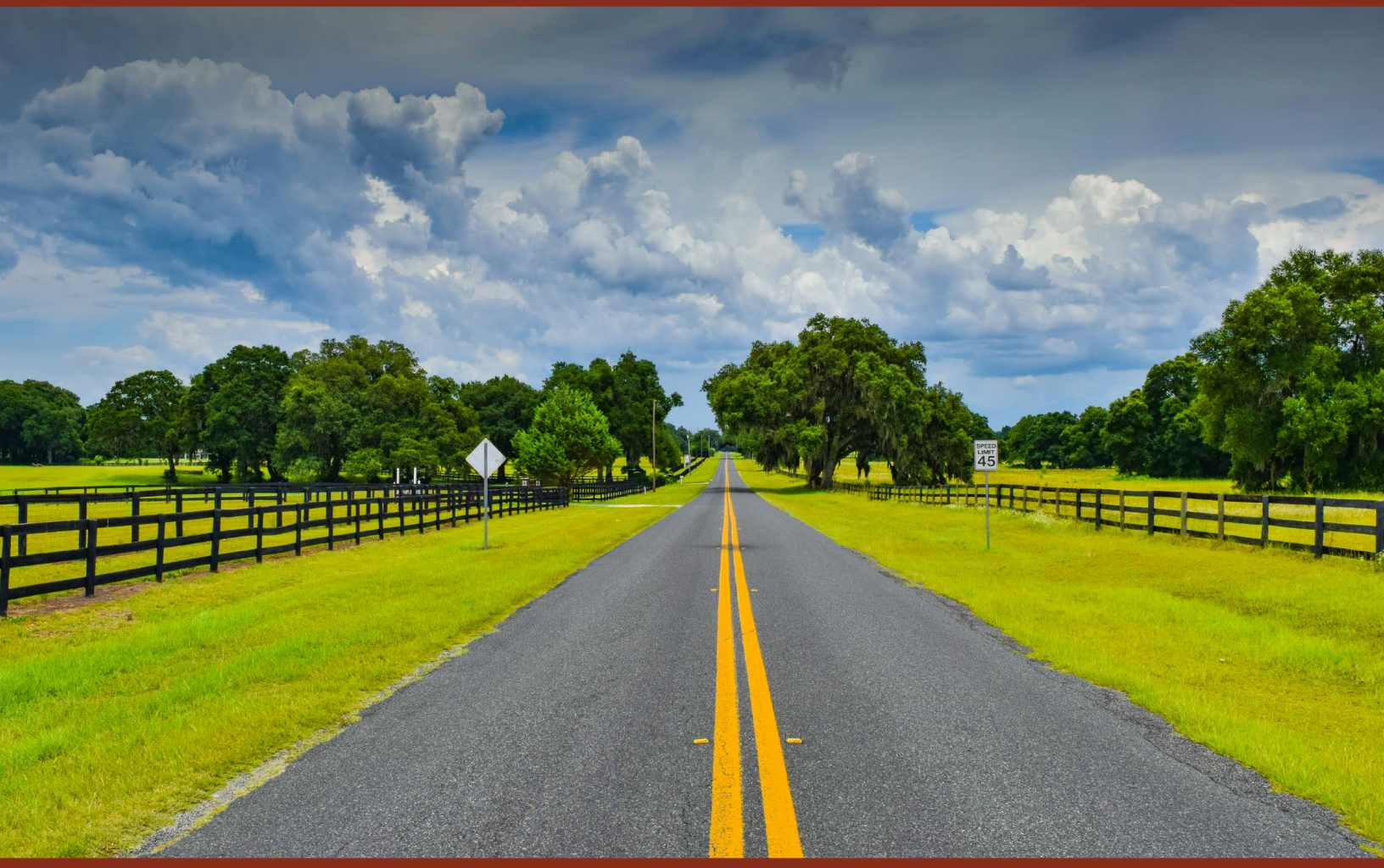
OCALA MARION TRANSPORTATION PLANNING ORGANIZATION

TRANSPORTATION RESILIENCE GUIDANCE



January 2022

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INTRODUCTION

The purpose of this guidance paper is to provide the Ocala/Marion County Transportation Planning Organization (TPO) and the residents of Marion County with a clear definition of Transportation Resilience, and an understanding of the opportunities and challenges of integrating resiliency into the transportation planning process. Specifically, this paper includes a review of federal policy, funding opportunities and peer area resiliency activities. The paper also explores at a cursory level some of the vulnerabilities to hazards present in Marion County, the exposure of the federal-aid transportation system to those vulnerabilities, and some potential mitigation strategies.

> FHWA defines resiliency as "the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions."

Resiliency is defined by the Federal Highway Administration (FHWA) as "the ability to anticipate, prepare for, and adapt to changing conditions and withtstand, respond to, and recover rapidly from disruptions."[1] In the broadly referenced sense of the term in transportation planning, "changing conditions" and "disruptions" are generally conceptualized more narrowly as sea level rise (SLR). There are, however, many potential disruptors, including both natural and man-made disasters, many of which are relevant to inland areas like Marion County. Some examples include:

- Flooding
- Sinkholes
- Wildfires
- Tornados
- Traffic crashes
- HazMat incidents

> I-75 FRAME makes the transportation system resilient to crashes, enabling it to function effectively when such incidents occur.

An example of a resiliency improvement recently implemented in Marion County is the Florida Department of Transportation (FDOT) I-75 FRAME project, which is designed to improve the resiliency and reliability of north/south travel in Marion County in the face of unpredictable traffic incidents by providing travelers real time information about incidents and facilitating detours. I-75 FRAME makes the transportation system resilient to crashes, enabling it to function effectively when such incidents occur.

1 *Integration of Resilient Infrastructure in the Emergency Relief Program - ER - Federal-aid Programs - Federal-aid Programs and Special Funding - Federal Highway Administration (dot.gov)*

US DEPARTMENT OF TRANSPORTATION (USDOT)

USDOT is the federal agency responsible for implementation of federal transportation policy, which includes working toward national goals established in legislation. TPOs are required to adhere to the guidelines set by USDOT in its rule making process, including consideration of a number of planning factors. Since passage of the FAST Act, resiliency is one of the planning factors that must be considered by TPOs in planning for transportation improvements. The Florida Department of Transportation, charged with implementing state transportation policy, maintains Planning Emphasis Areas that highlight key areas of specific importance to the State of Florida. Resilience is one of four emphasis areas established by FDOT in 2021.

This section focuses on the USDOT's guiding principles designed to inform and guide TPOs in future resiliency planning and a clearly defined series of steps to assess the vulnerability of the transportation system and address vulnerabilities with mitigation strategies.

US Department of Transportation Guidance

A more resilient transportation system is consistent with the USDOT Guiding Principles for Climate Change Adaptation set forth in June 2011. The USDOT's Guiding Principles for Climate Change Adaptations include the following:

- Integrate adaptation strategies to core policies, planning, practices and programs
- Prioritize vulnerable people, places, and infrastructure; implement meaningful involvement from "all parts of society" and address issues of inequality and environmental justice
- Use best available science and not be delayed waiting for complete understanding of climate change impacts; adjust plans/actions as better understanding becomes available
- Coordinate across multiple sectors, geographies, levels of govt; build on existing efforts/knowledge of wide range of stakeholders
- Apply risk management methods and tools because timing, likelihood, nature of climate risks difficult to predict; can aid in understanding potential consequences of inaction and risk reduction
- Apply eco-system based approaches to integrate biodiversity and ecosystem services into adaptation strategies which will increase resilience of human and natural systems to climate and non-climate risks, providing benefits to society and the environment
- Maximize mutual benefits by using strategies that complement, support other related climate/env. Initiatives
- Continuously evaluate performance through measure goals and performance metrics to assess whether adaptive actives are achieving desired outcomes (qualitatively and quantitatively)

Prior to passage of the Infrastructure Investment & Jobs (II&J) Act, US DOT guidance, and FEMA funding requirements for emergency operations, the Federal Highway Administration (FHWA) established FHWA Order 5520 – Transportation System Preparedness and Resilience to Climate Change and Extreme Weather Events in 2014. It is a directive to establish policy on preparedness and resilience to climate change and extreme weather events to comply with Executive Order 13653, Preparing the United States for the Impacts of Climate Change (EO 13653)(2013), and advance the U.S. Department of Transportation (DOT) Policy Statement on Climate Change Adaptation. The directive considers the transportation-specific impacts of climate change, such as:

- SLR/storm surge inundates coastal roads not historically inundated, necessitate more evacuations, require costly, recurring repairs
- Inland flooding from precipitation disrupts traffic, damage culverts, reduce service life
- Heat degrades materials costing more in maintenance and frequent replacement cycles

FHWA's policy is to identify risk of climate change and extreme weather events on existing and planned transportation systems, and it expands the scope beyond coastal areas and water-related resiliency efforts to include various hazards and impacts on inland areas.

FHWA's policy is to identify risk of climate change and extreme weather events on existing and planned transportation systems, and it expands the scope beyond coastal areas and water-related resiliency efforts to include various hazards and impacts on inland areas. FHWA managers are responsible for encouraging State departments of transportation (DOT), metropolitan/transportation planning organizations (MPO/TPO), Federal land management agencies (FLMAs), tribal governments, and others to practice resiliency planning. Recommended resiliency practices are to develop, prioritize, implement and evaluate risk-based and cost-effective strategies to minimize climate and extreme weather risks and protect critical infrastructure using the best available science, technology and information. Under this directive, FHWA managers are responsible for developing and providing technical assistance, research, and outreach, and encouraging the development and use of transportation-specific vulnerability assessment and adaptation tools. They must report on progress through the US DOT Adaptation Plan and internal FHWA strategic planning activities.

Furthermore, existing funding streams through the Federal-Aid and Federal Lands Highway Program describes the eligibility of activities to adapt to climate change and future weather events. Generally, activities to plan, design, and construct highways to adapt to current and future climate change and extreme weather events are eligible for reimbursement under the Federal-aid program and for funding under the Federal Lands program.

The Hillsborough TPO included climate resilience analysis in their transportation plan, finding that adaptation actions would cost $31M, but avoid $265M in losses.

