RESILIENT BROWARD

COUNTYWIDE RESILIENCE PLAN 2025

JULY 2026

BROWARD COUNTY FLORIDA

BROWARD COUNTY, FLORIDA

Aerial view of the Tarpon River, Fort Lauderdale. Photo by Luiz Cent / Unsplash.com

Cover image: Aerial view of Fort Lauderdale. Photo by Sepavone / Depositphotos.com

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> “This Resilience Plan is more than a blueprint; it is a call to action... [it has] become a practical, action-oriented roadmap to help us navigate the challenges ahead.”

Letter from the **Mayor**

Dear Broward County Community,

Our county’s future depends on the actions we take today, which is why I am pleased to introduce our Countywide Resilience Plan, a forward-thinking blueprint to safeguard our communities, economy, and natural environment against the challenges of a changing climate. As a county def ned by our stunning coastline, vibrant neighborhoods, and diverse ecosystems, we are at the forefront of both the risks and the opportunities that come with building a more resilient future.

Broward County has long been a leader in climate adaptation and sustainability, and this plan ref ects our unwavering commitment to proactive solutions. It outlines the risks our community faces if we do not act to mitigate the increasing threats of f ooding and extreme heat, while also presenting a vision for a stronger, more resilient future through county-wide infrastructure improvements and redevelopment strategies. By investing in strategic, science-driven solutions, we can signif cantly reduce risk, enhance our ability to withstand rising sea levels and extreme weather events, and protect our residents and our economy.

This Resilience Plan is more than a blueprint; it is a call to action. Six years ago, during the annual Broward Leaders Resilience Roundtable, business and municipal leaders identified a critical need for a strategic framework to guide our path forward to a more resilient community. In response, the County created the Resilience Steering Committee and, with dedicated staf and expert consultants, developed this comprehensive plan. What began as an idea has now become a practical, action-oriented roadmap to help us navigate the challenges ahead. This plan is a testament to our shared responsibility to safeguard Broward County for future generations.

Thank you for your partnership in this critical effort. Together, we will continue to innovate, strengthen our community, and lead the way toward a more resilient future.

Thank you,

MAYOR BEAM FURR
Broward County

Letter from the

Chief Resilience Officer

Dear Broward County Community,

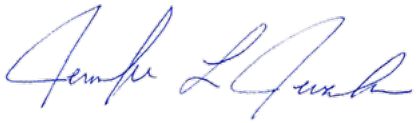
It is with great pleasure that we present the results and recommendations of a substantial multi-year effort with publication of this countywide Resilience Plan. This initiative was launched in response to a collective call by our local government and business leadership to develop a formal strategy to address evolving flood risk across our community.

Two years later, this Resilience Plan was finalized, providing a coordinated, multi-decade infrastructure improvement and redevelopment strategy to mitigate the increase in flood risk with rising sea level, more intense rainfall, and combined storm surge through the year 2070. The recommended strategies highlight water management improvements, enhanced water storage, an increase in green infrastructure, and heightened barriers to coastal waters, collectively estimated to deliver diverse and impactful countywide benefits. These include residential and commercial flood risk reduction, avoided flood damages and losses, preservation of property values, and maintenance of flood insurance affordability, along with general economic stability, protecting key economic sectors and jobs.

While produced by the County, this Plan represents a significant collaboration with agency and municipal staff, water managers, and planners, with input by residents and community partners, collected through listening sessions and surveys. It is multi-faceted, inclusive of not just infrastructure improvements, but policy recommendations, regulatory approaches, and an interactive platform for visualizing f ood risk and plan performance, with an aid for tracking project implementation.

It is our goal that, with coordinated implementation of the Plan by public and private sectors, Broward County will continue to innovate and lead in climate resilience ef orts focused on risk reduction, community af ordability, economic vitality and enhanced quality of life for all residents, visitors, and those doing business in Broward County.

Thank you for your support in this joint venture and what is designed and what is designed to generate positive outcomes and bold opportunities for all in Broward County.



DR. JENNIFER JURADO
Chief Resilience Of cer
Broward County

> “... this Plan represents a significant collaboration with agency and municipal staff, water managers, and planners, with input by residents and community partners, collected through listening sessions and surveys.”

Hazen

Brizaga, Inc.

Climate Resilience Consulting

Collective Water Resources, LLC

Craven Thompson & Associates, Inc.

Cummins Cederberg, Inc.

Good Alpha

HR&A Advisors

McKinsey & Company, Inc.

RJ Behar & Company, Inc.

The Water Institute of the Gulf

Hazen and Sawyer. *Countywide Resilience Plan 2025*. Hollywood, FL, 2025.
Prepared for Broward County Resilient Environment Department, March 2025.

Hazen and Sawyer
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List of Abbreviations

AAD	Average Annual Damage
AADT	Average Annual Daily Traffic
BC	Broward County
BCFM	Broward County Flood Map
BCRED	Broward County Resilient Environment Division
BFE	Base Flood Elevation
BRIC	Building Resilient Infrastructure Communities
C&SF	Central and Southern Florida
CADA	Central Area Drainage Assessment
CCAP	County's Climate Action Plan
CCC	Climate Change Compact
CDC	Center for Disease Control
CFE	Critical Flood Elevation
CIP	Capital Improvement Plan
CPI	Consumer Price Index
CWA	Clean Water Act
CWSRF	Clean Water State Revolving Fund
DEM	Digital Elevation Model
EAA	Economic Adjustment Assistance
EDA	Economic Development Administration
EMAS	Engineered Materials Arrestor System
FCI	Florida Climate Institute
FDEP	Florida Department of Environmental Protection
FEMA	Federal Emergency Management Agency
FFE	Finished Floor Elevation
FIRM	Flood Insurance Rate Maps
FMA	Flood Mitigation Assistance
FPLOS	Flood Protection Level of Service
F.S.	Florida Statute
GI	Green Infrastructure
GIS	Geographic Information System
GO	General Obligation
GVA	Gross Value Added
H&H	Hydrologic and Hydraulic
HMA	Hazard Mitigation Assistance
HMAP	Hazard Mitigation Assistance Program
HMGP	Hazard Mitigation Grant Program
IRR	Internal Rate of Return
KPI	Key Performance Indicators
LiDAR	Light Detection and Ranging
LMI	Low- and Moderate-Income
LST	Land Surface Temperature
MHW	Mean High Water
MODFLOW	Modular Finite-Difference Flow Model
MPO	Metropolitan Planning Organization
MSL	Mean Sea Level
NADA	North Area Drainage Assessment
NAVD	North American Vertical Datum
NFIP	National Flood Insurance Program
NGVD	National Geodatic Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
NOFO	Notice of Funding Opportunity
NPSMP	Non-Point Source Management Plan
PCP	Planning Checkpoints
PDM	PreDisaster Mitigation
RFGP	Resilient Florida Grant Program
RGPA	Resilient Growth Priority Areas
ROW	Right-of-Way
RSC	Resilience Steering Committee
SADA	South Area Drainage Assessment
SFHA	Special Flood Hazard Areas
SFWMD	South Florida Water Management District
SHGW	Seasonal High Groundwater
SLOSH	Sea, Lake and Overland Surges
SLR	Sea Level Rise
SWAG	State Water Quality Assistance Grant
SWUCA	Southern Water Use Caution Area
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
VA	Vulnerability Assessment
WIFIA	Water Infrastructure Financing and Innovation Act

List of Definitions

Adaptations: Adaptations are the methods to enhance resilience against climate-related impacts, including flooding, extreme heat, and sea level rise.

Average Annual Damage: Average Annual Damage (AAD) is the average annual cost to repair the physical damage caused by flooding or to replace the assets damaged by flooding, accounting for the likelihood and severity of all the flood scenarios considered in the modeling process.

Climate Change Resilience: The capacity of a community or system to withstand and adapt to the changing climate, including increasing flood risks.

Community Engagement: Involving local residents, stakeholders, and authorities in the assessment process to ensure their knowledge, concerns, and priorities are taken into account.

Critical Assets: Essential facilities, systems, and assets, such as hospitals, power plants, bridges, and roads, that could significantly impact public safety and the economy if disrupted.

Exposure: The extent to which people, assets, and the environment are subjected to potential flood hazards in a specific area.

Flood Risk Management: A comprehensive approach that integrates assessment, prevention, preparedness, response, and recovery measures to minimize the impacts of flooding.

Flooding: The overflow of water onto land, which is usually dry, often caused by heavy rainfall, storm surges, snowmelt, or the failure of dams and levees.

Gross Value Added: Gross Value Added (GVA) measures the difference between the value of goods and services an economy, industry, region, or business produces and the value of the raw materials required to produce them. It includes the income that residents receive, company profits, depreciation, interest payments, and net subsidies (subsidies minus taxes).

Hazard: A natural or human-induced event with the potential to cause flooding, such as heavy rainfall, river overflow, or coastal storm surges.

Insurance Affordability: A flood insurance policy is defined as affordable if the policy premium is less than 1% of the coverage of the policy, as per Homeowner Flood Insurance Affordability Act of 2014. (Affordability of National Flood Insurance Program Premiums Report 1, 2015; accessible at: https://nap.nationalacademies.org/read/21709/chapter/7#80.)

Insurance Coverage: Insurance coverage, as defined for this study, is the maximum payment amount that a property owner would receive from an insurance company to cover the repair or replacement of real estate assets in the event of a flood that damages them.

Insurance Penetration Rate: Ratio between National Flood Insurance Program (NFIP) policy count and total number of housing units at the census-tract level.

MIKE SHE / MIKE HYDRO Model: A hydrologic and hydraulic modeling system used by Broward County for flood risk and water resource management, integrating surface water, groundwater, and floodplain analysis.

National Flood Insurance Program: The NFIP, administered by the Federal Emergency Management Agency, provides affordable insurance to property owners and encourages communities to adopt and enforce floodplain management regulations.

Normal Maximum Daily Temperature: Long-term average of the highest temperature recorded each day over a specific period.

Property Damage: The cost to repair the physical damage caused by flooding or to replace the assets damaged by flooding as needed to bring the property to its intended use prior to the flood.

Rate of Return on Investment, Nominal Annual: This is the Internal Rate of Return which is the discount rate that causes the present value of annual benefits to equal the present value of annual costs for a given investment. It is nominal in that it includes inflation. It represents the opportunity cost of money to Broward County. The real internal rate of return excludes inflation. For example, if a project has a nominal rate of return of 10% per year and average annual inflation is 2.5%, then the project's real internal rate of return would be 7.5%.

Resilience: The ability of a community or system to absorb shocks from flooding, recover quickly, and adapt to new conditions, minimizing long-term impacts.

Risk: The combination of the probability of a flood event occurring and the potential consequences, including damages and losses, to people, property, and the environment.

Risk Rating 2.0: Risk Rating 2.0 is the NFIP's new pricing methodology, which was rolled out in late 2021. The methodology enables FEMA to deliver rates that are actuarially sound, easier to understand, and better reflect a property's flood risk.

Special Flood Hazard Areas: Special Flood Hazard Areas (SFHA) are defined by FEMA as areas that will be inundated by flood events with a 1% annual chance of occurring. Residences within SFHAs typically are required to have NFIP flood insurance policies.

Sales: As used in this report, "sales" is the commercial sales revenue by business type.

Storm Surge: Coastal flooding caused by hurricanes or other extreme storms; it is the ocean's response to surface winds and low pressure systems.

Stranded Business: A stranded business is a business which is not physically connected by roads to most of its consumers and suppliers (90%) due to flooded roads being impractical to use for transportation (defined as roads with flood depths above 0.5 feet).

Target Stormwater Volume: The specific amount of stormwater runoff that a site or stormwater management system is designed to capture, retain, infiltrate, or treat.

Underinsurance Rate: Ratio between non-insured replacement costs and total replacement value.

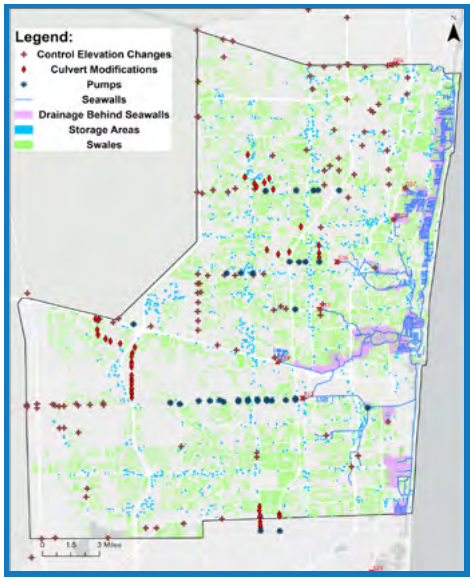
Vulnerability: The susceptibility of a community, infrastructure, or ecosystem to the impacts of flooding, including its capacity to cope with and recover from the event.

Executive Summary

UNDERSTANDING THE RESILIENCE PLAN

Broward County is on the front line of climate change, facing the growing impacts of rising sea levels, more intense rainfall, storm surges, and increasing heat. These challenges put homes, businesses, infrastructure, and natural ecosystems at signifcant risk. As one of the most vulnerable regions in the nation, the County's low-lying topography, dense urbanization, reliance on coastal resources, and historical drainage infrastructure make it particularly susceptible to the potential for widespread f ooding, declining property values, rising insurance costs, and disruptions to industries like tourism.

To address these pressing issues, the Broward County Resilience Plan (the "Resilience Plan" or the "Plan") provides a clear and actionable roadmap for the next 50 years. The Plan combines natural solutions, such as swales and expanded green spaces, with engineered systems like seawalls and upgraded drainage to protect critical infrastructure, manage stormwater, and reduce urban heat. Grounded in robust data, innovative strategies, and community input, the Plan lays the foundation for a thriving, resilient future.



Solutions have been tailored to meet the needs of **THE COUNTY'S THREE UNIQUE ZONES:**

- Central Areas
- Eastern Areas
- Inland Areas

At its core, resilience means more than just adapting to challenges—it ensures that Broward County can recover, adapt, and thrive in the face of climate risks. By safeguarding the wellbeing of its residents, economy, and ecosystems, the Resilience Plan ensures a vibrant and resilient community for future generations.

Vision for Resilience

- Integrate Robust Risk Analytics and Economic Analyses
- Include Resilient County Infrastructure Improvement Strategies
- Encourage Opportunities and Partnerships Among Municipalities and Districts for Future Funding
- Form the Foundation for the Collective Mitigation of Future Flooding
- Provide a Visualization Platform/Plan to Aid Regional Planning and Project Tracking
- Present Resilient Redevelopment Strategies

RESILIENCE IN ACTION

Approach

The Resilience Plan uses a structured and adaptive approach, employing detailed hydraulic and hydrologic modeling, to address evolving flood risk with climate change. By phasing strategies over time, the Plan prioritizes the adaptations to immediate risks while preparing for future challenges. The Plan is a vision to protect the residents and businesses of Broward County, providing a multi-decade coordinated blueprint to support future design development and financing of adaptations.

Key Strategies

The Resilience Plan includes a range of adaptation strategies to address the impacts of climate change and rising sea levels. The adaptive planning approach identifed two tiers of adaptation.

Tier 1 (By 2050): Focuses on preparing for a 2-foot rise in sea level by 2050. This phase includes constructing seawalls up to 5.0 feet NAVD to mitigate storm flooding, enhancing drainage systems to manage heavy rainfall, adding pumping stations, upsizing culvert crossings, modifying control structures, and implementing nature-based infrastructure, such as swales and expanded green spaces, to absorb water and reduce urban heat.

Tier 2 (By 2070): Addresses the challenges of a projected 3.3-foot rise in sea levels by 2070. This phase involves raising seawalls to 7.0 feet NAVD for enhanced coastal protection and adding advanced drainage systems, including pumping and collection systems, to manage increased stormwater volumes behind seawalls. Tier 2 also expands green spaces further to mitigate urban heat and enhance biodiversity.

Estimated Costs

The total cost of Tier 1 and Tier 2 adaptations is estimated at $28 billion, with the public portion at $9 billion and private property improvements accounting for the remainder. The public component is likely to be shared by the County, municipalities, and water control districts, leveraging State and Federal resources.

Modeled Adaptations

The Resilience Plan evaluates and incorporates various adaptations to address specific challenges across the county, including:

Storage

Includes above-ground storage systems and recovering underground storage to manage excess stormwater.

Nature-based Infrastructure

This type of infrastructure focuses on reducing impervious surfaces, adding localized surface storage, and enhancing natural water absorption areas.

Conveyance

Improves existing structures such as canals and culverts while incorporating additional pumping systems to enhance water flow management.

Barriers

Utilizes property-level seawalls and nature-based or engineered structures to prevent flooding and protect infrastructure.

Implementation

The phased approach of the Resilience Plan assumes new technologies and data will be incorporated over time to maintain strategies as effective and adaptable. By prioritizing near-term risks and scaling up for future challenges, the plan ensures efficient resource use. Community engagement and collaboration with municipalities, water management districts, and community groups maximize the Plan's impact, positioning the County as a leader in climate resilience.

THE IMPACT: RESULTS THAT MATTER

The Resilience Plan generates measurable economic, environmental, and community benefits, ensuring a safer and more prosperous future for Broward County. By investing in infrastructure upgrades such as seawalls, drainage systems, and green spaces, the Plan significantly reduces flood risks, preventing billions in potential property damage. These measures protect homeowner investments and property tax values, and make flood insurance more accessible and affordable.

Additionally, the Plan supports the local economy by minimizing business disruptions and safeguarding jobs, contributing hundreds of millions annually in economic activity and tax revenue. Beyond economic gains, the Plan enhances quality of life by reducing urban heat and expanding green spaces that foster biodiversity and community wellbeing. Together, these results highlight the Resilience Plan as a critical step toward a thriving, climate-resilient Broward County.

A COMMITMENT TO THE FUTURE

The Broward County Resilience Plan is a forward-thinking strategy to secure the County's future. By addressing immediate and long-term challenges, the Plan protects critical infrastructure, supports economic growth, and improves the quality of life for residents. It is more than a strategy—it is a commitment to strengthening Broward County for generations. Through innovation, collaboration, and determination, the County can rise to the challenges of climate impacts and build a thriving, resilient future.

Summary of Tier 1 and Tier 2 Benefit Value Estimates

Average Annual Property Damage Avoided	Average Annual Increased Short-term Economic Activity	Average Annual Increased Property Tax Collected	Increased Flood Insurance Coverage	Increased Real Estate Value
TIER 1 $776 Million	TIER 1 $109 Million	TIER 1 $211 Million	TIER 1 $12 Billion	TIER 1 $8 Billion
TIER 2 $3.6 Billion	TIER 2 $660 Million	TIER 2 $962 Million	TIER 2 $20 Billion	TIER 2 $31 Billion

RESILIENCE PLAN RECOMMENDED POLICIES

Develop Green Streets Program: Increase available greenspace for drainage along roadways, including bioswales and guidance to convert selected neighborhoods from two-lane to one-lane roads, widening drainage areas along the right-of-way.

Reduce Parking Minimums: Revise and adjust parking space requirements for new developments and redevelopments to promote more efficient land use, encourage resilience focused transportation options, reduce the footprint of parking areas, support community-oriented growth, and increase storage and pervious areas.

Promote Efficient Land Use: Offer incentives to encourage property owners to replace asphalt parking lots with parking garages or alternative solutions that maximize space and reduce impervious surfaces.

Enhance and Adapt the County's Seawall Ordinance: Revisit minimum elevation requirements for tidal flood barriers as sea levels rise.

Incorporate Resilience into Complete Streets Design Standards: Incorporate resilience standards into complete streets projects and standard designs.

Improve Resilient Development Requirements: Develop a resilient land development code to document requirements for compliance with the Resilience Plan.

Prioritize Resilient Growth Priority Areas: Conduct a study to identify and prioritize areas for development and redevelopment that align with the County's resilience objectives, promoting risk informed growth and community preparedness.

Promote Resilient Home Construction and Retrofits: Provide tools, incentives, and resources for homeowners to make resilience improvements to their properties.

Implement Resilient Improvements at Public Facilities: Implement resilient improvements to County facilities and encourage municipalities and other public entities to enhance their facilities.

Utilize Technology to Enhance Flood Protection: Establish a framework for remote monitoring and control of newly adapted structures, enabling timely adjustments to water level changes and effective management before storm events.

Encourage Redevelopment in Overlay Districts: Provide incentives for redevelopment in overlay areas where additional storage will improve flooding and reduce heat.

Develop Cleaning/Maintenance/Rehabilitation/Testing Program: Require routine cleaning and maintenance of stormwater infrastructure.

Document Future Seawall Requirements 2070: Provide information to the public to prepare for future modifications to the seawall ordinance.

Increase Pervious Percentages: Implement a program to incentivize property owners to convert impervious surfaces, such as concrete or asphalt, to pervious materials like uncompacted gravel or permeable pavers.

Increase Stormwater Storage Management Requirements: Enhance on-site storage capacity requirements for developed or redeveloped land to promote better stormwater management and resilience.

Promote Resilient Land Use: Encourage resilient development by offering incentives and variances for projects that provide additional stormwater storage, ensuring a positive impact and net benefit for the community.

Mitigate Rising Insurance Costs: Explore mechanisms to reduce the burden of rising windstorm and flood insurance costs.

Streamline Post-Disaster Redevelopment Planning and Processes: Proactively plan for redevelopment after disasters by streamlining recovery programs that assist residents in rebuilding or relocating, ensuring a more efficient and supportive recovery process.

1 Our County

OUR DIVERSE COMMUNITY

Broward County, located in southeastern Florida, is a diverse community with a unique blend of natural beauty and urban development. The county includes 31 municipalities and boasts 23 miles of Atlantic Ocean coastline featuring a series of beaches, including Hillsboro Beach, Deerf eld Beach, Pompano Beach, Lauderdale-By-The-Sea, Fort Lauderdale, Dania Beach, Hollywood, and Hallandale Beach. Each of these beaches has its own distinct character, of ering a variety of recreational activities, from sunbathing and swimming to boating and f shing.

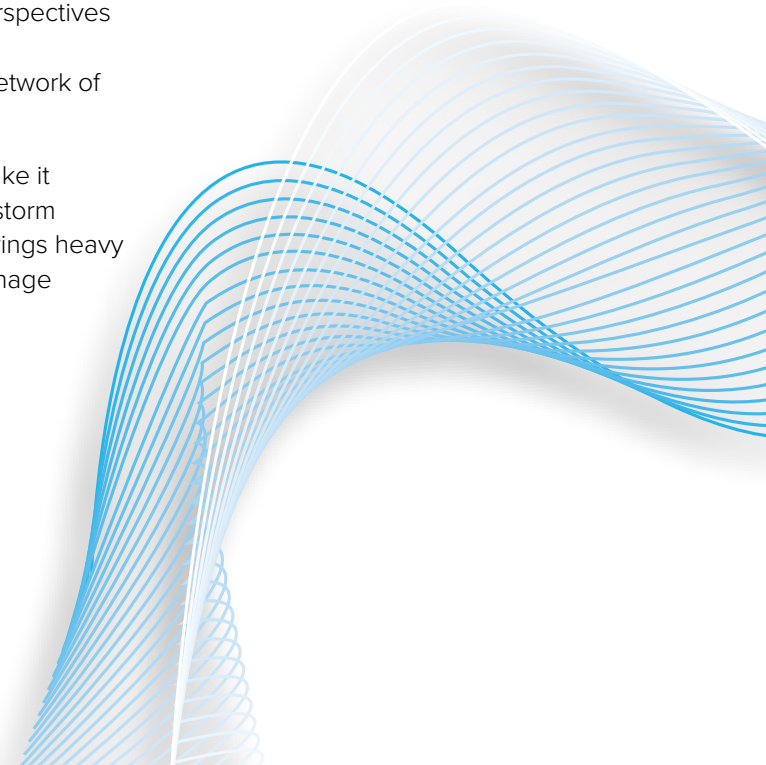
In addition to its oceanfront, Broward County is interlaced with over 300 miles of intracoastal waterway and navigable inland waterways. These waterways enhance the scenic beauty of the area and play a crucial role in the local economy, supporting tourism, marine industries, and residential waterfront living.

The county's low-lying location makes it a hub for maritime activities and a popular destination for tourists seeking beach vacations, water sports, and vibrant nightlife. Fort Lauderdale, the largest city in the county and often referred to as the "Venice of America," is renowned for its extensive canal system and luxury yachts. Additionally, the County's bustling port, Port Everglades, is one of the busiest cruise ship ports in the world.

The inland portion of Broward County is a blend of communities, natural preserves, and evolving urban landscapes, offering different perspectives on the county's overall character. It is characterized by its flat terrain and proximity to the Everglades, a vast and intricate network of wetlands that play a critical role in the region's ecology.

Broward County's low elevation and limited natural drainage make it susceptible to flooding, especially during the rainy season and storm events. The rainy season, extending from June to November, brings heavy rainfall that can quickly overwhelm the natural and artificial drainage systems. This period often coincides with the Atlantic hurricane season, further exacerbating the risk of flooding. Tropical storms and hurricanes can produce torrential rains and storm surges that inundate inland areas, causing significant damage to infrastructure and property.

The County's low elevation and limited natural drainage make it susceptible to flooding, especially during the rainy season and storm events.



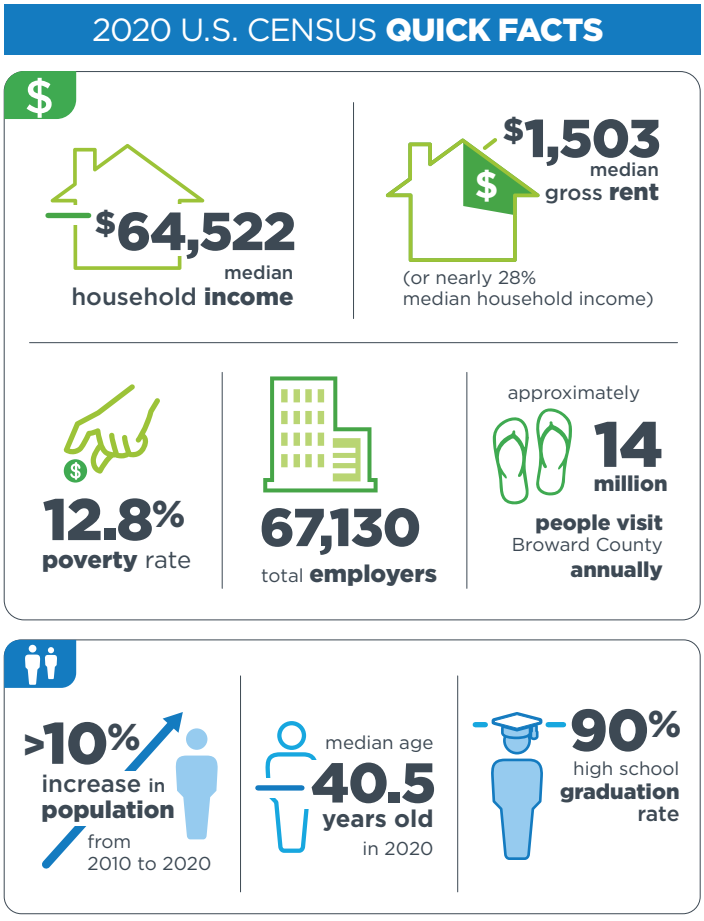
THE RESILIENCE PLAN PROVIDES THE BASIS FOR THE CONTINUED ECONOMIC DEVELOPMENT OF THE COUNTY through planned adaptations to mitigate potential future damages.

Aerial photo of Broward's coastal skyline.

Until the late 19th century, Broward County was almost unfit for human habitation except for the coastal ridge and scattered spots of high ground. Governor Napoleon B. Broward's efforts to drain the Everglades in the early 1900s initiated the development of inland Broward County, fueled in the following decades by the extension of the railroad and the seaport. However, the area was still vulnerable to the effects of nature.

One of the earliest and most devastating floods occurred during the Great Miami Hurricane of 1926. This powerful storm caused widespread flooding across South Florida, including Broward County.
The hurricane's storm surge and heavy rains led to catastrophic flooding, affecting coastal and inland areas. The storm's aftermath underscored the need for better flood management and infrastructure improvements.

In 1948, the Central and Southern Florida (C&SF Flood Control Project was authorized by the U.S. Congress in response to the devastating floods that plagued the region. The project's primary goals were to provide flood protection, improve water management, and support the growing population and agricultural industry.



The Project entailed the construction of over 1,000 miles of interconnected canals and levees and numerous pumping stations and water control structures designed to manage water resources, mitigate flooding, and facilitate urban and agricultural development.

The current drainage systems of the County's communities rely on the performance of the C&SF Flood Control Project primary system, operated and maintained by the South Florida Water Management District (SFWMD). However, due to this interconnected drainage system, flood control in South Florida is a shared responsibility between the District and counties, cities, local drainage districts, and homeowner's associations, which operate and maintain the secondary and tertiary systems.

The SFWMD and its partner, the U.S. Army Corps of Engineers (USACE, have embarked on initiatives aimed at adapting the components of the C&SF Flood Control project to the current hydrologic conditions, which are very different than the conditions observed in the last century when the project components were designed, and more importantly, adding a resilience component that will prepare the primary system of the C&SF Flood Control Project to mitigate the ef ects of sea level rise (SLR and climate change.

Being a coastal and inland community with highly interdependent drainage systems presents significant challenges. Broward County, with its low elevation, flat topography, and dense urban development, is particularly vulnerable to the impacts of climate change, including SLR, coastal erosion, increased precipitation, higher groundwater elevation/ less storage capacity, and increased storm surge. These factors necessitate robust coastal management and resilience planning to protect the County's residents, infrastructure, and natural resources.

Efforts to enhance resilience include converting impervious surfaces to pervious, increasing runoff storage capacity, constructing taller seawalls, and implementing risk informed urban planning practices. By addressing these challenges proactively, Broward County aims to preserve its charm and ensure a safe, thriving, and economically attractive environment for future generations.

The Countywide Resilience Plan will continue to be coordinated with and complemented by the C&SF Flood Control Project planned improvements.

Broward County is impacted today by sudden intense precipitation and high tide events. Residents, businesses, and visitors are already challenged by surprise inundations which are forecasted to be even more extreme in the future. Adaptations are necessary for today's conditions and even more necessary for the projected future.

OUR CHALLENGE

Presently, residents in Broward County occasionally experience intense tidal- and rainfall-induced f ooding. Existing infrastructure is adequate for typical rainfall events but can, at times, struggle to properly drain heavier and/or longer duration rainfall events and high-tide events.

For instance, on April 12, 2023, portions of Broward County experienced an unprecedented rainfall event that had significant and far-reaching impacts on the community. This particular event was considered to be "outlier" event and was not anticipated to recur with any frequency. However, a similar high intensity rainfall occurred in June 2024. The impacts of the two events created an awareness of the drainage concerns.

The following summarizes the April 12, 2023, intense event to provide an overview of the potential consequences for extreme events.

1. **Record-Breaking Rainfall.** The storm system brought torrential rains, with some areas, including Fort Lauderdale, receiving nearly 26 inches of rain within a 12-hour period. This extreme rainfall shattered previous County records and overwhelmed the area's drainage systems.
2. **Severe Flooding.** The intense rainfall led to widespread flash flooding. Streets, neighborhoods, and major thoroughfares were inundated, leaving many residents stranded in their homes and vehicles. The flooding was so severe that it shut down Fort Lauderdale-Hollywood International Airport for several days, causing significant travel disruptions.
3. **Economic Damage.** The flooding caused extensive damage to homes, businesses, and infrastructure. The estimated cost of the damage reached approximately $1.1 billion in direct costs (with additional unidentified indirect costs anticipated). Many businesses had to close temporarily, and the recovery efforts required substantial resources and coordination.

4. **Emergency Response.** In response to the flooding, Broward County and Fort Lauderdale declared a state of emergency. Emergency services were mobilized to rescue stranded individuals, provide shelter, and begin the cleanup and recovery process. The event highlighted the need for improved emergency preparedness and response strategies.
5. **Community Impact.** The flooding had a profound impact on the daily lives of residents. Schools and businesses were closed for several days, and many people faced significant challenges in accessing essential services and supplies. The event underscored the importance of community resilience and the need for robust support systems during extreme weather events.
6. **Environmental Consequences.** The heavy rainfall and flooding also had environmental impacts, including potential contamination of water sources and damage to natural habitats. The event emphasized the importance of resilient water management practices and the protection of natural ecosystems.

This historic rainfall event reinforced the critical need for Broward County to enhance its resilience to extreme weather events and the potential for severe flooding under varying conditions at any time of the year. By investing in infrastructure improvements, emergency preparedness, and community engagement, the County can better protect its residents and ensure a more resilient future.

Broward County's flood risk will continue to increase due to SLR, rainfall intensification, and heightened surge events.

Broward County motorists can be trapped on low-lying roads during intense rainfall events. The Resilience Plan identifies the areas of concern for future awareness and makes recommendations for improvements.

OUR PLAN FOR THE FUTURE (MEETING THE CHALLENGE)

The Countywide Resilience Plan is a Broward County initiative focused on addressing climate change impacts predicted over the next 50 years. The Resilience Plan focuses on building community resilience to climate change issues (including SLR, more intense rainfall, and heightened surge events) with a primary focus on combined flood and heat mitigation.

The Countywide Resilience Plan is a Broward County initiative focused on addressing climate change impacts predicted over the next 50 years.

This effort was conducted with the collective support of municipal and business leaders who meet annually to discuss the resilience needs of the Broward County community. Plan development was further supported by a Resilience Steering Committee consisting of private-sector and community representatives and the sustained engagement of local municipalities, water managers, and agency partners, as well as input from the general public, including the local youth. A Blue Ribbon Panel of industry experts reviewed and approved key deliverables, including the economic modeling methodology and output.

The Plan is designed to provide the foundation for a basin-level, multi-decade resilient infrastructure and adaptation plan for Broward County. The Plan includes new water management strategies, recommendations for increased water storage throughout the county, nature-based and gray infrastructure improvements, and long-term increases to current seawall heights.

The Plan assumes that SLR will gradually increase, following the trend of the Southeast Florida Regional Climate Change Compact's Unified Sea Level Rise Projection, while recognizing that exact prediction is not possible. The Plan recommends implementing improvements on a strategic basis, with adaptations complementing each other and building upon previous improvements. The Plan is intended to be dynamic, with technological improvements incorporated within future investment strategies. The Plan requires that the County, the municipalities within the county, the water control districts, the SFWMD, and other outside agencies continue to work together to maximize the benefits of the Countywide Resilience Plan.

Restoring swales and converting two-way roads (in certain appropriate locations) to one-lane roads for a reduction in impervious area and an increase in stormwater storage capacity will be a necessary redevelopment strategy to ensure the County adapts to changing future conditions.

HOW WILL THE RECOMMENDED ADAPTATIONS IMPROVE OUR LIVES?

Implementing resilience adaptations in Broward County is critical for ensuring a thriving future. These adaptations will address the County's unique vulnerabilities to climate change and environmental stressors, leading to numerous long-term benefits.

Enhanced Flood Protection. By investing in flood mitigation infrastructure, such as improved drainage systems, seawalls, and natural barriers, Broward County can significantly reduce the risk of flooding. This will protect homes, businesses, and critical infrastructure from water damage, ensuring the safety and wellbeing of residents.

Improved Public Health. Resilience adaptations aimed at mitigating extreme heat, such as urban greening, will help protect public health. These measures can reduce heat-related illnesses and improve overall quality of life, especially for vulnerable populations.

Economic Stability and Growth. By safeguarding key economic sectors, such as tourism and marine industries, resilience adaptations will help maintain and potentially boost the local economy. Investments in resilient infrastructure can also attract new businesses and promote risk informed development, creating jobs and fostering economic growth.

Environmental Preservation. Protecting and restoring natural ecosystems, including the Everglades, will enhance biodiversity and improve ecosystem services such as water filtration. This benefits the environment and supports recreational activities and tourism.

Community Cohesion. Engaging community stakeholders in the resilience planning process ensures that the process fosters a sense of community ownership and collaboration, leading to more effective and widely supported resilience strategies.

Increased Preparedness and Recovery. Resilience adaptations will enhance the County's ability to prepare for, respond to, and recover from extreme weather events and other climate-related impacts. This includes developing emergency response plans, improving communication systems, and ensuring that critical services remain operational during crises.

By proactively addressing these challenges, Broward County can build a more resilient, adaptive, and prosperous future. These efforts will not only protect the county's natural and built environments but also enhance the quality of life for the residents, visitors, and business community.

Photo by Stephen Baker / Unsplash.com

2 Overview

RISKS TO BROWARD COUNTY

Broward County is facing a variety of risks associated with climate change, many of which are interconnected, creating even greater combined challenges.

THE KEY RISKS ADDRESSED BY THIS RESILIENCE PLAN

HIGHER INTENSITY RAINFALL EVENTS
Existing stormwater drainage systems were designed/constructed for less precipitation than currently witnessed and may not be able to properly drain current and future rainfall events.

URBANIZATION IMPACTS
The urbanization of Broward County means that open areas are not available to store and attenuate large rainfall events.

INCREASING TEMPERATURES
Temperatures continue to increase and are magnif ed by highly impervious areas.

LOSS OF ECONOMIC ENGINES
If the County does not adapt, major industries may choose to move out of the area, which would negatively impact the economy of the region.

TOURISM DECLINE
Tourists may not visit if they feel their vacation will be threatened by rising floodwaters and/or sunny day flooding, further eroding the economy.

REDUCTION IN PERSONAL PROPERTY VALUE
Homeowners and business owners risk losing their investments due to flooding.

