



Resilient Jacksonville: An Interdisciplinary Strategy for a Resilient Future

Flooding Adaptation Symposium
October 28, 2024

CITY RESILIENCE is the ability of city systems to **adapt** and **thrive** in the face of **acute shocks** (*sudden, extreme events that threaten a community*) and **chronic stresses** (*long-term pressures that weaken the fabric of a community over time*).



ACUTE SHOCKS

Extreme Rainfall Events
Extreme Heat Events
Hurricanes / Tropical Cyclones
Winter Storms / Extreme Cold Events
Infrastructure Failure or Disruption
Energy Insecurity / Blackouts
High Winds
Wildfires
Infectious Diseases
Cyber Attack
Hazardous Materials Incidents

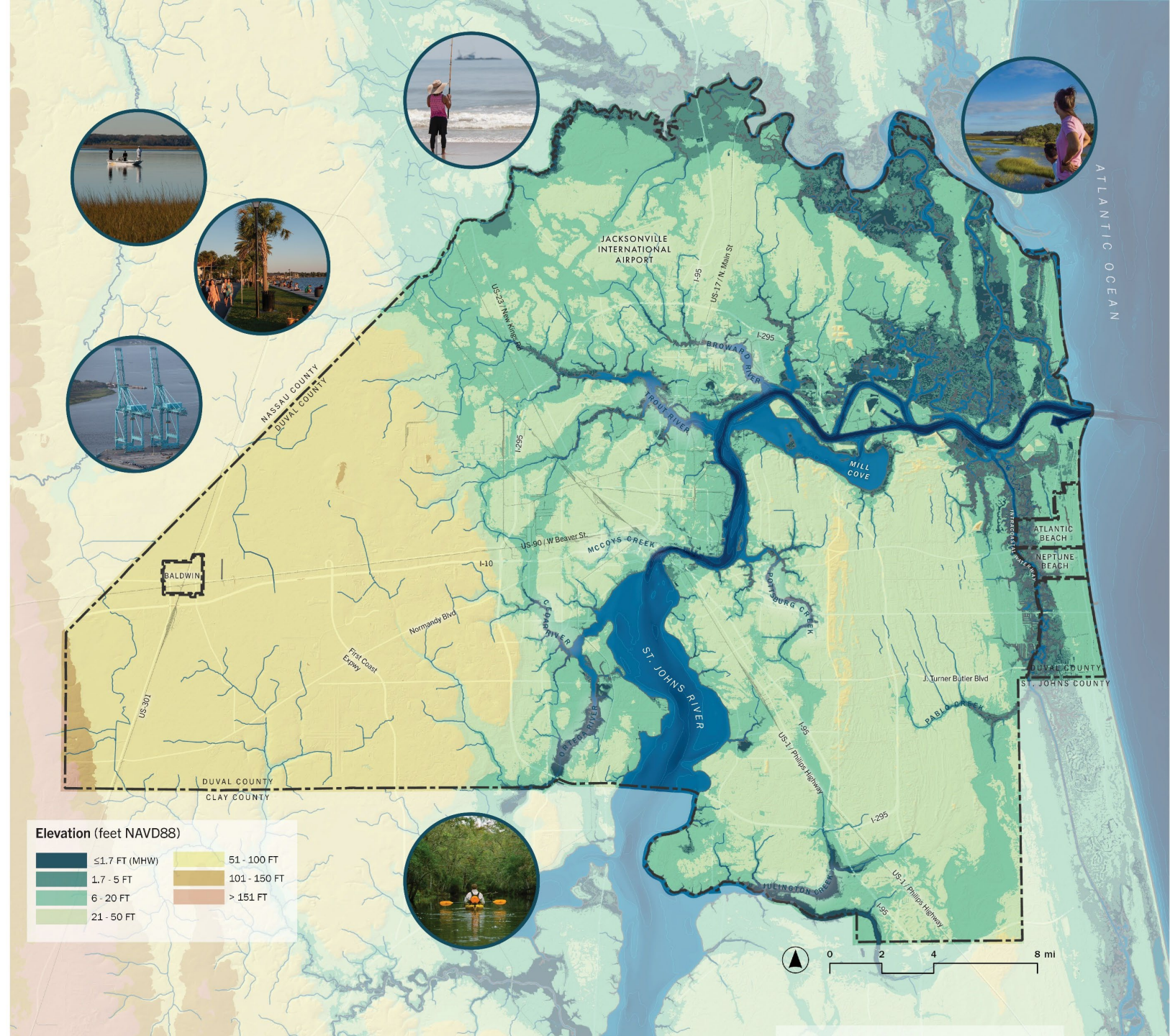


CHRONIC STRESSES

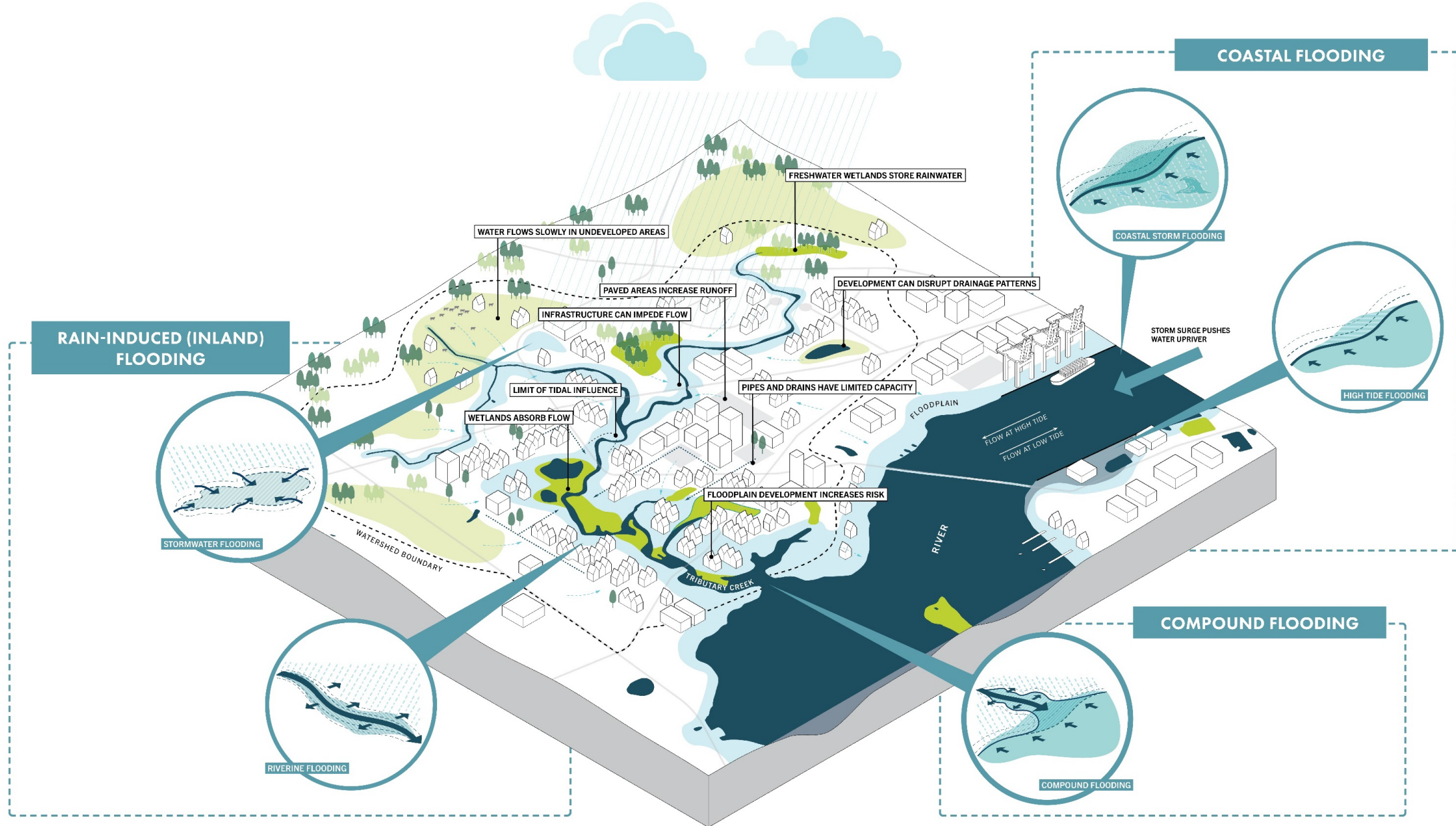
Sea Level Rise
High Tide Flooding
Heavy Rainfall
Coastal Erosion
Saltwater Intrusion
Groundwater Threats
Urban Heat Island Effect
Drought
Aging Infrastructure
Economic Downturns
Poverty
Social Inequality
Lack of Reliable Transportation
Lack of Safe and Affordable Housing
Food Insecurity & Supply Chain Disruptions
Lack of Healthcare Access
Chronic and Infectious Diseases

A CITY SHAPED BY WATER

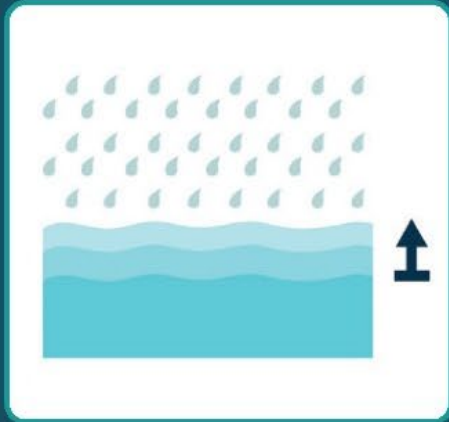
- Atlantic Coast, St. Johns River, 59 Tributaries
- Over 1,500 miles of shoreline
- Tidal influence up to 100 miles upriver



Jacksonville is exposed to many types of flooding



HOW WILL CLIMATE CHANGE IMPACT FLOODING?



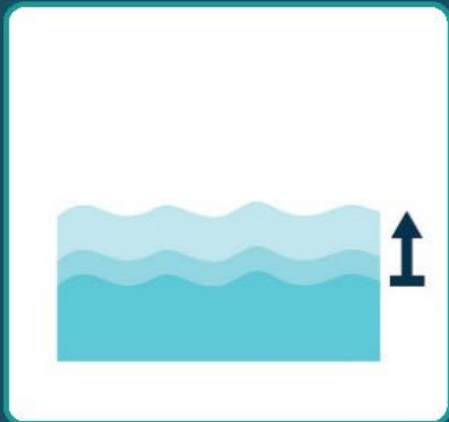
INLAND (RAIN-INDUCED) FLOODING

Jacksonville will experience more inland flooding due to more intense rainfall events (precipitation) and the associated stormwater runoff.

1.5-2x INCREASE IN EXTREME
PRECIPITATION EVENTS BY 2070

COMPARED TO HISTORIC AVERAGE FOR THE SOUTHEAST US

SOURCE: FOURTH NATIONAL CLIMATE ASSESSMENT, 2018



COASTAL FLOODING

Jacksonville will experience more coastal flooding due to sea level rise and from stronger coastal storms.

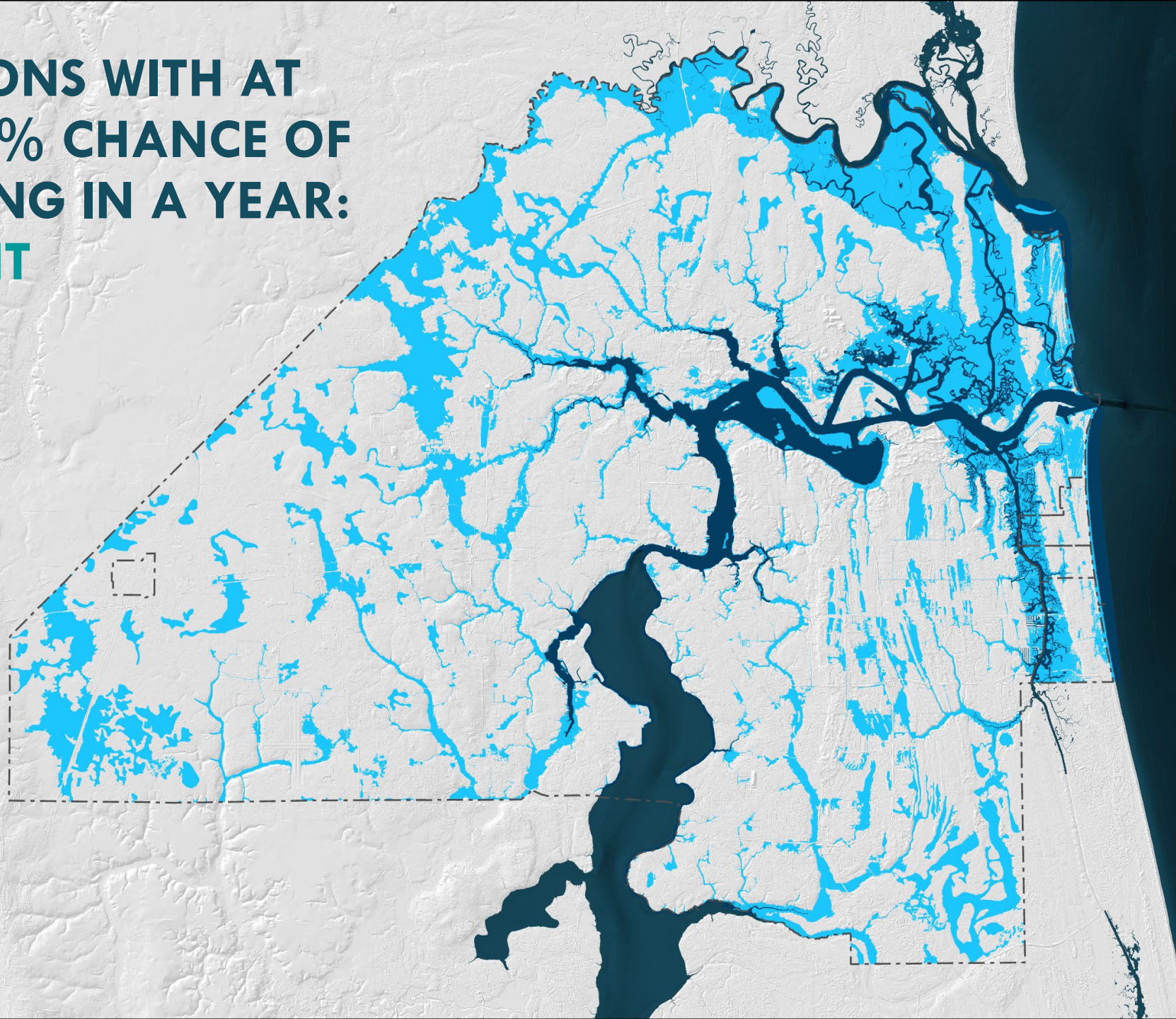
40-60 ANTICIPATED HIGH TIDE
FLOODING DAYS IN 2050