The FHWA allows DOTs, MPOs, local agencies, and Federal land management agencies to use aid and funds to consider impacts and apply adaptation strategies at project and system levels. Eligible activities include:

- Vulnerability and risk assessments of Federal aid-eligible highways related to climate change and extreme weather events
- Consideration of climate change and extreme weather events in highway project development, environmental review and design work
- Construction of projects or features to protect existing eligible assets from impacts and damage associated with climate change and extreme weather events
- Evaluation of potential impacts of climate change and extreme weather events on asset management cycles, life cycle costs, etc.

Under the FHWA's overall sustainability initiative, the Building Resilient Transportation law passed in 2015 requires inclusion of resilience as a planning factor and for metropolitan areas to develop resilience strategies. As one specific outcome of this, the Hillsborough TPO included climate resilience analysis in their transportation plan, finding that adaptation actions would cost $31M, but avoid $265M in losses. As part of building resilient transportation, the FHWA provides guidance to incorporate climate risks into design and asset management, which identifies sequence of actions to manage and preserve assets over the long-term, including asset inventory, evaluation of risks to assets, and prioritization of capital improvements to make them more resilient to future environmental conditions.

In August 2021, USDOT developed a Climate Action Plan establishing a policy statement to address climate change through a science based approach. The plan also recognizes the need to use an equity lens to ensure the most vulnerable populations are protected and that both community and global planning are critical to mitigating the impacts of climate change. The plan advances a range of actions, including infrastructure improvements, long range planning, research and education.

FHWA Vulnerability Assessment and Adaptation Framework

In an effort to assist DOTs, MPOs, tribal governments, and land management agencies plan for a more resilient transportation system, the FHWA has developed a Vulnerability Assessment and Adaptation Framework (Framework) detailing key steps to assessing the resiliency vulnerability of an area. The Framework describes primary steps to conduct a vulnerability assessment under seven key steps:

1. **Articulate objectives and define scope** — includes recognizing which hazards and specific assets will be analyzed in light of time and financial constraints.

2. **Obtain asset data** — major assets like roadways and bridges are typically available at the transportation agencies, but other smaller assets such as culverts might require interagency/interorganizational collaboration to obtain or collect.

3. **Obtain climate data** — data on current and future climate conditions can be obtained for commonly studied climate variables like temperature, sea level, hydrology, storm surge; starting with basic projections.

4. **Assess vulnerability** — through exposure which refers to whether an asset or system is located in an area experiencing direct effects of climate change; sensitivity refers to how the asset or system fares when exposed to a climate variable; and adaptive capacity refers to the system's ability to cope with existing climate variability or future climate impacts. Risk is a measure that considers both the probability that an asset will experience a particular impact and the severity or consequence of the impact.

5. **Identify, analyze, and prioritize adaptation options** — adaptation solutions can be natural, structural, or policy-based and can range from site-specific to regional. The multi-criteria analysis (MCA) and economic analysis. MCA involves comparing adaptation options across a range of qualitative and quantitative criteria.

6. **Incorporate assessment results in decision making** — the Framework provides options to include strategies into transportation planning, projects development and environmental review, project-level design and engineering, transportation systems management, and asset management.

7. **Lastly, monitor and revisit** — as new climate science becomes available, it may be necessary to revisit assumptions, underlying data, and approaches used in the original vulnerability assessment; overall, understanding climate risks changes over time and an iterative process to monitor and evaluate is standard practice.

As part of the Ocala-Marion TPO Transportation Resiliency Guidance Paper, the vulnerability of the Federal-aid transportation system to select natural hazards are identified, building upon past data and findings from the LMS.

PEER STUDIES AND CURRENT TRANSPORTATION RESILIENCY PRACTICES

DOTs and TPOs/MPOs throughout the United States have completed resiliency planning efforts to identify vulnerabilities in their regional transportation systems and develop adaptation and mitigation strategies for hazards including storms, wildfire, flooding, and sea level rise, to name a few. The generalized steps in the resiliency planning process include the Identification of hazards and vulnerable infrastructure, assessment of vulnerabilities, and identification and programming of mitigation strategies.

Table 4 lists peer agencies that have completed vulnerability analyses and implemented resiliency planning approaches to varying extents. In addition to MPO/TPO peers, it includes state DOTs and other transportation agencies' works in transportation resiliency. Five of the peer areas reviewed represent landlocked regions or states, emphasizing the relevance of resiliency planning for non-coastal areas.

As the peer agencies and case studies demonstrate, there are different ways to develop resiliency plans and mitigation strategies beyond identifying the hazards currently or potentially impacting a region. Various agencies in the state of Florida and across the country are at different stages in their resiliency planning efforts, and in the types of mitigation strategies that have been employed. These range from policy and programmatic approaches to hardening infrastructure or developing green infrastructure. Of the peer areas reviewed, three have completed the full spectrum of resiliency planning from hazard definition through funding strategies, and an additional five agencies are completing the majority of the steps, short of identifying funding and programming improvements. As rule-making to implement the new federal infrastructure law takes shape, more will likely advance their resiliency planning activities to meet federal requirements and compete for grant funding opportunities. More detailed information about selected peer areas with distinct features of their resiliency planning efforts are detailed in Appendix A.

FIGURE 1. AREAS REVIEWED FOR RESILIENCY

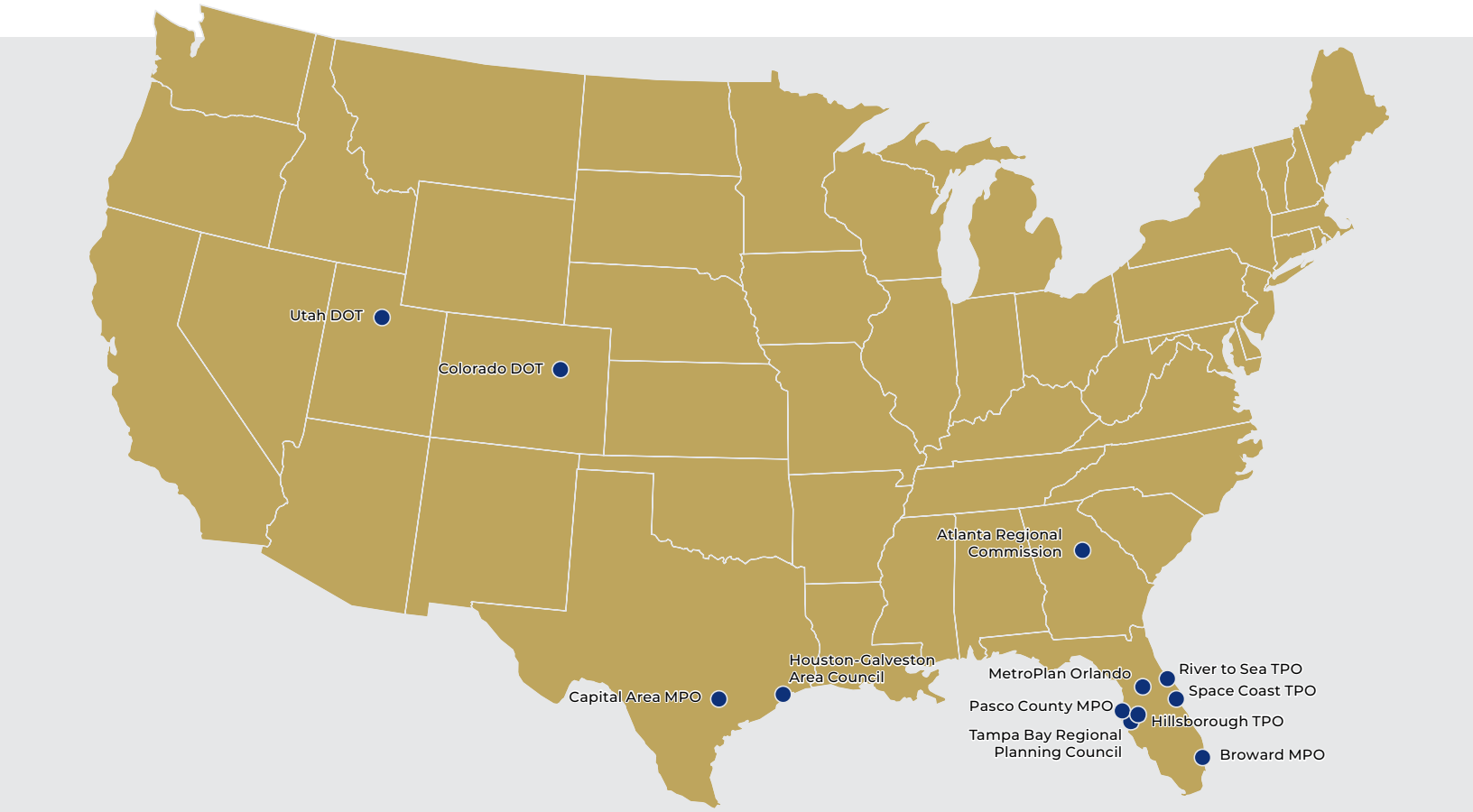

TABLE 1. PEER AGENCIES RESILIENCY EFFORTS

Agency/ Location	Plan	Description	Resiliency Actions				
			Defines Hazards	Identifies Critical Roadways	Assesses Vulnerabilities/ Exposure	Develops Mitigation Strategies	Specifies Funding Sources
Space Coast TPO Brevard County, FL	Transportation Resiliency Master Plan	Defines six unique shocks/stressors and their impact on roadways critical to the communities in Brevard County; develops mitigation strategies.	●	●	●	●	●
River to Sea TPO	SLR Vulnerability Assessment	Identified exposure/vulnerability to evacuation routes, major roadways, trails, and stormwater storage assets.	●		●		
MetroPlan Orlando	2045 Long Range Transportation Plan	Used scenario planning to identify potential risks and how they can impact the region. MetroPlan Orlando chose six key drivers of change: Population, Economy, Visitation, Development & Land Use, Technology, and Climate. These drivers were used to form four scenarios, to help guide the planning and needs assessment.	●				