DECREASE IN GROUNDWATER STORAGE CAPACITY
Higher groundwater levels throughout the county means less storage is available for rainfall in the unsaturated portion of the soil, resulting in a greater accumulation of water at the surface.

RISING SEA LEVEL
The sea level continues to rise and increases the risk of flooding to coastal areas.

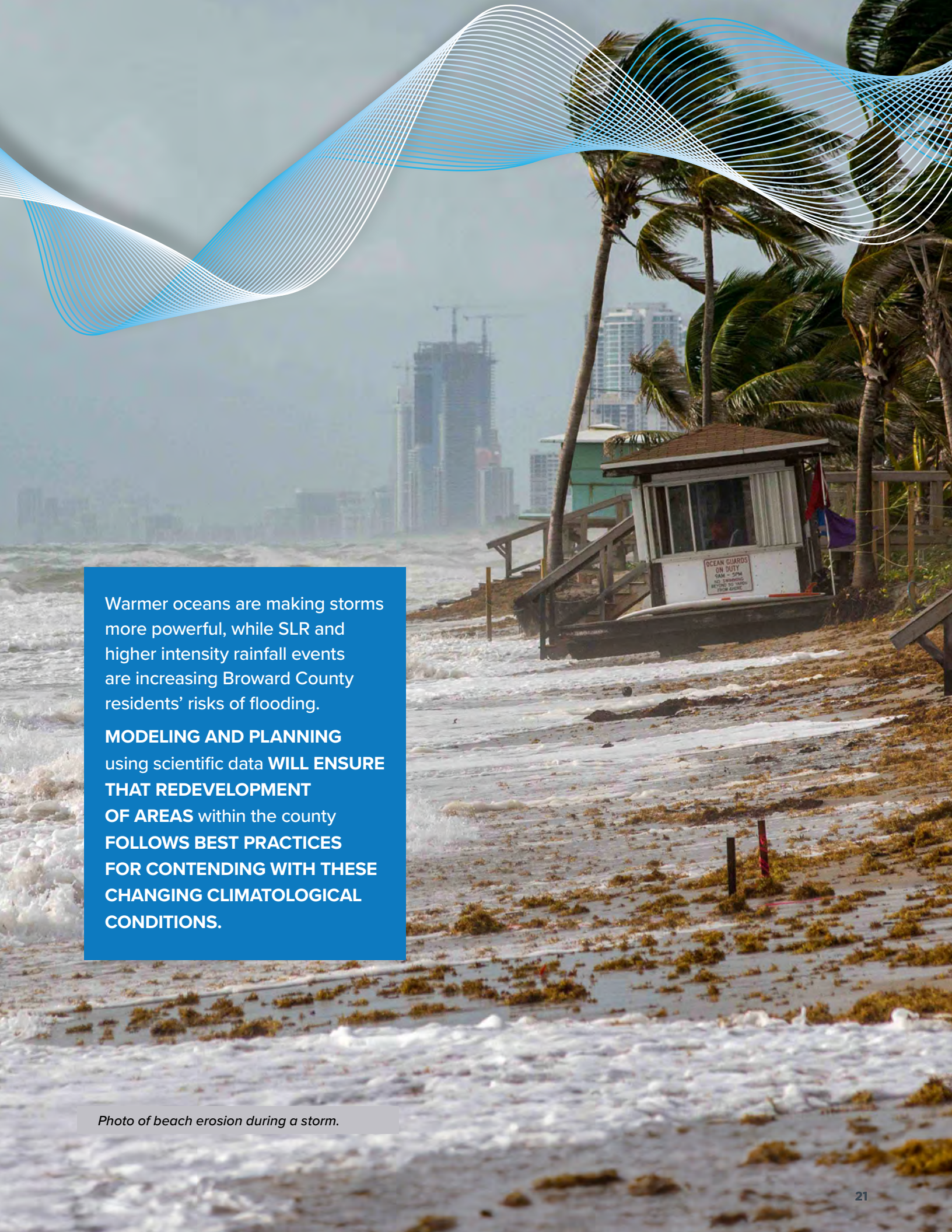
SURGE EVENTS
Broward County is vulnerable and will remain vulnerable to storm surge. With intensifying storms, coastal protections, such as seawalls, need to be maintained and bolstered.

REDUCED NUMBER OF RESIDENTS
If the risk of flooding is not minimized, residents might choose to reside elsewhere.

INCREASE IN HOME INSURANCE PREMIUMS Without community adaptations, home insurance premiums could signifcantly increase, making it difficult for residents to afford and to continue living in their homes.

LARGE COST TO REBUILD OR RETREAT
The risk of not adapting as a community is that each individual may need to rebuild or retreat from their existing residence to a residence outside of the food-prone areas, which will be shrinking in availability.

These risks are indicated for the purposes of developing strategies to improve the lifestyle of the residents and visitors to Broward County. The attributes that residents and visitors care about primarily are addressed in the Resilience Plan.



Warmer oceans are making storms more powerful, while SLR and higher intensity rainfall events are increasing Broward County residents' risks of flooding.

MODELING AND PLANNING using scientific data **WILL ENSURE THAT REDEVELOPMENT OF AREAS** within the county **FOLLOWS BEST PRACTICES FOR CONTENDING WITH THESE CHANGING CLIMATOLOGICAL CONDITIONS.**

Photo of beach erosion during a storm.

VISION FOR RESILIENCE

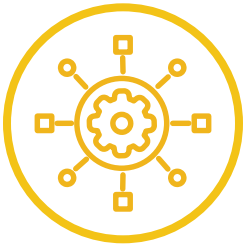
The County perceived the risks of climate change in the early 2000s and was instrumental in the formation of the Southeast Florida Regional Climate Change Compact with three neighboring counties. Established in 2009, the Compact is a partnership between Broward, Miami-Dade, Monroe, and Palm Beach counties to work collaboratively to reduce regional climate change impacts, implement adaptation strategies, and build climate resilience across the Southeast Florida region. Since then, the County authored the County's Climate Action Plan (CCAP), with a recent update in 2024. From the CCAP, the County further developed multiple tools, including future flood maps, Priority Planning Areas, future groundwater conditions, and this Resilience Plan.

The County's vision for resilience is detailed in this actionable, 50-year Resilience Plan.

The Plan provides sufficient detail to serve as the basis for a multi-decade, coordinated, and phased improvement plan with planning-level detail to support refined outreach, conceptual design development, and financing needed for implementation.

Vision for Resilience

Integrate Robust Risk Analytics and Economic Analyses



Include Resilient County Infrastructure Improvement Strategies

Present Resilient Redevelopment Strategies

Provide a Visualization Platform/Plan to Aid Regional Planning and Project Tracking

Encourage Opportunities and Partnerships Among Municipalities and Districts for Future Funding

Form the Foundation for the Collective Mitigation of Future Flooding

The Plan provides sufficient detail to serve as the basis for a multi-decade, coordinated, and phased improvement plan with planning-level detail to support refined outreach, conceptual design development, and financing needed for implementation. The Plan consists of adaptation strategies applicable to portions of the dense urban landscape of Broward County, informed by application of hydrologic and hydraulic models and model results produced and applied in future conditions modeling for Broward County.

3 Risk Assessment

Broward County faces increasing climate-related risks that threaten its residents, infrastructure, and economy. Rising sea levels, more intense rainfall, and stronger storm surges are exacerbating flood risks, while rising temperatures and the urban heat island effect are making extreme heat events more frequent and severe. These compounding factors place additional strain on drainage systems, public health, and economic stability.

The Resilience Plan begins with a critical question: what would Broward County look like if no action were taken to protect and enhance its resilience? This baseline scenario evaluates the county's current and future exposure to climate hazards without adaptation measures. It serves as a benchmark against which potential improvements can be measured, helping to identify the most effective strategies for reducing risks and safeguarding the County's future.

The hydrologic and hydraulic (H&H) flood modeling and urban heat analysis summarized in this chapter provide a data-driven foundation for Broward County's resilience planning.

Rising sea levels, more intense rainfall, and stronger storm surges are exacerbating flood risks, while rising temperatures and the urban heat island effect are making extreme heat events more frequent and severe.

WHEN THE RAINS CAME

IN A 24HR PERIOD NEARLY 26 IN OF RAIN FELL ON FORT LAUDERDALE-HOLLYWOOD INTERNATIONAL AIRPORT. IT WAS THE MOST EVER OBSERVED IN FORT LAUDERDALE IN A SINGLE DAY, ECLIPSING THE PREVIOUS RECORD OF 14.59 IN SET ON APRIL 25, 1979

On the evening of April 12th, over two feet of rain fell in parts of Broward County, as a supercell thunderstorm 'parked' near Fort Lauderdale, Pembroke Pines and Hollywood. To compound the issue, the ground was already saturated after days of heavy rainfall, reducing stormwater infiltration and overwhelming stormwater drainage systems. The results, as we all witnessed, were catastrophic.

It rained so much that the Fort Lauderdale-Hollywood International airport's flooded runways closed for 40 hours, affecting at least 1,119 flights, and the County reported at least $2 million in damages to schools across the region. Approximately a third of Fort Lauderdale's average annual rainfall came down during an eight-hour window, as rainfall of 25.91 inches of rain was reported at the airport, a State record.

The Broward County Resilience Unit team has long utilized compound flooding maps to predict how major flood conditions affect our water management and transportation, and with the help of strategic partners in our cities, neighboring counties, FDOT and the South Florida Management District, these models have proven to be very robust.

Now that these modeled conditions have been realized we can see how close our planning tools replicate such extreme flood events. Broward's Future Conditions models not only evaluate the impacts of rainfall intensification, but consider these events under the combined conditions of predicted sea level rise, king tides, and storm surge. This approach has proven effective in replicating what we can also expect from a 1,000-year event like this.

This flash flood event has underscored the realities of extreme weather, climate change, and the need for action across South Florida and globally. As waters recede from the Broward's lowest-lying points, homeowners, nonprofit organizers and government leaders can tabulate a list of lessons the storm has taught us.

Hard-hit neighborhoods, like River Oaks and Edgewood, will benefit from City of Fort Lauderdale's $200 million, five-year drainage system overhaul, with storm pumps and robust pipes on the way. Elsewhere, areas in Hollywood, Dania Beach and within the Broward Municipal

Areas that experience flooding under current conditions are expected to experience higher levels of flooding under future conditions.

THE RESILIENCE PLAN PROJECTS FUTURE FLOODING AND PRESENTS THE ADAPTATIONS AVAILABLE TO IMPROVE RESILIENCE TO FUTURE CONDITIONS.

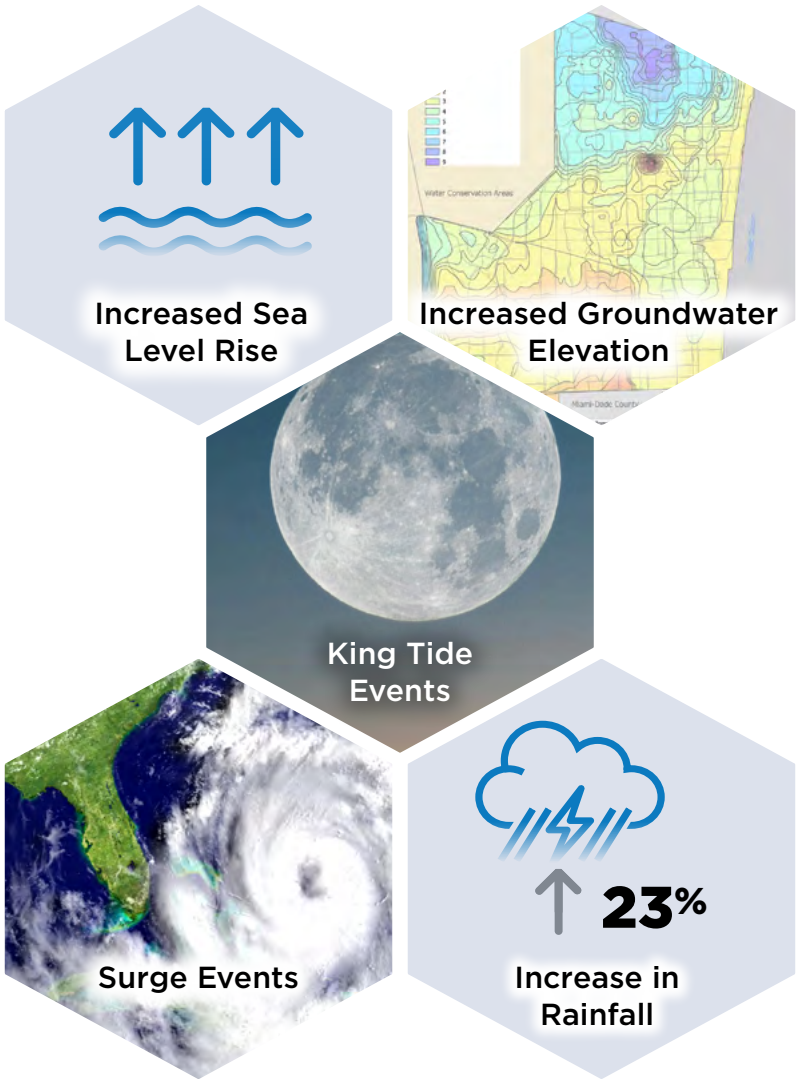
Photo of King Tides along a canal in Fort Lauderdale.

ASSUMPTIONS FOR THE FUTURE

To develop the Resilience Plan, assumptions for future climatological changes were first analyzed. The future conditions of increased SLR, more intense rainfall, surge events, King Tide events, and increased groundwater elevation were all estimated before developing the model.

Under the flood risk evaluation, it was assumed that the SFWMD would operate the C&SF Flood Control Project so that prior to each storm, the canals would be drawn down by 1 foot under both current and future conditions. The results of the future conditions evaluation were used to estimate the direct and indirect economic impacts caused by rainfall and tidal events. The impacts from each adaptation were compared to those obtained under the baseline condition of no action. It was not, and should not be expected, that the adaptations would remove all sources of flooding. However, the SFWMD and the USACE are currently evaluating improvements to the components of the C&SF Flood Control Project. The improvements to be achieved by their proposed plan would add to the benefits of the Resilience Plan.

Figure 3-1. Model Assumptions are Based on Scientific Observations and Predictions



HYDROLOGIC AND HYDRAULIC MODELING TO DETERMINE IMPACTS OF FLOODING

Development of the Resilience Plan utilized a scientific process that equips planners with tools to estimate future flooding conditions based on various factors. These tools include H&H models, which simulate the components of the hydrologic cycle, such as rainfall, evapotranspiration, infiltration, recharge, and runoff. These simulations help evaluate how the urban area of Broward County responds to different combinations of rainfall and tidal events. Since the early 2000s, Broward County has been developing a comprehensive H&H model. The Plan builds on previous efforts to develop, calibrate, and continuously refine the County's MIKE SHE/MIKE HYDRO model. The purpose of the model refinements was to add more hydraulic and hydrology details at the localized level, improve the representation of the basins, and improve the computational efficiency.

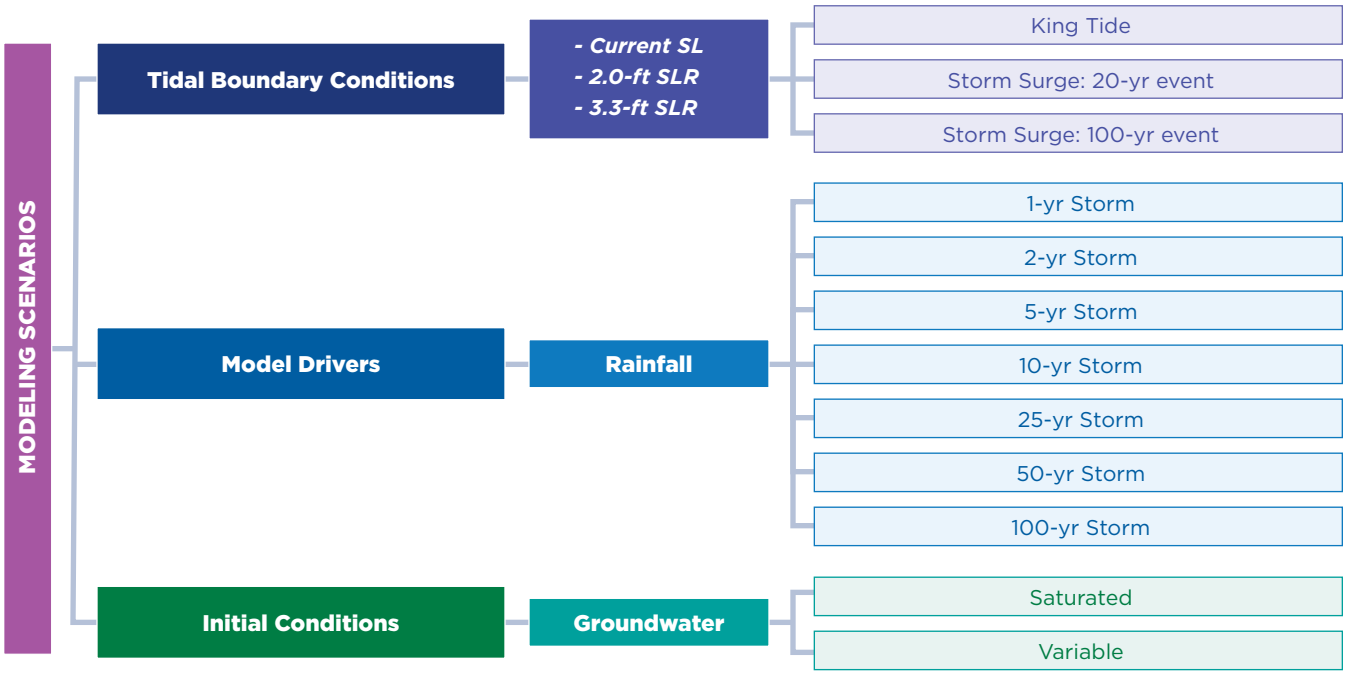
The adaptations developed under the Resilience Plan were determined through detailed H&H modeling. The Resilience Plan Model was built upon the most recent version of the H&H model:

- The SFWMD Flood Protection Level of Service (FPLOS) for Nine Watersheds in Broward County (Taylor Engineering, 2020) (herein referred to as the SFWMD BC FPLOS Model).
- The Broward County MIKE SHE/MIKE HYDRO model updated for the 100-year Flood Elevation Map (Taylor Engineering, 2019) (herein referred to as the BC FM Model).

The refined model was modified to incorporate numerous combinations of rainfall, SLR, tidal surge, and antecedent conditions. Figure 3-2 shows the components to develop each scenario. The outputs from the scenarios, specifically the peak overland flooding depths at a 125-foot resolution, along with flood durations, serve as inputs for the economic model used to estimate damage assessments under a conditional probability curve. The range of simulated conditions informs the development of the frequency-of-occurrence probability curve.

A description of the input data is provided in the following subsections.

Figure 3-2. Modeling Scenarios Resilience Plan – 51 Scenarios Evaluated



Rainfall

The initial design event rainfall for the 5-, 10-, 25-, and 100-year frequencies was already setup in the SFWMD BC FPLOS models, originating from the NOAA Atlas 14 database (PF Data Server-PFDS/HDSC/OWP [noaa.gov]).

All future conditions scenarios incorporated an increase in rainfall, with change factors ranging from 11% to 23% depending on event frequency. These factors were obtained from the SFWMD Resilience Metrics Hub, Future Extreme Rainfall Change Factors for Flood Resiliency Planning in South Florida Web Application | Resilience Metrics Hub (arcgis.com).

Sea Level Rise

SLR projections were incorporated into the scenario development based on guidance from the Broward County Resilience Team. The specif ed SLR values of 2 feet for 2040 and 3.3 feet for 2070 were applied across the Resilience Plan scenarios.

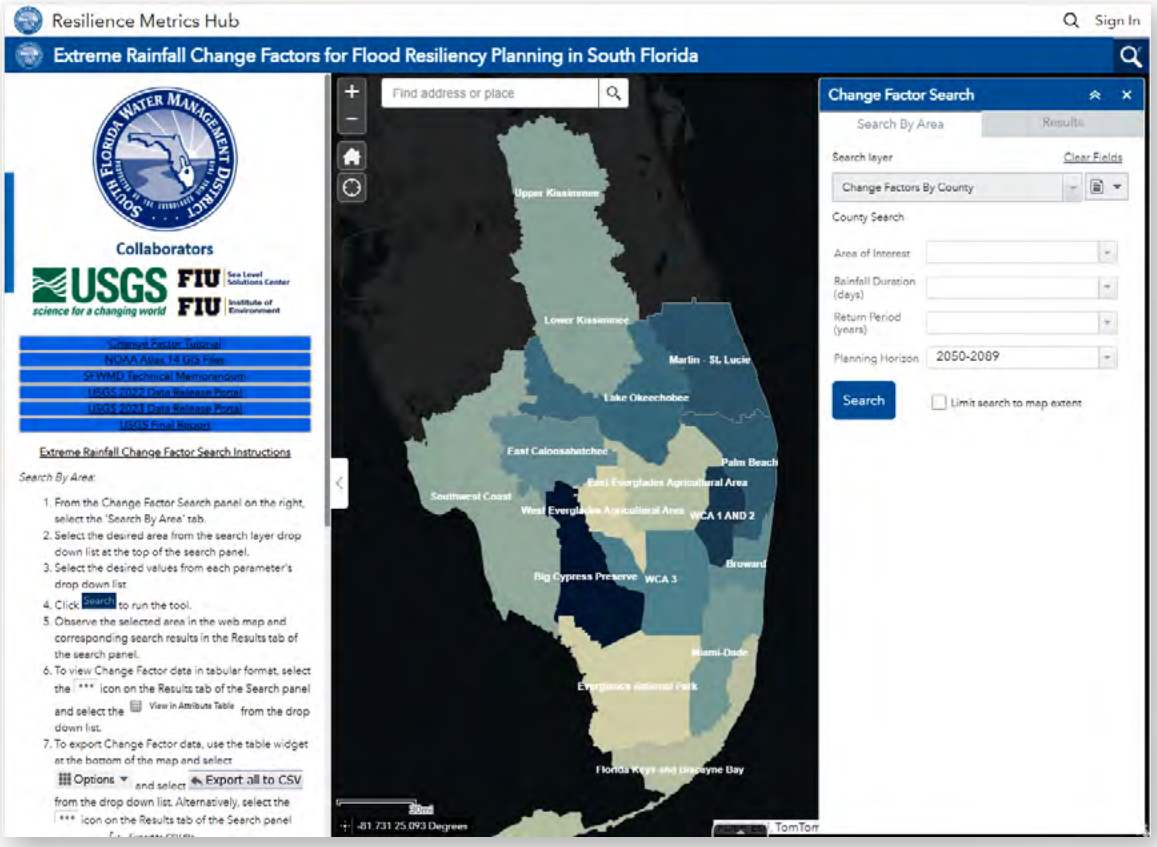
Tidal Surge

Tidal surges pose a significant flood risk, especially when combined with storm events. The Resilience Plan evaluates how rising sea levels, King Tides, and extreme storm surges will impact Broward County's coastal areas. Using historical data and predictive models, the Plan assesses how future storms—ranging from moderate events to Category 5 hurricanes—will intensify flooding risks.

Groundwater

Groundwater levels are influenced by SLR and extreme rainfall, affecting flood risks and drainage capacity. Using data from the U.S. Geological Survey (USGS) Broward County MODFLOW model and SFWMD's FPLOS model, the analysis examines changes in groundwater storage, soil saturation, and surface flooding potential. These insights guide strategies for managing groundwater levels to reduce flood impacts.

Figure 3-3. Screenshot of the South Florida Water Management District's Resilience Metrics Hub

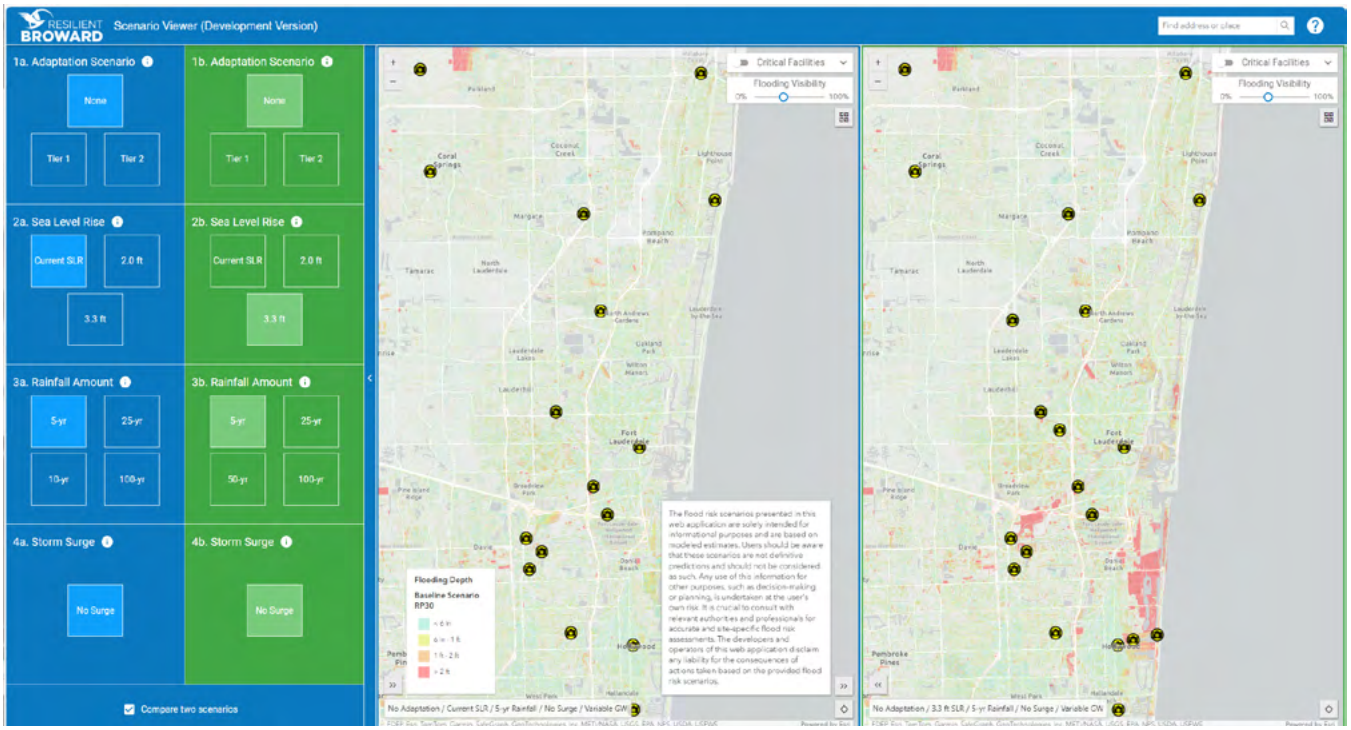


Model Results

The model yielded results that were representative of observed conditions based on discussions with stakeholders and the public. Model calibration was verified using the conditions observed during Hurricane Irene (September 2017). The intense rainfall events of November 10–11, 2020, further assisted with validation of the model.

Flood maps for a subset of the scenarios have been compiled in a scenario viewer that can be used to compare scenarios and zoom into locations of interest (Broward County Scenario Viewer [arcgis.com]). Flood maps (i.e., peak overland elevation) for a selection of scenarios zooming into a sample area around Fort Lauderdale are shown in Figure 3-4.

Figure 3-4. Scenario Viewer for Broward County Developed for this Resilience Plan



Note: These scenarios can also be shown in a side-by-side comparison view, for ease of visualization. (Broward County Scenario Viewer [arcgis.com]).

Additionally, the Scenario Viewer includes 360-degree photos with f ood renderings to create an immersive visualization of potential f ood impacts. Figure 3-5 and Figure 3-6 are examples of the 360-degree photos with flood renderings.

These tools further enhance the community's understanding of climate risks. By integrating these visualization technologies, the County can improve transparency, foster community engagement, and support evidence-based decision-making throughout the adaptation planning process.

Figure 3-5. Long Key Natural Area (360-Degree Photo with Flood Renderings)

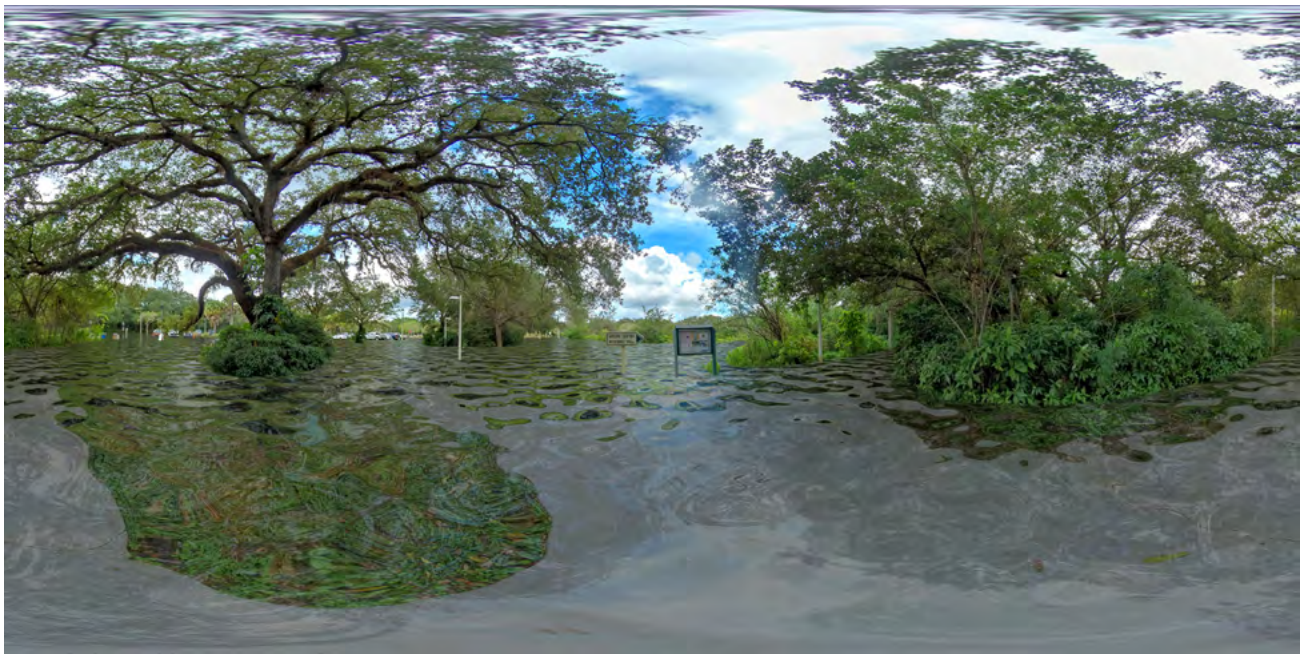


Figure 3-6. Memorial Regional Hospital (360-Degree Photo with Flood Renderings)

HEAT ANALYSIS RESULTS

As part of the risk assessment, this heat analysis examines rising temperatures and their impact on the county. The average land surface temperature (LST) for the county is shown in Figure 3-7 and ranged from 74–112° F for the year 2022. Recent research has also shown that observed temperatures are rising, and the number of days where a heat advisory is issued, is expected to increase Figure 3-8. The figure below shows the projection of extreme heat days (>105 degrees F) for Broward County.

Figure 3-7. Average 2022 Land Surface Temperature (°F)

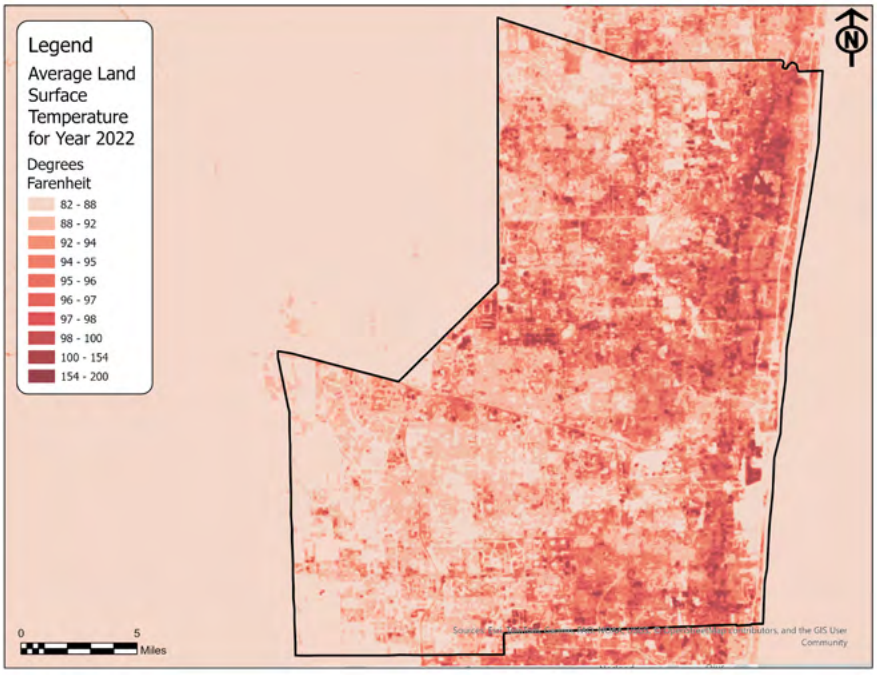
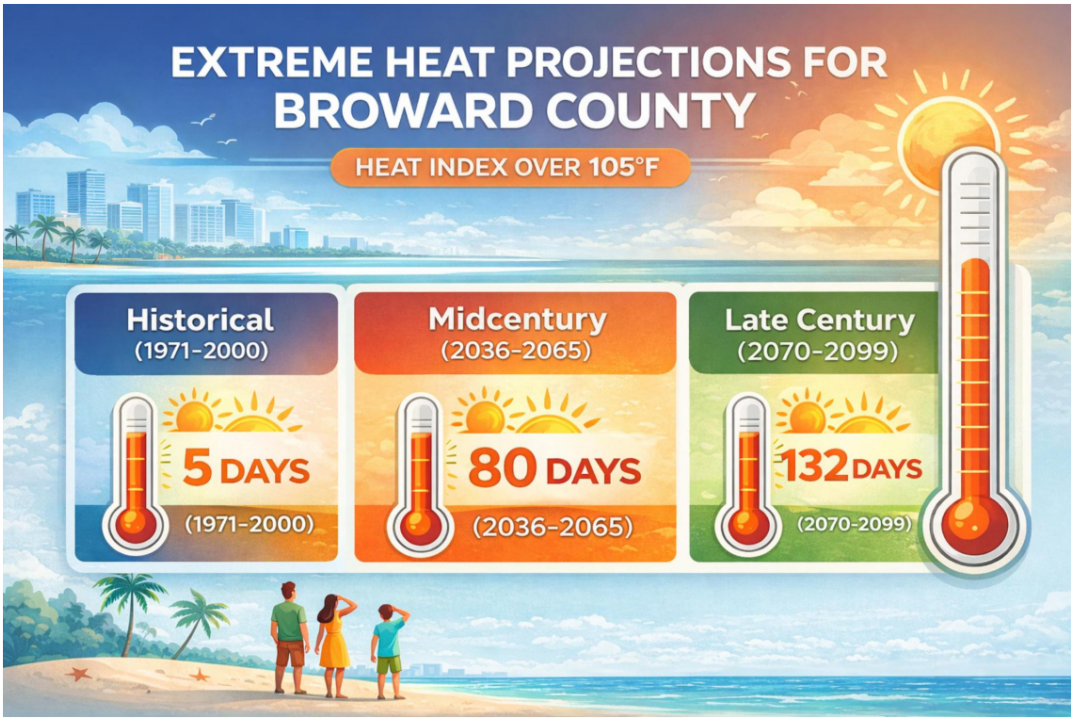


Figure 3-8. Projected Extreme Heat Days for Broward County



To evaluate the correlation between green areas and LST, a spatial analysis was carried out for two pilot areas within the county. Selection of these areas was based on the imperviousness of the surfaces (measured as a percentage). One area was selected in downtown Fort Lauderdale (with high rates of imperviousness), and the other was further west in a residential area of Pembroke Pines (with greater percentage of green space).

The analysis confirmed a correlation between the imperviousness of a cell and the LST in areas around that cell. Based on these analyses, a distance of 1,000 feet was used as the radius of influence that nature-based infrastructure best management practices have on lowering temperature. This radius of influence was used to delineate the areas that may see temperature reduction benefits from nature-based infrastructure.

The development of this Resilience Plan included adaptations that would benefit the hotspots identified in Figure 3-9, particularly where they intersect with high numbers of the low to moderate income population.

