RESILIENT BROWARD

COUNTYWIDE
# RESILIENCE PLAN 2025

MARCH 2025

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*

# Contents



BROWARD COUNTY FLORIDA

Hazen

## Letter from the
# Mayor

> “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.”

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 defined 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 reflects our unwavering commitment to proactive solutions. It outlines the risks our community faces if we do not act to mitigate the increasing threats of flooding 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 significantly 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 staff 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,

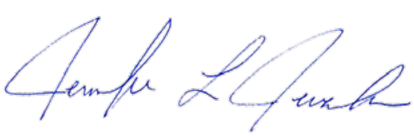
It is with great pleasure that we present the results and recommendations of a substantial multi-year effort with publication of this countywide Resilience Plan. This initiative was launched in response to a collective call by our local government and business leadership to develop a formal strategy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

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 Division, March 2025.

Hazen and Sawyer
4000 Hollywood Boulevard, Suite 750N
Hollywood, FL 33021

# 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 |
| **SVI** | Social Vulnerability Index |
| **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.

**Compact:** The Southeast Florida Regional Climate Change Compact, established in 2009, is a partnership between Broward, Miami-Dade, Monroe, and Palm Beach Counties to work collaboratively to reduce regional greenhouse gas emissions, implement adaptation strategies, and build climate resilience across the Southeast Florida region.

**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.

**High Vulnerability Census Tract:** Vulnerability data were obtained from the US Center for Disease Control's Social Vulnerability Index (CDC's SVI) dataset at the census tract level. High-vulnerability tracts were identified as those in the top quartile for a given vulnerability metric (e.g., elderly, disabled, housing burdened population) across Broward County.

**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, equitable, 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).

**Social Vulnerability Index:** The Social Vulnerability Index (SVI) consolidates information on 16 vulnerability indicators in CDC/ATSDR's SVI database at the census track level, covering four key dimensions of vulnerability: socioeconomic status, household characteristics, racial and ethnic minority status, and housing type/transportation.

**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.

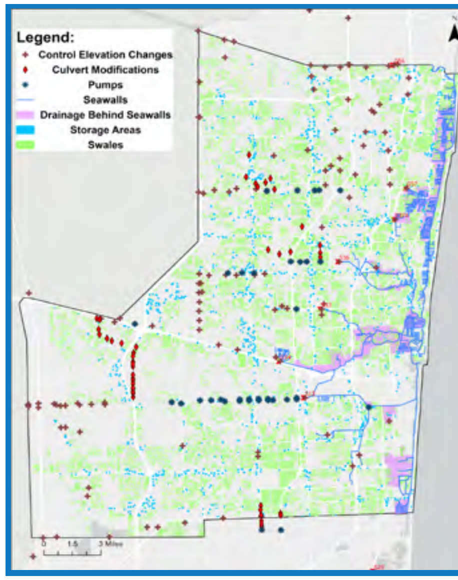
**Vulnerability:** The susceptibility of a community, infrastructure, or ecosystem to the impacts of flooding, including its capacity to cope with and recover from the event.

# 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 significant risk. As one of the most climate-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 flooding, 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, sustainable future.



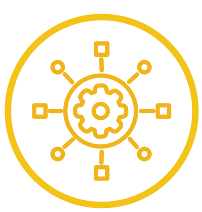

Solutions have been tailored to meet the needs of **THE COUNTY'S THREE UNIQUE ZONES:**

- Highly Vulnerable 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 sustainable 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. Collaboration with stakeholders and active community engagement ensure strategies are inclusive, equitable, and effective.

### 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 identified 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 green 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.

**Green 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 and sustainability.

# 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 | $109 Million | $211 Million | $12 Billion | $8 Billion |
| TIER 2 | $3.6 Billion | $660 Million | $962 Million | $20 Billion | $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 sustainable 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 sustainable 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, Deerfield Beach, Pompano Beach, Lauderdale-By-The-Sea, Fort Lauderdale, Dania Beach, Hollywood, and Hallandale Beach. Each of these beaches has its own distinct character, offering a variety of recreational activities, from sunbathing and swimming to boating and fishing.

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 diverse 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 effects 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 sustainable 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 flooding. 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 sustainable 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 diverse 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, green 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 (the "Compact") 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 sustainable and 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 sustainable 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 and carbon sequestration. This benefits the environment and supports recreational activities and tourism.

**Community Cohesion and Equity.** Engaging diverse community stakeholders in the resilience planning process ensures that adaptations are inclusive and equitable. This 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 magnified 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.

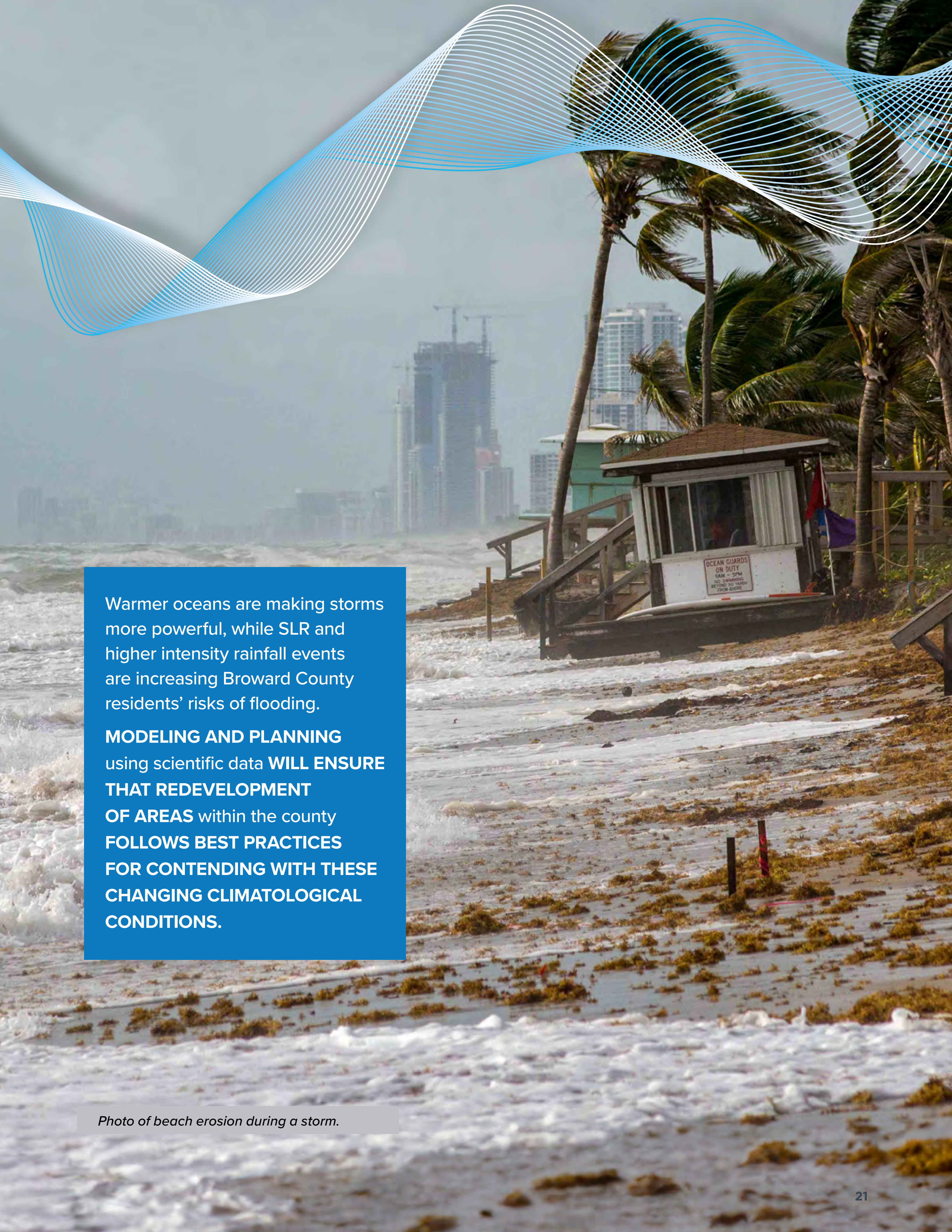
**REDUCED NUMBER OF RESIDENTS**
If the risk of flooding is not minimized, residents might choose to reside elsewhere.

**INEQUITABLE HARM BASED ON SOCIOECONOMIC STATUS**
Homeowners that do not have resources to redesign and rebuild their homes are at a disadvantage unless the community can assist with minimizing the risk of flooding.

**INCREASE IN HOME INSURANCE PREMIUMS**
Without community adaptations, home insurance premiums could significantly 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 flood-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 greenhouse gas emissions, 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

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.**

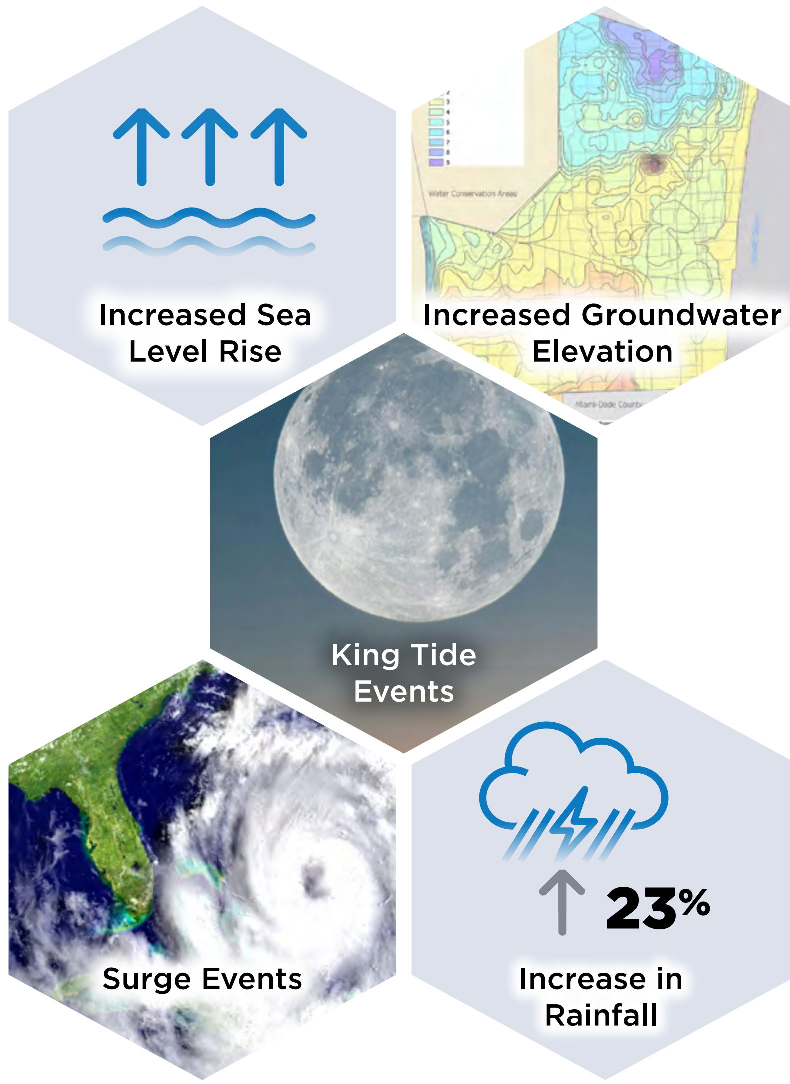
*Photo of King Tides along a canal in Fort Lauderdale.*