Agency/ Location	Plan	Description	Resiliency Actions				
			Defines Hazards	Identifies Critical Roadways	Assesses Vulnerablities/ Exposure	Develops Mitigation Strategies	Specifies Funding Sources
Broward MPO Broward County, FL	South Florida Climate Change Vulnerability Assessment and Adaptation Pilot Project	Examined SLR, inundation, storm surge flooding, and heavy precipitation induced flooding. Identify adaptation analysis capability, identify adaptation projects and strategies, apply a vulnerability framework and provide feedback to the planning process. Recommends formalization of proposed performance measures.	●	●	●	●	
Broward MPO Broward County, FL	Extreme Weather and Climate Change Risk to the Transportation System in Broward County, FL	Second study led by Broward MPO, that provides more detail about long-term effects of climate change on transportation based on existing scenario/projections data. Develops actions to refine understanding of risks over time.	●	●	●	●	
Hillsborough TPO Tampa, FL	Resilient Tampa Bay: Transportation Pilot Program Project	Tampa Bay region's exposure/ vulnerability to storms/surge, SLR, and flooding challenges and provides mitigation/adaptation strategies for inclusion in LRTP updates; provides high-level per-mile costs of adaptation strategies.	●	●	●	●	●
Pasco County MPO Pasco County, FL	Scope for Resilient PASCO Vulnerability Assessment and Sustainability & Resiliency Plan	Defines resiliency through continuation of fundamental services, or "community lifelines". Seeks to complete a vulnerability assessment and action items.	●	●	●	●	●
Tampa Bay Regional Planning Council Tampa, FL	Tampa Regional Resiliency Action Plan	Five-year roadmap focused on risk reduction and adaptation actions to anticipate and prepare for sea lever rise, storms, flooding, and extreme heat. Defines goals and objectives for resiliency.	●				

Agency/ Location	Plan	Description	Resiliency Actions				
			Defines Hazards	Identifies Critical Roadways	Assesses Vulnerablities/ Exposure	Develops Mitigation Strategies	Specifies Funding Sources
Capital Area MPO Austin, TX	2040 Regional Transportation Plan/ Extreme Weather and Climate Change Vulnerability Assessment of Central Texas Transportation Infrastructure	Summarizes climate related risks to the region's transportation system and identifies potential measures that can be implemented to increase resiliency.	●	●	●		
Colorado DOT Colorado	2020 Risk and Resiliency Analyis Procedure	Defines a criticality model to assess risk of flooding, rockfall, and fire; create a criticality index and develops calculations to assess partial and full road closures and other user costs.	●	●	●	●	
Atlanta Regional Commission Atlanta, GA	Vulnerability and Resiliency Framework for the Atlanta Region	Developed a vulnerability and resiliency framework that can be used as part of a system vulnerability assessment to track over time; suggested performance measures are defined.	●	●	●	●	
Utah DOT Utah	UDOT's Risk and Resiliency Initiative	Created a weighted system for criticality based on AADT, freight AADT, AASHTO Road Classification, Tourism $2015, and Maintenance Crew Miles. Developed a risk management process to assess critical corridors. Incorporates risk & resiliency in corridor planning process.	●			●	
Houston-Galveston Area Council Texas	Resilience and Durability to Extreme Weather in the H-GAC Region Pilot Program Report	To address threats posed by extreme flood events, storm surge, and sea level rise in the region, the Houston-Galveston MPO assessed the criticality and vulnerability of regional transportation assets to extreme weather events, developed strategies to make the transportation more resilient, and identified project criteria based on past work.	●	●	●	●	

FEDERAL GUIDANCE & FUNDING

The Ocala-Marion Transportation Planning Organization (TPO) reviews and administers policies for state and federal transportation funding. The 2021 Infrastructure Investment & Jobs (II&J) Act provides funding for surface transportation infrastructure planning and investment. The II&J Act requires consideration of a number of national goals and emphasis areas in TPO plans and programs. Beyond safety, mobility, and infrastructure condition provisions and guidance, the II&J Act expands the planning focus on resiliency planning. The resiliency provisions in the II&J Act include almost $50 billion for resiliency planning and mitigation, including the Promoting Resilient Operations for Transformative, Efficient, and Cost-saving Transportation (PROTECT) grant program, which provides $8.7 billion in grants to states and local communities for transportation infrastructure resilience projects. The new law also allocates $3.5 billion for FEMA's Flood Mitigation Assistance (FMA) program and $1 billion to FEMA's Building Resilient Infrastructure and Communities (BRIC) program, to assist local communities with hazard mitigation improvements.

The FEMA BRIC program has $1B available for Fiscal Year 2021. The program aims to categorically shift the federal focus away from reactive disaster spending and toward research-supported, proactive investment in community resilience. For Fiscal Year 2020, the 22 large, competitive projects that were awarded funding were organized into seven categories of primary activity type, including: Elevation, Flood Control, Floodproofing, Relocation, Saferoom/Shelter, Utility and Infrastructure Protection, and Wildfire Management. BRIC funds can be used for capability & capacity-building activities, mitigation projects, and management costs. Capability & capacity-building activities include building code activities, partnership activities, project scoping, mitigation planning and planning-related activities. The criteria used to select BRIC funded projects include:

- Cost effectiveness
- Reduction/elimination of risk and damage from future natural hazards
- Consistency with relevant consensus-based codes, specifications and standards
- Alignment with applicable hazard mitigation plans
- Consistency with relevant environmental and historic preservation requirements

The cost share for BRIC funding is 75 percent Federal and 25 percent non-Federal, although economically disadvantaged rural communities are eligible for increased federal cost share. These are communities with 3,000 or fewer individuals

In Fiscal Year 2020 FEMA received **1,227 subapplications** that requested an estimated **$4 billion** in funding across the BRIC and FMA grant programs.

Projects selected in the FY 2020 BRIC grants included:

- **12** FLOOD CONTROL
- **1** WILDFIRE
- **4** UTILITY/ INFRASTRUCTURE
- **1** ROADWAY ELEVATION
- **2** RELOCATION
- **1** SHELTER
- **1** FLOODPROOFING

and an average per capita annual income that does not exceed 80% of the national per capita income. Projects selected in the FY 2020 BRIC grants included 12 flood control projects, 4 utility and infrastructure protection projects, 2 relocation projects, and one each of roadway elevation, floodproofing, shelters, and wildfire projects. Another part of the Hazard Mitigation Grant Program is the FEMA FMA Grant program. This program is for projects that reduce or eliminate the risk of repetitive flood damage to buildings insured by the National Flood Insurance Program. State, local, and tribal governments must develop and adopt hazard mitigation plans as a condition for receiving non-emergency disaster assistance. For Fiscal Year 2021, $160 million is available for funding.

Top five project types (by cost) funded with BRIC in 2020:

1. Flood Control **$550 million**
2. Utility/ Infrastructure Protection **$91.3 million**
3. Wildfire Management **$49.3 million**
4. Relocation **$21.9 million**
5. Safe Room/ Shelters **$15.2 million**

The FEMA HMGP offers funds for any sustainable action that reduces or eliminates long-term risk to people and property from future disasters. On August 2021, President Biden announced $3.46 billion in funding to reduce the effects of climate change. The types of projects eligible for HMGP funding include the following:

- Retrofitting existing buildings, making them less susceptible to damage from variety of natural hazards
- Purchasing hazard prone property to remove people/structures
- Utility and infrastructure retrofits
- Drainage improvements and slope stabilization
- Developing/adopting hazard mitigation plans
- Aquifer storage and recovery, floodplain and stream restoration, flood diversion and storage, or green infrastructure methods to reduce the impacts of flood and drought

There is a tiered funding system for federal assistance based on project costs, which includes up to 15% (Federal assistance) for first $2 billion; 10% for $2—$10B; up to 7.5% for $10—$35.3B; and for states with enhanced mitigation plans, up to 20% not to exceed $35.3B. To receive these funds, states, DC, US territories, and tribal governments must have a FEMA-approved Hazard Mitigation Plan in place by the application deadline.

The HGMP Post Fire Grant also exists to plan and develop projects that mitigate the risks and impacts of wildfires. Projects are required to be cost-effective (using FEMA's benefit-cost analysis software tool) or meet specific criteria deemed to be cost-effective. Pre-calculated benefits of $5,250/acre are available for post-wildfire mitigation projects, including soil stabilization, flood diversion, reforestation projects.

STATE FUNDING OPPORTUNITIES

Funding opportunities for resiliency are also available at the state level through various grant programs. In 2021, Governor DeSantis signed the first piece of legislation dedicated to resiliency planning in Florida. Senate Bill 1954 establishes the Resilient Florida Grant Program, which is administered by the Florida Department of Environmental Protection (DEP).

The Resilient Florida Grant Program establishes a statewide resiliency planning and grant program for local and regional entities to complete resiliency analyses, plans, and implement resiliency mitigation projects. The new law also establishes a research program through the University of South Florida (USF) College of Marine Science. Another feature of the new law is a requirement for the Office of Economic and Demographic Research to conduct an annual statewide assessment of water resources and conservation lands. The assessment must include analysis of the economic impacts of local, regional, and state expenditures on inland and coastal flooding mitigation.

Statewide Planning

Under the new law, the DEP will complete a comprehensive statewide flood vulnerability and SLR data set and assessment. The intent of the initial database development is to establish a baseline, which will be used to track sea level rise and will be updated every five years. The database will include SLR projections in both inland and coastal communities and flooding risk. The DEP will complete a statewide assessment using the database to identify vulnerable infrastructure and establish an inventory of critical infrastructure assets. Other requirements established by the legislation include:

- DEP will submit Statewide Flooding and Sea Level Rise Resilience Plan to governor and Legislature.
- Statewide plan will be updated and resubmitted annually on December 1st.
- Plan will include a three-year horizon with ranked projects to address flooding and sea level rise.
- DEP will assess projects based on a four-tiered scoring system specified in bill.
- Funding cannot exceed $100M in one year and is subject to review and appropriation by Florida Legislature.
- Counties, municipalities, and regional entities must submit proposed project lists to DEP for inclusion in plan (specifically related to water supplies/resources).

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Research Hub

The research hub established by the bill creates the Florida Flood Hub for Applied Research and Innovation (Hub) within the University of South Florida (USF) College of Marine Science. The Hub will serve as the lead institution to coordinate efforts supporting applied research and innovation to address flooding and sea level rise across Florida. Specific activities to be conducted by the Hub include data development and modeling; coordination of research funds across participating entities; establishment of community-based programs; and assistance with training and workforce development activities. The Hub must submit a comprehensive report on the program goals and progress toward those goals on an annual basis, starting in July 2022.