Nature-based infrastructure is known to reduce the effects of heat islands by maximizing pervious surfaces within urban settings. Additionally, nature-based infrastructure often offers mitigation strategies for flooding and rainwater storage while providing sustainable landscaping. Nature-based infrastructure mitigation strategies for heat reduction may include:

- Sustainable landscaping and flood-resistant materials
- Pocket wetlands
- Rainwater harvesting
- Bioswales and bioretention
- Permeable pavement or pavers
- Enhanced stormwater ponds

Figure 3-9. Low Income Areas Overlain with Average Land Surface Temperature

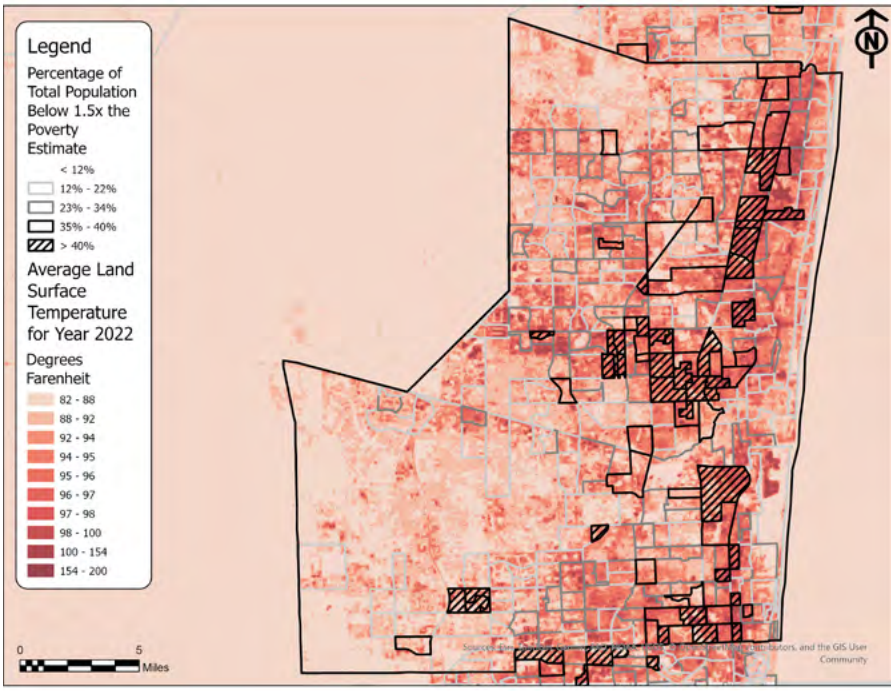


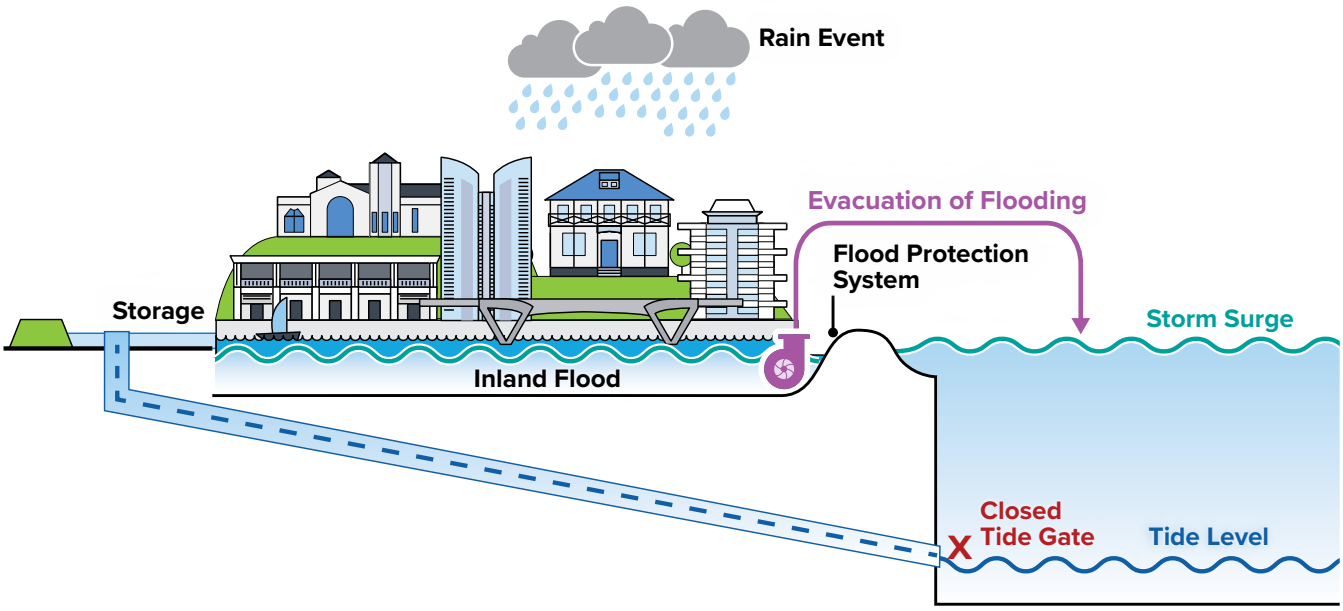
Photo of tree canopy at Hugh Taylor Birch State Park.

4 Adaptations Analysis

To develop effective adaptations, a comprehensive analysis was conducted to assess flood and heat vulnerabilities across Broward County and summarized in the previous chapter. This multi-step approach identified areas most at risk from SLR, increased precipitation, and higher groundwater levels, ensuring that strategies were data-driven and targeted. By first understanding these risks, the Resilience Plan was able to develop specific adaptation strategies to strengthen the County's ability to withstand future climate challenges while protecting infrastructure, communities, and the local economy. This risk-based foundation is essential in prioritizing adaptation measures that will be both effective and cost-efficient.

The Resilience Plan was able to develop specific adaptation strategies to strengthen the County's ability to withstand future climate challenges while protecting infrastructure, communities, and the local economy.

Figure 4-1. Additional Conveyance and Strategic System Storage Will Protect Against Storm Surge and SLR



Constructing **HIGHER SEAWALLS** now is an adaptation necessary for prevention of inundation from current King Tides and storm surge but will also **PROTECT PROPERTIES FROM FUTURE PREDICTED SEA LEVEL RISE.**

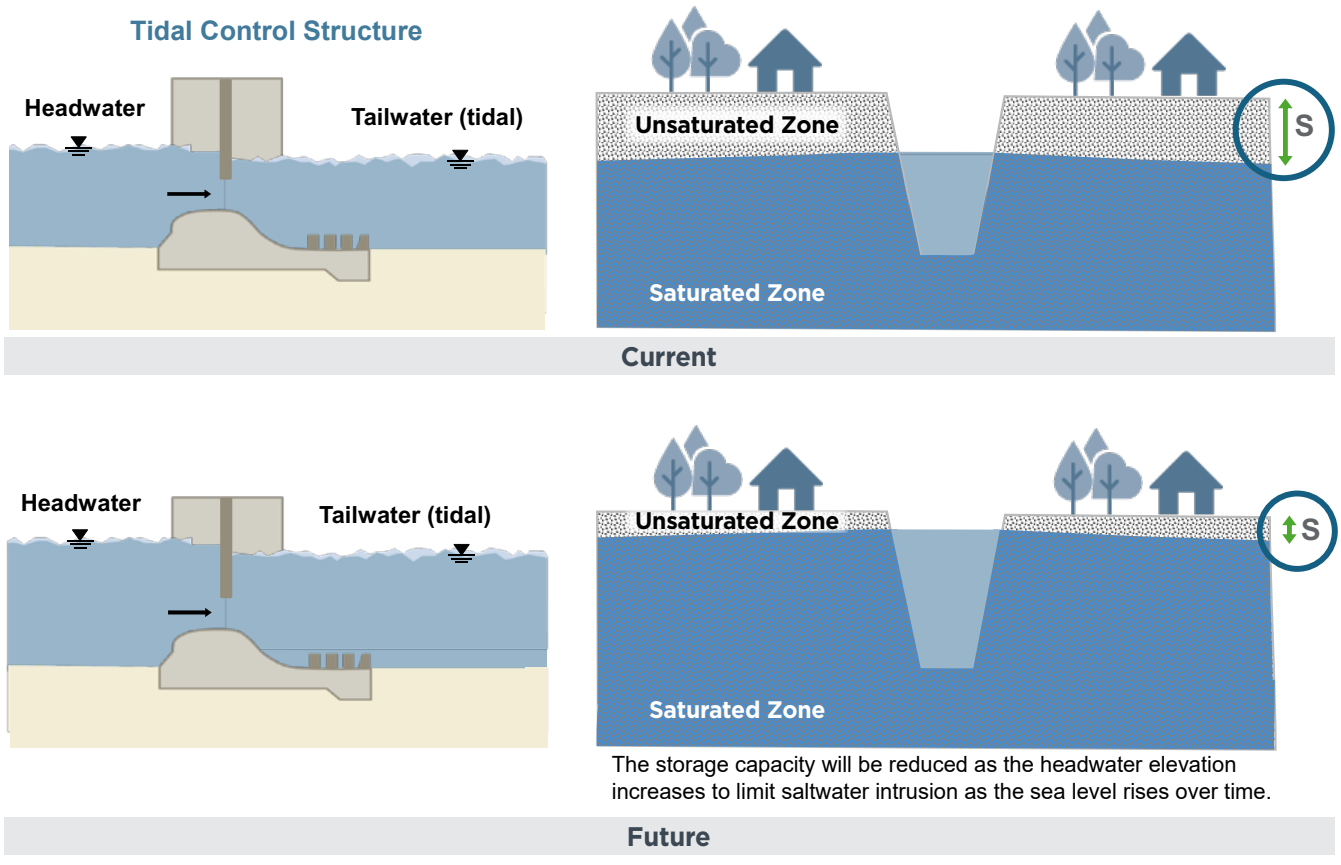
Las Olas Isles seawall prevents intrusion from King Tides and from future SLR.

By integrating the findings of the risk assessment and model runs, the County developed an initial assessment of flood-related economic losses, including damage to infrastructure, disruptions to critical services, and long-term financial implications.

The adaptations were geographically tailored, ensuring that each zone within the county receives solutions best suited to its challenges. The recommended adaptations take into account site-specific hydrology and existing infrastructure constraints.

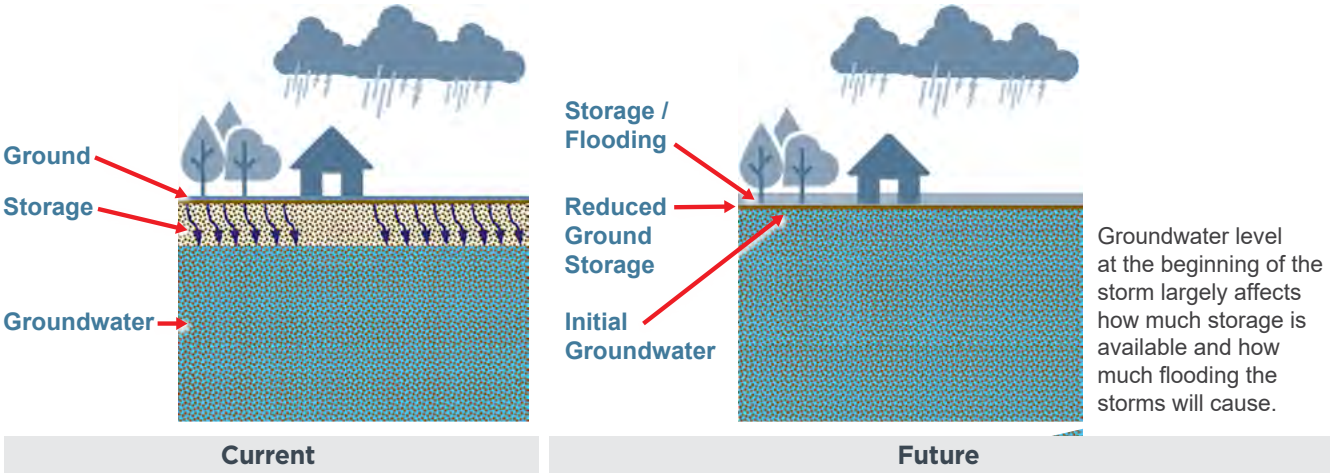
As the Resilience Plan progresses, these preliminary adaptation strategies were further ref ned through continued modeling, stakeholder engagement, and policy integration. The next sections will outline these strategies in greater detail, providing a roadmap for implementation that ensures long-term resilience for Broward County.

Figure 4-2. SLR Will Cause an Increase in Groundwater Levels, Which Translates to Reduced Storage



Broward County is part of an overall southeast Florida drainage network operated by the SFWMD. Improvements made within Broward County will impact how the overall SFWMD system works. Similarly, improvements made to the SFWMD primary canals will directly impact how well Broward County can adapt. Managing groundwater levels is fundamental to the efficacy of most of the selected adaptations.

Figure 4-3. The Stormwater Management System is Dependent on Ground Storage



ADAPTATIONS ANALYZED

The adaptations considered four approaches: nature-based infrastructure, storage, conveyance, and barriers. These adaptations are summarized and pictured below.

Nature-based Infrastructure: Broward County has promoted nature-based infrastructure improvements and will continue to do so as a result of this Resilience Plan. Those adaptations are assumed to occur in the near term and have the most positive impacts prior to the sea level rising and groundwater levels increasing.

Storage Solutions: In addition to the improvements, the County is implementing solutions to increase aboveground storage and recover underground storage where possible. Recovering underground storage can be accomplished by lowering the control elevation in the canal system ahead of the storm (much like SFWMD does before present-day storms), which lowers the groundwater levels and thereby increases stormwater storage.

Conveyance: Where possible, the County is considering locations where improved or additional conveyance (enlarged culverts, pipelines, pump stations) would be beneficial.

Barriers: In coastal areas, increasing the height of existing seawalls and/or adding seawalls will provide significant protection against SLR. The height of the barriers must be proportionate to the anticipated SLR. Additionally, collection and pump systems will need to be provided to pump stormwater over the increased barriers (where gravity flow might exist today).

Figure 4-4. Adaptations Modeled

Modeled Adaptations

The Resilience Plan evaluates and incorporates various adaptations to address specific challenges across the county, including:

Storage

Includes above-ground storage systems and recovering underground storage to manage excess stormwater.

Nature-based Infrastructure

This type of infrastructure focuses on reducing impervious surfaces, adding storage, and water absorption areas.

Conveyance

Improves existing structures such as canals and culverts while incorporating additional pumping systems to enhance water fow management.

Barriers

Utilizes property-level seawalls, nature-based or engineered structures to prevent fooding and protect infrastructure.

Swales

Inherent to all of the adaptation suites is the improvement and rehabilitation of swales and other nature-based infrastructure throughout the drainage system.

Two-Lane Road Conversions

The conversion of two-lane roads to one-lane roads results in a reduction in impervious area identical to the amount of roadway that was removed. This strategy was identifed through GIS tools only for residential areas where a homeowner's and/ or emergency vehicles' travel time would not increase over one minute. It was assumed that this strategy would not be acceptable if it negatively impacted the residents. Further, it is understood that this adaptation would be implemented over time in conjunction with future roadway or pipeline replacement projects.

Storage Areas

As identifed in the heat analysis, large swaths of impervious areas exist throughout the county, resulting in drainage issues and heat impacts. This adaptation strategy involved converting a portion of the large impervious areas (10%) to pervious areas. While these locations may not directly reflect where the pervious conversions would occur in the future, they are representative of how an increase of 10% more pervious area could impact the county.

Pumping Stations, Culvert Improvements, Improved Crossings

Presently, many of the County's waterways drain into adjacent waterways via gravity systems. In the future, as the height of the drainage system increases to provide positive head against SLR, increased culvert size, improved crossings, and/or additional pumping stations will be required. This adaptation strategy includes the locations determined by the H&H modeling efo rts to require upsized culverts, improved crossings, and/or pump stations in the future.

Control Elevation Changes

The ability to manage the system is recommended. The nimbleness of operation of the control structures can allow for the manipulations of groundwater elevations.

To analyze operational differences among suites of strategies, certain suites include changes in the control elevations of the drainage system. While the drainage system will typically operate at an increased elevation to maintain positive head against SLR, the system can be lowered just ahead of an anticipated signif cant rainfall event. Lowering the drainage system has historically shown a positive impact on soil storage capability in the surrounding areas.

Seawalls

The County presently has a seawall ordinance requiring seawalls be increased in height to 5 feet NAVD by the year 2050 (and 4 feet NAVD by the year 2035). The performance of the suites of adaptation strategies considered an increase in seawall height to the required 5 feet NAVD (Suites 1–5) against the baseline of no increase in seawall height. Based on these results, a seventh model run was performed with the suite of strategies, including an increase in seawall height to 7 feet NAVD. This increased height requires a drainage and pumping system behind the seawalls to ensure adequate drainage.

To analyze the adaptations, the county was first divided into three areas: Zone 1 – Central Areas; Zone 2 – Eastern Areas; and Zone 3 – Inland Areas.

The adaptations were then analyzed in combinations of adaptations over the different zones. The H&H model for the system as it exists today (the "baseline" run) was run first, followed by the models for the combinations of adaptation strategies.

Figure 4-5. Delineation of Adaptation Zones for Analysis

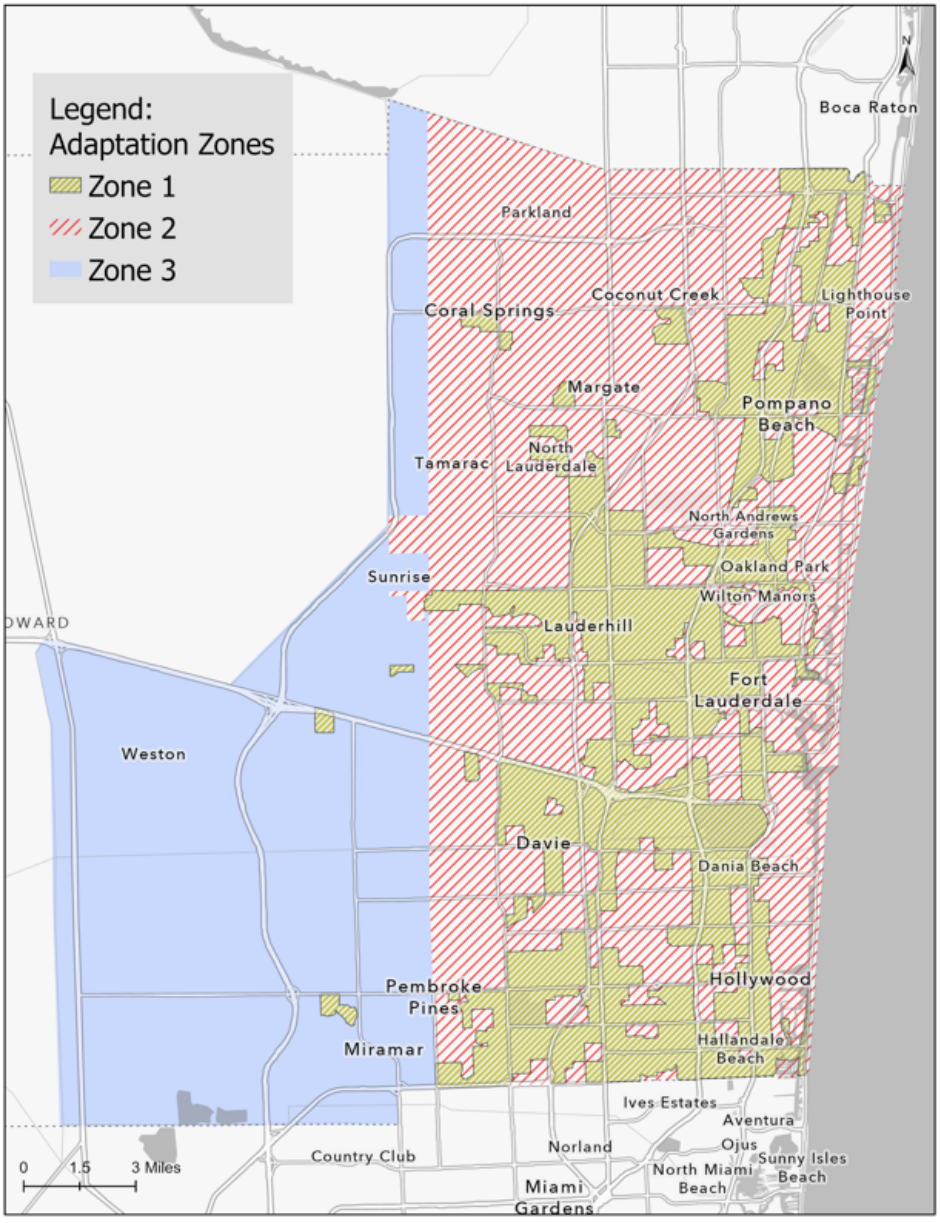


Figure 4-6. Overview of Adaptations Analyzed by Combinations of Strategies

Adaptations	Two Way Roads Converted	Pumping Stations	Storage Areas	Control Elevation Changes	Seawalls	Surge & Tidal Coastal Barriers
Baseline	⊖	⊖	⊖	⊖	⊖	⊖
Most highly vulnerable areas	☑	☑	☑	⊖	5 foot	⊖
Coastal areas	☑	☑	☑	⊖	5 foot	⊖
Coastal areas with control elevation changes	☑	☑	☑	☑	5 foot	⊖
Countywide	☑	☑	☑	⊖	5 foot	⊖
Countywide with control elevation changes (Tier 1)	☑	☑	☑	☑	5 foot	⊖
Countywide with 7-ft walls & control elevation changes (Tier 2)	☑	☑	☑	☑	7 foot	⊖
Large flood control structures	☑	☑	☑	☑	5 foot	☑

⊖ = Baseline, existing conditions ☑ = Additional measures

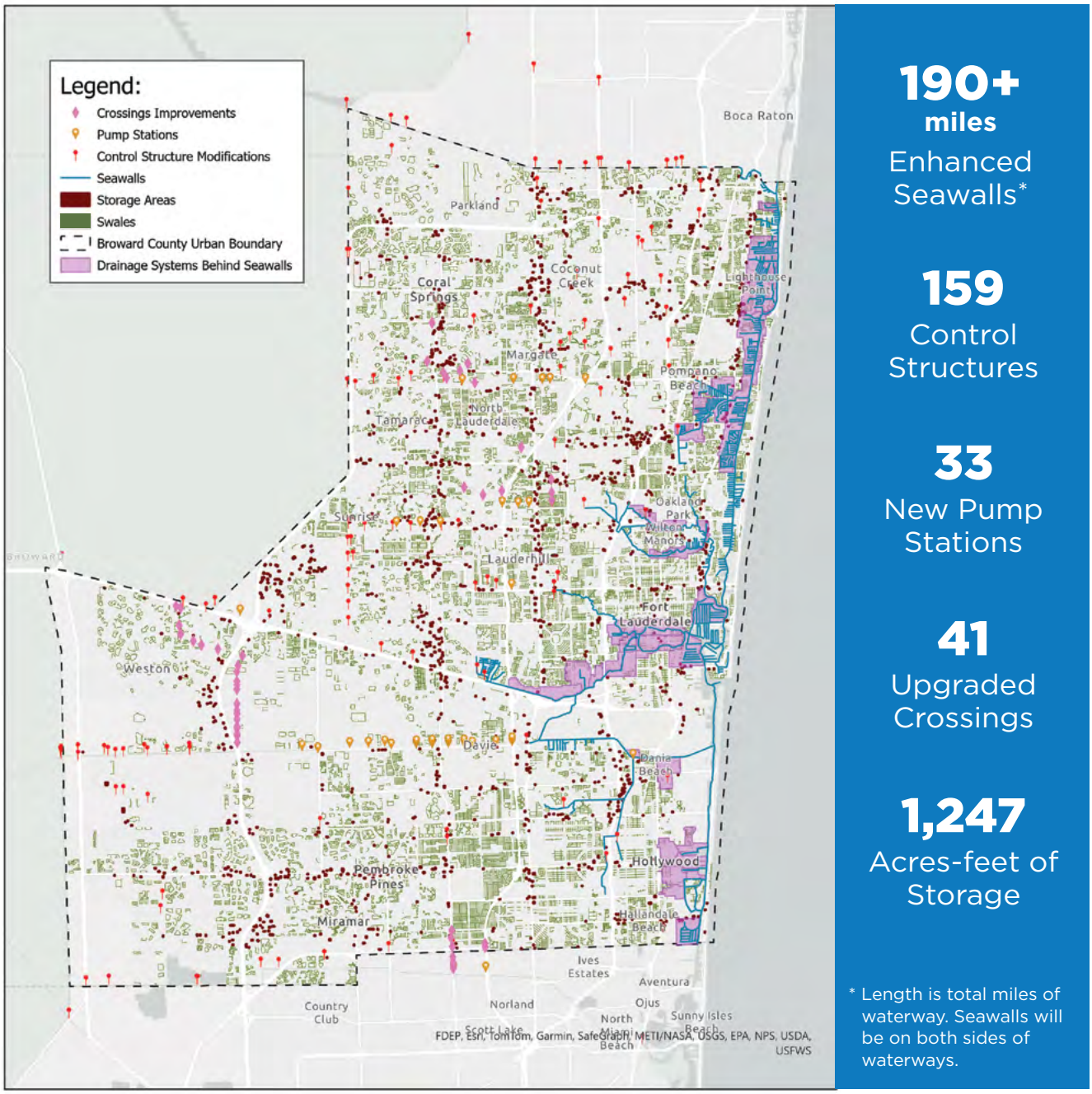
The modeling of the selected adaptations was conducted to analyze the effects of different combinations of individual adaptations and better inform the Resilience Plan (Figure 4-6). Through this process, weaknesses in the system under future SLR scenarios were identified. To address these gaps, an additional strategy—incorporating increased seawall heights (7 feet NAVD) and enhanced drainage/pumping behind the seawalls—was tested, resulting in improved system performance.

Based on these findings, the final adaptation framework consists of two tiers: Tier 1, which includes the full set of initial adaptations, and Tier 2, which builds upon Tier 1 with additional measures for greater resilience.

ADAPTATIONS SELECTED

While the combinations of adaptations served as an intermediate step in developing the Plan, the final recommendations are structured around Tier 1 and Tier 2 Adaptations for clarity and implementation. Adaptations selected are shown on Figure 4-7.

Figure 4-7. Summary of Adaptations



Note: Actual locations for adaptations may vary. The adaptation recommendations are inclusive of the strategies shown on this graphic and in the associated GIS. Variations in locations of actual adaptations within basins are considered to be insignifc ant.

The performance of Tier 1 compared to Tier 2 and to the baseline is shown in Figure 4-8.

Figure 4-8. Comparison of Tier 1 vs Tier 2 Performance (Under 2 Feet of SLR)

Baseline - Flooding Depth (feet) **Tier 1** - Flooding Depth (feet) **Tier 2** - Flooding Depth (feet)

While Tier 1 reduces flooding in most areas compared to the baseline, Tier 2 further reduces flooding.

Table 4-1. Distribution of Properties that Would Flood Under a 25-Year Storm, with 2 Feet of SLR During King Tide Event

Flood Depth (feet)	Baseline (No Action)	Tier 1 Adaptation Suite 5	Tier 2 Adaptation Suite 5B
0.01–0.25	16,099	9,969	7,902
0.25–0.50	7,589	4,383	3,094
0.50–1.00	4,856	2,561	1,603
1.00–1.50	966	479	329
1.50–2.00	184	110	90
2.00–2.50	67	65	57
2.50–3.00	51	48	44
>3.50	26	20	19
Total	**29,838**	**17,635**	**13,138**

It should be noted that large coastal barriers also reduce flooding, but at a cost significantly exceeding the cost of the other adaptations. Furthermore, the incorporation of large coastal barriers is anticipated to be more disruptive to the public and therefore generally less acceptable. Large coastal barriers will remain in the Resilience Plan as a possibility for future implementation depending on actual SLR over time. Future updates to the Resilience Plan should consider technological advancements, cost updates, and severity of climate impacts to determine whether large coastal barriers become more feasible.

HEAT MITIGATION STRATEGIES

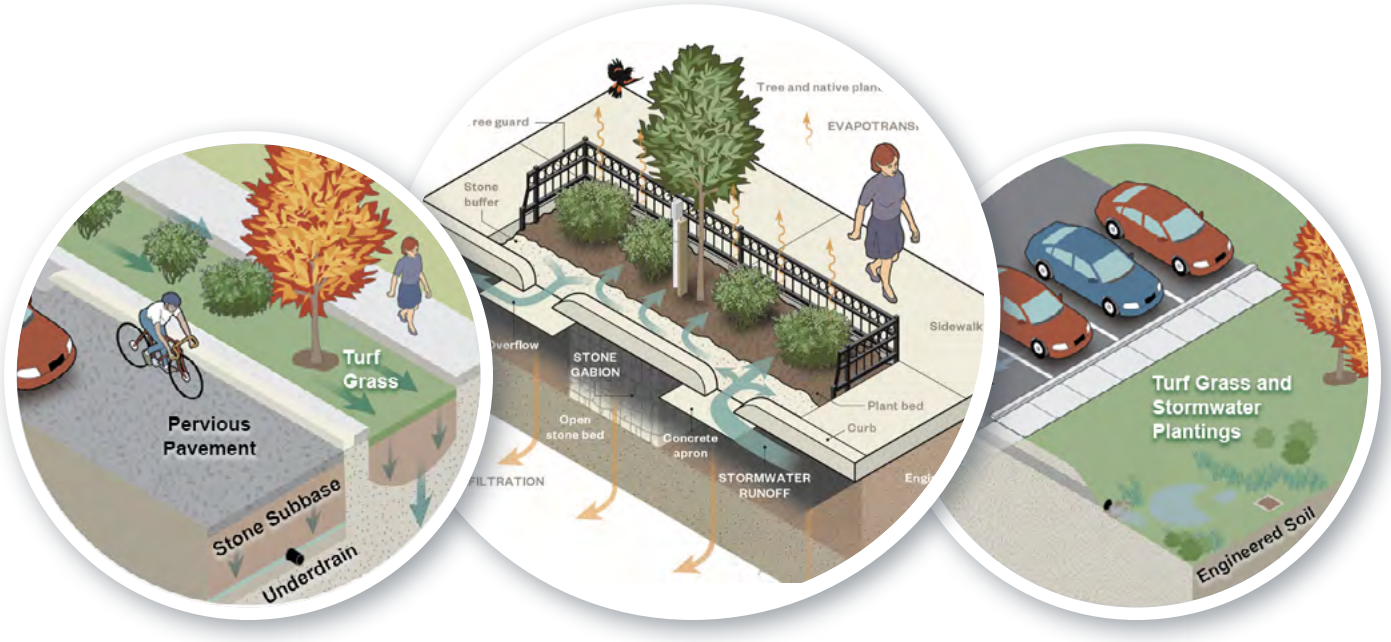
Nature-based infrastructure is known to reduce the effects of heat islands by maximizing pervious surfaces within urban settings. Additionally, nature-based solutions offers mitigation strategies for flooding and rainwater storage while providing sustainable landscaping. The strategies may include:

- Sustainable landscaping and flood-resistant materials
- Pocket wetlands
- Rainwater harvesting
- Bioswales and bioretention
- Permeable pavement or pavers
- Enhanced stormwater ponds

Nature-based infrastructure solutions are desirable as these adaptations often mitigate flooding impacts and reduce heat island effects.

Figure 4-10 highlights the benefits of nature-based solutions in urban settings. Both options reduce impervious surfaces within cities while providing landscaping, stormwater storage, and ultimately reducing the urban heat island effects.

Figure 4-10. Bioretention Examples

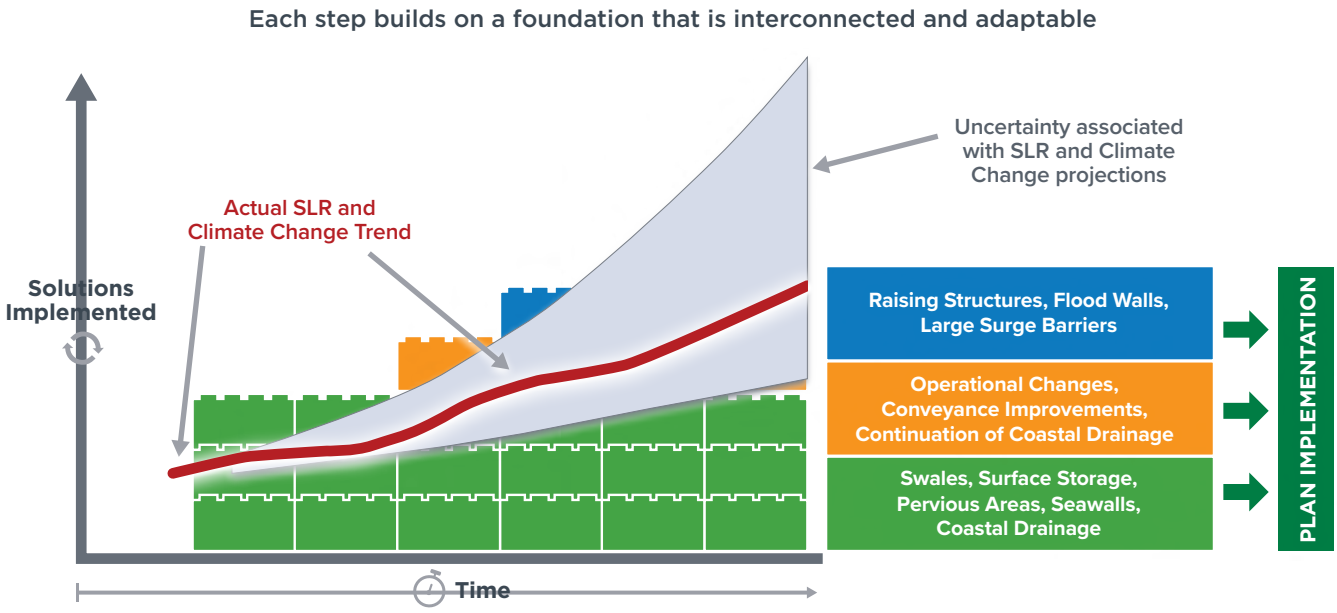


GENERAL ADAPTATION IMPLEMENTATION STRATEGY

Adaptations will be incorporated over a long period of time and in coordination with other ongoing infrastructure projects where possible. Certain adaptations, conversion to one-way roads for instance, may not be the preferred or most favorable under today's conditions, but may become more favorable with time. All of the strategies will require proper funding and, in many cases, coordination with other ongoing efforts.

The actual SLR is anticipated to be within the envelope of uncertainty. Implementing nature-based infrastructure first, while groundwater is at current levels, will maximize the benefits of nature-based infrastructure while structural revisions and operational changes are implemented to address rising sea and groundwater levels.

Figure 4-9. Implementation of Adaptable Solutions



Based on the estimated avoided flood damages among the combinations of adaptations, Tier 1 and Tier 2 were selected for further evaluation. The adaptation strategies, with seawalls at 5 feet NAVD, are referred to as Tier 1, while Tier 2 includes the same strategies but with seawall height increased to 7 feet NAVD (as summarized in Table 4-2).

The combination of adaptations called "Tier 1" includes the conversion of selected two-way roads into one-way or single lane roads, construction of pumping stations and culvert improvements, and development of new storage areas. The current County requirement for 5-foot NAVD seawalls remains in place, but with the addition of drainage improvements on properties in the City of Lighthouse Point to address the negative flood impacts from upstream drainage improvements.

The adaptation called "Tier 2" includes all of the investments under Tier 1 plus the requirement that all seawall heights be increased by 2 feet, from 5 feet NAVD to 7 feet NAVD. This increased height requires a drainage and pumping system behind the seawalls to ensure adequate drainage, and these improvements are provided in Tier 2.

Table 4-2. Summary of the Adaptations Under Tier 1 and Tier 2

	Tier 1 Countywide with Control Elevation Changes	Tier 2 Countywide with Control Elevation Changes and 7 ft NAVD seawalls
Assumed completion date	**2050** to prepare for 2 ft SLR	**2070** to prepare for 3.3 ft SLR
Adaption measures	• Two-way road conversion • Pumping stations and culvert improvements • Storage areas/green infrastructure • Control elevation changes • All seawalls are up to 5 ft NAVD with drainage	Same as Tier 1 plus seawalls raised to **7 ft NAVD** and coupled with additional drainage
Zone of implementation	Countywide	Countywide

CONCEPTUAL SITE REPRESENTATIONS OF CRITICAL COUNTY ASSETS

Following the risk assessment, the team reviewed the ranking of the critical assets and determined which of the highly ranked critical assets could be used as examples of adaptations. The selected sites serve as a model for future implementations across similar County sites.

The conceptual sites were selected to show a broad representation of dif erent types of facilities with potential for various types of strategic improvements necessary for the future. The purpose of these representations is to provide general guidance as to the type of adaptation to be implemented, the cost of the adaptation, and the calculated drainage improvement for that site. The representations are not intended to be mandates for each particular site; rather, they are examples of how similar sites could be improved.

Table 4-7. Selected Site Descriptions and Relevant Information

Site Name	Total Area (acres)	Approximate Impervious Area (%)	Description (Use)
Edgar P. Mills Multi-Purpose Center	3.19	68%	A multi-purpose facility providing community services such as health services, job training, and social support programs.
African-American Research Library & Cultural Center	4.22	88%	Located in Fort Lauderdale, this library holds over 1 million items related to African, African-American, and Caribbean culture.
Central Homeless Assistance Center	2.45	53%	Operated by Broward Partnership, the center provides emergency shelter and rehabilitative services for homeless individuals and families.
North Regional Courthouse	10.02	84%	A key legal institution for northern Broward County, offering various judicial services.
South Broward Mass Transit	9.09	71%	A key maintenance and operational hub for Broward County's public transportation system, ensuring essential transit services for the community.
Main Library	1.87	70%	Located in downtown Fort Lauderdale, the Main Library is the largest in the Broward County Library system. It houses the Historical Archives and offers spaces for public events.

Data Collection and Site Visits

Stormwater system information for the selected sites was obtained from the Broward County Stormwater Management database. Additionally, Broward County shared details on recent and ongoing projects at each site. To ensure proposed adaptations were in line with current designs and to minimize disruptions, the project team carefully aligned new proposed potential measures with existing improvements. Team members conducted site visits to verify and confirm desktop data, ensuring accuracy in both planning and execution.

Flood data and finished floor elevation (FFE) were gathered from FEMA's current Flood Insurance Rate Maps (FIRM) for existing conditions, and future projections were obtained from the Resilience Plan H&H model. These sources provide a comprehensive view of both present and future flood risks to guide effective site adaptation strategies.

