Cultural and Community Services	Privately owned and government-owned properties that provide important services and social and recreational opportunities; historical and cultural properties (approx. 3,360 parcels)
	Road Network	Major and minor road segments within the city that provide critical connection to neighborhoods and assets
Commercial and Industrial Properties	Commercial Properties	All types of commercial properties including retail, lodging, food, medical, and financial businesses, offices, and parking (approx. 11,600 parcels)
	Industrial Properties	All types of industrial properties including warehouses and manufacturing, processing, and storage facilities (approx. 5,110 parcels)
Open Space and Vacant Land	Protected/Managed and Working Lands	Agriculture, timber, and other working lands; federal, state, local land (including parks); and privately owned conservation or managed lands (approx. 4,280 parcels)
	Government-Owned Vacant Land	Properties owned by the City, county, state, or federal governments and identified as vacant by the Property Assessor's Office (approx. 4,700 parcels)

Core Community Assets	Asset Categories	Description
	Privately Owned Vacant Land	Privately owned vacant properties as identified by the Property Assessor's Office as commercial, industrial, institutional (approx. 28,100 parcels)

Community Asset Datasets

2022 property parcel dataset from Duval County Property Appraiser's Office, received through the City of Jacksonville's Information Technology Department, is the foundational asset data source for this assessment (City of Jacksonville IT Department, 2022). This dataset was then truncated to align with parcels found within the City of Jacksonville (i.e., does not contain information on parcels in Jacksonville Beach, Neptune Beach, or Atlantic Beach). Codes describing the use of a property were used to identify and categorize built environment and natural assets, and this data was supplemented with other point data from a variety of sources (Table 4). These supplemental data were spatially intersected with the parcel data to add granularity to the parcel use code.

Note that some asset types overlap between multiple categories. For example, City-owned parks are evaluated in the Government-Owned Properties as well as Community Services category and private hospitals are included in both Utility and Critical Infrastructure as well as Commercial categories. For this reason, the total number of assets across all categories is greater than the actual number of unique parcels in Jacksonville.

TABLE 4. ASSET DATA SOURCES USED FOR THE RESILIENT JACKSONVILLE VULNERABILITY ASSESSMENT.

Asset Type	Data Source
Property Parcels	Duval County Parcel Data Set (Received Fall 2022)
After School Programs	COJ IT Department (2022)
Aircraft Landing Facilities	CDM Smith (2022) (Department of Homeland Security, 2022)
Alternative Fuel Stations	CDM Smith (2022, HIFLD)
Animal Shelter	COJ IT Department (2022)
Assisted Housing	Florida House Data Clearinghouse (University of Florida Shimberg Center for Housing Studies, 2022)
City Hall	COJ IT Department (2022)
Colleges and Universities	CDM Smith (2022, HIFLD)
Communication Infrastructure	CDM Smith (2022, HIFLD)
Community Centers	COJ IT Department (2022)
Convention Center/Fairgrounds	CDM Smith (2022, HIFLD)
Correctional Facilities	CDM Smith (2022, HIFLD)
County Health Department	COJ IT Department (2022)
Courthouses	CDM Smith (2022, HIFLD)
Dialysis Center	COJ IT Department (2022)
Educational Facilities	CDM Smith (2022, HIFLD)

Asset Type	Data Source
Emergency Medical Services	CDM Smith (2022, HIFLD)
Fire	CDM Smith (2022, HIFLD)
Fire	COJ IT Department (2022)
Florida Forever Acquired Lands	Florida Natural Areas Inventory (2022)
Florida Forever Approved Lands	Florida Natural Areas Inventory (2022)
Group Homes	COJ IT Department (2022)
Historic Buildings	(Florida Department of State, 2022)
Hospitals	CDM Smith (2022, HIFLD)
Law Enforcement	CDM Smith (2022, HIFLD)
Major Sports Venues	CDM Smith (2022, HIFLD)
Managed and Working Land	Florida Natural Areas Inventory (2022)
Military Facilities	CDM Smith (2022, HIFLD)
Mining Operations	CDM Smith (2022)
Nonprofit	COJ IT Department (2022)
Nursing Homes	Florida House Data Clearinghouse (University of Florida Shimberg Center for Housing Studies, 2022)
Oil and Gas	CDM Smith (2022)
Parks	COJ IT Department (2022)
Pharmacies	COJ IT Department (2022)
Points of Distribution	COJ IT Department (2022)
Ports	CDM Smith (2022, HIFLD)
Power Plants	CDM Smith (2022, HIFLD)
Public Transit Stations	CDM Smith (2022)
Religious	CDM Smith (2022, HIFLD)
Residential Health Facilities	Florida House Data Clearinghouse (University of Florida Shimberg Center for Housing Studies, 2022)
Roads	(OpenStreetMap, 2023)
Senior Centers	COJ IT Department (2022)
Shelter	CDM Smith (National Shelter Inventory)
SNAP Retailers	U.S. Department of Agriculture (2022)
Solid Waste/Landfills	CDM Smith (2022, HIFLD)
Special Needs Facilities	COJ IT Department (2022)
Substations	CDM Smith (2022, HIFLD)
Urgent Care	CDM Smith (2022, HIFLD)
Wastewater Treatment Plants	CDM Smith (2022, HIFLD)

2.0 ASSESSMENT OF VULNERABILITY AND RISK

2.1 PROCESS AND METHODOLOGY

The Resilient Jacksonville Vulnerability Assessment applied a vulnerability and risk assessment framework to the combination of climate threats, social stressors, and community assets identified. The framework is a spatial assessment that evaluates each of the core community asset themes and categories separately for the climate threats of flooding, extreme heat, high winds, and wildfires.

Three key elements of the assessment framework used in this project are:

1. **Asset categories** for each of the core community asset themes. Each combination of asset category and climate threat is evaluated separately.
2. **Semantic rules** based on attributes of climate threat and asset data—hereafter termed "rulesets"—to classify community assets as having "high," "medium," or "low" characteristics of vulnerability and risk.
3. **Aggregation** or summarizing of asset-level results at scales relevant for planning (using Development Types; see Section 2.3).

Rulesets for Vulnerability and Risk

The rulesets used to classify community assets as having "high," "medium," or "low" characteristics include definitions for this assessment of exposure, vulnerability, and risk.

Exposure

Exposure is defined as the presence of people, assets, and ecosystems in places where they can be adversely affected by hazards (U.S. Climate Resilience Toolkit, 2023). For the purposes of this assessment, exposure specifically means that a community asset (e.g., a parcel or roadway) spatially coincides with a specific threat (e.g., flooding).

Vulnerability

Vulnerability describes the susceptibility of assets *exposed* to threats based on the two core concepts: (1) ***sensitivity***—the degree to which an asset is affected; and (2) ***adaptive capacity***—the ability that an asset has to cope or withstand potential impact with minimal disruption or loss.

For assessing levels of sensitivity, location of the structure and its criticality are considered together. This information is based on building footprints and type of asset use or nature of service provided.

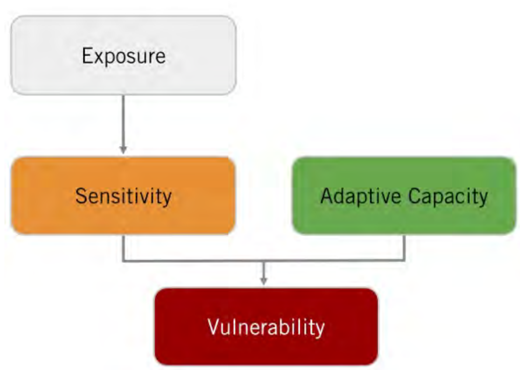


FIGURE 6. COMPONENTS OF VULNERABILITY.

The level of adaptive capacity of built environment assets is evaluated by looking at building regulations at the time of the construction. For example, if a structure was built before FEMA flood maps were established, it has low adaptive capacity. But if it was built after freeboard requirements (i.e., building height requirement above base flood elevation) were put in place, it has a higher adaptive capacity to be able to cope during a flood event.

Risk

Risk is the combination of ***probability*** or relative likelihood of a hazard occurring and the ***magnitude of impact***. Probability is often determined using annualized likelihood. For example, for the assessment using floodplain maps developed by FEMA National Flood Hazard Layer (NFHL) (e.g., Current Storm Surge and Riverine Flooding), the 1% annual exceedance probability (AEP)[1] floodplain and 0.2% AEP are used to differentiate the probability of risk faced by an asset.

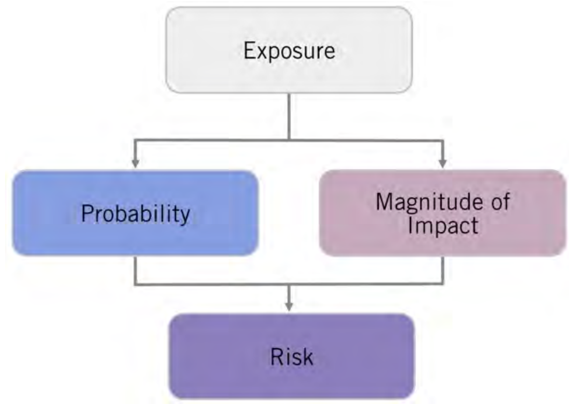


FIGURE 7. COMPONENTS OF RISK.

Combined Vulnerability and Risk

Once vulnerability and risk are determined, they are combined into one overall metric. Vulnerability considers how an asset, infrastructure, or service might be impacted and its ability to cope if a given hazard event were to occur, and risk considers the probability and the general consequence of the hazard. Combining these concepts allows decision makers to evaluate which assets are most susceptible and most likely to be impacted and to consider options according to different levels of risk thresholds.

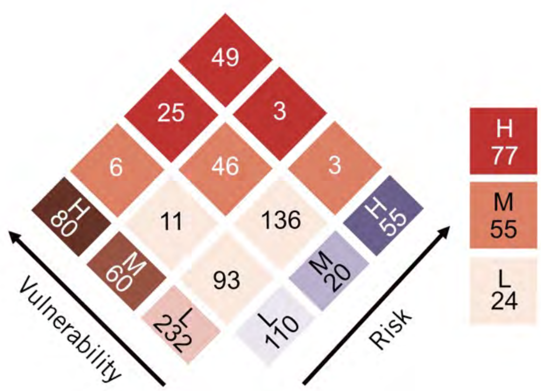


FIGURE 8. COMBINATION OF VULNERABILITY AND RISK.

[1] The annual exceedance probability is the probability for which a hazard of a given severity is likely to occur or be exceeded in any given year. For example, a 1% AEP flood depth of 3 feet at a certain location means that there is a 1% (1-in-100) chance that flood depth at that location will be 3 feet or more each year.

TABLE 5. SUMMARY OF RULESETS BY CLIMATE THREAT EVALUATED IN THE RESILIENT JACKSONVILLE VULNERABILITY ASSESSMENT.

Climate Threat	Exposure	Vulnerability		Risk	
		Sensitivity	Adaptive Capacity	Probability	Consequence
Current Coastal Storm and Riverine Flooding (FEMA NFHL)	Asset within entire inundation extent	Criticality of assets within threat extent (based on type and use)	**Floodplain development requirements during year of construction:** LOW: before 1978 or exposed but not in regulatory floodplain MED: between 1978 and 2013 (first FIRM) HIGH: after 2013 (BFE + 1 ft req. enacted)	**Flood zone:** LOW: 0.02% AEP MED: 0.1% AEP HIGH: In floodway	N/A
Current and Future 10% and 1% AEP Coastal Storm Flooding (USACE CHS)				N/A	**Depth of flood exposure:** HIGH: 3 ft or greater MED: Between 1 to 3 feet LOW: Less than one foot
Future Coastal Storm, High Tide, and Riverine Flood 1% AEP (Combined Future 1% AEP)				N/A	
Wildfire	Asset within Wildland Urban Interface extent (USFS)		**Drive time from nearest fire station for response:** LOW: outside 8-min MED: 5 to 8-min HIGH: within 5-min	**USFS Risk to Potential Structures** LOW: 0.001 - 0.1 MED: 0.101 - 1 HIGH: 1.001 - 11.938	
High Winds	Assets within wind borne debris region (entire study area)		**Wind-related building requirements in year of construction:** LOW: before 1974 MED: 1974-1994 HIGH: after 1994	N/A	N/A
Extreme Heat	**Developed land cover:** HIGH: > 75^{th} percentile MED: 25^{th}-75^{th} percentile LOW: <25^{th} percentile	N/A (Heat-sensitive groups are considered post-assessment)	LOW: < 25^{th} percentile tree canopy coverage AND/OR household median income MED: 25^{th}-75^{th} percentile tree canopy coverage AND/OR household median income HIGH: >75^{th} percentile tree canopy coverage AND/OR household median income	N/A	N/A

Aggregation of Vulnerability and Risk

To summarize the vulnerability assessment asset-level results at scales relevant for planning data have been aggregated by census block groups as well as Development Types.

Census Block Groups

To facilitate planning-level interpretations of parcel-based analyses and for comparison with census-based indicators of community vulnerability, the assessment results are aggregated (or summarized) at the census block group (block group) level. Specifically, this involves calculating the sum or proportion of assets with either a medium or high classification for combined vulnerability and risk (referred to as "highly vulnerable" assets in this document) for each block group.

Development Types

A similar aggregation is also performed for Development Types that were established as part of the *Resilient Jacksonville* Strategy development process. This aggregation provides a different view of the distribution of vulnerability in different areas of Jacksonville.

Development Types were established and mapped to better detect patterns of current and future vulnerability throughout Jacksonville and to help identify where different adaptation approaches and resilience opportunities and actions might be most effective (**Error! Reference source not found.**). The Development Types are intended to support the City of Jacksonville's resilience planning efforts by providing a more strategic approach to standardizing and scaling interventions across the city.

In determining different Development Types, several factors that can influence a neighborhood's relationship to flood risk and other climate hazards and its options for managing these risks were considered. These factors include age/era of development, density of development, street and roadway network characteristics, residential and commercial urban form, stormwater and wastewater infrastructure, use of and relationship to water bodies, and level of impervious surface and vegetated cover. A detailed description of the process to classify these development types is provided in the *Resilient Jacksonville* Strategy (City of Jacksonville, 2023). For the purposes of this assessment, a brief description of the Development Types used to aggregate vulnerability data is provided below.

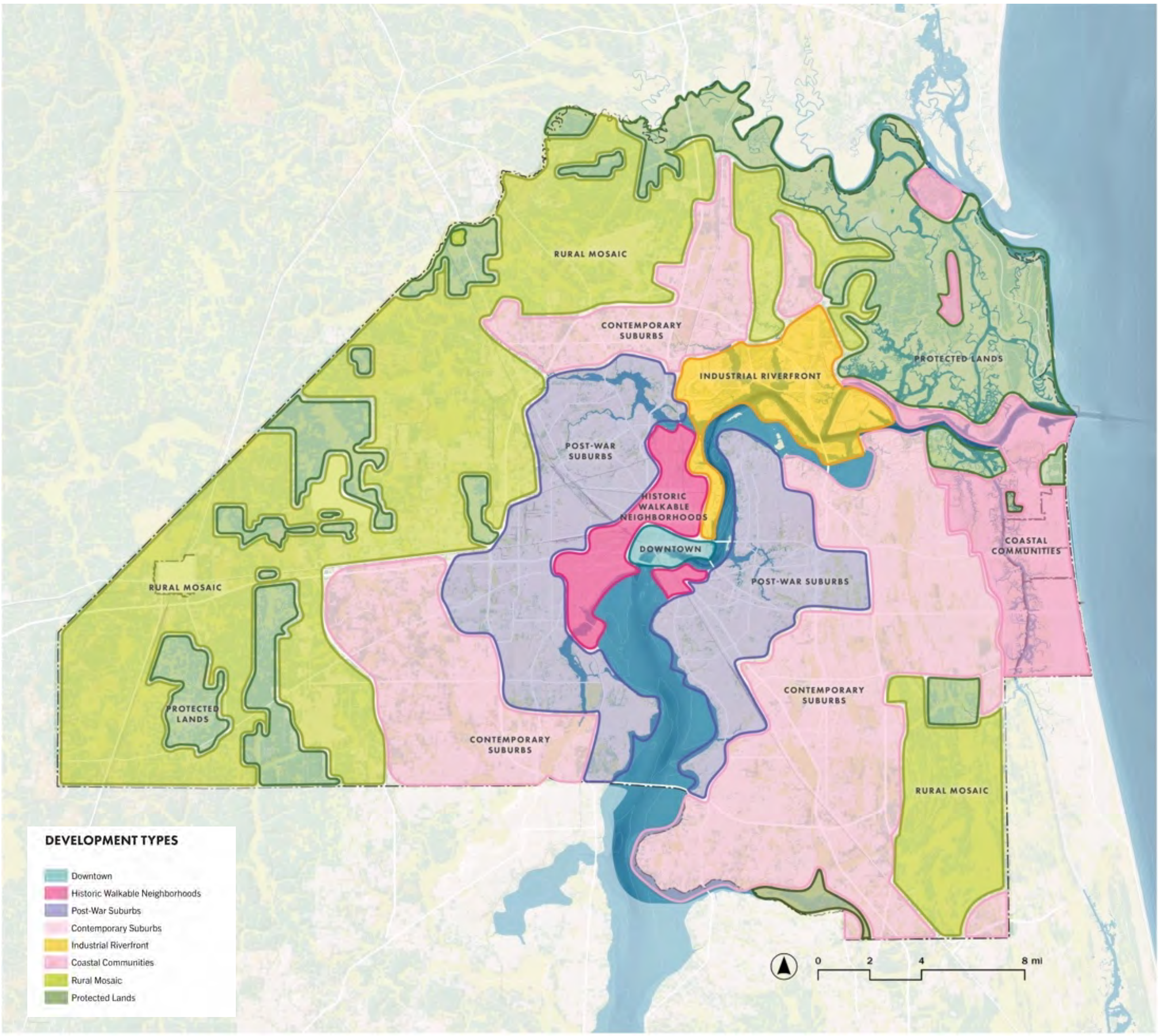


FIGURE 9. MAP OF JACKSONVILLE DEVELOPMENT TYPES DEVELOPED AS PART OF THE *RESILIENT JACKSONVILLE* STRATEGY.

Downtown

The Downtown Development Type boundaries coincide with the Downtown Investment Authority's Downtown Boundary (*DIA Jax: Downtown Investment Authority*, n.d.). Downtown has experienced the redevelopment of many parcels in the last 50 years and includes large amounts of critical infrastructure, City of Jacksonville-owned facilities, and sports and entertainment facilities. This Development Type is subject to storm surge, compound, and riverine (pluvial) flood risk.

Historic Walkable Neighborhoods

Historic Walkable Neighborhoods include much of the "urban core." Some areas within this Development Type may face coastal, compound, or pluvial flood risk depending on local factors such as elevation, distance to water, or topography. Examples of this Development Type include Avondale, Eastside, Riverside, San Marco, and Springfield.

Post-War Suburbs

Like Historic Walkable Neighborhoods, the Post-War Suburbs Development Type experiences highly variable flood risk that is contingent on local conditions such as distance to water, elevation, and local topography. Examples of this Development Type include Arlington, Cedar Hills, and Northwest Jacksonville.

Contemporary Suburbs

The Contemporary Suburbs Development Type includes suburban development that occurred primarily after 1980. This Development Type is often built in or near to freshwater ponds and is often characterized by its proximity to stormwater retention ponds.

Rural Mosaic

The Rural Mosaic is a landscape currently in flux. This Development Type is characterized by a mosaic of farms, timber plantations, country homes, rural neighborhoods, new developments, and logistics facilities. The rural mosaic is primarily located in the western and northwestern portions of Duval County. The western-most portions of the city are relatively high in elevation but include large swaths of freshwater forested wetlands.

Coastal Communities

The Coastal Communities Development Type represents the strand of development straddling Route A1A. Coastal Communities are characterized by open water on one side and tidal wetlands on the other side. A key defining feature of these communities is their unique relationship with water, development, and wetlands, making them highly vulnerable to storm surge and coastal flood risk.

Protected Lands (Federal, State, COJ)

Protected Lands include Timucuan Preserve, military facilities, and other lands permanently protected from commercial development.

Industrial Riverfront

This Development Type includes JAXPORT and other privately owned industrial facilities located adjacent to port facilities.

3.0 FLOOD VULNERABILITY AND RISK

3.1 FLOOD HAZARD MODELS AND SCENARIOS

Given its proximity to the Atlantic Ocean and the St. Johns River, Jacksonville is vulnerable to multiple types of flooding. For this Vulnerability Assessment, current and future flood vulnerability was assessed using three estimates of flood hazard under six different scenarios representing both present day and possible future conditions. These scenarios are briefly described below. It should be noted that each of these sources estimate flood risk using different models and assumptions (e.g., predicted levels of sea level rise). This means that flood risk results are not directly comparable between flood scenarios and should instead be used independently to evaluate flood risk from different types of flooding in Jacksonville. Additional details about each of these datasets and their assumptions are provided in Appendix A: Flood Risk Data & Terminology.

Current Coastal Storm and Riverine Flooding (FEMA NFHL)

In coastal areas like Duval County, FEMA flood zones represent a combination of rainfall-induced riverine flooding and storm surge flooding. FEMA flood zones are characterized by how likely a level or extent of flooding can recur or be exceeded over a period of time. For example, the terms "100–year flood" or "1% annual exceedance probability flood" (AEP) are used to refer to a magnitude of a flood that has a greater than one percent chance of occurring or being exceeded in any given year. Put differently, a 1% AEP flood event has a 26% chance of occurring over the course of 30 years or 39.5% chance over the course of 50 years. This assessment (Figure 10) uses the most recent FEMA NFHL for Jacksonville, which maps the riverine floodway (the studied reach of riverine (i.e., creeks, streams, rivers) flooding that depicts how far flood waters will expand around a stream reach during the 100-year storm event), wave action, and the 1% and 0.2% AEP floodplains (FEMA, 2021). This dataset is currently the best source for evaluating the current combined coastal storm and riverine flood risk for Jacksonville. Throughout this assessment, flood vulnerability results presented using this dataset are identified as "current coastal storm and riverine flooding (FEMA NFHL)."

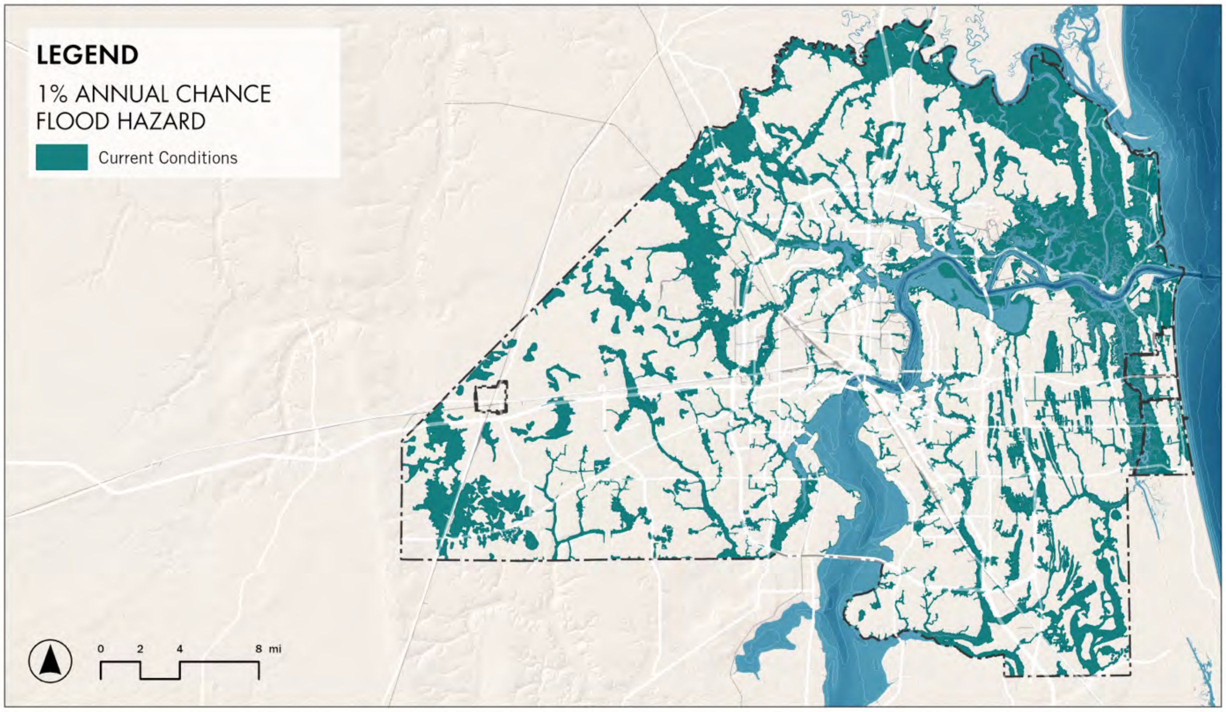


FIGURE 10. DUVAL COUNTY, FL, LOCATIONS WITH AT LEAST 1% CHANCE OF FLOODING IN A YEAR: CURRENT COASTAL STORM AND RIVERINE FLOODING (FEMA NFHL).

Current and Future Coastal Storm Flooding (USACE CHS)

The Coastal Hazards System (CHS) is an advanced numerical and statistical analysis system that provides coastal flood hazard information to be used in coastal engineering, coastal risk assessment, and coastal management (USACE, 2021b). CHS covers northeast Florida, including the St. Johns River, in its North Carolina to southeast Florida (NCSEFL) modeling phase. CHS data provides coastal flood hazard information from tropical and extratropical cyclones. The flood risk vulnerability analysis described for this assessment leverages the latest CHS data in the form of water depths for the 10% and 1% AEPs for present (i.e., 2020 sea level observations) and plausible future conditions. The future scenario assumes a sea level rise of 2.3 feet. This dataset (Figure 11) provides the most up-to-date source for evaluating the current and future risk for coastal storm flood risk in Jacksonville. Throughout this assessment, flood vulnerability results presented using this dataset are identified as either “current coastal storm flooding (USACE CHS)” or “future coastal storm flooding (USACE CHS).”

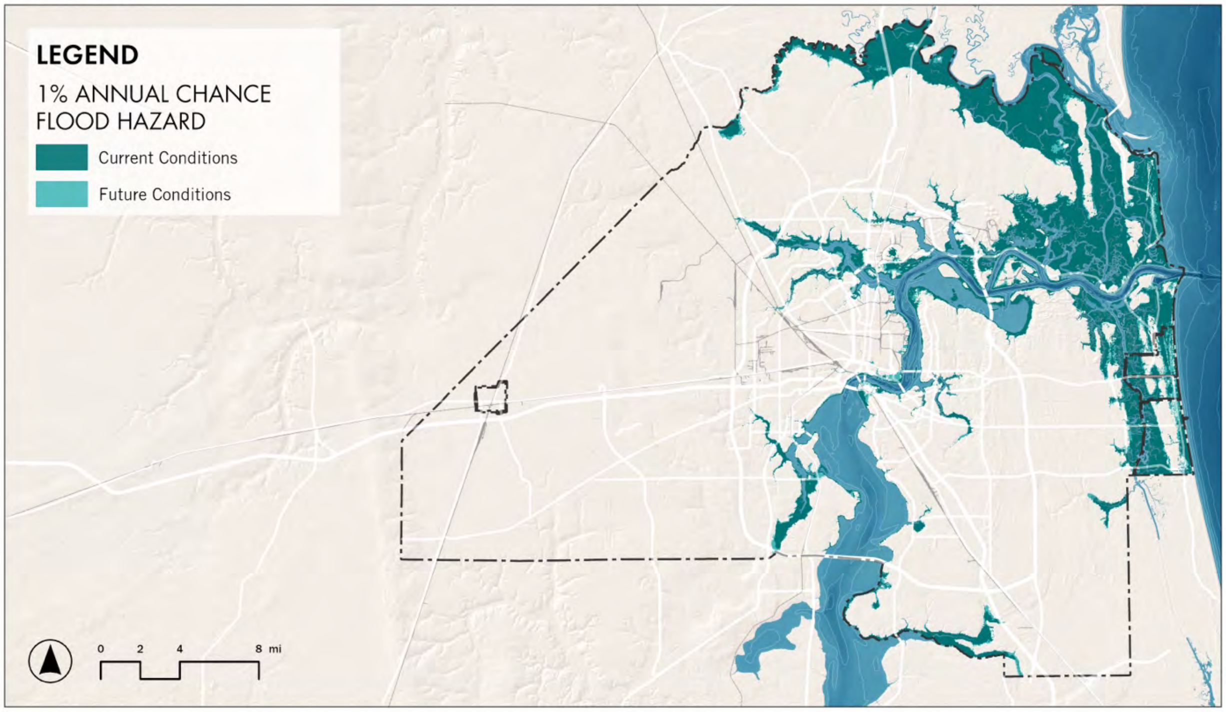


FIGURE 11. DUVAL COUNTY, FL, LOCATIONS WITH AT LEAST 1% CHANCE OF FLOODING IN A YEAR: CURRENT AND FUTURE COASTAL STORM FLOODING (USACE CHS).

Future Coastal Storm, High Tide, and Riverine 1% AEP Flooding (Combined Future 1% AEP)

To better understand future flood risk in Jacksonville, a combined estimate representing one possible projection of the potential additional depth and extent of flooding with future sea level rise and increased rainfall intensity was developed. This involved overlaying the future condition 1% AEP flood layers from the USACE CHS (coastal flooding) with recent projections from the City of Jacksonville Master Stormwater Management Plan and Vulnerability Study (riverine flooding, including streams and tributaries) (MSMP, CDM Smith, 2022).

The recent stormwater study conducted by CDM Smith estimates riverine flooding from tributaries with 1) one projection of the increase in future 1% AEP rainfall intensity by 2070; 2) one projection of future sea level rise by 2070 on the St. Johns River; and 3) an annual high tide level occurring across the St. Johns River estuary. Increased rainfall intensity directly contributes to more flooding in tributaries and rivers, while high tides and sea level rise will tend to increase upstream flooding by backing up water flowing in from tributary streams rivers.

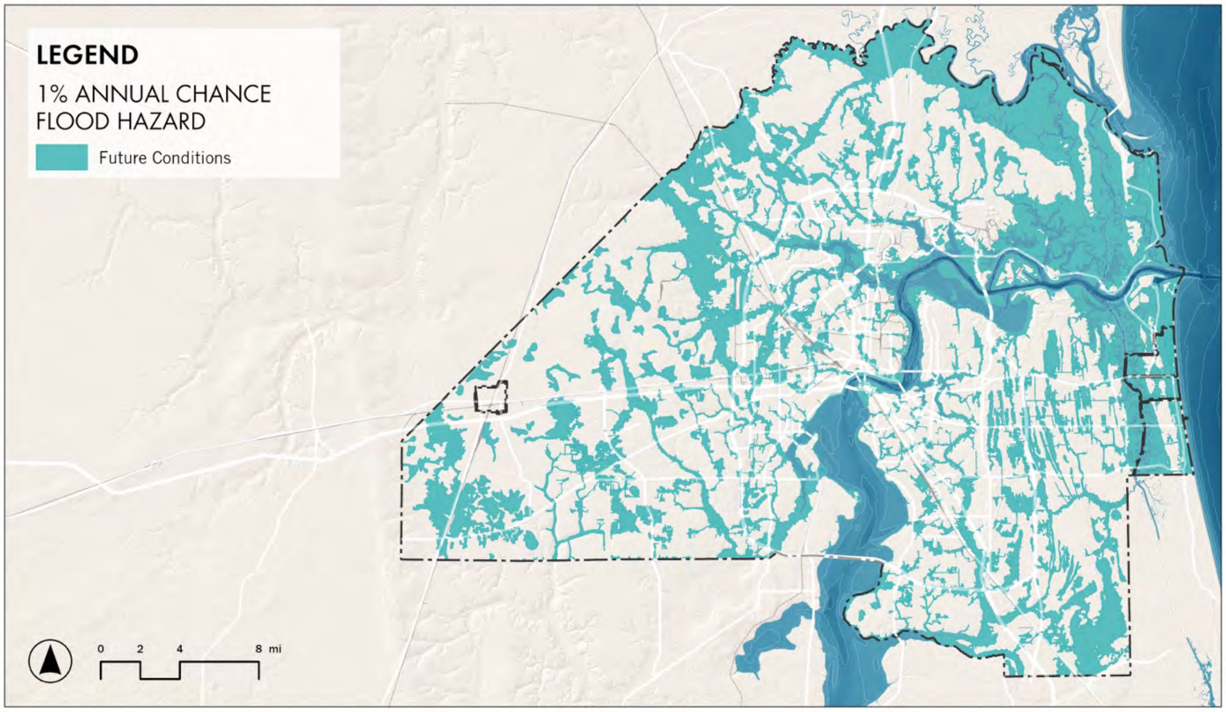


Figure 12 shows the flood extent projections for future locations in Duval County with at least 1% chance of flooding in a year resulting from this combined dataset. The greater extent and depth of flooding was selected where the coastal and riverine layers overlapped to ensure this combined map captured the greatest potential extent and impact. This map was also compared to the 2022 FEMA NFHL to ensure that the extent of the future flood boundary was always consistent with or greater than the current regulatory boundary. Although the various input layers were developed with different assumptions and methods, and thus are not precisely comparable, the goal of producing this combined estimate was to provide a basic understanding of how future sea level rise (+2.23 ft) and increased rainfall intensity might increase the area, assets, and population exposed to flooding at a 1% AEP by 2070. It should be noted this combined estimate represents a simplified take on one plausible future scenario and is not intended to communicate precise boundaries. This assessment identifies results generated using this dataset as “Future Coastal Storm, High Tide, and Riverine Flooding 1% AEP Flooding (Combined Future 1% AEP).”