## 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.

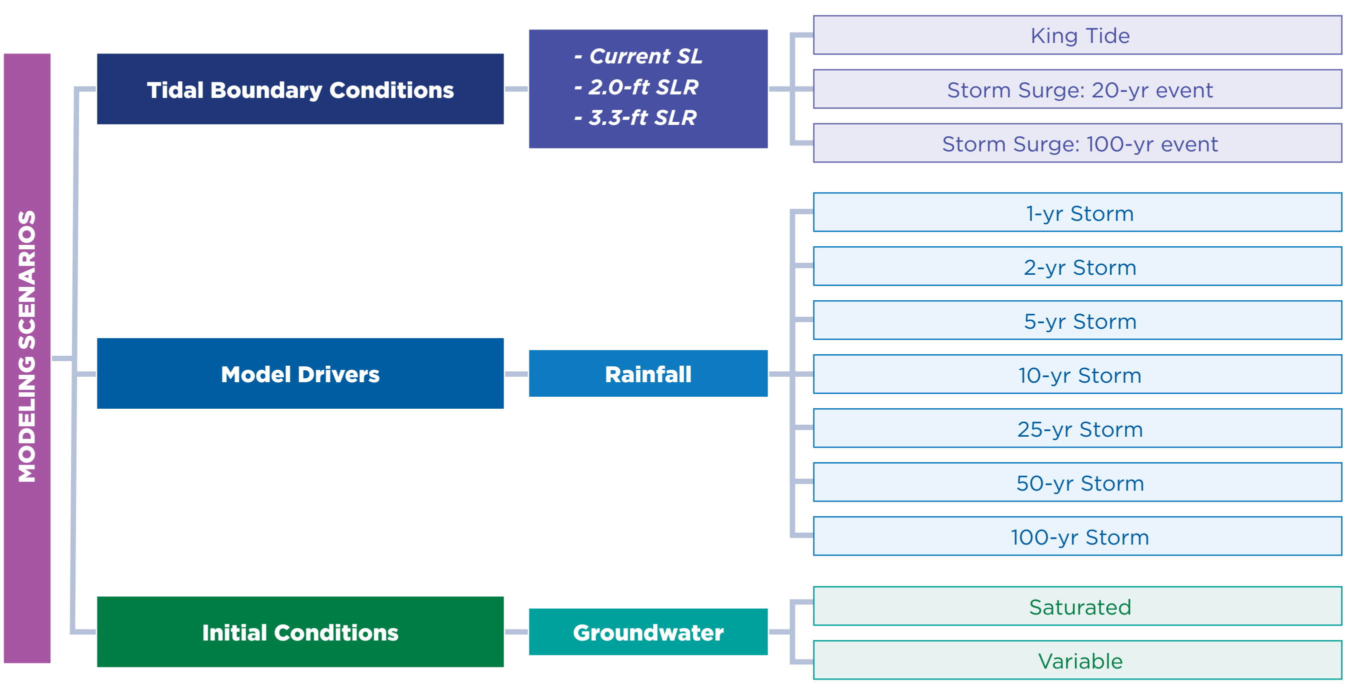
The adaptations developed under the Resilience Plan were determined through detailed H&H modeling. The Resilience Plan Model was built upon the most recent version of the H&H model:

- 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 (flood maps) 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. Appendix C lists the scenarios used to develop the Resilience Plan.

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 specified SLR values of 2 feet for 2040 and 3.3 feet for 2070 were applied across the Resilience Plan scenarios.

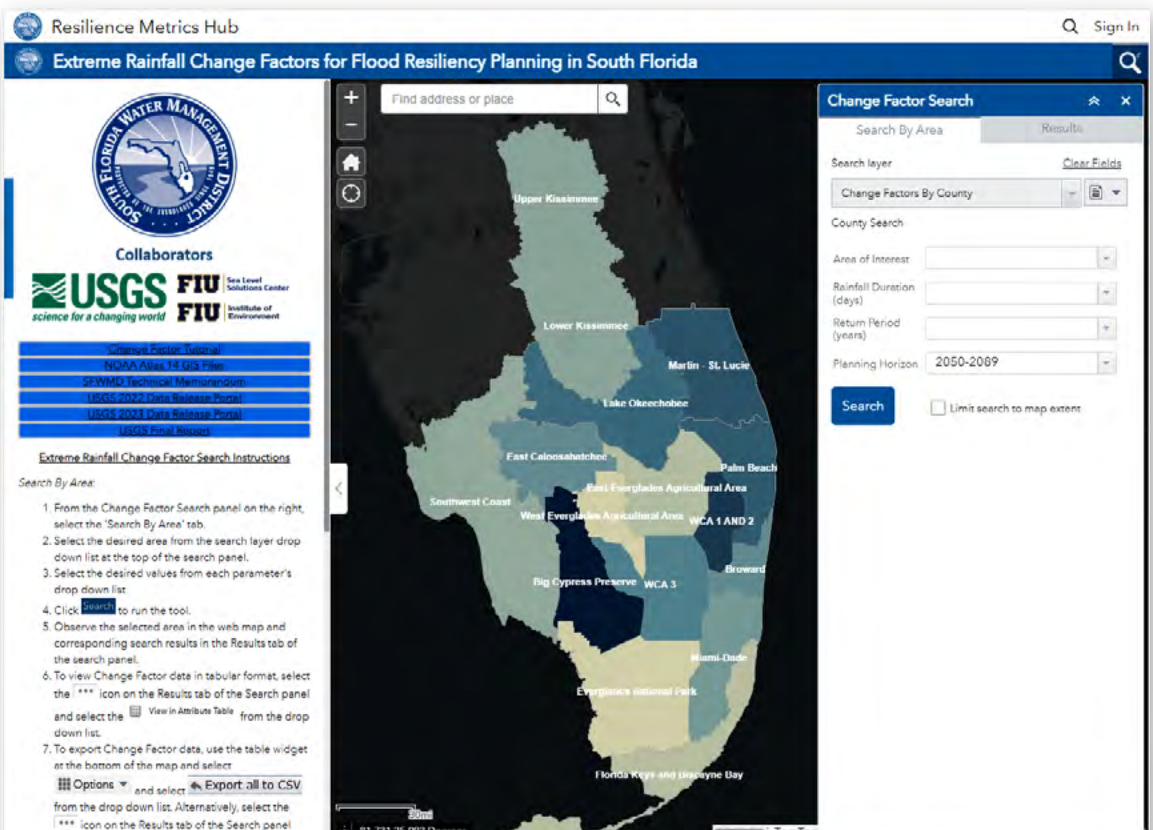
## Tidal Surge

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

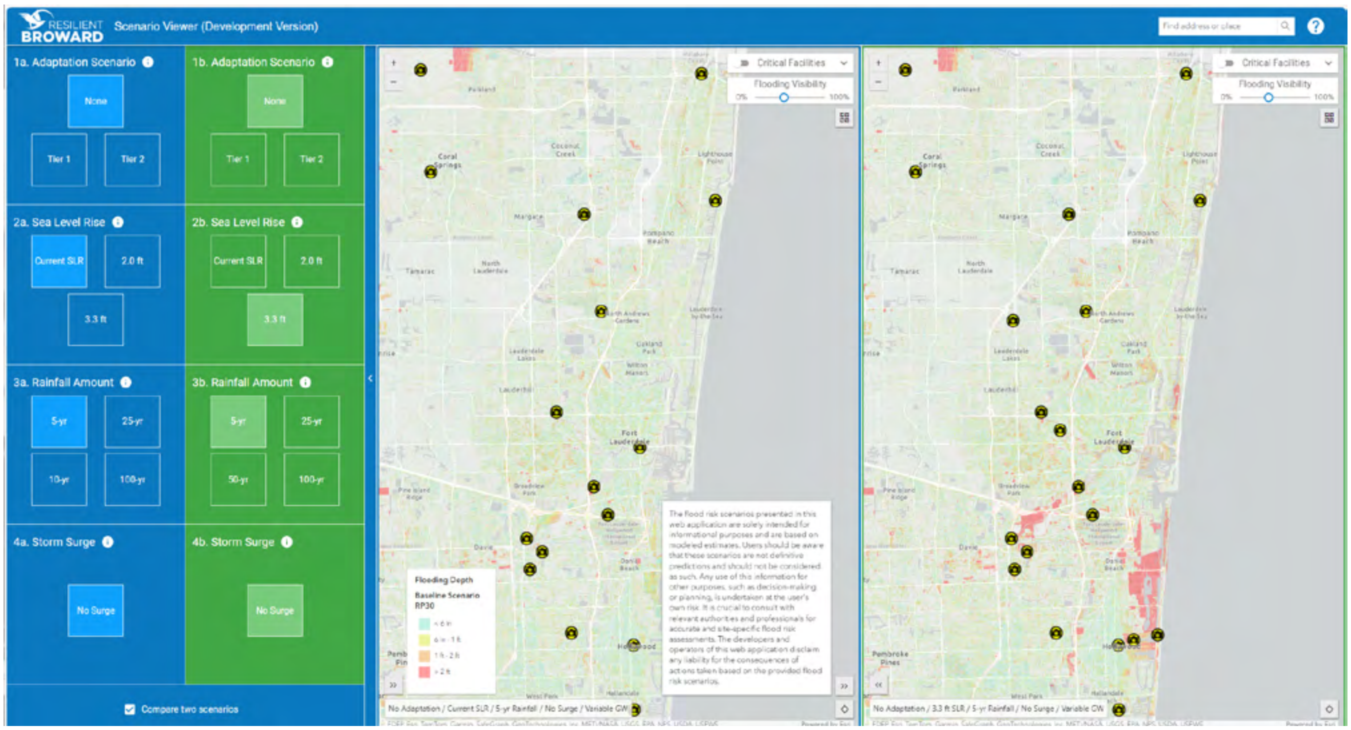


## Model Results

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 flood renderings to create an immersive visualization of potential flood 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)