Local Grants

The bill authorizes DEP to provide grants to regional resilience entities, including counties, municipalities, water management districts, flood control districts and regional resilience entities, for resilience activities. The first year of the grant program includes an allocation of $20 million. Specific types of eligible projects include the following:

- **Comprehensive plan amendments** and necessary analyses for complying with "Peril of Flood" statute (Sec. 163.3178(2)(f) F.S.) for communities with a Coastal Management Element in their comprehensive plan;

- **Vulnerability assessments**, other than that necessary for compliance with Peril of Flood, that identify or address risks of flooding and sea level rise;

- **Development of adaptation/resilience plans, projects, and policies** that allow for preparation for threats from flooding and sea level rise; and

- **Projects to adapt critical assets to the effects of flooding and sea level rise.** Critical assets are defined in the bill as follows:

1

Transportation assets and evacuation routes, including airports, bridges, bus terminals, ports, major roadways, marinas, rail facilities, and railroad bridges.

2

Critical infrastructure, including wastewater treatment facilities and lift stations, stormwater treatment facilities and pump stations, drinking water facilities, water utility conveyance systems, electric production and supply facilities, solid and hazardous waste facilities, military installations, communications facilities, and disaster debris management sites.

3

Critical community and emergency facilities, including schools, colleges, universities, community centers, correctional facilities, disaster recovery centers, emergency medical service facilities, emergency operation centers, fire stations, health care facilities, hospitals, law enforcement facilities, local government facilities, logistical staging areas, affordable public housing, risk shelter inventory, and state government facilities.

4

Natural, cultural, and historical resources, including conservation lands, parks, shorelines, surface waters, wetlands, and historical and cultural assets.

Eligible projects submitted by local agencies must have a 50% cost-share match, unless they benefit a financially disadvantaged small community.[1] Project proposals are evaluated by DEP based on a weighted tiered system of criteria and ranked from highest to lowest score. Projects with the highest scores are selected for funding up to the available funding allocation for the program. The project evaluation criteria and weighting specified in the bill include:[2]

Tier 1 criteria
(40% of total score)

- Degree to which project addresses the risks posed by flooding and sea level rise;
- Degree to which project addresses risks to regionally significant assets;
- Degree to which project mitigates risks in areas with an overall higher percentage of vulnerable critical assets; and
- Degree to which project contributes to existing flooding mitigation projects that reduce upland damage costs.

Tier 2 criteria
(30% of total score)

- Level of vulnerability of the project area to flooding and erosion;
- Project readiness, including permit/ easement status, local funding availability, and construction readiness;
- Inclusion of nature-based options for resilience, with priority given to state or federal critical habitat areas for threatened or endangered species; and
- The cost-effectiveness of the project.

Tier 3 criteria
(20% of total score)

- Availability of local, state, and federal matching funds;
- Previous state commitment and involvement in the project; and
- Exceedance of flood-resistant construction requirements of the Florida Building Code and applicable flood plain management regulations.

Tier 4 criteria
(10% of total score)

- Proposed innovative technologies designed to reduce project costs and provide regional collaboration and
- Extent to which the project assists financially disadvantaged communities.

1 Financially disadvantaged small community defined as having a separate public water system (permitted PWS) that serves a population less than 10,000 and whose per capita income is below the state average.

2 Statutes & Constitution :View Statutes : Online Sunshine (state.fl.us)

MARION COUNTY LOCAL MITIGATION STRATEGY (LMS)

Marion County developed a Local Mitigation Strategy (LMS) in 2020 to identify the natural hazards that affect one or more jurisdictions in the region and help establish the foundation for assessing risks, vulnerabilities, and identifying actions to mitigate the impacts of hazards. A Working Group composed of county and municipal agency representatives; key community groups; and some private sector organizations leads updates to the LMS on a 5 year update cycle. With consideration of the LMS, this resiliency guidance document includes a high level assessment of transportation facilities vulnerable to a variety of natural hazards and a mitigation strategy toolbox that can be used as a guiding resource for county planners and decision makers.

Structures/Infrastructure Vulnerability to Hazard Impacts

The LMS considers the impacts of hurricanes, tornados, storms, floods, wildfires, sinkholes, droughts, and man-made disasters. A complete list of hazards affecting Marion County is included below. Only the weather-related and natural hazards are included in the LMS. **The general process of the LMS is to identify and map potential hazards, identify at risk facilities, and analyze the vulnerability of those facilities.** Maps are included in the LMS showing wildfire potential, flood prone spots, FEMA Flood Zones, sinkholes, tornado risk, watersheds, and aquifer vulnerability.

TABLE 2. HAZARDS AFFECTING MARION COUNTY

Weather	Natural	Ecologial	Technological/Societal	Health
Hurricane/Tropical Storm	Wildfire	Pest Infestation	Power Failure	Epidemic
Severe Winter Storm	Flood	Animal Disease	HazMat Incidents	Aging Population
Tornado	Drought		Urban Fire	
Extreme Heat	Sinkholes		Radiological	
	Riverine Erosion		Societal/Civic Evacuation	
			Mass Casualty	
			Traffic Related	
			Civil Disturbance	

Source: Marion County Local Mitigation Strategy

The LMS includes the probability, frequency, impact area, and magnitude of impact for each natural hazard, summarized in the table below.

TABLE 3. HAZARD MATRIX: PROBABILITY, FREQUENCY, IMPACTS, AND SPATIAL EXTENT

Hazard-Natural	Probability	Impact	Frequency	Distribution
DROUGHT	Low	Minimum	N/A	Countywide
FLOOD	High	Moderate	1 event per year	Flood plains
RIVERINE EROSION	Low	Minimum	N/A	Riverine basins
TORNADO	Medium	Severe	1 event per 3 years	Countywide
HURRICANE AND TROPICAL STORM	Low	Severe	1 event per 10 years	Countywide
WILDFIRE	Medium	Severe	Several events per year	Rural areas
EXTREME HEAT	Low	Minimum	N/A	Countywide
SINKHOLES	Medium	Moderate	Several events per year	Countywide
SEVERE WINTER STORM	Low	Minimum	N/A	Countywide

Soure: National Climatic Data Center

Low: 1 event recorded per 10+ years
Moderate: 1 event recorded per 5-9 years
High: 1 event recorded per 1-4 years
N/A: No recorded events or insurffient data.

Minimum: 1-25% of the total structure/infastructure is damaged as a result of the hazard
Moderate: 25-50% of the total structure/infastructure is damaged as a result of the hazard
Severe: 50-100% of the total structure/ infastructure is damaged as a result of the hazard

Flooding is the only hazard identified in the LMS with a high level of probability. Flooding has a moderate impact in flood plains, and it would be expected that 25% to 50% of the structure/infrastructures in floodplains could be damaged. While tornados and wildfire have a moderate probability of occurring, their impact would be severe and damage 50% to 100% of the total structures/infrastructure in Marion County, including mobile homes, poorly constructed homes, non-elevated homes, telecommunications, and electrical utilities. Sinkholes have a moderate probability of occurring with a moderate impact countywide. Sinkholes can have a severe impact on Mobile Homes, Poorly Constructed Homes, and Non Elevated Homes, and a moderate impact on sewage systems, potable water, roadways, and airports. The LMS identified floods and sinkholes as having the greatest degree of impact on roadways, with an expected 25% - 50% of roadways damaged by either of these.

Vulnerable Critical Facilities

Each hazard in the LMS contains corresponding critical facilities that are vulnerable to its impact. Critical facilities are important for evacuation and sheltering purpose and typically include transportation facilities, medical facilities, communication facilities, potable water facilities, wastewater treatments plants, hospitals, and schools. Emergency operations centers, mobile home parks, childcare centers, and hazardous waste generators are also identified as critical for Marion County. Some facilities need extra evacuation support such as prisons, nursing homes, and hospitals. In Marion County, there are no critical facilities that demonstrate an overwhelming structural vulnerability to any particular hazard. Emergency management staff at Marion County maintain the Critical Facilities Inventory on an annual basis.

For a 100-year hurricane event and flooding, an estimated 4 of the 129 facilities classified as essential facilities would have at least moderate damage. It is projected that 100 facilities would have an expected loss of use greater than one day.

The Ocala National Forest is considered the area of greatest vulnerability in Marion County. There are residences within the Forest boundaries which are vulnerable to wildfires. Appropriate mitigation for wildfires can come in the form of enhanced warning systems and the establishment of defensible spaces around all structures.

Vulnerable critical facilities for sinkholes are those facilities that are near or adjacent to existing sinkhole activity. The LMS does not identify known vulnerable critical facilities, but it does reference the Florida Geological Survey's recording of 412 sinkholes or subsidence incidents in Marion County.

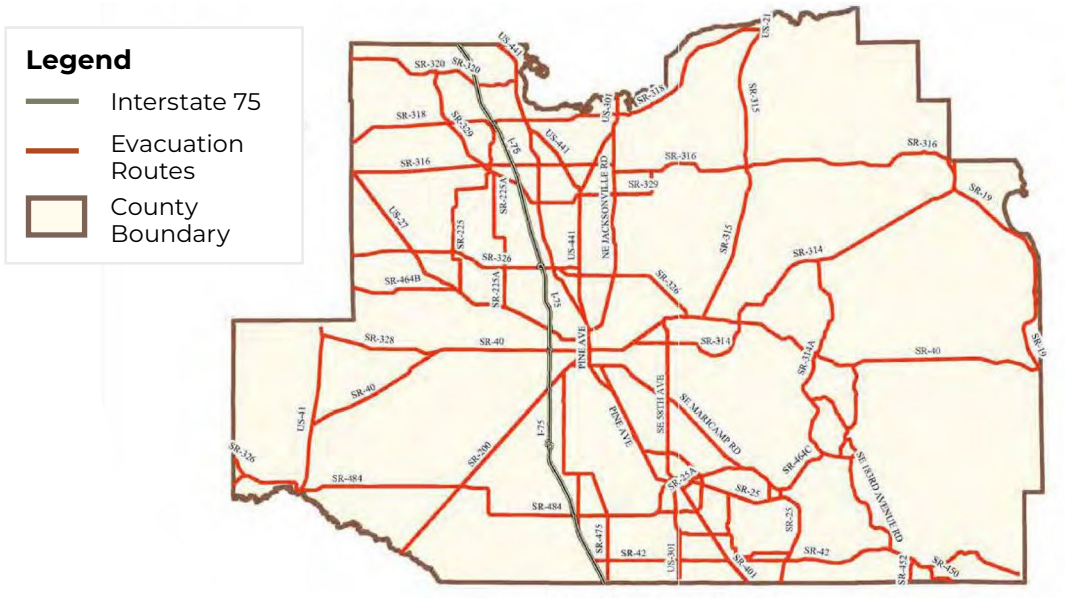
Drought and extreme heat can activate water restrictions to protect water supply. In extended periods of extreme heat, power supplies are also strained by the higher intensity of air conditioning systems usage. Appropriate mitigation for the potential loss of power is to maintain backup generators for critical facilities.