COMPARED TO 4 HIGH TIDE FLOODING DAYS IN 2021

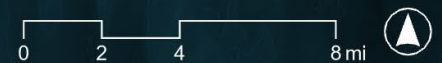
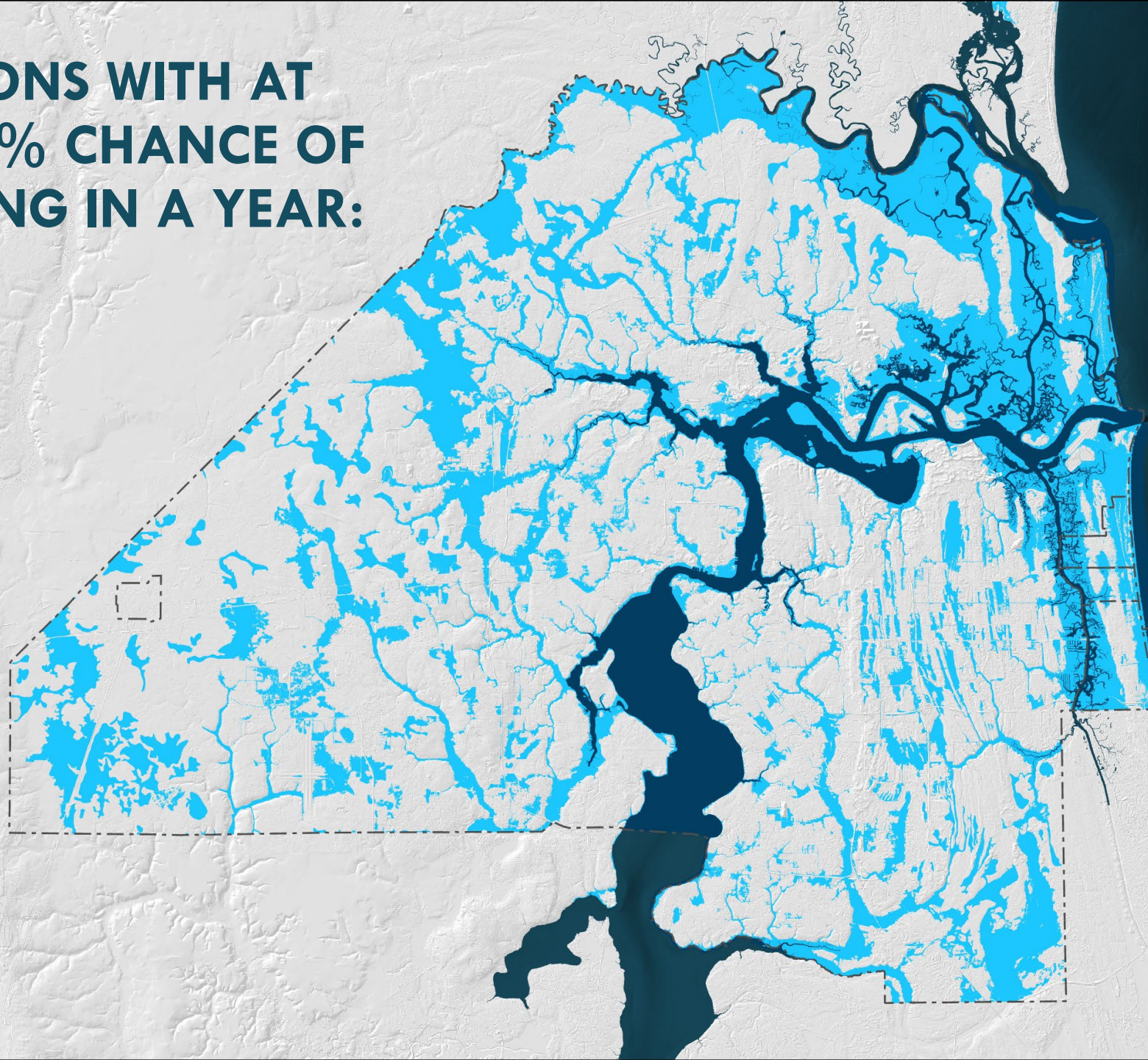
SOURCE: NOAA STATE OF HIGH TIDE FLOODING AND 2022 ANNUAL OUTLOOK FOR MAYPORT, FL



**LOCATIONS WITH AT
LEAST 1% CHANCE OF
FLOODING IN A YEAR:
CURRENT**



**LOCATIONS WITH AT
LEAST 1% CHANCE OF
FLOODING IN A YEAR:
FUTURE**



A FUTURE WITHOUT ACTION

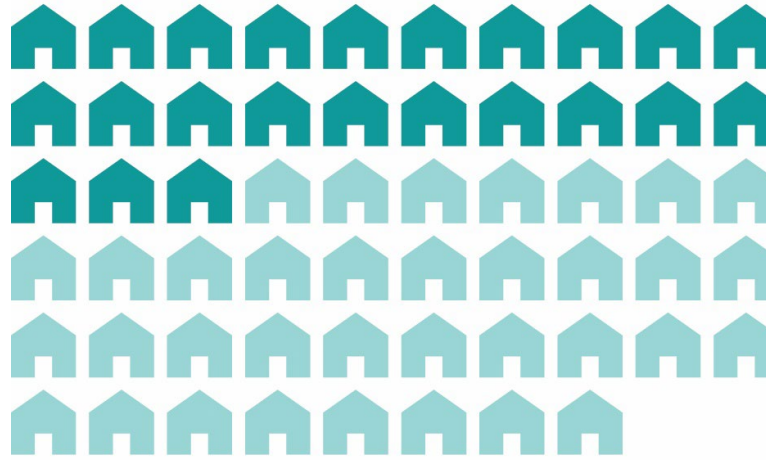
Residents Exposed to Potential Flooding



 = 10,000 people **TODAY**  = 10,000 additional people in 2070

140,000 -> **430,000**

Assets Vulnerable to Potential Flooding



 = 1,000 assets **TODAY**  = 1,000 additional assets in 2070

23,000 -> **58,000**

Residents Vulnerable to Extreme Heat



 = 10,000 people **TODAY**  = 10,000 additional people in 2070

536,000 -> **959,000**



RESILIENT JACKSONVILLE

CITY OF JACKSONVILLE
October 2023



SYSTEMS

Adaptation Approaches and Actions that work across multiple sites at a neighborhood, corridor, landscape, or regional scale.



SITES

Adaptation Approaches and Actions that can be implemented at the scale of a single asset or site.



PEOPLE

Resilience Approaches and Actions that focus on residents, communities, businesses, organizations, and partnerships.

GROW RESILIENTLY

Guide safe and connected development to areas of low flood risk and high resilience potential.

TRANSFORM

Redesign infrastructure and the built environment to make space for water, reduce urban heat, and improve connections between places.

PRESERVE

Conserve and enhance valuable open space and ecosystems and limit development in areas of high flood risk.

PROTECT

Fortify critical city systems against future threats.

PREPARE

Plan in advance of a threat to improve the response of city systems during an emergency.

ACCOMMODATE

Alter or retrofit vulnerable buildings and the built environment at the parcel level to adapt to heat and manage water.

RELOCATE

Offer voluntary, incentivized, or gradual retreat where fortification and accommodation are not efficient or effective.

SUPPORT

Invest in the health and quality of life of Jacksonville residents.

THRIVE

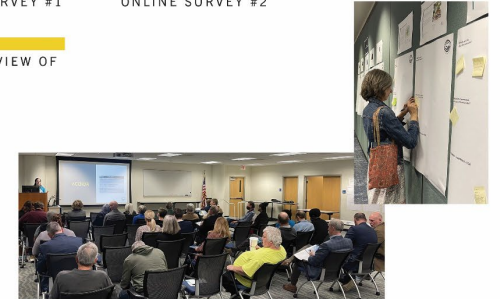
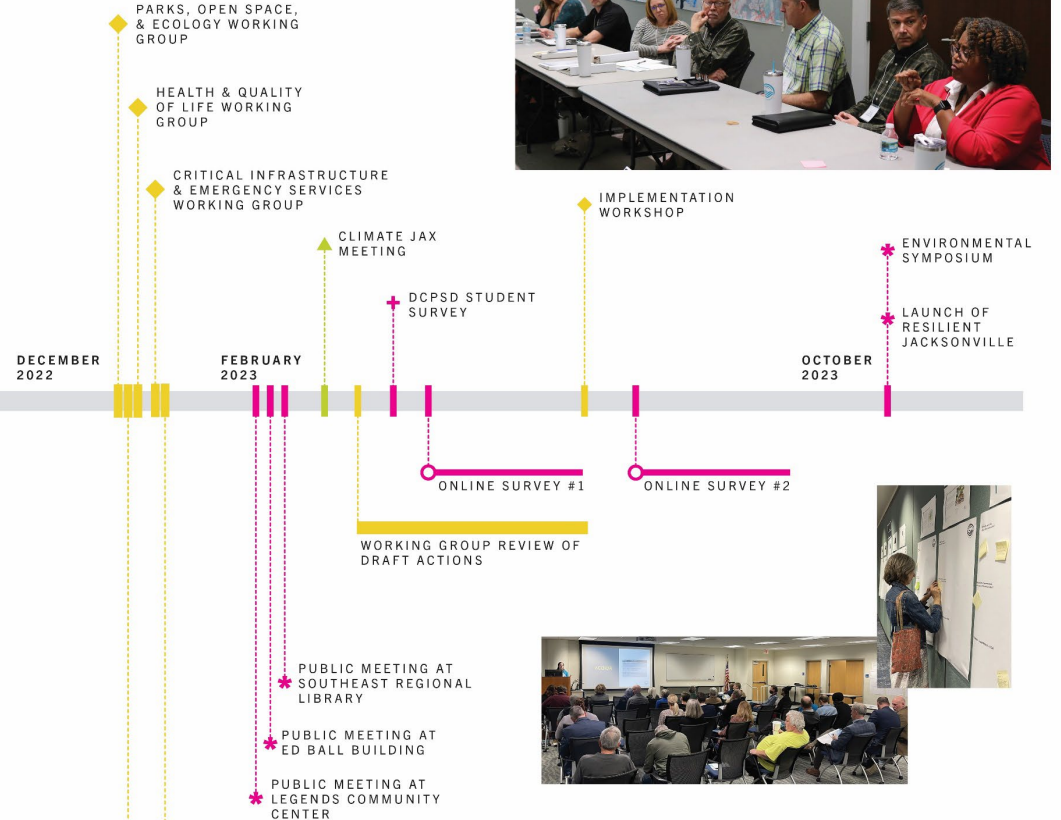
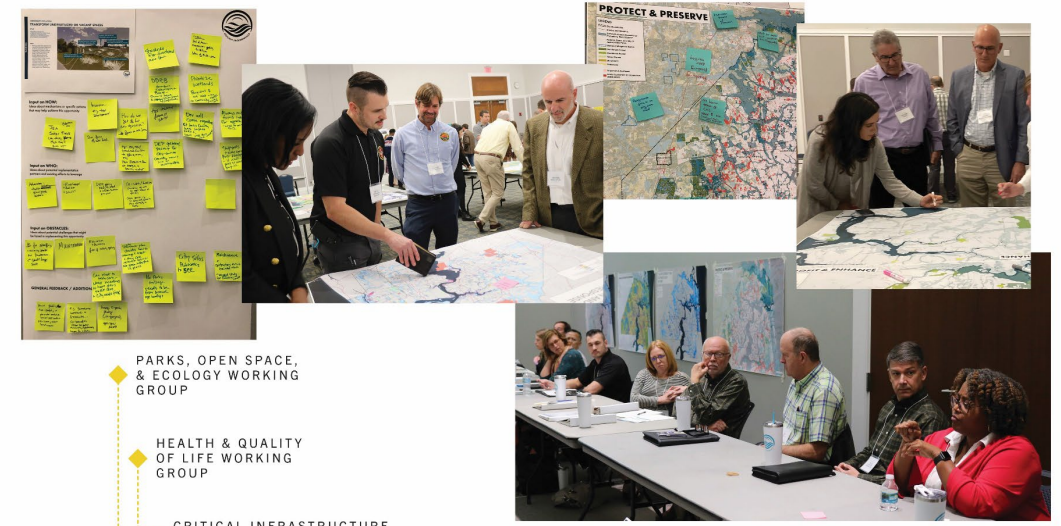
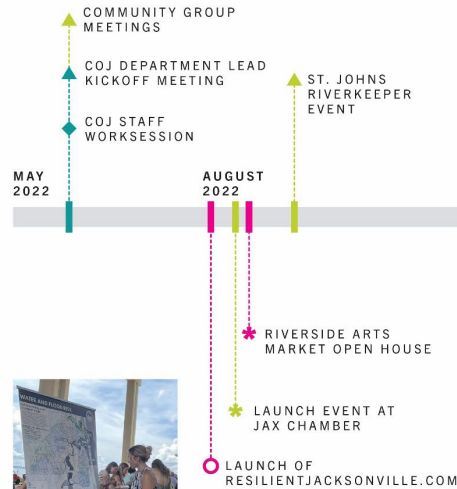
Ensure shared prosperity for Jacksonville's people and businesses for the long-term.

COLLABORATE

Strengthen partnerships and coordination among city departments, between government agencies, with civic organizations, and in support of regional coalitions.

COLLABORATIVE DEVELOPMENT OF ACTIONS

- 45 Actions
- 90 Sub-Actions
- Implementation details, partners, funding mechanisms, timelines, and costs



TYPE OF ENGAGEMENT	STAKEHOLDER GROUPS
◆ WORKSESSION	■ CITY STAFF
○ DIGITAL OUTREACH	■ SUBJECT MATTER WORKING GROUPS
▲ STAKEHOLDER MEETING	■ COMMUNITY, NGO, & BUSINESS LEADERS
* PUBLIC MEETING / OPEN HOUSE	■ BROADER PUBLIC
+ SURVEY	



1 | **Guide future growth in areas that are at low risk and well-connected to infrastructure.**

Resilience and growth can be complementary goals if new development is guided to areas that are at lower risk of flooding and other climate threats and well-connected to the existing infrastructure necessary to support thriving communities, such as various modes of transportation and energy and water utilities. Multiple interrelated dynamics shape decisions around where growth and development happen, making it challenging to advance resilience objectives alongside other economic and social considerations. Jacksonville can guide growth in a resilient way by using a suite of planning, regulatory, and incentive-based tools in concert toward a common vision for the city's future. By guiding growth in locations well-suited for low-risk development, the City can avoid increasing the number of homes, critical facilities, and people located in flood-prone areas and thus avoid further increasing potential damages from flood events.

Resilient strategies for growth, like infill development, can also provide additional benefits. Infill development focuses growth on underutilized sites, such as parking lots or vacant properties, within an already developed area. It is a model of growth that “fills in,” rather than expands from the existing urban fabric and supports increased density in areas where infrastructure and resources already exist. Infill development can reduce the distance that people need to travel to jobs and services; enable diverse modes of transportation, like public transit and bicycles; reduce urban sprawl and protect ecologically and recreationally valuable open spaces from development; make multi-unit housing options accessible for more residents; increase the return on investment in existing infrastructure; and reduce the extent and cost of infrastructure and services the City needs to provide and maintain.¹



Shocks and Stressors Addressed

Flooding / Sea Level Rise / Chronic Flooding / Housing Instability

Implementation Partners

Planning & Development / JEA / JTA / North Florida TPO / Development Community

Potential Funding Mechanisms

CIP / Modified Fee Structure

Implementation Timeframe



Relative Cost



SUB-ACTIONS

1.1 Update the City's land development regulations.

The City's land development regulations govern multiple aspects of where and how land is developed, including allowable uses, site requirements, and building and construction standards. Jacksonville's land development regulations include the Zoning Code, the Code of Subdivision Regulations, and the Floodplain Management Ordinance. Jacksonville's current land development regulations were written when climate threats were not a major consideration and do not account for the full range of current and future conditions that climate change brings. New homes, businesses, services, and subdivisions are permitted in a manner that may be inconsistent with the goals of *Resilient Jacksonville*, placing residents at greater risk from climate hazards. Projections for how climate change will increase flood risks to certain areas of the city are now available and can be used to regularly update regulatory tools to reflect the best available data and science in a way that serves Jacksonville residents for generations to come. The City is working on updating its land development regulations over the coming year to account for future flood risk projections in where and how land and buildings are developed. Land development regulations will also be regularly updated to account for changes in the environment and exposure to risk over time.

1.2 Facilitate strategic infill development in areas of low flood risk.

The City of Jacksonville, in partnership with Jacksonville Transportation Authority (JTA), JEA, the development community, and other partners, will explore and implement a range of tools to encourage infill development that is resilient to increasing climate impacts and located in high, dry, and connected

areas. These tools may include incentivizing redevelopment of vacant properties in high, dry, and connected areas; thoughtfully and strategically increasing allowable densities or providing density bonuses in those areas; partnering with developers to transfer development rights from one property to another; reducing utility connection fees in target areas; and reducing parking minimum requirements for new developments. City Council passed legislation in 2022 that expands where accessory dwelling units (ADUs), small housing units built on the same lot as a single-family home, are allowed in Jacksonville. This is another important tool that will support affordable infill development in Jacksonville. The City will combine tools for infill development with approaches for maintaining and expanding affordable housing (see Action 4) to ensure that making room for new neighbors improves conditions for existing residents and minimizes displacement.

1.3 Incorporate resilience considerations into future land use planning.

Jacksonville's 2030 Comprehensive Plan is a policy document required by Florida Statutes and the City's Code of Ordinances. This plan guides future growth and development with the goal of promoting public health, safety, and welfare. The plan also guides updates to the City's land development regulations. Jacksonville will incorporate resilience goals, climate threats, and risk considerations into updates of the Comprehensive Plan, including the Future Land Use Element and Future Land Use Map that describe the land uses and physical characteristics intended for all areas of the city.

5 | Update public works design standards to account for climate change impacts and support resilient infrastructure development.

Public works design standards set a precedent for the safety and resilience of public infrastructure and establish a baseline of resilience for any city investment. Prioritizing the resilience of infrastructure is critical, not only to avoid costly repairs but also to minimize the wide-ranging consequences of natural disasters for the livelihoods and well-being of residents.⁴ Integrating climate change data into public works design standards and the Capital Improvement Plan prioritization process will ensure that retrofits and new construction performed by the Department of Public Works are resiliently designed and built to withstand flooding, high winds, heat, and other extreme weather.