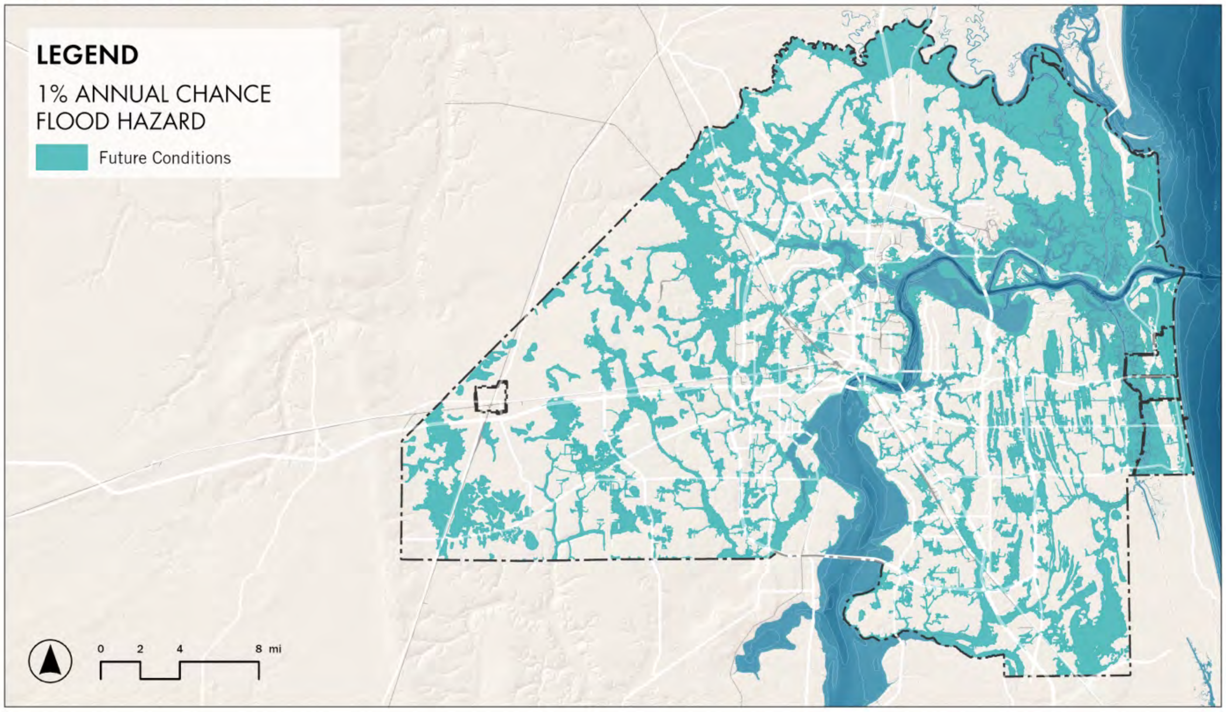


FIGURE 12. DUVAL COUNTY, FL, LOCATIONS WITH AT LEAST 1% CHANCE OF FLOODING IN A YEAR: FUTURE COASTAL STORM, HIGH TIDE, AND RIVERINE FLOODING, 2070 (COMBINED FUTURE 1% AEP).

3.2 FLOOD VULNERABILITY ASSESSMENT METHODOLOGY

As discussed in Section 2.0, the vulnerability assessment for the predicted flooding threat in Jacksonville is property-based and determines relative level of vulnerability and risk (i.e., high, medium, low) to flooding based on multiple criteria:

- location of a parcel and a building structure (exposure);
- floodplain regulations at the time of construction (adaptive capacity);
- property use or criticality (sensitivity); and,
- flood likelihood and depth (risk).

The assessment assumes that vacant properties and those included in the Managed and Working Lands asset categories (i.e., Open Space and Vacant Land Asset theme) do not contain built structures and thus are only evaluated for flood exposure.

In addition to the property-based assessments, a road network and connectivity assessment was conducted for all flood hazards. These assessments consider the following: 1) road inundation as a direct impact of flooding; 2) roads that may not be inundated but could become inaccessible by emergency response services; and 3) properties that could become isolated due to inundated or inaccessible roads.

3.3 VULNERABILITY TO FLOODING IN JACKSONVILLE

The amount of flood vulnerability predicted for assets in Jacksonville varies depending on the flood scenario assessed. Table 6 shows the total number of assets organized by asset category and the number and percentage of those assets with a medium or high flood vulnerability under the six flood scenarios assessed. It should be noted that while the flood vulnerability assessment results across the six scenarios are presented together, the data are not directly comparable between scenarios. For example, because the FEMA NFHL assessment combines both the 1% and 0.2% chance of current flooding, the number of currently vulnerable assets may appear higher for some asset categories than the predicted number of vulnerable assets under the Combined Future 1% AEP scenario. This should not be interpreted as the flood risk for those assets decreasing in the future. Rather, these results should be considered independently. The exception to this is for the USACE CHS coastal storm flooding 10% current vs. 10% future and the USACE CHS 1% current and 1% future scenarios, which are directly comparable to one another and can be used to project the increase in vulnerable assets to coastal flooding in the future.

While the vulnerability assessment results for the multiple flood scenarios evaluated may not be directly comparable, looking across the number and percentage of vulnerable assets in Jacksonville under these scenarios can provide a picture of the level and type of flood vulnerability in Jacksonville now and in the future. Section 3.4 discusses the flood vulnerability assessment results for each asset theme. For this report, maps depicting the proportions of vulnerable assets under specific different flooding scenarios have been selected for their ability to best show different types of current and future flood risk in Jacksonville.

TABLE 6. SUMMARY TABLE OF TOTAL NUMBER OF COMMUNITY ASSETS AND THE NUMBER AND PERCENT OF ASSETS WITH MEDIUM OR HIGH COMBINED VULNERABILITY AND RISK FOR SIX FLOODING SCENARIO ASSESSMENTS.

Asset Category	Total Assets	Current FEMA NFHL	USACE CHS				Combined Future 1% AEP
			Current		*Future (+ 2.3ft SLR)*		
		1% and 0.2% AEP	10% AEP	1% AEP	10% AEP	1% AEP	
Homes							
Residential	308,449	19,800 (6%)	7,473 (2%)	11,931 (4%)	9,451 (3%)	16,163 (5%)	22,471 (7%)
Infrastructure and Services							
Utility and Critical	2,452	262 (11%)	46 (2%)	102 (4%)	81 (3%)	151 (6%)	187 (8%)
Cultural and Community Services	19,332	1394 (7%)	701 (4%)	1064 (6%)	900 (5%)	1405 (7%)	1535 (8%)
Other Government Owned Properties	6,675	726 (11%)	649 (8%)	916 (14%)	779 (12%)	1,090 (16%)	481 (7%)
Economic Activity							
Commercial	11,663	756 (6%)	145 (1%)	279 (2%)	210 (2%)	420 (4%)	760 (7%)
Industrial	3,823	375 (10%)	57 (1%)	93 (2%)	66 (2%)	163 (4%)	463 (12%)
Roads and Connectivity							
Major Roads Inaccessible (Lane Miles)	2,866	790 (28%)	362 (13%)	388 (14%)	388 (13.5%)	527 (18%)	1,477 (52%)
Minor Roads Inaccessible (Lane Miles)	15,092	3,321 (22%)	1,039 (7%)	1,400 (9%)	1,155 (8%)	1,970 (13%)	6,947 (46%)
Inaccessible Property	364,833	51,076 (14%)	6,640 (2%)	13,920 (4%)	8,113 (2%)	22,037 (6%)	123,900 (34%)

Asset Category	Total Assets	Current FEMA NFHL	USACE CHS				Combined Future 1% AEP
			Current		*Future (+ 2.3ft SLR)*		
		1% and 0.2% AEP	10% AEP	1% AEP	10% AEP	1% AEP	
Open Space and Vacant Lands							
Managed and Working Lands	4,737	2,678 (57%)	1,243 (26%)	1,491 (32%)	1,393 (29%)	1,624 (34%)	2,740 (58%)
Government-Owned Vacant Land	4,669	1,685 (36%)	551 (12%)	661 (14%)	609 (13%)	746 (16%)	1,923 (41%)
Privately Owned Vacant Land	28,090	5,629 (20%)	1,586 (6%)	2,109 (8%)	1,812 (6%)	2,391 (9%)	6,753 (24%)

3.4 CURRENT AND FUTURE FLOOD VULNERABILITIES BY ASSET THEME

Residential Properties

This vulnerability assessment considered residential properties identified by parcel data as single family, multifamily, condo, assisted housing, manufactured housing, residential care facility, and residential miscellaneous.

The vulnerability of residential assets across the six flood scenarios are shown in Table 7.

TABLE 7. NUMBER AND PERCENT OF RESIDENTIAL ASSETS VULNERABLE TO CURRENT AND FUTURE FLOODING UNDER DIFFERENT FLOODING SCENARIOS.

Residential Asset Category	Total Assets	Current FEMA NFHL	USACE CHS				Combined Future 1% AEP
			Current		Future (+ 2.3ft SLR)		
		1% and 0.2% AEP	10% AEP	1% AEP	10% AEP	1% AEP	
Single Family	264,554	16435 (6%)	6083 (2%)	9711 (4%)	7575 (3%)	13212 (5%)	18,751 (7%)
Condo	23,497	1659 (7%)	924 (4%)	1372 (6%)	1218 (5%)	1821 (8%)	1,838 (8%)
Manufactured Housing	9,307	927 (10%)	128 (1%)	235 (3%)	180 (2%)	313 (4%)	1115 (12%)
Multifamily	4,915	470 (10%)	155 (3%)	258 (5%)	224 (5%)	363 (7%)	611 (12%)
Residential Miscellaneous	6,025	299 (5%)	180 (3%)	348 (6%)	250 (4%)	442 7%)	137 (2%)
Residential Care Facility	221	28 (13%)	6 (3%)	11 (5%)	9 (4%)	16 (7%)	23 (10%)
Assisted Housing	120	17 (14%)	3 (2.5%)	6 (5%)	3 (2.5%)	7 (6%)	20 (17%)

Residential: Current Coastal Storm and Riverine Flooding (FEMA NFHL)

About 6% of all residential properties in Jacksonville are currently highly vulnerable to coastal storm and riverine flooding (FEMA NFHL, Table 6). Figure 13 shows the percentage of residential properties with medium or high combined vulnerability and risk under the current coastal storm and riverine flooding scenario (FEMA NFHL). Block groups with high percentages of residential properties with medium and high combined vulnerability and risk are most contiguous along the shoreline of the St. Johns River, but other clusters of block groups with similar patterns of high combined vulnerability and risk can be found across the entire city. The data from this scenario demonstrates significant flood risk, even for areas located further from the river and major tributaries. Examples include block groups along the I-95 corridor south of San Marco and neighborhoods between I-10 and I-90, east of I-295 and west of the Intracoastal Waterway.

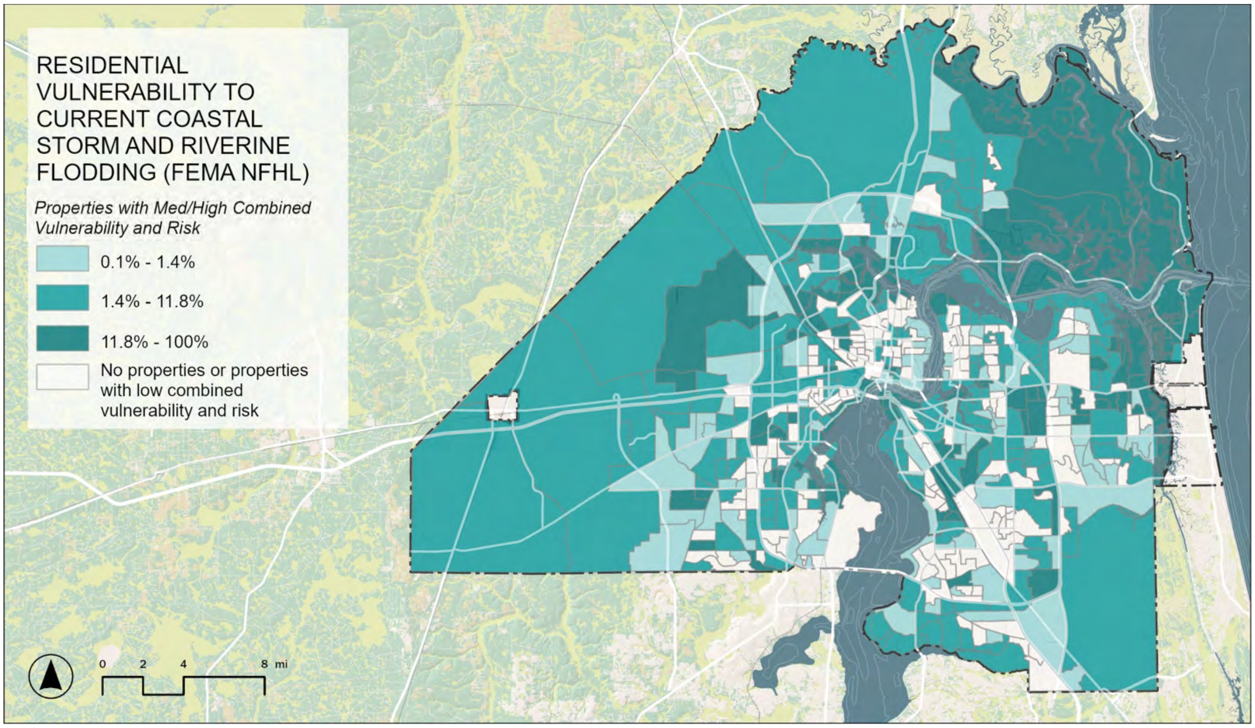


FIGURE 13. PERCENT OF RESIDENTIAL PROPERTIES WITH MEDIUM OR HIGH COMBINED VULNERABILITY AND RISK UNDER THE CURRENT COASTAL STORM AND RIVERINE FLOODING SCENARIO (FEMA NFHL).

To identify areas of the city that may be more vulnerable to residential flooding, vulnerability by Development Type was evaluated (Figure 14). This assessment found that most of Jacksonville's residential properties are situated in the Post-War or Contemporary suburbs Development Types, which consequently means that more of the properties classified as "highly vulnerable" are also located there. However, even though the Contemporary Suburbs contain 51% of the total residential properties in Jacksonville, they only account for 35% of the highly vulnerable residential properties. Conversely, 16% of currently vulnerable residential properties are in Coastal Communities even though they make up only 3% of total residential properties. In other words, approximately one in three homes in the Coastal Communities Development Type are currently highly vulnerable to flooding.

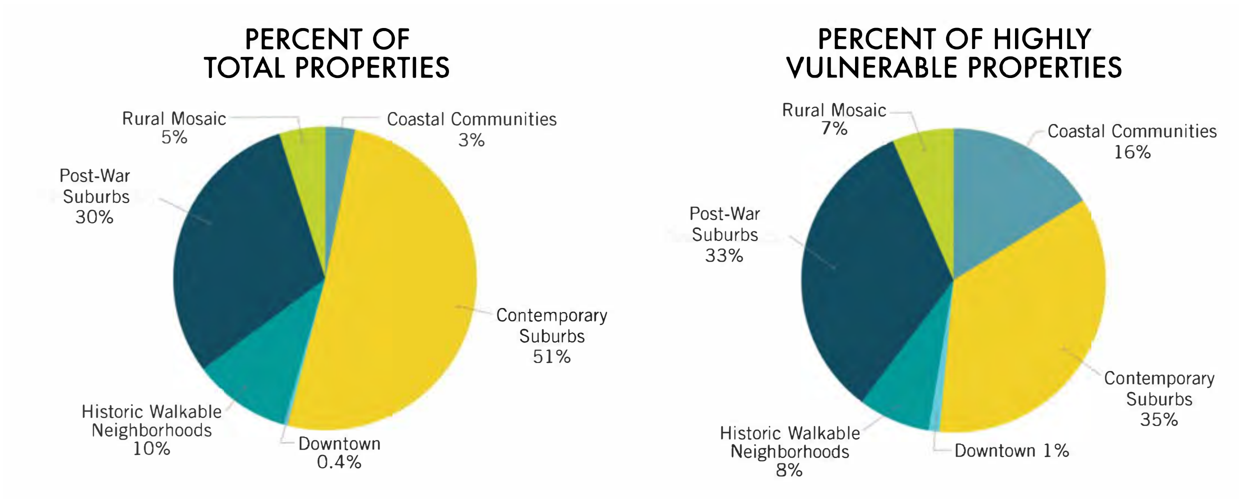


FIGURE 14. PERCENT OF TOTAL RESIDENTIAL PROPERTIES BY DEVELOPMENT TYPE AND THE PERCENT OF VULNERABLE PROPERTIES TO CURRENT COASTAL STORM AND RIVERINE FLOODING (FEMA NFHL) IN THOSE TYPES.

Residential: Current and Future Coastal Storm Flooding (USACE CHS)

The percent of residential properties vulnerable to 10% AEP coastal storm flooding now and in the future are shown in Figure 15 and Figure 16, respectively. It is important to highlight that these maps only depict predicted coastal storm flooding and do not take riverine or heavy rainfall flooding into consideration. These analyses are useful in comparing vulnerability to coastal storm flooding now and in the future. In comparing the current 10% AEP coastal storm flooding scenario to the future 10% AEP coastal storm flooding scenario, a higher percentage of combined vulnerability and risk for residential properties within the block groups in the Ortega neighborhood and in areas along the Trout River is observed under the future 10% AEP scenario. Similarly, the percent of vulnerable residential properties in block groups adjacent to the Jacksonville International Airport also increases.

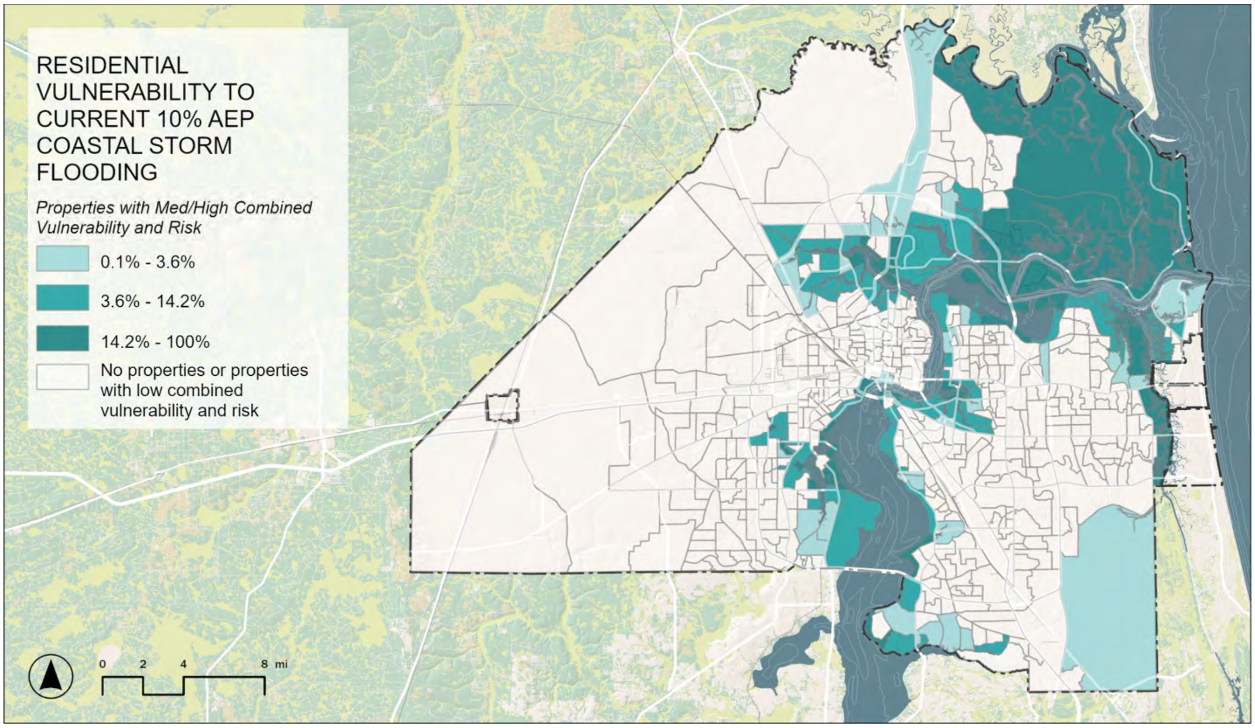


FIGURE 15. PERCENT OF RESIDENTIAL PROPERTIES WITH MEDIUM OR HIGH COMBINED VULNERABILITY AND RISK UNDER THE CURRENT 10% COASTAL STORM FLOODING SCENARIO (USACE CHS).

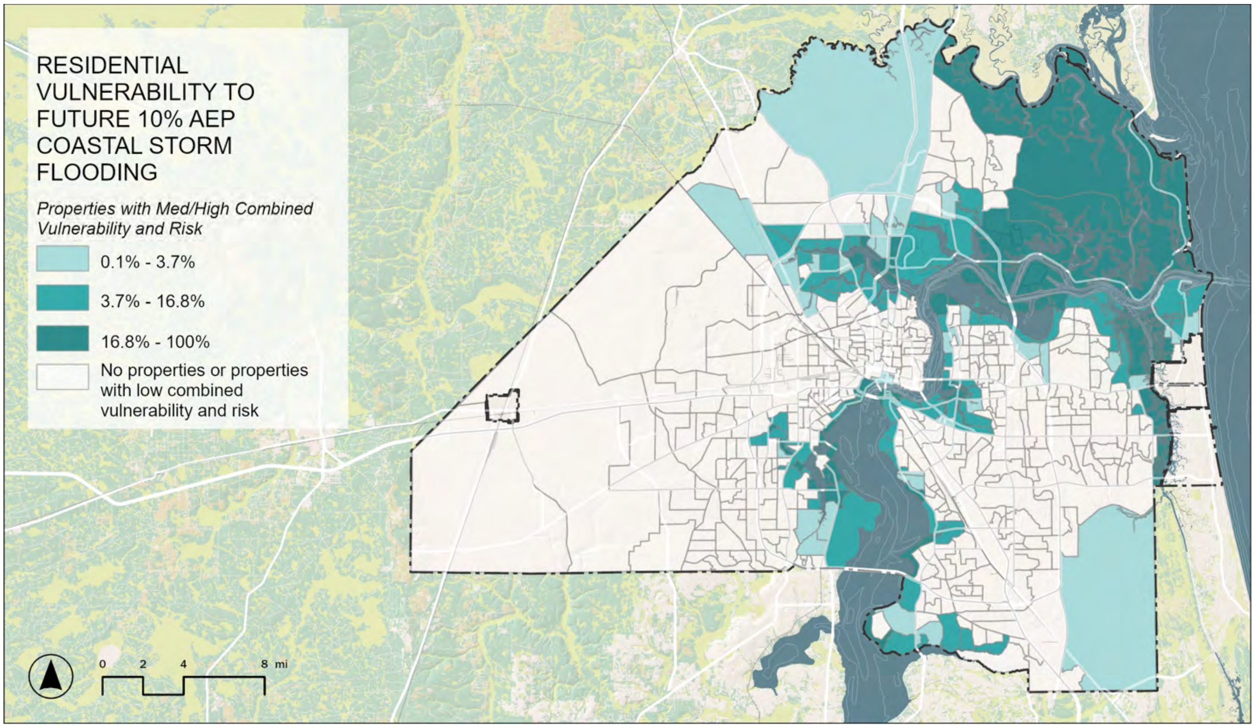


FIGURE 16. PERCENT OF RESIDENTIAL PROPERTIES WITH MEDIUM OR HIGH COMBINED VULNERABILITY AND RISK UNDER THE FUTURE 10% COASTAL STORM FLOODING SCENARIO (USACE CHS).

Residential: Future Coastal Storm, High Tide, and Riverine Flooding (Combined Future 1% AEP)

The results for the percentage of residential properties with medium or high combined vulnerability and risk to future coastal storm, high tide, and riverine flooding (Combined Future 1% AEP) are shown in Figure 17. While the results under this scenario are not directly comparable to the results from the FEMA NFHL, this analysis provides another lens for evaluating areas of Jacksonville that may become vulnerable to flooding in the future. Overall, the combined future 1% AEP scenario shows more block groups across the city with medium and high combined vulnerability for residential properties. Specifically, this scenario demonstrates more vulnerability for residential properties in block groups located within areas on the North Bank of the St Johns River such as Paxon, Moncrief, and Panama Park.

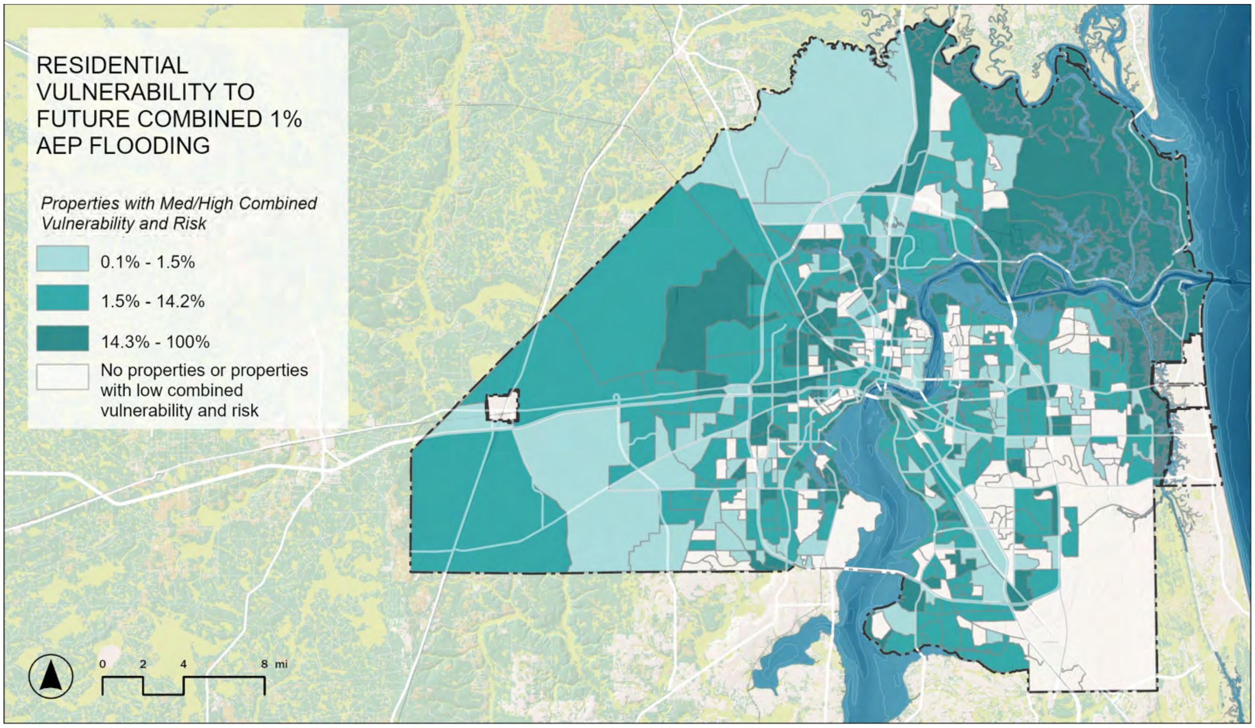


FIGURE 17. PERCENT OF RESIDENTIAL PROPERTIES WITH MEDIUM OR HIGH COMBINED VULNERABILITY AND RISK UNDER THE COMBINED FUTURE 1% AEP FLOODING SCENARIO.

The Combined future 1% AEP flood assessment provides a view of increased vulnerability of the built environment of today to both coastal storm and riverine flooding under a higher sea level and increased rainfall intensity. According to this assessment, about 7% of residential properties citywide are highly vulnerable, and Figure 18 shows their distribution across Development Types. Similar to the current condition assessment (FEMA NFHL), a significantly disproportionate number of properties are located in the Coastal Communities. In contrast, Contemporary Suburbs house only 28% of the highly vulnerable properties, despite comprising 51% of the total residential properties in Jacksonville. Whereas Downtown includes the smallest number of residential properties in the city, about one in five of those properties are highly vulnerable to 1% AEP flooding in the future.

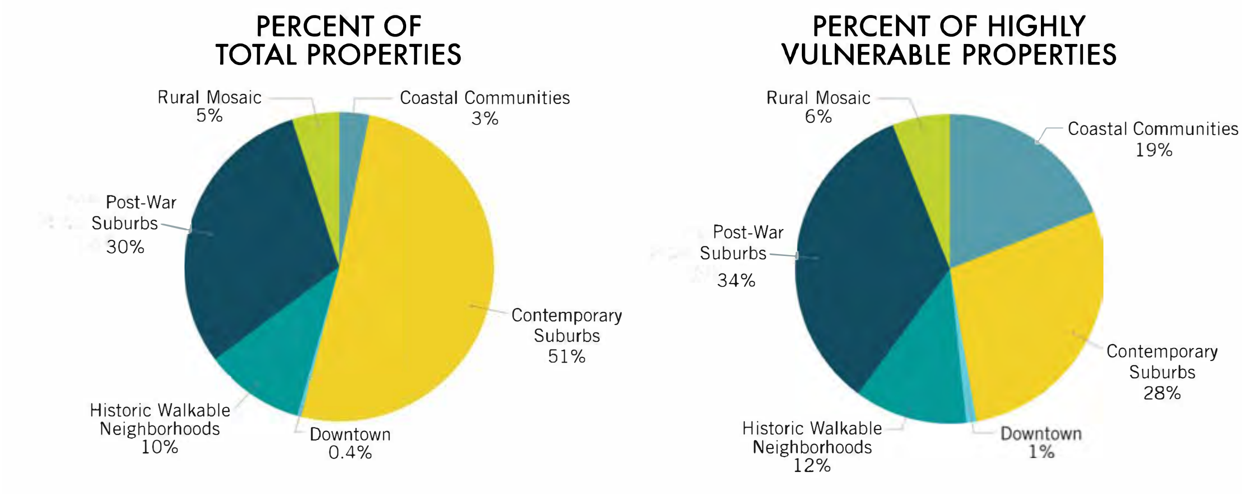


FIGURE 18. FUTURE RESIDENTIAL 1% COMBINED FUTURE 1% AEP FLOOD EXTENT BY DEVELOPMENT TYPE.

These results can be put into context by evaluating the adaptive capacity of residential properties in Jacksonville. About 37% of residential properties located in the Combined Future 1% AEP have low adaptive capacity (Figure 19). This classification stems from either their construction in the regulatory floodplain before they were mapped—meaning no elevation requirements were in place at the time of construction (Pre-FIRM))—or their location outside the regulatory floodplain, where elevation requirements do not apply. Properties with high adaptive capacity are those that are constructed in the current 100–year floodplain after the 1ft freeboard standard was adopted (2014).

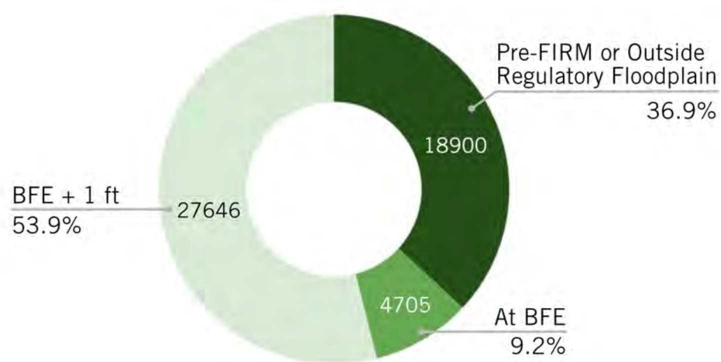


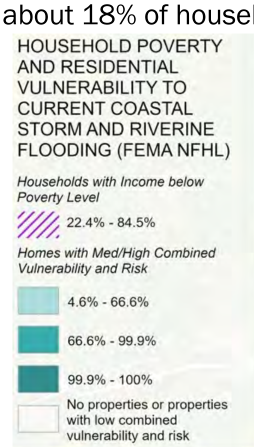
FIGURE 19. ADAPTIVE CAPACITY OF RESIDENTIAL PROPERTIES AS REPRESENTED BY THE PERCENTAGE OF PROPERTIES AT BASE FLOOD ELEVATION (BFE), 1 FT ABOVE BFE, AND THOSE BUILD BEFORE JACKSONVILLE ADOPTED ITS FIRST FLOOD INSURANCE RATE MAP (PRE-FIRM) OR BUILT OUTSIDE THE REGULATORY FLOODPLAIN.