Development of Conceptual Site Adaptations

To mitigate the risks posed by flooding and heat, adaptations were developed for each site to effectively manage stormwater and reduce heat exposure, with special consideration given to the county's high groundwater levels. The proposed adaptations include:

- **Green Roof or Cool Roof**
  - **Green Roof**: A vegetated roof system that helps absorb rainwater, reduce runoff, and provide insulation, lowering indoor temperatures and energy use. Green roofs also mitigate urban heat island effects and enhance biodiversity.
  - **Cool Roof**: Uses reflective or light-colored materials to reduce heat absorption, lowering the building's surface temperature and reducing cooling costs.
- **Vegetated Swales and Rain Gardens**: Shallow, landscaped channels designed to slow and filter stormwater runoff These systems promote infiltration, reducing surface water flow and preventing flooding. Additional conveyances are proposed to account for saturated conditions.
- **Pump Stations**: Mechanical systems used to move excess stormwater away from low-lying areas or to accelerate draining of excess runoff.
- **Pressurized Wells**: Proposed on areas where shallow groundwater levels are too high to move shallow groundwater into deeper aquifers.
- **Permeable Pavements**: Paving materials allow water to pass through them, reducing runoff and promoting groundwater recharge.
- **Infiltration Chambers**: Underground structures which capture and store stormwater, slowly releasing it into the surrounding soil. This reduces surface flooding and helps recharge groundwater supplies by promoting infiltration during and after heavy rain events.
- **Dry Proofing Buildings**: To protect buildings from higher flood elevation levels, buildings should be watertight to prevent floodwaters from entering. Techniques include sealing walls, doors, and windows with waterproof materials to protect the structure from water damage during floods.

Volume Calculations

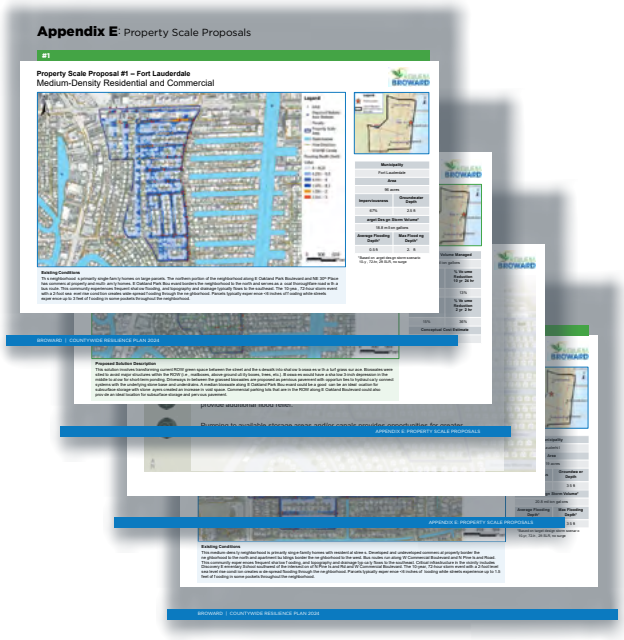
Target stormwater volumes for each site were calculated based on established storm event frequencies. For each adaptation, the potential volume reduction was computed to determine the percentage of stormwater that could be mitigated. This approach allowed for site-specific adaptations to maximize efficiency in stormwater management.

Planning Cost Estimate

A planning-level cost estimation was prepared for each site, providing detailed costs for the various proposed adaptations. These estimates allow for flexibility, as not all adaptations may be implemented at every site. By offering a range of costs, stakeholders can prioritize the most suitable and cost-effective solutions based on site-specific needs, available budget, and existing infrastructure.

RESIDENTIAL AND COMMERCIAL PROPERTY-SCALE PROPOSALS

Ten property-scale proposals were developed to illustrate the effectiveness of the water management adaptations on private properties in the county. These property-scale proposals are representative of various geographic settings and conditions within the county. As municipalities consider implementing adaptation standards, these property-scale proposals can serve as guidance for addressing site-specific challenges while allowing for modifications based on local conditions, regulatory requirements, and project goals. This approach ensures that the concepts remain scalable and transferable, supporting broader flood management and resiliency efforts.



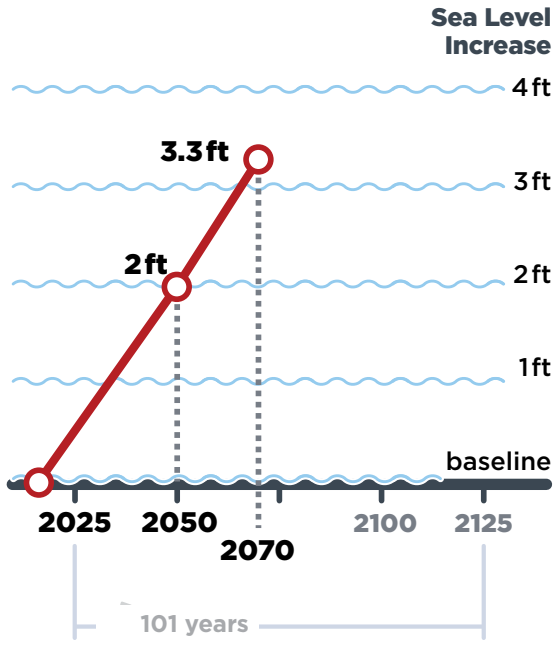
5 Economic Feasibility of the Adaptation Strategies

This chapter presents the present value of net benefits, the investment rate of return, and the benefit-cost ratio of the Tier 1 and Tier 2 adaptation suites. The economic evaluation begins in 2025 and ends 101 years later in 2125. Because the adaptation suites would be implemented over 45 years, a longer time period is needed to fairly assess the net benefits of the suites. An estimate of the year that the 2-foot SLR and the 3.3-foot SLR would be reached is also needed. For this study, it was assumed that the sea level would increase by 2 feet from 2022 to 2050 and by 3.3 feet from current conditions by 2070.

Included in this chapter are the estimated economic benefit values of Tier 1 and Tier 2 relative to the baseline (no-action) alternative, a description of the economic benefit values that were not estimated during this study, the estimated capital and annual cost of the Tier 1 and Tier 2 suites, the sources of uncertainty in the benefit and cost estimates, and the economic feasibility analysis.

The results of this economic evaluation can inform strategic and developmental planning, help to prioritize adaptation measures, and provide critical input for the preparation of financing proposals. The results may also be used to support communication with stakeholders, particularly the residential and business communities in Broward County.

To begin, **the definitions of terms used in this economic evaluation, provided on** pages 6 and 7, are useful to understand the economic metrics being estimated and the meaning of the economic feasibility results.



Timing of SLR in Broward County used to evaluate the economic feasibility of adaptation strategies.

FLOODING REDUCES THE ECONOMIC AND SOCIAL WELLBEING of residents and businesses.

People dining at restaurants along Route A1A in Fort Lauderdale during Spring Break. Photo by Felixtm / Depositphotos.com

ESTIMATED VALUE OF ECONOMIC BENEFITS PROVIDED BY TIER 1 AND TIER 2 ADAPTATIONS

The dollar values of the economic benefits from the Tier 1 and Tier 2 adaptations were estimated by examining the extent to which the baseline (no-action) impacts of future flooding within Broward County could be mitigated by each tier.

Initially, the dollar value of benefits associated with the adaptation combinations described in previous chapters of this report were estimated. The methods and data used to obtain these benefit estimates and the results of these benefit estimations were presented in two study memoranda provided in the project deliverables.

The Tier 1 and Tier 2 adaptations were two of the combinations evaluated. The benefit values of these two tiers were found to be significantly greater than the benefit values associated with the other combinations. While the large control structures scenario is also expected to provide relatively large benefit values, it was not further recommended at this time because its cost is significantly greater and it is anticipated to be much more publicly disruptive than the Tier 1 and Tier 2 adaptations.

The values of the estimated economic benefits were made under the assumption there are no changes in the economy of Broward County—including no changes in land use, gross domestic product, employment, or population from current levels. The results are best interpreted as the benefits of Tier 1 and Tier 2 that would occur today if faced with the flood conditions expected in 2050 (2 feet of SLR from current conditions) and 2070 (3.3 feet of SLR from current conditions). These dollar values were estimated in 2022 dollars and were increased to represent 2024 dollars during the economic feasibility evaluation.

The dollar values of four economic metrics were estimated during this study. These values are the benefits of Tier 1 and Tier 2 adaptations and are summarized as follows:

1. **Avoided loss to short-term gross value added (GVA).** Tier 1 and Tier 2 investments are expected to reduce transport disruption and damage to productive assets. This analysis quantified the reduction in short-term (e.g., less than one year) revenue loss from business downtime, economic losses generated through transport system disruption, and indirect impacts to the County's economy through changes in GVA, employment, and tax revenue.
2. **Avoided negative property insurance impacts.** Under Risk Rating 2.0, property insurance premia and coverage could be affected as flood risk increases. This analysis quantified how Tier 1 and Tier 2 could mitigate the negative impacts of SLR on flood insurance affordability, insurance penetration rate, total purchased coverage, and rates of underinsurance.
3. **Avoided reduction in real estate value.** Increased flood risk reduces the value of properties, as prospective buyers can expect to face higher repair and insurance costs and disruption of property use. This analysis quantified how Tier 1 and Tier 2 could result in real estate values that would be higher than under the baseline condition.
4. **Avoided loss of tax revenue to the County and local governments.** The County, its municipalities, and government agencies rely on ad valorem and production-related tax revenue to finance public goods and services. Under the baseline, ad valorem tax collections may fall as the value of properties decrease. Production-related tax revenue associated with disrupted economic activity may also decline. This analysis quantified the benefits of Tier 1 and Tier 2 in avoiding these tax revenue losses.

In addition, Tier 1 and Tier 2 are also expected to increase GVA by avoiding disruption to public services and critical infrastructure, avoiding investment risk, reducing demographic change such as out-migration, preserving tourism, and avoiding physical and mental health impacts. The dollar value of these benefits were not estimated during this study but would improve the estimated economic feasibility of the Tier 1 and Tier 2 investments.

Outputs from the Hydrologic Modeling Workstream

Flood information by flood scenario and land parcel for all parcels throughout the county were provided as inputs to the economic benefits estimation. Future flooding under the baseline (no action) and the Tier 1 and Tier 2 adaptations incorporate SLR, in addition to the expected rainfall and storm surge. Flood event scenarios under 2 feet of SLR (based on the 2017 NOAA Intermediate-High SLR projection) and 3.3 feet of SLR (using the same projection) were used.

For each flood event scenario, the hydrologic workstream provided the following information for the economic benefits workstream.

- Probability of the flood scenario occurring—same for the baseline and the Tier 1 and Tier 2 adaptation suites.
- Maximum flood depth for each building—influenced by the adaptation.
- Duration of flooding above elevation thresholds for each building—influenced by the adaptation.
- Expected damages to each building, disaggregated between structural and content damages—influenced by the adaptation.

These hydrologic data were used to prepare two key inputs: (1) disruptions to the road network, and (2) damages to residential and productive assets.

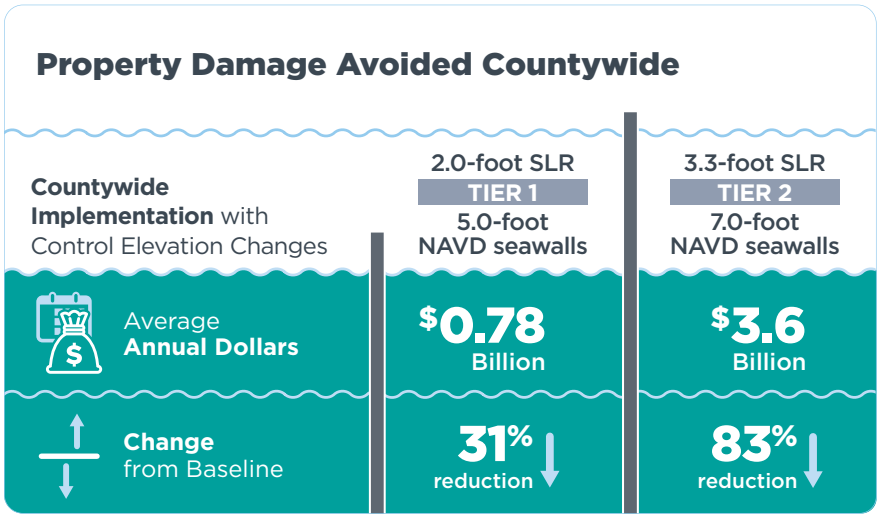
The flood scenarios were translated into average annual flood metrics (for example, average annual flood damage and average annual changes in GVA) by integrating the area under the frequency/severity curve. This curve is based on each event's probability and the resulting flood metric. This integration provides the expected value of the flood metric or the average metric value among all event probabilities.

A summary of the estimated economic benefit values is as follows.

Avoided Property Damage

The average annual property damages associated with Tier 1 and Tier 2 adaptation suites relative to baseline were estimated under 2 feet and 3.3 feet of SLR. The results are provided in Figure 5-1 and Figure 5-2. Under current flood conditions, average annual property damage countywide is about $820 million (0.82 billion).

As the sea level rises to 2 feet, average annual property damage is expected to increase to about $2.5 billion if no action is taken to mitigate the flooding (baseline). Under the Tier 1 investments, average annual property damage is expected to be reduced to $1.7 billion, which is a $0.78 billion annual reduction in property damage. Under the Tier 2 investments, average annual property damage is expected to fall to about $0.56 billion for a $1.9 billion damage reduction.



As the sea level rises to 3.3 feet, average annual property damage is expected to increase to about $4.9 billion if no action is taken to mitigate the flooding (baseline). Under the Tier 1 investments, average annual property damage is expected to be reduced from $4.9 billion to $4.7 billion, which is a $0.20 billion annual reduction in property damage. Under the Tier 2

investments, average annual property damage is expected to fall from $4.9 billion to $1.3 billion, which represents a reduction in average annual property damage of $3.6 billion.

The major benefit of the adaptation suites is the magnitude of the avoided property damage, which determines the magnitude of all the other benefit metrics. Comparing the avoided property damage between Tier 1 and Tier 2 under each SLR condition in Figures 5-1 and 5-2 finds that Tier 2 provides the greatest reduction in property damage under both 2 feet and 3.3 feet of SLR. The investments under Tier 1 and Tier 2 are identical, except that under Tier 2, the current 5.0-foot NAVD requirement for seawall height is increased to 7.0 feet NAVD, and additional drainage features are added to effectively drain the water that accumulates behind the seawalls as the sea level rises to 3.3 feet.

Figure 5-1. Property Damage Estimates, Average Annual

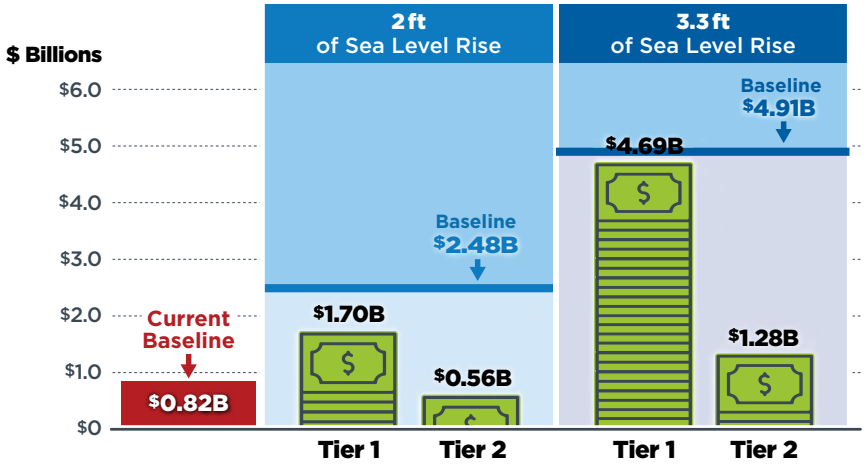
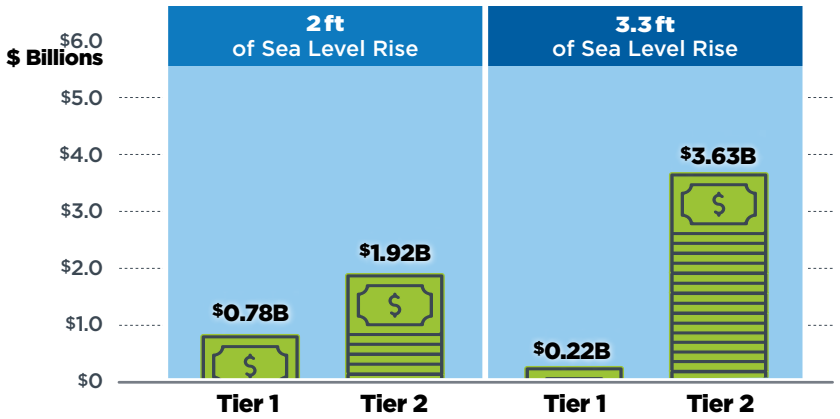


Figure 5-2. Estimated Benefits of Tier 1 and Tier 2 Adaptations as They Avoid Property Damage in Broward County, Average Annual



Given these results, the recommended implementation of the tiered investment strategy is to proceed with the countywide investments under Tier 1. Tier 1 is comprised of the full suite of adaptations with the seawall heights remaining at the current 5.0 feet NAVD by existing County ordinance. These investments would be completed by 2040 and would avoid an estimated $0.78 billion in average annual property damage as the sea level rises to 2 feet.

Once these needed investments are made and the sea level begins to rise toward 3.3 feet, an additional 2 feet would be added to the required seawall height to reach 7.0 feet NAVD and additional drainage features would be added to improve drainage behind the seawalls from 2040 to 2070.

Under this tiered investment strategy, the average annual avoided property damage by 2070 is estimated to be $3.6 billion as the Tier 2 investments are completed and the sea level rises to 3.3 feet above current levels. These avoided property damages are direct benef ts of adapting to SLR.

The average annual avoided property damage in each of the individual cities in Broward County under the Tier 1 investments (including the Lighthouse Point drainage features) and under the longer-term Tier 2 strategy are provided in Table 5-1.

Table 5-1. Average Annual Percentage of Residential Baseline Damages Avoided Under Tier 1 and Tier 2 Adaptations by Municipality

Municipality	Baseline Under 2 ft SLR	Tier 1 Damage Reduction from Baseline - Countywide with Control Elevation Changes Under 2 ft SLR	Baseline Under 3.3 ft SLR	Tier 2 Damage Reduction from Baseline - Countywide Measures, with Control Elevation Changes and 7 ft Seawalls Under 3.3 ft SLR
Coconut Creek	$3,690,000	40%	$3,710,000	40%
Cooper City	$6,190,000	55%	$6,660,000	58%
Coral Springs	$15,160,000	61%	$15,290,000	61%
Dania Beach	$44,850,000	20%	$94,890,000	78%
Davie	$43,540,000	34%	$45,060,000	23%
Deerfield Beach	$69,920,000	2%	$157,630,000	81%
Fort Lauderdale	$822,250,000	19%	$1,751,330,000	79%
Hallandale Beach	$68,940,000	23%	$164,910,000	49%
Hillsboro Beach	$25,680,000	10%	$37,180,000	10%
Hollywood	$322,520,000	57%	$610,540,000	72%
Lauderdale-By-The-Sea	$40,610,000	58%	$99,250,000	99%
Lauderdale Lakes	$2,350,000	75%	$2,590,000	69%
Lauderhill	$15,990,000	67%	$17,800,000	48%
Lighthouse Point	$58,620,000	69%	$176,000,000	91%
Margate	$13,170,000	40%	$13,270,000	40%
Miramar	$45,230,000	57%	$56,380,000	63%
North Lauderdale	$2,100,000	87%	$2,170,000	88%
Oakland Park	$42,440,000	41%	$72,060,000	75%
Parkland	$3,680,000	26%	$3,800,000	28%
Pembroke Park	$580,000	90%	$670,000	89%
Pembroke Pines	$15,500,000	67%	$16,100,000	67%
Plantation	$20,470,000	60%	$21,740,000	51%
Pompano Beach	$180,240,000	20%	$385,220,000	82%
Southwest Ranches	$2,920,000	17%	$2,950,000	18%
Sunrise	$4,830,000	67%	$5,290,000	68%
Tamarac	$3,890,000	72%	$4,170,000	70%
Unincorporated	$16,190,000	55%	$28,030,000	73%
West Park	$10,700,000	68%	$11,170,000	67%
Weston	$2,590,000	29%	$2,680,000	31%
Wilton Manors	$85,740,000	70%	$165,030,000	98%

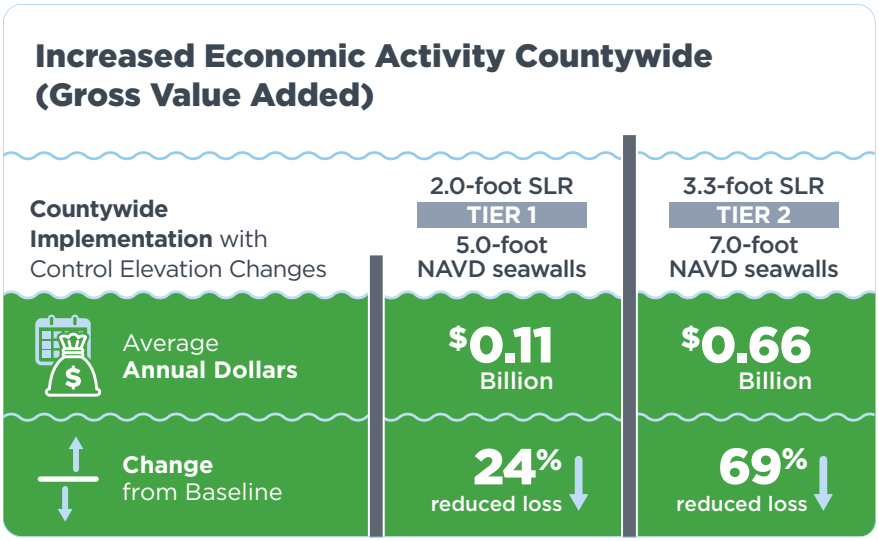
Note: Positive % means reduction in property damage. The municipalities of Lazy Lakes (Census Tract 040102) and Sea Ranch Lakes (051001) are included in the Wilton Manors and Lauderdale-by-the-Sea groupings respectively.

The remainder of this section focuses on the benefits of the Tier 1 adaptations under 2 feet of SLR and the benefits of the Tier 2 adaptation under 3.3 feet of SLR.

Increased Short-Term Economic Activity

GVA measures the contribution of business sectors to overall economic activity and includes the income produced within the county from all sources. Average annual avoided reductions in GVA resulting from the Tier 1 and Tier 2 adaptation suites are the difference between the impact of the adaptation suite on average annual GVA and the impact under the baseline. The economic benefits modeled here were based on the increased GVA from:

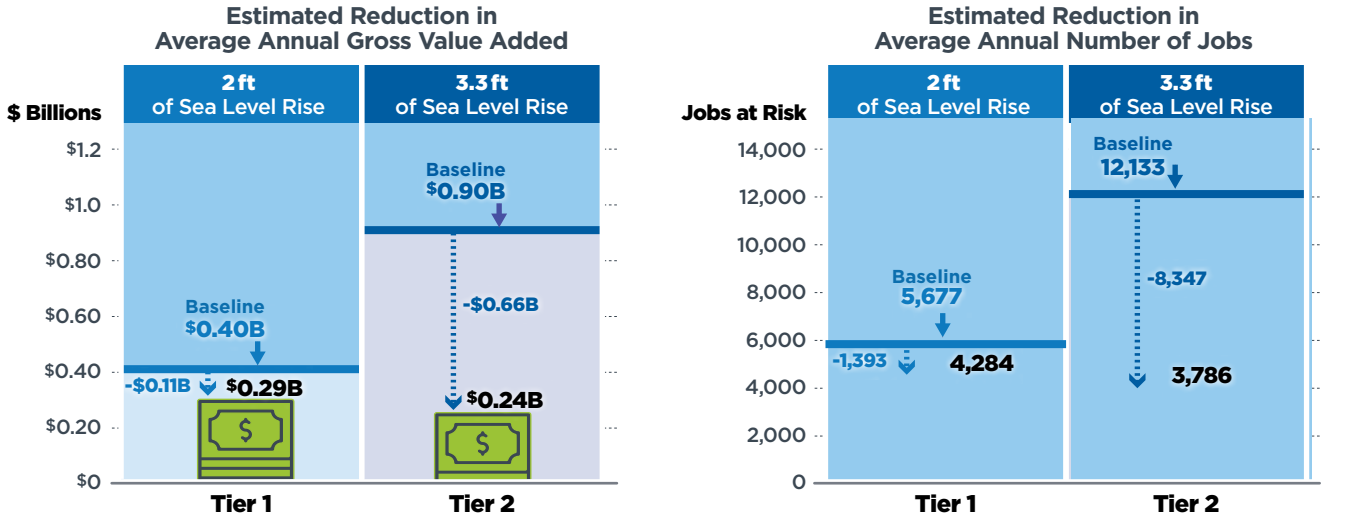
- Lower direct flooding impacts to businesses, and
- Reduced disruption to roads.



The benef t of Tier 1 is an average annual GVA that is estimated to be $0.11 billion higher than under baseline conditions. The benef t of Tier 2 is an average annual GVA that is estimated to be $660 million higher than under baseline conditions.

The average annual avoided GVA losses and avoided job losses associated with the Tier 1 and Tier 2 investments relative to baseline are presented in Figure 5-3. For perspective, current food conditions reduce the average annual GVA by $0.30 billion and the number of jobs by 3,340.

Figure 5-3. Avoided Losses in GVA and Jobs from Tier 1 and Tier 2 Adaptation Suites



As the sea level rises to 2 feet and no action is taken to mitigate the additional flooding, the average annual GVA loss is expected to be $0.40 billion, instead of the current $0.30 billion loss. The Tier 1 investments are expected to reverse this trend and keep GVA losses to their current level of $0.29 billion, providing a $0.11 billion benefit in reduced average annual GVA. Employment losses are expected to be lower under Tier 1, from 5,700 jobs lost under baseline to 4,300 jobs lost under Tier 1 for a benefit of 2,400 jobs.

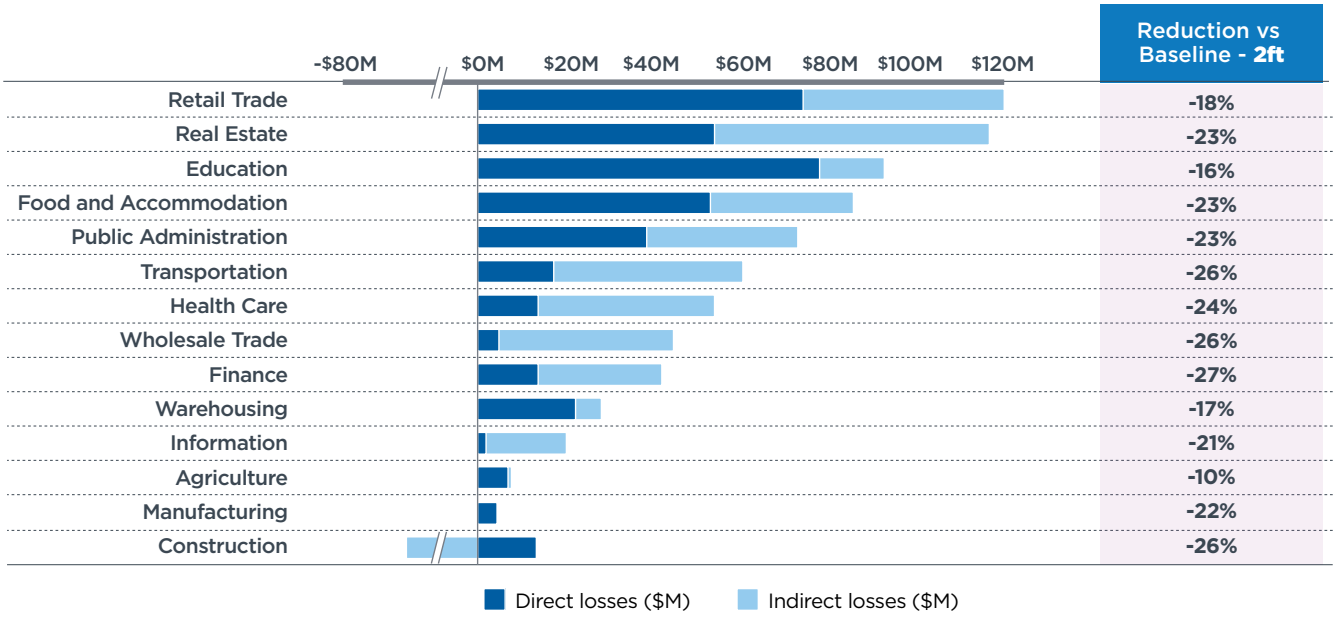
As the sea level rises to 3.3 feet, and no action is taken, the average annual GVA loss is estimated to be $0.90 billion with an estimated 12,100 fewer jobs. The Tier 2 investments would be expected to reduce these losses to $0.24 billion in lost GVA, which is the same as current losses, and there would be 3,800 fewer jobs instead of 12,100 fewer jobs. The benefits of Tier 2 are a $0.66 billion increase in average annual GVA relative to the baseline of no action and an increase of 8,300 jobs.

All business sectors are expected to avoid short-term economic losses under the Tier 1 and Tier 2 investments. Figure 5-4 provides the average annual short-term reductions in gross value added by industry type in Broward County with 2 feet of SLR and the percentage change in GVA losses under the Tier 1 investments relative to baseline. The bars in this f gure provide the absolute GVA losses by sector under Tier 1 with 2 feet of SLR. The negative values are GVA increases, and the positive values are GVA reductions.

The last column in the f gure provides the percent change in GVA losses under Tier 1 relative to the baseline. Negative values represent avoided losses. Direct losses are those caused by damage and repair to physical assets such as buildings. Indirect losses are those caused by reductions in the purchases of goods and services by the directly af ected businesses.

Countywide, most sectors would see a reduction in GVA losses of around 20% under Tier 1, with the variation in individual sectors driven by dif erences in their physical presence across the county. The retail trade and real estate service sectors would continue to be the most impacted and construction would continue to be the least impacted given the need for reconstruction ef orts across the county. The real estate service sector does not include the value of the real estate transactions. It only includes the real estate related services provided, such as those of the real estate agent.

Figure 5-4. Average Annual Short-term Reductions in Gross Value Added by Industry Type in Broward County with 2 feet of Sea Level Rise and Percentage Change in GVA Losses Under the Tier 1 Investments Relative to Baseline



Note: Negative values are GVA increases, and positive values are GVA reductions.

Greater Flood Insurance Coverage

Relative to the baseline conditions, **Tier 1 and Tier 2 investments would increase the number of residential housing units with National Flood Insurance Program (NFIP) flood insurance policies, resulting in greater insurance coverage countywide**.

The estimated NFIP policy counts currently and under the baselines, Tier 1, and Tier 2 are presented in Figure 5-5. The estimated policy counts under the SLR scenarios were made under the assumption that the NFIP premia would increase in line with average annual property damages. This assumption is consistent with the NFIP's Risk Rating 2.0, which is expected to make purchasing insurance less affordable in flood-prone areas without adaptation measures.

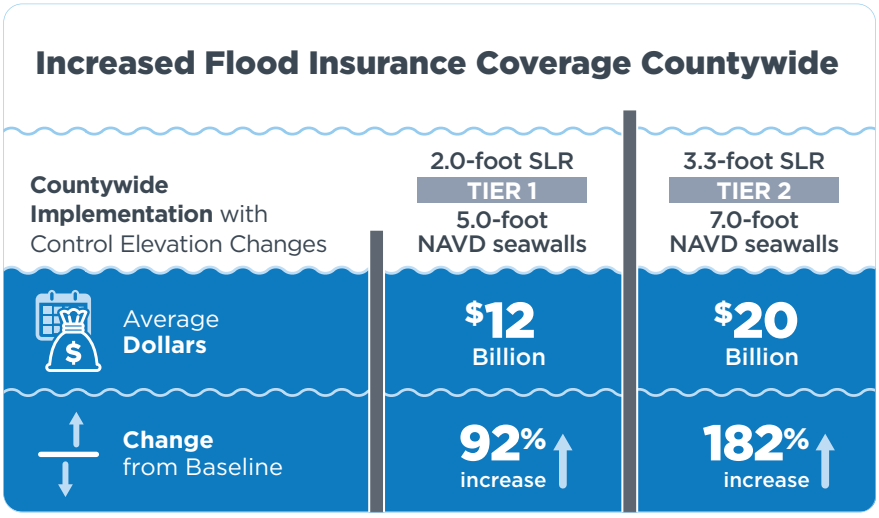
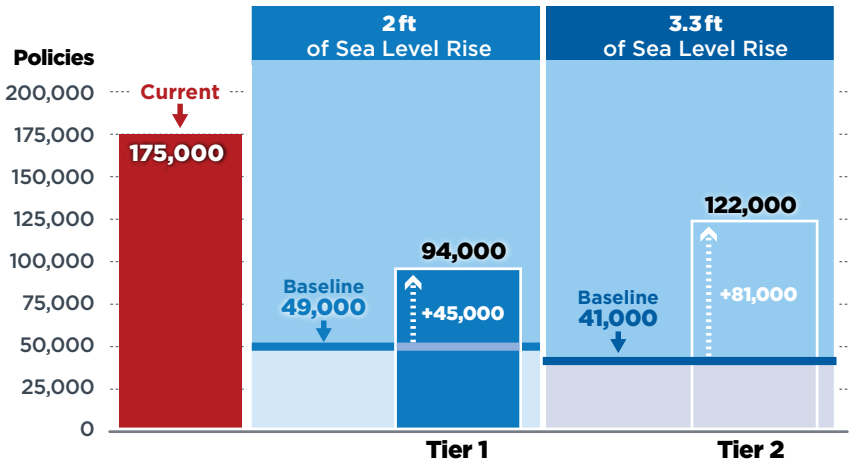


Figure 5-5. Number of NFIP Flood Insurance Policies in Broward County Under Baseline, Tier 1 and Tier 2



If no flood mitigation strategies are implemented, the NFIP flood insurance policy count in Broward County is expected to fall from the current 175,000 policies to an estimated 49,000 policies under 2 feet of SLR, and to 41,000 policies under 3.3 feet of SLR. The Tier 1 investments are expected to increase the number of NFIP flood insurance policies by 45,000 for a total of 94,000 policies once the sea level rises to 2 feet. The Tier 2 investments are expected to increase the number of policies by 81,000, for a total of 122,000 policies, once the sea level rises to 3.3 feet. Thus, the Tier 2 investments are expected to preserve about 54% of current policies, and the Tier 2 investments are expected to preserve 70% of current policies.

Most properties experiencing increased flood damage due to SLR would initially see an increase in the cost of flood insurance under the baselines (2 feet and 3.3 feet of SLR) and the Tier 1 and Tier 2 investments. Where the greatest food damages are expected, the owners of these properties would drop out of the market as their premiums become unaffordable. As this happens, average annual property damage, and therefore premiums, would fall for those who chose to keep their policies. After

premia and flood insurance demand respond to these changes in market conditions, the market reaches equilibrium, resulting in stable premia and demand.

The average annual NFIP flood insurance premiums under the baselines, Tier 1 and Tier 2 after the market reacts to the increase in flood damages (market equilibrium) are provided in Figure 5-6 for single-family homes and Figure 5-7 for multi-family dwelling units.