Resilient design standards will also guide the development of community services, jobs, retail, and affordable housing in low-risk areas with existing infrastructure, transit networks, and underutilized sites, and reduce the amount of capital spent on repairing infrastructure. In addition, actions intended to improve infrastructure resilience—for example, a park that is “designed to flood” and provide additional water storage capacity during heavy rainfall events—can often yield additional benefits during non-emergency conditions.⁵ The multiple benefits derived from interventions like this are often referred to as the “resilience dividend,” which represents the many benefits that accrue by investing in actions that strengthen the city’s resilience. Extensive research from the National Institute of Building Sciences has repeatedly shown that investments in mitigation provide substantial benefits over cost. Their study of federal mitigation grant programs found a \$6 benefit for every dollar invested.⁶



Credit: Montgomery County DEP

Shocks and Stressors Addressed

Flooding / Sea Level Rise / Chronic Flooding / Urban Heat Island Effect

Implementation Partners

Public Works / JEA / Subdivision Standards and Policy Advisory Committee / Context Sensitive Streets Committee

Potential Funding Mechanisms

Resilience Office / Fuse Fellows

Implementation Timeframe



Relative Cost



SUB-ACTIONS

5.1 Align above-ground and below-ground infrastructure specifications and review processes.

To ensure consistency in design for above- and below-ground infrastructure, it’s important that the committees setting these standards are in close coordination. The City will facilitate the merging of the Subdivision Standards and Policy Advisory Committee (SSPAC) and the Context Sensitive Streets Committee to allow for holistic planning and streamlined decisionmaking. Additionally, to save on costs and materials and improve sustainability citywide, the City and JEA will closely coordinate projects and maintenance, collaborate to improve standards and specifications, and implement resilient standards where applicable.

5.2 Update the standard details and specifications for City of Jacksonville street designs.

If you laid all of Jacksonville’s City-managed roads in a straight line, you could get from Downtown to Los Angeles and halfway back—a total of over 3,400 miles. Each road has the potential to provide significant resilience benefits beyond transportation. The City will undergo a streetscape design update that will comprehensively look at the various types of roadways in Jacksonville and provide standards for roadway design and upgrades that provide additional quality of life, stormwater management, and urban heat reduction benefits. These redesigns could include multiple components, such as multimodal active transportation with lanes and pavement

markings for buses and bicyclists. They could also include light-colored roadways to reduce urban heat absorption and additional street trees to provide shade, absorb stormwater, and lower air temperatures. Redesigns could both benefit pedestrians through the installation of safe and accessible sidewalks and include permeable paving to reduce runoff and promote infiltration. Updating the City’s streetscape design standards is an opportunity to make significant improvements to meet resilience goals.

5.3 Incorporate green infrastructure features into drainage specifications.

Though not a catch-all solution for drainage, green infrastructure features can take pressure off the city’s drainage system while simultaneously providing multiple benefits by filtering, storing, and even infiltrating stormwater (the process by which water flows into and through the soil). Development of design guidelines for green infrastructure features as part of a drainage guidebook is one mechanism that can be used to implement citywide standards around green infrastructure installation (e.g., determining what an urban bioswale should look like in specific parts of the city). In addition to establishing design guidelines and standard details—and separate from the regular flow capacity the city relies on from the traditional drainage system—the City can set targets for how much water different parts of Jacksonville should be able to temporarily retain during and after one or more major rainfall events.

8 | **Make room for the river and tributaries.**

Rivers and tributaries naturally carry and hold rainfall runoff from their watershed. Providing more room along riverbanks for floodable open spaces can reduce flood risk by systematically holding more water in the riparian corridor, limiting assets at risk in the floodplain, and improving health and quality of life by providing connective recreational and ecological corridors. In planning for new structures along the St. Johns River and tributaries, the City will support the restoration of natural, historic floodplains by making investment decisions and prioritizing projects that make room for flood water, avoiding placing structures in the floodplain, and actively returning areas of the floodplain to natural space that can provide Jacksonville residents benefits such as flood risk reduction, improved water quality, urban heat reduction, and recreation areas.

Action Description

The Office of Resilience will collaborate with the Parks Department and the Department of Public Works to limit the use of City funds along tributaries to water-dependent structures, like docks, piers, boat ramps, or elevated walkways. The City agencies will further encourage the addition of vegetated buffers along rivers, wetlands, and stormwater ponds; replace hardened shorelines with green or hybrid infrastructure where feasible; and limit new bulkhead permits on private property.

Shocks and Stressors Addressed

Flooding / Chronic Flooding / Groundwater Threats

Implementation Partners

Parks / Public Works / Groundwork Jacksonville / St. Johns Riverkeeper

Potential Funding Mechanisms

Resilient Florida / National Fish and Wildlife Foundation

Implementation Timeframe



Relative Cost



EXAMPLE
MCCOYS CREEK RESTORATION

The McCoys Creek Recreation and Restoration Project, currently underway, exemplifies the efforts of Action 8: Make Room for the River. Like many creeks in Jacksonville, much of the historic McCoys Creek was channelized underneath highways or hidden behind dense overgrowth. The creek suffered from water quality and acute flooding issues. Through City, nonprofit, community, and stakeholder collaboration, the project is making a significant impact in improving resilience, ecology, and quality of life in Jacksonville.

The City of Jacksonville has committed \$105.4 million to restore McCoys Creek through natural channel design and mitigate the ongoing and frequent flooding in nearby neighborhoods.⁸ Groundwork Jacksonville, a local nonprofit, has partnered with the City to engage residents and community stakeholders to craft a vision plan and

design for McCoys Creek that reduces flooding, improves water quality, restores fish and wildlife habitats, expands recreational opportunities and access through a multimodal greenway, and establishes wayfinding that honors McCoys Creek's rich social and cultural history.

The McCoys Creek project is a great example of the resilience dividend: by building a larger project with multiple benefits, many funding sources can be combined and leveraged, rather than used piecemeal. Combining the expertise of multi-disciplinary teams with community engagement, feedback, and values has led to a project with broad support and extensive benefits. While still under construction, this project is already demonstrating flood risk reduction benefits, evidenced by its ability to mitigate against the impacts of Hurricane Ian in fall 2022.

EXAMPLE
REBAULT RIVER CORRIDOR PROJECT

The Ribault River Corridor Project demonstrates ways in which Jacksonville can maintain environmental health at the neighborhood scale and prioritize investments that expand access to waterways and seek to address the needs of individual communities. For this project—located on the banks of the historic Ribault River—LISC (Local Initiative Support Corporation) Jacksonville and the St. Johns Riverkeeper partnered with community and academic leaders to identify community

assets, social and environmental vulnerabilities, and community-defined investments for parks and waterway access, housing, infrastructure, and environmental quality. Different from McCoys Creek which is highly urbanized, the Ribault River Corridor Project will help determine how creek restoration can work on a larger scale and identify elements that are transferrable to many other tributaries throughout Jacksonville.

9 | Develop a green stormwater infrastructure program across Jacksonville based on the best available science and data.

The growing trend of “cloudburst” rain events that drop many inches of rainfall in a short period of time is a phenomenon impacting every part of Jacksonville. These increasingly regular events can overwhelm the city’s drainage systems and worsen flooding. Oftentimes, cloudbursts are not named storms, not always easy to predict, and may arrive as one single heavy rain event or many sustained days of rain when the ground is saturated and storage systems are full. Like many other cities experiencing these types of events, Jacksonville’s drainage systems, including underground pipes, stormwater ponds, and open-air drainage ditches on the side of the road, can be overwhelmed by the frequency and severity of such rainfall events. Simply put, there is often too much water and not enough places for it to go. Green stormwater infrastructure can help relieve the pressure that heavy rainfall puts on Jacksonville’s drainage system by capturing and holding water before it reaches the storm drain system and absorbing overflow during rain events. Green infrastructure also improves water quality, mitigates extreme heat, expands natural space, and creates a healthier environment for residents.

Action Description

Up until now, Jacksonville and other cities across the U.S. have sought to address stormwater flooding by looking at historical data to identify where it has already been happening. Analyzing reported flood data from 630-CITY, for example, is a useful first step to identify key areas that experience repeat stormwater flooding, but the City recognizes the need for more sophisticated estimates that can more accurately project future flood risk from both heavy rainfall events and compound flood events (events when different types of flooding, such as storm surge and heavy rain, occur at the same time). Using new estimates of flood risk and mapped outputs from Jacksonville’s upcoming compound flood analyses, the City will establish a new program focused on green stormwater infrastructure, identify locations with the greatest need for these types of interventions, and invest resources accordingly.

Shocks and Stressors Addressed

Stormwater Flooding / Urban Heat Island Effect

Implementation Partners

Resilience / Public Works / Parks

Potential Funding Mechanisms

Resilient Florida / USACE Silver Jackets

Implementation Timeframe



Relative Cost



CASE STUDY

GREEN CITY, CLEAN WATERS

Philadelphia, PA | 2011

Credit: Philadelphia Water Department

Green City, Clean Waters is a comprehensive 25-year plan developed by the Philadelphia Water Department (PWD) to implement green stormwater infrastructure (GSI) citywide. The primary goal of this program is to reduce water pollution by utilizing GSI such as rain gardens, swales, and stormwater tree trenches to store stormwater runoff before it reaches the sewers and causes an overflow of polluted waters into the city’s rivers. PWD has partnered with other city departments, agencies, private developers, and organizations to install GSI at recreation centers and schools, as well as in parking lots. Green City, Clean Waters is also looking into opportunities for GSI to be coupled with future renovations, such as upgrades to athletic fields.

In the program’s first decade of implementation, nearly 800 sites across the city have incorporated GSI, resulting in more than 2.7 billion gallons of polluted water kept out of local waterways. These efforts yield additional environmental benefits like reduced stormwater flooding, improved air quality, energy conservation, ecological support, and reduced impacts from extreme heat. They also provide economic and social benefits such as improved opportunities for recreation, increased property values, investment in local businesses, and reductions in crime.



12 | Preserve ecologically important areas with the capacity to manage water and mitigate extreme heat.

Jacksonville's ecosystem diversity is impressive—its habitats include marine and estuarine, intertidal, subtidal, estuarine wetlands, freshwater wetland, rivers and streams, ponds and lakes, coastal beaches, coastal uplands, scrub and prairie, and upland and pine forests. Each ecosystem plays a role in a resilient Jacksonville. Establishing mechanisms for preserving and protecting existing natural areas, especially wetlands and flood-prone areas, can provide many benefits for the city. Ecologically important areas are defined as supporting native plant communities and wildlife, providing environmental benefits such as improved air and water quality, and reducing risks associated with natural disasters and climate change. Specifically, they help to purify air and water, lower air temperatures, stabilize soil which reduces erosion, reduce flood risks and impacts, recharge the aquifer, and provide important habitat. Strategic land preservation is critical to improving Jacksonville's resilience and maintaining its identity as a spacious city with the largest urban park system in the nation.



Shocks and Stressors Addressed

Flooding / Extreme Heat / Wildfires / Air Quality / Water Quality

Implementation Partners

Parks / SJRWMD / North Florida Land Trust

Potential Funding Mechanisms

SJRWMD

Implementation Timeframe



Relative Cost



12.1 Protect existing park and preserve lands in perpetuity.

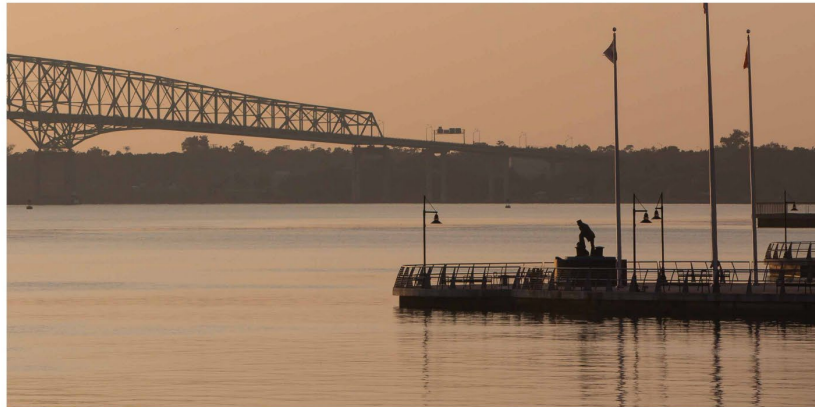
Protecting lands in perpetuity allows important ecological areas to grow without risk of development. Within the city limits, there are many protected parklands, including state parks, wetland mitigation banks, and the Timucuan Ecological and Historical Preserve National Park. The City of Jacksonville manages more than 400 park and recreational sites providing many services to residents. Some of these are preserve lands, which are larger, natural areas with specific types of recreational use. The services these existing parks and preserve lands provide Jacksonville include benefitting mental and physical health, naturally absorbing and filtering rainwater, recharging the aquifer, providing safe and natural places for riparian flooding, improving air quality, and storing carbon, among others. Furthermore, according to the Natural Areas Conservancy's 2022 Cooling Study, which included 12 U.S. cities (two in Florida), forested natural areas are 3–9°F cooler on average and are the coolest type of greenspace in cities.⁹ Some of Jacksonville's parks and preserve lands are threatened by development pressures. Removing existing parkland from the city's green space network is counterproductive to achieving citywide resilience as it results in a loss of the benefits listed above. To prevent the loss of Jacksonville's park and preserve lands for the next century, the Parks Department

will develop a program to add important preserve lands and existing parks into long-term conservation easement agreements. Additionally, the Office of Resilience will develop a citywide policy to limit the sale of existing City-owned park and preserve lands and will work with the Planning and Development Department to add restrictions to the land-use code to prevent the conversion of City park land into other types of land uses.

12.2 Support strategic land acquisition for conservation.

Acquiring lands that support important ecological functions and provide citywide benefits is an effective strategy for long-term conservation. The Office of Resilience, in partnership with the Parks Department and Real Estate Division, will identify and pursue methods for acquiring strategic areas of land. This may include large natural areas or contiguous parcels of natural areas, areas adjacent to existing park land, properties experiencing repetitive flooding, or areas of land within future floodplains. The City can partner with other organizations such as the North Florida Land Trust, Florida Forever Program, the St. Johns River Water Management District, and the Timucuan Parks Foundation to leverage resources to apply to grants for land acquisition.

Shoreline hardening along the river and tributaries is a resilience measure appropriate to use for shoreline stabilization and flood risk reduction in some areas. Costs to harden shorelines are high and some construction options can damage ecosystems or limit recreational options. Site suitability, tradeoffs, and overall benefit must be considered when opting for a hardened shoreline solution. Where appropriate, elevating publicly owned bulkheads and designing bulkheads with adaptive capacity (i.e., which can be raised over time as needed) will reduce the city's level of risk during storm surge events from hurricanes and nor'easters. Notably, bulkheads and seawalls can trap runoff behind them causing residual flooding. To address the risk of residual flooding, a combination of tide valves and pump stations is often necessary to drain runoff during high tide. Pump station design, construction, operation, and maintenance significantly increases the overall cost of the flood protection project. The City will set height standards for public and privately owned bulkheads, provide material resources for privately owned bulkheads in locations necessary for contiguous shoreline protection to benefit the city as a whole, and use the best available data to make informed spatial decisions about hardening along the St. Johns River and its tributaries.



Shocks and Stressors Addressed

Flooding / Sea Level Rise / Chronic Flooding / Infrastructure Failure

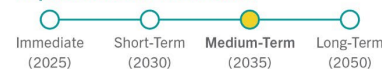
Implementation Partners

Resilience / Public Works / USACE

Potential Funding Mechanisms

CIP / Resilient Florida

Implementation Timeframe



Relative Cost



16.1 Manage publicly owned bulkhead heights in accordance with best available flood data.

Structural interventions, like bulkheads or seawalls, are some of the costliest resilience interventions that a city can undertake. These structures can also change riverine and stormwater flow patterns, remove shoreline ecosystems, disconnect the river or creek from its floodplain (which worsens water quality), and be ineffective if not built to sufficient height or durability standards. Structural interventions do not remove the need for evacuation during extreme storms because their primary function is to protect property and physical assets. For these reasons, the City will use the best available science and data to select sites and design bulkheads for shoreline stabilization and flood risk reduction where such protection is the most appropriate option. For example, downtown Jacksonville saw extreme flooding and damage during Hurricane Irma in 2017, and the City is now elevating these bulkheads and incorporating adaptive capacity to elevate them to additional heights in the future.

16.2 Set height standards for privately owned bulkheads.

The City owns only 4.4 of the 100 linear miles of hardened shorelines in Jacksonville, limiting the effectiveness of public bulkhead management as a resilience measure. Setting bulkhead height standards for privately constructed and owned sections of bulkhead, therefore, has a more widespread potential impact on increasing the city's resilience. Jacksonville will consider best practice and lessons learned in other areas, such as South Florida, to identify how to set and implement private bulkhead height standards. For example, sea level rise projections can be considered to ensure that any newly constructed or modified bulkhead is designed to mitigate increasing future flood risks. Jacksonville's bulkhead height standards will be set based on the best available science and data, particularly through the upcoming compound flood risk assessment (see Sub-Action 40.2).