Residential Flood Vulnerability and Sensitive or At-Risk Populations

While multifamily properties and manufactured housing comprise a small percentage of housing types in Jacksonville, these housing types are generally considered “affordable housing.” Together with subsidized housing, about 10% of this affordable housing stock in Jacksonville is currently highly vulnerable to according to the FEMA NFHL current coastal storm and riverine flooding scenario. The number and percent of residential assets vulnerable to current and future flooding under different flooding scenarios are also represented in

Table 7. This includes five manufactured housing parks with more than 100 units each. Assessment results also demonstrate that 13% of residential care facilities such as nursing homes, group homes, assisted living, and memory care facilities are highly vulnerable to current coastal storm and riverine flooding (FEMA NFHL).

The map shown in Figure 20 offers a higher resolution view of the distribution of current residential flood vulnerability throughout the city (FEMA NFHL). The darkest areas on the map represent block groups with higher proportions of residential properties within them that are classified as highly vulnerable to flooding. By overlaying census-based indicators of social stressors on this map, we can identify areas where both physical and social vulnerability is concentrated. In this case, the purple border and cross-hatching symbology indicates block groups where households with incomes below the poverty level (according to 2020 U.S. Census) make up more than 24% and up to 85% of households. Among these hatched block groups, 23 of them also have a high proportion of homes vulnerable to current flooding. Notably, about 18% of households facing poverty in Jacksonville live in



these 23 block groups (

Figure 21).

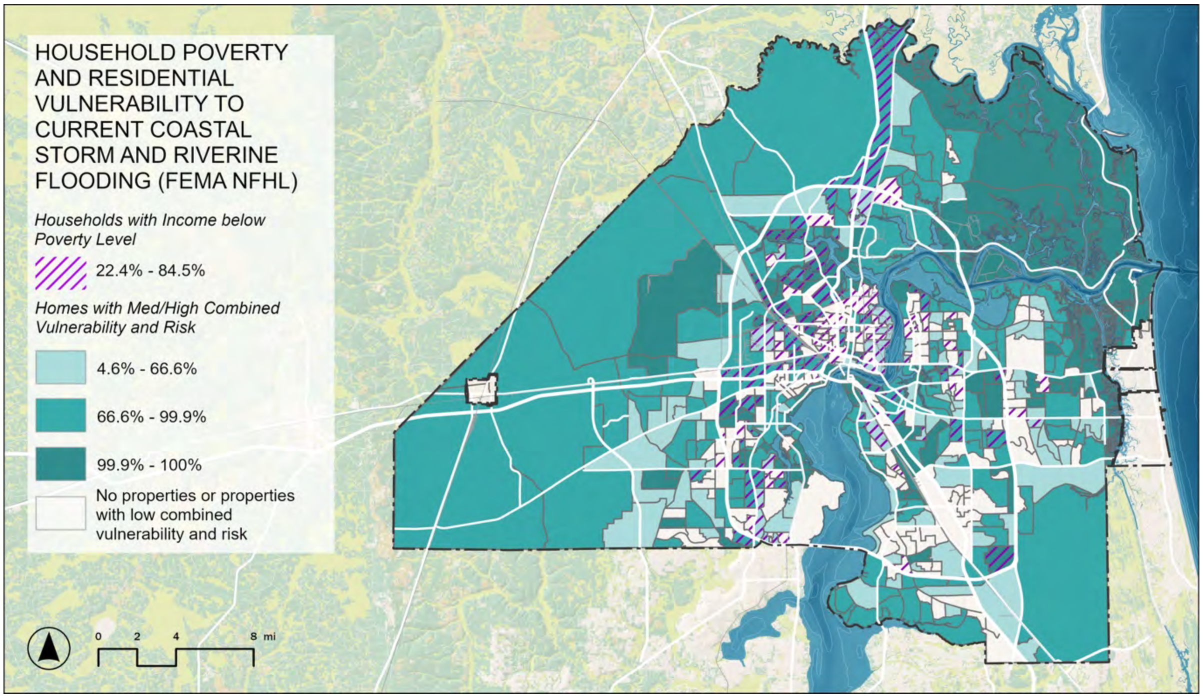


FIGURE 20. BLOCK GROUP-LEVEL MAP SHOWING AREAS WITH SOME OF THE HIGHEST PERCENT OF HOUSEHOLDS WITH INCOME LEVELS BELOW THE POVERTY LEVEL (SHOWN IN PURPLE) AND THE PROPORTION OF RESIDENTIAL PROPERTIES THAT ARE HIGHLY VULNERABLE TO CURRENT COASTAL STORM AND RIVERINE FLOODING (FEMA NFHL).

FIGURE 21. ZOOMED-IN VIEW OF BLOCK GROUP-LEVEL MAP SHOWING AREAS WITH SOME OF THE HIGHEST PERCENT OF HOUSEHOLDS WITH INCOME LEVELS BELOW THE POVERTY LEVEL (SHOWN IN PURPLE) AND THE PROPORTION OF RESIDENTIAL PROPERTIES THAT ARE HIGHLY VULNERABLE TO CURRENT COASTAL STORM AND RIVERINE FLOODING (FEMA NFHL).

Infrastructure and Services

This vulnerability assessment considered government-owned and utility-owned critical infrastructure and emergency services as well as government-owned, privately owned, and nonprofit assets that provide important services and amenities to Jacksonville year-round. Table 8 shows the results for the total number of assets and the percentage of total assets for Infrastructure and Services across the six flood scenarios categorized by the services provided by those assets.

TABLE 8. NUMBER AND PERCENT OF INFRASTRUCTURE AND UTILITY ASSETS VULNERABLE TO CURRENT AND FUTURE FLOODING UNDER SIX DIFFERENT FLOODING SCENARIOS.

Infrastructure and Services Asset Category	Total Assets	*Current* FEMA NFHL	USACE CHS				Combined *Future* 1% AEP
			Current		*Future (+ 2.3ft SLR)*		
		1% & 0.2% AEP	10% AEP	1% AEP	10% AEP	1% AEP	
Critical Facilities and Infrastructure (selected)							
EMS and Fire Stations	62	11 (18%)	4 (6%)	6 (10%)	6 (10%)	7 (11%)	13 (21%)
Emergency Shelters	42	4 (10%)	2 (5%)	3 (7%)	2 (5%)	4 (10%)	2 (5%)
Correctional Facilities	10	5 (50%)	0 (0%)	2 (20%)	2 (20%)	3 (30%)	3 (30%)
Senior Center	18	3 (17%)	1 (6%)	1 (6%)	1 (6%)	1 (6%)	3 (17%)
Utility Properties	378	35 (9%)	6 (2%)	16 (4%)	11 (3%)	24 (6%)	9 (2%)
Wastewater[2]	6	1 (17%)	1 (17%)	1 (17%)	1 (17%)	1 (17%)	1 (17%)
Substations	87	17 (20%)	11 (13%)	12 (14%)	12 (14%)	14 (16%)	11 (13%)
Hospitals	20	11 (55%)	5 (25%)	6 (30%)	6 (30%)	7 (35%)	9 (45%)
Other Community Services							
Public Schools and Colleges	327	44 (13%)	20 (6%)	25 (8%)	23 7(%)	31 (9%)	34 (10%)
Religious	1,747	97 (6%)	24 1(%)	41 (2%)	30 (2%)	59 (3%)	113 (7%)
Day Cares	234	5 (2%)	0 (0%)	2 (1%)	2 (1%)	4 (2%)	14 (6%)
Afterschool Programs	90	6 (7%)	1 (1%)	1 (1%)	1 (1%)	1 (1%)	11
Historical Properties	16,390	1,165 (7%)	515 (3%)	830 (5%)	688 (4%)	1,129 (7%)	1,299 (8%)
Mortuary/Cemetery	136	7 (5%)	0 (0%)	4 (3%)	2 (2%)	6 (4%)	2 (1%)

[2] Note: The datasets and methodology used for this assessment differ from the vulnerability assessment evaluated by the JEA Volume 1: Resilience Plan (Jacobs, 2020). Therefore, the number of total and vulnerable assets in these categories may differ between analyses and assessments.

Infrastructure and Services Asset Category	Total Assets	*Current* FEMA NFHL 1% & 0.2% AEP	USACE CHS *Current* 10% AEP	USACE CHS *Current* 1% AEP	USACE CHS *Future (+ 2.3ft SLR)* 10% AEP	USACE CHS *Future (+ 2.3ft SLR)* 1% AEP	Combined *Future* 1% AEP
SNAP Retailer (includes convenience stores)	521	32 (6%)	4 (1%)	10 (2%)	6 (1%)	16 (3%)	46 (9%)
Library	24	2 (8%)	0	0	0	1 (4%)	2 (8%)
Community Center	44	1 (<1%)	1 (<1%)	1 (<1%)	1 (<1%)	1 (<1%)	1 (<1%)
Public Transit Stations	6	2 (33%)	0	0	0	2 (33%)	2 (33%)

Figure 22 shows the location of a subset of Jacksonville's facilities critical for emergency response during an extreme event. The map points outlined with a red circle indicate assets that have a high vulnerability to current coastal storm and riverine flooding (FEMA NFHL). Notably, vulnerable critical assets are found across Jacksonville, and in some cases, far from Jacksonville's major bodies of water.

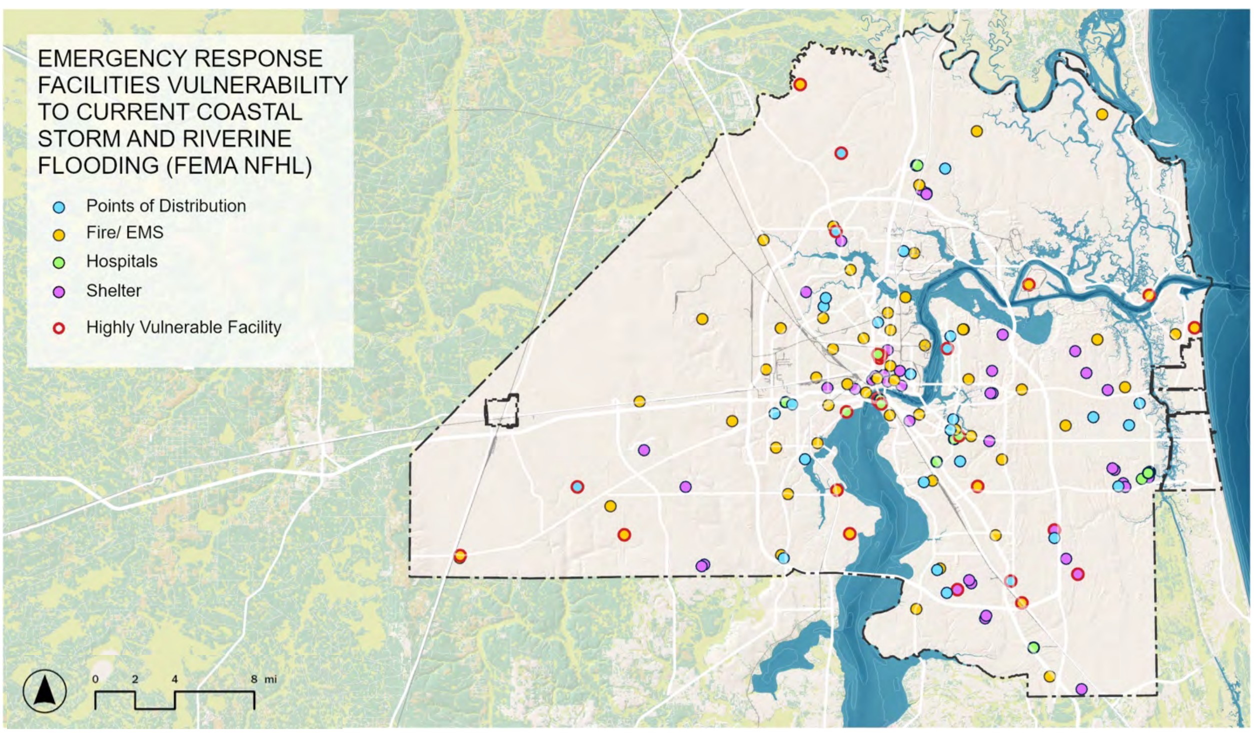


FIGURE 22. EMERGENCY RESPONSE FACILITIES HIGHLY VULNERABLE TO CURRENT COASTAL STORM AND RIVERINE FLOODING (FEMA NFHL). ASSETS WITH HIGH VULNERABILITY TO CURRENT FLOODING ARE OUTLINED IN RED.

Critical infrastructure and utility assets impact the wellbeing of Jacksonville's residents, and vulnerability data surrounding these assets can inform both near-term and long-range planning decisions. Near term planning decisions, such as where to protect or build EMS stations, might consider the 11 EMS and fire stations vulnerable to current coastal storm and riverine flooding (FEMA NFHL, Table 8, Figure 22).

Figure 23 displays the spatial distribution of all utility and other critical infrastructure and service properties that are highly vulnerable to future flooding with 1% AEP combined inland and coastal flooding occurring. The darker-colored block groups indicate a higher concentration of combined vulnerability and risk. Of note are the block groups near the shoreline of the Southbank, highlighted in yellow, which have an estimated 26 utility and critical service properties that are highly vulnerable.

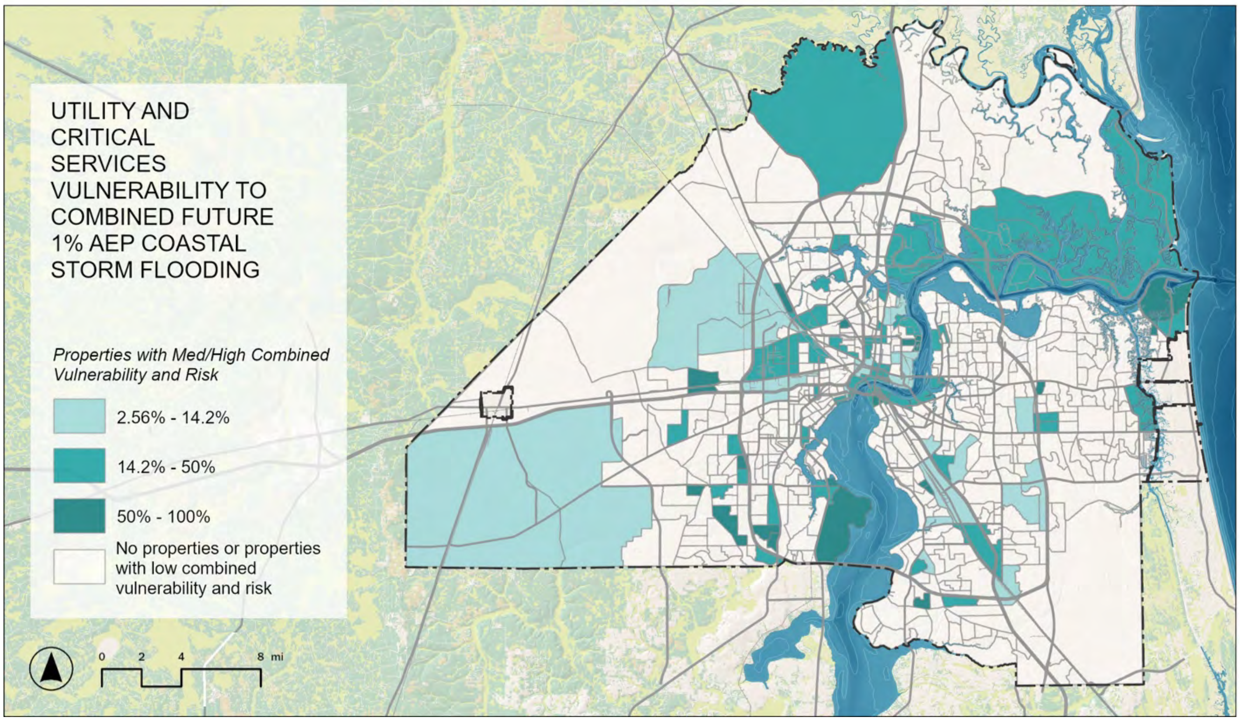


FIGURE 23. SPATIAL DISTRIBUTION OF UTILITY AND OTHER CRITICAL INFRASTRUCTURE AND SERVICE PROPERTIES THAT ARE HIGHLY VULNERABLE TO FUTURE INLAND AND COASTAL FLOODING (COMBINED FUTURE 1% AEP).

Flood Vulnerability and Social Stressors

Studies on social vulnerability and flooding indicate that the connection between demographic and socioeconomic factors, such as ethnicity, gender, age, and income, significantly influence a community's resilience to flood events (Rufat et al., 2015). Studies also show that hidden or existing inequalities can be exacerbated by flooding events (Forrest et al., 2020).

As an example of this process, food insecurity, defined as limited or uncertain access to adequate food, can often be exacerbated by flooding (USDA, 2022). The 2019 USDA Food Access Research Atlas identifies 38 census tracts within the city as “Low Income and Low Access,” meaning an area where residents have limited access to healthy food in combination with limited buying power.

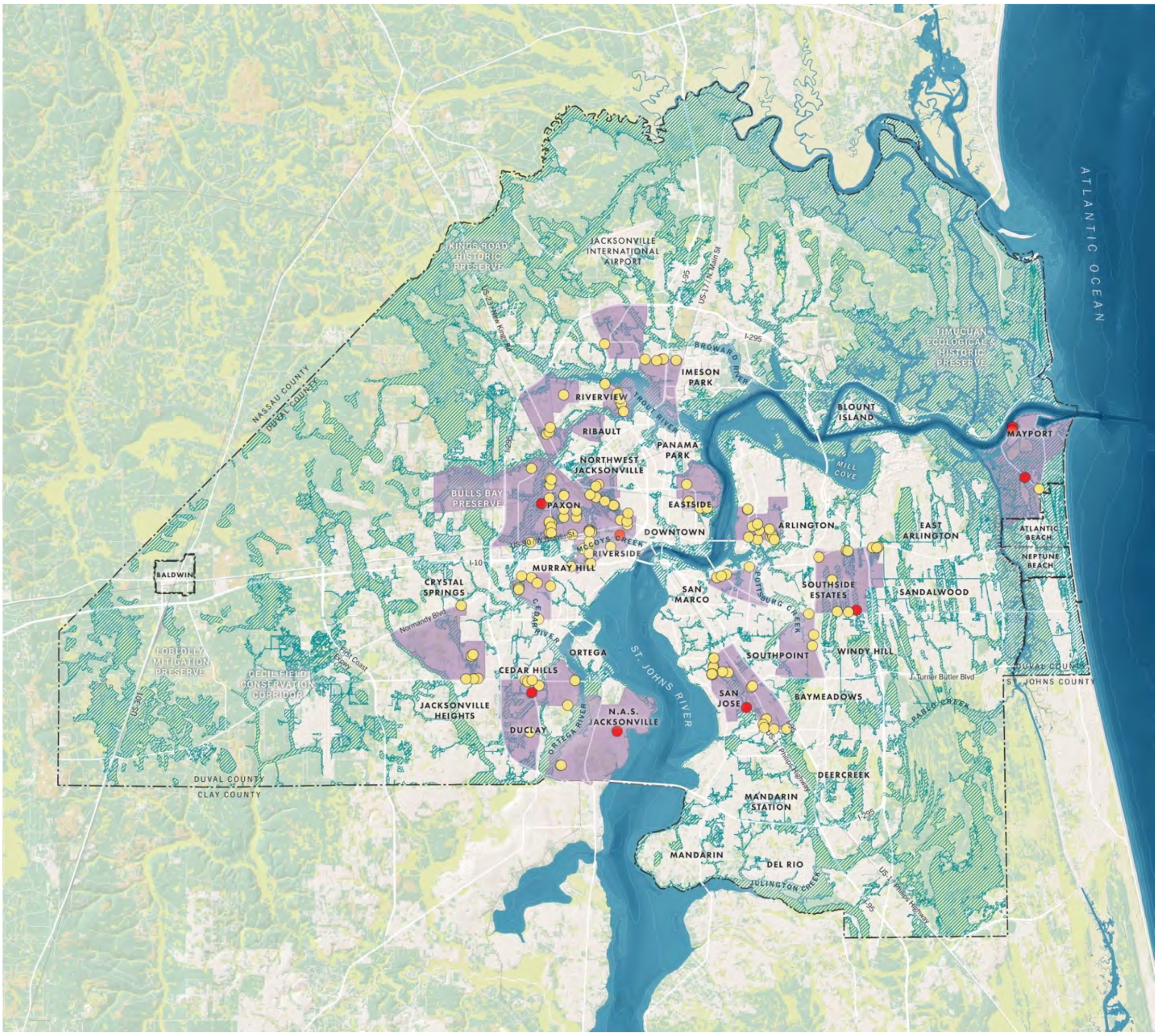


Figure 24 below shows low income and low access census tracts in Jacksonville (symbolized by the hatched lines). The red points represent highly vulnerable SNAP retailers under the current coastal storm and riverine flooding scenario. There are 32 SNAP retailers vulnerable under the FEMA NFHL scenario, and 46 vulnerable under the combined future 1% AEP flooding scenario. SNAP provides low-income families or individuals with food benefits to supplement their grocery budget to make nutritious food more affordable. When low-income families or individuals are cut off from stores that accept SNAP benefits, they may experience limited access to nutritious food.

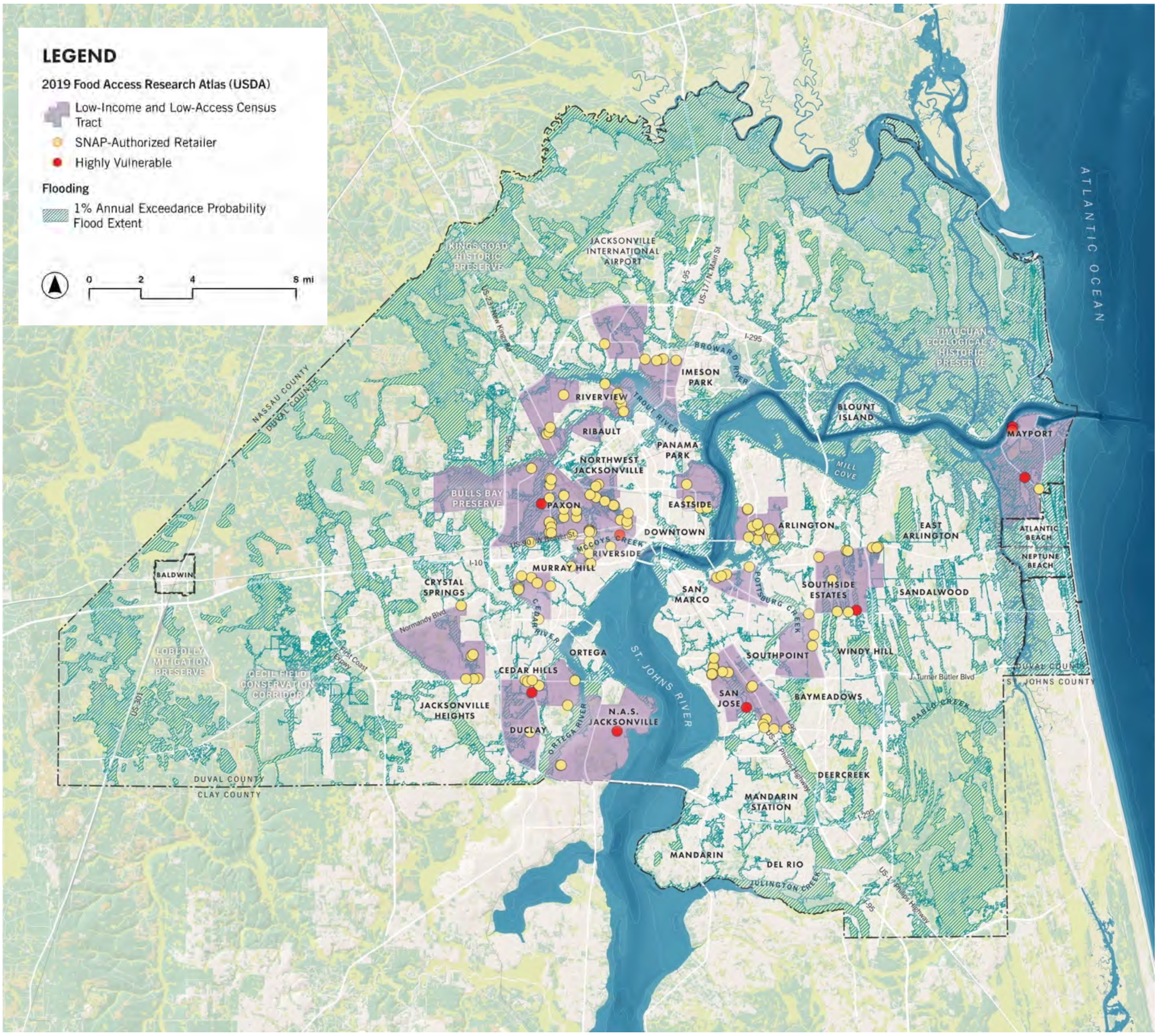


FIGURE 24. FLOOD VULNERABILITY OF SNAP RETAILERS AND LOW-INCOME, LOW-ACCESS CENSUS TRACTS. SNAP RETAILER LOCATIONS SHOWN IN RED ARE HIGHLY VULNERABLE.

Road Network Analysis

Approximately 28% of major roads and 22% of minor roads (measured in lane miles) within Jacksonville have the potential to become inaccessible to emergency response in flood events that are represented by current coastal storm and riverine flooding (FEMA NFHL) (Table 6). This could occur either because they are directly inundated by floodwaters or because they become cut off by other flooded roads even as they remain dry themselves. Figure 25 shows roads maintained by the City of Jacksonville and their exposure to flooding using the current coastal storm and riverine flooding scenario (FEMA NFHL). Out of 9,160 lane miles maintained by the City, 630 (7%) are exposed. Figure 26 shows state roads within Jacksonville exposed to flooding under the same current coastal storm and riverine flooding scenario (FEMA NFHL). Out of 2,450 lane miles maintained by the state of Florida, 160 (7%) are exposed.

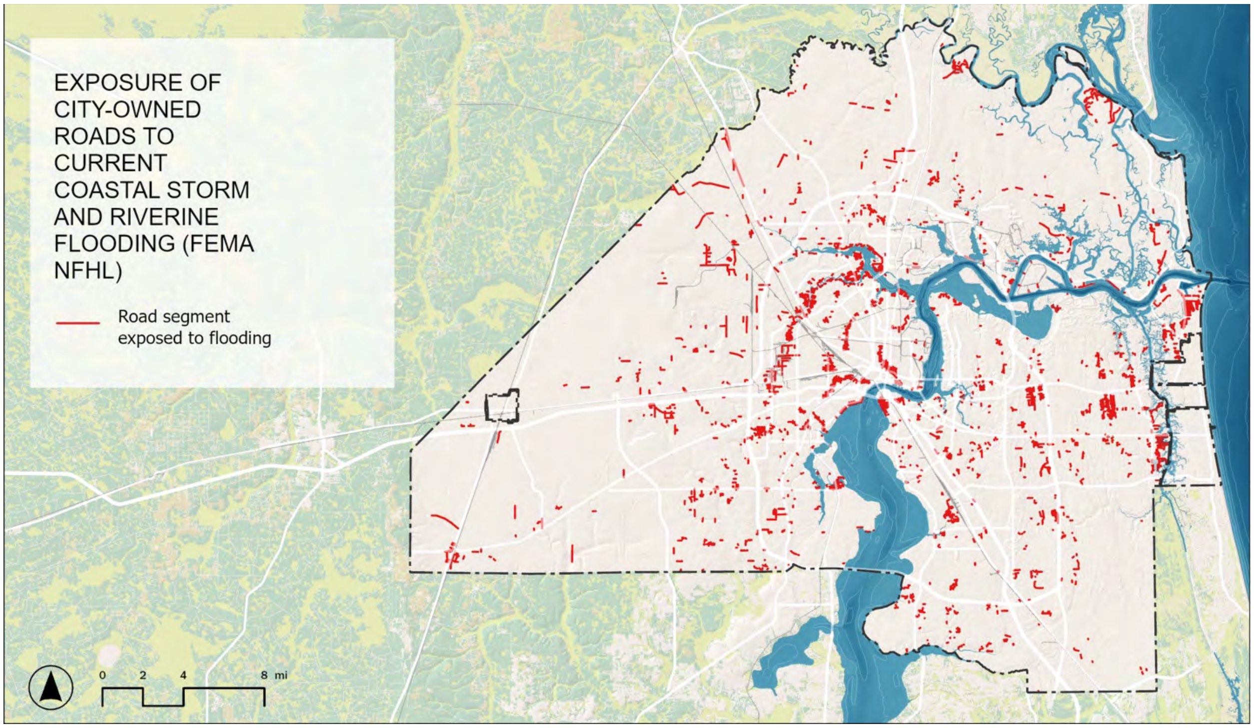


FIGURE 25. CITY-MAINTAINED ROADS AND CURRENT COASTAL STORM AND RIVERINE FLOOD EXPOSURE (FEMA NFHL).

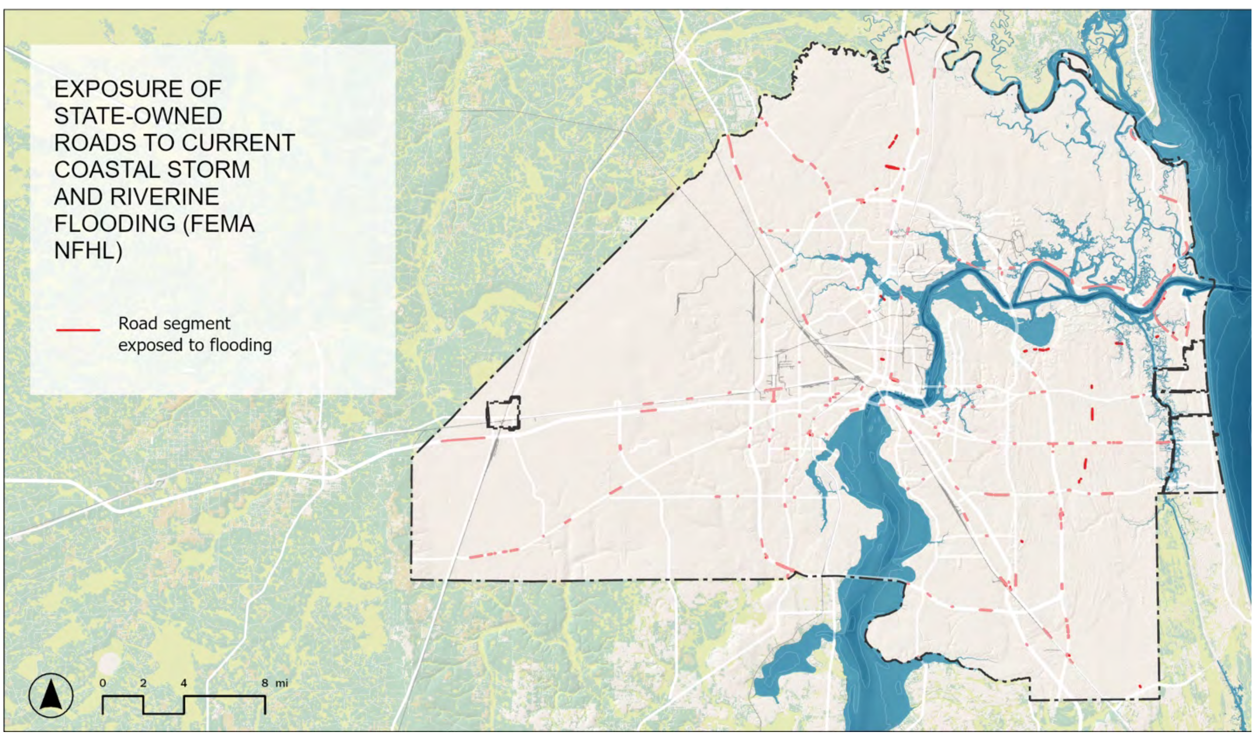


FIGURE 26. STATE ROADS AND CURRENT COASTAL STORM AND RIVERINE FLOOD EXPOSURE (FEMA NFHL).

Figure 27 highlights parcels/neighborhoods in red that have the potential to become inaccessible to emergency services (i.e., fire stations/EMS) due to inundated or disconnected roads. As an example, the neighborhood located north of Pottsburg Creek may become temporarily inaccessible during a major flood event. This area includes multiple multifamily parcels, three schools, and dozens of single-family homes.