Figure 5-6. Single-Family Home Average Annual Premiums After Market Reaction in Broward County Under Baseline, Tier 1 and Tier 2

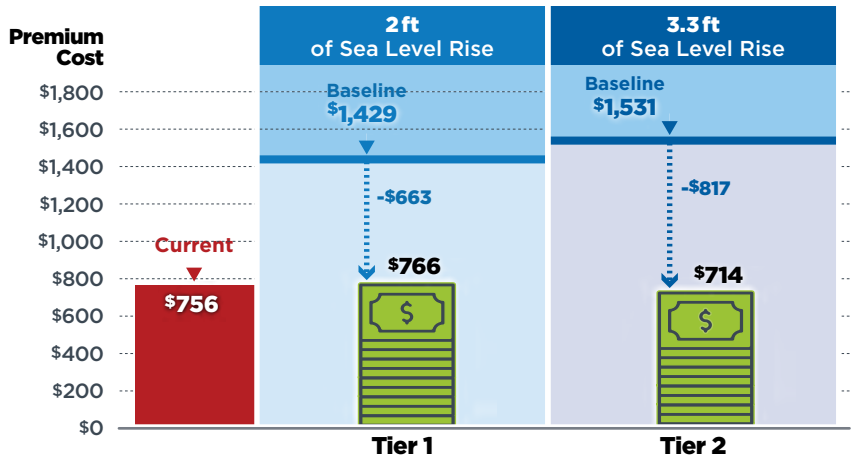
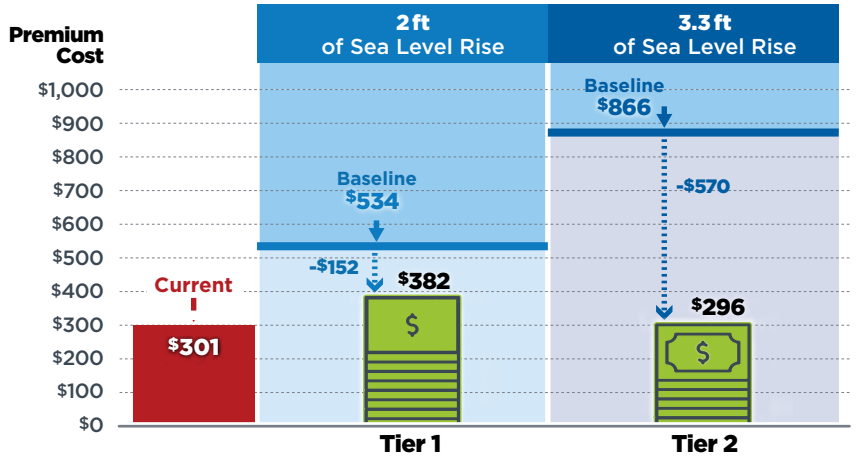


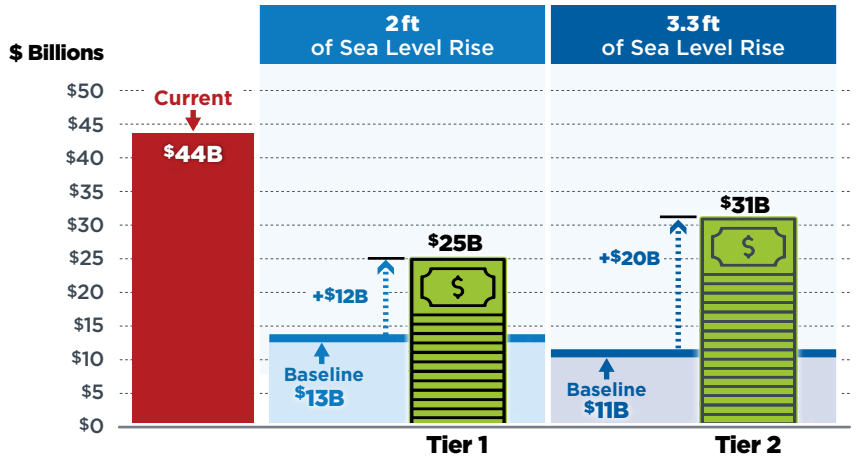
Figure 5-7. Multi-Family Home Average Annual Premiums in Broward County Under Baseline, Tier 1 and Tier 2



For single-family and multi-family dwelling units, the average annual flood insurance premia would remain very close to current premia once the Tier 1 and Tier 2 investments are implemented and the insurance market reaches equilibrium. This expected result would take place after several years as the sea level rises and the flood insurance market completes its response to these changes. During this adjustment period, higher flood insurance premia can be expected as property owners adjust to the rising premia and insurance providers respond to the change in the quantity of flood insurance demanded until, ultimately, the premia falls to current levels, as expected.

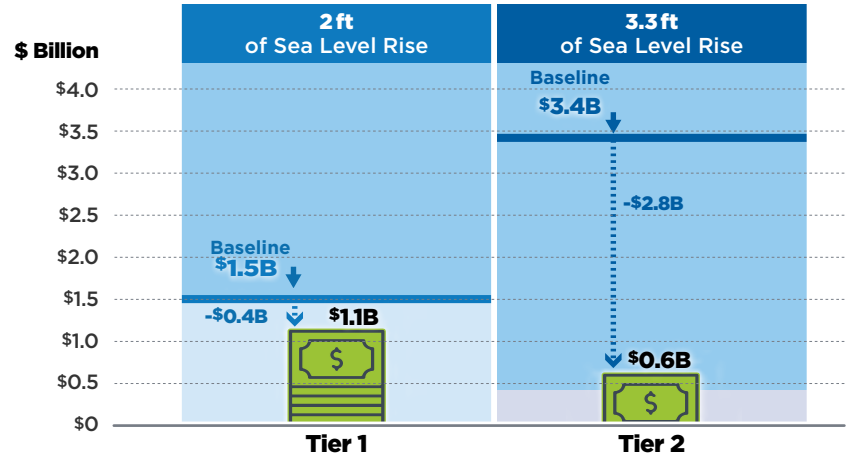
The resulting NFIP flood insurance coverage that can be expected under the baselines, Tier 1, and Tier 2 are provided in Figure 5-8. Today, total countywide NFIP flood insurance coverage is $44 billion. Under 2 feet of SLR, coverage falls to $13 billion. The Tier 1 investments increase coverage by $12 billion so that, countywide, insurance coverage would be an estimated $25 billion, which is still lower than current levels. Under 3.3 feet of SLR, coverage falls from today's level of $44 billion to only $11 billion when no action is taken. However, once the Tier 2 investments are in place, total countywide coverage increases by $20 billion so that, countywide, insurance coverage reaches $31 billion, which is much closer to, but still below, the current level.

Figure 5-8. Total Flood Insurance Coverage in Broward County Under Baseline, Tier 1 and Tier 2



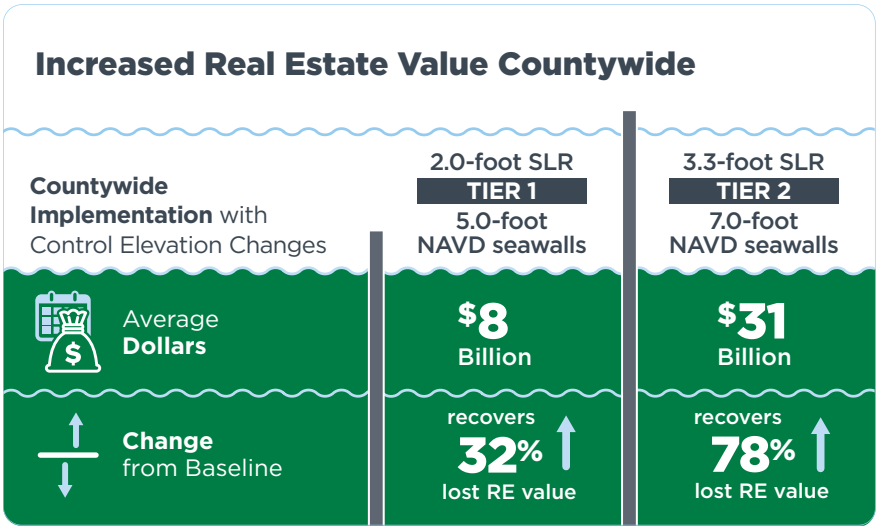
As the Tier 1 and Tier 2 investments result in higher insurance coverage than under baseline, annual uninsured damages are expected to be lower. As presented in Figure 5-9, annual uninsured damage in the baseline is estimated to be $1.5 billion under 2 feet of SLR and $3.4 billion under 3.3 feet of SLR. The Tier 1 investments are expected to reduce uninsured property damage by $0.4 billion as uninsured damages fall to $1.1 billion. The Tier 2 investments are expected to reduce uninsured property damage by $2.8 billion as uninsured damages fall to $0.6 billion.

Figure 5-9. Average Annual Uninsured Property Damages and Tier 1 and Tier 2 Benefits



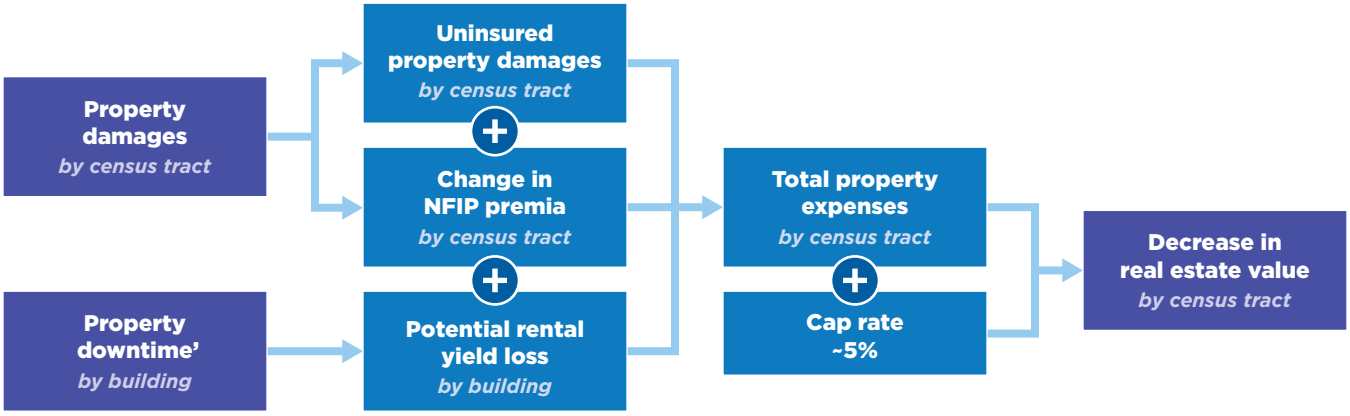
Increased Real Estate Values

The real estate analysis assessed the benefits of adaptation on the valuations of homes throughout the county. This first-order analysis focused on the real estate directly affected by floods and did not consider market effects in other neighborhoods. For example, losses in neighborhoods affected by flooding could depress the real estate values of other properties in the vicinity. On the flip side, migration to other parts of the county from affected areas could increase prices elsewhere.



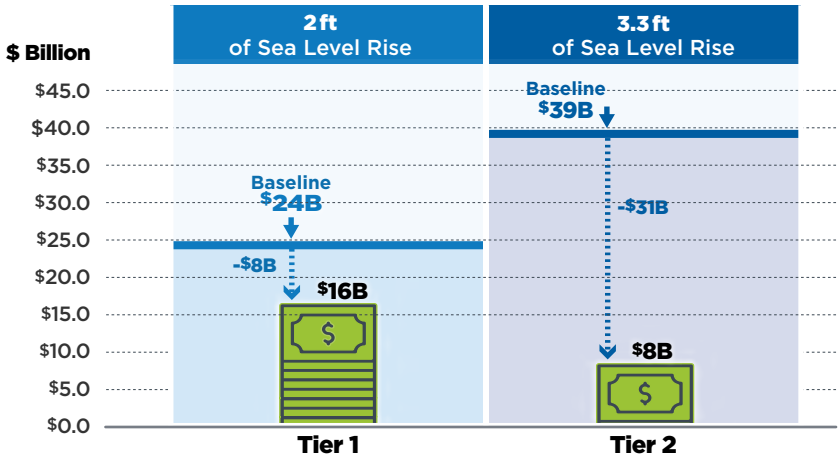
The method used to estimate the impact of the baselines, Tier 1, and Tier 2 on real estate values is summarized in Figure 5-10. The estimated increase in property values under Tier 1 and Tier 2 are to be interpreted as how much more the property would be worth if the adaptation suite were implemented. Property values could be higher or lower over time and not track this estimated increase because other factors also influence property values, including mortgage interest rates, nationwide economic activity, and the propensity of people and businesses to move to south Florida independent of the effects of SLR.

Figure 5-10. Costs of Increased Flooding are Expected to Devalue Residential Properties



The impacts of SLR and the Tier 1 and Tier 2 investments on residential property values are provided in Figure 5-11. Under 2 feet of SLR, the countywide residential property value is expected to be $24 billion lower without flood mitigation. With the Tier 1 investments, an estimated $8 billion of property value is preserved as countywide property value is $16 billion lower instead of $24 billion lower. Under 3.3 feet of SLR, residential property values are expected to be $39 billion lower under baseline. With the Tier 2 investments, an estimated $31 billion of property value is preserved as property value is $8 billion lower under Tier 2 instead of $39 billion lower under baseline.

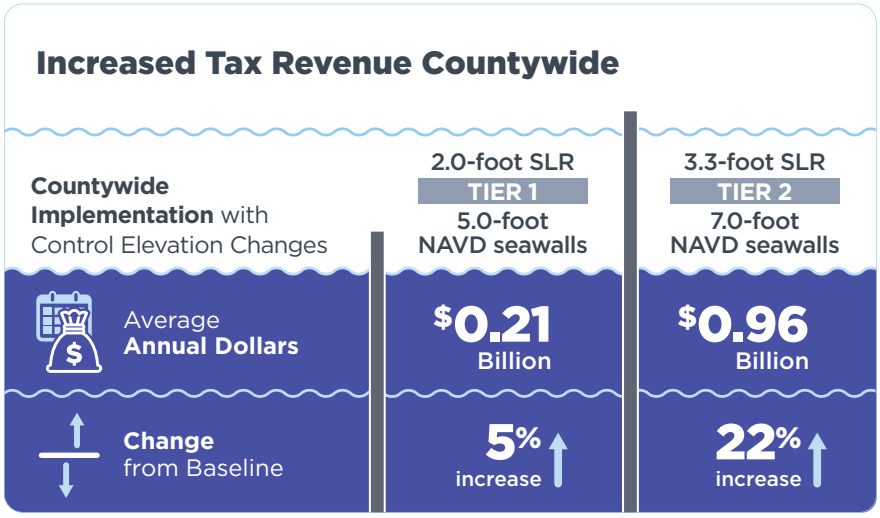
Figure 5-11. Residential Property Value Losses and Tier 1 and Tier 2 Benefits



Increased Tax Revenue

Two categories of taxes collected in Broward County are potentially impacted by increased flooding over time. The first tax category is called a "production-related tax" and includes sales and excise taxes, customs duties, business property taxes, motor vehicle licenses, severance taxes, other taxes, and special assessments. The revenue collected from these taxes is expected to fall over time in line with the loss in short-term economic activity, as was estimated and described previously as changes to GVA.

The second tax category is the ad valorem tax, which is based on the market value of real estate. As real estate values become lower than they would be if levels remained stable, this loss eventually translates into lower taxable values of real estate. Given the millage rate assessed by the County, municipalities, and government agencies, ad valorem tax revenue would be expected to fall as flooding increases under SLR.



The benefit of the Tier 1 investments is a countywide average annual tax revenue that would be $0.21 billion higher, which recovers 5% of the tax revenue losses under the 2.0-foot SLR baseline. The benefit of the Tier 2 investments is a countywide average annual tax revenue that would be $0.96 billion higher, which recovers 22% of the tax revenue losses under the 3.3-foot SLR baseline.

The impacts of SLR on production-related tax revenue and the extent to which these impacts can be mitigated by the Tier 1 and Tier 2 adaptation investments are provided in more detail in Figure 5-12. Under the current sea level, about $0.022 billion in production-related tax revenue is lost annually on average due to flooding. As the sea level rises to 2 feet, revenue loss is estimated to be $0.042 billion annually if no actions are taken. Under the Tier 1 investments, this loss falls to $0.031 billion in average annual lost revenue. The overall benefit of the Tier 1 investment is an avoided loss of about $0.011 billion annually in production-related tax revenue on average.

As the sea level rises to 3.3 feet, production-related tax revenue falls by $0.88 billion annually, on average, if no action is taken. The benefit of the Tier 2 investment is a reduction in this loss by $0.062 billion such that the average annual tax revenue loss of $0.026 billion is close to today's level.

The impacts of SLR on ad valorem tax revenue and the extent to which the Tier 1 and Tier 2 investments are expected to mitigate these impacts are summarized in Figure 5-13. Under the current sea level, ad valorem tax revenue is estimated to be $4.7 billion per year on average. As the sea level rises to 2 feet, ad valorem tax revenue is expected to be $3.8 billion. The benefit of the Tier 1 investment is that average annual ad valorem tax revenue is expected to be $4.0 billion or $200 million higher.

As the sea level further rises to 3.3 feet, ad valorem tax revenue falls to $3.4 billion annually, on average, if no action is taken. The benefit of the Tier 2 investment is an increase in ad valorem tax revenue by $0.9 billion. The resulting $4.3 billion average annual ad valorem tax collection would be only $0.4 billion lower than the amount collected currently.

Figure 5-12. Production-related Tax Revenue Losses and Tier 1 and Tier 2 Benefits (Average Annual)

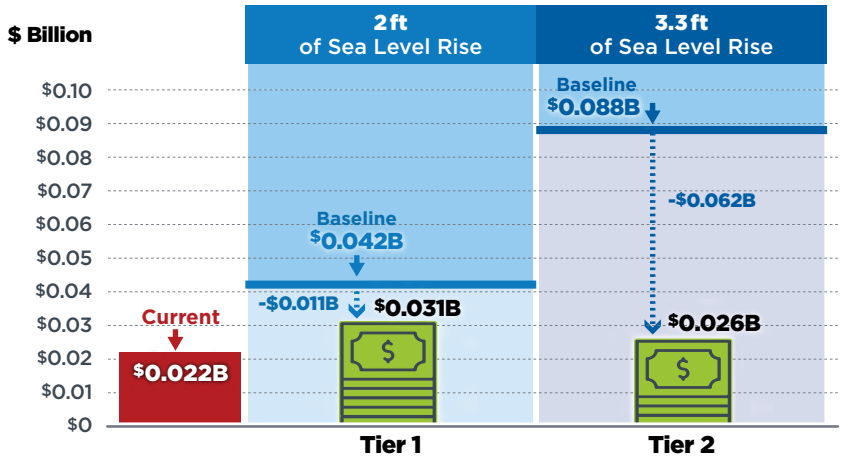
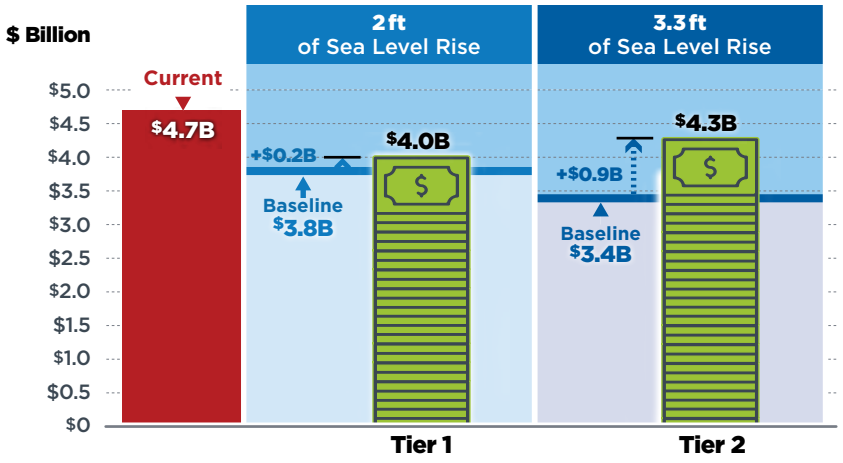


Figure 5-13. Ad Valorem Tax Revenue Collected and the Benefits of Tier 1 and Tier 2 (Average Annual)



Summary of Estimated Benefit Values

A summary of the estimated benef ts of the Tier 1 and Tier 2 investments is provided in Table 5-2.

Table 5-2. Summary of Countywide Tier 1 and Tier 2 Benefit Values

Benefit Category	Unit of Measure	Tier 1 Adaptation Strategy to Mitigate 2 foot SLR	Tier 2 Adaptation Strategy to Mitigate 3.3 foot SLR
Property Damage Avoided	Average Annual	$780,000,000	$3,600,000,000
Increased Short term Economic Activity	Average Annual	$109,000,000	$660,000,000
Increased Property Tax Collected	Average Annual	$211,000,000	$962,000,000
Increased Real Estate Value	Dollar Amount	$8,000,000,000	$31,000,000,000
Increased Flood Insurance Coverage	Dollar Amount	$12,000,000,000	$20,000,000,000

The average annual countywide benefits of the Tier 1 adaptations when SLR is 2 feet include an estimated $0.78 billion in avoided property damage, $0.11 billion in short-term economic activity (gross value added, and a $0.21 billion increase in taxes collected. Residential real estate value is estimated to be $8 billion higher, and flood insurance coverage is expected to be $12 billion larger than under the baseline strategy of no action.

The average annual benefits of the Tier 2 adaptations when SLR is 3.3 feet include an estimated $3.6 billion in avoided property damage, $0.66 billion in short-term economic activity (gross value added, and a $0.96 billion increase in taxes collected. Property values are expected to be $31 billion higher, and flood insurance coverage is expected to be $20 billion larger than in the absence of flood mitigation action.

The values for avoided property damage, increased economic activity, and 60 percent of the increased real estate value were included along with the capital and annual cost of the Tier 1 and Tier 2 investments to assess the economic feasibility and economic internal rate of return of these two adaptation strategies, as described later in this chapter.

TIER 1 AND TIER 2 BENEFITS ACROSS THE COUNTY, INCLUDING VULNERABLE AREAS

The Tier 1 and Tier 2 adaptations reduce the negative impacts of flooding in vulnerable areas as well as other parts of the county. The charts in Figures 5-14 through 5-17 present these results through the lens of four types of impacts: including residential damages, number of NFIP flood insurance policies, average premiums for single-family homes, and impacts on property values. The areas outlined in red are census tracts with relatively high food risk and low incomes/ high poverty.

For the 2-foot SLR scenario, the baseline map in Figure 5-14 can be compared to the Tier 1 adaptation suite that includes countywide adaptations with control elevation changes under the current 5.0-foot NAVD seawall height requirement. For the 3.3-foot SLR scenario, the baseline map in Figure 5-14 can be compared to the Tier 2 adaptation suite, which includes the countywide coverage provided by the Tier 1 investments with an increase in required seawall height to 7.0 feet NAVD.

The negative impacts of SLR across the county are lower for all four metrics when moving from the baseline map to the Tier 1 or Tier 2 map.

Figure 5-14. Average Annual Damages to Residential Assets as a Share of Property Value Across Broward County (Estimated)

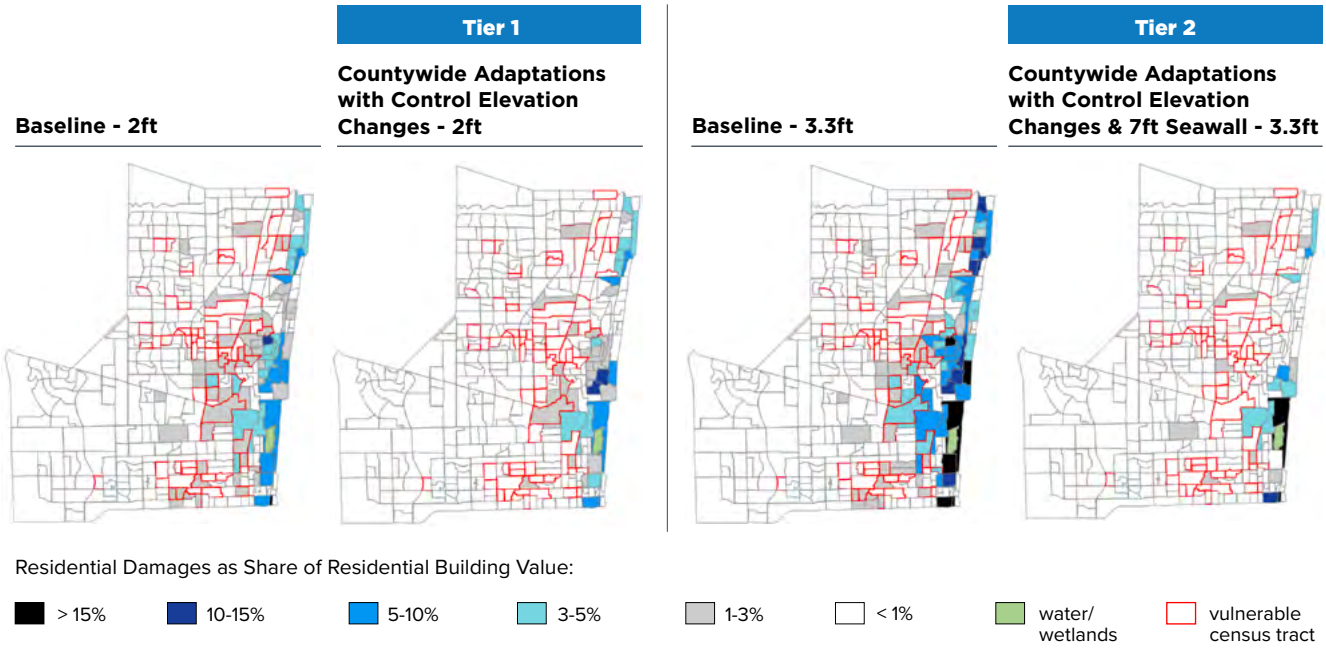


Figure 5-15. Number of NFIP Flood Insurance Policies

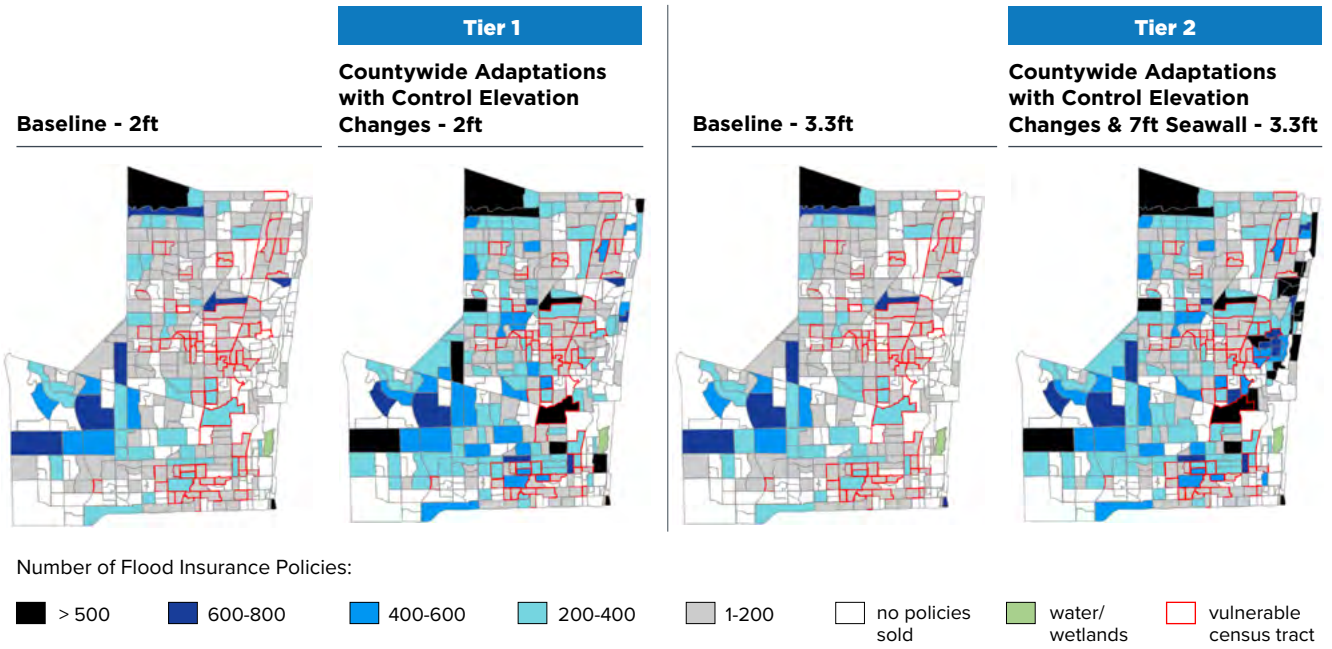


Figure 5-16. Single-family Home Annual Flood Insurance Premiums (Estimated Dollars)

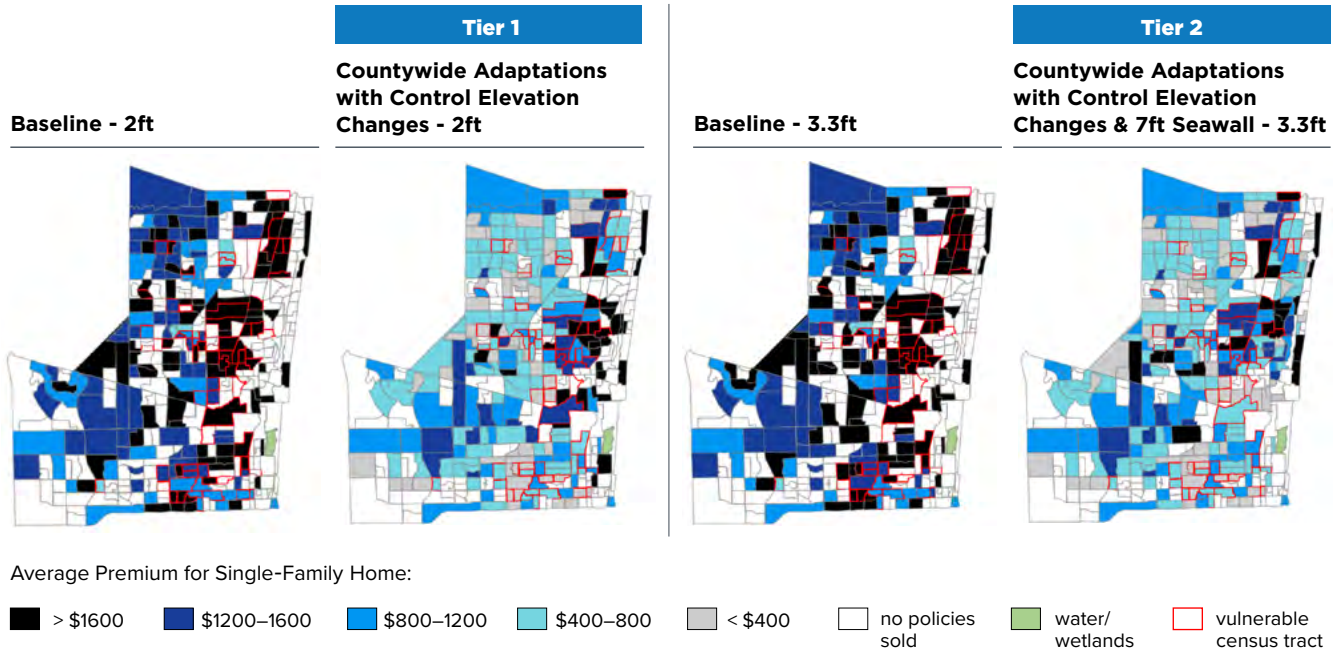
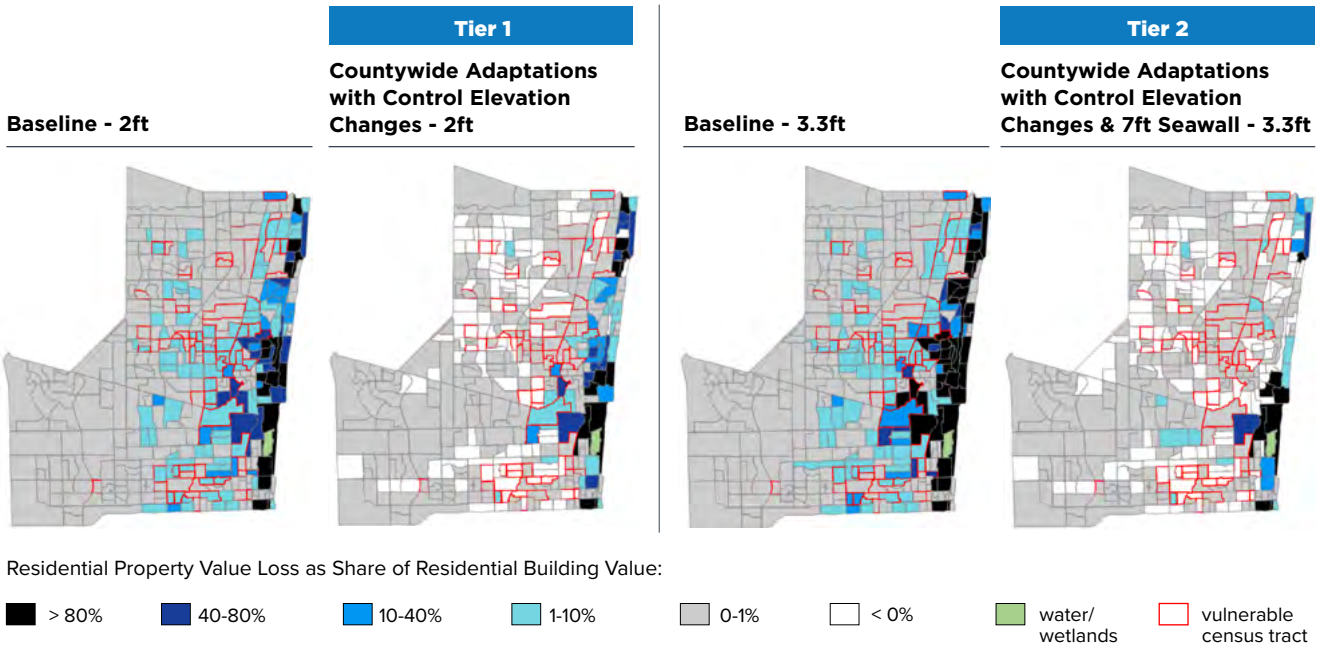
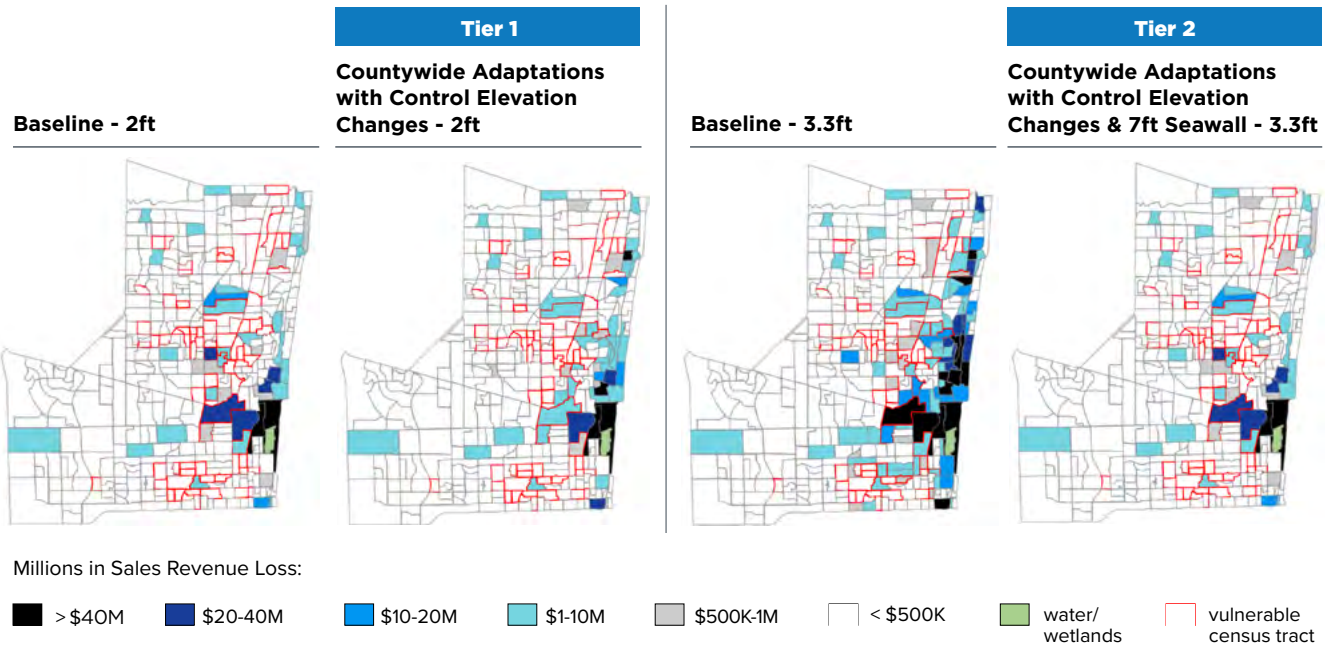


Figure 5-17. Real Estate Value Losses Across Broward County (Estimated Percent of Property Value)



As depicted in Figure 5-18, the Tier 1 investments are expected to reduce business sales losses along the I-95 corridor, including those businesses located inside the Fort Lauderdale–Hollywood International Airport, not including the airlines themselves. The airlines would likely experience short-term and long-term costs associated with flooding that would be mitigated under the Tier 1 and Tier 2 investments, but these benefits are not reported here. The Tier 2 investments are expected to reduce sales losses along the coast.

Figure 5-18. Average Annual Business Sales Losses Across Broward County (Estimated Dollars in Millions)



SEA LEVEL RISE IMPACTS ON THE COUNTY'S AIRPORT AND PORT

Fort Lauderdale–Hollywood International Airport. In April 2023, Fort Lauderdale–Hollywood International Airport experienced an extraordinary weather event, recording around 26 inches of rainfall in 12 hours. This unprecedented event, classif ed as a 1-in-1000-year occurrence, resulted in rainfall levels exceeding those typically observed during hurricanes.

The severe weather caused significant disruption to both the airfield and surrounding roadways, necessitating the closure of the airport by the Aviation Department. The estimated cost of direct damages at the airport was $17.5 million, primarily attributed to the extensive damage sustained by the Engineered Materials Arrestor System (EMAS beds.

The three main types of disruption and losses that the airport could face in the future are: (1) direct damages to terminal buildings, (2) disruption to access roads, and (3) disruption to flight traffic due to flooding on the airfield, especially runways and taxiways. Of these, the largest economic loss from a flood event (not just the airport, but air carriers and the public) would likely come from disrupted flight traffic.

Estimating the annual average loss in airport sales and prof ts due to more frequent and severe flooding is challenging due to the complex nature of airport operations. For example, flooding in certain areas may only close one runway, or only selected taxiways or hangers. Flooding of access roads to the airport can impede passengers and crew.

The airlines can reallocate their fleets to other airports under a four to six month lead time or even faster, as network planning conditions warrant. Potentially, the increased frequency and extent of flooding has the potential to increase airport costs and reduce airport revenue. When considering potential reductions in flight activity as a function of reputational disruptions caused by unmitigated flood impacts, a 5% reduction in commercial operations could result in about a $12 million annual reduction in revenue and a 15% reduction could result in about a $35 million annual revenue reduction.