16.3 Evaluate where additional publicly funded structural shoreline protection may be technically and financially feasible.

Adding new bulkhead segments into the City's capital inventory should be managed strategically given the high initial investment required for structural interventions and the long-term operation and maintenance costs needed to support assets like bulkheads, flood gates, and pump stations. The City will consider available data on future flood risk, initial and maintenance costs, and site suitability in determining what new locations may be appropriate for shoreline hardening. In addition, Jacksonville will identify opportunities to partner with the U.S. Army Corps of Engineers as a technical and cost-sharing partner to assess the feasibility of sites for structural shoreline protection and to design and construct new infrastructure where appropriate.



17 Identify shorelines where natural and nature-based solutions can provide long-lasting ecosystem service benefits.

Natural and nature-based solutions, when implemented strategically, have the capacity to provide multiple resilience benefits. As defined by the U.S. Army Corps of Engineers, natural and nature-based features refer to landscape features that produce flood risk management benefits. Projects such as oyster reef installation, salt marsh restoration, dune establishment, and hybrid gray-green infrastructure have the potential to mitigate impacts from coastal hazards, improve ecosystem health, and even lower long-term costs of shoreline maintenance. For example, oyster reefs can serve as breakwaters as they absorb the force of waves, slow coastal erosion, create habitat, and provide water filtration that enhances surrounding ecosystems. Restoration of salt marsh can also contribute to many of these benefits. The Parks Department, in partnership with the Office of Resilience, will prioritize sites for nature-based shoreline stabilization opportunities, develop solutions for coastal erosion within the City's park system, and identify additional opportunities to implement nature-based solutions that yield multiple public benefits. Additional partnerships with the University of Florida and homeowner associations can facilitate the identification of potential private property natural and nature-based opportunities. To facilitate a data-driven process, the Parks Department will combine results from the *Resilient Jacksonville Vulnerability Assessment* with federally funded research and analyses.



Credit: University of North Florida

Shocks and Stressors Addressed

Coastal Erosion / Chronic Flooding / Water Quality

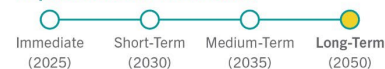
Implementation Partners

Parks / Resilience / USACE

Potential Funding Mechanisms

Resilient Florida / NFWF Coastal Resilience Fund

Implementation Timeframe



Relative Cost



17.1 Conduct research and analyses to identify waterfront edges most suitable for natural and nature-based solutions.

With 59 tributaries, the St. Johns River, and the Atlantic Ocean, Jacksonville has hundreds of miles of waterfront edges. Many of these edges may be suitable for natural and nature-based solutions, particularly to address shoreline erosion. The City will pursue a Living Shoreline Suitability Model, as was developed for the Tampa Bay Area by the Florida Fish and Wildlife Research Institute, and will use the results in conjunction with the vulnerability assessment to prioritize sites for stabilization solutions like oyster reefs, living breakwaters and/or salt marsh restoration.¹³ Hybrid gray-green approaches may also be suitable where some degree of hardening is needed, but additional habitat area might provide cascading benefits.

17.2 Address shoreline erosion in coastal parks.

Hurricanes and tropical events can cause large-scale erosion to Jacksonville's coastal parks and beaches. Past projects, like the Duval County Shore Protection Project implemented by the Jacksonville District of the U.S. Army Corps of Engineers, have successfully renourished hurricane-eroded beaches, adding sand to provide recreation and tourism opportunities as well as shorebird and marine turtle habitat.¹⁴ Renourished beach and dune systems also provide protection to life and property from storm surge and waves during hurricanes and nor'easters. New partnerships, like the University of North Florida's work with the National Park Foundation, Groundwork Jacksonville, and Stericycle, are bringing oyster reefs to protect sensitive areas in the Timucuan Preserve from erosion.¹⁵ The City and its partners will continue to search for new and innovative ways to address shoreline erosion.

17.3 Identify sand and sediment resources for natural and nature-based solutions.

Natural and nature-based solutions like beach nourishment and marsh creation can help protect communities and ecosystems while providing recreational benefits to residents, beachgoers, and local businesses. These approaches rely on sand and other sediments which, in the future, may become increasingly expensive as readily available sources of suitable material become depleted. The City of Jacksonville will coordinate with partners such as the U.S. Army Corps of Engineers to identify long-term solutions for supporting beach nourishment, thin layer placement of dredged materials, and other coastal protection measures.

27 | Harden vulnerable critical assets to mitigate damage from hazards and ensure continuity of operations.

Recent global heat records and unprecedented flood events have demonstrated the need for cities to reassess the vulnerability of their most critical infrastructure and consider the cascading impacts that might occur if infrastructure were to temporarily or permanently break down. When structures cannot be relocated and preparedness is not sufficient to overcome risks and hazards, critical assets can be hardened to reduce downtime and maintain operations during and after hazard events. Fortification of vulnerable critical assets is expensive and should be prioritized based on criticality, the best available data, and site-specific context. For Jacksonville to achieve long-term resilience, fortification decisions must be well-informed, with consideration for the services they provide and the people and institutions they serve. Fortifying should be deployed after other alternatives are considered and determined to be less effective and should be reserved for infrastructure that is used by the most people.



Shocks and Stressors Addressed

Flooding / Infrastructure Failure / Sea Level Rise

Implementation Partners

Public Works / JEA

Potential Funding Mechanisms

CIP / FEMA / FHWA / HUD CDBG

Implementation Timeframe



Relative Cost



SUB-ACTIONS

27.1 Fortify City-owned assets, such as evacuation roads and bridges.

Asset-by-asset fortification is time consuming and expensive, and generally should prioritize infrastructure that impacts the most people. Evacuation roads, bridges, and other critical links in Jacksonville's transportation network are examples of the types of infrastructure that are vital to all residents and might be considered for fortification. For example, as a city with bridges providing the critical and sometimes only route between communities, Jacksonville must be prepared for all acute shocks that could potentially compromise these critical structures (including but not limited to: high wind events, storm surge, and even extreme heat events) and fortify these assets appropriately. The City will use data from the vulnerability assessment to inform the identification and further evaluation of assets that should be considered for fortification measures such as flood-proofing, elevating, or other hardening methods.

27.2 Work with utilities and independent agencies to identify and fortify their vulnerable critical assets.

Independent agencies and utilities must also periodically consider fortification for vulnerable critical assets under their ownership. Because the City's vulnerability assessment also includes assets outside of City operations, the Office of Resilience will coordinate with the owners of these assets so that they can make informed decisions about fortification. For example, social vulnerabilities analyzed in the City's vulnerability assessment could help JEA understand where underground power lines could have the greatest impact or highest rate of return within communities with the least resources to recover from acute shocks and significant events.



28 | Develop relocation plans for vulnerable critical assets that can be moved outside the floodplain.

Some assets do not need to remain in high-risk areas to preserve critical functions and can be relocated to areas of lower flood risk. This may depend on factors such as the cost of future maintenance or weighing costs to harden against costs to relocate. Understanding when and why these critical assets should be moved will be important for formulating plans that can consider changing risks over time. Instances when the City is considering major upgrades or replacement of an asset at the end of its useful lifespan can be ideal moments to consider relocating an asset to a less flood-prone location.



Shocks and Stressors Addressed

Flooding / Chronic Flooding / Sea Level Rise / Infrastructure Failure

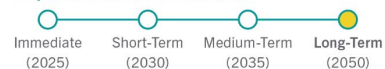
Implementation Partners

Resilience / Public Works

Potential Funding Mechanisms

FEMA HMGP

Implementation Timeframe



Relative Cost



SUB-ACTIONS

28.1 Develop plans for moving City-owned critical assets where alternative adaptation options are infeasible.

Often, offlining an asset and rebuilding it somewhere else is costly and should only be used when no other alternatives exist. However, the period of time at the end of an asset's life is an opportunity to consider where that asset should be located (with level of risk as one of the many factors to account for) before investing in major renovations or upgrades. The City's vulnerability assessment data can guide the identification of the City's highest-risk assets, and though there may not be many high-risk assets right now, this data can help the City anticipate what may need to be relocated in the future and allow the City to proactively plan for shifting risk, including incorporating relocation for some critical assets into the Capital Improvement Plan.

28.2 Work with utilities and independent agencies to develop and implement relocation plans for their critical assets.

As levels of risk continue to grow, utilities and other independent agencies across Jacksonville are sometimes faced with questions about relocating critical assets. As the City makes decisions for City-owned assets, the Office of Resilience will also communicate current and future risks to outside agencies to provide guidance for relocation of critical assets, ensure that plans for relocation are in alignment, and help inform long-term capital planning.

Establish an Office of Resilience to facilitate the ongoing implementation of *Resilient Jacksonville*.

To guarantee that the recommendations set forth in *Resilient Jacksonville* are coordinated and well-positioned for implementation, the City will establish and adequately staff an Office of Resilience. The office will be responsible for the ongoing implementation of *Resilient Jacksonville* by leading coordination across City departments and with external partners and collaborating with local academic partners to organize a system that tracks implementation progress. The office will also prioritize the development, sharing, and application of the best available data and science on climate projections, flood and heat risk, and other shocks and stressors to inform decisions across City government. The Office of Resilience will also ensure that the use of resilience data is managed ethically and accessed through the appropriate channels.



Shocks and Stressors Addressed

All Shocks and Stressors

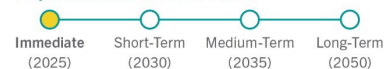
Implementation Partners

COJ / The Water Institute / JU

Potential Funding Mechanisms

General Fund / FUSE Fellows

Implementation Timeframe



Relative Cost



SUB-ACTIONS

40.1 Facilitate interdepartmental and interagency collaboration throughout City government and with external partners.

The main purpose of establishing the Office of Resilience is to ensure all aspects of City government are well-coordinated, and that decisions are made holistically rather than in silos. The development of this Strategy began a process of inter-agency collaboration, and the success of *Resilient Jacksonville* will rely on the creation of collaborative processes that continue into implementation. By filling this role, the Office of Resilience can ensure that investments make the best use of taxpayer dollars and are aligned with resilience goals—that infrastructure is designed and built to withstand future conditions and that city staff are able to build stronger relationships across departments. Additionally, this office can help articulate a cohesive vision in partnership with other outside agencies to ensure that all key entities in Jacksonville are moving towards a shared future.

40.2 Use the best available science and data to inform decisions.

Just as *Resilient Jacksonville* was developed using the latest and most comprehensive science and data, continuing to develop and use the best available data will be critical for achieving the many goals set forth in this Strategy. The Office of Resilience will serve as the agency in charge of maintaining and deploying robust climate and vulnerability datasets across all departments and helping to contextualize data for city leaders to use in decision-making processes. More specifically, over the next two years, the Office of Resilience will be developing a compound flood model in conjunction with The Water Institute that will provide the City with the most advanced flood data in the state. This work will identify the most flood-prone areas of the city and guide project development. As new datasets become available—whether it be the compound flood model or future national climate assessments—the Office of Resilience will be responsible for updating policies and procedures that reflect the most accurate data.



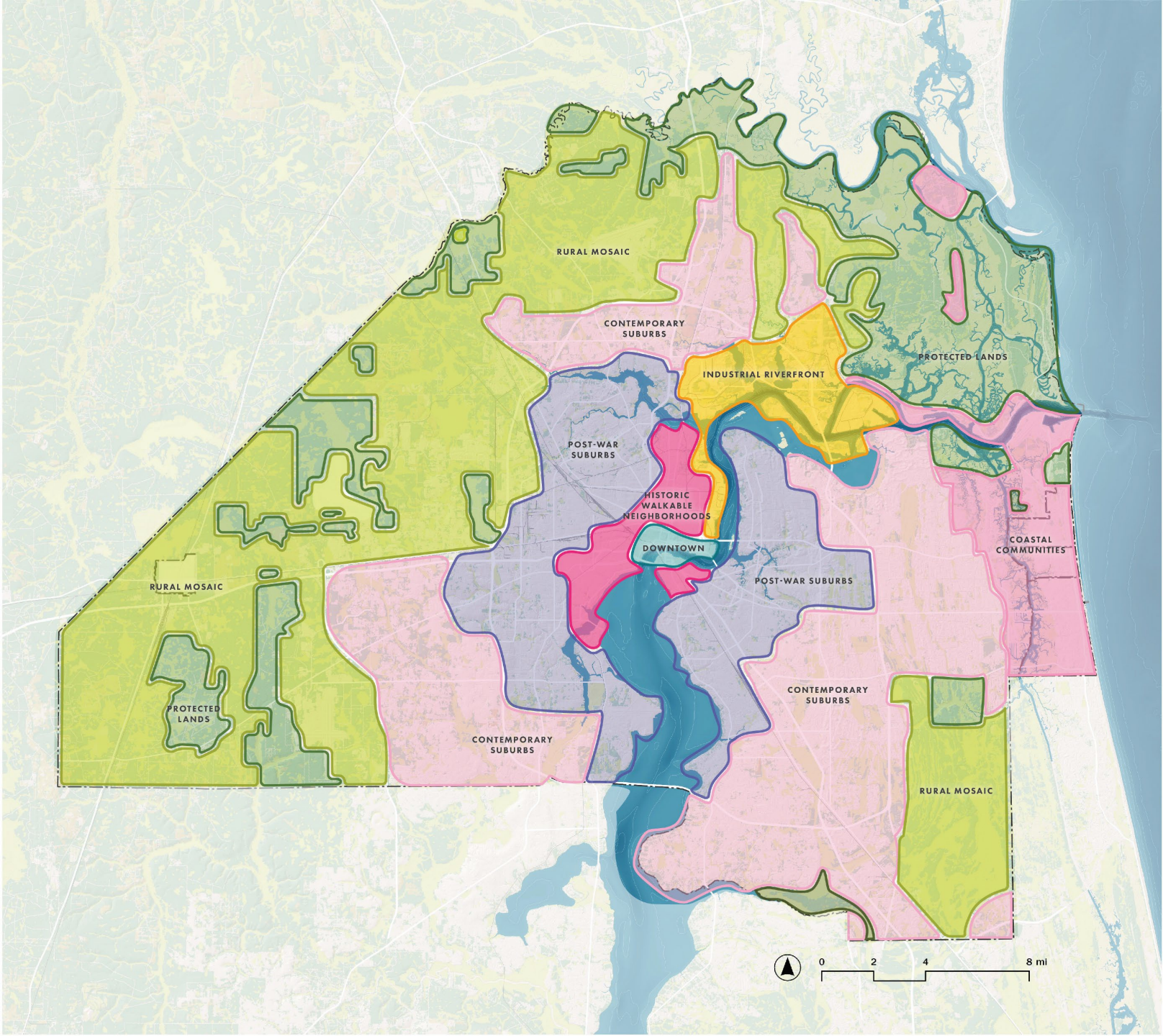
PLACE-BASED STRATEGIES

Defining where different adaptation approaches make sense



DEVELOPMENT TYPES

-  Downtown
-  Historic Walkable Neighborhoods
-  Post-War Suburbs
-  Contemporary Suburbs
-  Industrial Riverfront
-  Coastal Communities
-  Rural Mosaic
-  Protected Lands

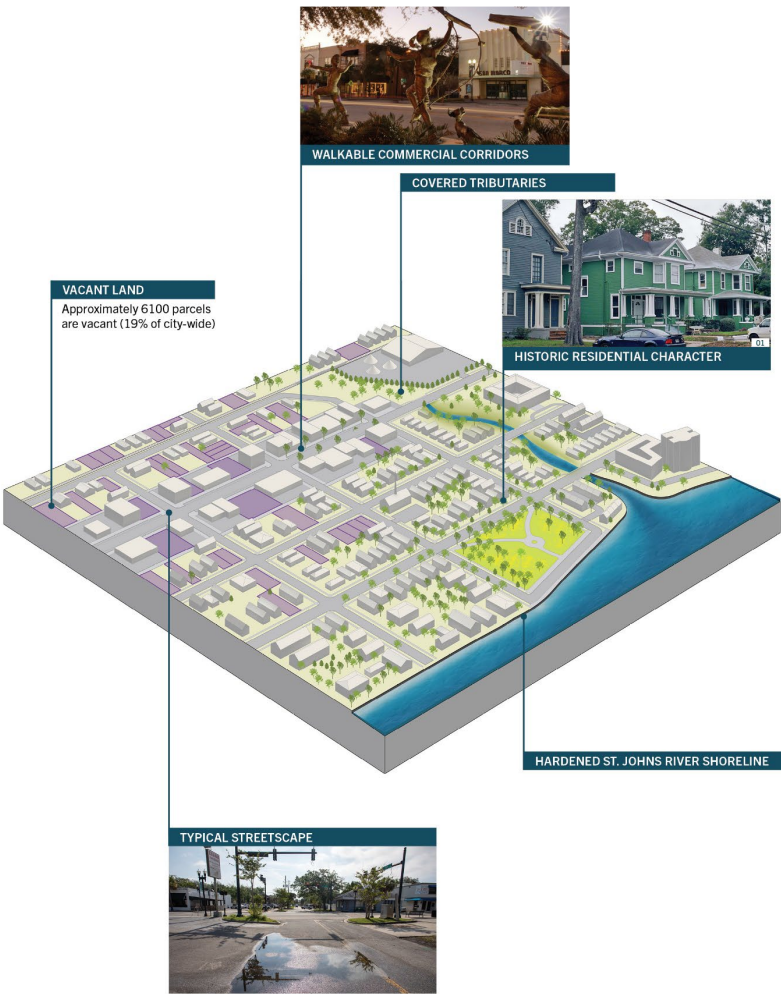


DEFINING DEVELOPMENT TYPES

What characteristics influence a neighborhood's vulnerability to climate threats?