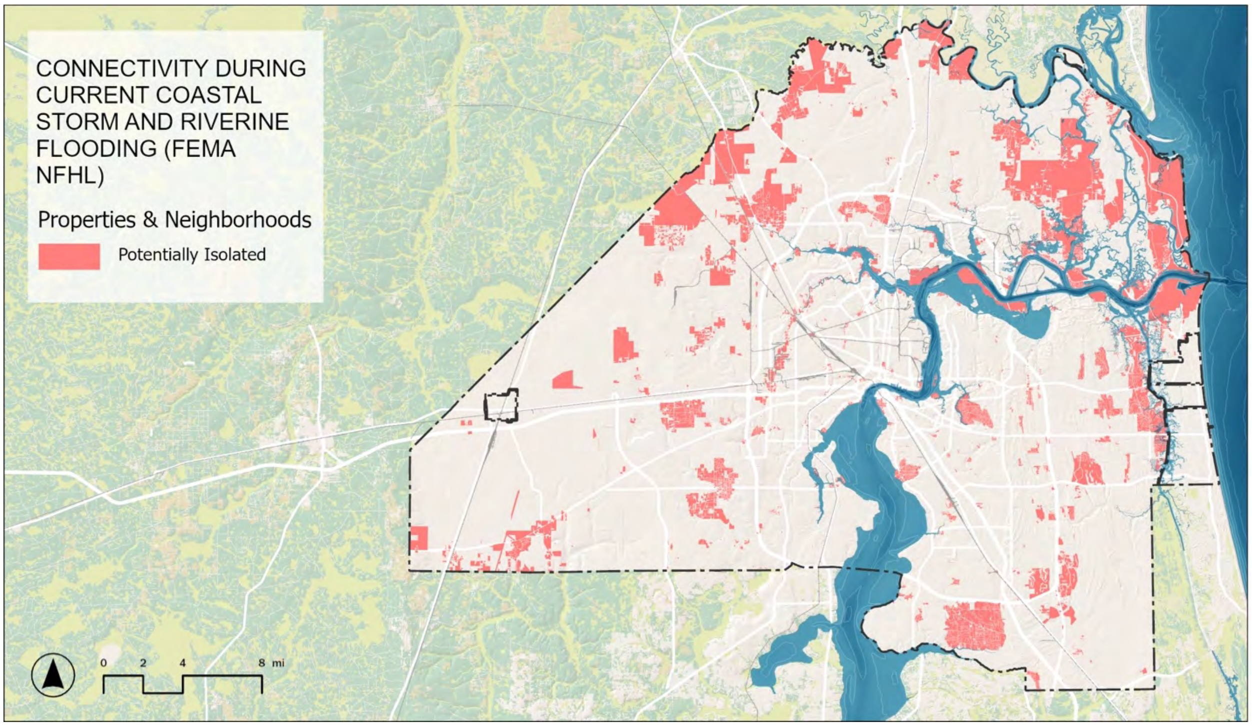


FIGURE 27. NEIGHBORHOODS THAT HAVE THE POTENTIAL TO BE ISOLATED OR INACCESSIBLE TO EMERGENCY SERVICES UNDER THE CURRENT COASTAL STORM AND RIVERINE FLOOD SCENARIO (FEMA NFHL).

shows neighborhoods that could potentially be isolated and inaccessible to emergency services under the current 10% coastal storm flooding scenario. Of note, neighborhoods along Heckscher Drive and A1A around the eastern edge of Fort George Island and into Little Talbot Island have the potential to be cut off under this scenario. Areas along the western shoreline of the Intracoastal Waterway represent other neighborhoods that could potentially be cut off from services, as well as some neighborhoods in the northern part of the city such as the streets on the tributary edge along Half Moon Island, the Eagle Bend neighborhood, and communities between Samples Creek and Starratt Road. Additionally, communities along the Trout River, between I-295 and I-95, and the Turtle Creek area near the intersection of I-295 and I-95 demonstrate potential isolation under the current 10% coastal storm flooding scenario.

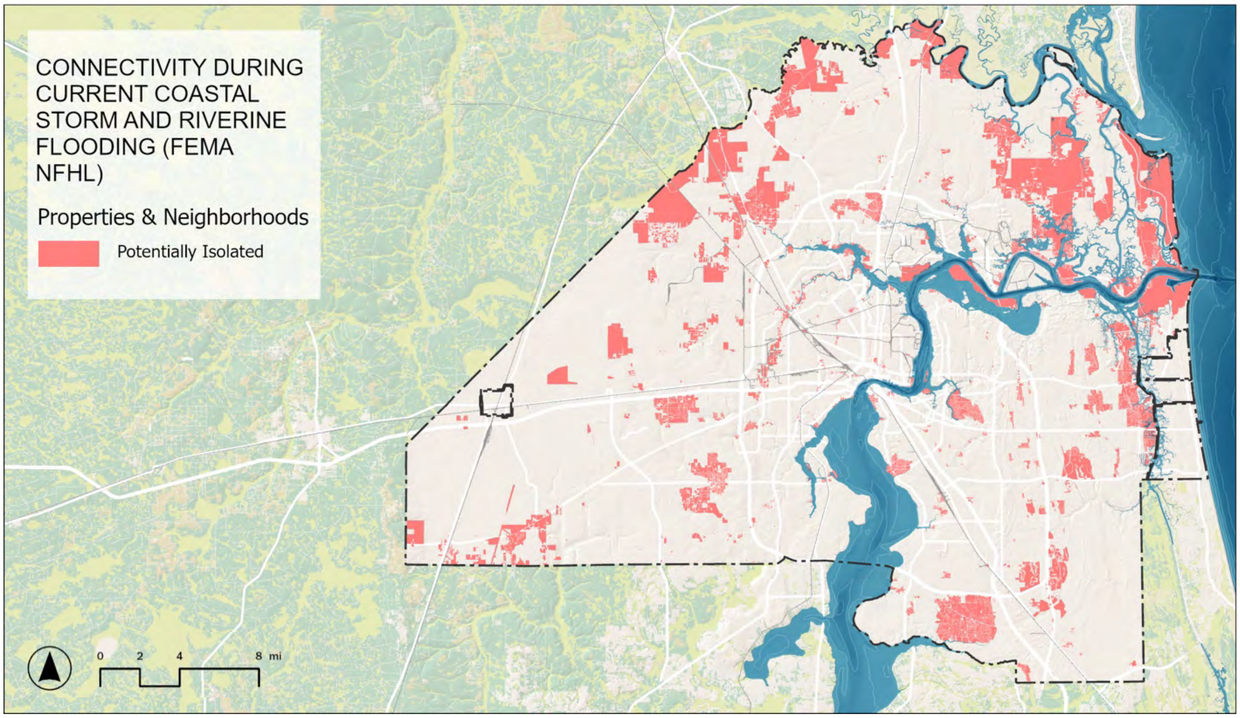


FIGURE 28. NEIGHBORHOODS THAT HAVE THE POTENTIAL TO BE ISOLATED AND INACCESSIBLE TO EMERGENCY SERVICES DUE TO FLOODING UNDER THE CURRENT 10% COASTAL STORM FLOODING SCENARIO (USACE CHS).

Under the future 10% AEP coastal storm flooding scenario (Figure 29) neighborhoods with the potential to be isolated and inaccessible to emergency services remain largely the same. The risk of being cut off increases slightly in some locations along the western edge of the Intracoastal Waterway, but other locations with increased exposure are mostly natural areas and do not contain any residences.

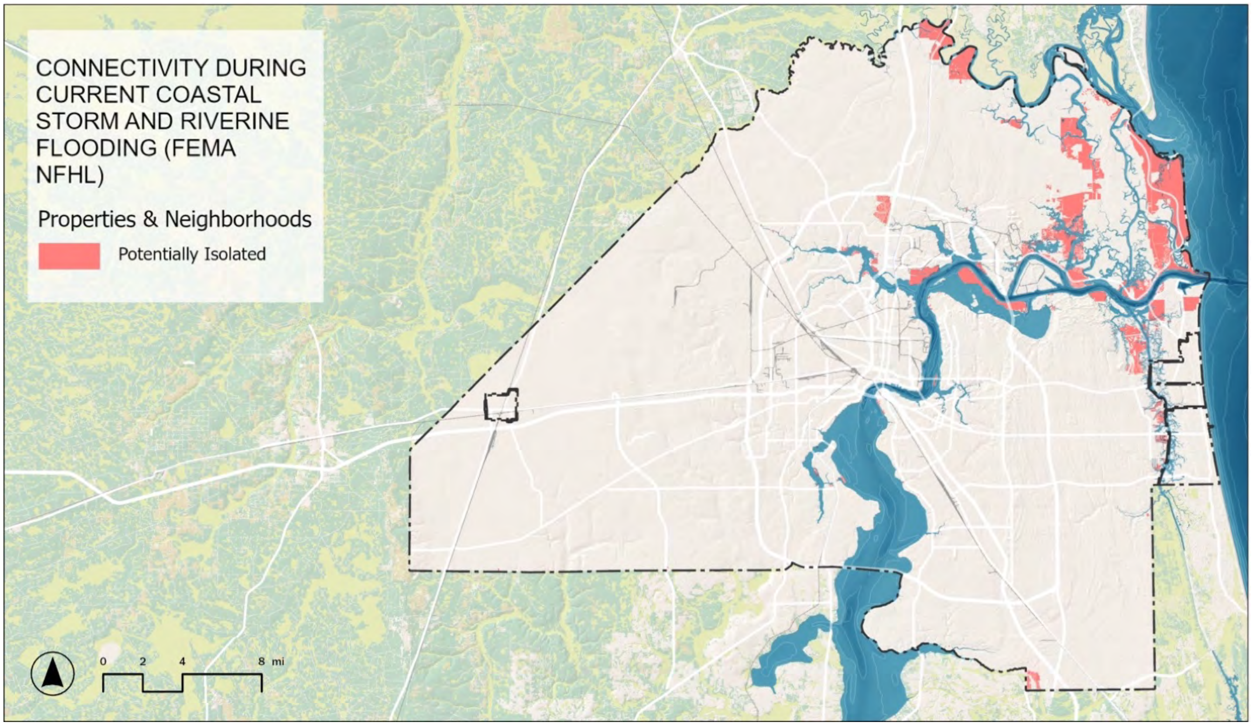


FIGURE 29. NEIGHBORHOODS THAT HAVE THE POTENTIAL TO BE ISOLATED AND INACCESSIBLE TO EMERGENCY SERVICES DUE TO FLOODING UNDER THE FUTURE 10% COASTAL STORM FLOODING SCENARIO (USACE CHS).

Commercial and Industrial Property

About 6% of commercial properties and 10% of industrial properties are vulnerable to current coastal storm and riverine flooding (FEMA NFHL, Table 6).

Table 9 identifies the total number of vulnerable assets for a subset of commercial and industrial properties by asset type. Notably, across all flooding scenarios assessed, a large number of retail, manufacturing, and distribution assets have medium to high flood vulnerability.

TABLE 9. NUMBER OF COMMERCIAL AND INDUSTRIAL PROPERTY ASSETS VULNERABLE TO CURRENT AND FUTURE FLOODING UNDER SIX FLOODING SCENARIOS.

		Current FEMA NFHL	**USACE CHS**				
			Current		***Future (+ 2.3ft SLR)***		
Commercial and Industrial Asset Category	**Total Assets**	**1% & 0.2% AEP**	**10% AEP**	**1% AEP**	**10% AEP**	**10% AEP**	**Combined Future 1% AEP**
Commercial Properties							
Hotel and Motel	169	24 (14%)	6 (4%)	7 (4%)	6 (4%)	11 (7%)	24 (14%)
Service Station	58	6 (10%)	0	0	0	0	5 (9%)

Commercial and Industrial Asset Category	Total Assets	Current FEMA NFHL	USACE CHS				
			Current		*Future (+ 2.3ft SLR)*		
		1% & 0.2% AEP	10% AEP	1% AEP	10% AEP	10% AEP	Combined Future 1% AEP
Supermarket	31	4 (13%)	0	0	0	0	1 (3%)
Retail	2,955	203 (7%)	34 (1%)	76 (3%)	54 (2%)	111 (4%)	227 (8%)
Restaurants	701	33 (5%)	10 (1%)	13 (2%)	11 (2%)	21 (3%)	42 (6%)
Industrial Properties (selected)							
Manufacturing	505	67 (13%)	17 (3%)	20 (4%)	17 (3%)	26 (5%)	95 (18%)
Refrigerated Warehouse	17	5 (29%)	1 (5%)	1 (5%)	1 (5%)	1 (5%)	9 (53%)
Distribution Warehouse	354	68 (19%)	0	1 (<1%)	0	3 (<1%)	86 (24%)
Food Processing	6	2 (33%)	2 (33%)	2 (33%)	2 (33%)	2 (33%)	2 (33%)

Commercial Property: Current Coastal Storm and Riverine Flooding (FEMA NFHL)

Figure 30 shows the proportion of commercial properties with medium or high combined vulnerability and risk by block group under the current coastal storm and riverine flooding scenario (FEMA NFHL). Compared to combined vulnerability and risk levels for residential properties under the same scenario (Table 7)Table 7. Number and percent of Residential assets vulnerable to current and future flooding under different flooding scenarios. commercial properties demonstrate a smaller proportion of vulnerability and risk to flooding (FEMA NFHL). This is most notable in Jacksonville's western-most block groups bordering Nassau County and Baker County, as well as block groups in the northern-most part of the city adjacent to the Jacksonville International Airport. Block groups on both banks of the St. Johns River, including block groups along the Intracoastal Waterway, tend to have significantly less combined vulnerability and risk for commercial properties compared to residential properties.

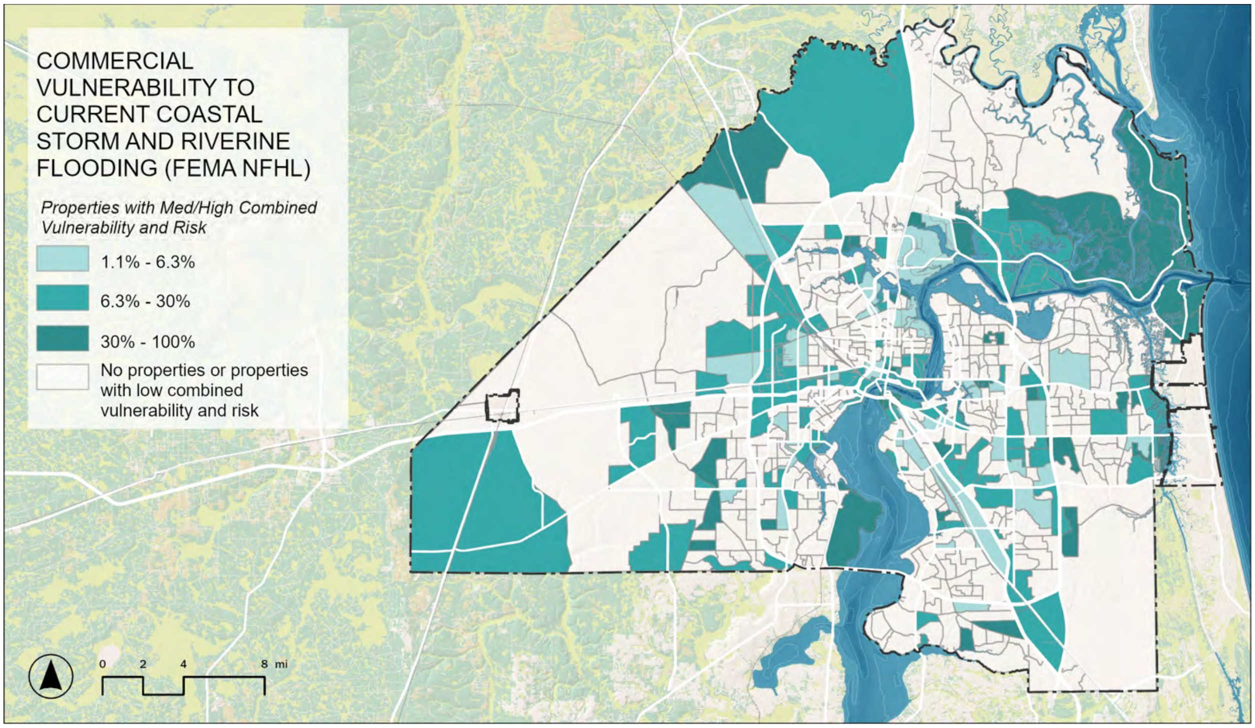


FIGURE 30. PERCENT OF COMMERCIAL PROPERTIES WITH MEDIUM OR HIGH COMBINED VULNERABILITY AND RISK UNDER THE CURRENT COASTAL STORM AND RIVERINE FLOODING SCENARIO (FEMA NFHL).

Commercial Property: Current and Future Coastal Storm Flooding (USACE CHS)

Figure 31 shows the percentage of commercial properties with medium or high combined vulnerability and risk by block group under the current 10% AEP coastal storm flooding scenario. Under this scenario, most block groups across the city demonstrate no vulnerability or risk for commercial properties. This is the result of the coastal storm flood model that does not take riverine flooding into consideration. Despite this, there are block groups along the shoreline in the urban core (Downtown) that maintain medium or high vulnerability and risk for commercial properties, and some of the larger block groups just south of the Jacksonville International Airport also demonstrate medium levels of combined vulnerability and risk to coastal storm flooding for commercial properties.

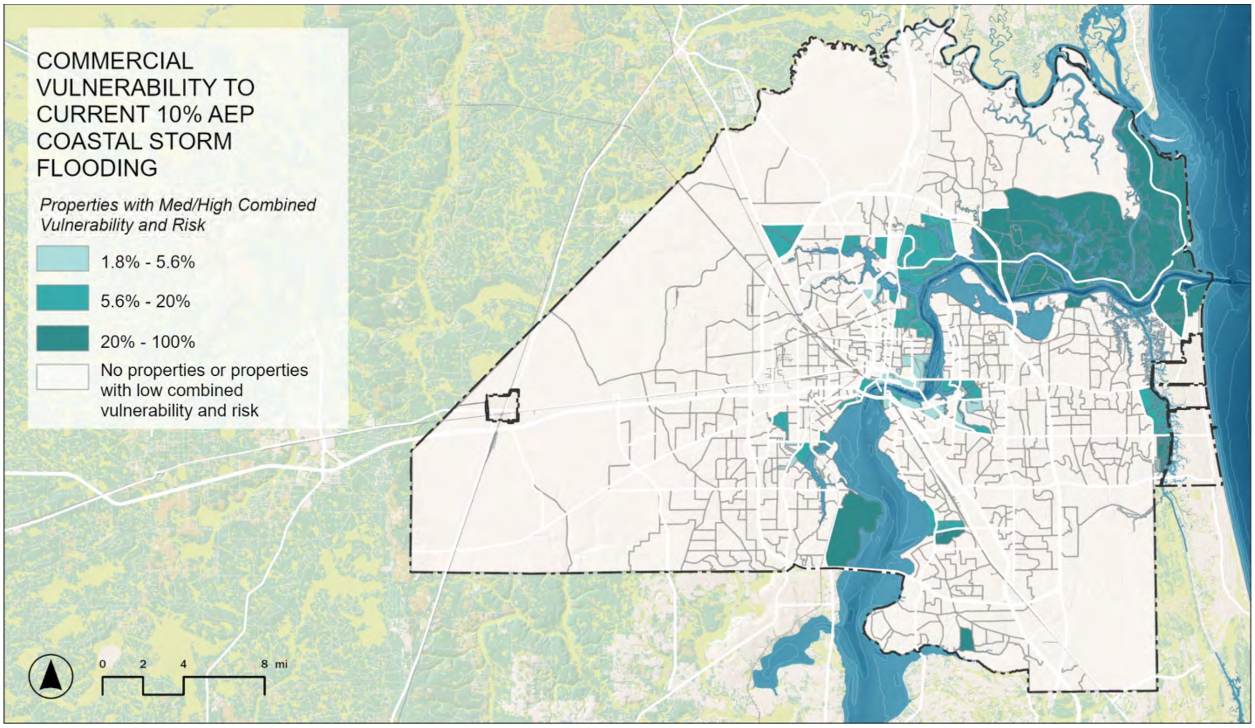


FIGURE 31. PERCENT OF COMMERCIAL PROPERTIES WITH MEDIUM OR HIGH COMBINED VULNERABILITY AND RISK UNDER THE CURRENT 10% COASTAL STORM FLOODING SCENARIO (USACE CHS).

The percentage of commercial properties with medium or high combined vulnerability and risk by block group under the future 10% AEP coastal storm flooding scenario is shown in Figure 32. Though similar patterns of vulnerability and risk exist between this scenario and the current 10% AEP coastal storm flooding scenario, these results demonstrate increased levels of future vulnerability and risk in a few areas of Jacksonville—most notably within the block groups closest to the Southbank portion of Downtown and San Marco and another block group adjacent to Jacksonville's Naval Air Station.

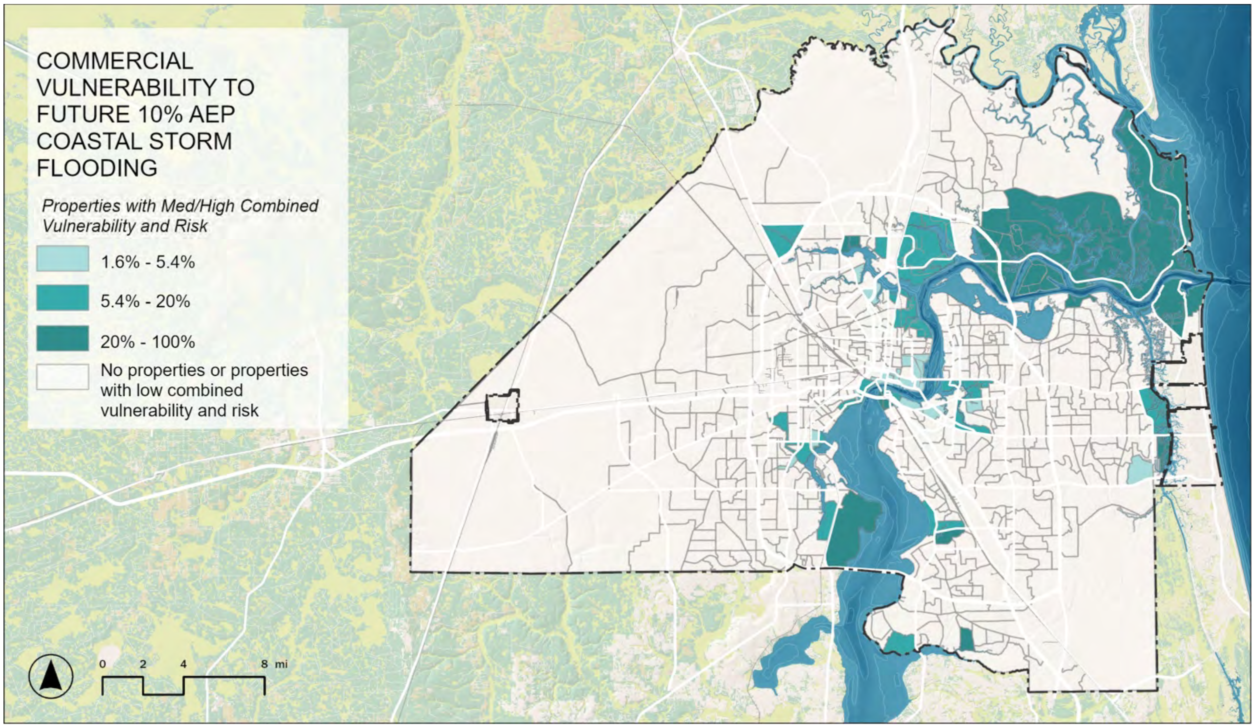


FIGURE 32. PERCENT OF COMMERCIAL PROPERTIES WITH MEDIUM OR HIGH COMBINED VULNERABILITY AND RISK UNDER THE FUTURE 10% COASTAL STORM FLOODING SCENARIO (USACE CHS).

Commercial: Future Coastal Storm, High Tide, and Riverine Flooding (Combined Future 1% AEP Sources)

The percent of commercial properties with medium or high combined vulnerability under the 1% AEP future coastal storm and riverine flood scenario (Combined Future 1% AEP) is shown in Figure 33. The proportion of commercial assets vulnerable to future inland flooding in the Northside and Westside neighborhoods is highlighted by this analysis.

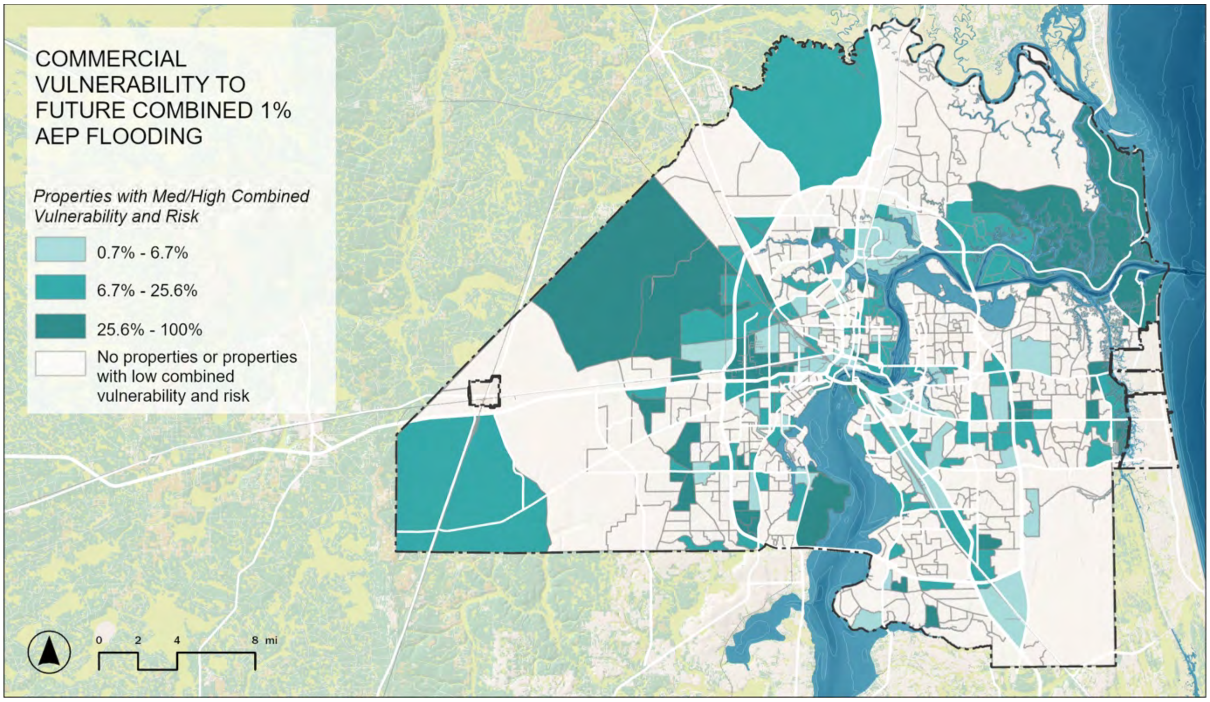


FIGURE 33. PERCENT OF COMMERCIAL PROPERTIES WITH MEDIUM OR HIGH COMBINED VULNERABILITY AND RISK UNDER THE FUTURE 1% AEP INLAND AND COASTAL FLOODING SCENARIO (COMBINED FUTURE 1% AEP).

Industrial Property: Current Coastal Storm and Riverine Flooding (FEMA NFHL)

10% of industrial properties have a medium or high combined vulnerability and risk to current coastal storm and riverine flooding scenario (FEMA NFHL, Table 6, Figure 34). In comparing industrial vulnerability with commercial property vulnerability, while the total percentage of vulnerable properties is higher for industry than commercial, there are areas of the city where the proportion of vulnerable industrial properties is lower than they are for commercial properties. For example, block groups between I-10 and I-90, east of I-295 and west of the Intracoastal Waterway demonstrate a lower proportion of vulnerable industrial assets under the same current coastal storm and riverine flooding scenario (FEMA NFHL).

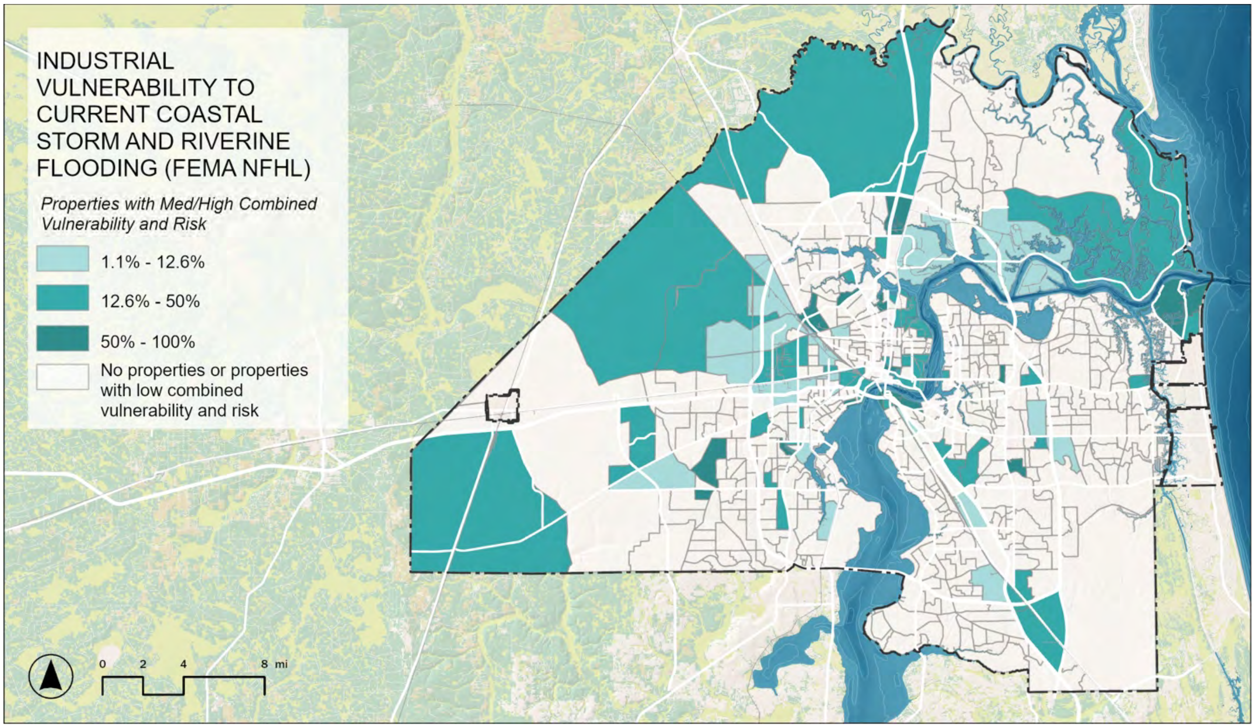


FIGURE 34. PERCENT OF INDUSTRIAL PROPERTIES WITH MEDIUM OR HIGH COMBINED VULNERABILITY AND RISK UNDER THE CURRENT COASTAL STORM AND RIVERINE FLOODING SCENARIO (FEMA NFHL).

Industrial Property: Current and Future Coastal Storm Flooding (USACE CHS)

Under the current 10% AEP coastal storm flooding scenario, the percent of industrial properties with medium or high combined vulnerability and risk is relatively low across block groups around the city (Figure 35). The future 10% AEP coastal storm flooding scenario represented in Figure 36 shows similar levels of combined vulnerability and risk for industrial properties when compared to the current 10% AEP coastal storm flooding scenario. Under the future coastal storm flooding scenario there are some increases in percentages of combined vulnerability and risk—most notably in the block group containing Atlantic Highlands and Holiday Harbors, the Southbank shoreline near the bridges, and the block group adjacent to Jacksonville's Naval Air Station (Figure 36).