The unpredictable nature of tornados means that specific vulnerable facilities cannot be identified. Of the structures/infrastructure in Marion County, mobile homes are of the greatest concerns, along with wood frame structures and concrete block structures with wooden roof truss systems. Appropriate mitigation for tornadoes is to construct a safe room specifically engineered for such use.

While severe winter storms are not the highest hazard threat in Marion County, they pose a threat to power supply facilities and can result in power supplies needing to generate a pattern of "rolling brown-outs" that create temporary power outages in a geographic pattern.

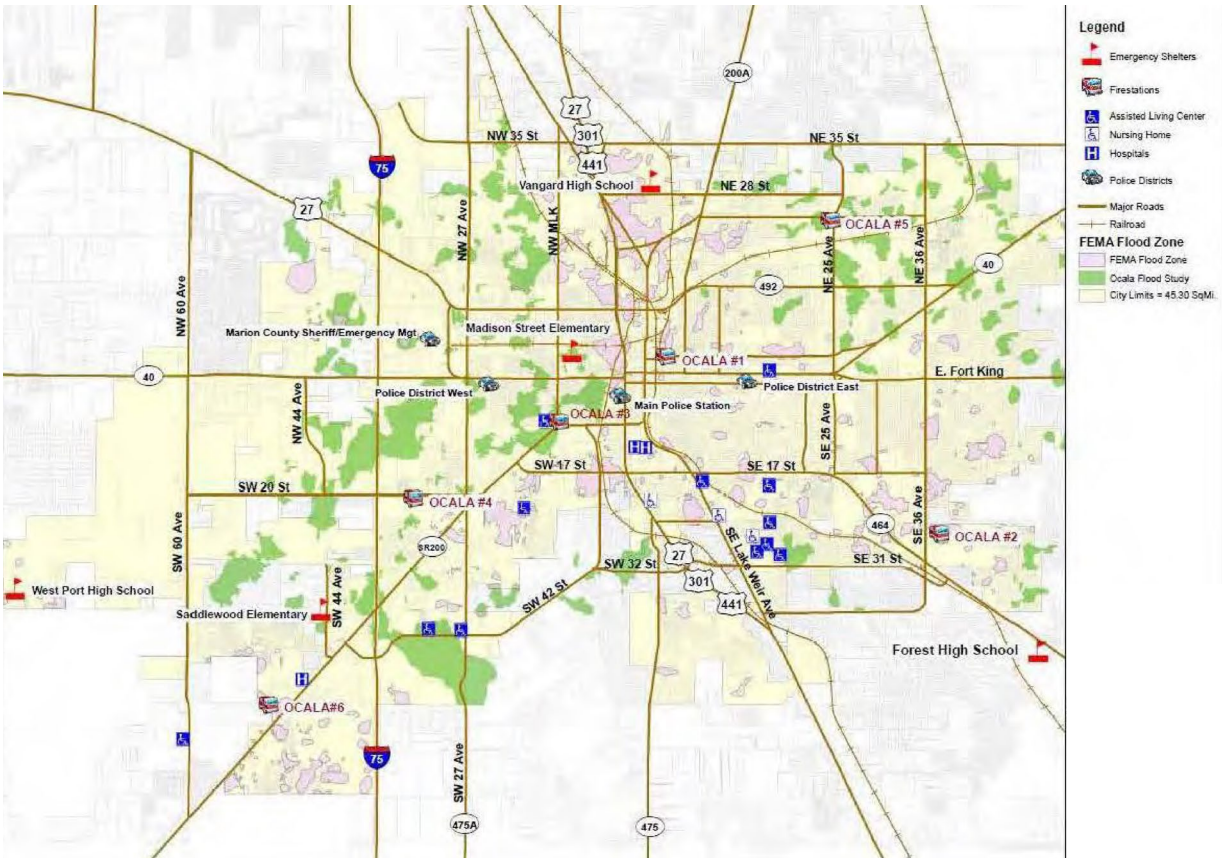
The LMS identifies the critical highway facilities in Marion County as those facilities designated as evacuation routes, including Interstate 75. The City of Ocala has an Emergency Preparation Priority Road Clearing database with major roads deemed critical for emergency preparation.

FIGURE 2. MARION COUNTY CRITICAL HIGHWAY FACILITIES



Source: Marion County Local Mitigation Strategy

FIGURE 3. CITY OF OCALA PRIOTIRY ROAD CLEARING



Source: Marion County Local Mitigation Strategy

The LMS is intended to be reviewed annually by the LMS Working Group to revise County, agency, municipal, and private business representation's roles, update the vulnerability assessment with new data, and revise mitigation initiatives. The LMS also formalizes mitigation goals to reduce the impacts of identified hazards assuming an equal level of risk throughout the county. The Working Group reviews and analyzes the existing plans, programs of County and municipal government, for mitigation programming. Any gaps in local government initiatives in addressing the hazards is determined, and the Working Group's review also determines if local government goals and mitigation initiatives will address risks posed by the impacts of future disasters. The gaps or inconsistences in analysis of existing local plans and programs result in one or more mitigation initiatives defined for incorporation into the LMS. If there is a sponsor for an initiative under consideration, then that agency or organization would include the initiative in its portion of the County Strategy.

For the mitigation initiatives developed, project scoring and prioritization procedures are detailed in the LMS to consistently evaluate, score, and prioritize projects for potential available funding sources. Funding Sources in the state are detailed in the LMS. The LMS Steering Committee evaluates ten factors for initiative prioritization:

1. **The population benefited**
2. **The percentage of the jurisdiction benefited**
3. **Health and safety considerations**
4. **The cost of implementing the project**
5. **The cost impact of the initiative**
6. **The benefit to cost / cost impact ratio**
7. **The probability of community acceptance**
8. **The probability of funding**
9. **The feasibility of implementation**
10. **Consistency with other plans and programs**

The primary mitigation activities by action item are listed in the table below. The values of High (H), Medium (M) and Low (L) have been assigned to each jurisdiction's need to focus their primary mitigation strategies on a particular action item.

TABLE 4. PRIMARY MITIGATION ACTIVITIES BY ACTION ITEM

	Belleview	Dunnellon	McIntosh	Ocala	Reddick	Unincorporated County
Actions that promote control of hazards	**M**	**M**	**L**	**H**	**L**	**H**
Stormwater controls – Stormwater management plans through grants and fees.	L	H	L	L	L	M
Structures to lessen hazard impacts – Hurricane shutters are one of the most cost-effective mitigation measures. All critical public facilities should be "hurricane hardened." New facilities should be built to current structural standards for withstanding hurricane winds.	H	H	H	H	H	H
Actions that protect public facilities and infrastructure	**M**	**M**	**L**	**H**	**L**	**H**
Adjust infrastructure location, design – Avoid building new public infrastructure that will encourage growth in high hazard areas. Design new public infrastructure to withstand disasters	M	L	L	H	L	H
Retrofit community facilities – shutters, hurricane clips, roof retrofits, door	H	H	H	H	H	H
Hazard-proof new community facilities – Assure proper elevation, backup generators, safeguard computors and communications.	M	H	L	M	L	M
Site community facilities to maintain services – Site community facilities near trunk lines for utilities and ensure that access roads don't flood.	M	M	M	M	M	M

	Belleview	Dunnellon	McIntosh	Ocala	Reddick	Unincorporated County
Actions that promote emergency preparedness and response	**M**	**M**	**L**	**H**	**M**	**H**
Preparedness plan/program – Increase communications system and warning procedures for all disasters, increase weather monitoring capabilities.	M	H	L	M	L	M
Emergency response plans – Continue ongoing efforts for planning, preparedness and training. Focus on issues identified in needs assessments.	L	L	L	L	L	L
Evacuation plan/program – Begin with population/ housing analysis possibly following the census. Perform transportation analysis using updated traffic counts and roadway capacities.	M	H	L	H	L	M
Sheltering plans – Perform structural analysis of shelters and incorporate population analysis	M	M	M	M	M	M

Source: Marion County Local Mitigation Strategy

Concept papers for the Working Group are detailed for LMS development. A proposed concept paper in the LMS specific to transportation was determined for evacuation routes threatened by hazards. All evacuation routes important to the effective evacuation of specific neighborhoods, or to supporting regional hurricane evacuation that are vulnerable to localized flooding would be defined and mitigation initiatives proposed for implementation (e.g., roadway elevation, storm drainage improvement, etc.)

VULNERABILITY ANALYSIS

Purpose of Analysis

A high level Vulnerability Analysis was completed and summarized in this paper to identify segments of the Federal-Aid Highway System exposed to three key hazards in Marion County: **sinkholes, flooding, and wildfire** hazards, based on readily available data. All three of these hazards are included in the 2020 Marion County LMS. The results of the analysis are presented below in terms of miles of roadways on the Federal-Aid Highway System impacted by each of the three hazards, broken down by functional classification. Evacuation routes were analyzed separately, to represent critical facilities in the event of a natural or man-made disaster requiring evacuation. Understanding those highway facilities impacted by hazards sheds light on where to develop resiliency strategies and prioritize resiliency funding. The TPO Board can use these results to understand the magnitude and general location of potential impacts to transportation infrastructure of these three hazards. This analysis can be built upon to further assess the most critical facilities and perform more in-depth analysis.

Methodology and Data Sources

The Federal-Aid Highway System used as the study network for this analysis includes the roadways within Marion County that are eligible for federal funding. The network database, along with functional classification data, were downloaded from the Florida Department of Transportation's (FDOT) GIS repository. Roadways designated as evacuation routes represent a subset of the Federal-Aid Highway System obtained from Marion County in 2021. Hazard data were obtained from the City of Ocala and Marion County. Flooding and sinkhole data were provided by the City of Ocala and Marion County, and wildfire hazard data created by the U.S. Department of Agriculture (USDA) Forest Service was provided by Marion County.
The following definitions were used for the three hazards:

Sinkholes. A 150-foot buffer was created around the sinkholes based on the average distance between sinkholes and the centerline of the Federal-Aid Highway System.