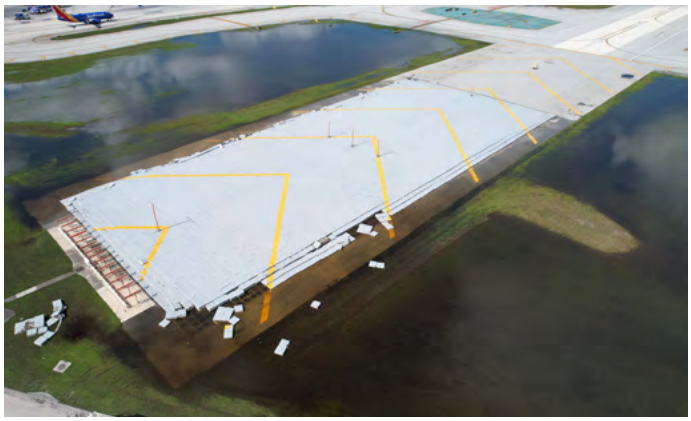
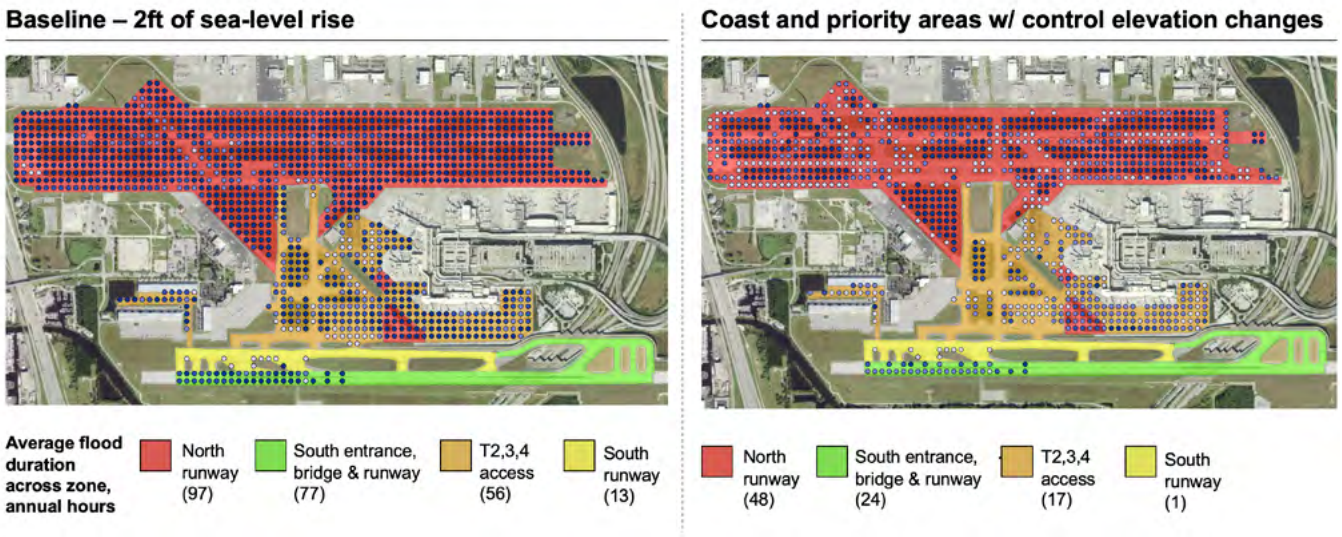


Photo taken at Fort Lauderdale International Airport on April 13, 2023 of the damaged Engineered Materials Arresting System (EMAS) at the east end of the north airport runway.

Further losses to the economy are possible if businesses and tourists decide to use airports and stay at locations outside of Broward County because of airline reallocation or to avoid flood-induced airport disruptions. The GVA and job losses associated with this impact were not estimated during this study.

In Figure 5-19, the impacts of the Tier 1 adaptation strategy were compared to the baseline for an RP-3 flood event (2 feet of SLR and 100-year rainfall event with no storm surge). The metric is the number of hours of annual flood duration above 6 inches.

Figure 5-19. Fort Lauderdale–Hollywood International Airport Average Annual Hours of Maximum Flood Duration by Airport Zone



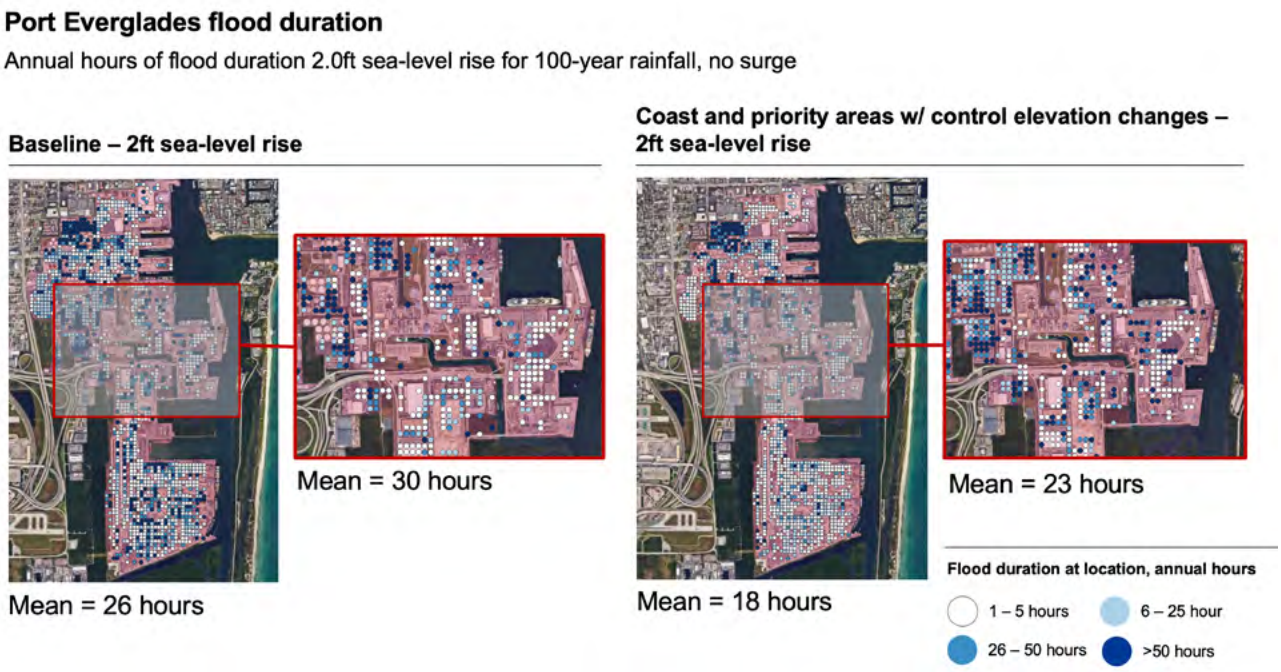
The figure shows that the area marked in red associated with the north runway could experience a significant reduction in flood duration of approximately 50% with the implementation of the Tier 1 adaptation strategy, decreasing from around 100 hours in the baseline to around 50 hours under adaptation. The south entrance, aircraft bridge, and south runway areas marked in yellow and green are relatively less impacted by flooding. In the baseline, only the eastern area is flooded, and this is mostly mitigated by the Tier 1 adaptation strategy. For example, in the green area, which includes the aircraft bridge, the south aircraft entrance, and the main south runway, the hours of flood duration fall from 77 under baseline to 24 under Tier 1. The yellow area is part of the south runway and would experience a reduction in hours flooded from 13 to 1.

Port Everglades. Port Everglades is also at risk of flooding due to its location on the Intracoastal Waterway. During the 1-in-1,000-year rainfall event in April 2023, the pump systems used at the petroleum terminals were impacted, leading to severe disruption in fuel distribution. All 12 petroleum terminals were closed for 1 day, with the last one returning to service 9 days after the flood. While direct damage to the facilities was relatively minor, the disruption to fuel distribution was felt throughout the region.

Figure 5-20 presents the results of a similar analysis conducted for Port Everglades under a 100-year rainfall event with no storm surge at 2 feet of SLR. The annual number of hours flooded in the baseline at 2 feet of SLR could be about 26 hours across all port facilities, including storage areas with up to 30 hours of flooding in the area directly connected to the main access road (see inset).

Under 2 feet of SLR, annual flood duration would be approximately 25% to 30% lower if adaptation measures were pursued under Tier 1. The average annual number of hours flooded could be reduced from 30 hours to 23 hours at the main access area and from 26 hours to 18 hours across all port facilities.

Figure 5-20. Port Everglades Annual Hours of Maximum Flood Duration



ECONOMIC BENEFITS VALUES NOT ESTIMATED

There are other benefits of the Tier 1 and Tier 2 adaptation strategies that should also be included in the economic feasibility evaluation but could not be estimated during this study. These benefits further stabilize the County's wellbeing and economy by reducing the negative impacts of SLR. Many of these benefits increase economic activity as measured by GVA and could, therefore, be included in the economic feasibility evaluation. These other benefits are as follows.

- **Reduced disruption to public services.** Mitigating flood damage to critical infrastructure, such as power grids and road networks, can reduce the negative impacts to other services (e.g., communication and health care) with cascading benefits to health and wellbeing.
- **Increased investment.** Mitigating property damage from flooding is expected to reduce perceived investment risk, resulting in lower borrowing costs and potentially improving economic investment, growth, and wellbeing relative to the baseline no action strategy.
- **Avoided demographic disruptions.** Decreases in the frequency and extent of flooding caused by SLR could improve the quality of life and public safety, which could reduce or prevent out-migration, increase or stabilize in-migration, and incentivize people to continue to live in areas that would have experienced higher flood risks. The results of these benefits would be an increase in population, higher consumer demand, higher employment, and greater tax revenue relative to baseline.
- **Increased tourism.** Flood mitigation can stabilize and possibly increase tourism capacity and improve the county's attractiveness as a vacation destination, resulting in economic growth relative to baseline.
- **Human capital benefits.** Flood mitigation can improve physical and mental health, increase household wealth, and improve education relative to baseline.

These benefits could be further evaluated in future studies as the adaptation strategies are refined.

CAPITAL AND ANNUAL COSTS OF TIER 1 AND TIER 2

The capital and annual costs of the Tier 1 and Tier 2 adaptations, as conceptualized during this study, were estimated and are presented in Tables 5.3 and 5.4. These costs are in 2024 dollars. The capital costs are comprised of the costs to construct new swales, pump stations, road crossings, storage areas, seawalls and associated drainage, and water control structures. The annual costs include those associated with administration, operation, maintenance, and the renewal and replacement of project components.

The capital cost of the Tier 1 investments was estimated to be $20.1 billion in 2024 dollars. The Tier 2 investments include all Tier 1 investments plus the cost to increase the height of the seawalls countywide from 5.0 feet NAVD to 7.0 feet NAVD and the cost of the additional drainage features behind the seawalls. The additional cost was estimated to be $7.9 billion for a total Tier 2 capital cost of $28.0 billion in 2024 dollars.

Separate costs were estimated for those investments that are expected to be financed by the public sector and those by the private sector. For the Tier 2 investments, the public sector is expected to finance all the investments except for investments related to seawalls, water storage, and swales on private property. The breakdown is $9 billion in public capital cost and $19 billion in private capital cost for a total capital cost of $28 billion.

Table 5-3. Estimated Capital Cost of the Tier 1 and Tier 2 Investments in 2024 Dollars

Table 5-3A. Public and Private Capital Costs of the Tier 1 Investments

Investment Type	Public Cost	Private Cost	Total Cost
Control Structure	$388,000,000	$0	$388,000,000
Crossings	$19,000,000	$0	$19,000,000
Drainage Behind Seawalls	$1,861,000,000	$0	$1,861,000,000
Pump Station	$575,000,000	$0	$575,000,000
Seawall	$2,566,000,000	$9,597,000,000	$12,163,000,000
Storage	$1,965,000,000	$1,965,000,000	$3,930,000,000
Swale	$771,000,000	$426,000,000	$1,197,000,000
Seawall 5-7ft	$0	$0	$0
Grand Total	**$8,145,000,000**	**$11,988,000,000**	**$20,133,000,000**

Table 5-3B. Additional Public and Private Capital Costs of the Tier 2 Investments

Investment Type	Public Cost	Private Cost	Total Cost
Control Structure	$0	$0	$0
Crossings	$0	$0	$0
Drainage Behind Seawalls	$0	$0	$0
Pump Station	$0	$0	$0
Seawall	$0	$0	$0
Storage	$0	$0	$0
Swale	$0	$0	$0
Seawall 5-7ft	$953,000,000	$6,915,000,000	$7,868,000,000
Grand Total	**$953,000,000**	**$6,915,000,000**	**$7,868,000,000**

Table 5-3C. Public and Private Capital Costs of the Tier 2 Investments

Investment Type	Public Cost	Private Cost	Total Cost
Control Structure	$388,000,000	$0	$388,000,000
Crossings	$19,000,000	$0	$19,000,000
Drainage Behind Seawalls	$1,861,000,000	$0	$1,861,000,000
Pump Station	$575,000,000	$0	$575,000,000
Seawall	$2,566,000,000	$9,597,000,000	$12,163,000,000
Storage	$1,965,000,000	$1,965,000,000	$3,930,000,000
Swale	$771,000,000	$426,000,000	$1,197,000,000
Seawall 5-7ft	$953,000,000	$6,915,000,000	$7,868,000,000
Grand Total	**$9,098,000,000**	**$18,903,000,000**	**$28,001,000,000**

Table 5-4. Estimated Annual Cost in 2024 Dollars

Table 5-4A. Annual Operations, Maintenance, Renewal and Replacement Cost of the Tier 1 Investments (Estimates in 2024 Dollars)

Sector	Capital Cost Estimate	Annual Cost as Proportion of Capital Cost	Annual Cost
(1)	(2)	(3)	(4) = (2) x (3)
Private	$11,988,000,000	0.01	$119,880,000
Public	$8,145,000,000	0.01	$81,450,000
Grand Total	**$20,133,000,000**		**$201,330,000**

Table 5-4B. Annual Operations, Maintenance, Renewal and Replacement Cost of the Tier 2 Investments (Estimates in 2024 Dollars)

Sector	Capital Cost Estimate	Annual Cost as Proportion of Capital Cost	Annual Cost
(1)	(2)	(3)	(4) = (2) x (3)
Private	$18,903,000,000	0.01	$189,030,000
Public	$9,098,000,000	0.01	$90,980,000
Grand Total	**$28,001,000,000**		**$280,010,000**

For each of the two tiers, the annual cost was estimated as 1% of its estimated capital cost. This percentage value was based on the consultant's past experience in cost estimating given the conceptual nature of the Tiers, when only about 23% to 25% of the total capital cost is for structures that require significant annual costs, including pump stations, road crossings, storage areas, and control structures. The other investments, swales and seawalls, are not expected to require significant annual costs. The annual cost of Tier 1 is estimated to be $201 million, and the annual cost of Tier 2 is estimated to be $280 million, which includes the costs of the Tier 1 investments. These costs are in 2024 dollars.

DISCUSSION OF UNCERTAINTY

Climate change is an ongoing process with a variety of outcomes possible in the 21st century and beyond. As a result, this analysis provides a view of possible scenarios in which a warming world could cause sea levels to rise and storm surge and rainfall to increase in severity.

For the purposes of this analysis, local SLR scenarios of 2 feet and 3.3 feet were chosen, which correspond approximately with 2050 and 2070 estimates using NOAA's 2017 SLR projections under the intermediate-high scenario. Under other scenarios, increases in sea level could occur at different times in the future. The timing and magnitude of SLR is the largest uncertainty in the results of this analysis.

This analysis used a case study of 2.0-foot SLR by 2050 and 3.3-foot SLR by 2070. Significant deviations in SLR will affect the need for and timing of the measures that comprise the Tier 1 and Tier 2 adaptation strategies. Given these two SLR scenarios, the best available information was used to assess the Tier 1 and Tier 2 benefits and their economic feasibility.

Other uncertainties are those typical when evaluating conceptual projects and include the following:

- Land uses, economic conditions, and drainage infrastructure existing at the time of this study could be different during engineering design and construction of the adaptation strategies, resulting in differences in benefits and costs than those reported during this study.
- While the data used to assess damages and economic activity are of good quality, human and business responses to emergencies, regulations, incentive systems, and prices do not always mimic their past behavior as reflected in the historic and current data used in this study.

For these reasons, the economic feasibility of adaptation measures and strategies should be revisited on a regular basis as investment decisions are contemplated.

ECONOMIC FEASIBILITY ANALYSIS

A project is economically feasible if the present value of its benefits is greater than the present value of its costs. The economic feasibility evaluation includes estimating the present value of net benefits (benefits minus costs), the benefit-cost ratio, and the internal rate of return (IRR). The present value of net benefits takes the stream of annual benefits and costs and "discounts" them to "present value" using a selected annual discount rate that reflects the project owner's opportunity cost of money (or capital.

The internal rate of return, also called "rate of return on investment" in this study, is the value of the annual discount rate that equates the present value of benefits to the present value of costs. Its calculation requires that an investment is made at the beginning of the period that is recovered through a future stream of annual revenue and other costs incurred each year.

The last metric estimated was the benefit-cost ratio, which measures, in present-value terms, the dollar value of benefits per dollar of cost.

The timing of the benefits and costs of the Tier 1 and Tier 2 investments are described in Table 5-5. The project study period for which economic feasibility was evaluated is 2025 to 2125, which includes the construction and operation of the Tier 1 and 2 investments over a 100-year period beginning in 2025.

Table 5-5. Estimated Timing of Annual Benefits and Costs Used to Calculate the Present Value of Net Benefits and Investment Rate of Return

Assumption	Tier 1 – Countywide with Control Elevation Changes and 5 ft NAVD Seawalls	Tier 2 – Countywide with Control Elevation Changes and 7 ft NAVD Seawalls
Study Period	101 Years from 2025 to 2125	101 Years from 2025 to 2125
Year Construction Begins	2025	2040
Year Construction Completed	2040 (15 years)	2070 (30 years)
Year Benefit Phase-In Begins [a]	2026	2041
Years 100% of Benefits Realized	2041 to 2125	2071 to 2125

[a] Considers the proportion of the Tier constructed and the timing of the 2.0-foot and 3.3-foot SLR scenarios. Real estate benef ts begin in year 2031.

Construction of the Tier 1 investments begins in 2025 and would be completed 15 years later in 2040. The Tier 1 benefits associated with avoided flood damage and avoided short term GVA loss begins in 2026 as a percentage of the Tier 1 capital cost expended the previous year. In all future years, these benefits are equal to the total Tier 1 benefits times the proportion of the capital cost expended in all previous years. The annual benefits of Tier 1 as presented earlier in this chapter are fully realized each year after 2040.

The estimated avoided loss in real estate value was estimated only for those properties that are expected to experience increased flooding mitigated by the adaptation strategies. Under baseline, real estate values in less flooded areas of the county would be expected to increase as they become relatively more desirable. As a result, some of the reduced values in the flooded areas would be of set by the increased values in the less flooded areas. On the other hand, the values of properties near to those experiencing reduced value are also expected to fall, which would mitigate some or

all the increase in real estate value. These two values were not estimated during this study. To account for these two values, only 60% of the estimated real estate benefits of $8 billion under Tier 1 and $31 billion under Tier 2 were used in the economic feasibility evaluation.

To provide time for the benefits of the Tier 1 investments to be reflected in real estate value, the real estate benefit begins in 2031, which is six years after construction begins. In the years after 2031, the incremental increase in real estate value was based on the proportion of the Tier 1 capital cost expended three years prior, minus the real estate benefit already realized. Because the real estate benefit is a capitalized value and not an annual value, its value is recognized only once in the benefit-cost analysis. In essence, once the avoided property value loss is realized by a property, this benefit value is only counted in the year it is realized.

Construction of the additional Tier 2 investments (higher seawalls) begins in 2040 and would be completed 30 years later in 2070. The additional Tier 2 benefit associated with avoided flood damage and avoided short-term GVA loss begins in 2041 as the total benefit of Tier 2 minus Tier 1 presented earlier in this chapter times the proportion of the additional Tier 2 capital cost expended the previous year. These benefits grow each year as a proportion of the cumulative additional Tier 2 capital cost expended by the previous year. The annual benefits of Tier 2 minus Tier 1 are fully realized each year after 2070.

The real estate benefit under the additional Tier 2 begins in 2045, which is six years after construction begins, to provide time for the benefits of the Tier 2 investments to be reflected in real estate value. In the years after 2045, the incremental increase in real estate value is based on the proportion of the additional Tier 2 capital cost expended three years prior minus the real estate benefit already realized. In 2074 and beyond, the real estate benefit value was set to $0 because the full real estate benefits would have been realized by this time.

The annual cost includes administration, operation, maintenance, renewal, and replacement of the Tier 1 and Tier 2 investments and was based on the annual costs of the fully built tier multiplied by the proportion of the cumulative capital cost that was spent as of the year before. Tier 2's incremental annual cost relative to Tier 1 was allocated as the additional Tier 2 structures are built. Once the tier's construction is 100% complete, the full annual cost of the tier is entered for each year. After 2070, the annual cost is that of Tier 2.

Given the renewal and replacement of project components as needed during the evaluation period, the overall projects are expected to remain fully operational through 2125. By this year, the overall Tier 1 and Tier 2 investments will have been fully operational for 84 years and 54 years, respectively. The remaining useful value of these investments in year 2126 was assumed to be $0. While the remaining value may be greater than zero, its realization in 101 years does not change the economic feasibility values or results.

Changing the timing of Tier 1 and Tier 2 construction within the period 2025 to 2070 will change the values of the economic feasibility metrics but will not change whether they are economically feasible. This conclusion holds under the SLR assumptions made within the economic feasibility evaluation and in the estimated values of the Tier 1 and Tier 2 benefits and costs.

The annual stream of benefits and costs over the 101-year study period beginning in 2025 were discounted at 5% per year. The discount rate is used to calculate the present value of annual net benefit as follows.

Present Value of Annual Net Benefit $= \sum_{t=1,101} [(B_t - C_t) / (1+d)^t]$

where,

- $\sum_{t=1,101}$ is the **summation sign** from year t equals 1 to 101;
- B_t is the **dollar value of benefits** in year t;
- C_t is the **dollar value of costs** in year t;
- d is the **annual discount rate** (for example. d = 0.05 for a 5% discount rate)

The 5% annual discount rate represents Broward County's opportunity cost of money, which is the forgone value to the County of the best alternative use of the money when it invests in adaptation strategies. For this evaluation, the 5% discount rate value is the median coupon rate paid by municipalities

and counties in Florida for bonds that finance water, wastewater and stormwater projects (Municipalbonds.com). This discount rate includes inflation. Over the past 30 years (August 1994 to August 2024, the average annual consumer price index (CPI for all urban consumers was 2.53% annually. Thus, the real discount rate is 2.47% (5% minus 2.53%).

For this evaluation, the benefit values, which had been estimated in 2022 dollars, were adjusted to reflect 2024 to be in line with the 2024 cost estimates. For each year of the 101-year evaluation period, the benefits and costs were increased by 2.53% average annual inflation. The present value of net benefits was calculated using the 5% annual discount rate.

As stated earlier, the project is economically feasible if the present value of net benefits is greater than zero. When this happens, the project's rate of return on investment (internal rate of return) is greater than the 5% annual discount rate used, and the project's benefit-cost ratio will be greater than 1.0.

For this evaluation, the economic feasibility was evaluated for two scenarios of SLR. Scenario 1 assumes that SLR will be 2 feet by 2050 and 3.3 feet by 2070. In this case, the Tier 1 investments would be made from 2025 through 2040, and the additional investments under Tier 2 would be made from 2040 to 2070.

Under Scenario 2, the sea level is assumed to rise 2 feet by 2050 and remain at this level through the rest of the 101-year evaluation period. In this case, only the Tier 1 investments are made beginning in 2026 and completed in 2040.

A summary of the economic feasibility results is provided in Table 5-6. Both the Tier 1 and Tier 2 investments are economically feasible, as indicated by their net present values, rate of return on investment, and benefit-cost ratio.

Table 5-6. Benefit Cost Analysis of Tier 1 and Tier 2 Investments to Mitigate Flood Risk

Economic Metric	Tier 1 and Tier 2	Tier 1 Only
(1)	(2)	(3)
Present Value of Net Benefits at 5% discount rate over 101 years from 2025 to 2125	At least $82 billion	At least $10 billion
Rate of Return on Investment, Nominal annual	At least 12%	At least 7%
Benefit to Cost Ratio at 5% real annual discount rate	At least 3.90	At least 1.40

Note: The benefits and costs used in this analysis are in nominal dollars assuming an average annual inflation rate of 2.53%. Benefit categories included are Avoided Property Damage, Increased Short-Term Economic Activity, and Increased Real Estate Value. Benefit categories not included are the longer-term benefits to economic activity and wellbeing generated from (a) avoided disruption to public services, (b increased investment, (c avoided population exodus, (d increased tourism, and (e favorable human capital impacts.

The estimated economic values of benefits, costs, and economic feasibility reported in this chapter provide actionable information for the County to conduct resiliency planning. Because these analyses are based on scenarios, they do not require that the future is known. Rather, they allow leaders to plan for a range of possible futures and act now with the best information available at the time of the analysis.

Photo of the intracoastal waterway in Broward County.

6 Stakeholder Engagement and Public Outreach

Stakeholder engagement was a critical component of Broward County's resilience planning process. The County recognizes that building a resilient community requires the input and collaboration of stakeholders, including local municipalities, water management agencies, private-sector representatives, community organizations, and residents. Broward County included the following stakeholder engagement mechanisms to develop this Plan:

1. **Resilience Steering Committee.** The development of the Resilience Plan was guided by a steering committee composed of representatives from various sectors. This committee includes members from local governments, environmental organizations, business leaders, and community advocates. Their diverse perspectives ensure that the plan addresses the needs and concerns of all community segments.
2. **Public Workshops and Meetings.** Broward County conducted numerous public workshops and meetings to gather input from residents and stakeholders. These sessions provided a platform for community members to voice their concerns, share ideas, and contribute to the planning process. Topics discussed often included flood management, heat mitigation, and risk informed development.
3. **Sub-Regional Workshops.** To address specific local issues, the County conducted sub-regional workshops. These workshops focused on reviewing preliminary models, identifying flood-prone areas, and discussing water management challenges. By engaging stakeholders at a more localized level, the County tailored solutions to the unique needs of different communities.
4. **Virtual Engagement.** Recognizing the importance of accessibility, Broward County also utilized virtual platforms to engage stakeholders. Virtual meetings and roundtables, such as the Planning and Utility Directors Roundtable, allowed for broader participation and ensured that stakeholders who cannot attend in person can still contribute.
5. **Ongoing Communication.** The County maintains continuous communication with stakeholders through newsletters, updates, and an online resilience dashboard. This ensures that stakeholders are kept informed about the progress of the Resilience Plan and upcoming opportunities for engagement.

DEVELOPMENT OF NATURE-BASED INFRASTRUCTURE throughout Broward County **IS RECOMMENDED** for implementation **IN THE EARLY YEARS OF THE PLAN,** while its impact is most significant.

Photo of Broward County volunteers planting in a swale.

COUNTYWIDE RISK ASSESSMENT AND RESILIENCE PLAN

ENGAGEMENT TIMELINE

JUNE 2022

06/08/2022
Resilience Steering Committee Presentation #1

AUGUST 2022

08/10/2022
Resilience Steering Committee Presentation #2

SEPTEMBER 2022

09/2022
Broward Resilience in the Making Project Update #1

09/15/2022
Planning and Utility Directors Roundtable – Stakeholder Workshop Presentation

NOVEMBER 2022

11/12/2022
Resilience Steering Committee Presentation #3

Broward Resilience in the Making Project Update #2

DECEMBER 2022

12/14/2022
Resilience Steering Committee Presentation #4

Broward Resilience in the Making Project Update #3

FEBRUARY 2023

02/08/2023
Resilience Steering Committee Presentation #5

Broward Resilience in the Making Project Update #4

APRIL 2023

04/09/2023
Resilience Steering Committee Presentation #6

Broward Resilience in the Making Project Update #5

MAY 2023

05/22/2023
Subregional Stakeholder Meetings
Meeting 1/Group 1

05/22/2023
Subregional Stakeholder Meetings
Meeting 2/Group 2

05/30/2023
Subregional Stakeholder Meetings
Meeting 3/Group 3

JUNE 2023

06/05/2023
Subregional Stakeholder Meetings
Meeting 4/Group 4

06/05/2023
Subregional Stakeholder Meetings
Meeting 5/Group 5

08/23/2023
Resilience Steering Committee Presentation #7

AUGUST 2023

10/31/2023
Community Foundation Listening Session

Broward Resilience in the Making Project Update #6

OCTOBER 2023

11/14/2023 7PM
Urban League Listening Session

NOVEMBER 2023

11/07/2023
Broward Social Post on Threats

Broward Resilience in the Making Project Update #7

11/07/2023
Broward Social Post – Infrastructure Resilience

11/11/2023
Resilience Steering Committee Presentation #8

11/14/2023 5PM
Ecoexplorers Listening Session

DECEMBER 2023

12/01/2023
Residents for Resilience Listening Session

12/13/2023
Resilience Steering Committee Presentation #9

12/20/2023
Hispanic Unity Listening Session

JANUARY 2024

01/22/2024
Broward Social Post – Dr. Jennifer Jurado Survey Invitation

FEBRUARY 2024

02/07/2024
Resilience Steering Committee #10

MARCH 2024

03/14/2024
Broward Resilience Plan - Adaptation Results Review Meeting
South Inland

03/19/2024
Broward Resilience Plan - Adaptation Results Review Meeting
Coastal

03/25/2024
Broward Resilience Plan - Adaptation Results Review Meeting
North Inland

JUNE 2024

06/12/2024
Resilience Steering Committee #11

AUGUST 2024

08/28/2024
Resilience Steering Committee #12

2022 | 2023 | 2024

7 Achieving the Resilient Future

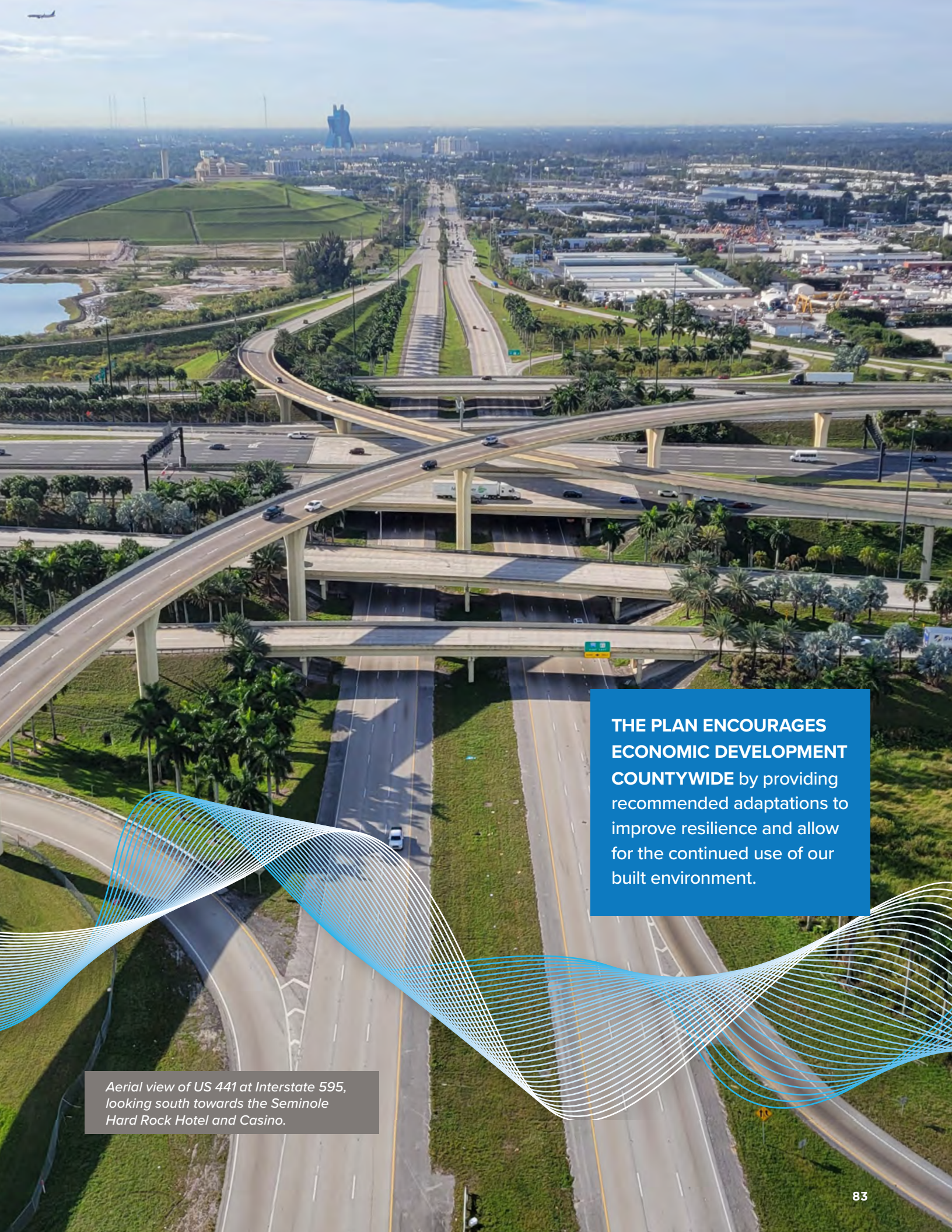
INTRODUCTION

This chapter outlines the Resilience Plan's implementation strategy, guiding the phased roll-out of projects and interventions that will increase protection against climate-related risks and enhance community resilience.

The planning horizon for the Countywide Resilience Plan extends from 2025 to 2070. This multi-decade horizon allows for the phased implementation of resilience projects, planning checkpoints for reassessment, and adjustments based on evolving climate data and projections. This long-term scope ensures that the plan addresses immediate adaptation needs and prepares for future climate impacts anticipated over the next 50 years.

The Plan is recommended for implementation in parallel with improvements to the C&SF Flood Control Project Primary System by the USACE and SFWMD. The SFWMD C&SF Flood Resiliency Study is still in progress and will be revisited during planning checkpoints. Additionally, improvements to stormwater management capital infrastructure planning by each municipality to address localized and frequent flooding will also be implemented in parallel.

The Plan will be implemented in parallel with improvements to the C&SF Flood Control Project Primary System by the USACE and SFWMD.



THE PLAN ENCOURAGES ECONOMIC DEVELOPMENT COUNTYWIDE by providing recommended adaptations to improve resilience and allow for the continued use of our built environment.

Aerial view of US 441 at Interstate 595, looking south towards the Seminole Hard Rock Hotel and Casino.

ADAPTATIONS

Drainage systems in South Florida are driven by unique topographic and hydrographic conditions. Extremely low topographic gradients across a vast area and relatively pervious soils require that stormwater management systems rely heavily on natural underground storage (saturated and unsaturated zones rather than using conventional conveyance structures and large outfalls. Perhaps the most significant effect of climate change on the South Florida drainage systems, aside from the increase in rainfall intensities, is the loss of underground storage capacity.

Rising sea levels have a direct impact on groundwater levels in the county. This increase in groundwater levels reduces the space between the groundwater level and the ground, thus reducing the available storage. Most adaptation strategies developed as part of the plan are envisioned to recover that lost storage capacity. This could be accomplished by adding above-ground storage, modifying operations, and adding flexibility to water control structures that connect the secondary and primary systems and increase permeability in certain areas. In some parts of the system, where the hydrologic and hydraulic analysis showed bottleneck and conveyance issues, strategies were added to remove them. In coastal areas, additional barriers were added to the set of strategies to protect properties from higher levels directly caused by SLR and to improve the drainage condition of those areas.

The key strategies are summarized in Chapter 5 and below.

Swales and Nature-based Infrastructure

Improve stormwater absorption and reduce runoff through enhanced nature-based infrastructure throughout the drainage system.

Two-Lane Road Conversions

Convert selected two-way roads to one-lane, increasing pervious surface area to aid stormwater management. This is implemented only in places where minimal impact on residents' travel time (<one minute) is anticipated.

Storage Areas

Convert a portion (10% of large impervious areas to storage areas covered by pervious surfaces to reduce drainage issues. This will provide the additional benefit of heat reduction.

Pumping Stations, Culvert Improvements, and Improved Crossings

Upgrade and expand pumping stations, culverts, and crossings as needed to support increased drainage capacity and handle rising sea levels.

Control Elevation Changes

Adjust drainage system elevations to optimize water flow ahead and during rainfall events while maintaining positive head pressure against SLR. This strategy extends the SFWMD's current practices of lowering water levels in the primary system by adding the required flexibility to control structures, allowing the secondary system to benefit from the district's pre-storm management practices.

Seawalls

Gradually increase seawall heights, with the current mandate of 5.0 feet NAVD by 2050 and up to 7.0 feet NAVD in the long term, supported by drainage and pumping systems to manage water levels effectively.

POLICIES FOR CONSIDERATION

The following policies are recommended for review and consideration by Broward County, its municipalities, and the private sector. The intent of these policies is to facilitate implementation of the recommended adaptation strategies to mitigate SLR impacts and create a resilient future.

Policy Strategy 1
Develop Green Streets Program

Policy/Action: Increase available green space for drainage along roadways, including bioswales, and provide guidance to convert select residential roadways from two-way to one-way (or one-way roads), widening the drainage areas along the ROW.

Policy Details: Broward County would establish a program comprised of a pilot study and incentive system.