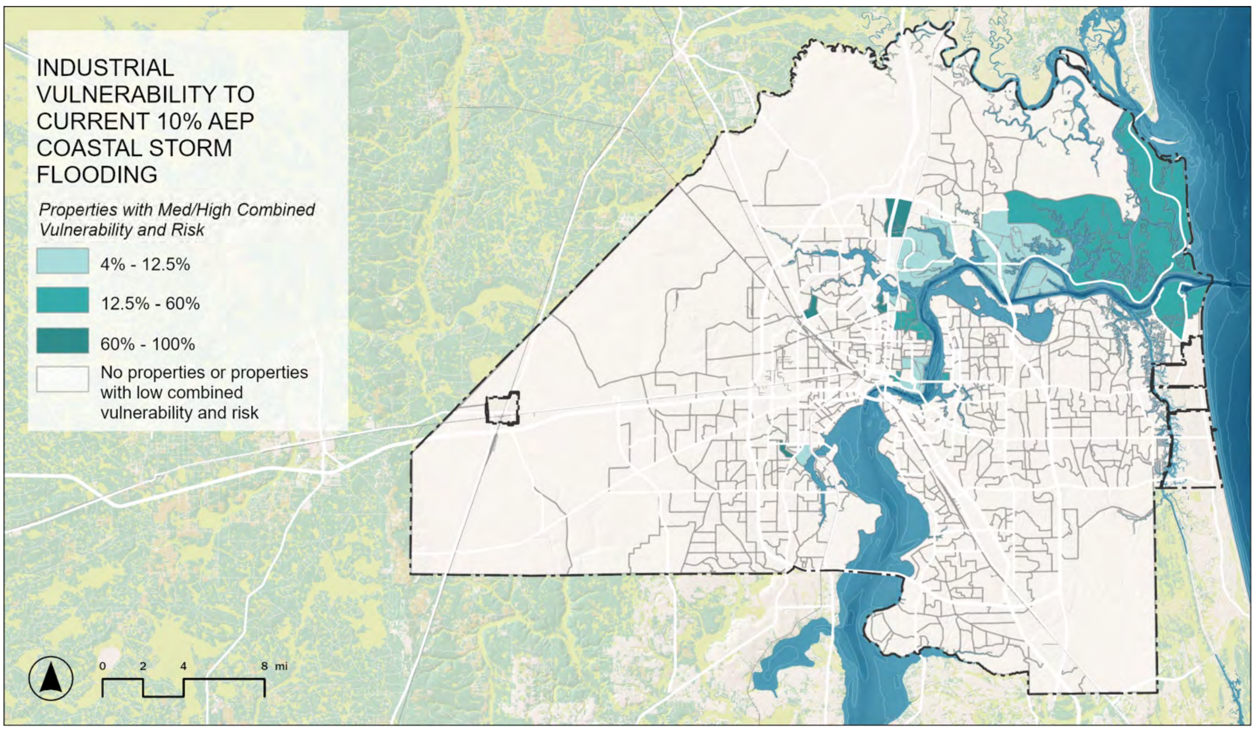


FIGURE 35. PERCENT OF INDUSTRIAL PROPERTIES WITH MEDIUM OR HIGH COMBINED VULNERABILITY AND RISK UNDER THE CURRENT 10% COASTAL STORM FLOODING SCENARIO (USACE CHS).

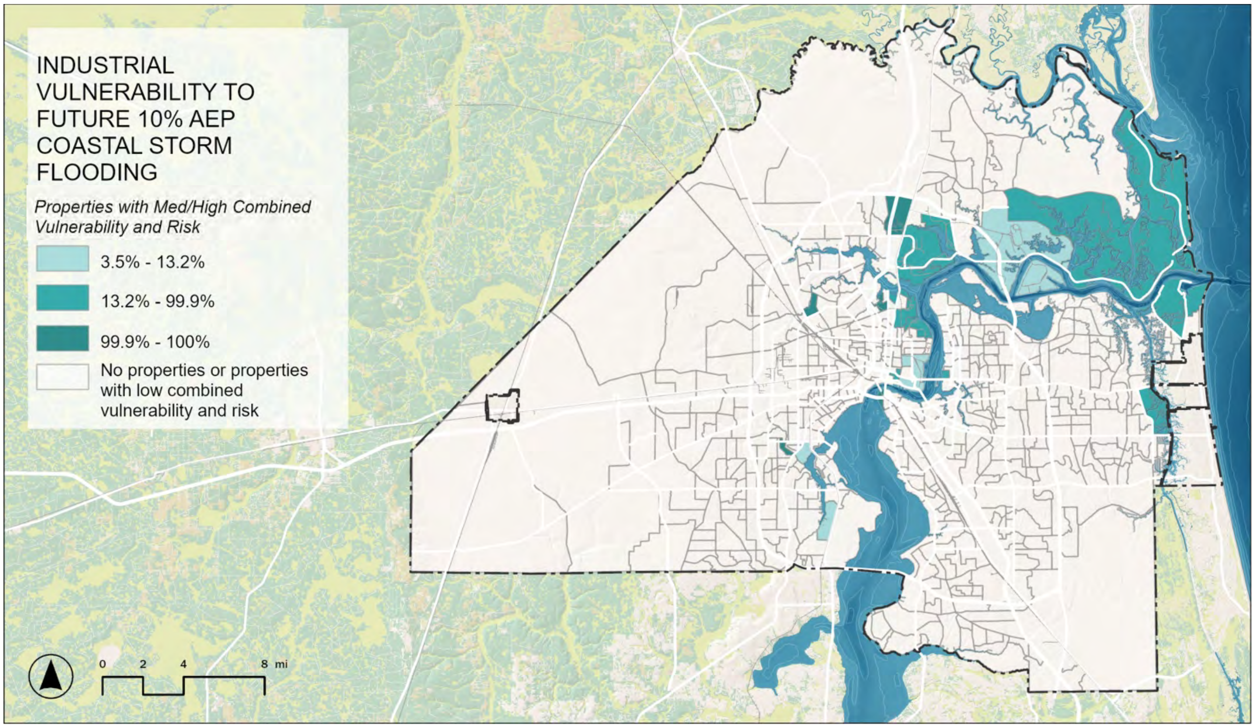


FIGURE 36. PERCENT OF INDUSTRIAL PROPERTIES WITH MEDIUM OR HIGH COMBINED VULNERABILITY AND RISK UNDER THE FUTURE 10% COASTAL STORM FLOODING SCENARIO (USACE CHS).

Industrial Property: Future Coastal Storm, High Tide, and Riverine Flooding (Combined Future 1% AEP)

The results for the percentage of industrial properties with medium or high combined vulnerability and risk to future coastal storm, high tide, and riverine flooding (Combined 1% AEP) are shown in Figure 37. Overall, the combined future 1% AEP scenario appears to show less vulnerability to industrial asset flooding across the city than commercial asset vulnerability under the same scenario (Figure 30). This is likely due, in part, to the larger distribution and number of commercial assets across Jacksonville, in particular in the more suburban and rural areas of the city.

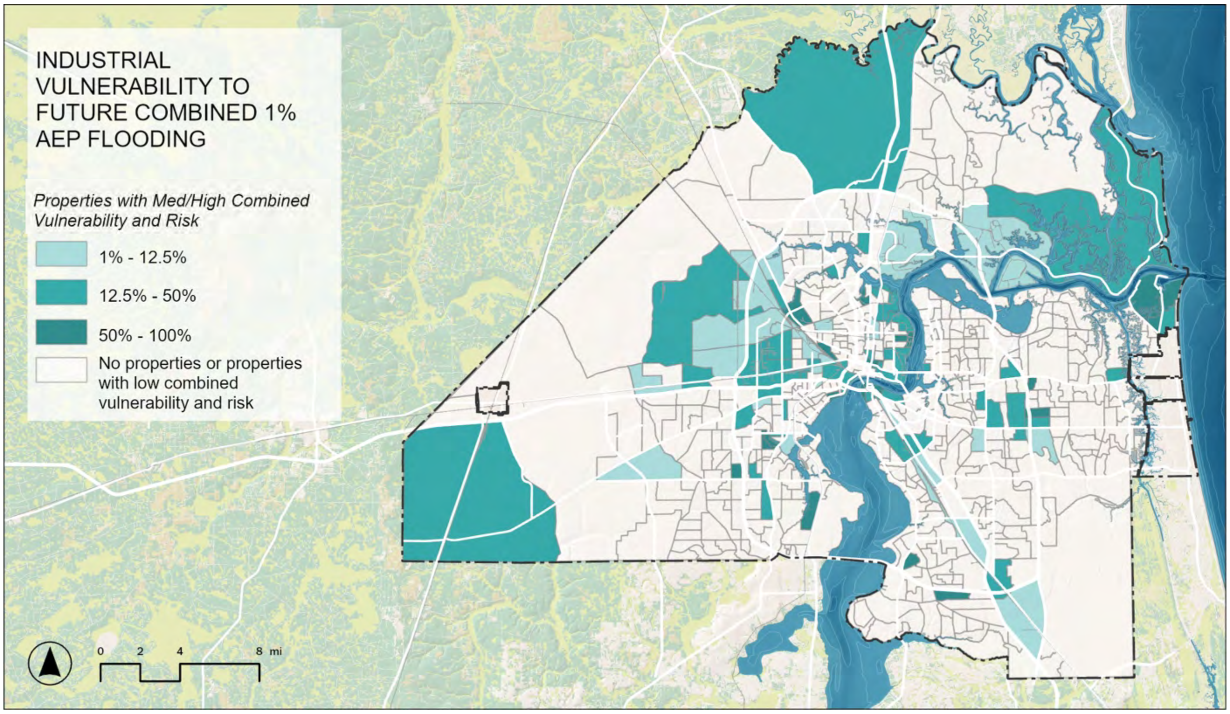


FIGURE 37. PERCENT OF INDUSTRIAL PROPERTIES WITH MEDIUM OR HIGH COMBINED VULNERABILITY AND RISK UNDER THE FUTURE 1% AEP INLAND AND COASTAL FLOODING SCENARIO (COMBINED FUTURE 1% AEP).

Commercial and Industrial Asset Vulnerability by Development Type

The assessment evaluated the distribution of vulnerable commercial and industrial properties by Development Type. Not surprisingly, Downtown and the surrounding Historic Walkable Neighborhoods have a higher proportion of commercial and industrial properties compared to other Development Types in Jacksonville (Figure 38, Figure 39). The flood vulnerability assessment by Development Type shows a higher proportion of vulnerable commercial and industrial assets in comparison to total proportion of properties in those asset categories across Jacksonville in the Downtown and Coastal Communities Development Types. For example, about one third of industrial properties in Downtown (outside the Industrial Riverfront core) are highly vulnerable to current coastal storm and riverine flooding (FEMA NFHL).

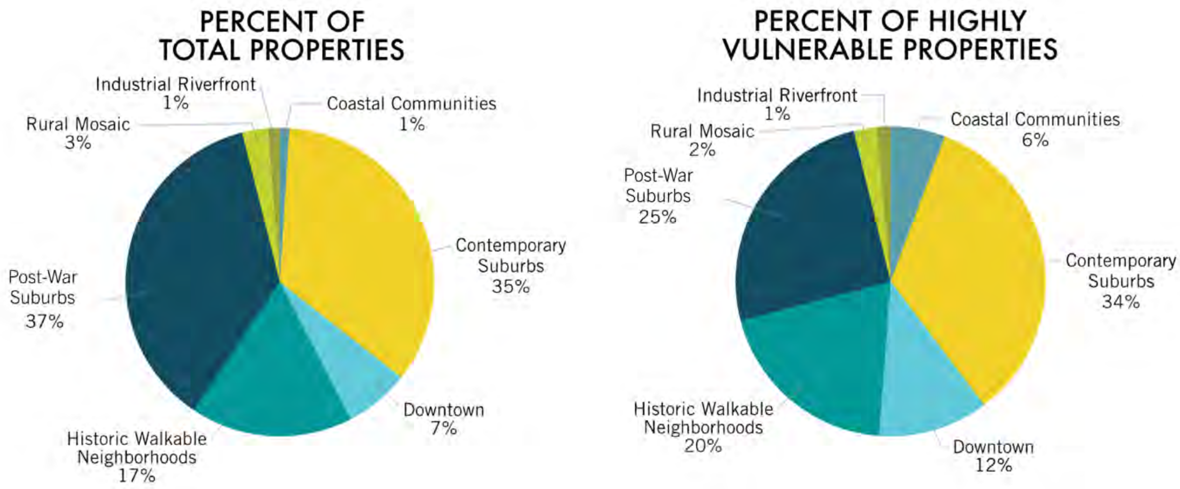


FIGURE 38. COMMERCIAL PROPERTIES AND CURRENT COASTAL STORM AND RIVERINE FLOODING BY DEVELOPMENT TYPE (FEMA NFHL).

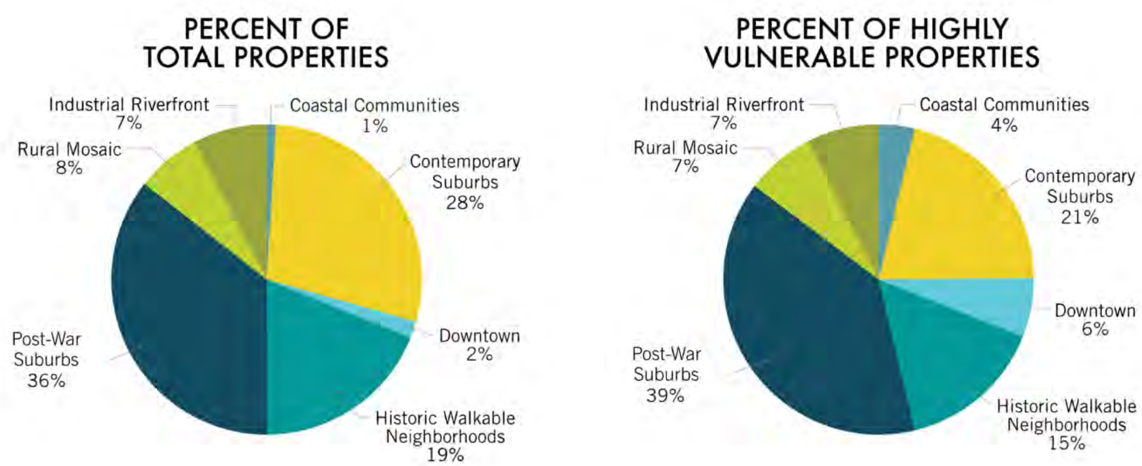


FIGURE 39. INDUSTRIAL PROPERTIES AND CURRENT COASTAL STORM AND RIVERINE FLOODING BY DEVELOPMENT TYPE (FEMA NFHL).

Open Space and Vacant Land

Open space and vacant land located in areas of low flood risk have the potential to guide resilient development, especially in places where infrastructure and services already exist. Flood vulnerability data can be used to inform strategic decisions around growth to ensure that future development is safe from flood risk and that flood prone vacant land and existing park areas are protected to allow places for water to flow. This assessment identified vacant land and open space under the following asset categories: government-owned vacant properties, privately owned vacant properties, and managed and working lands.

This assessment assumes that vacant properties and those included in the managed and working lands asset categories do not contain built structures and thus are only evaluated for flood exposure.

Figure 40 shows the exposure of government- and privately owned vacant land with the current coastal storm and riverine flooding scenario overlayed (FEMA NFHL).

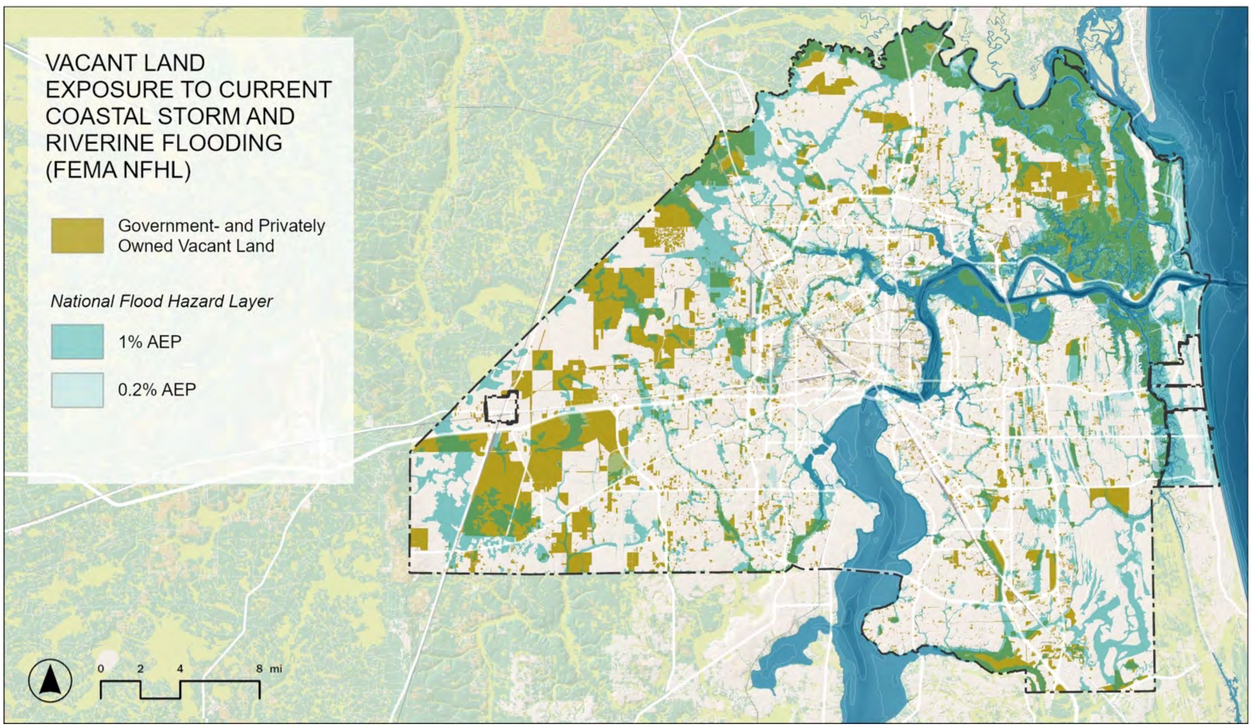


FIGURE 40. GOVERNMENT- AND PRIVATELY OWNED VACANT PROPERTIES AND CURRENT 1% AND 0.2% AEP OF COASTAL STORM AND RIVERINE FLOODING (FEMA NFHL).

Government-Owned Vacant Properties

36% of government-owned vacant properties (federal, state, and local) or 70,787, acres are exposed to current coastal storm and riverine flooding (FEMA NFHL). The distribution of exposed properties is more or less proportional to their occurrence in the Post-War Suburbs, Downtown, and the Rural Mosaic Development Types. Whereas, in the Coastal Communities and Protected Lands, the exposed vacant properties constitute a higher proportion (Figure 41). The higher percentage of protected lands exposed to flooding highlights the importance of these areas for water management.

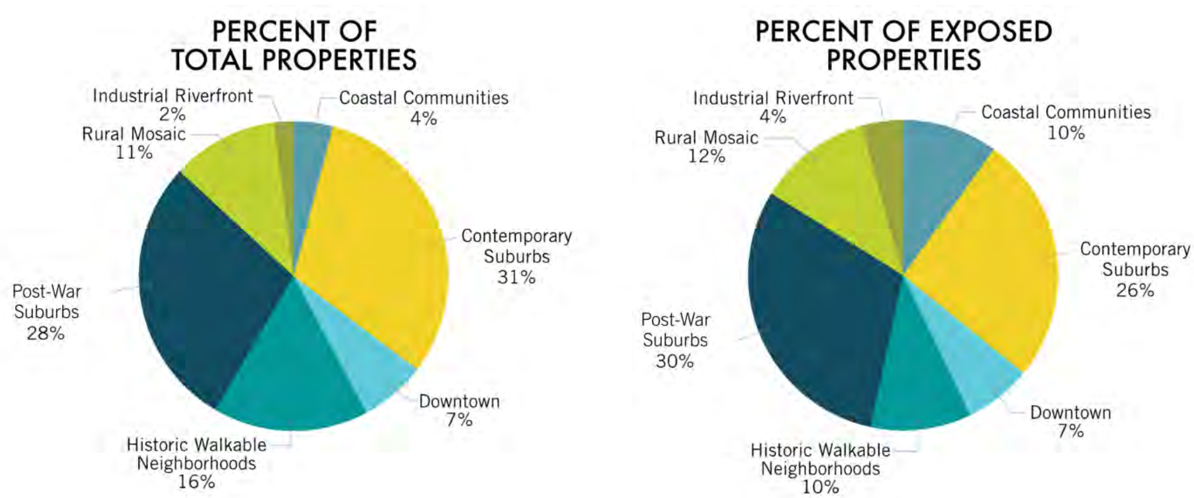


FIGURE 41. PERCENT GOVERNMENT-OWNED VACANT PROPERTIES AND EXPOSURE TO CURRENT COASTAL STORM AND RIVERINE FLOODING (FEMA NFHL) BY DEVELOPMENT TYPE.

Privately Owned Vacant Land

Privately owned undeveloped properties are those that are identified as “vacant” by the County Assessor’s Office. The parcel use type further classify vacant land as being zoned for residential, commercial, industrial, or institutional.

Out of 28,090 properties officially designated as vacant, 5,629 (or 20%) are currently exposed to coastal storm and riverine flooding (FEMA NFHL). As shown in Figure 42 three quarters of the privately owned vacant properties in Coastal Communities are exposed; however, less than half of vacant properties within the Industrial Riverfront and a third of vacant properties located Downtown are exposed. In contrast, only 4% of vacant properties in Historic Walkable Neighborhoods are exposed to flooding. These results suggest that urban core infill and other opportunities to increase density would be best suited for the Downtown and Historic Walkable Neighborhoods Development Types.

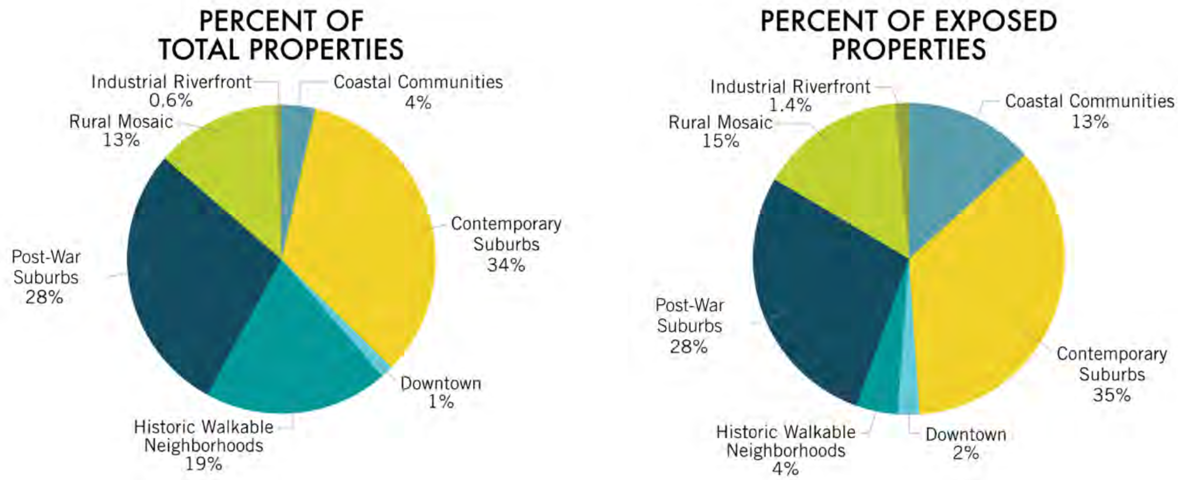


FIGURE 42. PRIVATELY OWNED VACANT LAND AND EXPOSURE TO CURRENT COASTAL STORM AND RIVERINE FLOODING (FEMA NFHL) BY DEVELOPMENT TYPE.[3]

Managed and Working Lands

This vulnerability assessment identified 4,737 total assets as managed and working lands. As shown in Figure 43, the majority of the managed and working lands are found in the Rural Mosaic, Coastal Communities, and Contemporary Suburbs Development Types.

The breakdown of these assets by type and vulnerability to flooding in the six flood scenarios are summarized in Table 10. Across all flooding scenarios, large percentages of the managed and working lands in Jacksonville are vulnerable to flooding now and in the future.

---

[3] Note that there is some overlap between properties in this category and those in the managed and working lands category due to different data sources used to identify them.

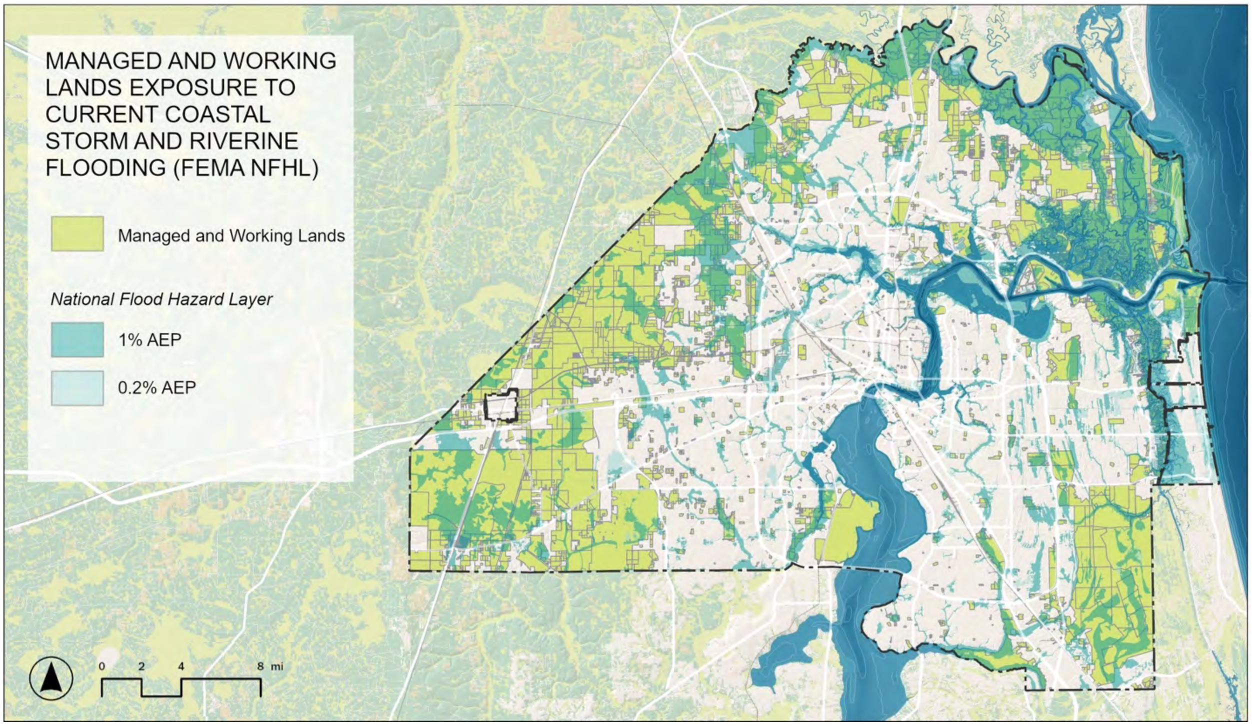


FIGURE 43. MANAGED AND WORKING LANDS AND EXPOSURE TO CURRENT COASTAL STORM AND RIVERINE FLOODING (FEMA NFHL).

TABLE 10. SUMMARY OF FLOOD VULNERABILITY OF MANAGED AND WORKING LANDS UNDER SIX CURRENT AND FUTURE SCENARIOS.

		Current FEMA NFHL	USACE CHS				
			Present		*Future (+ 2.3ft SLR)*		
Managed and Working Land Type	**Total Assets**	**1% & 0.2% AEP**	**10% annual chance**	**1% annual chance**	**10% annual chance**	**1% annual chance**	**Future 1% AEP**
Timber	1,102	573 (52%)	61 (6%)	84 (8%)	74 (7%)	90 (8%)	577 (52%)
Agricultural	80	30 (38%)	6 (8%)	9 (11%)	10 (11%)	10 (13%)	33 (41%)
Pasture	367	134 (37%)	11 (3%)	17 (5%)	14 (4%)	21 (6%)	131 (36%)
Locally Managed	564	319 (57%)	116 (21%)	147 (26%)	132 (23%)	159 (28%)	311 (55%)
Federally Managed	347	278 (80%)	228 (66%)	260 (75%)	248 (72%)	265 (76%)	264 (76%)
DOD Managed	113	73 (65%)	27 (24%)	52 (46%)	50 (44%)	55 (49%)	77 (68%)
State Managed	651	268 (41%)	108 (17%)	119 (21%)	115 (18%)	121 (19%)	276 (42%)
Florida Forever Acquired	376	145 (39%)	11 (3%)	20 (5%)	15 (4%)	25 (7%)	147 (39%)

Managed and Working Land Type	Total Assets	Current FEMA NFHL	USACE CHS				
			Present		Future (+ 2.3ft SLR)		
		1% & 0.2% AEP	10% annual chance	1% annual chance	10% annual chance	1% annual chance	Future 1% AEP
Florida Forever Approved	753	609 (81%)	471 (63%)	552 (73%)	525 (70%)	635 (84%)	638 (85%)
Mitigation Bank	178	135 (76%)	12 (7%)	13 (7%)	14 (7%)	15 (7%)	128 (72%)
Privately Managed	718	567 (79%)	264 (51%)	409 (57%)	385 (54%)	423 (59%)	571 (80%)

Among the different types of managed and working lands, timber, Florida Forever approved, privately managed, state managed, and locally managed have the highest number of total assets. Among these types, Florida Forever approved parcels have the highest percentage of vulnerable assets to current (FEMA NFHL) flooding (81%) and future 1% AEP flooding (85%). This category also has the highest number/percentage of vulnerable assets in coastal flooding. Timber lands have a substantial number of total assets (1,102), with 52% currently vulnerable. Federally managed lands show the highest current flood vulnerability (80%) and continue to remain highly vulnerable in future scenarios (76% under future 1% AEP), indicating a sustained high risk. For privately managed lands, the flood vulnerability is high both currently (79%) and in the future (80% under future 1% AEP). Agricultural and pasture lands show relatively lower current flood vulnerability (38% and 37% respectively). Regardless of the scenario assessed, however, managed and working lands in Jacksonville face considerable flood risks now and in the future.

4.0 EXTREME HEAT VULNERABILITY AND RISK

Though Jacksonville is no stranger to hot weather, extreme heat is a growing threat. Extreme heat events are periods of excessively hot and/or humid weather that can last for multiple days (CDC, 2017). Extreme heat events have always occurred, but changes in climate have made extreme heat events more common, more severe, and longer-lasting (EPA, 2016).

4.1 HEAT VULNERABILITY ASSESSMENT METHODOLOGY

Heat vulnerability in this assessment is evaluated by *exposure* to higher temperatures and *adaptive capacity*.

To assess vulnerability to extreme heat, the proportion of developed land cover was used as an environmental indicator of *exposure* to higher temperatures.

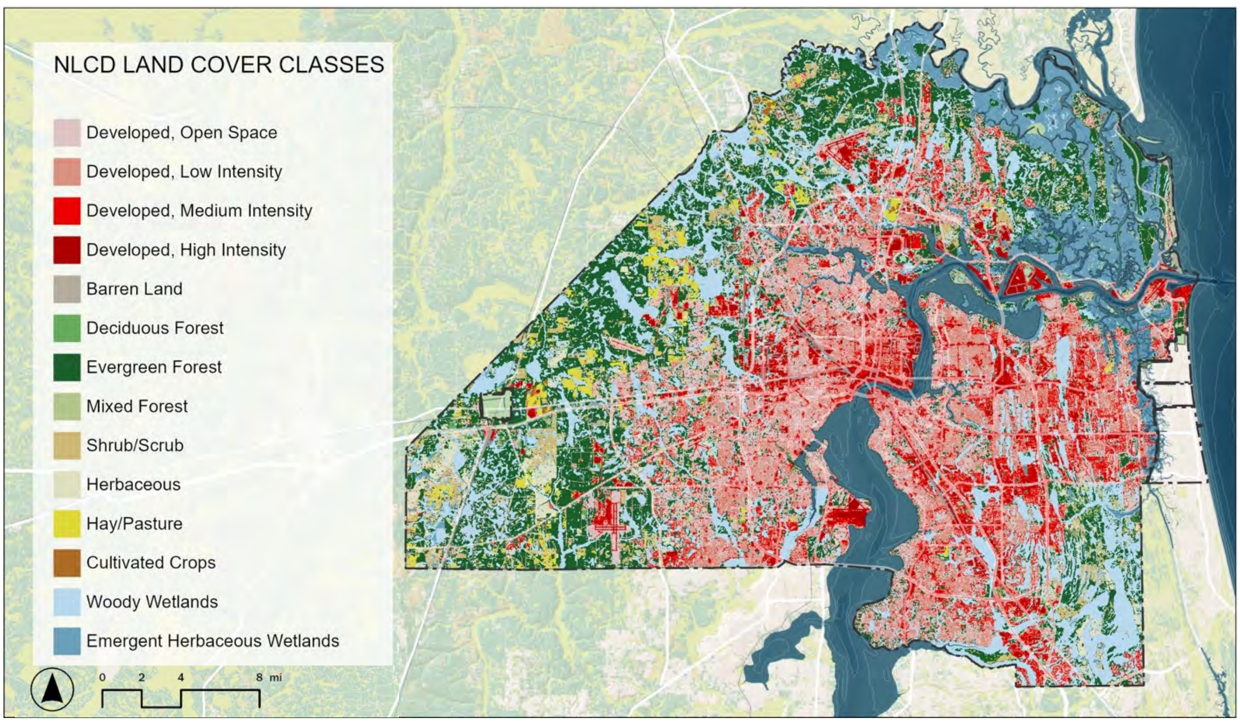


FIGURE 44. MAP OF LAND COVERS WITHIN JACKSONVILLE (NLCD, 2019). THE DEVELOPED LAND COVER CLASSES SYMBOLIZED IN RED ARE USED AS INDICATORS OF EXPOSURE TO EXTREME HEAT.