Flooding. The flood data represent flood prone areas based on historical tracking in Ocala and the Marion County Office of the County Engineer - Stormwater Division.

803 sinkholes in Marion County between 2015 and 2020

315 square miles in Marion County are prone to flooding

Wildfires. The Wildfire Hazard potential (WHP) data were developed by the USDA Forest Service and Fire Modeling Institute to help inform the assessment of wildfire risk and prioritization of fuels management needs across large landscapes. Only those areas identified as the highest WHP were used in the analysis.

960 square miles in Marion County are prone to wildfires

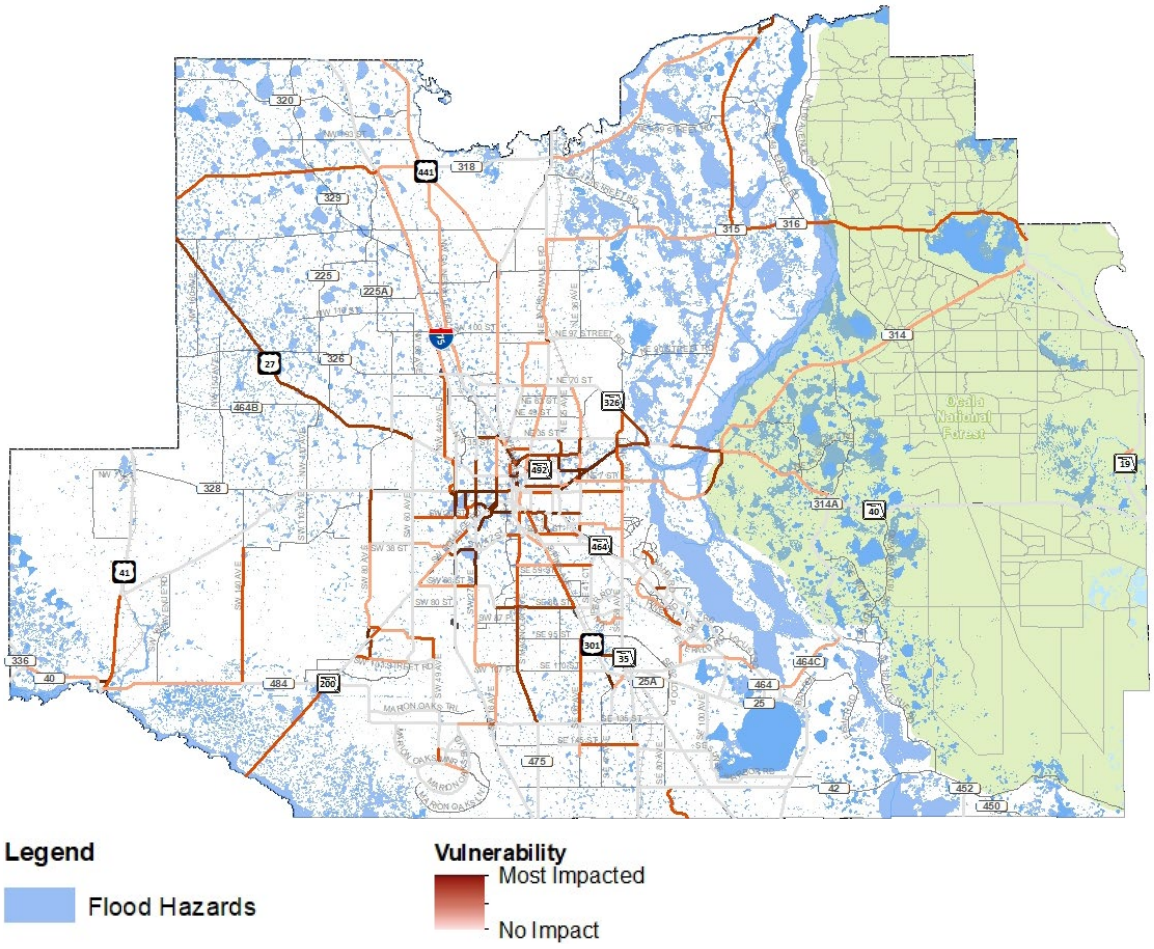
The Federal-Aid Highway System network is composed of 506 segments which were split at the boundaries of the three hazard areas: sinkholes, flooding, and high/very high wildfire hazard potential. Splitting the Federal-Aid Highway System at the hazard boundaries resulted in 3,102 segments which were joined to the hazards to determine the specific segments that were impacted by hazards.

Results

The results of the Vulnerability Analysis are presented in maps and tables on the following pages. For each hazard, the impacted roadway segments are color coded in the maps based on the impacted length of each respective roadway segment.

Flooding

61% of the centerline miles of federal-aid roadways in Marion County are prone to flooding, including 91% of the evacuation routes.



FLOODING IMPACTS
ON FEDERAL-AID SYSTEM

Functional Classification	Centerline Miles Impacted	Percent Centerline Miles Impacted
Principal Arterial	129	58%
Minor Arterial	56	44%
Major Collector	151	79%
Minor Collector (Fed Aid)	101	57%
All Road Classifications	**436**	**61%**

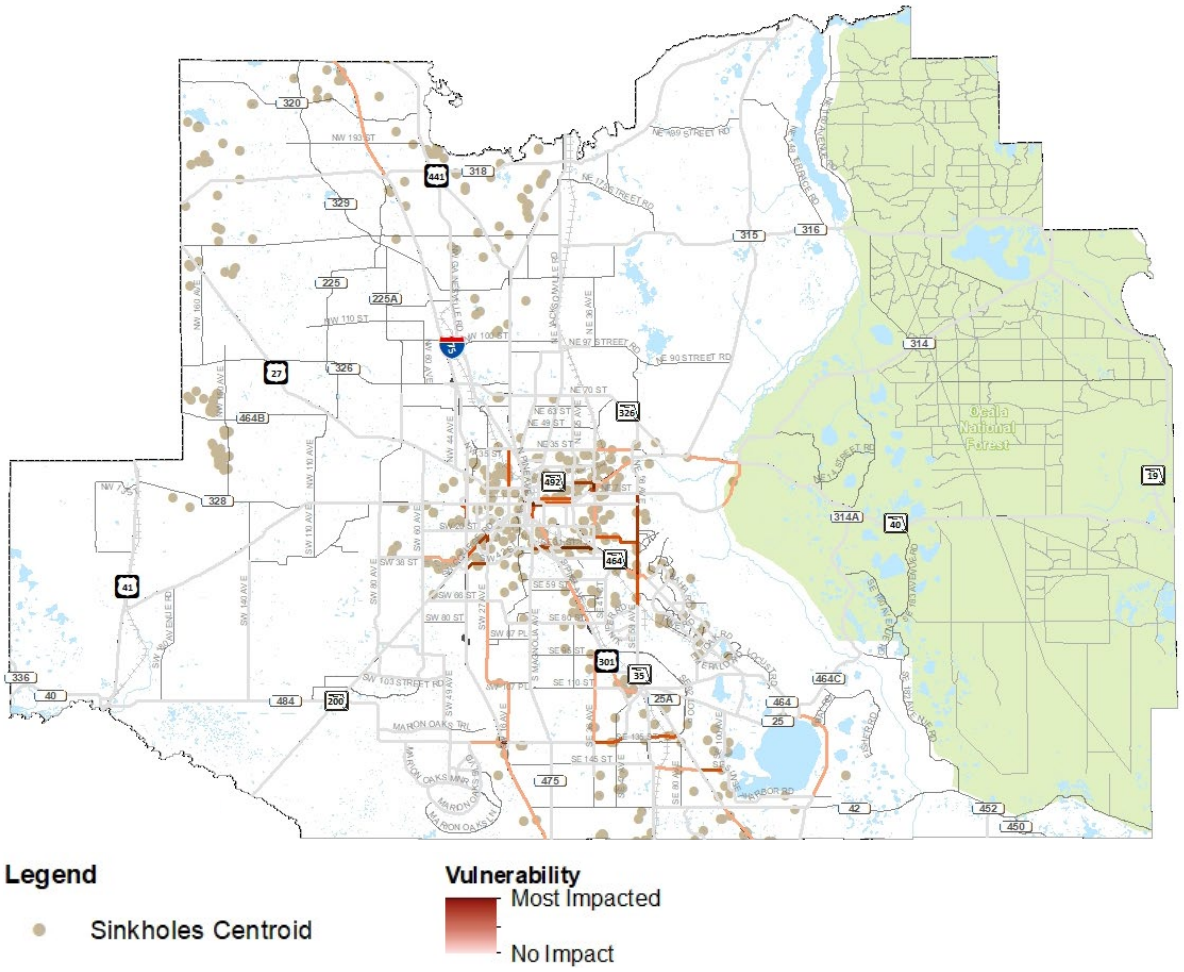
FLOODING IMPACTS
ON EVACUATION ROUTES

Functional Classification	Centerline Miles Impacted	Percent Centerline Miles Impacted
Principal Arterial	192	88%
Minor Arterial	71	97%
Major Collector	25	100%
Minor Collector (Fed Aid)	4	57%
All Road Classifications	**292**	**91%**

Source: Marion County, Florida | Flood Factor

Sinkholes

There have been more than 800 sinkholes in Marion County since 2015.