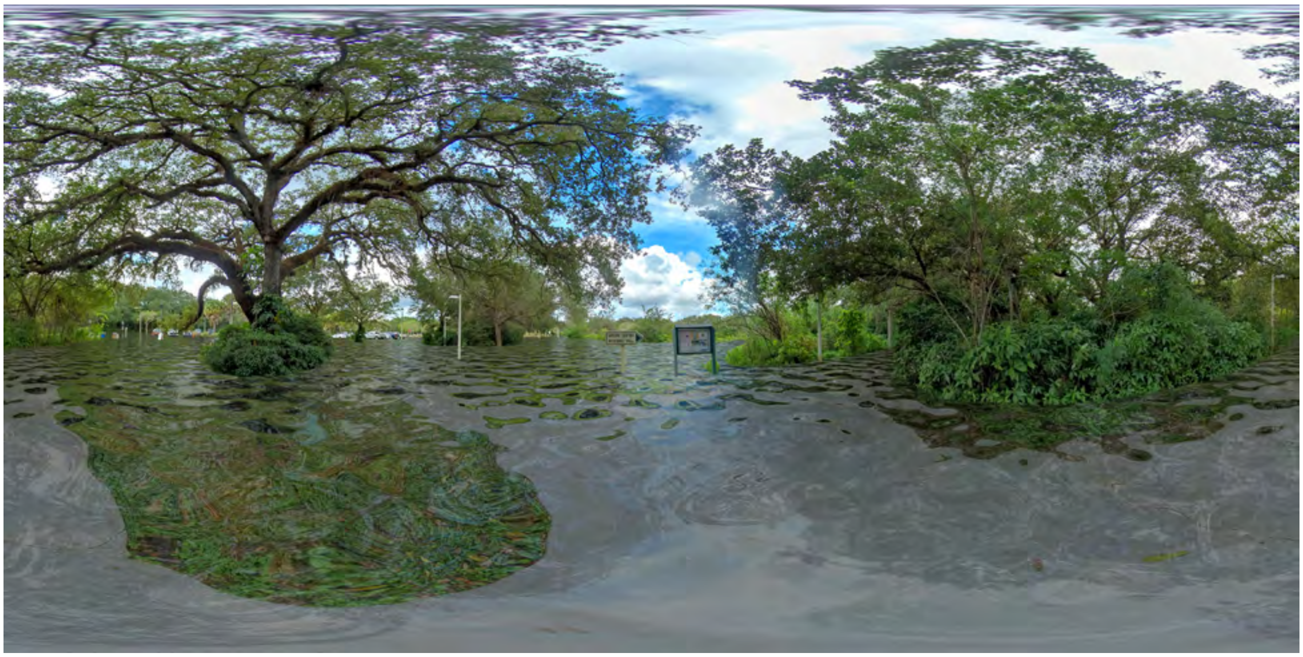


**Figure 3-6.** Memorial Regional Hospital (360-Degree Photo with Flood Renderings)

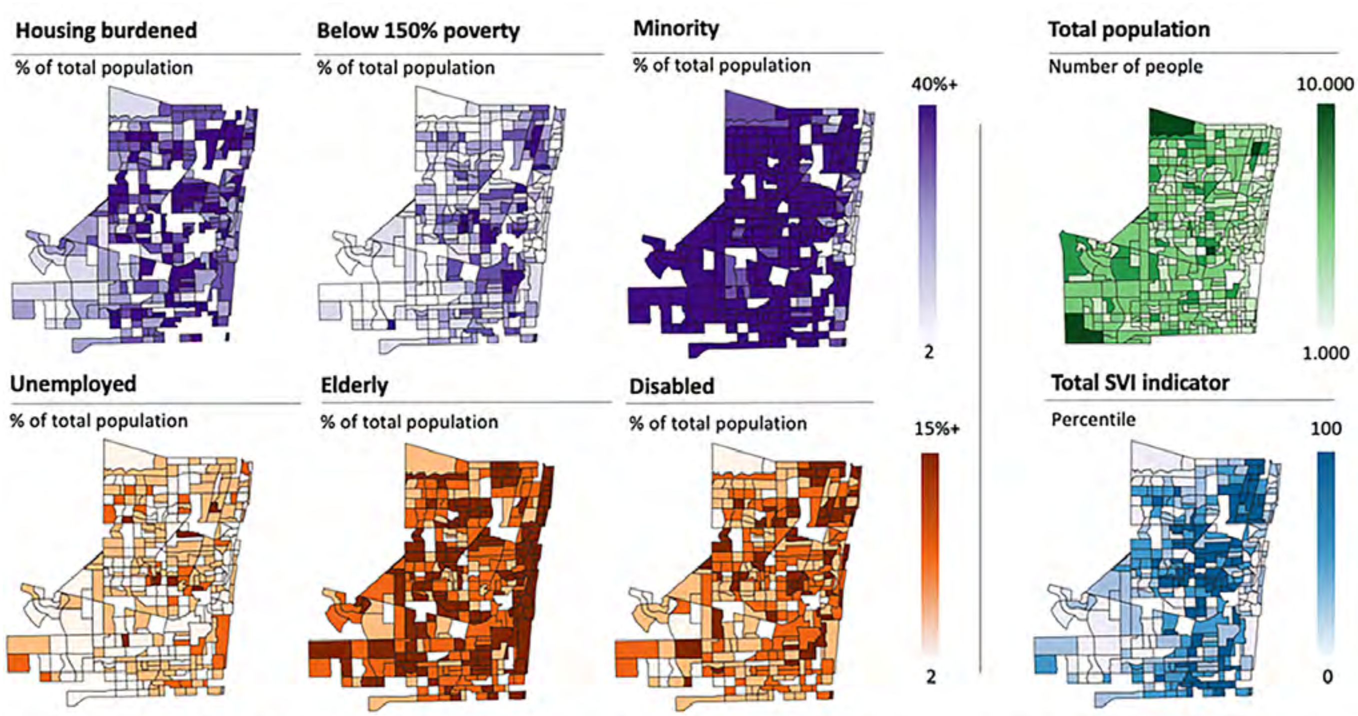
# HEAT ANALYSIS RESULTS

As part of the risk assessment, this heat analysis examines rising temperatures and their impact on vulnerable communities. 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.

The County's economically vulnerable populations are within or near areas that experience high LSTs, making them more susceptible to heat-related deaths and illnesses. Figure 3-8 below highlights the vulnerable populations. The figure depicts the geographical distribution of several indicators: Housing Burdened, Below 150% Poverty, Minority, Unemployed, Elderly, Disabled, and Total Population.

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


**Figure 3-8.** Vulnerable Populations per Social Vulnerability Index (SVI) Database




Vulnerability metrics and total population derived from SVI database for state of Florida, covering 16 indicators across 4 key dimensions: socioeconomic status, household characteristics, racial & ethnic minority status and housing type/transportation.

Note: This figure is taken from the Economic Evaluation of the Baseline. The darker areas have more population because the polygon is larger. Map shows population and not density.

This information is used to calculate the Social Vulnerability Index (SVI), also depicted in the figure. The SVI helps identify communities that may need support during disasters or emergencies. The SVI is a percentile-based index that uses 15 U.S. Census Bureau data points to rank census tracts on 14 social factors. In all maps in the figure, the darker the color of the polygons shown, the higher the percentage. Therefore, the areas shown in dark blue in the Total SVI indicator inset in the figure correspond to the most vulnerable populations based on the 14 social factors within the county. These areas were used to prioritize the adaptations.

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 green 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 green infrastructure.

The development of this Resilience Plan included adaptations that would benefit the hotspots identified in Figure 3-9, particularly where the hotspots are overlain with the most vulnerable population.

Green infrastructure is known to reduce the effects of heat islands by maximizing pervious surfaces within urban settings. Additionally, green infrastructure often offers mitigation strategies for flooding and rainwater storage while providing sustainable landscaping. Green 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.** Most Vulnerable Areas Overlain with Average Land Surface Temperature

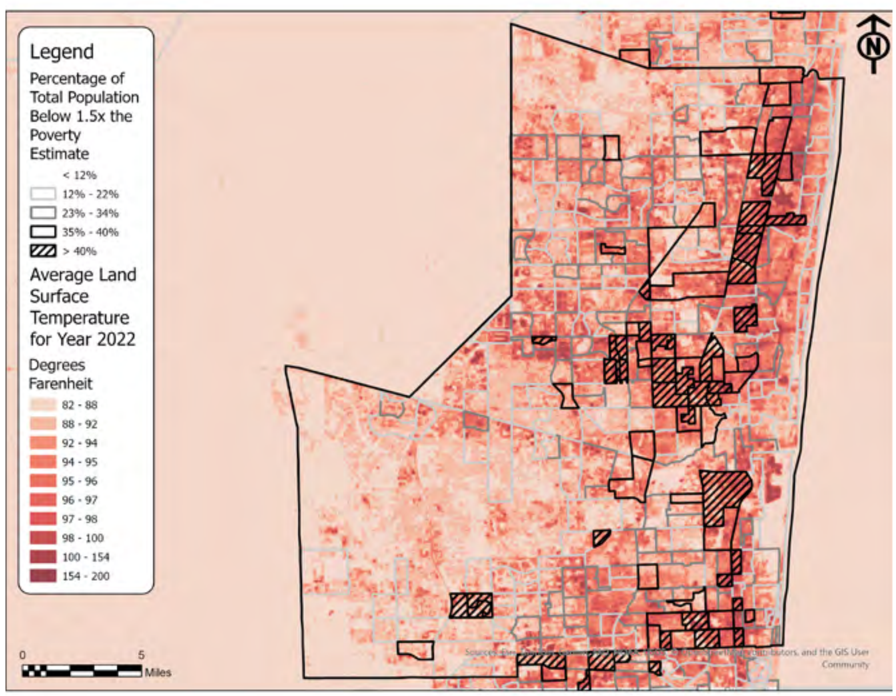


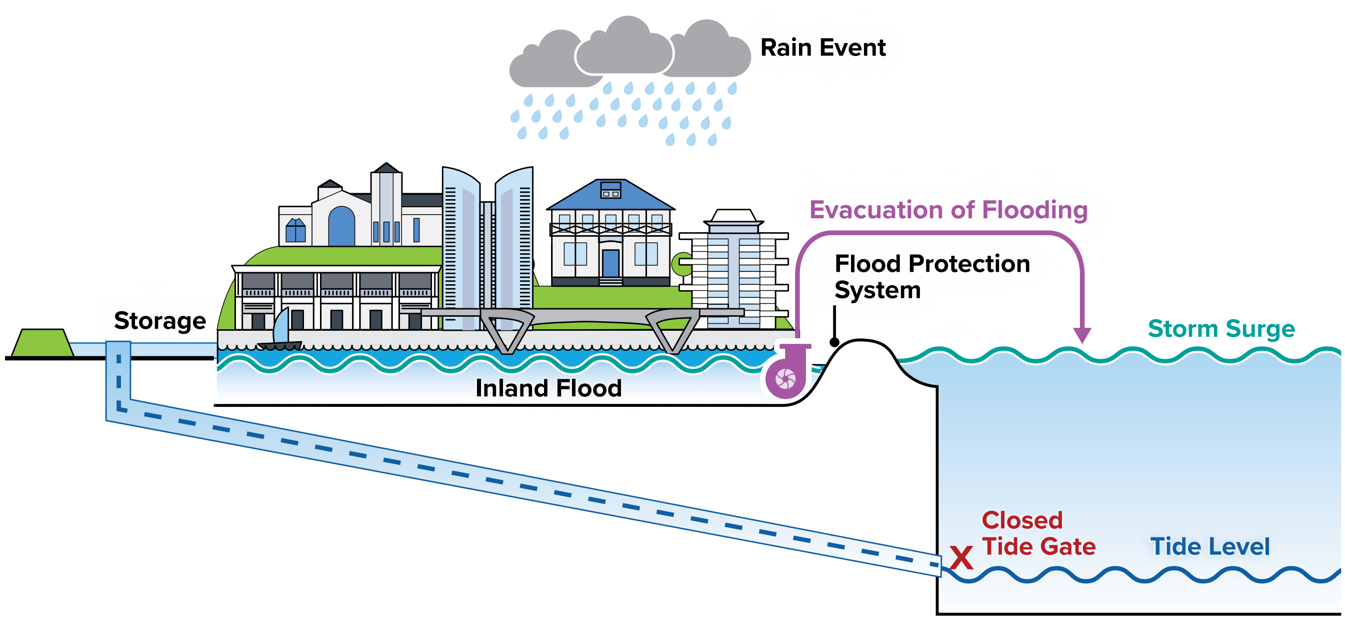
*Photo of tree canopy at Hugh Taylor Birch State Park.*