For this assessment, the proportion of tree canopy coverage is used as an indicator of environmental *adaptive capacity,* recognizing the potential cooling benefits of tree canopy. Median household income is used as a social/financial indicator of *adaptive capacity*, as financial stability may facilitate access to adequate cooling, medical care, reliable transportation, etc. Figure 45 summarizes the adaptive capacity to extreme heat in Jacksonville. Block groups shown with darker green colors are areas with low tree canopy coverage and low median incomes.

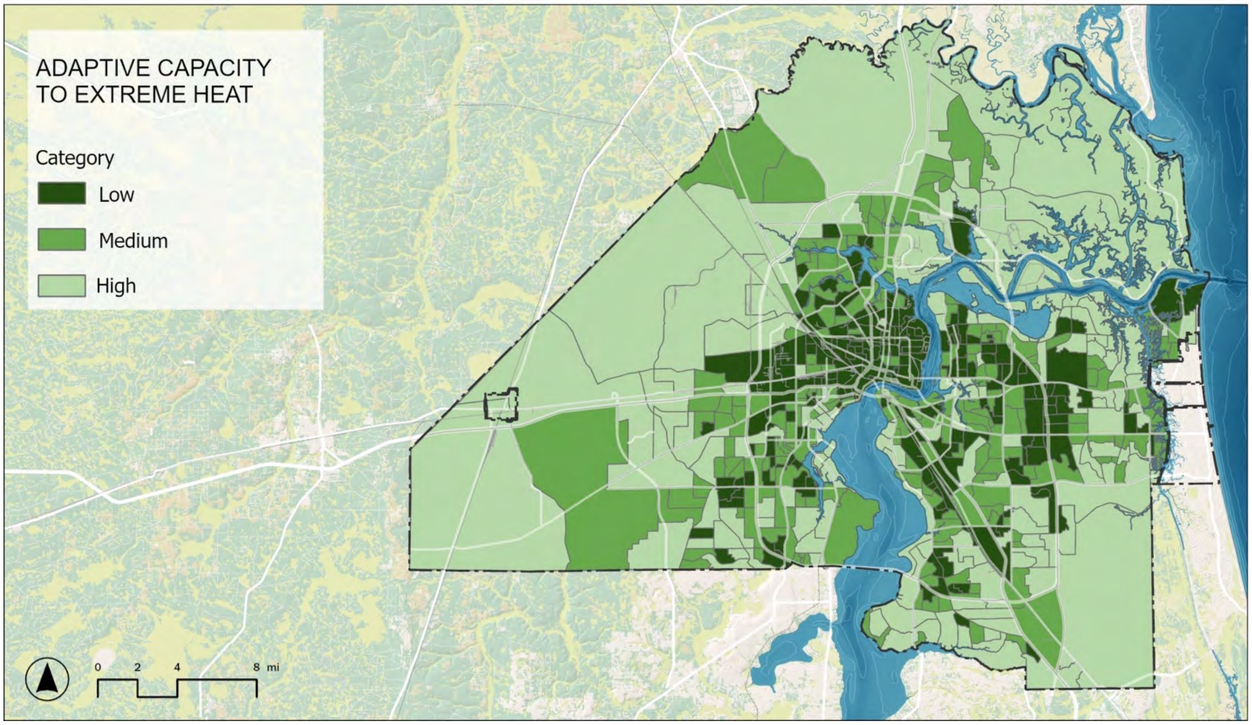


FIGURE 45. ADAPTIVE CAPACITY TO EXTREME HEAT IN JACKSONVILLE AS EVALUATED BY TREE CANOPY COVERAGE AND MEDIAN INCOME. LIGHT GREEN AREAS ARE PREDICTED TO HAVE HIGHER CAPACITY TO COPE WITH EXTREME HEAT AS A RESULT OF HIGHER TREE CANOPY COVERAGE AND HIGHER INCOMES. DARKER GREEN AREAS HAVE LOWER ADAPTIVE CAPACITY DUE TO LESS TREE CANOPY COVERAGE AND LOWER MEDIAN INCOMES.

These exposure and adaptive capacity indicators are combined to assign a relative heat vulnerability classification for each block group which are shown graphically in maps in Section 4.2.

4.2 VULNERABILITY TO EXTREME HEAT IN JACKSONVILLE

Heat vulnerability occurs across all areas of Jacksonville except for in the Rural Mosaic Development Type. In

Figure 46 areas highlighted in darker red (n = 220 block groups) indicate an area with a relatively high heat vulnerability, meaning they have a higher percentage of developed land cover, lower tree canopy, and high percentage of households with lower incomes. Of the block groups with the heat vulnerability, 56 are particularly vulnerable. These areas have some of the lowest tree canopy in the city (<30%), lowest household median income (<$41k), and the highest developed land cover (>65%).

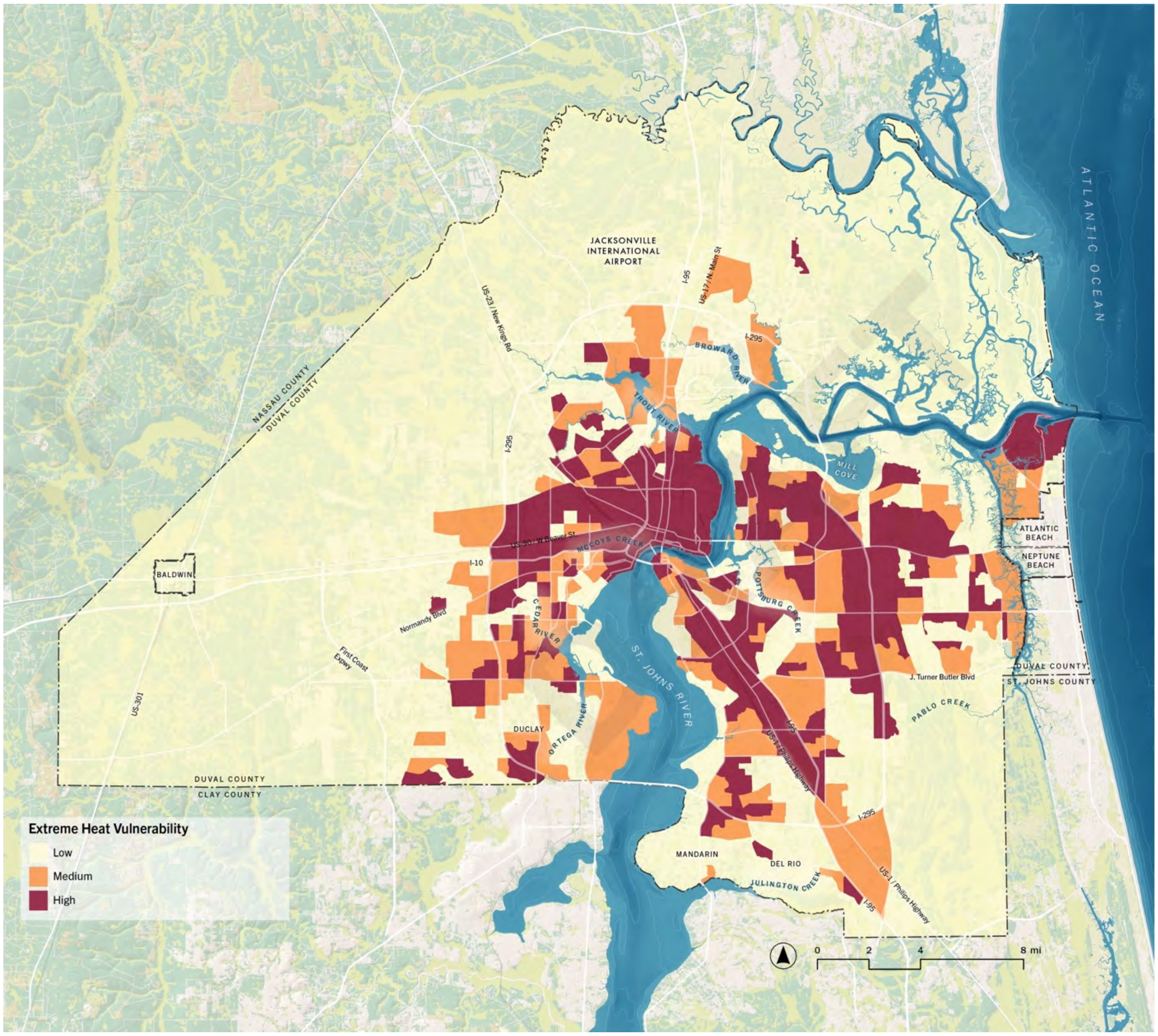


FIGURE 46. MAP OF VULNERABILITY TO EXTREME HEAT IN JACKSONVILLE.

Extreme Heat and Sensitive or At-Risk Populations

Infants and young children may be more susceptible to extreme heat due to possessing less efficient thermoregulation mechanisms in extreme conditions (Smith, 2019) as well as their potentially limited resources and knowledge to protect themselves. In addition to their homes and neighborhoods, young children that attend daycare facilities in high heat vulnerable areas may face increased exposure. Many student athletes are also likely to experience higher exposure due to extended time spent in unshaded outdoor environments. As shown in Figure 47 about half of the school properties and 60% of afterschool care facilities are located in areas highly vulnerable to extreme heat. Another potentially at-risk population to extreme heat is older adults as they might face barriers to heat mitigation (Kohon et al., 2023). Table 11 shows that 34% of households (30,741 households) with individuals over 65 years old are located in highly heat vulnerable areas.

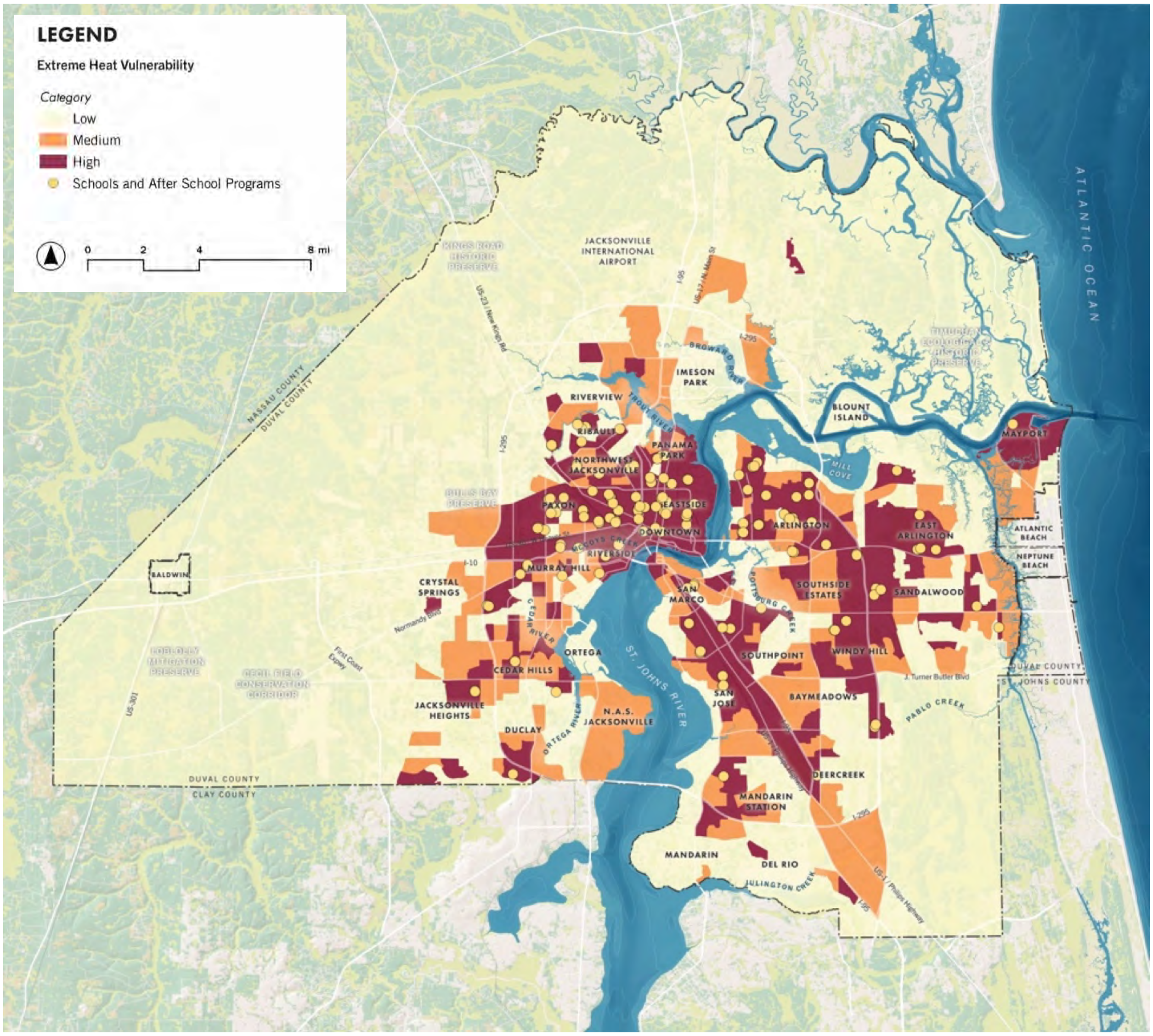


FIGURE 47. EXTREME HEAT VULNERABILITY AND LOCATIONS OF SCHOOLS AND AFTERSCHOOL PROGRAMS IN JACKSONVILLE.

Renters are likely to have limited control to improve or make modifications to insulation or cooling in their accommodations and hence face higher risk on very hot days. Table 11 shows renters occupy 58% of housing units in neighborhoods with high heat vulnerability compared to 44% citywide. The percentage of households with one or more individuals over 65 years old in high heat vulnerability areas is roughly proportional to the citywide percentage.

Although most rural areas do not have a high percentage of developed land cover and hence are not highlighted as vulnerable in the assessment, outdoor workers in agriculture, timber, and other similar industries within these areas are also likely to have higher exposure to extreme heat.

TABLE 11. HEAT SENSITIVE OR AT-RISK POPULATIONS IN AREAS VULNERABLE TO EXTREME HEAT.

Heat-sensitive or At-risk Population	Number and Percentage of Individuals or Households in Highly Heat Vulnerable Areas
Households with individual(s) over 65 years old	30,741 (34%)
Households with individual(s) under 18 years old	35,211 (35%)
Renter-occupied housing	74,803 (58%)
Manufactured housing	4,964 (3.4%)

The City of Jacksonville designates public libraries, park pools and splash pads, and Senior Services Division senior centers as places where residents can cool off on very hot days. The map below (Figure 48) shows areas within a 15-minute walking distance to each of these 69 facilities or cooling centers. The largest gaps in access to these cooling center locations within high heat vulnerable areas appear to be near the Southside neighborhood and along Phillips Highway and State Road 9.

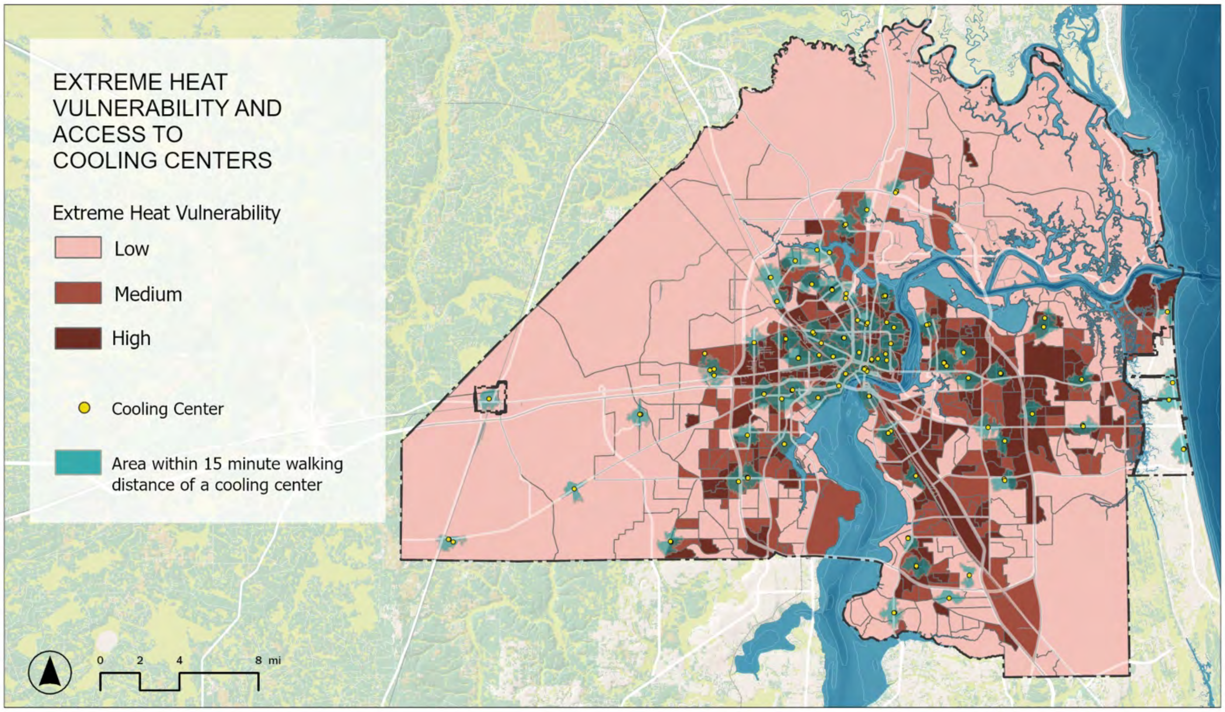


FIGURE 48. EXTREME HEAT VULNERABILITY AND COOLING CENTER ACCESS AREAS WITHIN A 15-MINUTE WALKING DISTANCE TO COOLING FACILITIES ARE SHOWN IN BLUE.

5.0 HIGH WINDS

5.1 ASSESSMENT METHODOLOGY

For this study, a screening-level assessment was developed for the residential, utility, and critical services, cultural and community services, and commercial and industrial asset categories in Jacksonville in to estimate vulnerability to high winds. The following asset and hazard-based criteria were used for the assessment:

- ASCE wind-borne debris regions (exposure),
- Property use or criticality (sensitivity),
- Wind-related building design regulation (adaptive capacity),

It is important to note that this assessment should not replace site-specific assessments of wind vulnerability and is not intended to be used for insurance purposes (FEMA, 2019).

Wind-borne Debris Regions

ASCE wind-borne debris regions and related risk categories were considered within the region. While different risk categories apply to different types of assets (e.g., residential vs. medical facilities) all of the study area is within the same debris region and mean recurrence interval (MRI) zones. Therefore, the entire study area was considered exposed to the threat of high winds.

Building Design Requirements and Standards

The year of construction for structures is particularly important for estimating vulnerability to high winds in Jacksonville, especially the wind-load and wind-pressure design requirements in place at the time of construction. Years used for determining levels of adaptive capacity in the vulnerability assessment are described below:

- Buildings constructed before 1974 in Duval County were built before the inception of Florida's first building code (Florida Housing 2017). Therefore, properties with buildings constructed before this year are considered to have low adaptive capacity (more vulnerability) based on the lack of general structural design requirements.

- Between 1974 and 1995 general structural design requirements were in place through the Florida Building Code and through adoptions of design standards from the American Society of Civil Engineers (ASCE) (Mehta & Colbourne, 2010). No jurisdiction-specific amendments within the county are documented to have been made during this time. These standards included minimum wind-load design criteria. Properties with buildings constructed during this period are considered to have medium/moderate adaptive capacity for the purposes of this assessment.

- In 1995, the County adopted ASCE 7-95. This adoption included significant changes in the wind-load criteria for building construction, with the most significant change being the wind-speed reference that changed from fastest-mile to the 3-second gust (Mehta 2010). Properties with structures built after 1995 are considered to have high adaptive capacity.

Additional changes to wind design criteria include:

- A topographic factor to consider wind speed-up over certain terrains.
- Wind-load parameters to account for torsional effects.
- A separate procedure for determining wind-loads on main wind-force resisting systems.
- Main Wind Force Resisting System (MWFRS) of buildings with roof heights less than 60 feet.
- Internal pressure coefficients in hurricane-prone regions to reflect debris impact.
- Pressure coefficients for components and cladding (C&C) for multiple roof types.
- The Gust Effect Factor (GEF) for structures in a unified equation form.

Since 1995, additional changes in wind-borne debris region maps and building design requirements have taken place. Changes in wind-load design criteria also continue to be made in more recent ASCE codes and standards, such as in how pressure coefficients are applied (Florida Dept of Business and Professional Regulation). However, for the purposes of this screening-level assessment, this ASCE 7-95 (after 1995) is the most significant in terms of considering property-level adaptive capacity (Mehta & Colbourne, 2010).

5.2 HIGH WIND VULNERABILITY BY ASSET CATEGORY

A summary of the high wind vulnerability across the residential, utility, and critical services, cultural and community services, and the commercial and industrial asset categories is shown in Table 12. These results show the majority of all structural assets in Jacksonville are vulnerable to high winds.

TABLE 12. SUMMARY OF HIGH WIND VULNERABILITY IN JACKSONVILLE BY ASSET CATEGORY.

Asset Category	Total Assets	Assets Vulnerable to High Winds
Residential	308,449	186,244 (60%)
Utility and Critical Services	2,452	1,799 (73%)
Cultural and Community Services	19,332	18,653 (96%)
Government-Owned Properties	7,231	2,645 (37%)
Commercial	11,663	6,987 (60%)
Industrial	3,823	2,377 (62%)

Residential Properties

60% of the residential assets in Jacksonville are currently vulnerable to high winds (Table 12). These high percentages are, in part, a result of wind vulnerability's relationship to the year a residential asset was constructed. Table 13 shows the percentage of properties that were constructed before 1974 for types of residential properties that are likely to house residents facing social stressors (i.e., housing types considered to have higher sensitivity or criticality of impact). These housing types have a low adaptive capacity to high winds, and therefore, often present as highly vulnerable to this hazard.

TABLE 13. PERCENTAGE OF PROPERTIES CONSTRUCTED BEFORE 1974 BY HOUSING TYPE.

Sensitive Housing Type	Percentage of Properties Constructed Before 1974
Multifamily	80%
Group Home	56%
Residential Health Facilities	48%
Assisted Housing	43%
Retirement Homes	34%
Nursing Homes	24%
Mobile Homes	13%

Figure 49 shows the high wind vulnerability across Jacksonville with median income levels overlayed. Block groups with purple hash marks indicate those with median income levels below poverty level. Residential households in these areas may be particularly vulnerable to high winds if they are unable to repair damaged residences after a high wind event.

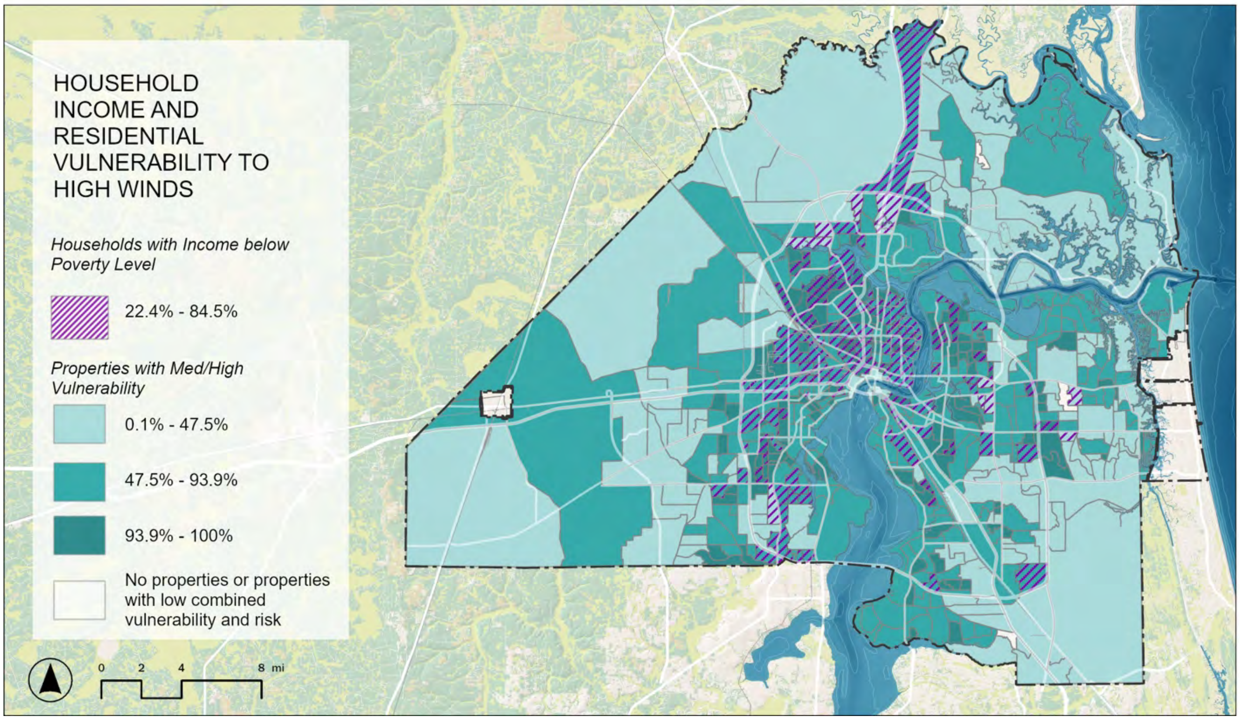


FIGURE 49. RESIDENTIAL ASSET VULNERABILITY TO HIGH WIND AND MEDIAN INCOME. BLOCK GROUPS SHOWN WITH PURPLE HASHING HAVE MEDIAN INCOMES BELOW POVERTY LEVEL.

Residential Vulnerability by Development Type

Vulnerability to high winds is found across Jacksonville, however variability is observed in high wind vulnerability by Development Type. As shown in Figure 50, although there are fewer residential properties in the Post-War Suburbs and Historic Walkable Neighborhoods, these Development Types have higher percentages of residential properties vulnerable to high winds. This is largely due to the differences in the median age of houses. As shown in Figure 51, about 35% of all residential properties in Jacksonville were constructed before 1974 and, therefore, have low adaptive capacity to high winds (dark green). A large number of these properties are found in the Post-War Suburbs and Historic Walkable Neighborhoods.

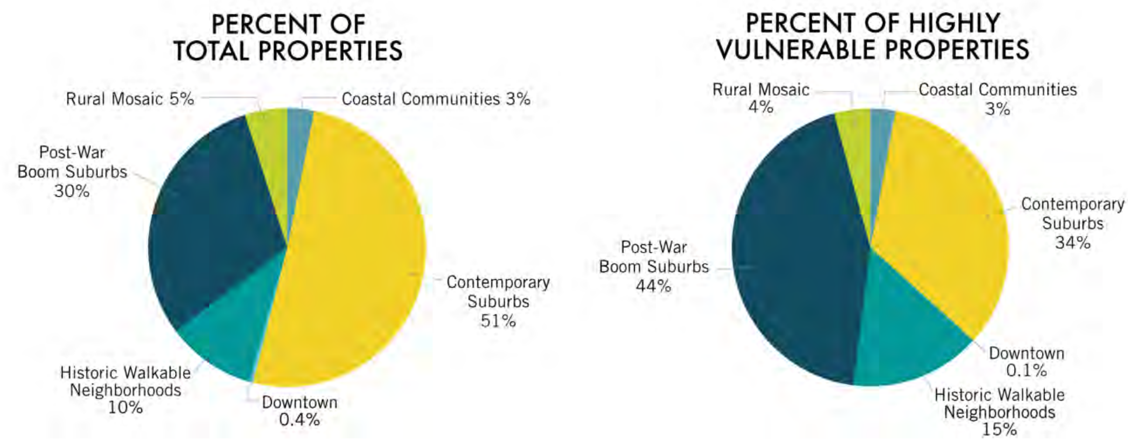


FIGURE 50. PERCENT OF TOTAL RESIDENTIAL PROPERTIES AND PERCENT OF RESIDENTIAL PROPERTIES VULNERABLE TO HIGH WINDS BY DEVELOPMENT TYPE IN JACKSONVILLE.

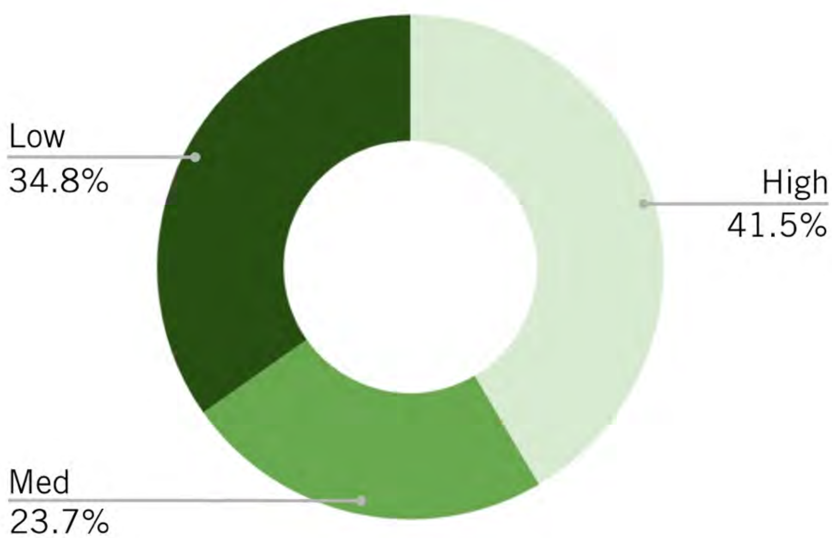


FIGURE 51. LEVELS OF ADAPTIVE CAPACITY FOR ALL RESIDENTIAL PROPERTIES EXPOSED TO HIGH WINDS.

Infrastructure and Services

94% of Jacksonville assets under the infrastructure and services theme, as represented by critical facilities and infrastructure and community services asset categories, are vulnerable to high winds Table 12. Table 14 summarizes this vulnerability further by asset type.

TABLE 14. NUMBER OF INFRASTRUCTURE AND SERVICES ASSETS IN JACKSONVILLE VULNERABLE TO HIGH WINDS.

Infrastructure and Services	Total Assets	Highly Vulnerable Assets
Selected Critical Facilities and Infrastructure		
EMS and Fire Stations	62	53 (85%)
Emergency Shelters	42	22 (52%)
Correctional Facilities	10	9 (90%)
Utility Properties	378	78 (21%)
Wastewater	6	5 (83%)
Substations	87	49 (56%)
Medical Care (Hospitals, Urgent Care, Dialysis Center, and Pharmacies)	782	31 (4%)
Other Community Services		
Public Schools and Colleges	327	149 (46%)
Religious	1,747	1,149 (66%)
Day Cares	234	196 (84%)
After School Programs	90	79 (88%)
Historical Properties	16,390	13,980 (85%)
Mortuary/Cemetery	136	46 (34%)
SNAP Retailer	521	347 (67%)
Library	24	16 (67%)
Community Center	44	34 (77%)

The majority of critical facilities and infrastructure assets are vulnerable to high winds. This includes EMS and fire stations (85%) and correction facilities (90%) (Table 14). As shown in Figure 52, vulnerability to high wind for these assets in Jacksonville are distributed across most areas of the city.