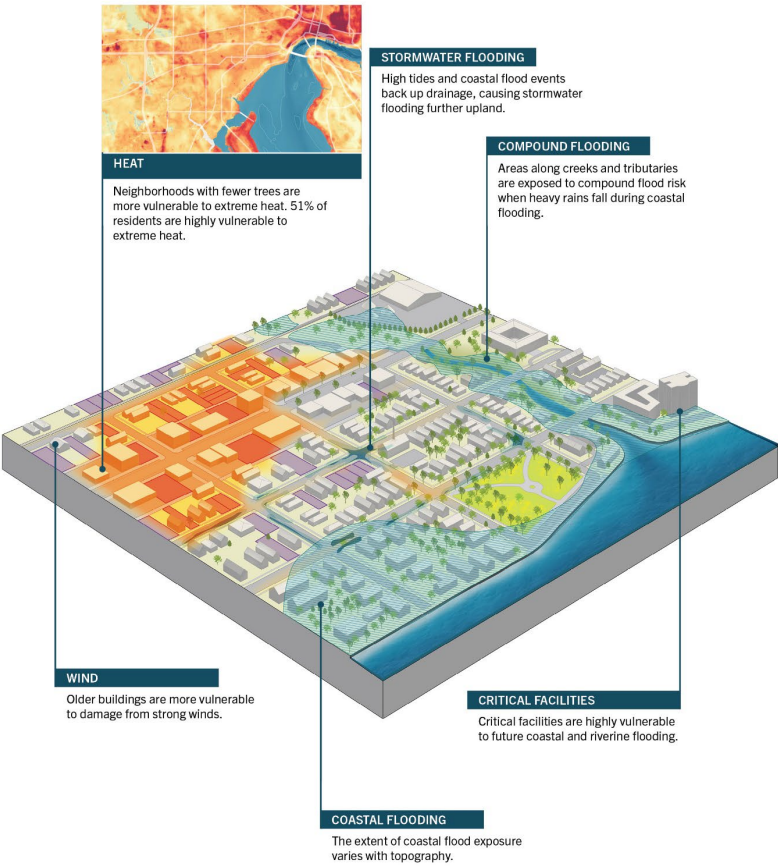
	Age/Era of Development	Density of Development	Street + Roadway Network	Residential + Commercial Urban Form	Stormwater + Wastewater Infrastructure	Use of + Relationship to Waterbodies	Impervious + Vegetated Cover
URBAN	Historic / pre-WWII	High density	Gridded, connected, walkable	Mixed Use	Curbs and Gutters + Sewered	Oriented to Waterfront	Significant impervious surface with limited tree canopy
SUBURBAN	Post-WWII to 1978	Medium density	Mostly gridded, mostly connected, somewhat walkable	Long Linear Commercial corridors	Curbs and Gutters +Septic/Sewered mix	No Access to water	Older, large mature tree canopy and small lots
	1978 to today	Low density	Curvilinear, disconnected, designed for motorized transit	Regional Commercial hubs	Ditches + Ponds + Septic/Sewered mix	Adjacent to Open Water/Wetlands	Large lots of lawn and impervious surface with new small trees
RURAL	Primarily undeveloped	Rural residential	Primarily highways, interstates and state roads	Makes use of regional commercial hubs	Ditches + Septic Tanks	Adjacent to open water / wetlands	Older, more dense vegetation and less impervious surface

HISTORIC WALKABLE NEIGHBORHOODS



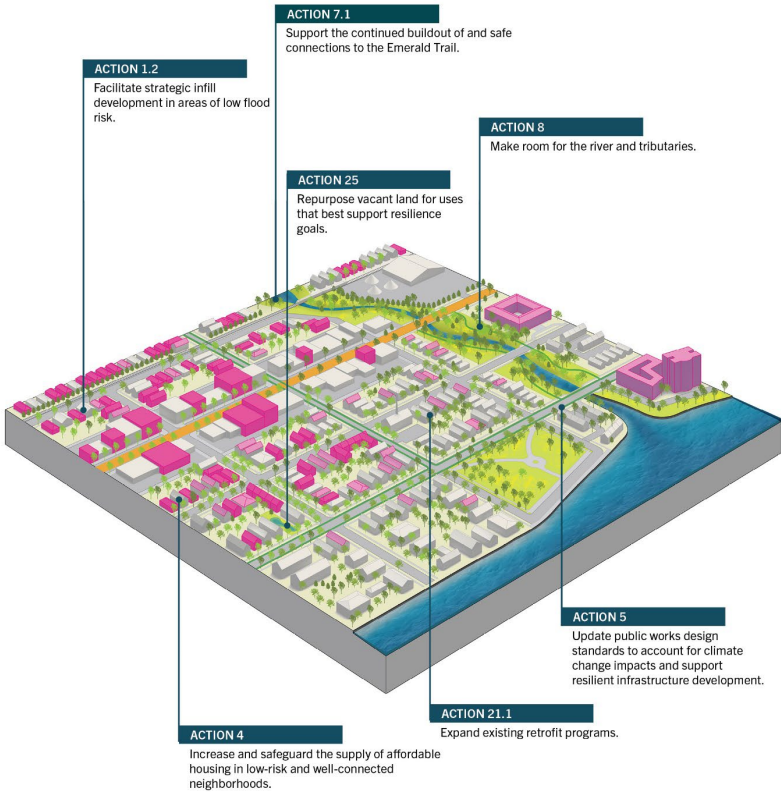
Scale: Tile above represents approximately 0.1 sq miles.

Character



- Floodplain
- Stormwater Flooding
- Urban Heat

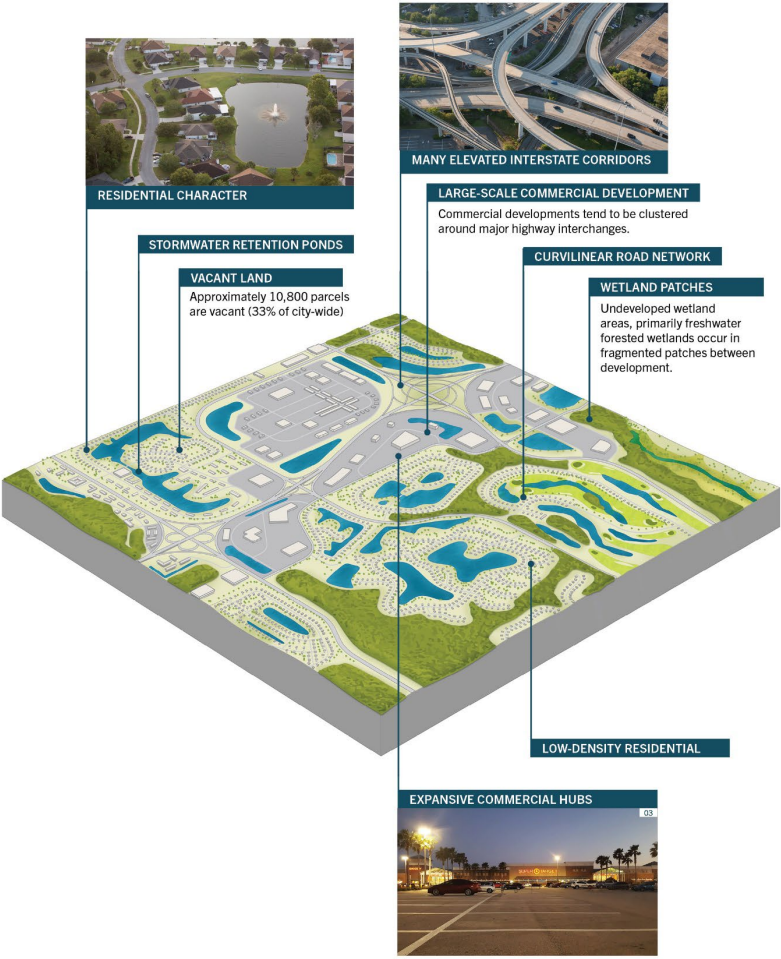
Risks



- Resilient development
- Improved evacuation routes
- Resilient streetscape
- Building retrofits

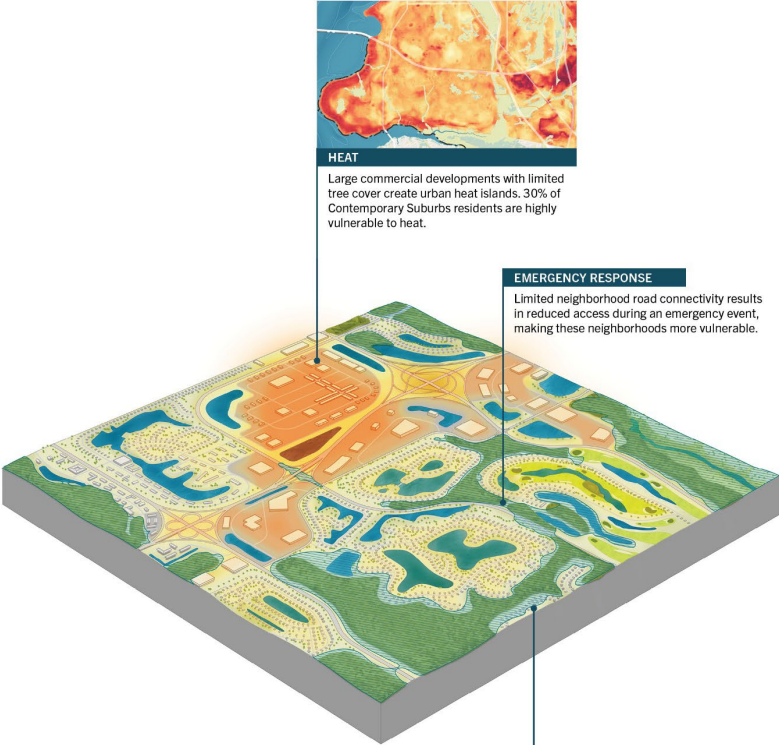
Opportunities

CONTEMPORARY SUBURBS



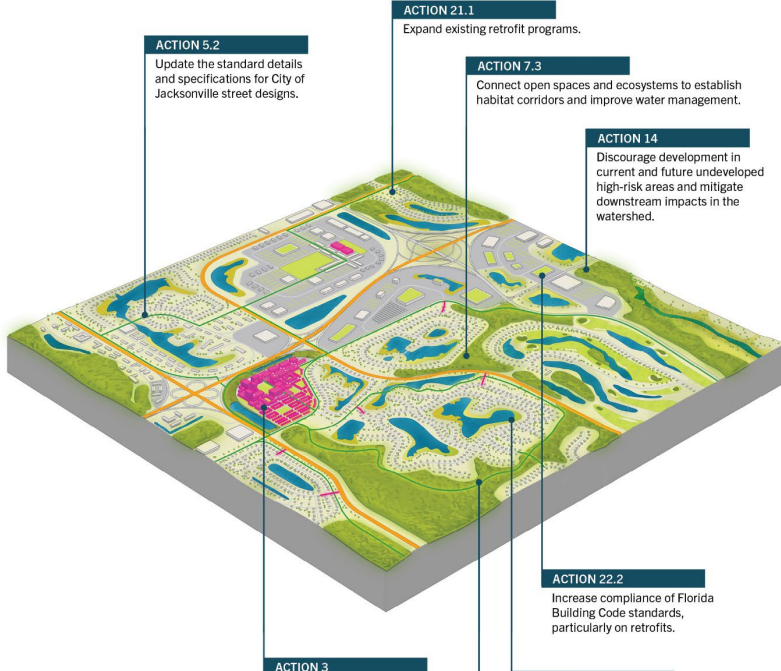
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Character



Floodplain
Stormwater Flooding
Urban Heat

Risks



Resilient parking garage
Improved evacuation routes
Resilient streetscape or greenway
Solar panels or green roof
Subdivision additional access

Opportunities

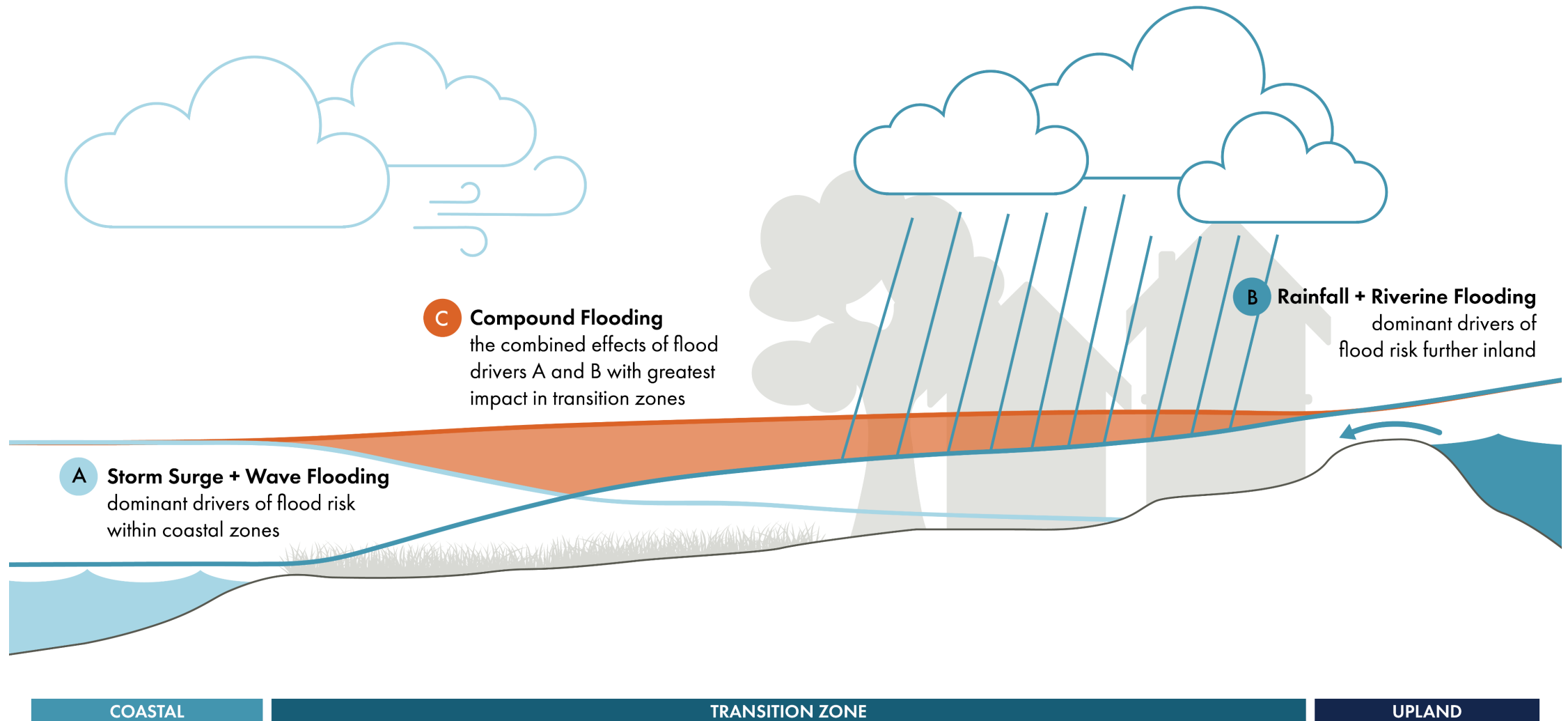
COMPOUND FLOOD MODEL

Identifying risk using best available
science and data



COMPOUND FLOODING

IN COASTAL TRANSITION ZONES



Compound flooding occurs when rainfall, riverine flow, and storm surge hazards interact to produce combined flood hazards.