SINKHOLE IMPACTS
ON FEDERAL-AID HIGHWAY SYSTEM

Functional Classification	Centerline Miles Impacted	Percent Centerline Miles Impacted
Principal Arterial	37	17%
Minor Arterial	22	17%
Major Collector	6	3%
Minor Collector (Fed Aid)	22	12%
All Road Classifications	**86**	**12%**

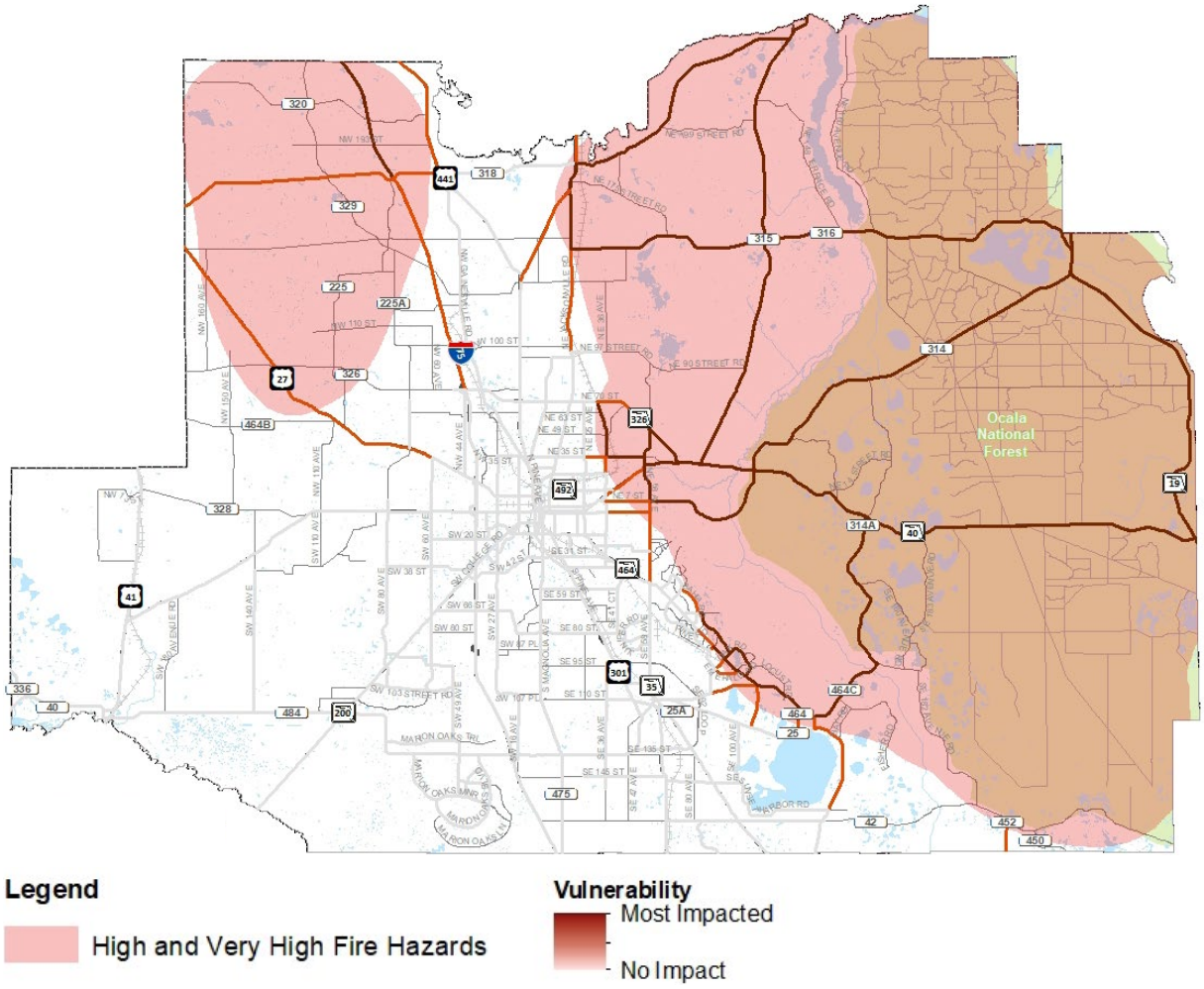
SINKHOLE IMPACTS
ON EVACUATION ROUTES

Functional Classification	Centerline Miles Impacted	Percent Centerline Miles Impacted
Principal Arterial	70	32%
Minor Arterial	41	57%
Major Collector	0	0%
Minor Collector (Fed Aid)	0	0%
All Road Classifications	**111**	**34%**

Source: Marion County, Florida

Wildfires

There were 29 wildfires in Marion County in 2019, burning 144 acres.



WILDFIRE IMPACTS ON FEDERAL-AID SYSTEM

Functional Classification	Centerline Miles Impacted	Percent Centerline Miles Impacted
Principal Arterial	78	35%
Minor Arterial	38	30%
Major Collector	116	61%
Minor Collector (Fed Aid)	23	13%
All Road Classifications	**255**	**36%**

WILDFIRE IMPACTS ON EVACUATION ROUTES

Functional Classification	Centerline Miles Impacted	Percent Centerline Miles Impacted
Principal Arterial	83	39%
Minor Arterial	33	45%
Major Collector	18	73%
Minor Collector (Fed Aid)	4	100%
All Road Classifications	**140**	**43%**

Source: Marion County, Florida

RESILIENCY STRATEGIES

There are many strategies that can be employed to prevent, mitigate, or adapt to hazards such as flooding, wildfires and others. As with any infrastructure improvement strategy, resiliency improvements range in terms of type, expense, and purpose. This section of the paper includes a description of more than thirty resiliency strategies, including relative cost, purpose, benefits, and examples of application. The strategies are presented in a matrix below, categorized in terms of four broad types of strategies.

The four categories of resiliency strategies include:

Prevention: Strategies that reduce the likelihood of a shock or stressor impacting the system. Prevention strategies are ones that address the root cause of hazards or reduce the likelihood of impact on the transportation system. Examples include fire use restriction policies to prevent wildfires and realignment of waterways to prevent flooding.

Adaptation: Strategies that change the system in ways that reduces the impacts of shocks and stressors. Adaptation strategies effectively make shocks and stressors less impactful to the normal function of the transportation system. Examples of adaptation strategies include policies limiting development in vulnerable areas or relocation of infrastructure to less vulnerable areas (e.g. move signal cabinet higher to be less prone to flooding impacts).

Absorption: Strategies that help the system experience shocks and stresses and keep functioning normally. Absorption strategies harden the transportation system to be able to withstand the impacts of shocks and stressors. Examples range from increased maintenance of drainage infrastructure to ensure that it performs optimally to more capital intensive strategies like raising roadways, rendering them less vulnerable to flooding events.

Restoration: Strategies that help the system recover quickly and return to normal functioning. A local example of a restoration strategy is the I-75 Florida's Regional Advanced Mobility Elements (FRAME), which coordinates detouring to parallel roadways in the event of traffic disruptors like crashes on I-75 using coordinated communications technologies.

One of the key considerations in any transportation infrastructure analysis is equity. Potential benefits and burdens resulting from transportation improvements must always be assessed in terms of their effects on the transportation disadvantaged populations in the region, which are defined in Florida state statute as "those persons who because of physical or mental disability, income status, or age are unable to transport themselves or to purchase transportation and are, therefore, dependent upon others to obtain access to health care, employment, education, shopping, social activities, or other life-sustaining activities". The transportation disadvantaged should be considered when prioritizing and implementing strategies, as the transportation system must provide opportunity for access to the entire community before, during, and after shocks and stressors.

1 2021 Statutes 0427.011 | Florida House of Representatives (myfloridahouse.gov)

TABLE 5. RESILIENCY STRATEGY MATRIX

Strategy	Descritpion	Hazards	Considerations	Benefits	Cost	Source
Prevention: Strategies that reduce the likelihood of a shock or stressor impacting the system.						
Reduce VMT	Reducing Vehicle Miles Travelled (VMT) reduces the strain on the network associated with rerouting trips or reducing the available route choices.			· Reduce community reliance on automobile trips · Reduce the number of vehicles that must use detour routes		
Develop a Stormwater Management Plan	Develop a plan to address existing conditions and the required capacity for new facilities.			· Determine effectiveness of centralized facilities and other regional opportunities		· Houston Galveston Resilience Pilot Program
Construct green roofs	Utilize green roofs that provide shade, reduce surrounding air temperature, and reduce runoff.			· Reduce runoff · Reduce urban heat island effect		· USFS Compendium of Adaptation Practices
Realign or reconnect water courses	Realign waterways away from critical infrastructure. Reconnect waterways to allow natural flood plains to absorb impact of storm events.			· Allow natural flooding to occur, rather than constraining waterways		· World Road Association International Climate Change Adaptation Framework for Road Infrastructure
Implement fire-use restrictions	Implement policies to reduce the likelihood of wildfire during conditions that are conducive to wildfire ignition.			· Reduce chances of wildfire		· USFS Compendium of Adaptation Practices
Use forest management techniques such as thinning, prescribed burn, and fuels removal	Reduce the likelihood for an extreme fire, with intermittent fire and other management practices.			· Maintain ecosystems that require fire		· USFS Compendium of Adaptation Practices
Adaptation: Strategies that change the system in anticipation of shocks and stressors to maintain normal functioning.						
Discourage development and growth in vulnerable areas	Create zoning requirements that encourage dense development to occur outside of impact areas, for example the flood plain.		· Consider impacts to communities living in less vulnerable areas · Consider conservation projects, especially in areas that coincide with environmentally vulnerable/valuable areas	· Reduce the amount of vulnerable infrastructure over time		· FEMA Nature-Based Solutions · Houston Galveston Resilience Pilot Program
Site new facilities outside of hazard area	When developing new assets or infrastructure, consider locating outside of the hazard area.			· Consider hazards during the planning phase to reduce the cost of relocation		· FHWA Adaptation Framework
Change the nature of access to critical facilities	Provide access to critical facilities under hazards by considering alternative accesses. For example, access through the rear of the building, provide for walking or using a mode other than automobile for a portion of the access trip.			· Provides redundant access during normal operations		· USFS Compendium of Adaptation Practices
Provide redundant routes	Maintain redundant routes in the network that are functional for all modes.		· Consider access to critical facilities and critical routes	· Reduces the consequence of segments being impacted by shocks or stressors · Offers traffic management in non-hazard times		· Resilient California

Legend General · Heat · Wildfire · Flood · Tornado · Low cost · Medium cost · High cost