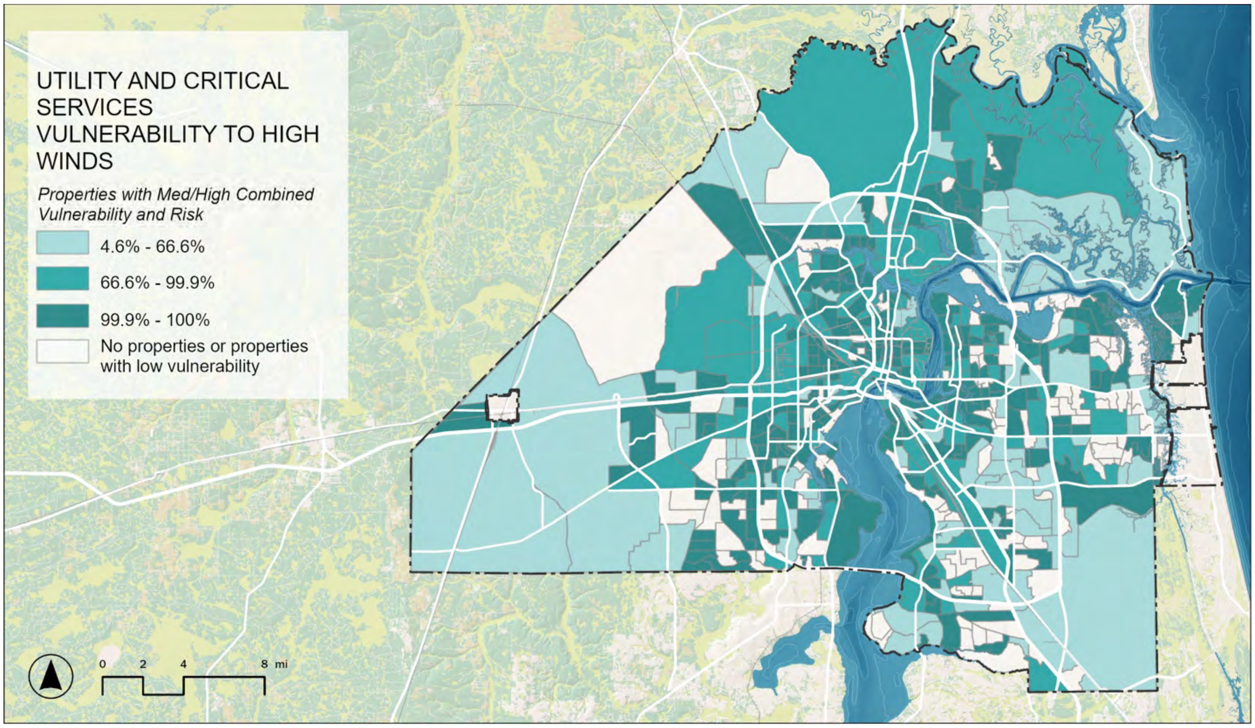


FIGURE 52. PERCENTAGE OF HIGH WIND VULNERABILITY FOR CRITICAL FACILITIES AND INFRASTRUCTURE IN JACKSONVILLE BY BLOCK GROUP.

Public schools and colleges represent a significant number of total assets (327), nearly half of which are highly vulnerable to high winds (46%). Even higher percentages of religious, day care, and afterschool programs show high vulnerability to high winds (Table 14). Similar to critical infrastructure, high wind vulnerability for cultural and community services is observed in the majority of Jacksonville's neighborhoods (Figure 53).

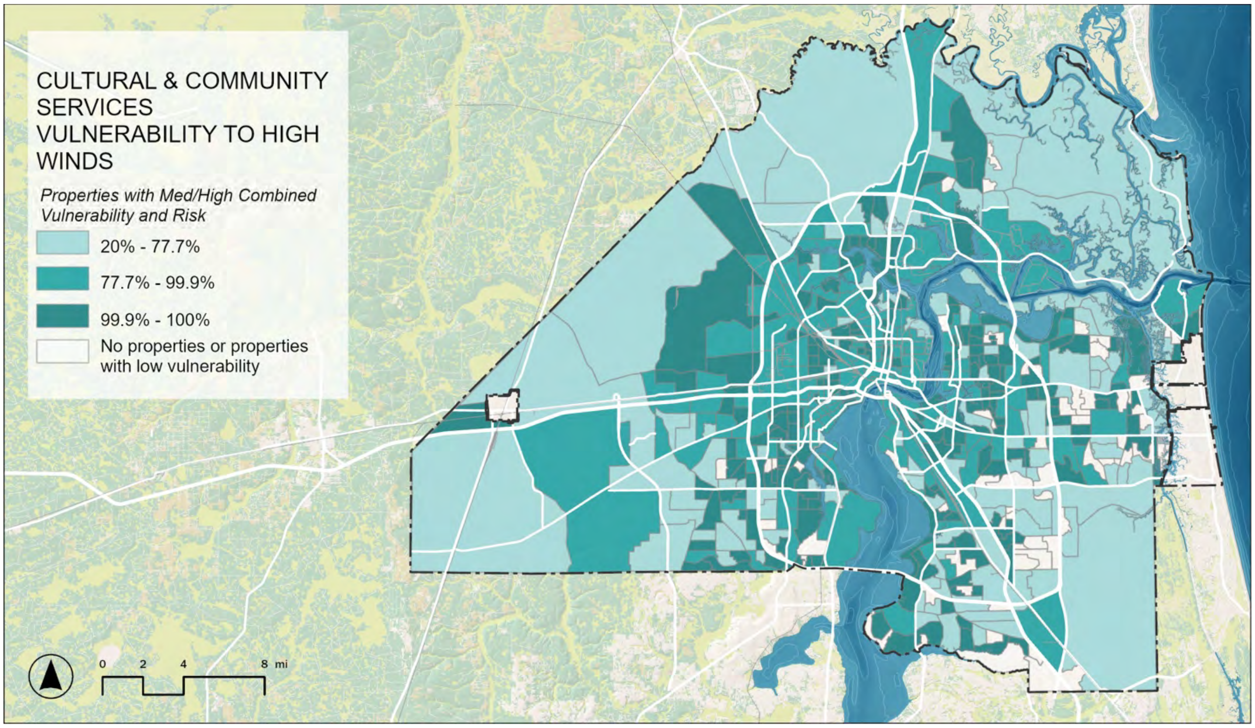


FIGURE 53. PERCENTAGE OF HIGH WIND VULNERABILITY FOR CULTURAL AND COMMUNITY SERVICES IN JACKSONVILLE BY BLOCK GROUP.

Commercial and Industrial Property

Commercial Property: High Wind Vulnerability

60% of commercial assets in Jacksonville are vulnerable to high winds (Table 12). These vulnerable assets are found predominately in the Post-War Suburbs and Historically Walkable Neighborhoods (Figure 54); however, as shown in Figure 55, commercial assets vulnerable to high winds are distributed across most areas of Jacksonville.

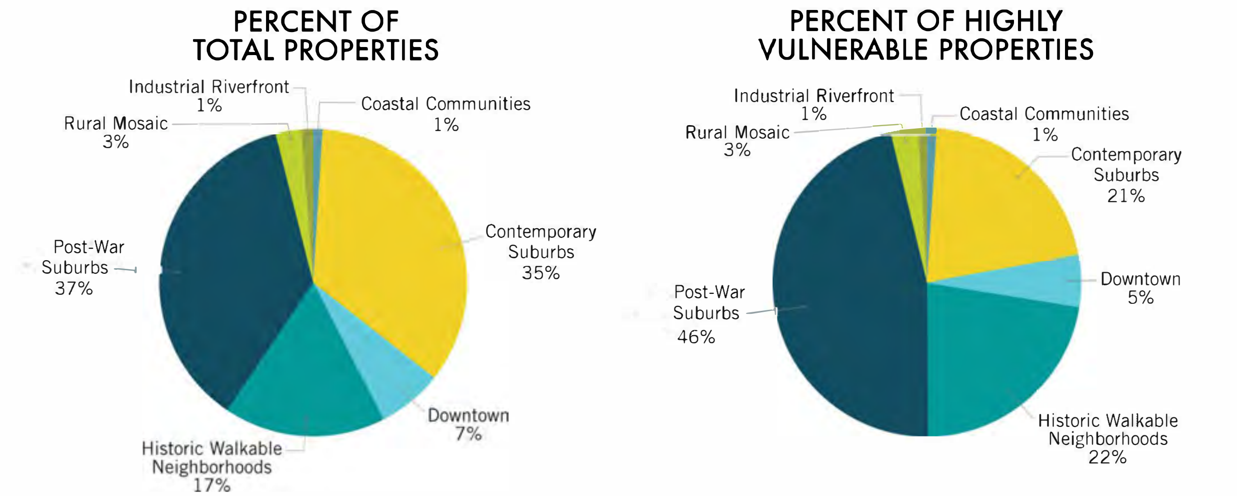


FIGURE 54. PERCENT OF TOTAL COMMERCIAL PROPERTIES AND PERCENT OF COMMERCIAL PROPERTIES VULNERABLE TO HIGH WINDS IN JACKSONVILLE BY DEVELOPMENT TYPE.

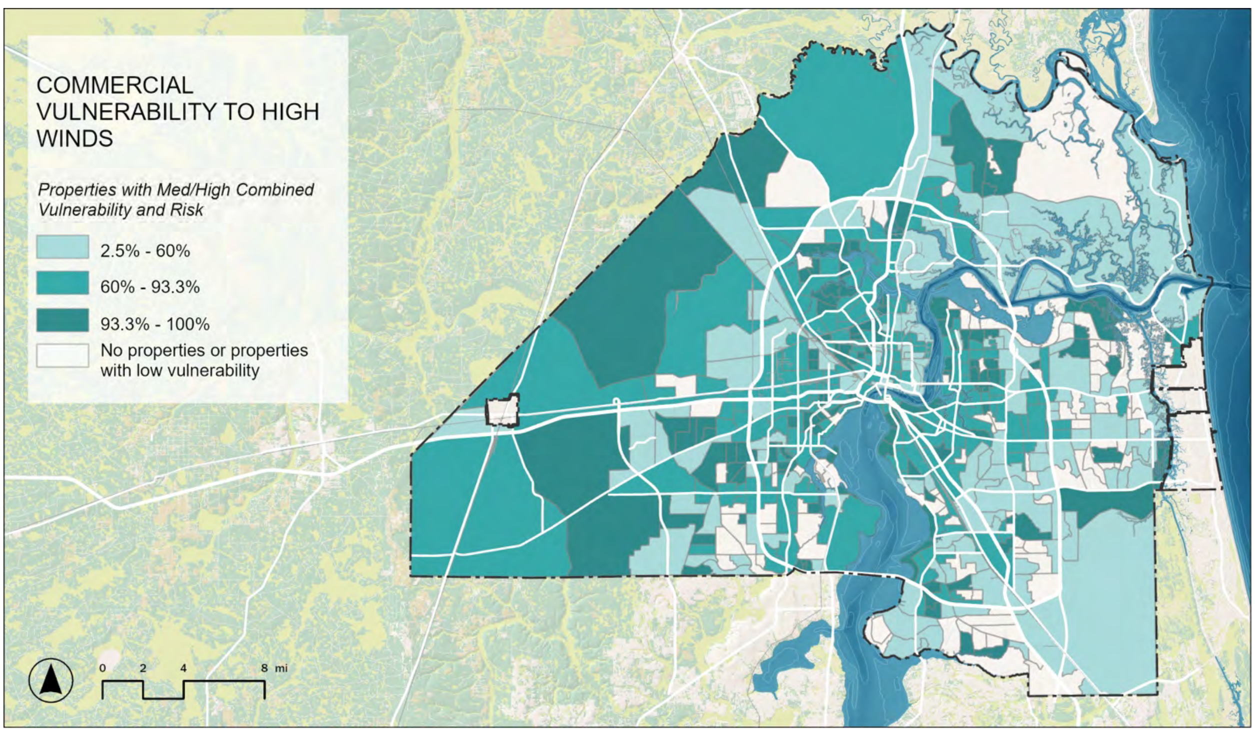


FIGURE 55. PERCENTAGE OF COMMERCIAL ASSETS WITH VULNERABILITY TO HIGH WIND IN JACKSONVILLE BY BLOCK GROUP.

Industrial Property: High Wind Vulnerability

62% of industrial assets in Jacksonville are vulnerable to high winds (Table 12). Similar to commercial assets, these vulnerable assets are found predominately in the Post-War Suburbs and Historically Walkable Neighborhoods (Figure 56), however, as shown in Figure 57, industrial assets vulnerable to high winds are also distributed across the Industrial Riverfront, and in the Rural Mosaic Development Types.

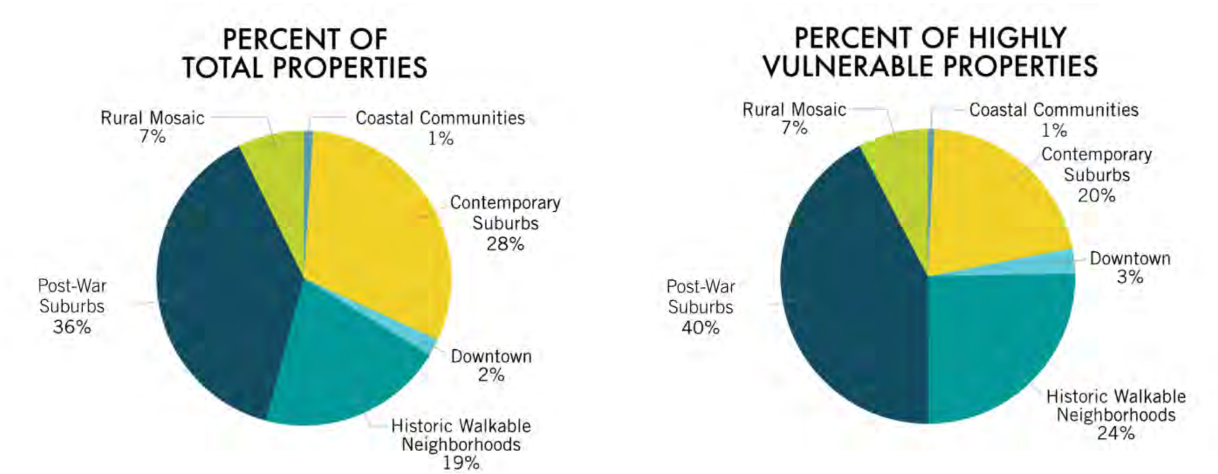


FIGURE 56. PERCENT OF TOTAL INDUSTRIAL PROPERTIES AND PERCENT OF INDUSTRIAL PROPERTIES VULNERABLE TO HIGH WINDS BY DEVELOPMENT TYPE.

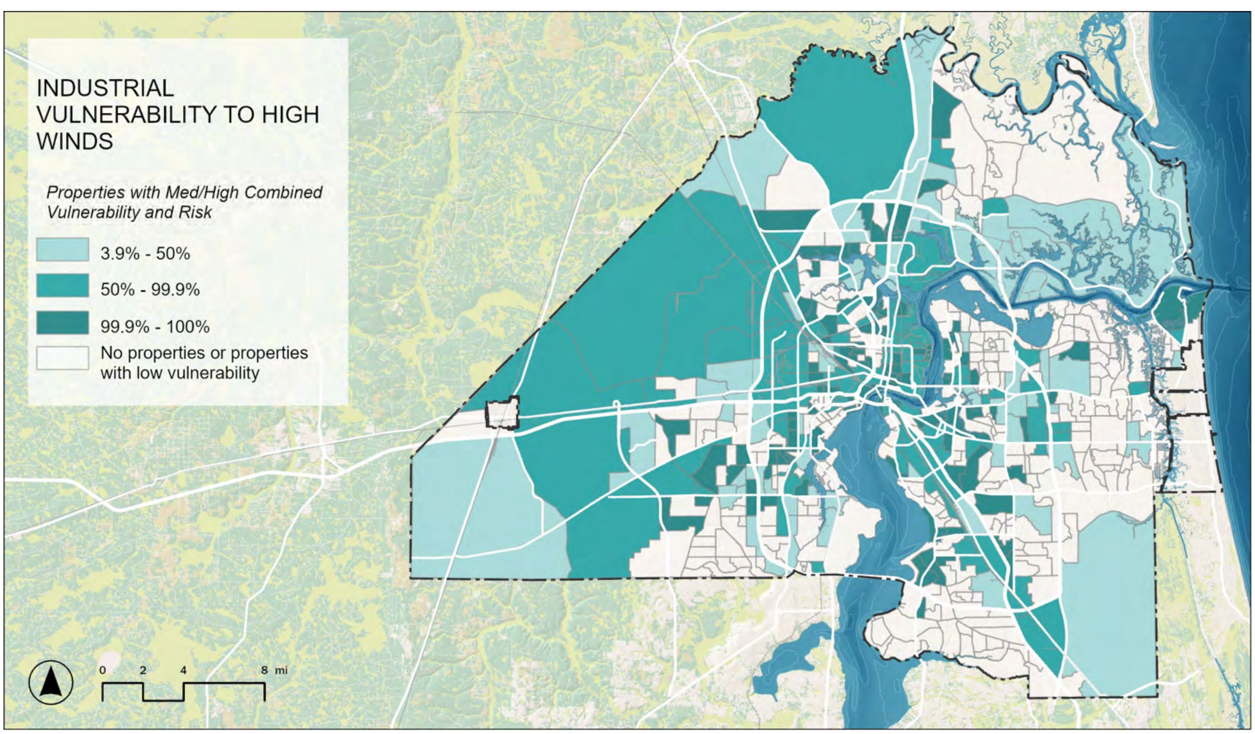


FIGURE 57. PERCENTAGE OF INDUSTRIAL ASSETS VULNERABLE TO HIGH WINDS IN JACKSONVILLE BY BLOCK GROUP.

6.0 WILDFIRE VULNERABILITY AND RISK

6.1 ASSESSMENT METHODOLOGY

The assessment of wildfire examines the hazard of wildfire in the Wildland Urban Interface (WUI). The WUI refers to areas where the built environment assets are within or adjacent to vegetation and fuels for wildfire (Radeloff et al., 2005). The assessment of vulnerability and risk to wildfire may help identify vulnerable geographic areas and prioritize areas for active fuel management, especially in areas where fire response may be more challenging.

Data from the USDA Forest Service's Wildfire Risk to Communities dataset was used to assess vulnerability and risk to wildfire in Jacksonville (USDA Forest Service, 2020). This dataset was developed as part of the Community Wildfire Defense Grant Program (USDA Forest Service, 2023). In particular, the Risk to Potential Structures product from this dataset was used to examine the potential likelihood, or risk probability, and consequence at the property level in Jacksonville. High levels of risk were attributed to properties in areas within the highest 25th percentile of risk compared to the entire state of Florida.

In addition to the Wildfire Risk to Communities dataset, the criticality and types of properties (for sensitivity) and drive-time to the properties from the nearest fire stations (for adaptive capacity) were also examined for vulnerability. Both property-level vulnerability and risk information were used together to inform classifications of vulnerability and risk for properties across the city. Landscape treatments for wildfire reduction or site-specific conditions were not considered as part of this assessment.

6.2 WILDFIRE VULNERABILITY BY ASSET CATEGORY

TABLE 15. SUMMARY OF JACKSONVILLE WILDFIRE VULNERABILITY BY ASSET CATEGORY.

Asset Category[4]	Total Assets	Assets with High Vulnerability to Wildfire
Residential	308,449	4,480 (1%)
Utility and Critical Services	2,452	136 (6%)
Cultural and Community Services	19,332	303 (2%)
Government-Owned Properties	7,231	463 (6%)
Commercial	11,663	73 (1%)
Industrial	3,823	48 (1%)

[4] As the vacant and open land asset categories only consider exposure, all assets in those categories (e.g., vacant land, managed and working lands) are vulnerable to wildfire under this assessment methodology, and therefore are not presented here.

Residential Properties

About 1% of residential properties in Jacksonville are highly vulnerable to wildfire, which includes more than 4,400 properties (Table 15). Of these, the residential property type most vulnerable to wildfire are residential care facilities (Table 16).

TABLE 16. NUMBER OF TOTAL RESIDENTIAL ASSETS AND RESIDENTIAL ASSETS VULNERABLE TO WILDFIRE.

Residential Properties Type	Total Assets	Highly Vulnerable Assets
Assisted Housing	120	2 (2%)
Manufactured Housing	9,307	3597 (4%)
Multifamily	4,915	209 (4%)
Residential Care Facility	221	15 (7%)
Single Family	264,554	553 (<1%)
Condo	23,497	69 (<1%)
Residential Miscellaneous	6,025	44 (<1%)

Figure 58 shows block groups with those in dark red indicating the highest percentage of residential properties with high/medium combined vulnerability and risk. Of these, a few block groups have over 50% vulnerability and risk, including in the far northeastern and western areas of the city. The most vulnerable areas are concentrated on the outskirts of the city, where homes are in closer proximity to wildland areas and potential wildfire fuels (Figure 58).

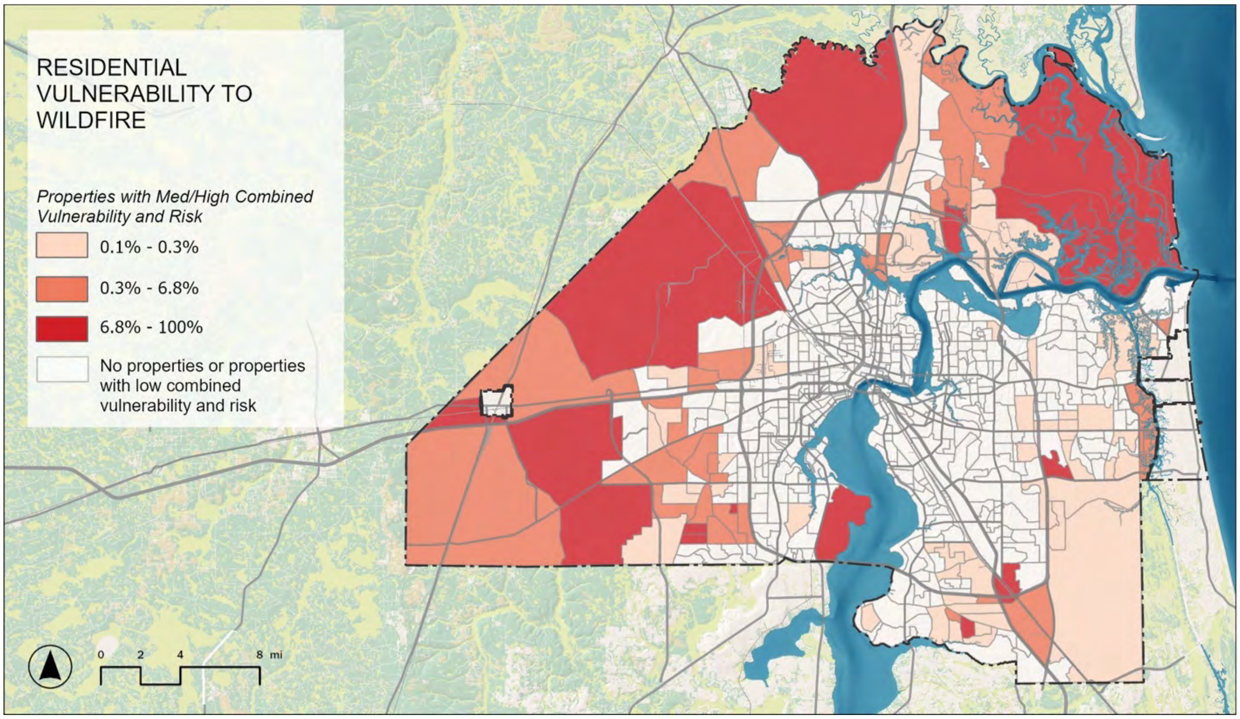


FIGURE 58. PERCENTAGE OF WILDFIRE VULNERABILITY FOR RESIDENTIAL ASSETS IN JACKSONVILLE BY BLOCK GROUP.

Most of these vulnerable areas are within the Rural Mosaic Development Type (2384 parcels, 53% of residential assets in Jacksonville vulnerable to wildfire) and the Contemporary Suburbs (1299 parcels, 29%) where more recent developments have occurred adjacent to wildland areas (Figure 58).

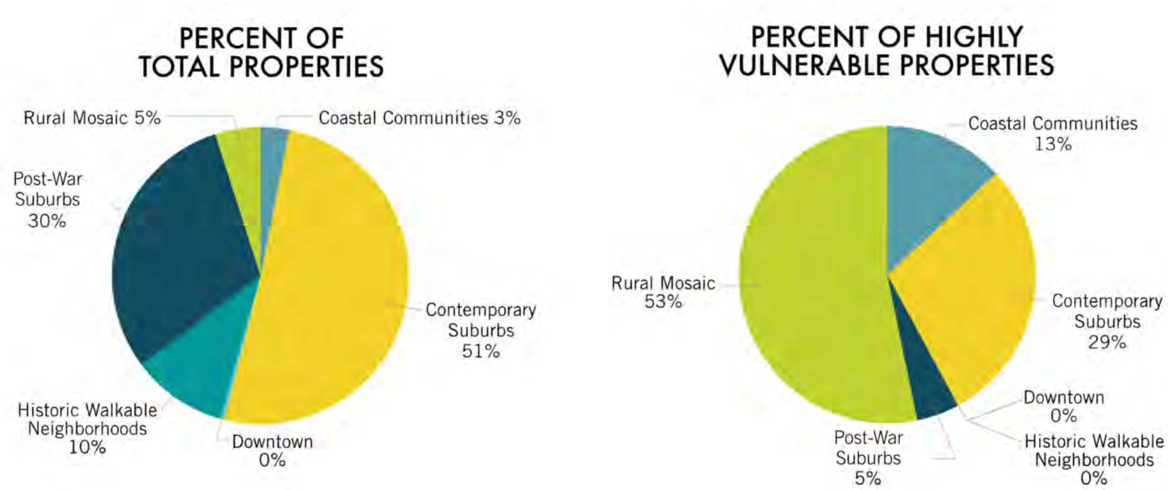


FIGURE 59. PERCENT TOTAL RESIDENTIAL PROPERTIES AND PERCENT RESIDENTIAL PROPERTIES VULNERABLE TO WILDFIRE IN JACKSONVILLE BY DEVELOPMENT TYPE.

One of the indicators used to assess property-level vulnerability to wildfire is the drive time required for fire response. Figure 60 shows that a little over 3% of the residential properties exposed to wildfire in Jacksonville are outside an 8-minute response drive time. More than 78% of residential properties in the city are within a 5-minute response drive time.

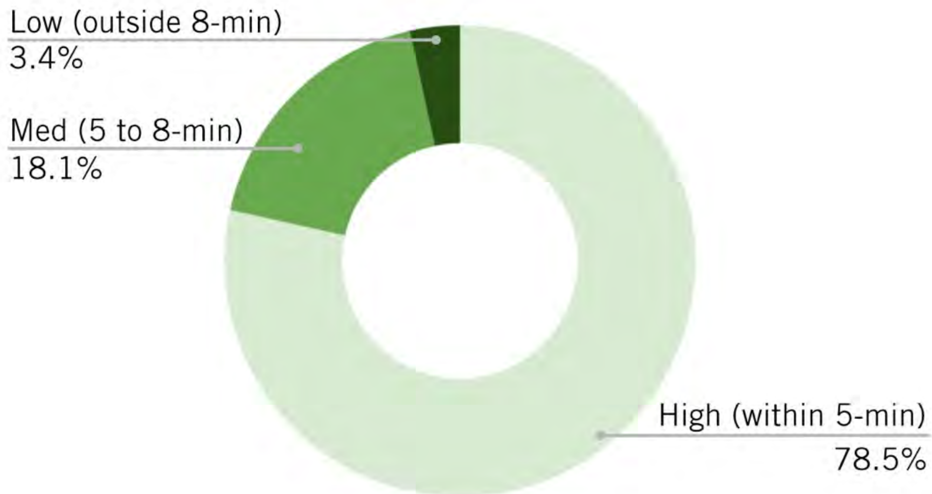


FIGURE 60. PERCENTAGE OF RESIDENTIAL PROPERTIES WITHIN 5-MINUTE, 5- TO 8-MINUTE, AND BEYOND 8-MINUTE DRIVE TIMES FROM THE NEAREST FIRE RESPONSE STATION.

Many of the areas this assessment identifies as having higher vulnerability and risk to wildfire above coincide with areas that contain Florida State Forests and Wildlife Management areas (Figure 61). These areas are subject to fire management programs as part of their current State Forest Management Plans (Florida Department of Agriculture and Consumer Services, 2023). These plans include objectives and activities for wildfire prevention, detection and suppression, and prescribed burning to reduce heavy fuel loads and wildfire hazard. The wildfire vulnerability data and maps included in this assessment do not account for the potential risk reduction these land management activities may have on the landscape. Therefore, a clear understanding of land management activities is important for understanding vulnerability and risk to wildfire and in considering the implementation of wildfire resilience strategies in Jacksonville.

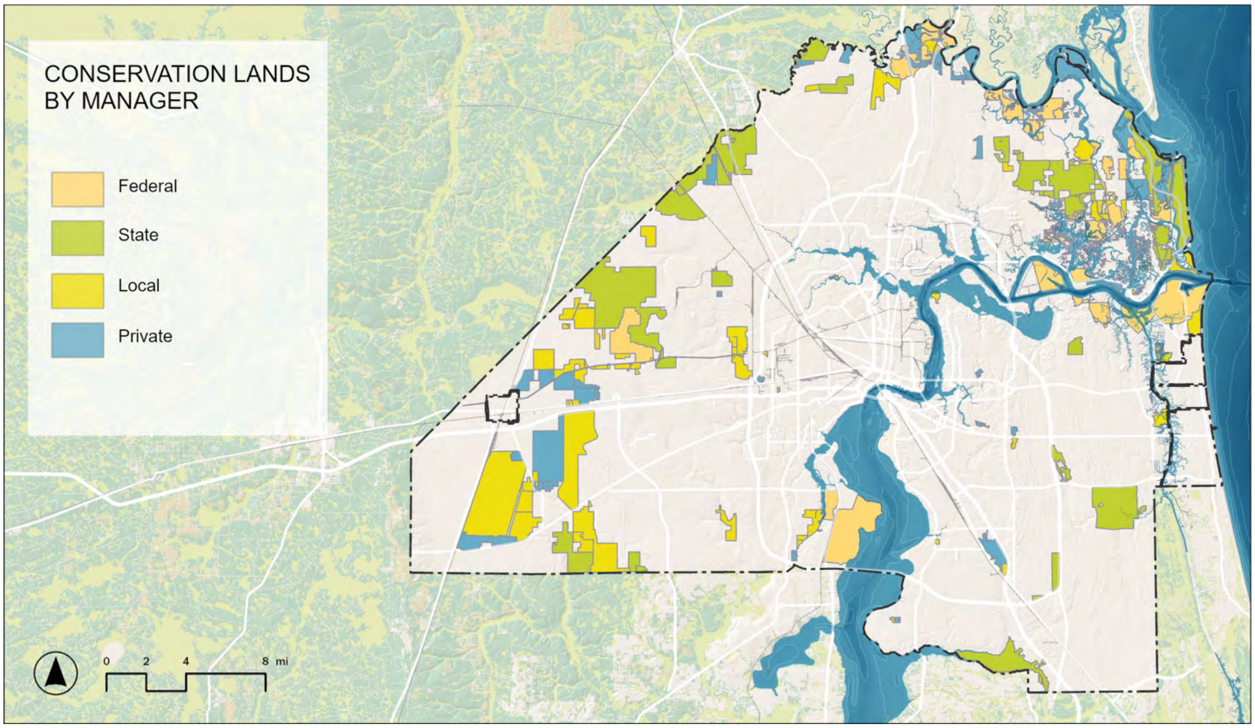


FIGURE 61. FLORIDA NATURAL AREAS INVENTORY OF CONSERVATION LANDS BY MANAGER (FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION, 2023).

As the climate continues to change, the importance of land management and wildfire risk reduction activities in mitigating wildfire risk will only grow. Jacksonville recognizes the importance of continued partnerships and coordination between city and state, federal, local, and private land managers.

Infrastructure and Services

About 6% of both government-owned properties and utility and critical services are highly vulnerable to wildfire. Like residential properties, the areas with highest vulnerability and risk include the northeastern, western, and southern areas of the city. The types of government-owned and critical service properties at risk include schools, communications, and substation properties. The map below shows the percentage of all government-owned properties that are highly vulnerable to wildfire. Block groups symbolized in darker red are areas where more than 24% of properties are highly vulnerable and at-risk to wildfire.

TABLE 17. NUMBER AND PERCENT OF SELECTED INFRASTRUCTURE AND SERVICES VULNERABLE TO WILDFIRE.

Infrastructure and Services	Total Assets	Highly Vulnerable Assets
Critical Facilities and Infrastructure (selected)		
Schools	327	39 (12%)
Correctional Facilities	10	3 (30%)
EMS Stations	62	5 (8%)
Fire Stations	44	1 (2%)
Law Enforcement	6	0 (0%)
Emergency Shelters	42	8 (19%)
Utility	378	28 (7%)
Wastewater	6	1 (17%)
Substations	87	19 (22%)
Solid Waste	7	3 (43%)
Medical Care (Hospitals, Urgent Care, Dialysis Center, and Pharmacies)	782	4 (1%)
Special Needs	57	2 (3%)
Other Community Services		
Library	24	1 (4%)
Community Center	44	4 (9%)
SNAP Retailer	521	16 (3%)
Religious	1,747	8 (0.5%)
Cultural	5	0 (0%)
Day Cares	234	9 (4%)
Afterschool Programs	90	1 (1%)
Historical Properties	16,390	150 (1%)
Mortuary/Cemetery	136	16 (12%)

Figure 62 shows the percentage of selected types of government-owned, community, and critical services by block group that are highly vulnerable to wildfires.