The pilot study, intended to generate publicity, knowledge, and public support, could include three to five selected neighborhoods for retrofit of selected streets with nature-based infrastructure. The County would facilitate resident participation in a community co-development process offering engineering design services and negotiate a cost-share with the road's owner (municipality and/or HOA. This would include all services needed to create a new road, swale, sidewalks, and landscaping such that the pervious area is significantly increased, flooding is significantly reduced, and the County's requirements are met.

From the pilot study results, the County would develop an incentive system to encourage the private sector to convert two-way to one-way roads by: (1) disseminating information about the benefits and costs of two-to-one way/lane road conversions, and (2) negotiating a cost-share agreement between the County and the road's owner.

Benefits: The participating neighborhoods could expect improved water drainage, less flooding and reduced food damage, cooling effects, increased recreation and amenities, improved traffic safety, neighborhood beautification, and higher property values.

Funding (Other than County General Fund): County transportation surtax, County and municipal stormwater funding, and grants.

Issues: Broward County would develop a plan of action to implement this policy and the criteria for choosing the pilot neighborhoods.

Policy Strategy 2

Increase Pervious Percentages

Policy/Action: Implement a program that provides incentives for property owners to convert impervious areas to pervious areas on private property for purposes of drainage.

Policy Details: The County, working with the SFWMD and municipalities, could provide financial or other incentives for a property owner to further reduce the impervious area on their property and/or invest in nature-based infrastructure features.

One example is the use of the stormwater utility fee by municipalities and the County to incentivize this action. Part or all of the fee would be based on the impervious area of the property. One of three types of fee structures could be implemented: (1) a flat fee per unit of impervious area, (2) an inclining block rate structure where the fee per unit increases with the size of the impervious area, or (3) a fee credit system where a portion of the stormwater fee is returned to the property owner, or the stormwater fee is signifcantly reduced over time as the size of the impervious area decreases. These fee structures would incentivize property owners to implement certain nature-based infrastructure best management practices that reduce impervious areas and improve drainage.

Benefits: Improved drainage and reduced flooding.

Funding (Other than County General Fund): County and municipal stormwater funding and grants; County could explore stormwater credit system.

Issues: Methods to incentivize the creation and preservation of pervious areas would need to be developed. If stormwater fees are used, the County and municipalities may need to create stormwater utilities and/or implement or re-design stormwater utility fees.

Policy Strategy 3

Increase Stormwater Storage Management Requirements

Policy/Action: Enhance on-site storage capacity requirements for land being developed or redeveloped, promoting better stormwater management and resilience.

Policy Details: Owners of property being developed or significantly re-developed would be required to provide on-site water retention or detention to a specified amount beyond existing requirements. On-site water storage could be used for irrigation, aquifer recharge, or other non-potable uses.

A variance from this requirement would be provided to owners who build affordable housing on the property or provide other public benefit. If a development is unable to manage the required amount of stormwater, a fee in lieu could fund nature-based infrastructure projects elsewhere. In some cases, when affordable housing is being constructed, the local government could agree to pay for the additional storage using the funding from the “fee in lieu.”

Benefits: Increase water storage and reduce flooding. Encourage the development of affordable housing.

Funding (Other than County General Fund): Private sector.

Issues: The County would work with the SFWMD, the local drainage/water control districts, and municipalities to develop this policy.

Policy Strategy 4

Reduce Parking Minimums

Policy/Action: Revise and adjust parking space requirements for new developments and redevelopments to promote more efficient land use, encourage resilience focused transportation options, and reduce the footprint of parking areas, supporting community-oriented growth.

Policy Details: A reduction in the number of parking spaces would free up land for other needed uses, including increasing pervious areas and providing additional storage. Reducing minimum parking requirements could also enable more affordable housing construction, better land uses, and walkable neighborhoods.

Benefits: More efficient land uses that improve drainage and reduce flooding, encourage more affordable housing construction, and make communities more livable.

Funding (Other than County General Fund): None needed, except for the study.

Issues: A parking sufficiency study would update the types and patterns of transportation over the years and hopefully justify a reduction in the required number of parking spaces for developments. The reduction in the number of parking spaces should not cause parking problems that affect neighboring properties.

Policy Strategy 5

Promote Efficient Land Use

Policy/Action: Provide incentives to encourage property owners to replace asphalt parking lots with parking garages or alternative solutions that reduce impervious surfaces.

Policy Details: The County would provide incentives for property owners to replace asphalt surface parking lots with parking garages, including allowing an unlimited number of garage floors (within engineering feasibility) and assessing an annual County fee per 1,000 square-feet of existing asphalt parking.

This fee would be justified by the negative impacts of asphalt parking on the community, including acting as a heat island and exacerbating the need to store additional flood water that was not contemplated when the developer's Environmental Resource Permit from the SFWMD was issued.

Further justification would be the fact that parking garages are feasible substitutes for asphalt parking. Alternatively, or in addition, the County could ban asphalt parking beyond a certain percentage of the building's footprint for new development and redevelopment. The County could directly participate by cost-sharing new community parking garages in exchange for the removal of asphalt parking lots.

Benefits: This policy has the potential to minimize the acreage in asphalt parking and open a large part of the county to redevelopment, including affordable housing. The policy would be designed to increase pervious areas throughout the county to reduce flooding and flood damage and to increase cooling.

Funding (Other than County General Fund): Funding from the annual fee, private sector.

Issues: Broward County and municipalities would need to work together to develop this policy in cooperation with the SFWMD and the local drainage/water control districts.

Policy Strategy 6

Promote Resilient Land Use on Private Properties

Policy/Action: Provide development incentives and variances at new developments and redeveloping properties in exchange for additional storage and/or signifcant infrastructure if a "net beneft" to the community would be achieved.

Policy Details: Where a "net benefit" to the community could be achieved, variances from certain land development requirements could be provided when a developer goes beyond stormwater management requirements on their property. Incentives could include density or height bonuses in exchange for signifcant infrastructure and allowing greater impervious surface area if it is more than offset by on-site storage capacity. The stored water could be used for irrigation, aquifer recharge, or other non-potable uses.

Benefits: Improved drainage and reduced flooding, increased water supply, cooling benefit. Enables denser development.

Funding (Other than County General Fund): Private sector.

Issues: Broward County and municipalities would need to work together to define "net benefit" and establish allowable variances in cooperation with the SFWMD and the local drainage/water control districts. The use of "net benefit" to permit water withdrawal quantities from the Southern Water Use Caution Area (SWUCA) has been employed by the Southwest Florida Water Management District for over 20 years.

Policy Strategy 7

Enhance and Adapt the County's Seawall Ordinance

Policy/Action: Revisit minimum elevation requirements for tidal flood barriers as sea levels rise and prepare a revised seawall ordinance accounting for additional SLR and added adaptation.

Policy Details: The County would prepare an updated seawall ordinance to be implemented in approximately the year 2050 with requirements to upgrade seawalls from the current 5.0 feet NAVD to 7.0 feet NAVD or appropriate flood protection levels based on SLR trends and projections. The County should also explore an update of the current seawall ordinance to require construction in a manner that will accommodate the 7.0-foot NAVD adaptation.

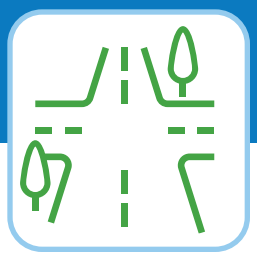
Benefits: The County would be prepared for the eventual increase in SLR to 3.3 feet or above. Analysis has demonstrated that increases in SLR to 3.3 feet would reduce the effectiveness of the 5.0-foot NAVD seawalls.

Funding (Other than County General Fund): None needed, except staff and consultant efforts to study and draft the ordinance and obtain approval.

Issues: Financing greater seawall heights would be shared by the private and public sector. Residents, businesses, and government would already be facing increasing costs from SLR and/or costs to build resilience. The County should explore financing solutions that provide benefits to all sectors.

Policy Strategy 8

Incorporate Resilience into Complete Streets Design Standards



Policy/Action: Incorporate resilience standards into complete streets projects and standard designs.

Policy Details: As the County works to implement Complete Streets that serve walkers, bicyclists, transit riders, motorists, and freight handlers in partnership with the MPO, FDOT, RPC, municipalities, and the private sector (see Broward County CAP 2020 Action 42), the County would encourage the incorporation of resilient design elements, such as bioswales, permeable paving, planted areas, street trees, lighter/ref ective paving, and shade structures through resilient complete streets design standards. The NACTO urban street design guide is a good starting reference.

Benefits: Incorporating food resilience into future County programs and projects is a potentially cost-effective way to achieve the County's goals.

Funding (Other than County General Fund): County and municipal stormwater funding and grants.

Issues: None.

Policy Strategy 9

Prioritize Resilient Growth Areas

Policy/Action: Conduct a study to identify and prioritize areas for development and redevelopment that align with the County's resilience objectives, promoting risk informed growth and community preparedness.

Policy Details: The County would identify Resilient Growth Priority Areas (RGPAs). These are areas of lower flood risk connected to the desired infrastructure and community services. The intent would be to encourage development in RGPAs (as opposed to other riskier locations).

The first step is a study to define the criteria, identify RGPAs, determine appropriate development/redevelopment strategies to encourage/incentivize growth in these areas, and coordinate their implementation with municipalities. The study should also include considerations and protections to abate potential climate gentrification outcomes, including the consideration of long-term housing affordability and the provision of support to low- and moderate-income communities (see 2020 CAP Action 16 and update).

Benefits: The County would be taking a proactive approach to land use development that supports a resilient county as its people and economy evolve over time.

Funding (Other than County General Fund): None needed, except for the study.

Issues: The County should carefully identify RGPAs, considering the impacts to property values, property rights, and future development.

Policy Strategy 10

Streamline Post-Disaster Redevelopment Planning and Processes

Policy/Action: Proactively plan for redevelopment following future disasters by streamlining recovery programs that assist residents in rebuilding or relocating, ensuring a more efficient and supportive recovery process.

Policy Details: The County identifies processes for streamlining Federal voluntary buyout programs and rebuilding programs that make it easier for residents to access these resources. Identify areas with repetitive flood losses where proactively offering voluntary buyouts and relocation support may provide a public benefit.

Benefits: The County would be taking a proactive approach to land use development that supports a resilient county as its people and economy evolve over time.

Funding (Other than County General Fund): Grants.

Issues: This is a policy that will need active attention over the long term.

Policy Strategy 11

Promote Resilient Home Construction and Retrofits

Policy/Action: Provide and/or advocate for tools, incentives, and other resources for homeowners to make resilience improvements to their properties.

Policy Details: Residents who implement resilient improvements to existing buildings could receive benefits or help from the County either in the form of monetary assistance and/or the provision of educational materials and resources.

For example, the County could provide low-interest or subsidized loans or grants, particularly to support retrofits for lower income homeowners or rental properties.

The County could maintain resilient design standards for residential structures or provide prototypical engineering design drawings for residential stormwater/ resilience improvements to assist property owners in negotiating with contractors. Examples might include drawings for a pool with retaining walls, seawalls, drainage, and pump system through or over the seawall.

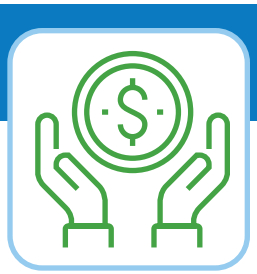
Benefits: Improved drainage and reduced flooding.

Funding (Other than County General Fund): Grants, Develop loan a program for residents.

Issues: Funding could be a challenge, but a local loan program could help homeowners make these changes at little cost to the County.

Policy Strategy 12

Mitigate Rising Insurance Costs



Policy/Action: Explore mechanisms to address rising homeowner and flood insurance costs.

Policy Details: As the County, municipalities, communities, and individuals invest in wind and flood risk-reduction measures, these should be reflected in flood and wind insurance premiums.

The County would work with regional, State, Federal, and private entities to ensure that the benefits of these risk-reduction measures are fully realized through reduced premiums. This may include continuing participation and further actions to improve the County's Community Rating System class as well as exploring emerging models of hazard insurance. It may also involve working with other coastal communities to lobby the Federal government to ensure that flood insurance premiums accurately reflect investments in risk reduction.

Benefits: Lowered property insurance premiums and increased property insurance coverage.

Funding (Other than County General Fund): None needed except for the professional staff effort.

Issues: Insurance markets can be complicated. The insurance markets in Broward County are part of larger market areas with competing insurance needs. However, the County should continue to advocate for its residents and businesses.

Policy Strategy 13

Implement Resilience Improvements at Public Facilities

Policy/Action: Implement resilience improvements to County facilities and encourage municipalities and other public entities to improve their facilities.

Policy Details: The County would incorporate stormwater retention/storage improvements, storm fortification, and shading/cooling features at County facilities.

The County would encourage/incentivize municipalities to increase storage at municipal sites, especially where benefits extend beyond municipal boundaries.

The County would provide design standards for use by the municipalities.

The County would identify opportunities to work with the Broward County School Board to address the repurposing of closed school properties and ways to use these properties to increase flood resilience.

Benefits: The County and its municipalities would provide positive examples to the community on the importance and benefits of resilience improvements that increase drainage and reduce flooding.

Funding (Other than County General Fund): Grants.

Issues: None.

Policy Strategy 14

Utilize Technology to Enhance Flood Protection

Policy/Action: Establish a framework to enable remote monitoring and control of newly adapted structures to facilitate timely adjustments to water level changes and provide effective management.

Policy Details: The County would establish a remote monitoring and control system for newly adapted structures to ensure real-time adjustments to water levels.

By integrating sensors and automated responses, the system will enable timely intervention to prevent flooding and reduce infrastructure damage. It will enhance storm resilience by allowing proactive water management before, during, and after storm events.

Overall, this framework will provide more effective and efficient management of water resources in storm-prone areas, creating transparency in the way water is managed in our community.

Benefits: This policy would enhance transparency in the way water is managed in the County and allow for immediate reaction to events that could cause localized damage.

Funding (Other than County General Fund): Public-private partnerships, grants.

Issues: None.

Policy Strategy 15

Establish Overlay Districts to Enhance Resilience

Policy/Action: Incentivize redevelopment in resilience overlay districts where additional requirements such as stormwater storage will reduce flooding and heat.

Policy Details: Overlay zones can be established to require additional regulations on top of the underlining zoning requirements. These can be a tool for establishing higher levels of protection or resilient design requirements in areas susceptible to coastal or other types of flooding. The County and municipalities would provide incentives to support redevelopment in these zones to of set the additional costs of building to higher standards and to encourage inf ll and growth that supports flood risk and heat reduction for neighbors.

Benefits: Providing a higher level of safety while still encouraging redevelopment.

Funding (Other than County General Fund): In addition to financial incentives, the County may be able to explore development bonuses that would not require General Funds.

Issues: Designing appropriate incentives may be challenging. Consistency of overlay districts and associated requirements across County and municipality zoning codes may be difficult to achieve and create confusion.

Policy Strategy 16

Develop Cleaning and Maintenance Program for Infrastructure

Policy/Action: Develop the skills, capacity, and requirements for the routine cleaning and maintenance of stormwater infrastructure.

Policy Details: Advancing and investing in new approaches to nature-based stormwater infrastructure require regular cleaning and maintenance to ensure functionality over the long term. A Cleaning and Maintenance Program could clarify and standardize what those maintenance requirements are, help to train workers in new skills to support that cleaning and maintenance, and coordinate across the county and its partners on resources, roles, and capacities to support consistent long-term maintenance of stormwater infrastructure.

Benefits: Opportunities for local workforce and businesses to develop new skills in nature-based stormwater infrastructure and benefit directly from the County's investments in resilience.

Funding (Other than County General Fund): Grants to support skill development. County and municipal stormwater funding to support long-term maintenance.

Issues: Grants that may fund infrastructure construction often do not fund its long term maintenance, and ensuring sufficient and consistent cleaning and maintenance funds is a challenge many local governments face. Additionally, the roles and responsibilities for maintaining stormwater infrastructure may not fit squarely in a single department or agency's existing mission or capacities. Navigating the governance questions of stormwater infrastructure maintenance requires significant coordination, in addition to the necessary skill development. A centralized program could support tackling some of these challenges.

Policy Strategy 17

Improve Resilient Development Requirements

Policy/Action: Incorporate requirements for compliance with the Resilience Plan into County and local land development codes.

Policy Details: The County, working with municipalities, could identify specific updates to development standards and requirements that could be incorporate into land development codes to ensure consistency and compliance with the data and actions in the Resilience Plan. This would include identifying where existing standards and requirements need to be updated to incorporate updated flood protection standards and where new codes should be considered, particularly to support continued implementation of other identified policies such as reducing pervious cover, increasing stormwater storage, reducing parking requirements, and promoting efficient and resilient land use.

Benefits: Consistency and alignment of plans and codes with the Resilience Plan ensures comprehensive and lasting implementation. Resilient development requirement support new growth and development that is safe and resilient.

Funding (Other than County General Fund): None needed, except for the policy study.

Issues: Buy-in among the development community and consistency with municipality land development codes could be a challenge and will require signif cant discussion and coordination.

Policy Strategy 18

Document Future Seawall Requirements Post-2070

Policy/Action: Provide information to the public now to prepare them for future modifications to the County's seawall ordinance.

Policy Details: The County would alert the public of the County's intent to increase the recommended height of seawalls so that individual residents can plan for their private seawall improvements ahead of the future requirement.

Benefits: This policy would enable residents who are preparing to redevelop their sites to consider what modif cations may be necessary in the future to attain the 7.0-foot NAVD seawalls. This may also encourage innovative product development to allow for adding flood barriers in lieu of concrete caps to 5.0-foot NAVD seawalls to achieve the 7.0-foot NAVD requirement. This policy is likely to reduce the cost of increasing seawall heights.

Funding (Other than County General Fund): Private.

Issues: The County would identify the types of information to be provided and begin an outreach program.

Policy Strategy 19

Designate Zone 1 as an Adaptation Action Area

Policy/Action: The County would adopt guidance and standards to ensure land use proposals and major redevelopment deliver optimized heat and flood mitigation benefits.

Policy Details: The County would establish Priority Zone 1 as an Adaptation Action Area within the County's land use plan, providing for an additional level or review for water storage and nature-based infrastructure requirements as part of land use decisions and surface water management licensing.

Benefits: This policy would enhance flood and heat mitigation investments in areas with the highest vulnerability.

Funding (Other than County General Fund): No funding required.

Issues: None.

IMPLEMENTATION

The Plan presents a comprehensive, phased strategy to address the County's vulnerability to climate change impacts. By dividing the county into specific geographic zones and implementing a two-tiered project approach, this plan provides a flexible and scalable blueprint for resilience that will evolve over time as new data and projections become available.

Spanning from 2025 to 2070, with strategic planning checkpoints embedded throughout the timeline, the plan's implementation will allow for periodic assessments and adjustments to ensure that adaptation measures remain effective and aligned with the latest climate projections. These checkpoints provide opportunities to review progress, incorporate emerging data, and refine strategies as necessary, ensuring that the plan continues to enhance flood protection, increase infrastructure durability, and enhance climate adaptability for the communities of Broward County.

Phased Project Tiers Details

The plan's implementation is organized into two main tiers of projects, each tailored to specific SLR projections and time frames. This phased approach allows the County to address immediate risks while preparing for more severe long-term conditions.

Tier 1 (Completion by 2050)

Tier 1 addresses urgent resilience needs to prepare the County for a 2-foot rise in sea level. Projects in this phase include:

- **Seawalls up to 5.0 feet NAVD**: Assumes seawall or equivalent tidal flood barriers will be implemented across Zones 1 and 2 to protect against current and future flood risks and losses driven by storm surge and tidal flooding.
- **Road Conversions, Pumping Stations, and Culvert Upgrades**: Two-way roads in selected residential areas are converted to one-way roads, increasing pervious surfaces to improve stormwater absorption. Additional pumping stations, improved crossings, and larger culverts will be added to strengthen the drainage system.
- **Storage Areas and Nature-based Infrastructure**: Investments are focused on creating dedicated storage areas and expanding pervious surfaces across all zones to improve foodwater retention, reduce runoff, and alleviate urban heat.
- **Control Elevation Adjustments**: Control elevations within the drainage system are adjusted to maintain positive head pressure against SLR, with the capacity to temporarily lower elevations during heavy rainfall events.

Tier 2 (Completion by 2070)

Tier 2 builds on Tier 1 measures, preparing the County for a more extreme 3.3-foot SLR. This tier enhances resilience by increasing the capacity and height of infrastructure to account for additional SLR and impacts. Primarily, this includes raising seawalls up to 7.0 feet NAVD. This will provide additional protection against anticipated SLR and higher storm surge.

- **Seawalls up to 7.0 feet NAVD**: In this phase, seawalls in Zones 1 and 2 will be raised to 7.0 feet NAVD, of ering additional protection against anticipated SLR and higher storm surges.

Geographic Implementation Zones

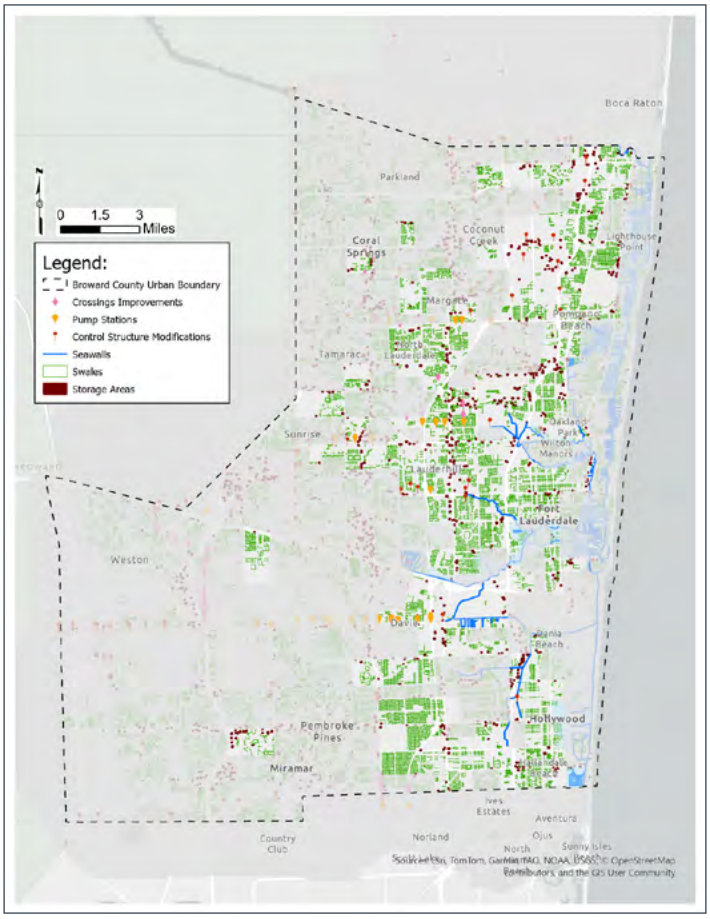
To ensure that adaptation measures are appropriately targeted, Broward County is divided into three geographic zones based on vulnerability and proximity to the coast. This zoning approach enables the County to deploy customized strategies to address the distinct resilience needs of each area.

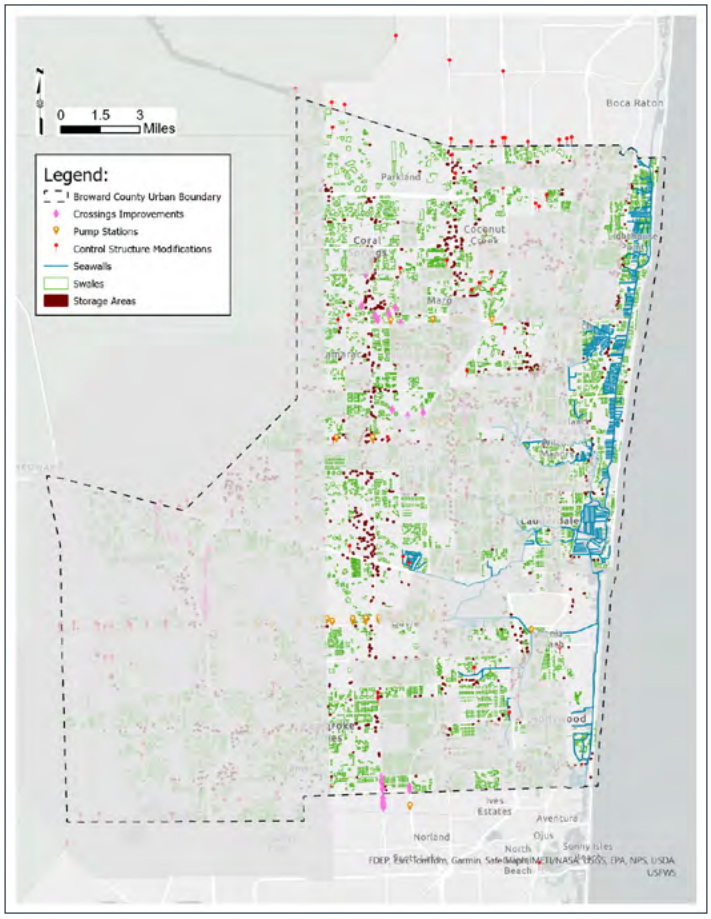
Zone 1: Central Areas

The vulnerable areas are characterized by overlapping challenges, including high flood risks, extreme heat impacts, and the presence of low- and moderate-income (LMI) communities.

Zone 2: Eastern Areas

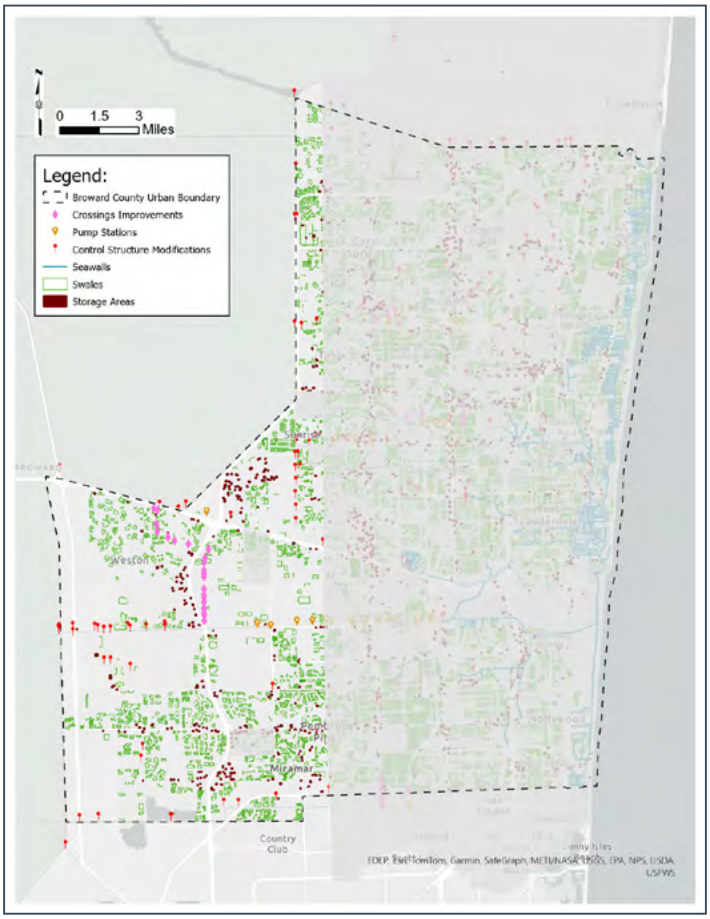
Eastern areas of the county are more influenced by SLR and storm surge.





Zone 3: Inland Areas

Western areas of the county have more inland characteristics.



Adaptable Implementation Framework

The phased implementation of the Resilience Plan is designed to be adaptable, allowing Broward County to adjust its strategies based on evolving climate data, observed changes, and new projections. Planning Checkpoints (PCP) are embedded in the timeline to review progress, update projections, and make any necessary adjustments to adaptation measures.

Planning checkpoints are recommended to occur every seven years, with a two-year period allocated for assessment and updates. Each PCP is advised to include the following:

Review of Climate Data and Projections

- Update SLR, rainfall intensity, and extreme weather projections.
- Reference Climate Change Compact projections.

Assessment of Project Performance

- Evaluate the effectiveness of completed projects.

Community and Stakeholder Feedback

- Conduct surveys, public meetings, and consultations to gather input from residents, businesses, and local stakeholders.
- Identify any new concerns or issues that may require adjustments to the plan.

Regulatory and Policy Updates

- Review local, State, and Federal regulations for any changes that may affect the Resilience Plan.
- Adjust strategies to remain compliant with the latest environmental and construction standards.

Funding Needs

- Project future funding needs and identify potential sources (grants, local funding, etc.) for upcoming projects.

Technology and Innovation Review

- Explore advancements in resilience technology (e.g., remote monitoring systems, flood sensors).

Adaptation Strategy Adjustments

- Reassess and adjust the scope of planned projects for the next cycle based on updated projections and feedback.
- Make necessary modifications to Tier 2 and future Tier 1 timelines.
- Timeline and Implementation Schedule Update.

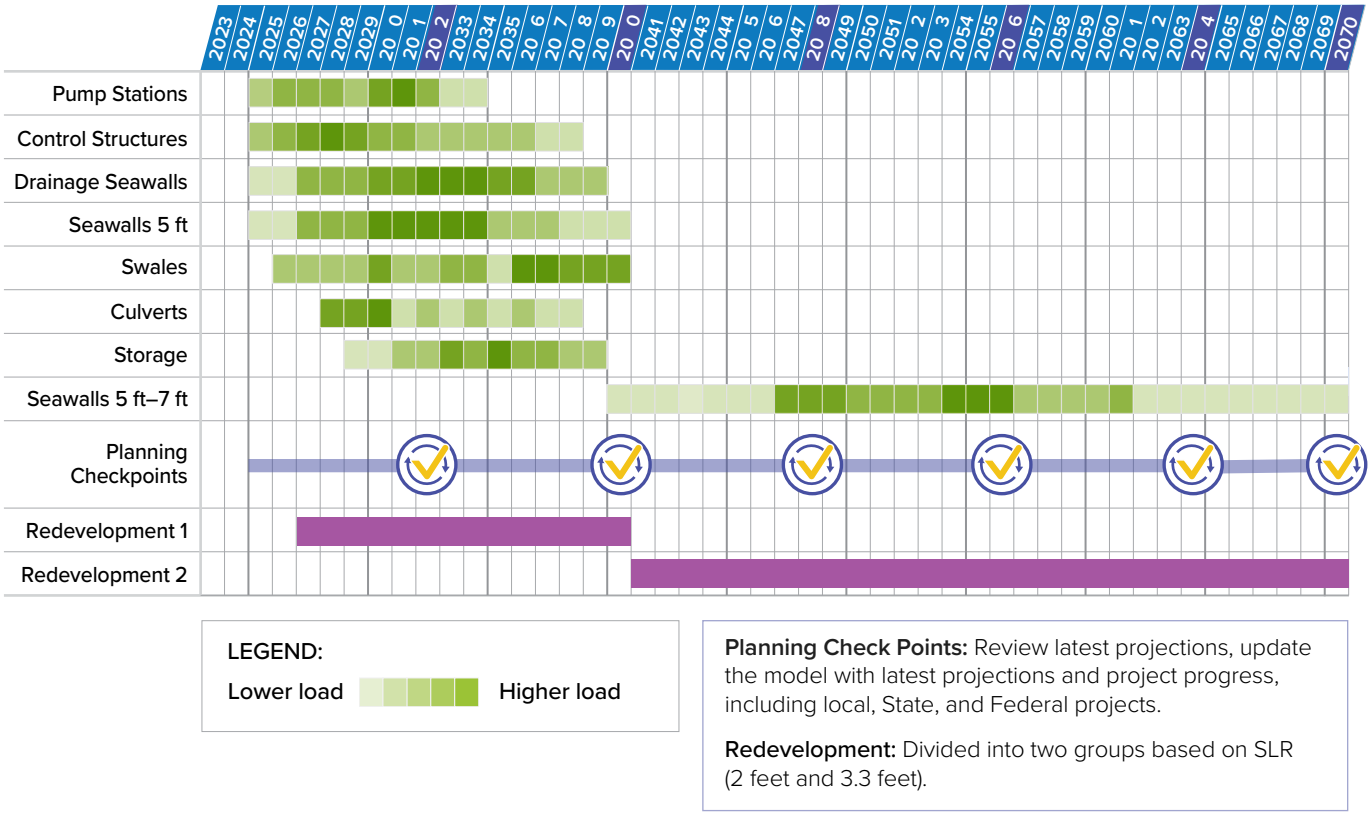
Documentation and Reporting

- Document the findings, updates, and decisions made during the checkpoint.

Timeline

The Implementation Plan timeline is structured to guide the phased deployment of adaptation strategies from 2025 through 2070. The actual timeline will vary based on the budget available and the employed funding mechanisms of the County, municipalities, and water management districts. Figure 7-1 summarizes the implementation plan.

Figure 7-1. Implementation Plan for Tier 1 and Tier 2 Investments



* The Implementation Plan is conf gured from 2025-2070. However, the Plan will not begin until approximately 2027.

Additionally, the timeline includes two Redevelopment Phases (Redevelopment 1 and Redevelopment 2) triggered by SLR benchmarks of 2 feet and 3.3 feet, respectively. These phases focus on redeveloping areas to accommodate higher sea levels, potentially through actions such as raising structures, implementing dry-proofing techniques, or creating sacrificial building levels.

Prioritization

The criteria for assigning start dates to projects as presented in the graphic are based on the geographic zones, project locations (relative to upstream or downstream of canals), and the severity of base flood scenarios. The phasing strategy begins with the previously established zones: Zone 1, representing the central areas; Zone 2, encompassing the coastal regions; and Zone 3, covering the western parts of the county.

To refine the prioritization within these zones, the severity of flooding across various scenarios was considered. Projects in the most severely impacted areas were scheduled for earlier phases. Additionally, projects were assigned a priority ranking from 1 to 4, aiding in the logical grouping of projects within each phase.

When sequencing projects, downstream effects were evaluated to ensure execution progressed from downstream to upstream (or east to west, minimizing the risk of unintended impacts during implementation.

Interventions across different strategies were synchronized to ensure cohesive execution. For example, seawall improvements and drainage enhancements behind seawalls were prioritized in areas where upstream pump stations were also recommended within the same drainage basin.

In actuality, projects will become prioritized by opportunities that exist with other ongoing infrastructure projects. While the Plan is conceived with this implementation strategy, the County recognizes that opportunistic ventures will reprioritize certain projects and funding limitations may push off other projects. However, the integrated planning approach ensures efficient and effective implementation of resilience measures.

Further, projects are being planned by each municipality presently under separate master planning efforts. These projects could be prioritized and budgeted in parallel with the Resilience Plan. The implementation of these projects should be tracked by the County against this baseline prioritization schedule.

Post-Implementation Redevelopment Options

Areas that remain vulnerable to flooding after the implementation of resilience strategies were identified. While the Resilience Plan was developed and analyzed at a high-level scale, a more detailed, smaller-scale analysis is necessary to address localized flood risks within specif c sub-basins. This granular approach ensures that Base Flood Elevations (BFEs) assigned to structures are accurately tailored to the unique conditions and vulnerabilities of each area.

The sub-basins used in the redevelopment analysis were developed using a GIS-based hydrological modeling approach. A custom GIS script was applied to delineate sub-basins of approximately 100 acres each, using Digital Elevation Models (DEMs combined with known stormwater features and canal alignments. To ensure the basins aligned with real-world property boundaries and infrastructure, the sub-basin perimeters were adjusted to snap to road alignments, preventing the division of parcels or structures. Following the initial delineation, a manual QA/QC process was conducted to validate the accuracy of the sub-basins and refine any irregularities.

Flagging of sub-basins was based on hydrological and structural vulnerability criteria. Structures within each sub-basin were evaluated under a 2-foot SLR scenario combined with a 20-year surge and 25-year storm event. Sub-basins were flagged if they contained clusters of structures with flood depths exceeding 6 inches and where more than 30% of the properties were affected. This methodology ensured that flagged sub-basins represented areas with significant flood risks, allowing for a focused approach to redevelopment and resilience measures. The BFE proposed for each basin will correspond to a 100-year storm with 2-foot SLR flood elevation rounded up to the nearest 1/2 foot.

To address flood-prone structures in flagged sub-basins, additional measures will be required to reduce future flood risks. The proposed strategies include:

1. Elevating Structures to Meet BFE Standards

For properties undergoing significant reconstruction or major retrofits, compliance with updated higher BFE standards developed using future conditions is required. Elevating structures to or above BFE significantly mitigates flood risk by placing occupied spaces and critical building components above anticipated flood levels. This approach aligns with FEMA's flood resilience recommendations, which emphasize elevation as a primary strategy for flood protection, especially in high-risk food zones.

Elevating a building requires structural modifications to raise the foundation to the specif ed elevation level. Techniques may vary based on the building type and foundation system but typically involve lifting the structure and installing new, flood-resistant foundation walls or piers. Incorporating a safety margin above the BFE, often referred to as "freeboard," provides additional protection against uncertainties in flood projections, such as unexpected storm surge or increased rainfall intensity. By elevating structures, Broward County can reduce flood insurance premiums for residents and ensure that buildings are resilient against future SLR scenarios.