Quantify compound flood hazards

Develop probabilistic compound flood model to better understand flood risks.



Forecast flooding in real time

Design FloodID support dashboards to facilitate dynamic disaster preparedness and response.



Develop data and model catalog

Deploy Jacksonville EnDMC to support efficient and centralized data sharing.



Guide implementation of Resilient Jacksonville

Estimate flood consequences and improve decision making, policy, and resilient infrastructure design.

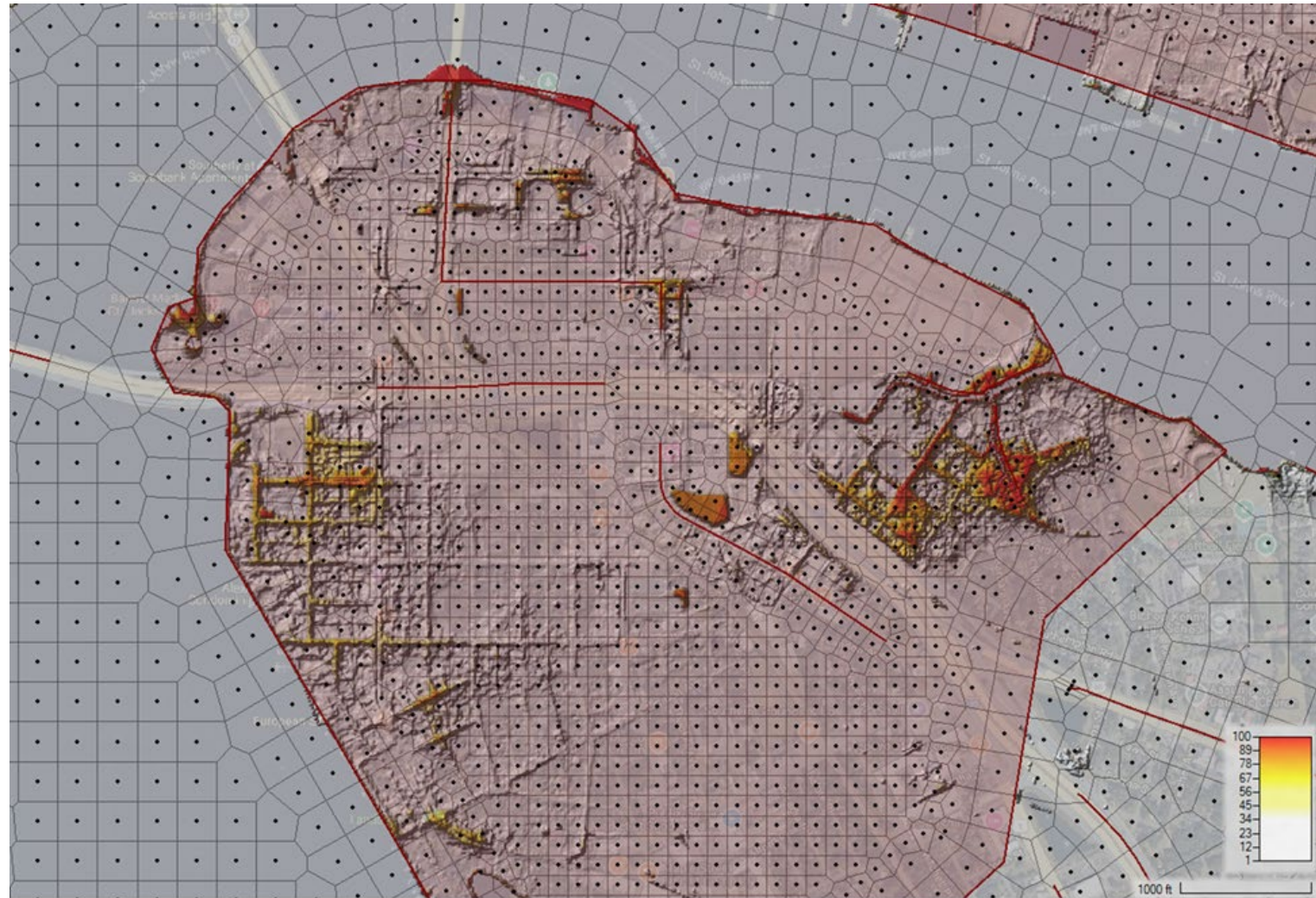


cutting edge science and data

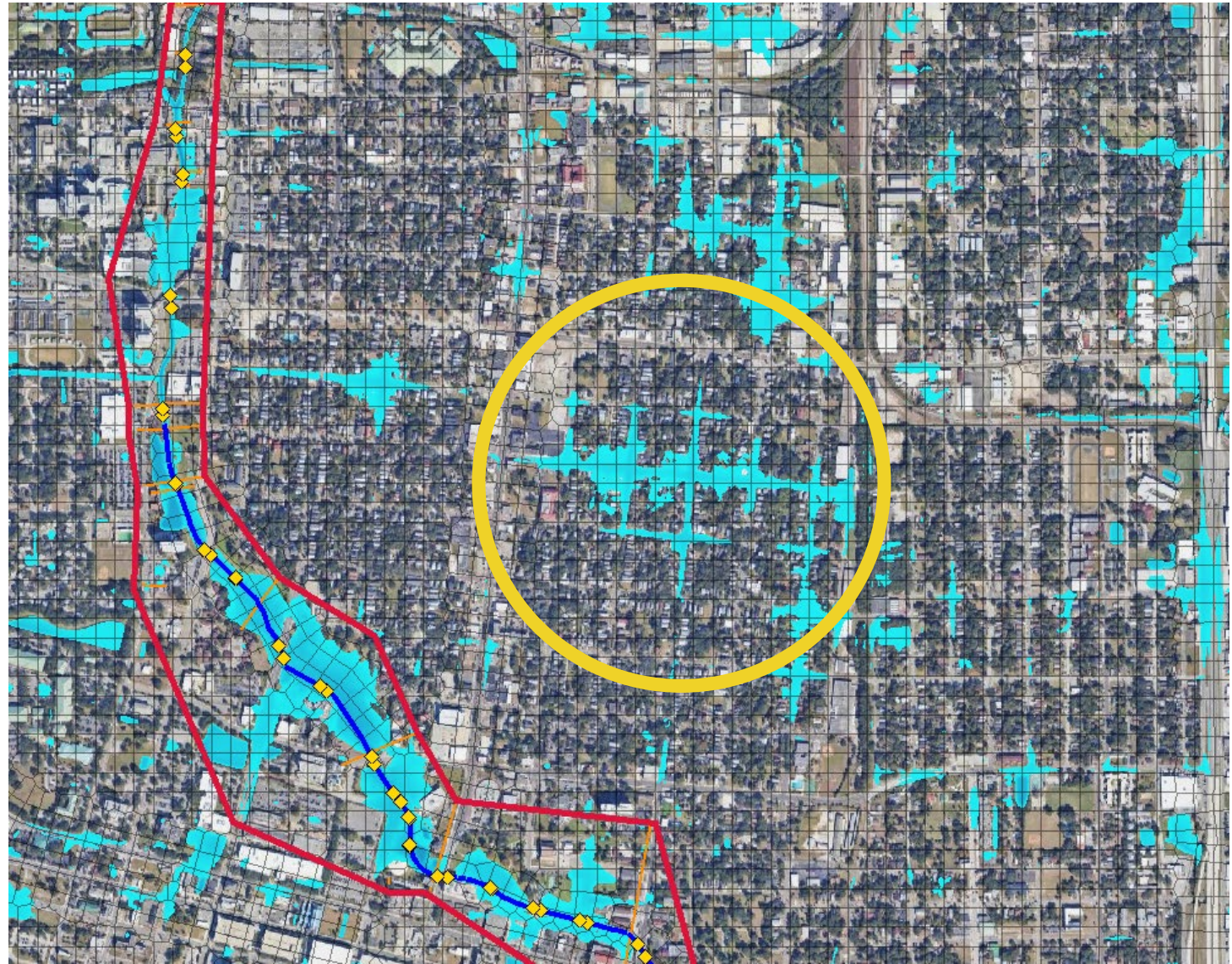
**TO SUPPORT A MORE
RESILIENT JACKSONVILLE**



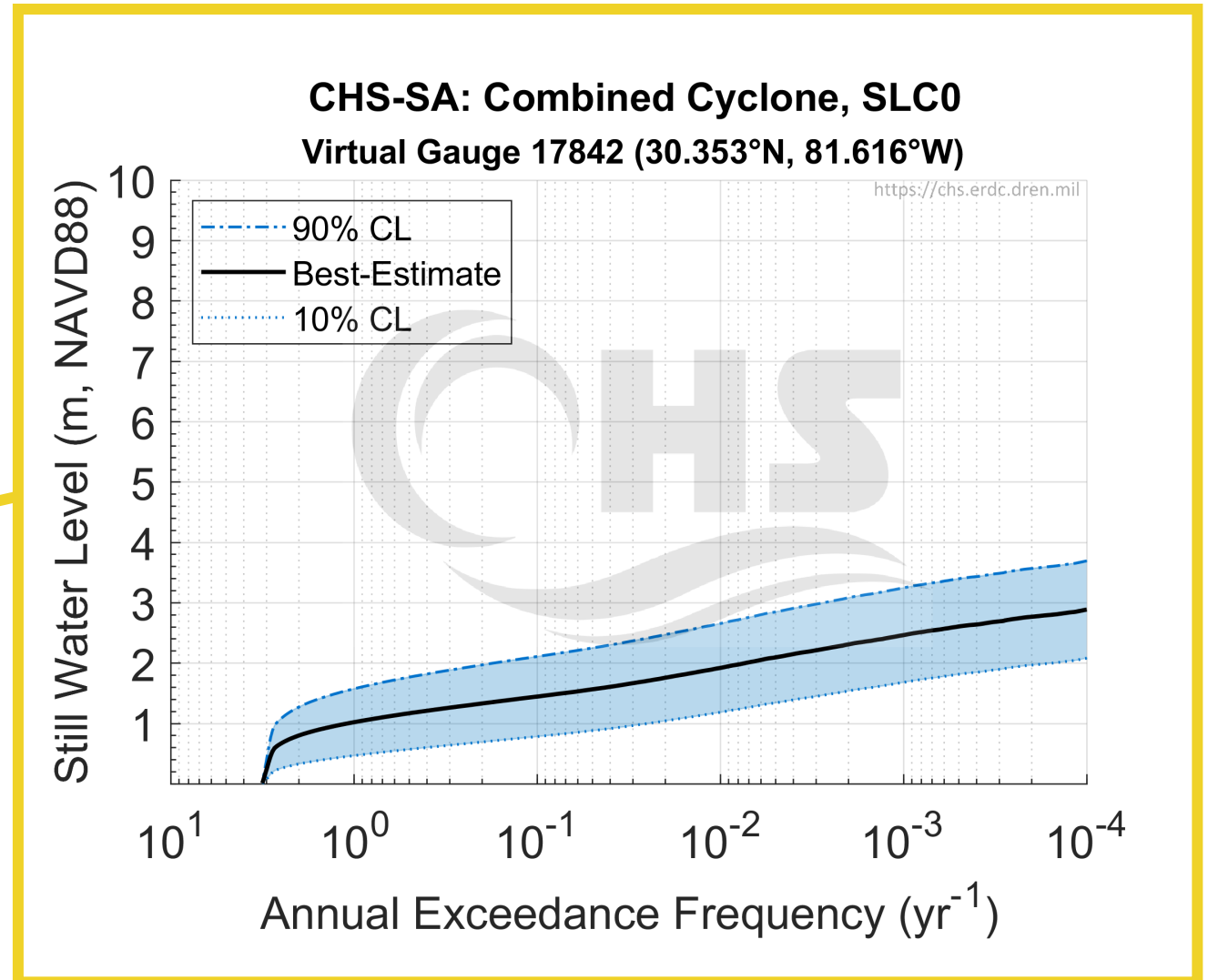
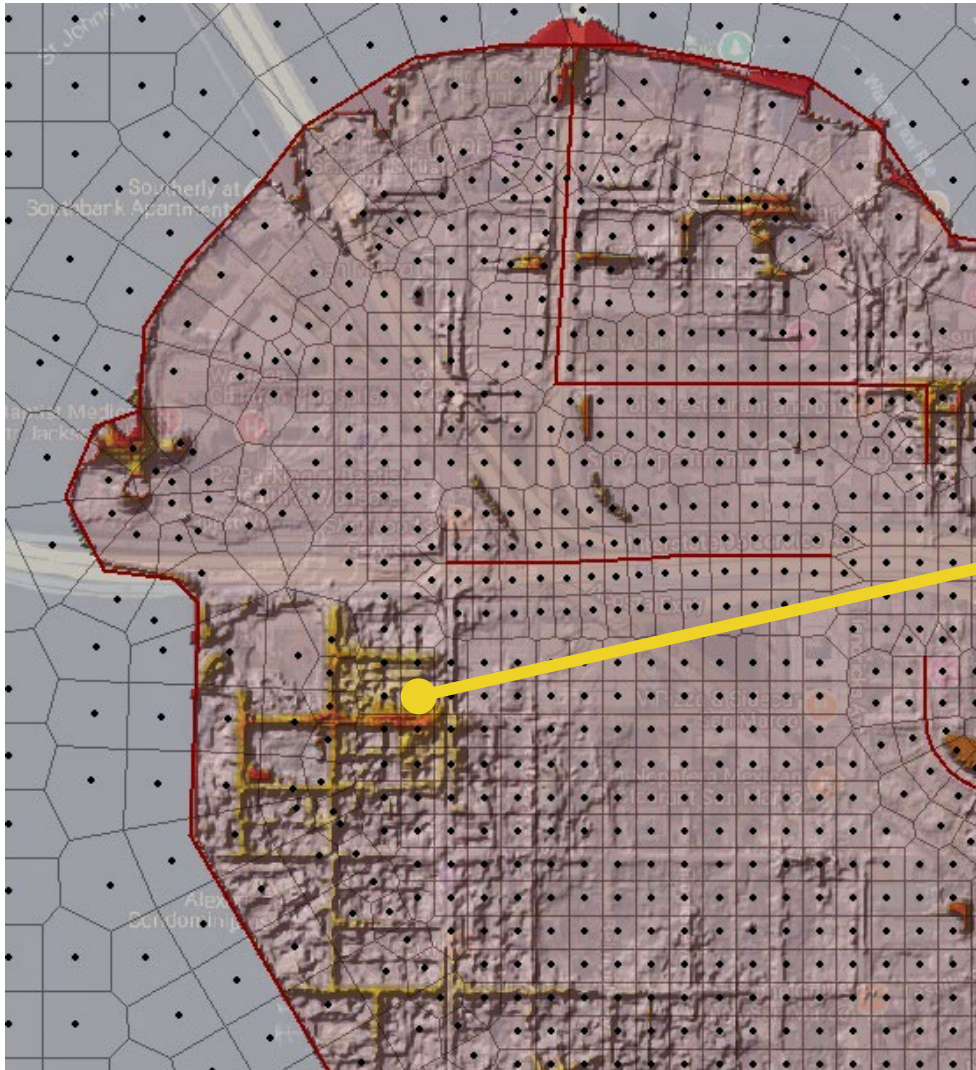
New detailed
models better
capture
complex flood
dynamics