Strategy	Descritpion	Hazards	Considerations	Benefits	Cost	Source
Construct green stormwater infrastructure	Combine natural landscape and vegetation with engineered solutions. Allow spaces to be used for recreation or horizontal/ vertical separation of transportation users during normal conditions and water management during severe events.		· Maintenance costs, but life cycle benefits · Community is committed to maintaining during establishment	· Filter water · Infiltrate water · Retain water		· Resilient Tampa Bay · Houston Galveston Resilience Pilot Program
Relocate assets to avoid damage	Move critical infrastructure or components to avoid or reduce the probability of impact. For example, relocate signal cabinet to higher elevation at intersection.					· FHWA Adaptation Framework · Houston Galveston Resilience Pilot Program
Install battery backups at traffic signals	Provide batteries for signal operation during power disruption. Power disruption may occur if powerlines are knocked down from wind debris.		· Battery capacity and need for replacement or installation of a generator · Prioritize signals with greatest impact	· Continue operations during shock		· Space Coast TPO Resiliency Master Plan
Absorption: Strategies that help the system function normally during events that cause shocks and stressors.						
Conduct regular maintenance of infrastructure	Maintain the working order of infrastructure, for example keeping culverts clear.			· Proactive measure to maintain flow at critical points · Maintain clear of overgrown vegetation which may spread wildfire across the roadway		· South Florida Climate Pilot · Houston Galveston Resilience Pilot Program
Construct hardened shoulders	Widen roadway structure to reduce impact to travel lanes.		· Requires clearance around roadway · Along roadways experiencing strong flows	· Limit inundation to one side of roadway · Reduce erosion from overtopping		· Resilient Tampa Bay
Use permeable pavements	Slows, filters, and cleans stormwater runoff by installing porous surfaces.		· Especially relevant in areas with large parking lots · Appropriate only for gentle slopes · Can become clogged. · Appropriate for low traffic volumes, loads, and speed	· Reduce runoff · Allow water to infiltrate · Reduced particulates in water		· Resilient Tampa Bay · Houston Galveston Resilience Pilot Program
Construct enhanced road surface	For flooding: Increase the thickness of hot mix asphalt (consider increasing 2”) and binder course using larger aggregate. For heat and wildfire: Design road with materials resistant to fire and heat.			· Resist water movement and inundation · Withstand impacts of prolonged exposure to heat or submersion		· Resilient Tampa Bay · Resilient California · Houston Galveston Resilience Pilot Program
Construct enhanced sub-surface	Increase the thickness of subbase layers to provide additional drainage, structural strength, and resistance to flow damages (consider increasing 4-6”).			· Resist water movement and inundation		· Resilient Tampa Bay · Houston Galveston Resilience Pilot Program
Construct berms or barriers	Construct a barrier to prevent water from flooding the roadway.		· Consider available right-of-way to construct barrier	· Prevent water from reaching roadway or flowing across roadway		· FHWA Adaptation Framework
Construct protected or depressed medians	Separate the roadway and potential effect of inundation with a median between the travel lanes in each direction.		· Especially effective along roadways in flat areas · Requires maintenance of vegetation and keeping drains clear	· Reduce the occurrence of floods across the full roadway · If depressed, serve as a holding area for water		· Resilient Tampa Bay · Houston Galveston Resilience Pilot Program

Legend General · Heat · Wildfire · Flood · Tornado · Low cost · Medium cost · High cost

Strategy	Descritpion	Hazards	Considerations	Benefits	Cost	Source
Harden or armor key infrastructure components	Protect key infrastructure, for example embankments, signal wires, or bridge piers, against extreme weather events.		• Consider the impact of armoring to the transportation and ecological system during shocks and stressors, but also during normal operations	• Reduce disruption to traffic flow • Maintain access during storm		• South Florida Climate Pilot
Construct swales or ditches	Drains stormwater away from infrastructure toward larger stormwater facilities.		• Requires clearance around roadway • Stability and durability of slopes and ditches • Must be maintained and cleared of debris	• Retain water prior to entering the sewer system. • Reduce standing water which may serve as insect breeding areas		• Resilient Tampa Bay • Houston Galveston Resilience Pilot Program
Construct retention/ detention ponds or rainwater harvesting	Where roadside swales are insufficient capacity, ponds may be constructed to retain water and release it at a manageable rate. Alternatively rainwater harvesting systems can collect, store, and make use of water.		• Requires a potentially large area to be availableMaintenance to ensure proper drainage is required	• Retain water prior to entering the sewer system • Reduce flooding due to overwhelmed systems • Enhance natural environment		• Resilient Tampa Bay • FEMA Nature Based Solutions • Miami Beach Stormwater Management Master Plan • Houston Galveston Resilience Pilot Program
Construct recharge wells	Directly discharge water into deep water-bearing zones.			• Reduce stormwater to be managed by other conveyance infrastructure		• Miami Beach Stormwater Management Master Plan
Reduce the gradient of slopes	Reduce the grade of slopes abutting roadways.			• Reduce the likelihood of erosion		• World Road Association International Climate Change Adaptation Framework for Road Infrastructure
Construct stormwater parks	Recreational spaces designed to flood. Brazilian city Curitiba has extensive system of wet parks, Tallahassee, Tampa parks.			• Provide recreational facilities most of the time • Relocate critical infrastructure from flood prone areas.		• FEMA Nature Based Solutions
Restore and protect wetlands and floodplains	Develop or restore facilities at the watershed level to manage severe events.			• Act as a barrier to the spread of fire • Provide water storage		• FEMA Nature Based Solutions • Houston Galveston Resilience Pilot Program
Construct raised roadways	Raise the profile of the road in critical areas.		• Requires clearance around roadway • Areas where extended inundation is expected and other drainage options are insufficient • Connection to other raised facilities. • Construct flow structures to prevent the roadway from acting as a dam • Access to adjoining properties	• Increase runoff possibilities. • Reduce damage to surface and base elements from pooling.		• Resilient Tampa Bay • Miami Beach Stormwater Management Master Plan • Houston Galveston Resilience Pilot Program

Legend General Heat Wildfire Flood Tornado Low cost Medium cost High cost

Strategy	Descritpion	Hazards	Considerations	Benefits	Cost	Source
Install tie-downs	Use tie downs for buildings at risk of high winds					· USFS Compendium of Adaptation Practices
Create and maintain defensible space around facilities	Buffer facilities with an area that is resistant to quick spreading fire, for example grass.			· Prevent fire from spreading to structures · Offer additional warning and time for evacuation		· USFS Compendium of Adaptation Practices
Restoration: Strategies that help the system recover quickly and return to normal functioning.						
Install generator connections at traffic signals	Provide built in connections on signal cabinets to connect a generator.		· Battery capacity and need for replacement or installation of a generator · Prioritize signals with greatest impact	· Quickly resume operations after shock		· Space Coast TPO Resiliency Master Plan
Prioritize roadways	Prioritize roadways based upon network effectiveness. In all response activities focus on roadways in priority order, for example send crews to clear debris from priority roadways before non-priority roadways.		· Include community input regarding critical routes and facilities	· Clear and defined plan that can be communicated to the community		· Resilient California
Develop warning systems with resilient communications	Warning system may consist of sensors, cameras, citizen reporting tool, or other means.			· Quickly alert of hazard to allow response to occur		· Houston Galveston Resilience Pilot Program
Develop a coordination plan with other agencies to respond to changes and hazards						· FHWA Adaptation Framework
Coordinate with transit providers to identify alternative routes and stops if normal infrastructure is impacted				· Continue to operate transit in a predetermined manner consistent with rider expectations.		· Resilient California
Establish stand-by contracts for damage response	Establish mechanisms to pay for rapid response to hazards.			· Proactive measure to reduce the length of impact.		· FHWA HOP-15-025
Stockpile materials (culvert pipe, fuel, components) and equipment (generators, traffic control devices) at appropriate locations	Maintain an inventory of critical materials to quickly respond to needs during and after shocks.		· Different materials will be needed at different locations to address each hazard · Consider in conjunction with prioritized roadways · Consider cost of storage and potential deterioration of materials over time	· Proactive measure to reduce the length of impact.		· FHWA HOP-15-025

Legend General · Heat · Wildfire · Flood · Tornado · Low cost · Medium cost · High cost

The relative cost estimates provided in the strategy matrix below are intended to illustrate high, medium, or low cost strategies. Actual costs vary from project to project, and for some projects strategies vary in cost-effectiveness. For example, if right-of-way width allows, implementing green stormwater infrastructure along a roadway segment may be a more cost-effective strategy than developing a stormwater park, but there may be other projects where the inverse is true.

NEXT STEPS

Transportation resiliency planning can be completed at both the system or facility level, using a variety of data and methodologies. Recommended next steps for the Ocala Marion TPO include a comprehensive transportation system analysis that builds upon Marion County's LMS, with a specific emphasis on transportation and vulnerabilities associated with all relevant hazards, including those discussed and assessed in this paper. A resiliency master plan based on the results of the analysis would provide the TPO with a guide to advance the highest priority resiliency improvements. The master plan would involve a series of steps, including:

Public and stakeholder coordination

Hazard data collection

Scenario planning analysis;

Identification of critical facilities; and

Identification and prioritization of needed resiliency improvements.

The master planning effort would be coordinated closely with the TPO's planning partners, including Marion County and municipalities, the Florida Department of Transportation, the East Central Florida Regional Planning Council, and others. The resulting plan would provide an important guide to implement specific improvements and resiliency analysis to consider as part of other infrastructure plans and improvement strategies.

Other recommended resiliency planning efforts include consideration of resiliency as part of all transportation improvements. Much the same way that safety is a consideration as part of any transportation infrastructure project, resiliency ought to also be a regular consideration. A framework to guide resiliency analysis at the project level could be a part of the resiliency master plan, or could be developed independently for project planning efforts.

The TPO's system planning efforts, which include the prioritization of short range improvements in the Transportation Improvement Program (TIP), and longer term projects in the Long Range Transportation Plan (LRTP), ought also consider resiliency in several ways. First, the needs assessment process can include data analysis similar to that done in this paper to highlight identify needs for facilities exposed to potential flooding or wildfires. Also important to the LRTP is the quantitative evaluation criteria used to prioritize investments. Resiliency considerations can and should be built into that evaluation process. The TPO can also access new discretionary funding for resiliency improvements through the various state and federal programs discussed in this paper. Working hand in hand with local partners like Marion County and municipal partners, the TPO can assist in the completion of grant applications to secure some of this funding.

Recommended next steps for the Ocala Marion TPO include a comprehensive transportation system analysis that builds upon Marion County's LMS, with a specific emphasis on transportation and vulnerabilities associated with all relevant hazards, including those discussed and assessed in this paper.