# 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



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

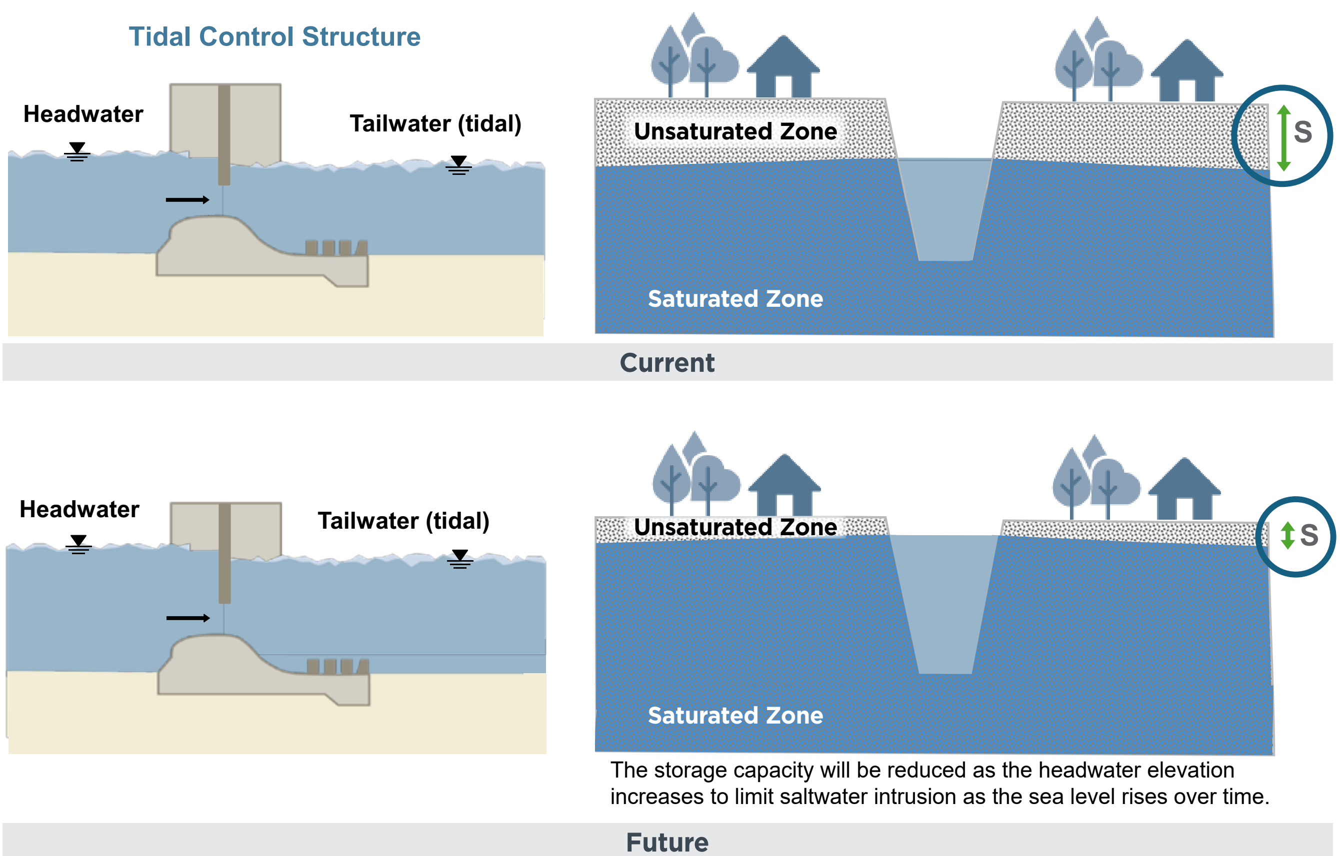
Constructing **HIGHER SEAWALLS** now is an adaptation necessary for prevention of inundation from current King Tides and storm surge but will also **PROTECT PROPERTIES FROM FUTURE PREDICTED SEA LEVEL RISE.**

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.

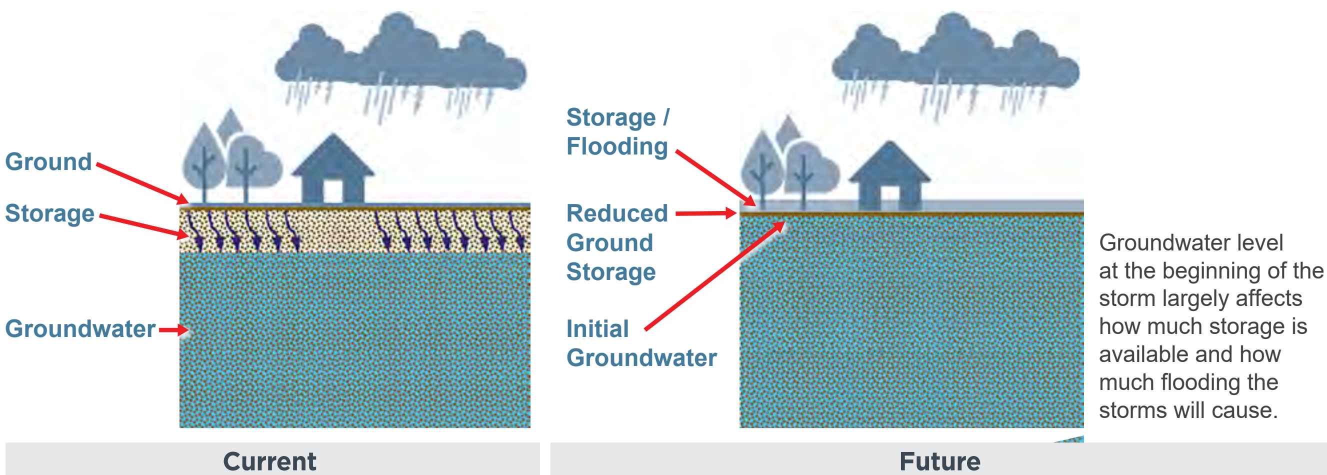
As the Resilience Plan progresses, these preliminary adaptation strategies were further refined through continued modeling, stakeholder engagement, and policy integration. The next sections will outline these strategies in greater detail, providing a roadmap for implementation that ensures long-term 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: green infrastructure, storage, conveyance, and barriers. These adaptations are summarized and pictured below.

**Green Infrastructure:** Broward County has historically promoted green infrastructure (GI) 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 GI 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.

**Green 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, nature-based or engineered structures to prevent flooding and protect infrastructure.

### Swales

Inherent to all of the adaptation suites is the improvement and rehabilitation of swales and other GI 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 identified 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 identified 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 efforts 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 significant 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 – Highly Vulnerable Areas; Zone 2 – Eastern Areas; and Zone 3 – Inland Areas. The boundaries of Zone 1 were defined based on a combination of factors, including the economically vulnerable areas more affected by flooding, FEMA Community Disaster Resilience Zones, areas with a higher concentration of community service points, and Justice40 disadvantaged communities.