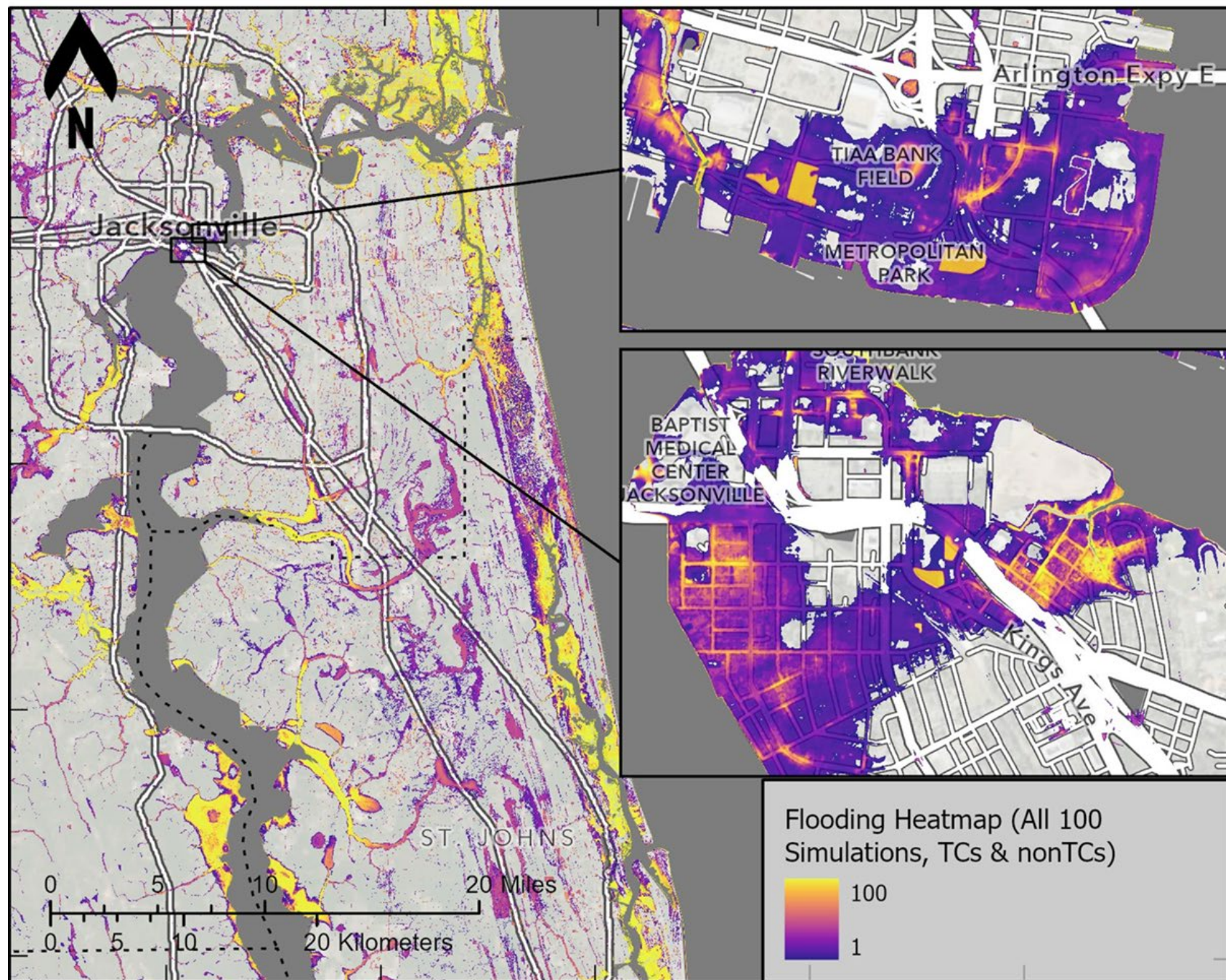
Compound
flood model
captures
localized
flooding not
included in
existing flood
data



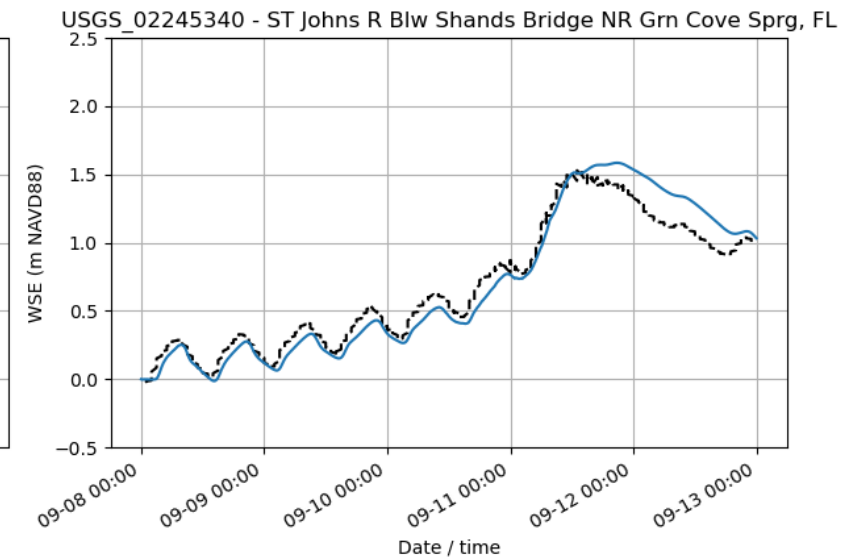
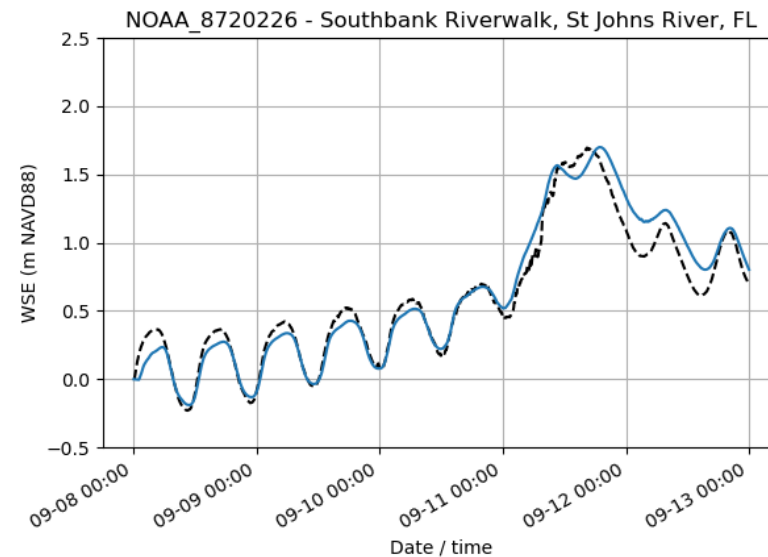
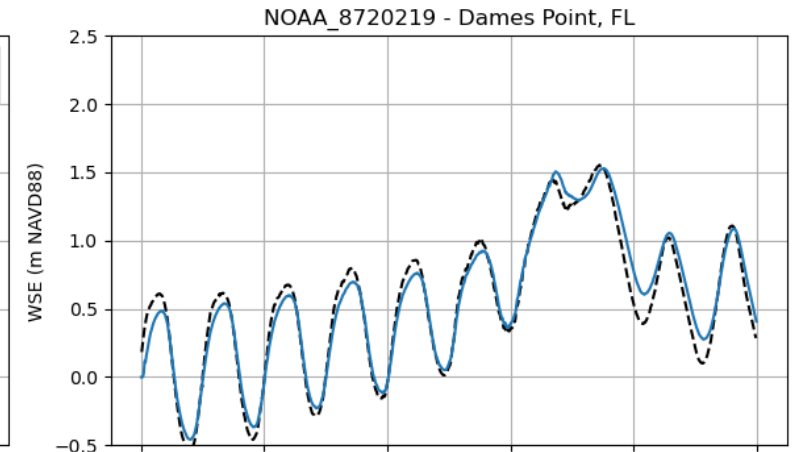
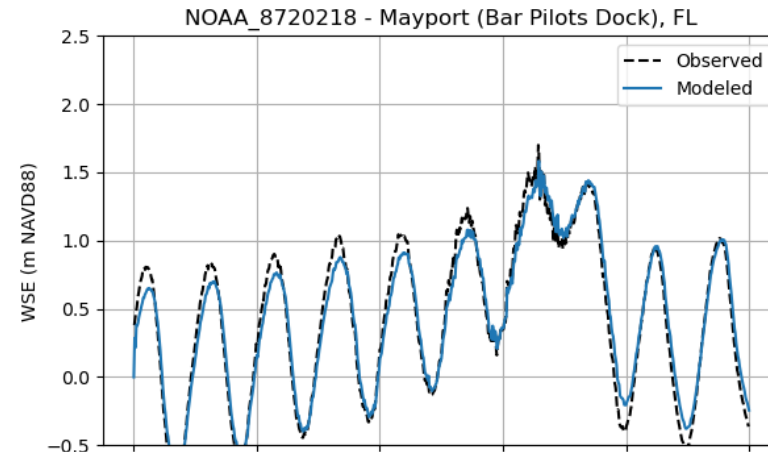
ESTIMATING COMPOUND FLOOD FREQUENCY AND SEVERITY



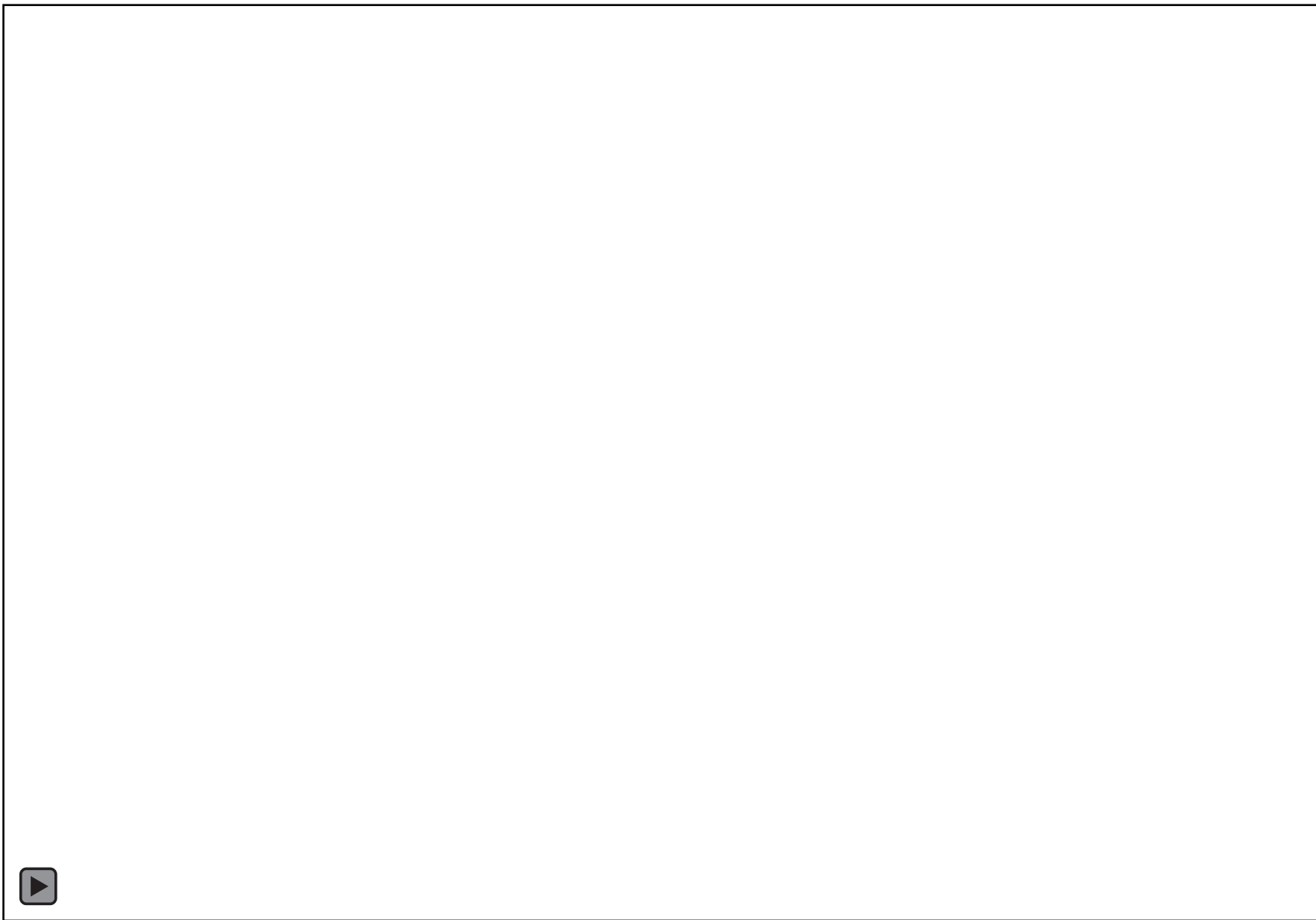
VISUALIZING RESULTS



MODEL PERFORMANCE: HURRICANE IRMA

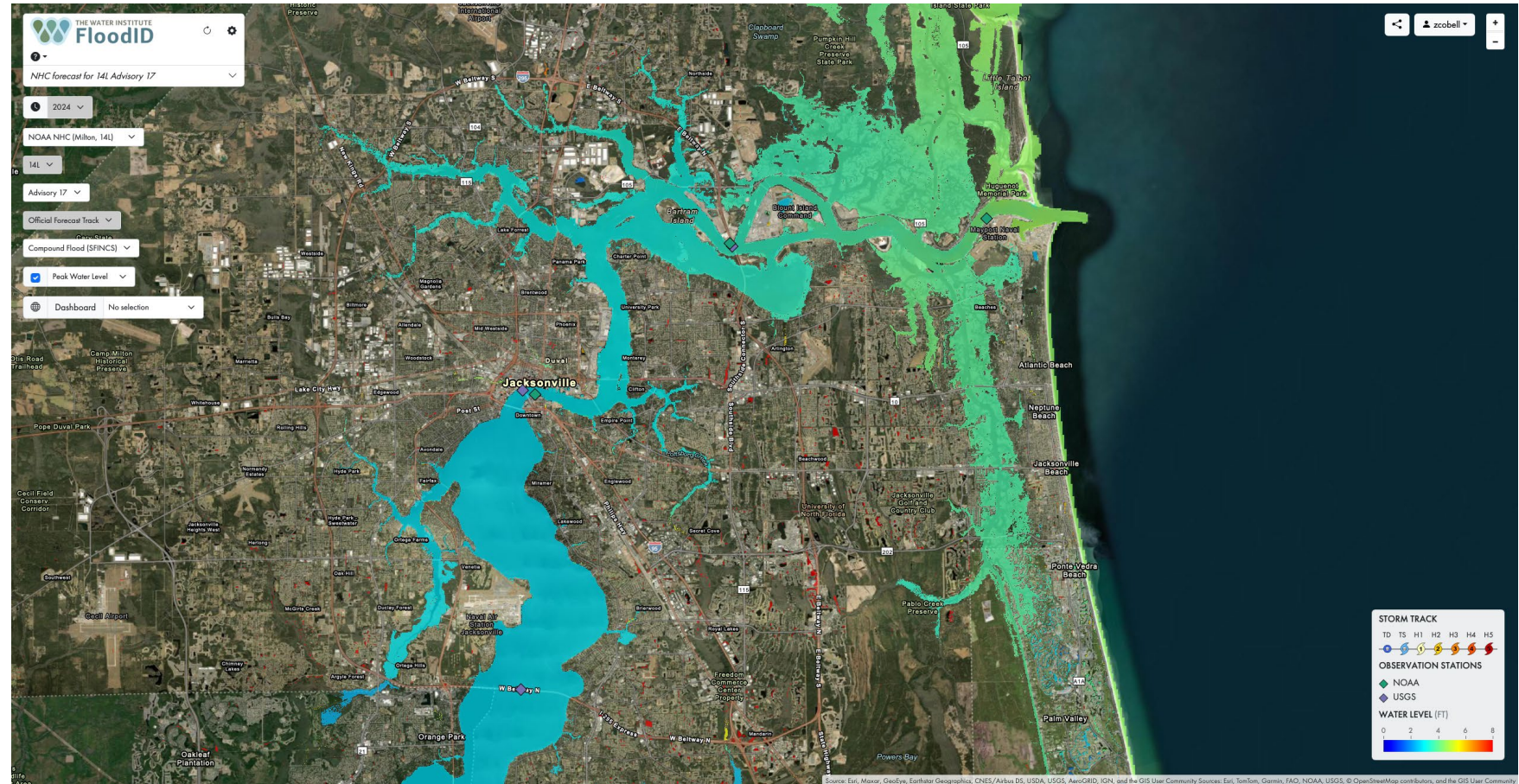


New modeling captures complexity of Hurricane Irma



FLOOD ID

- SFINCS Model
- Real-time forecasting
- Flooding extent, duration, and water depth



METEOROLOGICAL FORECAST: WIND AND PRESSURE FIELDS

Leverage NOAA
atmospheric pressure
and wind velocity,
which drive the
coastal storm surge
response



METEOROLOGICAL FORECAST: RAINFALL

NOAA rainfall
forecasts appropriate
to combine with
pressure and
wind forecast for
estimating compound
flooding



TROPICAL STORM SURGE MODELING

Using pressure/
wind forecast
data to estimate
storm surge and
wave conditions,
extents and
timing



COMPOUND FLOOD MODELING

Using rainfall and
streamflow data,
as well as storm
surge forecasts to
estimate compound
flooding