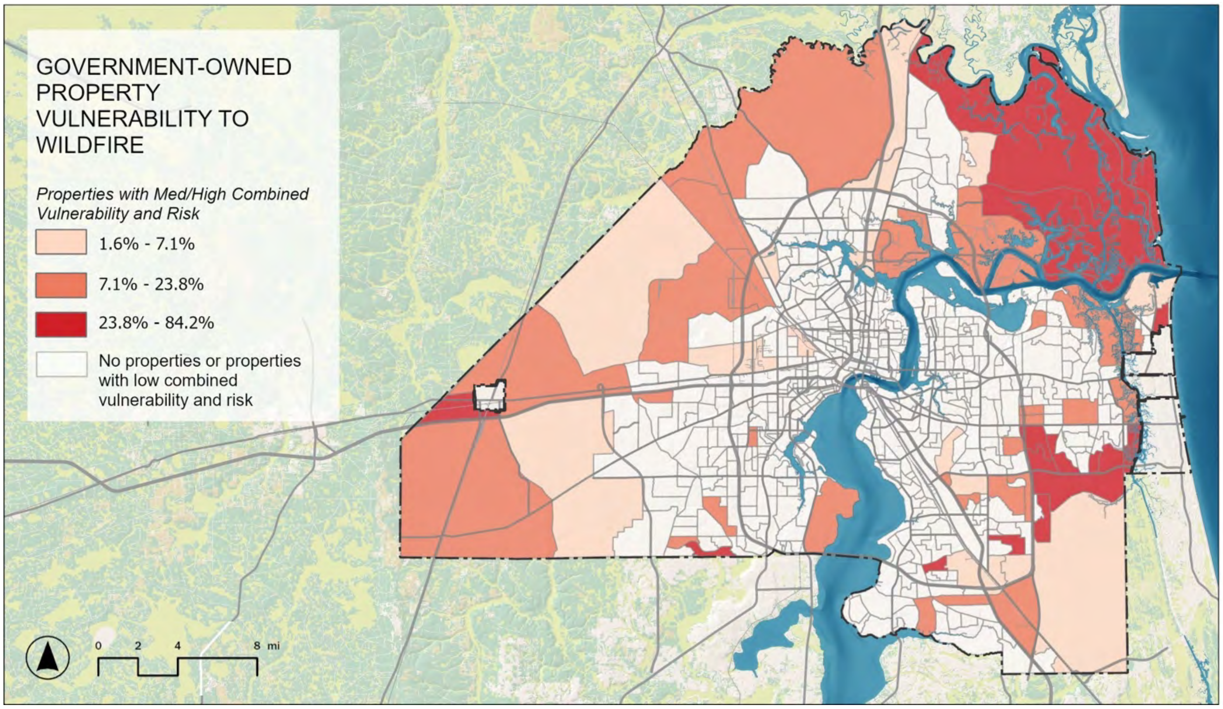


FIGURE 62. PERCENTAGE OF ALL GOVERNMENT-OWNED PROPERTIES THAT ARE VULNERABLE TO WILDFIRE BY BLOCK GROUP.

The majority of the highly wildfire-vulnerable census block groups with the focus on government-owned, community, and critical services assets are located in Rural Mosaic, Contemporary Suburbs and Coastal Communities.

Industrial and Commercial

Citywide, only a little over 1% of Commercial Properties and less than 1% of Industrial Properties are highly vulnerable to wildfire, which is about 120 vulnerable properties in total. Most of the highly vulnerable commercial properties are located in the Contemporary Suburbs, followed by Coastal Communities and Rural Mosaic (whereas most highly vulnerable industrial properties are located in Contemporary Suburbs and Industrial Riverfront (see Figure 63, Figure 64 and Figure 65, Figure 66).

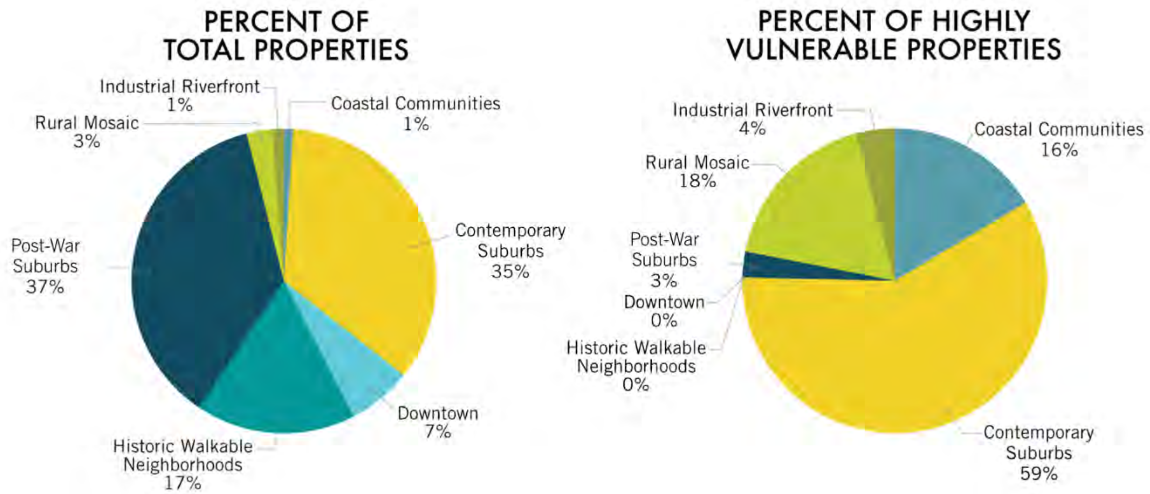


FIGURE 63. PERCENT OF TOTAL COMMERCIAL PROPERTIES AND PERCENT COMMERCIAL PROPERTIES VULNERABLE TO WILDFIRE BY DEVELOPMENT TYPE.

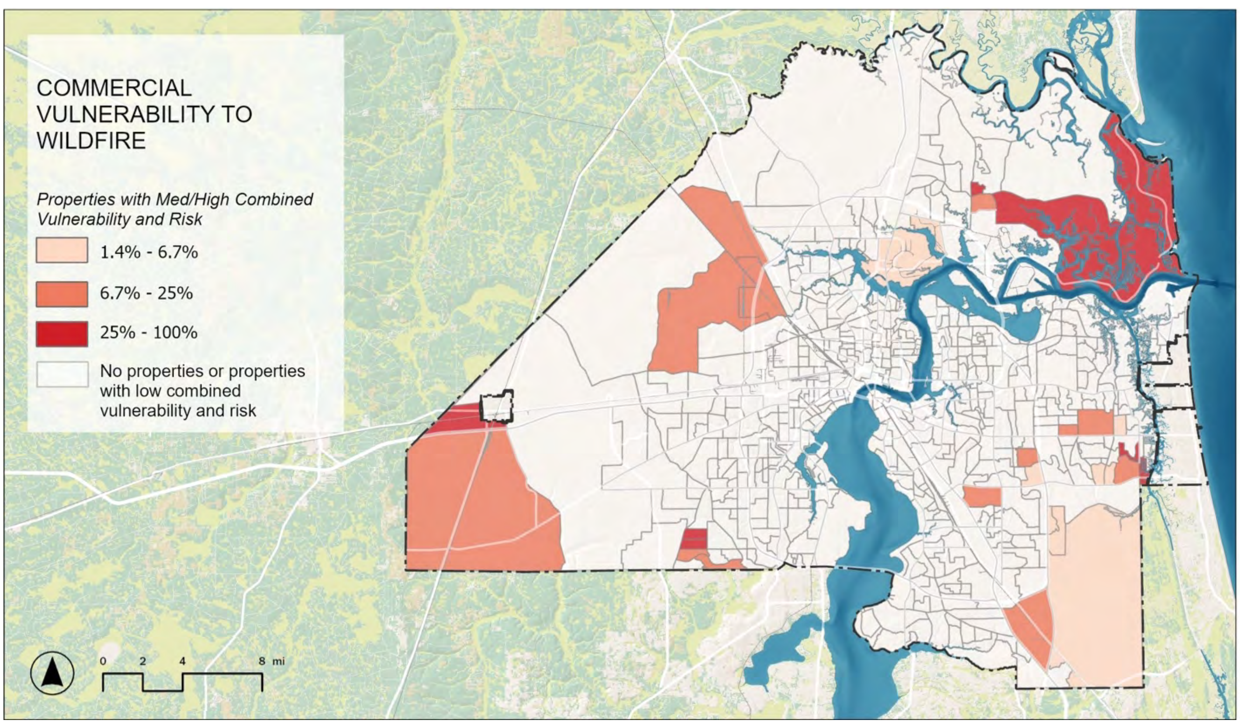


FIGURE 64. PERCENTAGE OF HIGHLY VULNERABLE COMMERCIAL ASSETS TO WILDFIRE IN JACKSONVILLE BY BLOCK GROUP.

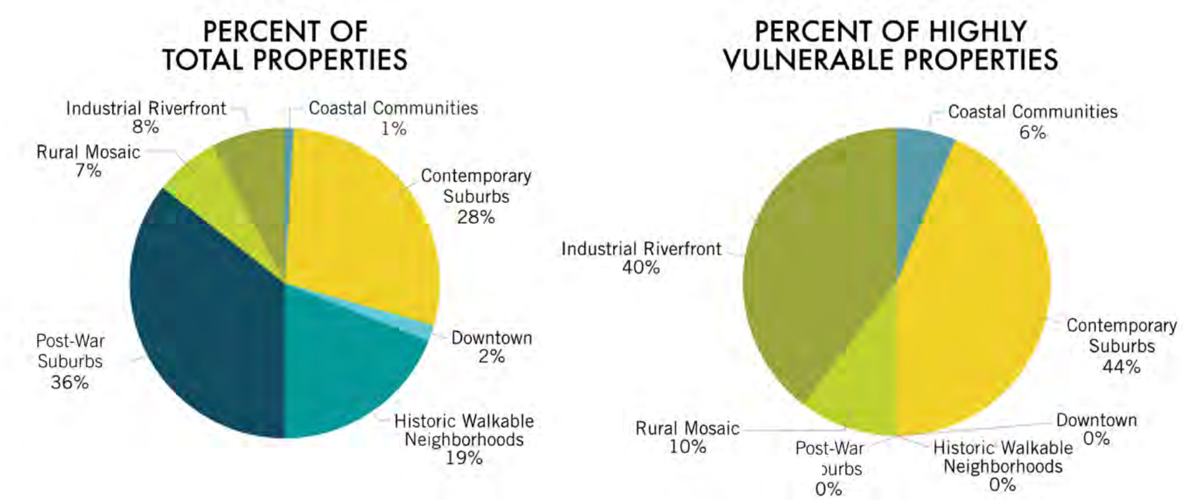


FIGURE 65. PERCENTAGE OF TOTAL INDUSTRIAL PROPERTIES AND PERCENT INDUSTRIAL PROPERTIES VULNERABLE TO WILDFIRE BY DEVELOPMENT TYPE.

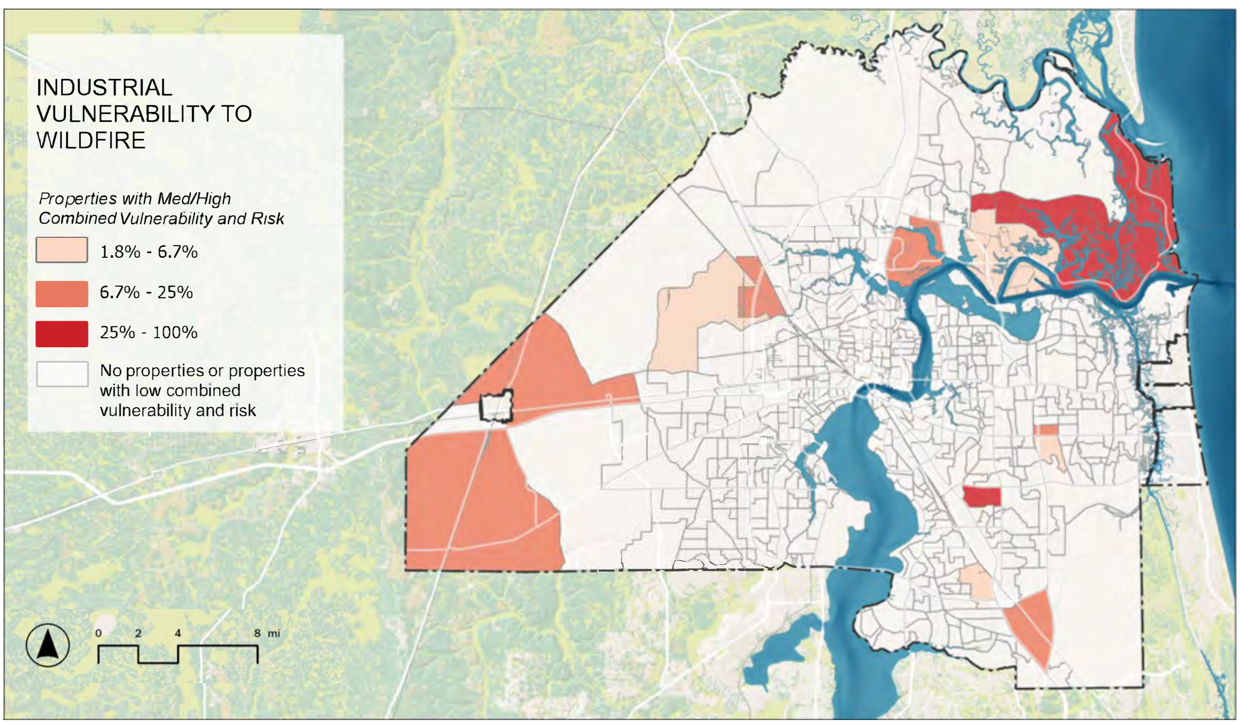


FIGURE 66. PERCENTAGE OF INDUSTRIAL ASSETS VULNERABLE TO WILDFIRE BY BLOCK GROUP IN JACKSONVILLE.

7.0 CITYWIDE SUMMARY OF VULNERABILITY AND NEXT STEPS

All areas of Jacksonville and many assets are vulnerable to the climate threats evaluated by this assessment; however, there are differing types and levels of vulnerability in different areas of the city.

Characteristics of the climate threat scenarios assessed, including the type of impact and the likelihood of occurrence, should be considered when comparing vulnerability and risk metrics across different threats. For example, impacts from coastal storm flooding and riverine flooding are inherently different.

NEXT STEPS

The goal of this assessment is to provide city leaders and staff with an actionable resource to make informed decisions. The assessment process recognized the importance of using a tailored, transparent approach to meet this goal. Key elements of this assessment process were designed with these principles in mind. These included:

1. Transparency in how vulnerability and risk is defined in the assessment. Assessment rulesets are Jacksonville-specific and consider the best available science-based datasets that help to describe the unique characteristics of the city.

2. The development of asset theme insights. Using the asset themes developed in coordination with Jacksonville City staff, the assessment considers different elements that make the people, infrastructure, and services of Jacksonville vulnerable to climate threats. All summary information and maps provided in this assessment are centered around supporting those insights.

3. Staff engagement. Jacksonville's Chief Resilience Officer and other City staff were engaged throughout the entire assessment process, resulting in valuable input and feedback throughout the process.

Information from this assessment has already been integrated into the development of the *Resilient Jacksonville* strategy. Other planning efforts that staff have identified as opportunities for integration of the assessment include capital improvement planning, emergency management and public safety, land use and comprehensive planning, and parks and open space planning.

For these and future planning efforts, this assessment can serve as a science-based resource for those looking to better understand and address key issues across Jacksonville and its neighborhoods. As more data and analyses of future risks and vulnerabilities in Jacksonville become available, regular updates of this type of science-based vulnerability assessment are recommended to ensure that the City continues to plan and build toward a more resilient Jacksonville.

REFERENCES

American Society of Civil Engineers. (2022). *Highlights of significant changes to the wind load provisions of ASCE 7-22* (FEMA fact sheet) [dataset]. https://www.fema.gov/sites/default/files/documents/fema_asce-7-22-wind-highlights_fact-sheet_2022.pdf

Berko, J., Ingram, D. D., Saha, S., & Parker, J. D. (2014). Deaths attributed to heat, cold, and other weather events in the United States, 2006-2010. *National Health Statistics Reports*, *76*.

CAPA Strategies. (2022). *CAPA Strategies heat watch report*. CAPA Strategies.

Center for Disease Control. (2017, June). *About extreme heat*. https://www.cdc.gov/disasters/extremeheat/heat_guide.html

CDM Smith, & Jacobs. (2022). *Flood Risk Assessment for High Priority Assets*.

Centers for Disease Control and Prevention. (2020). *Agency for Toxic Substances and Disease Registry, Geospatial Research, Analysis, and Services Program. Social Vulnerability Index 2020. Database: Florida* [dataset]. https://www.atsdr.cdc.gov/placeandhealth/svi/data_documentation_download.html

City of Jacksonville. (2022). *Master Storm Water Management Plan (MSPM)*. [dataset].

City of Jacksonville. (2023). *Resilient Jacksonville*. https://www.resilientjacksonville.com/resources

City of Jacksonville IT Department. (2022). *Duval County Property Appraiser's Office property parcel assessment dataset.* [dataset]. https://maps.coj.net/duvalproperty/#

Colbert, A. (2022, June 1). *A force of nature: Hurricanes in a changing climate*. Climate.Nasa.Gov. https://climate.nasa.gov/news/3184/a-force-of-nature-hurricanes-in-a-changing-climate/

Department of Homeland Security. (2022). *Homeland infrastructure foundation-level data (HIFLD)* [Dataset]. https://hifld-geoplatform.hub.arcgis.com/

DIA Jax: Downtown investment authority. (n.d.). [Map]. https://investdtjax.com/tools-resources/development-map/

EPA. (2016). *Climate change and extreme heat*.

EPA. (2022). *Heat Islands*. https://www.epa.gov/heatislands/learn-about-heat-islands

FEMA. (2019). *Guidelines for wind vulnerability assessments of existing critical facilities* (P-2062). FEMA.

FEMA. (2021). *National Flood Hazard Layer (NFHL)* [dataset]. https://www.fema.gov/flood-maps/national-flood-hazard-layer

Florida Department of Agriculture and Consumer Services. (2023). *Current state forest management plans*. Fdacs.Gov. https://www.fdacs.gov/Forest-Wildfire/Our-Forests/Land-Planning-and-Administration/Land-Management-Plans-for-State-Forests2/Current-State-Forest-Management-Plans

Florida Department of Environmental Protection. (2023). *Florida conservation lands* [Map].

Florida Department of State. (2022). *Division of historical resources publications* [Dataset]. https://dos.myflorida.com/historical/explore/publications/

Forrest, S. A., Trell, E.-M., & Woltjer, J. (2020). Socio-spatial inequalities in flood resilience: Rainfall flooding in the city of Arnhem. *Cities*, *105*, 102843. https://doi.org/10.1016/j.cities.2020.102843

IPCC. (2023). *IPCC, 2023: Summary for Policymakers. In: Climate Change 2023: Synthesis Report. A Report of the Intergovernmental Panel on Climate Change. Contribution of Working Groups I,* *II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)].* IPCC. https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_SPM.pdf

Jay, A., Reidmiller, D. R., Avery, C. W., Barrie, D., DeAngelo, B. J., Dave, A., Dzaugis, M., Kolian, M., Lewis, K. L. M., Reeves, K., & Winner, D. (2018). *Overview. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* (pp. 33–71). U.S. Global Change Research Program. https://nca2018.globalchange.gov/chapter/1/

Kohon, J. N., Tanaka, K., Himes, D., Toda, E., Carder, P. C., & Carlson, B. (2023). Extreme Heat Vulnerability among Older Adults: A Multi-level Risk Index for Portland, Oregon. *The Gerontologist*, gnad074. https://doi.org/10.1093/geront/gnad074

Mehta, K. C., & Colbourne, W. L. (2010). *Wind loads: Guide to the wind load provisions of ASCE 7-05*. American Society of Civil Engineers.

NOAA. (2022). *Relative sea level trend 8720218 Mayport, Florida*. Tidesandcurrents.Noaa.Gov. https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=8720218

NOAA. (2023). *U.S. Climate resilience toolkit: Southeast*. Toolkit.Climate.Gov. https://toolkit.climate.gov/regions/southeast

OpenStreetMap. (2023). *OpenStreetMap* [Dataset]. https://www.openstreetmap.org/#map=4/31.74/-82.27

Radeloff, V. C., Hammer, R. B., Stewart, S. I., Fried, J. S., Holcomb, S. S., & McKeefry, J. F. (2005). The wildland-urban interface in the United States. *Ecological Applications*, *15*(3), 799–805. https://doi.org/10.1093/jof/105.4.201

Reidmiller, D. R., Avery, D. R., Easterling, K. E., Kunkel, K. L. M., Lewis, T. K., Maycock, & Stewart, B. C. (2018). *Impacts, risks, and adaptation in the United States: Fourth national climate assessment, volume II* (p. 1515). U.S. Global Change Research Program.

Rufat, S., Tate, E., Burton, C. G., & Maroof, A. S. (2015). Social vulnerability to floods: Review of case studies and implications for measurement. *International Journal of Disaster Risk Reduction*, *14*, 470–486. https://doi.org/10.1016/j.ijdrr.2015.09.013

Smith, C. J. (2019). Pediatric thermoregulation: Considerations in the face of global climate change. National Library of Medicine, *11*(9). https://doi.org/10.3390/nu11092010

Southern group of state foresters. (2023). https://southernforests.org/

Sweet, W. V., Dusek, G., Obeysekera, J., & Marra, J. J. (2018). *Patterns and projections of high tide flooding along the U.S. coastline using a common impact threshold* (NOS CO-OPS 086; p. 44). National Oceanic and Atmospheric Administration. https://tidesandcurrents.noaa.gov/publications/techrpt86_PaP_of_HTFlooding.pdf

Terando, A., Carter, L., Dow, K., Hiers, K., Kunkel, K. E., Lascurain, A., Marcy, D., Osland, M., & Schramm, P. (2018). *Southeast* (4; Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II, pp. 743–808). U.S. Global Change Research Program.

Union of Concerned Scientists. (2019). *UCS Killer Heat Data* [dataset]. http://www.ucsusa.org/killer-heat

United States Census Bureau. (2020). 5-Year *American community survey (ACS)* [dataset]. https://www.census.gov/programs-surveys/acs

University of Florida Shimberg Center for Housing Studies. (2022). *Florida housing data clearinghouse* [Dataset]. http://flhousingdata.shimberg.ufl.edu/

U.S. Climate Resilience Toolkit. (2023, February). *Understand exposure*. Toolkit.Climate.Gov. https://toolkit.climate.gov/steps-to-resilience/understand-exposure

U.S. Department of Agriculture. (2022). *SNAP Retailer Locator*. https://www.fns.usda.gov/snap/retailer-locator

USACE. (2021a). *SACS Tier 1 Risk Assessment- Storm Surge Inundation Risk for Existing and Future Conditions*. https://sacs.maps.arcgis.com/apps/MapSeries/index.html?appid=c54beb5072a04632958f2373eb1151cf

USACE. (2021b). *Coastal hazards system, V2.0*. https://chs.erdc.dren.mil/Home/Index

USDA. (2019). *Food access research atlas* [dataset]. https://www.ers.usda.gov/data-products/food-access-research-atlas/download-the-data/

USDA Forest Service. (2020). *Wildfire risk to communities* [dataset]. https://wildfirerisk.org

USDA Forest Service. (2023). *Community wildfire defense grant program*. Fs.Usda.Gov. https://www.fs.usda.gov/managing-land/fire/grants

USFS. (2016). *Tree canopy cover dataset* [dataset]. https://data.fs.usda.gov/geodata/rastergateway/treecanopycover/#table1

USGS. (2019). *National Land Cover Database* [dataset]. https://www.usgs.gov/data/national-land-cover-database-nlcd-2019-products

Wood, E., Sanders, M., Frazier, T. (2021) The practical use of social vulnerability indicators in disaster management. *International Journal of Disaster Risk Reduction. 63.* https://doi.org/10.1016/j.ijdrr.2021.102464.

APPENDIX A: FLOOD RISK DATA & TERMINOLOGY

The complexity of the natural environment surrounding Jacksonville can lead to different types of flood hazards. At present, there are multiple flood datasets for Jacksonville that address different types of flood risk in Jacksonville. For this vulnerability assessment, current and future flood vulnerability was assessed using three flood prediction datasets under six different prediction scenarios. Descriptions of the flood prediction datasets and the assumptions of each scenario are described in this Appendix.

FEDERAL EMERGENCY MANAGEMENT AGENCY NATIONAL FLOOD HAZARD LAYER (FEMA NFHL)

The National Flood Hazard Layer (NFHL) is a geospatial database that contains the current flood hazard data developed by FEMA to support the National Flood Insurance Program. The NFHL is a compilation of effective Flood Insurance Rate Map (FIRM) databases and Letters of Map Revision (LMRs). The FIRM database is the digital, geospatial version of the flood hazard information (location and attributes for boundaries of flood insurance risk zones). The primary risk classifications used in the FIRM database are the 1% annual chance flood event (1% AEP).

While the FEMA FIRMS have been providing ongoing flood information to most communities in the United States for over 50 years, there is uncertainty associated the modeling of FIRMS, some of which are created using a single Hydrologic Engineering Center River Analysis System (HEC-RAS) one-dimensional steady-flow model. In addition, as FEMA's predictions and flood designations are based, in part on historical data, this flood does not reflect the potential impacts from climate change including more intense precipitation and frequent hurricanes.

Despite the limitations of the FEMA NFHL, this source is currently the most complete single dataset (i.e., considers the entirety of Duval County vs. only tributary watersheds to the St Johns River) for current flood risk in Jacksonville that assesses risk from multiple types of flooding. This assessment uses the most recent FEMA NFHL for Jacksonville developed in 2022, which maps the riverine floodway (the studied reach of riverine (i.e., creeks, streams, rivers) flooding that depicts how far flood waters will expand around a stream reach during a 100-year and 500-year storm event), wave action, and the 1% and 0.2% annual chance AEP floodplains (FEMA, 2021). Throughout this assessment, results of vulnerability using this database are referenced as "current coastal and riverine flooding" (FEMA NFHL).

U.S. ARMY CORPS OF ENGINEERS SOUTH ATLANTIC COASTAL STUDY (SACS) COASTAL HAZARDS SYSTEM DATA (USACE CHS)

The CHS is an advanced numerical and statistical analysis system that provides coastal flood hazard information to be used in coastal engineering, coastal risk assessment, and coastal management (USACE, 2021). CHS covers northeast Florida, including the St. Johns River, in its North Carolina to southeast Florida (NCSEFL) modeling phase.

CHS data provides coastal flood hazard information from tropical and extratropical cyclones. The modeling system applies ADCIRC to simulate water levels and STWAVE to simulate waves. Notably, STWAVE calculates radiation stresses, an increase in water level also known as wave setup caused by breaking waves. In addition, CHS simulations combine baseline conditions, tides, and sea level change for hundreds of hypothetical storms affecting the area of interest. Finally, CHS performs a statistical analysis of flood levels at each computational node to calculate the chance of a given water level to occur any given year.

The *Resilient Jacksonville* Strategy leverages the latest CHS data in the form of water depths for the 10% (1-in-10 year) and 1% (1-in-100 year) annual-exceedance probabilities (AEPs) for present day and future conditions. The future dataset assumes a sea level rise (SLR) of 0.83 m (2.3 feet; USACE SLC1 scenario).

The CHS applies years of constant improvements in hydrodynamics and probabilistic modeling methods—particularly post-Hurricane Katrina—and takes advantage of advanced high-performance computing. USACE CHS modeling represents state-of-the-art prediction of flood hazards for northeast Florida.

CITY OF JACKSONVILLE MASTER STORMWATER MANAGEMENT PLAN (MSMP) AND VULNERABILITY STUDY

The City of Jacksonville, through its consultant CDM Smith, developed a suite of hydrology and hydraulic models for 59 tributaries to the St Johns River throughout the city. The City developed its MSMP originally in the 1990s based on the Environmental Protection Agency's (EPA) SWMM model, also known as EPASWMM. The latest major MSMP update took place around 2010, when the City modernized aging FEMA flood maps and directly incorporated the updated MSMP into FEMA flood maps, which became effective in 2013. However, many EPASWMM models still include data and methods older than 2010. The MSMP does not include any coastal flood hazards assessments.

In 2022, the City updated precipitation parameters to evaluate future flood risks in each of the 59 tributaries for which the MSMP has an EPASWMM model. The MSMP, which was initially developed in 1992 and updated in 2011, uses the EPASWMM in 59 subbasins to consider combined riverine and tidal flooding to estimate flood risk and flood management improvements. The 2022 update migrates the existing MSMP SWMM Version 5 model datasets into the CHI PCSWMM 2021 Version 7 geodatabase and graphical user interface modeling tool. Additional updates were made to land use conditions, projected future rainfall, and existing and future St. Johns River and tidal tailwater boundary conditions.

CDM Smith simulated several current and future flood risk scenarios, including the 10-year, 25-year, and 100-year AEP 24-hour design storm events for 2020 (current), 2040, and 2070 horizons. The open channels, roadway overflows, and storage elements in the models were extended to contain a "worst-case year 2070 conditions," which include tailwater elevations of 5.0 feet NAVD88 at the St Johns River and 15 inches of rain in a 24-hour model simulation. All scenarios include a 2.8 ft high tide condition represented by the 2020 1-year Stillwater at the Lower St. Johns River (LSJR) mouth applied uniformly as the tailwater for all tributaries that outfall to the LSJR and Intracoastal Waterway (ICW). CDM Smith simulated the 2022 NOAA Intermediate-High SLR scenarios to account for SLR in 2040 (0.59 ft above 2020) and 2070 (2.23 ft above 2020). These SLR predictions were added to the 2.8 ft tailwater value to estimate the 2040 and 2070 conditions.

While nine scenarios in total were modeled by CDM Smith, only one scenario was converted to a 2D map in time to inform this vulnerability assessment (the 100-year, 2070 "worst case" scenario). Thus, only this future scenario is represented in the discussion above, even though additional model simulations are available representing 2020 and 2040 conditions.

In general, this data represents the best currently available data source for understanding inland riverine flood risk along the LSJR and its tributaries today and into the future in Jacksonville. It also represents a current and future high-tide flooding condition occurring concurrently to the riverine flooding. However, the CDM Smith team chose a conservative approach to modeling high tides along the LSJR and ICW, applying the condition at the mouth uniformly for all tributary outfalls. As a result, the results likely over-estimate tailwater conditions at outfalls further inland if a tidal flood were to coincide with riverine flooding.

Additionally, this data does not fully account for surface (pluvial) flooding that might occur away from the river and tributaries, and therefore, only partially represents the sources of rain-induced inland flooding. Finally, the model extent is only for areas of Jacksonville within the LSJR watershed. Parts of northwest Jacksonville are in another watershed and are therefore not represented by this data.

COMBINED FUTURE 1% AEP FLOODING: FUTURE COASTAL, RIVERINE, TIDAL FLOOD RISK

The Jacksonville Resilience Team developed a combined extent to represent an outer boundary of potential flooding with future sea level rise and increased rainfall intensity. This entailed overlaying the future condition 1% AEP flood layers from the CHS and CDM Smith sources described above and identifying the furthest extent and depth of 1% AEP flooding from these layers combined. This map was also compared to the FEMA NFHL to ensure that the extent of the future flood boundary was always at or greater than the current regulatory boundary.

Although the various input layers were developed with different assumptions and methods, and thus are not precisely comparable, the goal of producing this new floodplain extent is to provide a basic understanding of how future SLR and increased rainfall intensity might increase the area, assets, and population exposed to flooding at a 1% AEP by 2070.

The vulnerability assessment describes this as a “combined” flood extent, because it does not necessarily represent or capture how compound flooding—when multiple flood hazard conditions occur simultaneously—might contribute to the extent or depth of flooding at this AEP. This represents a simplified take on one plausible future scenario, and this assessment aimed to not over-interpret this exact boundary given the issues described above.

REFERENCED FLOOD RISK DATA

Name	Mode(s) of Flooding	Current/ Future	AEP	24-Hr Rainfall Assumptions	SLR Assumptions (2020 ref)	Stillwater / Steric Setup	Data Reference
FEMA NFHL	Coastal Storm + Riverine Flooding	Current	1%	N/A	0 = SLC0	Coastal BFEs	(FEMA, 2021)
			0.2%	N/A			
USACE CHS	Coastal Storm Flooding	Current	10%	N/A	0 = SLC0	0.25 ft	(USACE, 2021a)
			1%	N/A			
		Future	10%	N/A	+2.3ft = SLC1 (USACE Intermediate)		
			1%	N/A			
CDM Smith	Riverine + High Tide Flooding	Current (2020)	10%	7.8”	+2.23 ft (NOAA Int-High 2070)	2.8 ft	(City of Jacksonville, 2022) (CDM Smith & Jacobs, 2022)
			1%	11”			
		Future (2070)	10%	8.2”			
			1%	15”			
Combined Extent	Coastal + Riverine + High Tide Flooding	Future	1%	15”	+2.23-2.3 ft	Varies	(USACE, 2021a), (City of Jacksonville, 2022) (CDM Smith & Jacobs, 2022)