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

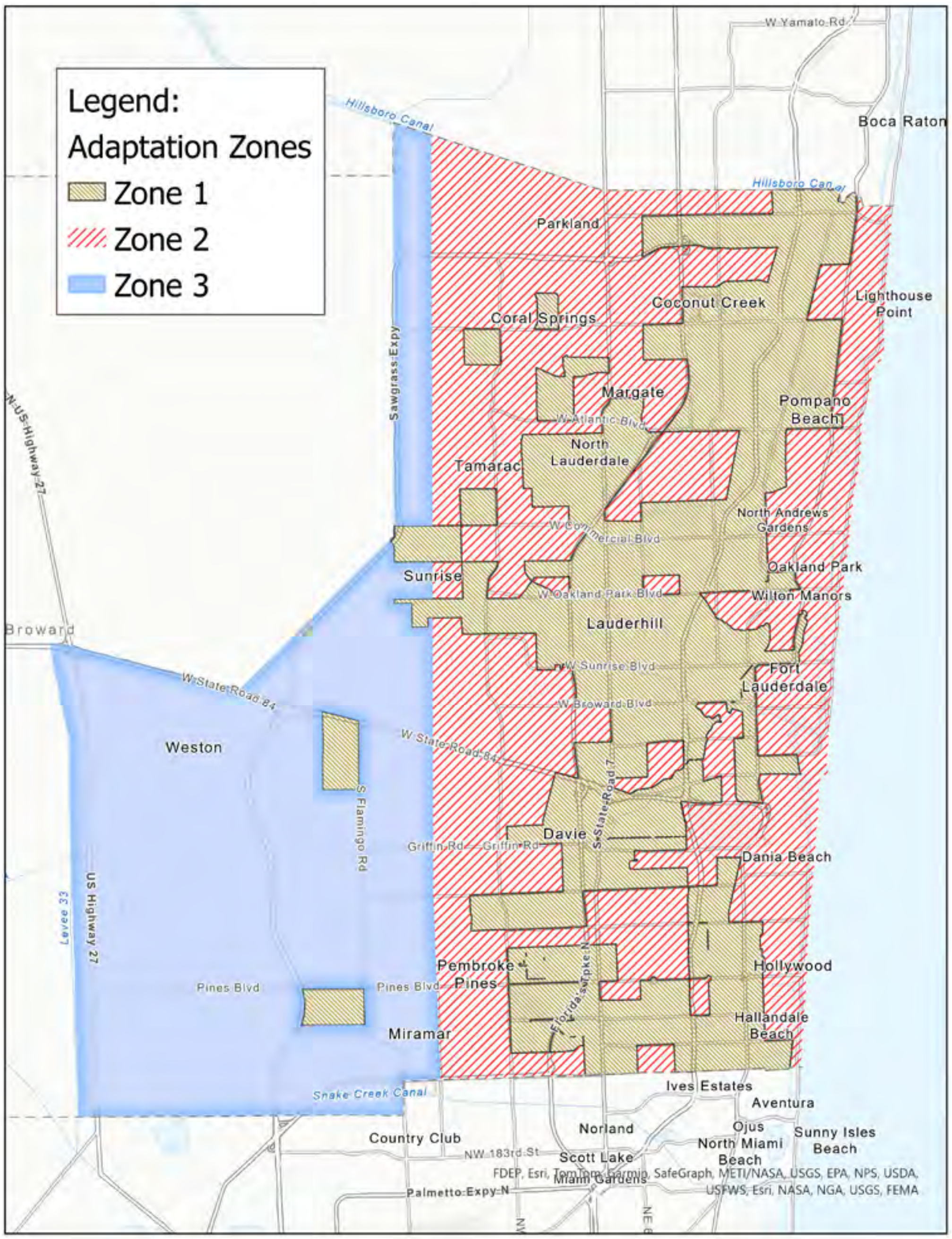


**Figure 4-6.** Overview of Adaptations Analyzed by Combinations of Strategies

| 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

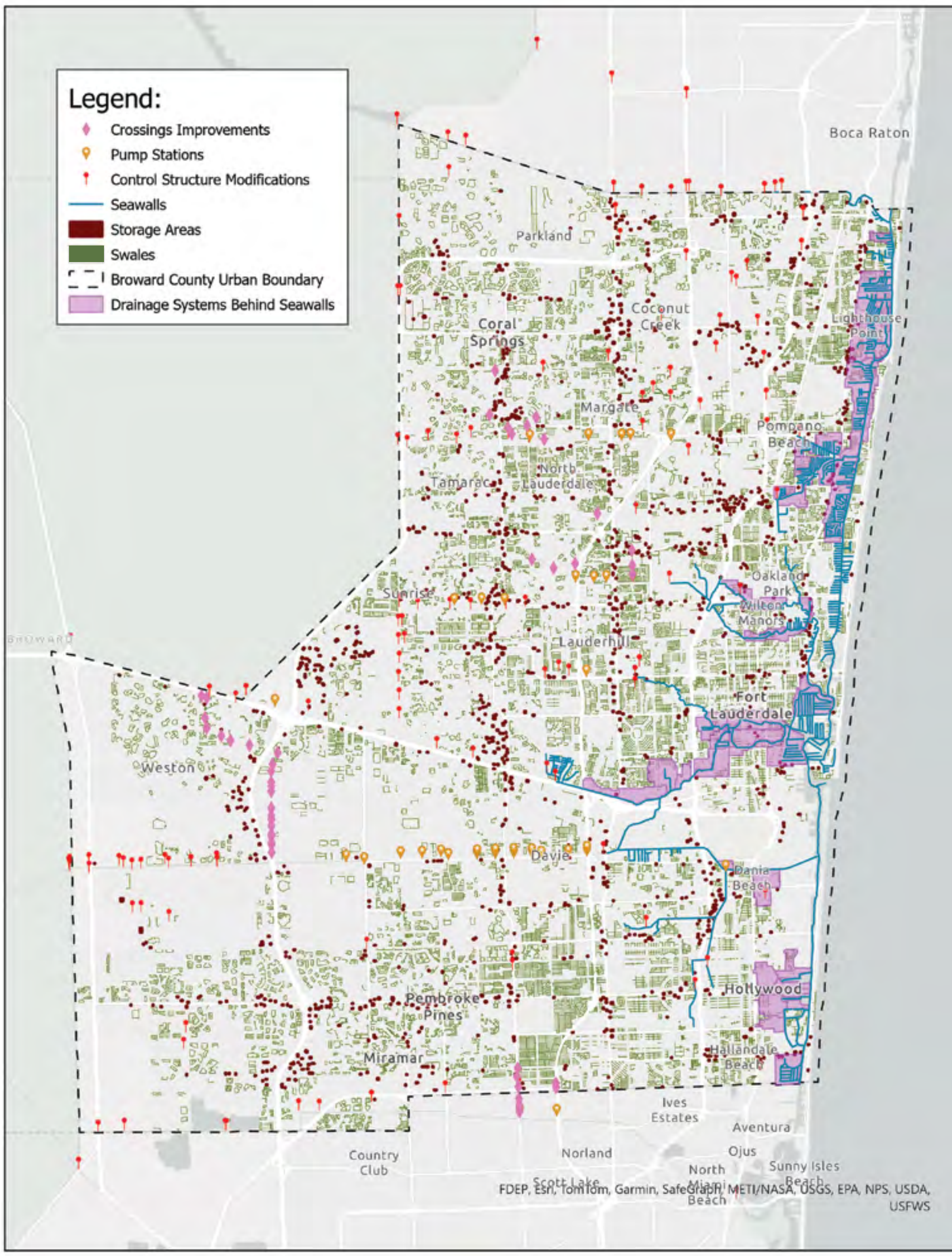
The modeling of the selected adaptations was conducted to analyze the effects of different combinations of individual adaptations and better inform the Resilience Plan (Figure 4-6). Through this process, weaknesses in the system under future SLR scenarios were identified. To address these gaps, an additional 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




**190+ miles** Enhanced Seawalls*

**159** Control Structures

**33** New Pump Stations

**41** Upgraded Crossings

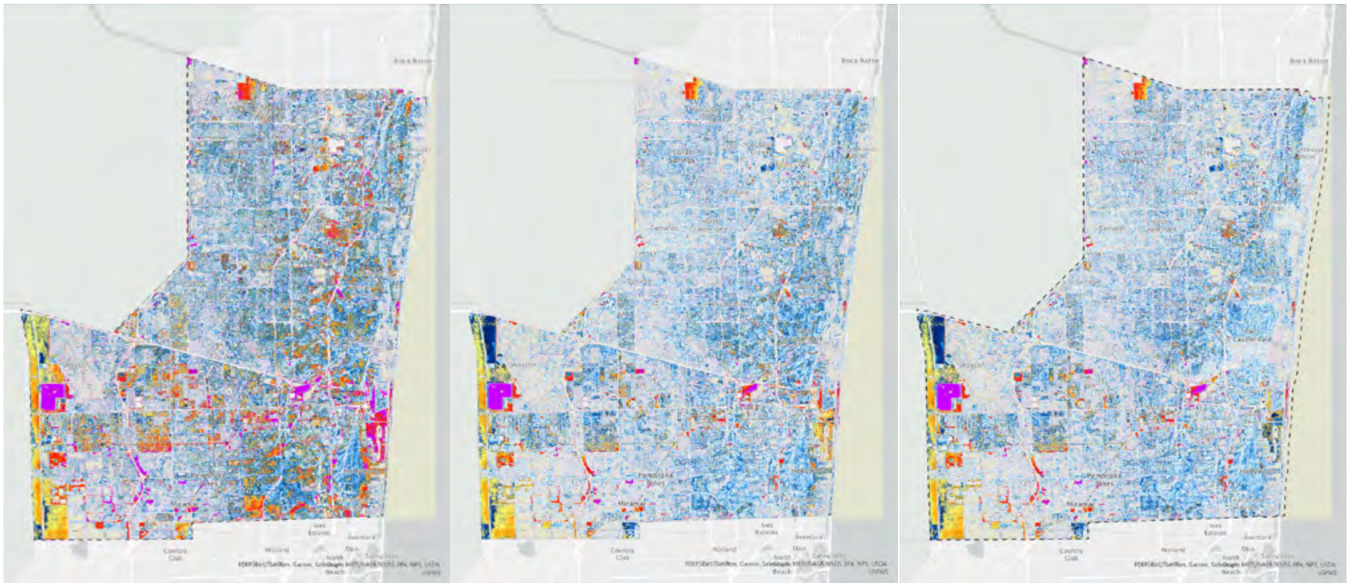
**1,247** Acres-feet of Storage

* Length is total miles of waterway. Seawalls will be on both sides of waterways.

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 insignificant.

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)

0.25' - 0.50' | 0.50' - 1.00' | 1.00' - 1.50' | 1.50' - 2.00' | 2.00 - 2.50' | 2.50' - 3.50' | >3.50'

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.

## GREEN INFRASTRUCTURE HEAT MITIGATION STRATEGIES

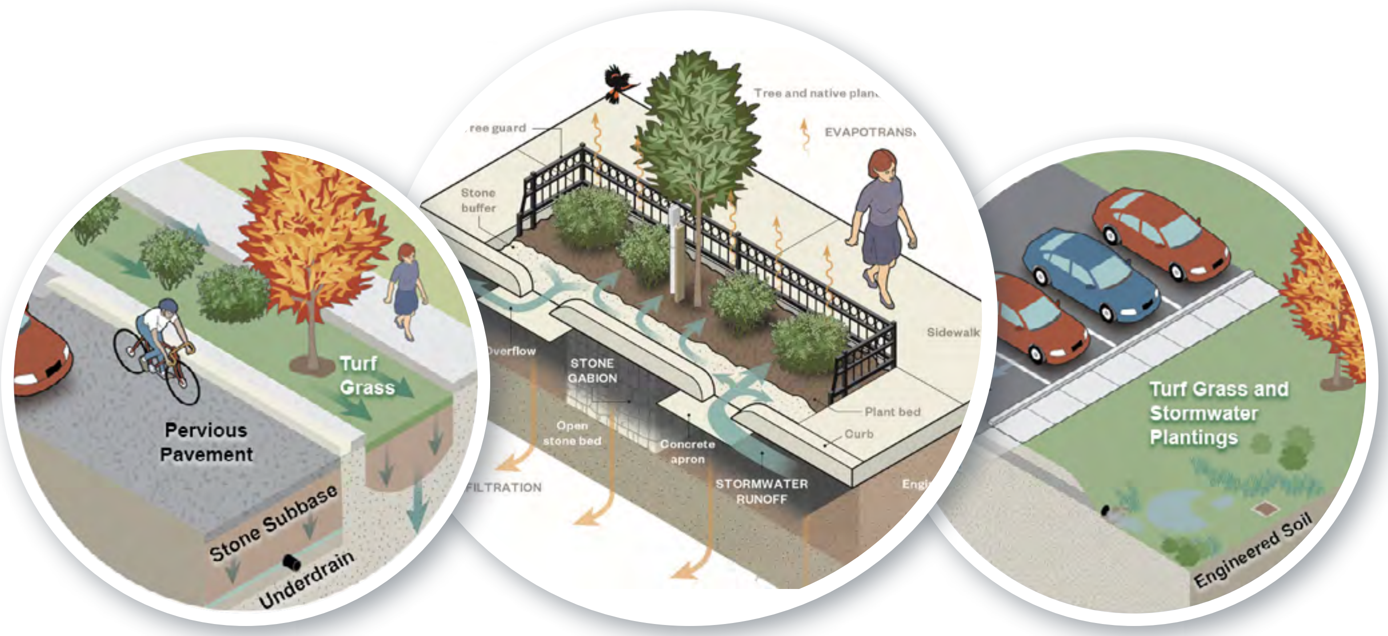
GI is known to reduce the effects of heat islands by maximizing pervious surfaces within urban settings. Additionally, GI often offers mitigation strategies for flooding and rainwater storage while providing sustainable landscaping. GI best management practices will be specifically considered for implementation in areas with vulnerable populations, as they offer co-benefits in areas where vulnerable populations may be lacking. GI mitigation strategies may include:

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

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

Figure 4-10 highlights the benefits of GI 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

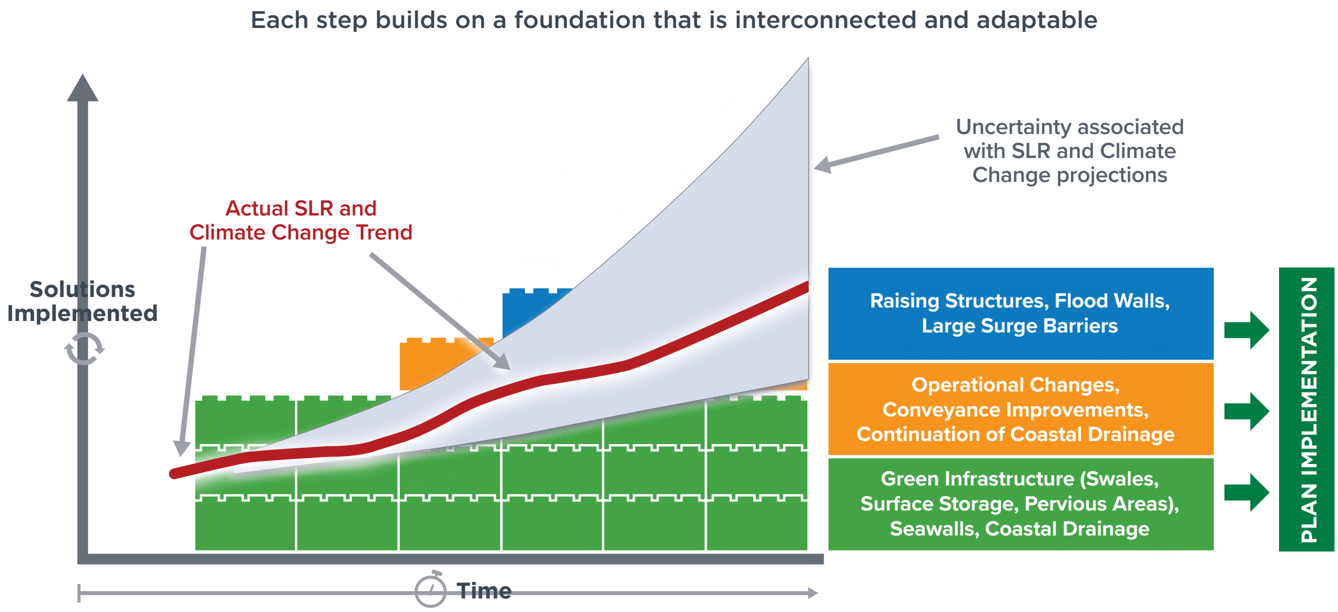


# GENERAL ADAPTATION IMPLEMENTATION STRATEGY

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 green infrastructure first, while groundwater is at current levels, will maximize the benefits of green 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<br>Countywide with Control Elevation Changes | Tier 2<br>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<br>• Pumping stations and culvert improvements<br>• Storage areas/green infrastructure<br>• Control elevation changes<br>• 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

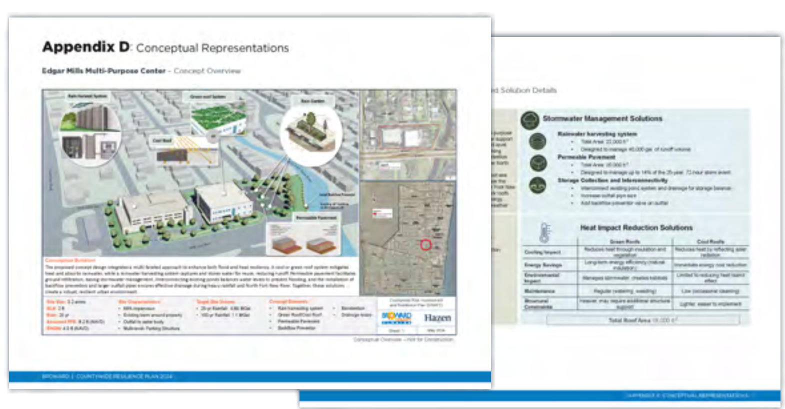
Following the risk assessment, the team reviewed the ranking of the critical assets and determined which of the highly ranked critical assets could be used as examples of adaptations. The selected sites serve as a model for future implementations across similar County sites.

The conceptual sites were selected to show a broad representation of different 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. |

Six conceptual site representations were developed and are provided in Appendix D.



## 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.

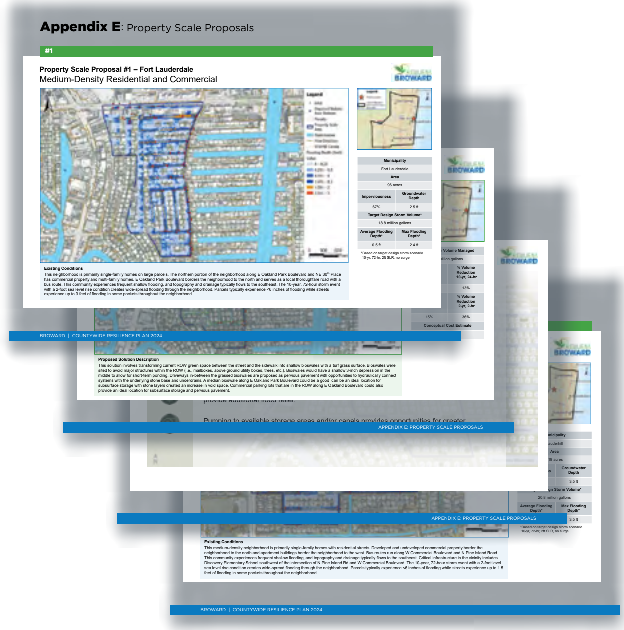
## Planning Cost Estimate

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.

The Property Scale Proposal sheets can be found in Appendix E of this document.



ECONOMIC MODELING

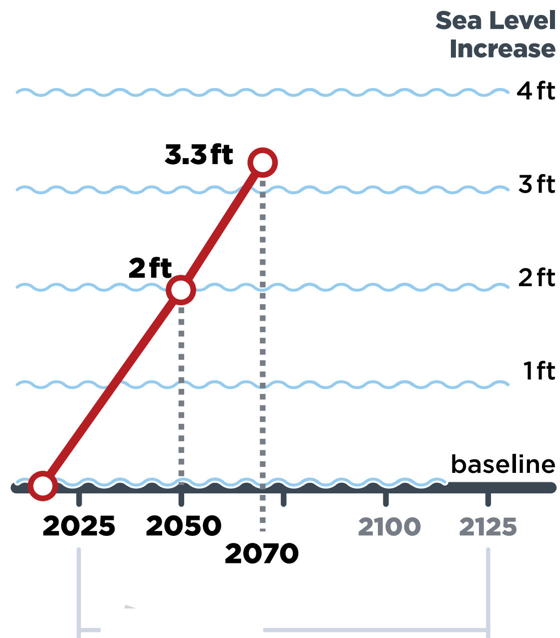
# 5 Economic Feasibility of the Adaptation Strategies

**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 Appendix F of this report.

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

**Property Damage Avoided Countywide**

| **Countywide Implementation** with Control Elevation Changes | 2.0-foot SLR<br>TIER 1<br>5.0-foot NAVD seawalls | 3.3-foot SLR<br>TIER 2<br>7.0-foot NAVD seawalls |
|---|---|---|
| Average **Annual Dollars** | $0.78 Billion | $3.6 Billion |
| **Change** from Baseline | 31% reduction | 83% reduction |

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

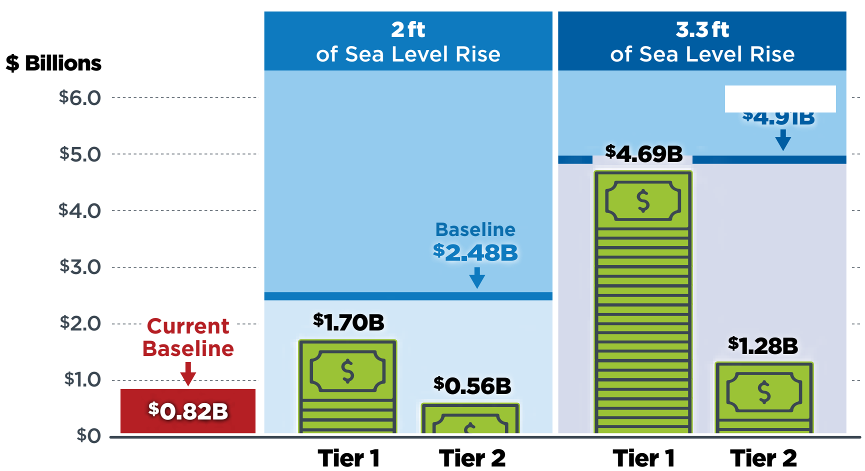
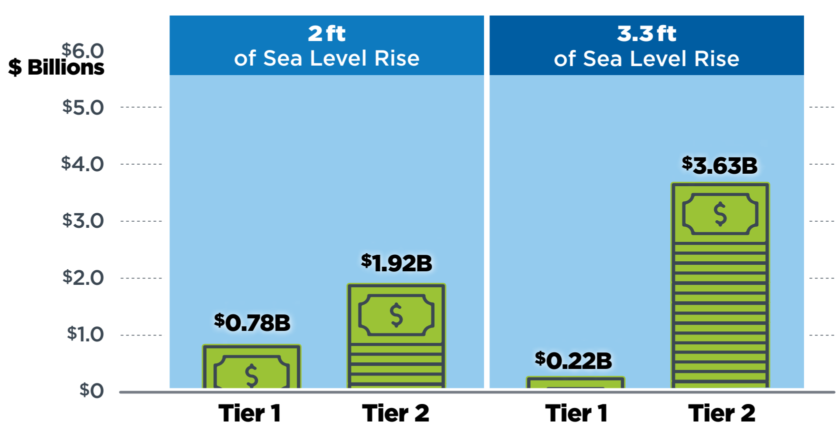



**Figure 5-2.** Estimated Benefits of Tier 1 and Tier 2 Adaptations as They Avoid Property Damage in Broward County, Average Annual




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 benefits 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.