2. Dry Floodproofing for Adaptation of Existing Structures

In cases where elevating a structure is not feasible, particularly for certain non-residential buildings or in densely built areas, dry floodproofing serves as a practical alternative. Dry floodproofing involves a series of measures designed to make a structure watertight, preventing floodwater from entering. FEMA's guidance for primary techniques and materials for dry floodproofing, includes:

- **Watertight Shields and Barriers**: Install barriers over openings, such as doors and windows, to prevent water from entering. These shields are typically designed to be easily deployed before a flood event and should be capable of withstanding the expected hydrostatic and hydrodynamic pressures.
- **Application of Sealants and Membranes**: Apply specialized waterproof coatings and sealants to exterior walls to prevent seepage. These coatings are particularly useful for protecting vulnerable areas at the ground level and can be combined with additional barriers at entry points.
- **Structural Reinforcements**: Reinforce walls and foundations to withstand lateral pressures exerted by floodwaters. This may include strengthening masonry or concrete walls and ensuring that any materials used are compatible with long-term water exposure.
- **Internal Drainage and Sump Pumps**: Incorporate sump pumps and internal drainage systems to manage any water that may infiltrate, as well as to relieve hydrostatic pressure on foundation walls. Backup power sources for pumps are recommended to ensure functionality during power outages associated with severe storms.

Dry floodproofing is primarily intended for non-residential structures due to the complexity of making residential properties fully watertight. However, it may be appropriate for some residential applications with shallow flooding risks and limited exposure duration, provided these measures meet local building code requirements. Regular inspection, maintenance, and testing of dry floodproofing systems are essential to ensure their reliability and effectiveness over time.

3. Voluntary Property Acquisition and Conversion for Stormwater Management

For properties with recurrent and severe flooding issues, where structural retrofits are neither feasible nor cost-effective, voluntary property acquisition is recommended. Should funding be made available for such applications, funds might be used to of er buyouts to property owners in high-risk areas, enabling them to relocate to safer locations. Once acquired, these properties are then repurposed for stormwater management or converted into open green spaces, effectively removing vulnerable structures from the floodplain and restoring the land to its natural flood-absorbing function.

The acquired land could be transformed into various forms of nature-based infrastructure, such as retention basins, wetlands, or open parks, which serve multiple functions. These areas not only absorb and slow stormwater runoff but also provide ecological and recreational benefits to the community. For example, retention basins can hold excess rainwater during heavy storms, reducing pressure on the drainage system and minimizing downstream flood risks.

4. Raising Roads

Although raising roads was not included in the Resilience Plan modeling, it remains a critical strategy to address flooding and future SLR. Elevating roads ensures vital transportation networks, such as evacuation routes and access to emergency services, remain functional.

Road elevation projects are suggested to meet future flood levels, incorporating freeboard for added protection. Advanced stormwater systems, including bioswales, retention basins, and upgraded culverts, may be integrated to manage runoff and prevent downstream impacts. In urban areas, pervious pavements could also be considered to improve water infiltration.

Efforts are recommended to prioritize coastal zones, major transportation corridors, and low-lying neighborhoods prone to flooding. Designs may include measures like berms and additional drainage to prevent impacts on adjacent properties, and projects could be phased to minimize disruptions.

Raising roads is an essential step to enhance flood resilience, protect infrastructure, and support long-term community safety in Broward County.

Swale and Stormwater System Maintenance

Proper maintenance of swales and stormwater systems is essential to ensure the long-term effectiveness of flood mitigation and water management efforts across Broward County. Swales and stormwater systems help control runoff, reduce localized flooding, and improve water quality by filtering pollutants. To maintain these benefits, each municipality within the county is required to comply with established maintenance protocols to ensure that these systems function as designed and contribute to overall community resilience.

Note: Legislation enacted in 2020 by the State of Florida and referred to as the "Clean Waterways Act" requires landowners to specify O&M plans and cost estimates by June 28, 2024. This is a requirement of the State intended to ensure stormwater systems are maintained to provide waterway protection at the level for which they were originally designed.

Swale Maintenance

Swales are shallow, vegetated channels that capture and absorb stormwater, allowing it to infiltrate into the ground. Regular maintenance of swales is critical to prevent blockages and ensure optimal infiltration rates. Each municipality is responsible for the following swale maintenance activities.

Vegetation Management

Regularly mow grass in swales to prevent overgrowth while maintaining enough vegetation to support water absorption and filtration. Remove invasive plants that can disrupt native vegetation and reduce the effectiveness of swales in filtering pollutants.

Sediment and Debris Removal

Clear accumulated sediment, leaves, and debris that may obstruct water f ow or reduce infiltration capacity. Sediment buildup can cause swales to overflow, leading to localized flooding. Inspect swales after major storm events to remove any debris that may have been carried into the system.

Slope and Erosion Control

Check for signs of erosion along the swale, particularly after heavy rainfall. Re-grade swales as necessary to maintain a consistent slope that promotes water flow and prevents pooling. Apply erosion control measures, such as re-vegetation or the installation of erosion control mats, where needed to stabilize the soil.

Inspection and Reporting

Conduct routine inspections to identify maintenance needs and document any issues. Municipalities should keep records of inspection dates, findings, and actions taken to maintain accountability and track the effectiveness of maintenance efforts.

Protection and Enhancement of Existing Swales

Incorporating new regulations to protect existing swales is essential to maintaining their functionality and effectiveness. This includes preventing the use of heavy machinery on swales during utility projects, as excessive compaction can significantly reduce their permeability and infiltration capacity. Additionally, rehabilitating existing swales by implementing improvements that enhance infiltration rates can further support stormwater management efforts. To ensure these enhancements are effective, infiltration rates should be tested and compared against assumed design conditions, allowing for adjustments and optimizations as needed.

Stormwater System Maintenance

Stormwater systems, including catch basins, pipes, and retention/detention ponds, are essential for managing large volumes of runoff. Proper maintenance ensures these systems continue to control flood risks and support water quality. Each municipality is required to conduct the following stormwater system maintenance activities:

Catch Basin and Inlet Cleaning

Regularly clean catch basins, grates, and inlets to remove debris, sediment, and litter that may clog the system and restrict water f ow. Schedule more frequent cleanings during the rainy season to prevent blockages and ensure the system operates at full capacity.

Pipe and Culvert Inspections

Inspect stormwater pipes and culverts for blockages, cracks, and sediment buildup that may reduce their efficiency. Clear any obstructions and repair damaged pipes as necessary. Use camera inspections periodically to identify potential issues within underground pipes and culverts that may not be visible from the surface.

Retention and Detention Pond Maintenance

Remove sediment, debris, and excessive vegetation from retention and detention ponds to maintain their storage capacity and filtration abilities. Monitor water levels and check for signs of bank erosion or structural damage. Repair any damage to pond banks or outflow structures to prevent flooding and erosion.

Pump Station Maintenance (where applicable)

For stormwater systems that rely on pumps to move water, perform regular maintenance checks to ensure they are operational, especially before and during the rainy season. Test backup power sources to confirm that pump stations can continue to function during power outages.

Monitoring and Record-Keeping

Each municipality must document maintenance activities, inspection results, and repairs performed on stormwater infrastructure. These records will help assess the effectiveness of the maintenance program and identify recurring issues that may need additional attention.

Nature-Based Solutions

Although nature-based solutions were not explicitly included in the Resilience Plan modeling, Broward County will continue to assess and implement specific nature-based solutions as part of its broader resilience strategy. These initiatives will be targeted to areas where they can provide the greatest impact, addressing flooding, heat, and ecological restoration needs.

Living Shorelines

In areas prone to coastal erosion and storm surge, such as along the Intracoastal Waterway and other low-lying coastal zones, living shorelines offer a nature-based alternative to traditional seawalls. By incorporating native vegetation, oyster reefs, and other natural materials, living shorelines can dissipate wave energy, stabilize shorelines, and provide critical habitats for marine and coastal species. Potential projects in Hollywood and Fort Lauderdale Beach, for example, could use mangrove replanting to reduce storm impacts while restoring ecological balance to these high-risk areas.

Wetland Restoration

Degraded wetlands, particularly in western parts of the county adjacent to the Everglades, represent an opportunity to expand the region's natural food mitigation capacity. Restoring these wetlands involves the removal of invasive species, re-establishment of native vegetation, and reconnection to natural water systems. These actions not only absorb stormwater and reduce flooding downstream but also enhance water quality and biodiversity. Future efforts could include partnerships with the South Florida Water Management District to restore wetland areas near regional retention basins, increasing the County's overall resilience to heavy rainfall and storm events.

Urban Tree Planting

Urban tree planting initiatives provide a targeted solution to the dual challenges of extreme heat and flooding, particularly in low- and moderate-income (LMI) communities with limited tree cover. Expanding tree canopies in neighborhoods where canopy is reduced such as Lauderhill, Pembroke Park, and parts of unincorporated Broward County can reduce heat exposure, improve air quality, and enhance the aesthetic quality of these communities. A structured urban tree canopy program, guided by heat vulnerability mapping, could focus on planting native, heat-resilient species in parks, rights-of-way, and public spaces. These efforts would not only address heat impacts but also contribute to stormwater management by increasing water infiltration and reducing runoff.

By integrating these nature-based approaches alongside the Resilience Plan's core strategies, Broward County can create a more sustainable and adaptive infrastructure. These projects provide multiple co-benefits, including ecological restoration, improved public health, and enhanced quality of life, ensuring that investments in resilience deliver long-term value for the county's residents and natural resources.

NATURE BASED INFRASTRUCTURE INCORPORATION

Nature-based Infrastructure Performance Targets

Nature-based infrastructure is a critical component for enhancing the County's resilience to climate change impacts, particularly increasing precipitation and increasing temperatures. Establishing clear performance targets for nature-based infrastructure within the Resilience Plan ensures that these systems effectively contribute to the County's overall resilience. Clear performance targets fare especially important, as the sizing and design to support flood mitigation and heat mitigation may differ from conventional stormwater sizing and design for water quality improvement.

Historically, nature-based implementation has focused on treatment and retention of approximately 1.25 inches of runoff from impervious surfaces, as this runoff volume is often the most polluted portion of annual runoff volumes. In the context of food reduction, this runoff depth represents less than 15% of the current 10-year, 72-hour design storm. Consequently, conventional implementation will have limited utility in managing runoff from a tributary impervious area to relieve flooding. Conventional implementation can have a key impact on food mitigation by managing incremental increases in rainfall associated with climate change.

The 20% projected increase in the 10-year, 72-hour design storm equates to a storm depth increase of approximately 2 inches, which is a storm depth that can be practically captured and retained using conventional designs. Conventional storm water practices are generally well suited for implementation as a retrofit due to the variety of available design configurations, distributed footprints, and their ability to be implemented incrementally. The combination of these characteristics allow for existing storm water facilities to be retrofitted within an area of existing development, mitigating the impacts of future precipitation increases and delaying or avoiding the need for upsizing or replacement of existing stormwater conveyance infrastructure. Additionally, retrofitting to manage a storm depth up to 2 inches can alleviate demands on existing drainage infrastructure with limited capacity.

Nature based solutions with a capacity to manage storm depths less than 2 inches provides incremental drainage relief, water quality benefits, and heat reduction, and thus should be encouraged and incentivized even if the 2-inch rainfall depth performance target cannot be achieved.

Drainage relief provided by nature-based solution can be enhanced by providing adaptations to conventional design, particularly through implementation of a controlled drainage mechanism. Bioretention, a common stormwater control, functions by capturing runoff from a tributary drainage area, temporarily holding that runoff within a shallow surface depression, infiltrating runoff through an engineered soil media, then infiltrating into the underlying soil (Figure 4-9). When the capacity of the surface depression and soil pore space is exceeded, runoff bypasses the stormwater control or is captured and discharged by an overfow structure. This configuration can be problematic to provide drainage relief, as the available storage capacity can quickly fill early in a storm and provide little storage capacity during the peak of a storm when it is needed most.

An underdrain is a common bioretention design component when underlying soils do not have sufficient infiltration capacity to drain bioretention within a reasonable timeframe after a storm event (typically 48 hours). An underdrain with an unrestricted capacity can create a flow-through system that provides water quality improvement but little benefit with regards to runoff volume or peak flow reductions. By incorporating a underdrain flow restriction, such as a cap on the underdrain pipe with a drilled orifice, the downstream release of flow can be tailored to maximize the use of storage capacity for a drainage design storm, such as the 10-year, 72-hour event. This design element also provides the adaptability for future conditions to adjust the retention and release of captured runoff under future storm conditions.

It is recommended that the County quantifies and tracks several key performance indicators (KPIs to understand the effectiveness of implemented nature-based solution. Tracking the volume of runoff can indicate the effectiveness of several different stormwater management efforts and help guide future planning. The reduction of a specific volume of runoff over a

certain period of time can quantify the performance of rain gardens, permeable pavements, green roofs, and others that has been implemented. A reduction of total impervious area will further influence this KPI by reducing the amount of surface runoff. Furthermore, the addition of runoff conveyance systems capable of rerouting large volumes of water to areas with more available storage should be tracked. These systems can be modified to best suit the environment of specif c communities. Large volumes of water can be routed to surrounding water systems, such as the ocean or rivers, or to designated water infrastructure, such as storage tanks or rain water harvesting systems. Another strategy to mitigate flooding is the restoration or creation of floodplains and wetlands that enhances natural floodwater absorption and storage while providing habitats for wildlife.

Nature-based infrastructure provides several other benefits that could be tracked and quantified. To understand the improvement in water quality, a standardized quantification practice should be established along with reduction goals for particular pollutants. Heat mitigation should also be tracked as a KPI. The percentage of urban tree canopy in a particular area will reflect sunlight away from surfaces that capture heat, provide shade, reduce urban heat islands, and improve air quality. Green roofs, while also reducing runoff volumes, provide reduced surface temperatures and support reductions in energy consumption tied to HVAC demands. The majority of the potential projects will create potential habitats for animals and support the growth of native plants, boosting biodiversity and the local ecosystem.

Tracking specific KPIs in quantitative and qualitative methods will be crucial in tracking the performance and effectives of the implemented solutions. Creating metrics that apply to all stormwater projects will enable the County to compare their various choices and select the solution that best suits their needs and environment.

The specific KPIs that the County will track are as follows:

Stormwater Management

- Volume of runoff absorbed over a period of time.
- Volume of runoff conveyed to an area with more available storage.
- Volume of runoff captured and stored for later use in rainwater harvesting systems.

Flood Mitigation

- Volume of storage made available per acreage of food plain restoration.
- Volume of water absorbed per acreage of created or restored wetlands.

Heat Mitigation

- Percentage of urban tree canopy in a particular area.
- Reduction of energy use in a building after green roof and/or wall installation.

Biodiversity and Habitat Enhancement

- Percentage of projects that create potential habitats for animals.
- Percentage of native plants used in each project.

Community Engagement and Education

- Track public participation in volunteer programs, workshops, and educational campaigns that involve nature-based efforts.
- Collect qualitative data, such as feedback from trainings of local government staff, developers, and residents.

Economic and Community Benefits

- Capital and maintenance cost of projects.
- Costs related to food damages as a result of infrastructure limitations after storms.
- Create models that simulate potential storm and food scenarios to ensure the community is protected.
- Assess community benef ts, such as increased green space, improved aesthetic value, and enhanced biodiversity.

EVALUATION OF COMMUNITY ECONOMIC STRATEGIES

Broward County requires a multifaceted approach that addresses the unique vulnerabilities and needs of different communities. The Plan recommends the following continued strategies:

Community Engagement

- **Participatory Planning**: Involve residents from all backgrounds in the planning process through public meetings, workshops, and surveys. This ensures that their voices are heard and their needs are addressed.
- **Education and Awareness**: Provide accessible information about climate risks and resilience strategies. Use multiple languages for all of our residents.

Affordable Housing and Relocation Assistance

- **Resilient Housing**: Promote the construction and retrofitting of affordable, resilient housing that can withstand extreme weather events.
- **Relocation Support**: Provide financial and logistical support for residents who need to relocate from high-risk areas. Ensure that relocation plans are voluntary and community-driven.

Health and Social Services

- **Heat Mitigation**: Establish cooling centers and distribute resources like fans and air-conditioning units to vulnerable populations during extreme heat events.
- **Emergency Preparedness**: Develop and disseminate emergency response plans tailored to the needs of the communities. Ensure that shelters and emergency services are accessible to all residents.

Economic Opportunities and Workforce Development

- **Job Training**: Offer training programs for resilience workforce development and resilience-related fields to create economic opportunities for residents.
- **Small Business Support**: Provide grants and low-interest loans to small businesses in vulnerable areas to help them implement resilience measures and recover from climate impacts.

POTENTIAL FUNDING STRATEGIES

Solutions for future growth, development, and resiliency begin with creating the means to finance these investments. Sufficient and diversified funding sources can be established using the support of multiple stakeholders and partnerships that, together, provide for feasible cost-sharing arrangements. The potential funding sources from within the county and outside the county are summarized as follows.

Many types of Federal and State funding programs are available to fund the County's Resilience Plan, depending on the nature of the investment. Since the amount of money available from these programs changes from year to year, these sources should be evaluated annually to identify opportunities and constraints. The following financial mechanisms are available as of 2024.

1. Federal Funding

Federal Emergency Management Agency (FEMA) Grants

FEMA offers Hazard Mitigation Assistance (HMA) grant programs designed to support communities as they build resilience against natural disasters. Grants are available for eligible mitigation activities that reduce disaster losses and protect life and property.

HMA programs consist of Building Resilient Infrastructure and Communities (BRIC), Flood Mitigation Assistance (FMA), and the Hazard Mitigation Assistance Program (HMGP). The BRIC and FMA programs of er funding through an annually solicited Notice of Funding Opportunity (NOFO) and the HMGP program is offered after a Presidentially Declared Disaster.

Pre-Disaster Mitigation (PDM) Grant Program

This program is funded at the request of a Member of Congress to approve a specif c amount of discretionary funding to a State or local government entity, or 501(c)(3) as provided for under "Congressionally Directed Spending" in the U.S. Senate and "Community Project Funding" in the U.S. House of Representatives.

Under this grant program, Federal funds are made available to State, local, Tribal, and Territorial governments to plan for and implement cost-effective measures designed to reduce the risk to individuals and property from future natural hazards.

The intent of this program is to reduce reliance on Federal funding from future disasters.

National Coastal Resilience Fund

This program is a partnership between the National Oceanic and Atmospheric Administration (NOAA) and the National Fish and Wildlife Foundation to enhance fish and wildlife habitat and protect coastal communities. In 2023, the Fund invested $189 million across 136 coastal resilience projects. The funding is to restore, increase, and strengthen natural infrastructure to protect communities and enhance habitats for f sh and wildlife.

Water Infrastructure Financing and Innovation Act (WIFIA)

The EPA manages this program and supports long-term strategies to create a more resilient water infrastructure to address the increasing impacts of extreme weather and help communities address water quantity and quality concerns. Eligible projects include those that address sustained or intermittent increases in water flow, such as projects that address flood risks due to stormwater, and septic to sewer efforts where septic systems are undermined by rising groundwater.

The WIFIA program works in tandem with State Revolving Fund loan programs, community revenue, and/or bond proceeds to fund 51% of total project costs. The interest rate for a WIFIA loan is set at the U.S. Treasury's rate for securities of a similar maturity on the date of loan closing. These rates are lower than private financing options. Loan repayment can be deferred up to five years after the project has been completed. In 2024, $6.5 billion was made available through WIFIA for long-term, low-cost financing.

Clean Water Act (CWA) Section 319(h) Funding

The CWA supports a variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects and monitoring to assess the success of specific nonpoint source pollution reduction and elimination projects. In Florida, this program is managed by the Florida Department of Environmental Protection (FDEP). Section 319 (h) specifically authorizes the EPA to award grants to states with approved Nonpoint Source Assessment Reports and Nonpoint Source Management Programs. The funds are used to

implement programs and projects designed to reduce nonpoint source pollution as identified in the State's Non-Point Source Management Plan (NPSMP).

Coastal Program

The U.S. Fish and Wildlife Service Coastal Program provides funding for habitat improvement projects. Eligible projects increase coastal resiliency by improving the ability of coastal ecosystems to adapt to environmental changes and by supporting natural and nature-based infrastructure projects to protect and enhance coastal habitats.

Disaster Supplemental Funding

The U.S. Economic Development Administration (EDA) solicits applications under the authority of its Economic Adjustment Assistance (EAA) program. The EAA program is intended to be flexible and responsive to the economic development needs and priorities of local and regional stakeholders, including those seeking assistance recovering from Federally declared disasters. EAA funds can be awarded to assist a wide variety of activities related to disaster recovery, including strategic planning grants, and public works construction assistance.

Public Works and Economic Adjustment Assistance Programs

EDA's Public Works Program funds the construction, expansion, or upgrade of public infrastructure and facilities. The Economic Adjustment Assistance program funds projects, such as long-term disaster recovery and resiliency plans and upgrades that make infrastructure more resilient, that address diverse economic development needs, and prioritize local and regional stakeholders.

2. State Funding

Resilient Florida Grant Program (RFGP)

This State program offers Planning grants and Implementation grants. The Planning grants are used to develop a vulnerability assessment (VA) that addresses SLR concerns for critical infrastructure assets. The Implementation grants are provided to assist communities with the construction and upgrade of the projects identified in the approved VA documents.

Clean Water State Revolving Fund Loan Program (CWSRF)

The CWSRF program, managed by the FDEP, provides low-interest loans to entities for the implementation of stormwater-related projects. The CWSRF fund provides up to $20 million per community issued on a quarterly basis at priority list meetings held beginning in August. The loans issued by the State have a 20-year term and are offered at very low to zero percent interest rates.

State Water-quality Assistance Grant (SWAG)

Funding for this program is offered through the FDEP's NPSMP. Funding is available for projects that implement green stormwater infrastructure projects.

Funding Opportunities in Broward County

Broward County will need to acquire internal funding sources that rely on residents and businesses to contribute to the cost of the County's Resilience Plan. They are the primary beneficiaries of the Plan and so their contributions are economically justified. The following financial mechanisms are available.

3. Community-Based Funding

County Sales Surtax

The County could seek State and voter approval of a surtax to be applied to the sale of taxable goods in the county. The surtax could be a partial penny sales tax (half-cent per dollar of sales) or a full penny sales tax, as desired. The proceeds would be used to finance some or all of the County's resilient investments.

County Ad Valorem Tax

The County could raise the millage rate of taxable property to generate the money needed to finance some or all of the County's resilient investments.

Stormwater Utility Fees

Stormwater utility fees are charged to property owners to fund the construction, maintenance, and operation of stormwater infrastructure, including treatment and flood prevention projects. They are usually based on the square footage of impervious surfaces such as roofs, driveways, and parking lots. They can be collected using the monthly water bill or using the non-ad valorem assessment on the property tax bill.

Revenue Bonds

A revenue bond is a category of municipal bond secured with the revenue generated from a specif c

project or service. Bond financing terms are typically issued at a 40-year repayment period at current market interest rates.

General Obligation Bonds (GO Bond)

A GO bond is a type of municipal bond backed entirely by the issuer's creditworthiness and ability to levy taxes. GO bonds are not backed by collateral. However, the local government may need to pledge that property taxes would be levied to meet the local government's obligation to the bondholders.

4. Regional Collaboration

Regional collaboration, including the creation of public-private partnerships and continued participation in the Southeast Florida Regional Climate Change Compact, should be encouraged because all residents and businesses in southeast Florida will be adversely affected by climate change. Efforts should focus on cost-efficient design of resiliency investments and sharing of their costs. Public-private partnerships are based on creating a win-win situation between the public and the private entity and the specific projects and agreements should be identified on a case-by-case basis as opportunities arise.

Other areas of collaboration include the County working with insurance companies to develop premium reduction programs to property owners who implement resilience measures. This can provide incentives for residents and businesses to invest in adaptation.

A Note on Broward County's Transportation and Infrastructure Surtax

Broward County funds projects through a transportation surtax, which was approved by voters in November 2018. Here's a breakdown of how the process works:

1. **Revenue Collection**
   The surtax is a one-cent sales tax added to purchases within Broward County. This generates significant revenue dedicated to transportation and infrastructure projects.
2. **Project Identification and Prioritization**
   Municipalities within Broward County can propose projects for funding. These projects are reviewed and prioritized by the Broward Metropolitan Planning Organization (MPO) based on their ability to alleviate traffic congestion and enhance connectivity.
3. **Funding Allocation**
   Once projects are prioritized, the available surtax revenues are allocated annually to fund these projects. The allocation process is governed by an Interlocal Agreement among the County, MPO, and municipalities.
4. **Project Management and Monitoring** Approved projects are managed and monitored through the Surtax Performance Measurement System. This system ensures transparency and accountability by tracking project progress, documentation, and reporting.
5. **Grant Application Process**
   Municipalities can apply for surtax grants through a structured application process. This includes identifying the need, coordinating with roadway owners, and submitting detailed project proposals.
6. **Public Involvement and Transparency**
   Broward County maintains a high level of transparency by providing public access to information about surtax-funded projects. This includes an online portal where residents can view project details and progress.

These steps ensure that the surtax funds are used ef ectively to improve transportation infrastructure and enhance the overall resilience of the County.

FINANCE PLAN

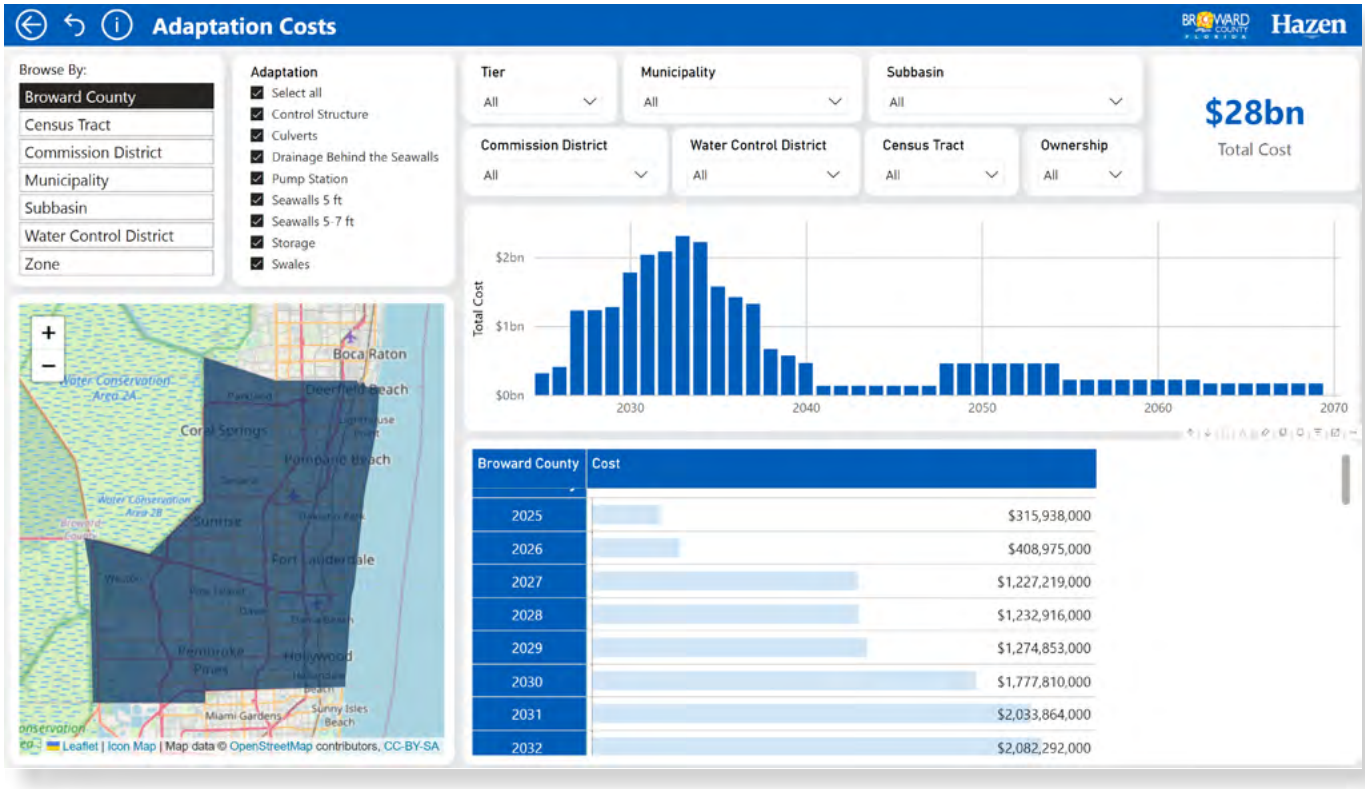
The economic feasibility analysis demonstrated that the present value benefits of the County's Resilience Plan is greater than the present value of its costs. The benefits included were avoided property damage, avoided reductions in economic activity within the county, and avoided reductions in property values. These benefits would be realized by residents and businesses throughout the county and there would be additional benefits whose monetary values were not estimated during this study,

In addition, the State of Florida and the Federal government benefit from the avoided property damage and increased economic activity provided by the Resilience Plan so that its political and economic power can be sustained and even improved. Private entities may benefit from projects included in the implementation plan and might desire to partner with the County or its municipalities to share the costs.

Several potential funding sources could support the Resilience Plan investments. They fall into the categories of Federal funding, State funding, community-based funding, and regional collaboration as was discussed in the previous section. A mix of these sources will likely provide continued funding. Care should be taken to ensure that the Resilience Plan is sufficiently funded throughout the 45-year investment period to achieve the intended outcomes.

It is anticipated that the County will work with the municipalities, the neighboring counties, and the State and Federal governments as well as the private sector to identify sufficient funding sources that would comprise the finance plan.

During development of the Resilience Plan, the costs were developed for each adaptation using Power BI. This tool allows the user to browse by City, commission district, water control district, census tract, or sub-basin.



CAPITAL PLANNING CHECKLIST

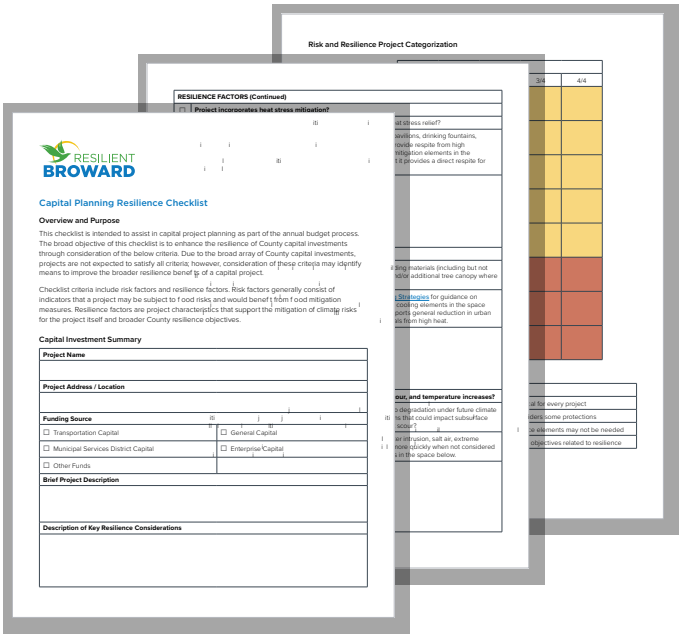
Broward County developed the capital planning resiliency checklist to facilitate consideration of resiliency across all County capital projects as part of the annual budget process. Due to the broad array of County capital investments, it is understood that not all of the criteria in the checklist may be relevant or necessary. However, understanding climate risks and resiliency opportunities across as many projects as possible is expected to support broader County goals.

The checklist criteria include risk factors and resilience factors. Risk factors are indicators that a project may be subject to flood risks and would benefit from flood mitigation measures. Resilience factors are project characteristics that support the mitigation of climate risks for the project itself along with broader County resilience objectives. Each factor includes a space to denote whether the factor applies to a capital project, a description of the criteria, additional guidance on the reason for the criteria and how it may apply, and an opportunity to provide additional notes or context. These notes are expected to be brief and provide an opportunity to explain risks or resilience considerations beyond what a simply yes/no designation would allow.

The number of applicable risk and resilience factors is tabulated for each project and classified as one of the project categories in Table 7-1 accordingly. County capital projects have diverse characteristics, and it is understood why some risks may be unavoidable and resilience measures not practical or needed. However, this checklist is intended to facilitate consideration of resilience where appropriate.

Table 7-1. Summary of Capital Checklist Project Categorization

Project Categorization	Category Description
Low Risk, High Resilience	Generally preferred but may not be practical for every project.
High Risk, High Resilience	Risk may be unavoidable but project considers some protections.
Low Risk, Low Resilience	Limited resilience contribution but resilience elements may not be needed.
High Risk, Low Resilience	Project may not support long-term County objectives related to resilience.



ACHIEVING RISK RESILIENCE

The Resilience Plan is designed to provide the foundation for a basin-level, multi-decade resilient infrastructure and adaptation plan for Broward County. The Plan includes recommendations for increased water storage throughout the county, nature-based and gray infrastructure improvements, and long-term increases to current seawall heights. The Plan assumes that SLR will gradually increase, following the trend of
the Compact's Regionally Unified Sea Level Rise Projection but recognizing that exact prediction is not possible. Hence, the Plan recommends implementing improvements on a strategic basis, with adaptations complementing each other and building upon previous improvements. The Plan is intended to be dynamic, with technological improvements incorporated within future investment strategies.

The Plan is anticipated to be implemented in parallel with improvements to the C&SF Flood Control Project Primary System by the USACE and SFWMD. Additionally, each municipality could then consider implementing, in parallel, improvements to its stormwater management capital infrastructure to address localized and frequent flooding.

Through implementation of the Resilience Plan, the coordinated improvements by the SFWMD, the municipalities, and the water control districts, Broward County will be more resilient towards the inevitable climatological changes in the region. Taking collective, comprehensive action now ensures that the County is protected as much as possible from the future risks of climate change and the potential damage to the local economy. The Resilience Plan investments are proven by the calculated benef ts to be worthwhile. The County will work to ensure that the investments are properly prioritized to achieve the highest possible benef ts.

References

Bean, E., Jarrett, L., Searcy, J.K., & Szoka, M. (2019). *Low-Impact Development & Green Infrastructure: Pollution Reduction Guidance for Water Quality in Southeast Florida*.

Bradt et al., 2021, "Voluntary purchases and adverse selection in the market for f ood insurance" Accessible at: https://www.sciencedirect.com/science/article/abs/pii/S0095069621000826.

Broward County Resilience Unit. (2022, July 22). *Beat the Heat Broward*. Retrieved from Beat the Heat Broward: https://storymaps.arcgis.com/stories/9b7ef2cf5f2d4580bc6d16edb200a7a5

Broward County. (n.d.). *A Shared Approach for a Changing Climate*. Retrieved from https://experience.arcgis.com/experience/97beefc5b5134750b42e26de5daf17a8/page/Broward's-Approach/

Dingel and Neiman (2020). How many jobs can be done at home? Available at: https://www.sciencedirect.com/science/article/pii/S0047272720300992

Esri (2023) Data in Business Analyst. Accessed at: https://doc.arcgis.com/en/business-analyst/web/data.htm

Federal Emergency Management Agency (FEMA). (2021). *Requirements for the Design and Certification of Dry Floodproofed Non-Residential and Mixed-Use Buildings*. NFIP Technical Bulletin 3. Washington, DC: FEMA.

Hallegate (2008) An adaptive regional input-output model and its application to the assessment of the economic cost of Katrina. Available at: https://pubmed.ncbi.nlm.nih.gov/18643833/

Hallegatte (2014) Modeling the Role of Inventories and Heterogeneity in the Assessment of the Economic Costs of Natural Disasters. Available at: https://onlinelibrary.wiley.com/doi/10.1111/risa.12090

Hino and Burke (2021) The ef ect of information about climate risk on property values. Available at: https://www.pnas.org/doi/full/10.1073/pnas.2003374118

Jerch et al. (2022), "Local Public Finance Dynamics and Hurricane Shocks." Accessible at: https://www.nber.org/papers/w28050

McKinsey Global Institute (2020), "Will Mortgages Stay Afloat in Florida?" Accessible at: https://www.mckinsey.com/capabilities/sustainability/our-insights/will-mortgages-and-markets-stay-afloat-in-florida

Masson, V., Bonhomme, M., Salagnac, J.-L., Briottet, X., & Lemonsu, A. (2014, 06 04). *Solar panels reduce both global warming and urban heat island*. Retrieved from frontiers: https://www.frontiersin.org/articles/10.3389/fenvs.2014.00014/full#:~:text=It%20is%20shown%20that%20solar,to%200.3%20K%20at%20night

NOAA (2022), Billion-dollar disasters. Accessible at: https://www.ncei.noaa.gov/access/billions/

NYC Department of City Planning. (2013). *Designing for Flood Risk*.

Painter (2020), "The ef ects of climate change on municipal bonds." Accessible at: https://econpapers.repec.org/article/eeejfinec/v_3a135_3ay_3a2020_3ai_3a2_3ap_3a468-482.htm

SAMHSA (2017). Disaster Technical Assistance Center Supplemental Research Bulletin Greater Impact: How Disasters Af ect People of Low Socioeconomic Status. Available at: https://www.samhsa.gov/sites/default/files/dtac/srb-low-ses_2.pdf

Urban Land Institute (2020) The Business Case for Resilience in Southeast Florida: Regional Benef ts of Climate Adaptation, Washington, D.C., Urban Land Institute, 2020. Available at: https://southeastfloridaclimatecompact.org/wp-content/uploads/2020/10/The-Business-Case-for-Resilience-in-Southeast-Florida_reduced.pdf

Wade et al (2022), “Few Florida Homes Hit by Hurricane Ian Are Covered for Floods.” Accessible at: https://www.bloomberg.com/news/articles/2022-10-01/few-florida-homes-hit-by-hurricane-ian-are-covered-for-floods#xj4y7vzkg

Wright (2017), Jobs numbers feel the ef ects of hurricanes Harvey and Irma. Accessible at: https://www.brookings.edu/blog/jobs/2017/10/06/jobs-numbers-feel-the-effects-of-hurricanes-harvey-and-irma/