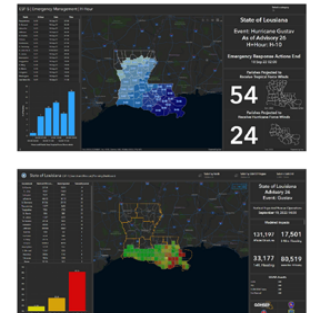
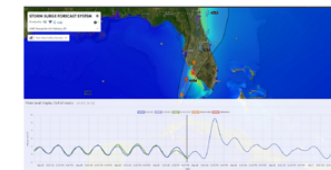
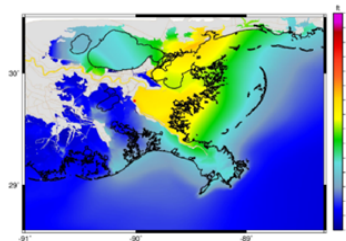
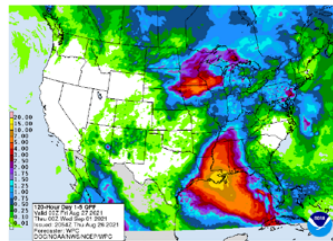
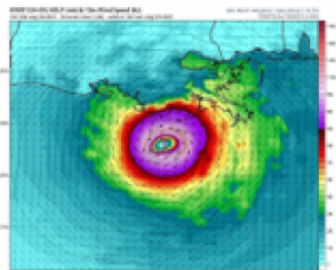
FLOOD EXTENT, DEPTH, AND TIMING VISUALIZATION

Visualize the
outputs from
tropical storm
surge modeling
and compound
flood modeling



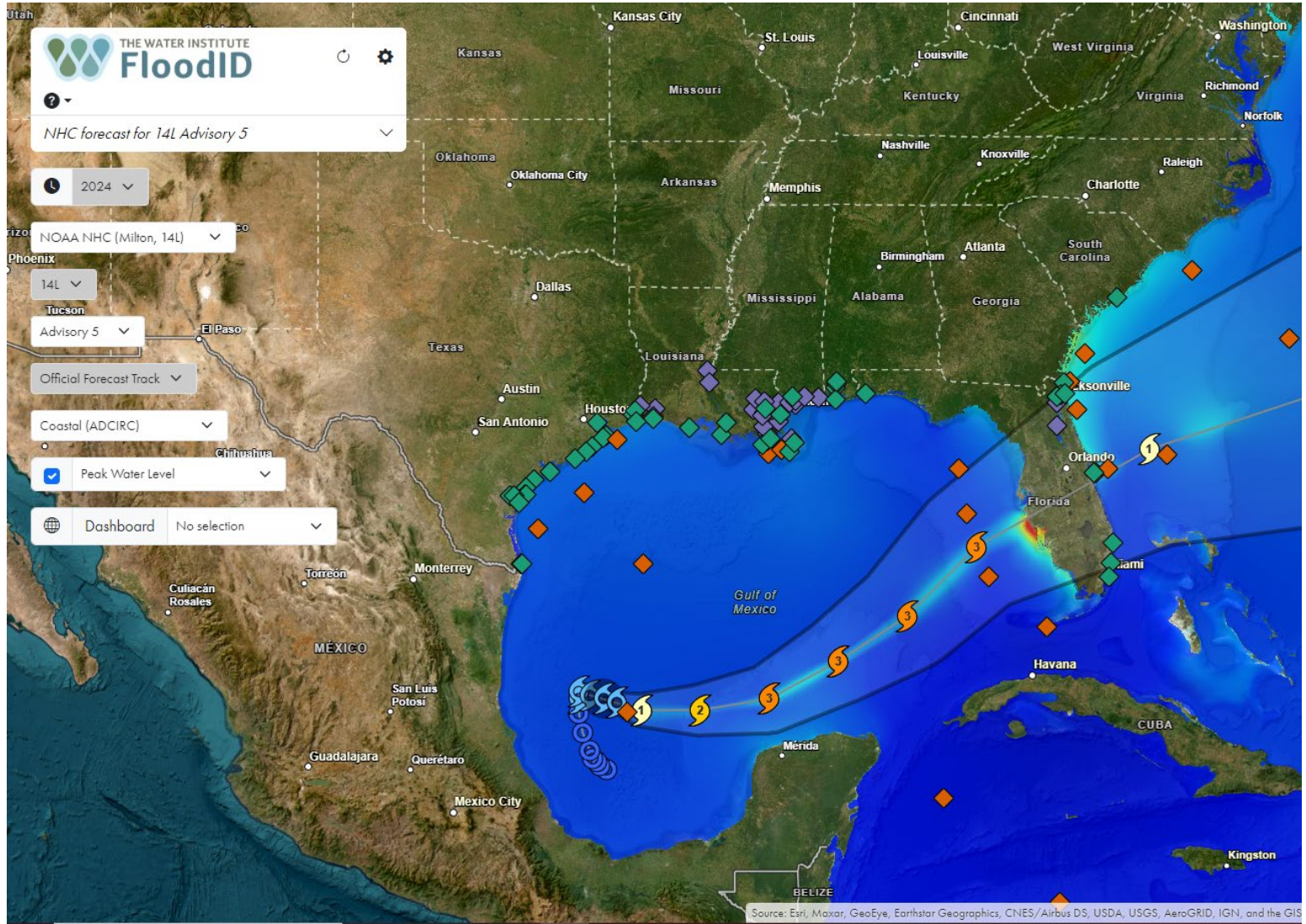
DECISION SUPPORT TOOLS

Custom set of
decision support
tools to meet
stakeholder-
specified needs



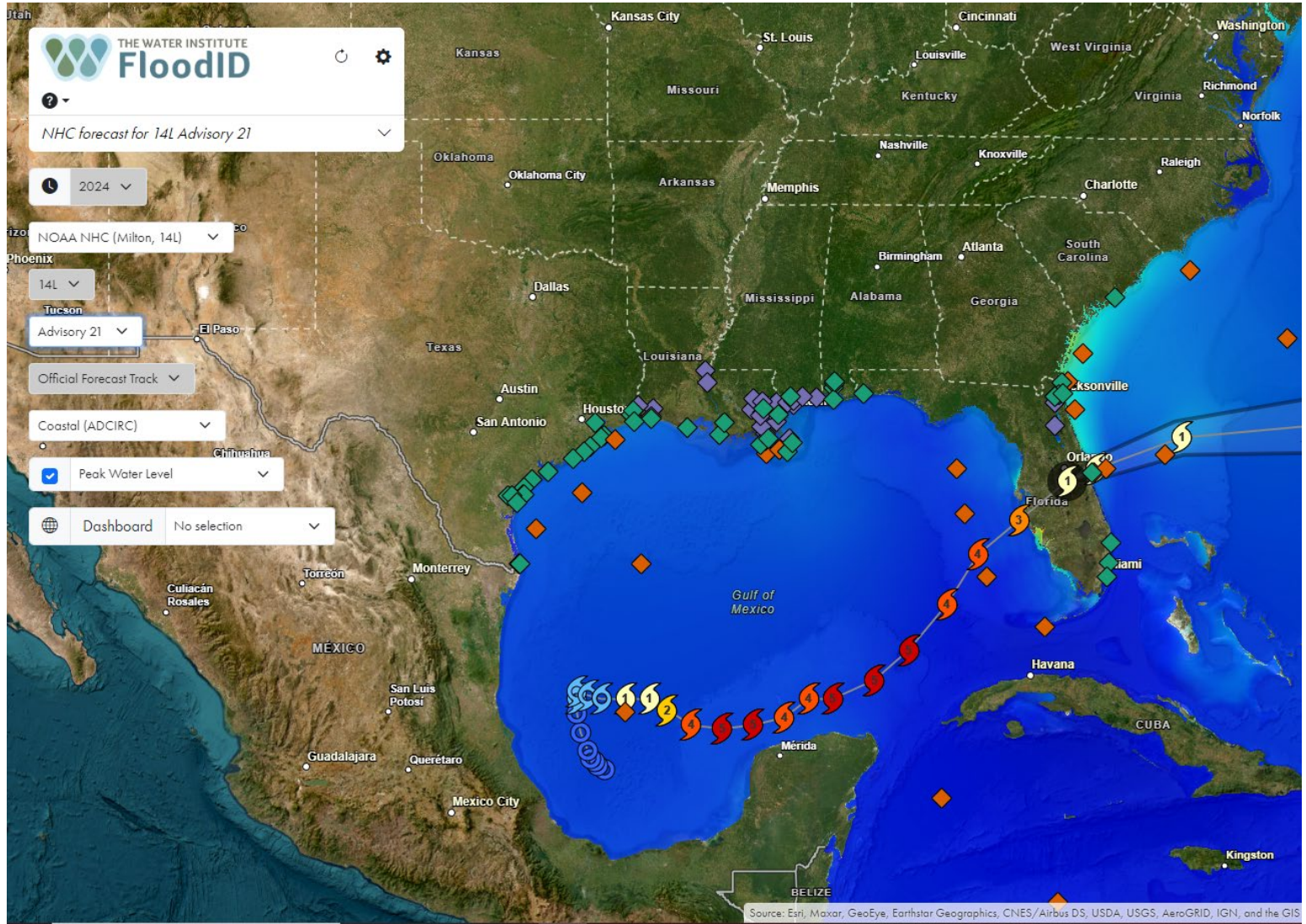
EMERGENCY RESPONSE:

Supporting real-time
decision making



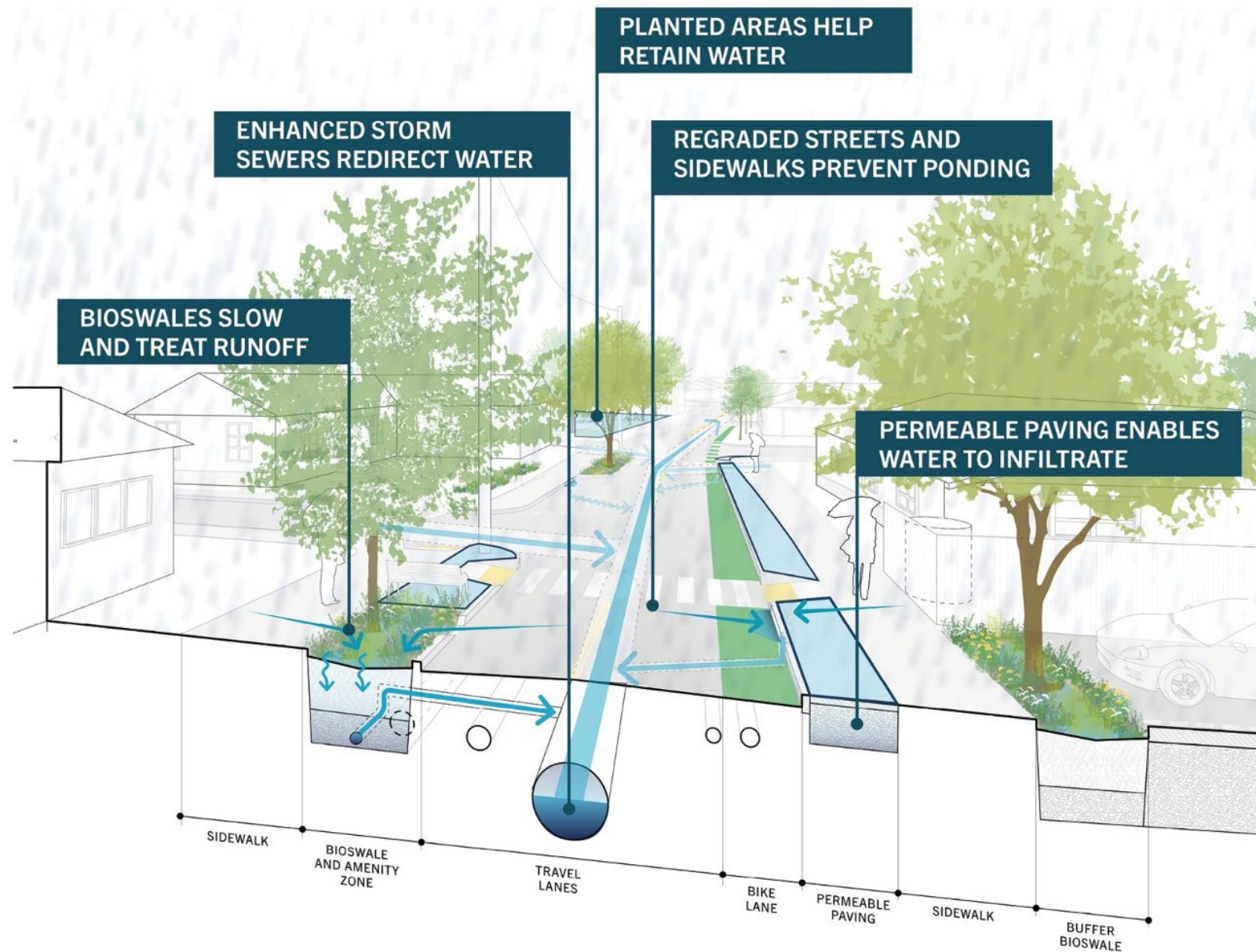
EMERGENCY RESPONSE:

Supporting real-time
decision making



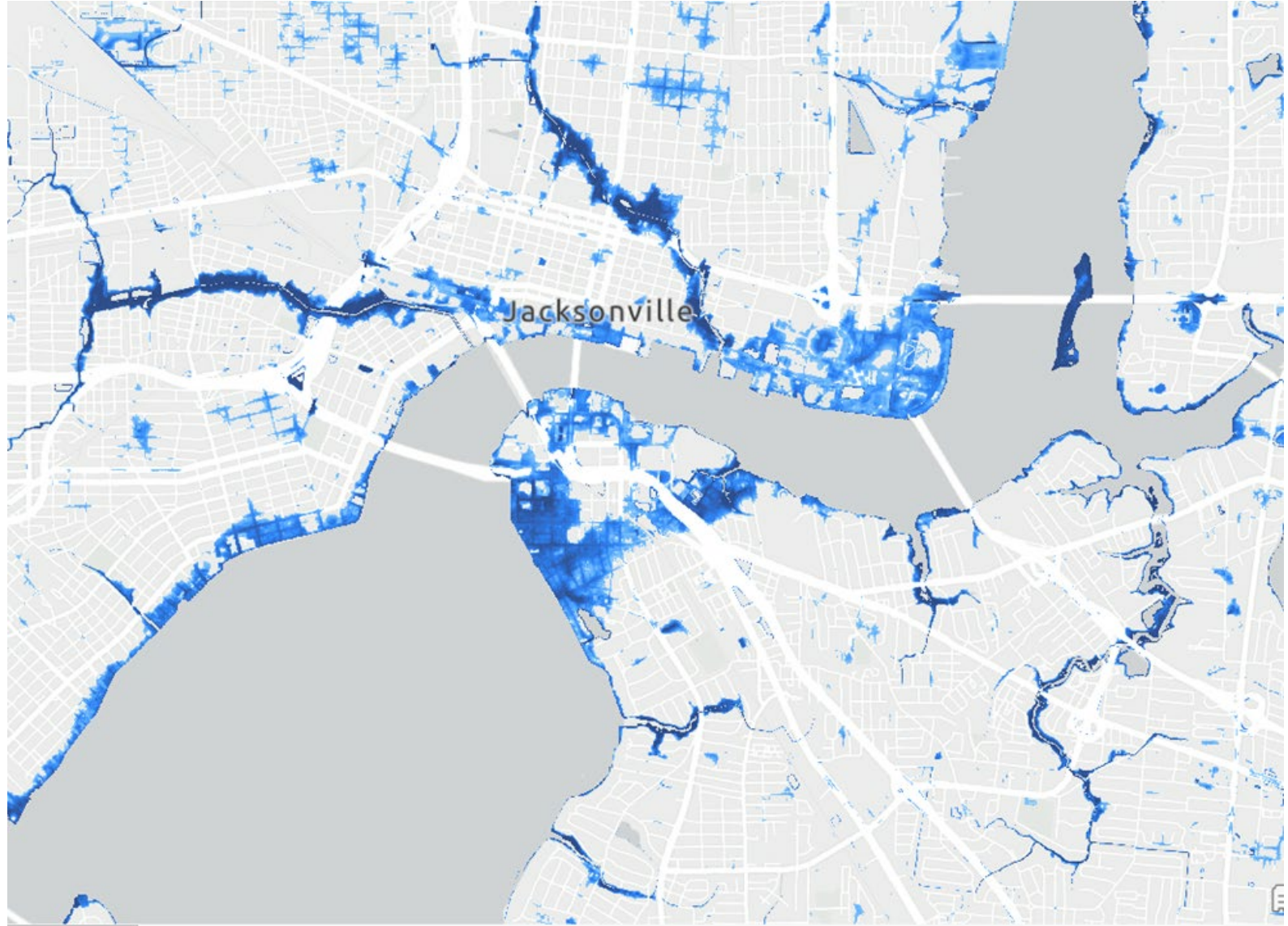
ENGINEERING & DESIGN APPLICATION:

Supporting resilient
infrastructure design



PLANNING APPLICATION:

Guiding future
growth in areas that
are low risk and well-
connected to
infrastructure





**DOWNLOAD THE STRATEGY
AND FOLLOW OUR PROGRESS**

resilientjacksonville.com