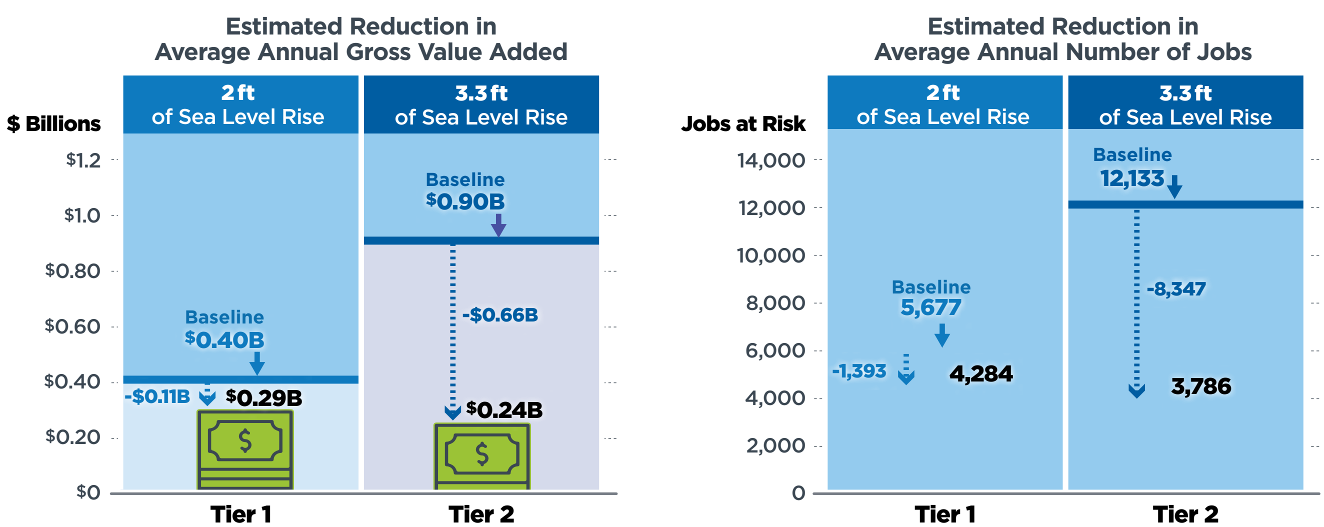
The benefit of Tier 1 is an average annual GVA that is estimated to be $0.11 billion higher than under baseline conditions. The benefit of Tier 2 is an average annual GVA that is estimated to be $660 million higher than under baseline conditions.

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 flood conditions reduce the average annual GVA by $0.30 billion and the number of jobs by 3,340.

### Increased Economic Activity Countywide (Gross Value Added)

| **Countywide Implementation** with Control Elevation Changes | 2.0-foot SLR<br>**TIER 1**<br>5.0-foot NAVD seawalls | 3.3-foot SLR<br>**TIER 2**<br>7.0-foot NAVD seawalls |
|---|---|---|
| Average **Annual Dollars** | **$0.11** Billion | **$0.66** Billion |
| **Change** from Baseline | **24%** reduced loss | **69%** reduced loss |

**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.

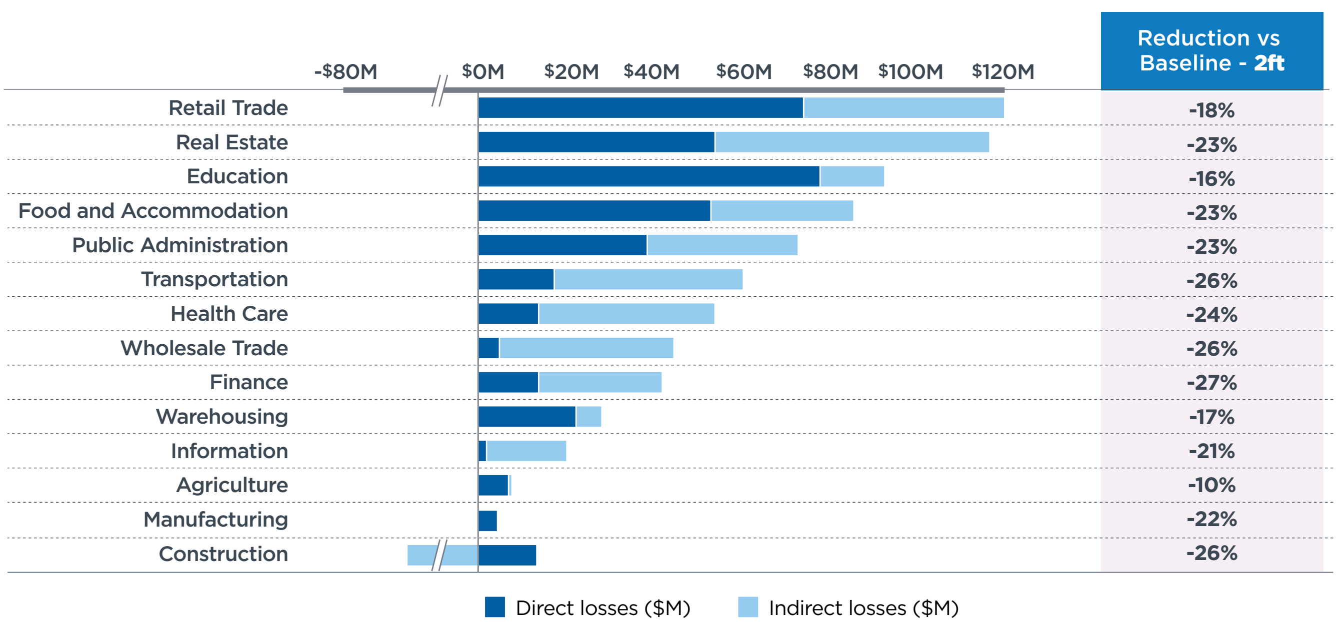
As the sea level rises to 3.3 feet, and no action is taken, the average annual GVA loss is estimated to be $0.90 billion with an estimated 12,100 fewer jobs. The Tier 2 investments would be expected to reduce these losses to $0.24 billion in lost GVA, which is the same as current losses, and there would 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 figure 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 figure 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 affected 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 differences 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 efforts 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

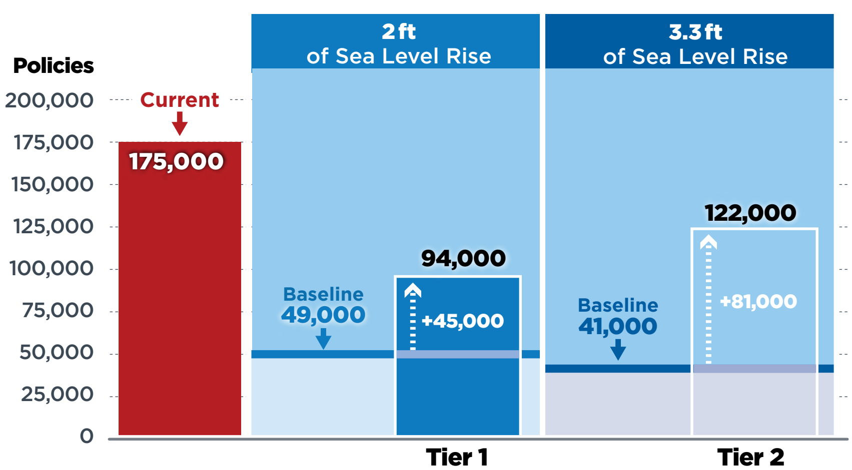
Relative to the baseline conditions, **Tier 1 and Tier 2 investments would increase the number of residential housing units with National Flood Insurance Program (NFIP) flood insurance policies, resulting in greater insurance coverage countywide**.

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.

### Increased Flood Insurance Coverage Countywide

| **Countywide Implementation** with Control Elevation Changes | 2.0-foot SLR<br>TIER 1<br>5.0-foot NAVD seawalls | 3.3-foot SLR<br>TIER 2<br>7.0-foot NAVD seawalls |
|---|---|---|
| Average **Dollars** | $12 Billion | $20 Billion |
| **Change** from Baseline | 92% increase | 182% increase |

**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 flood 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

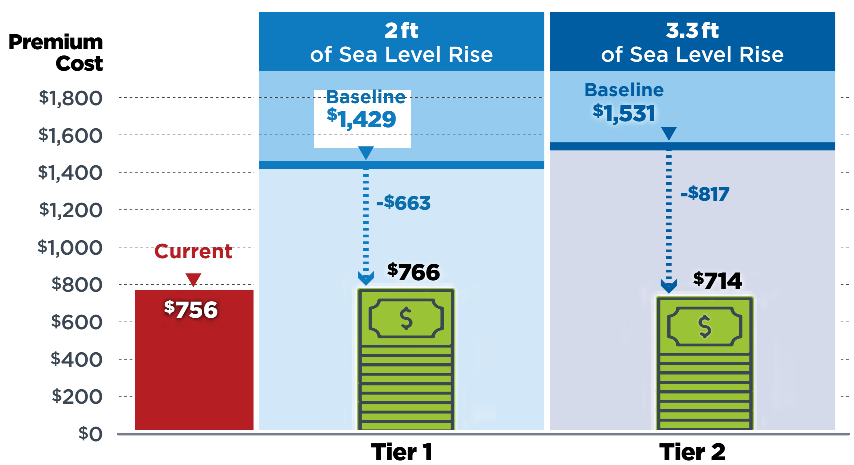
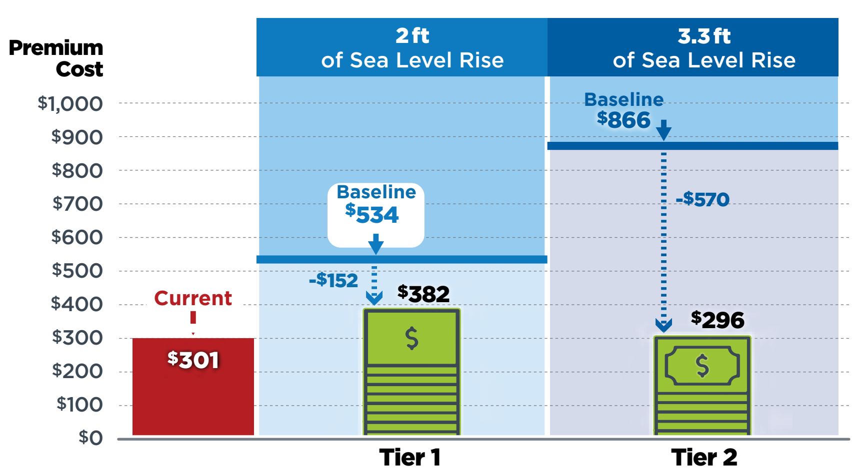


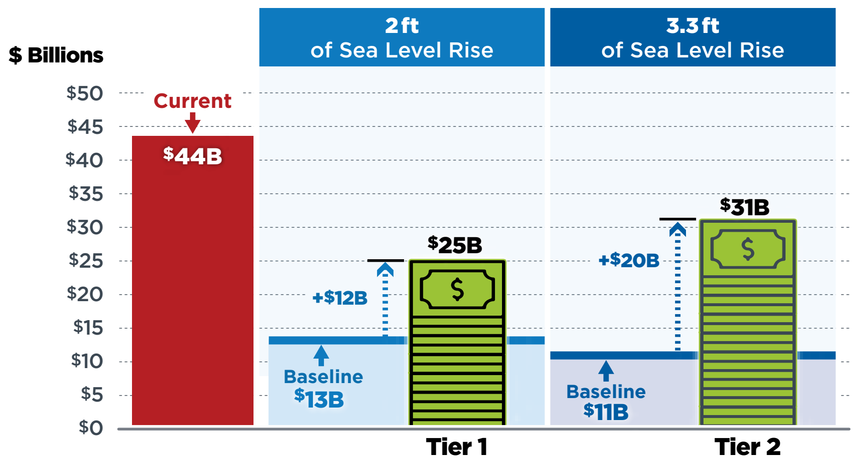

**Figure 5-7.** Multi-Family Home Average Annual Premiums in Broward County Under Baseline, Tier 1 and Tier 2




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.

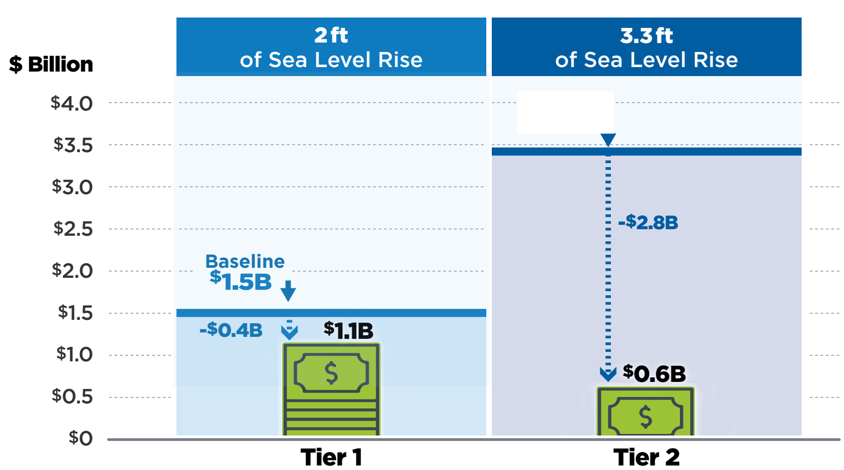
The resulting NFIP flood insurance coverage that can be expected under the baselines, Tier 1, and Tier 2 are provided in Figure 5-8. Today, total countywide NFIP flood insurance coverage is $44 billion. Under 2 feet of SLR, coverage falls to $13 billion. The Tier 1 investments increase coverage by $12 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

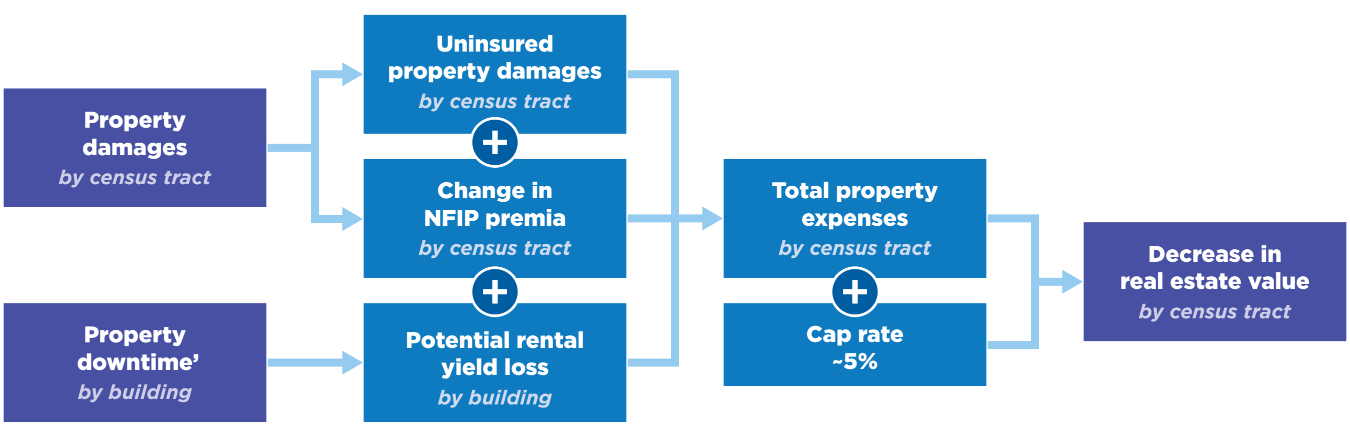

**The real estate analysis assessed the benefits of adaptation on the valuations of homes throughout the county.** This first-order analysis focused on the real estate directly affected by floods and did not consider market effects in other neighborhoods. For example, losses in neighborhoods affected 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.

### Increased Real Estate Value Countywide

| **Countywide Implementation** with Control Elevation Changes | 2.0-foot SLR **TIER 1** 5.0-foot NAVD seawalls | 3.3-foot SLR **TIER 2** 7.0-foot NAVD seawalls |
|---|---|---|
| Average **Dollars** | **$8 Billion** | **$31 Billion** |
| **Change** from Baseline | recovers **32%** lost RE value | recovers **78%** lost RE value |

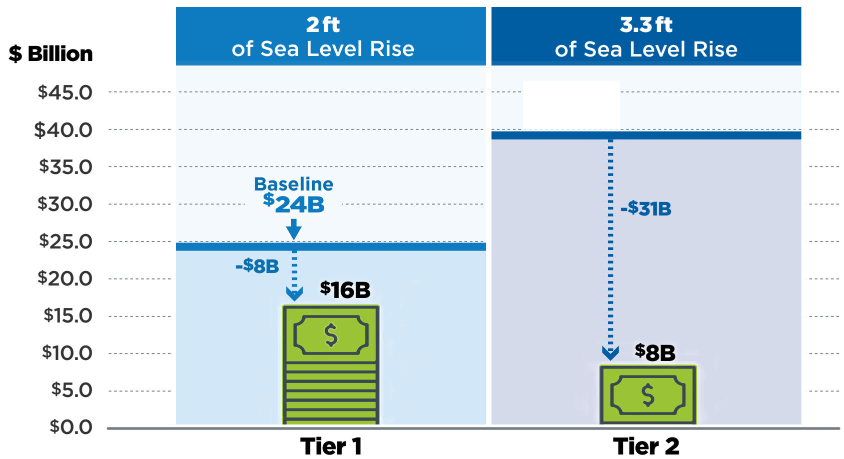
The method used to estimate the impact of the baselines, Tier 1, and Tier 2 on real estate values is summarized in Figure 5-10. The estimated increase in property values under Tier 1 and Tier 2 are to be interpreted as how much more the property would be worth if the adaptation suite were implemented. 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.

**Increased Tax Revenue Countywide**

| **Countywide Implementation** with Control Elevation Changes | 2.0-foot SLR<br>TIER 1<br>5.0-foot NAVD seawalls | 3.3-foot SLR<br>TIER 2<br>7.0-foot NAVD seawalls |
|---|---|---|
| Average **Annual Dollars** | $0.21 Billion | $0.96 Billion |
| **Change** from Baseline | 5% increase | 22% increase |

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)

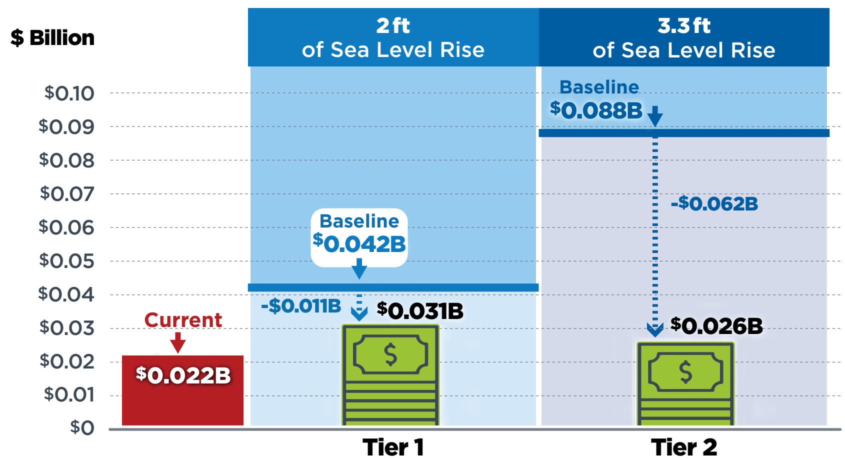
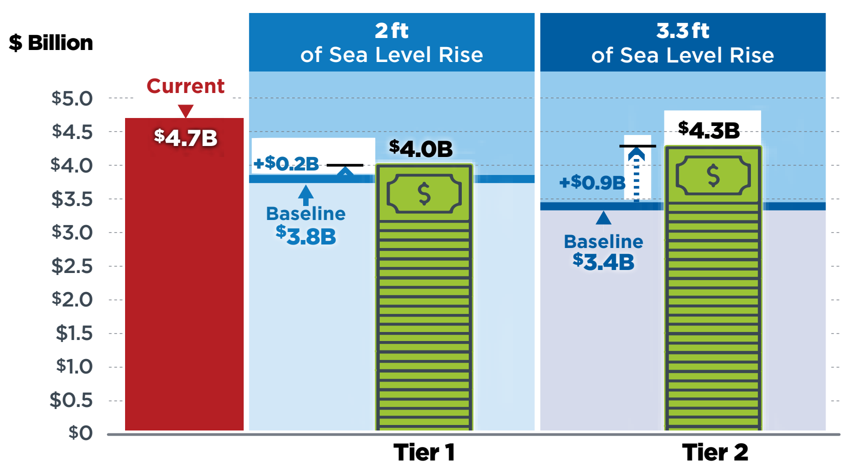



**Figure 5-13.** Ad Valorem Tax Revenue Collected and the Benefits of Tier 1 and Tier 2 (Average Annual)



## Summary of Estimated Benefit Values

A summary of the estimated benefits 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 flood risk that are considered to be socio-economically vulnerable.

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)

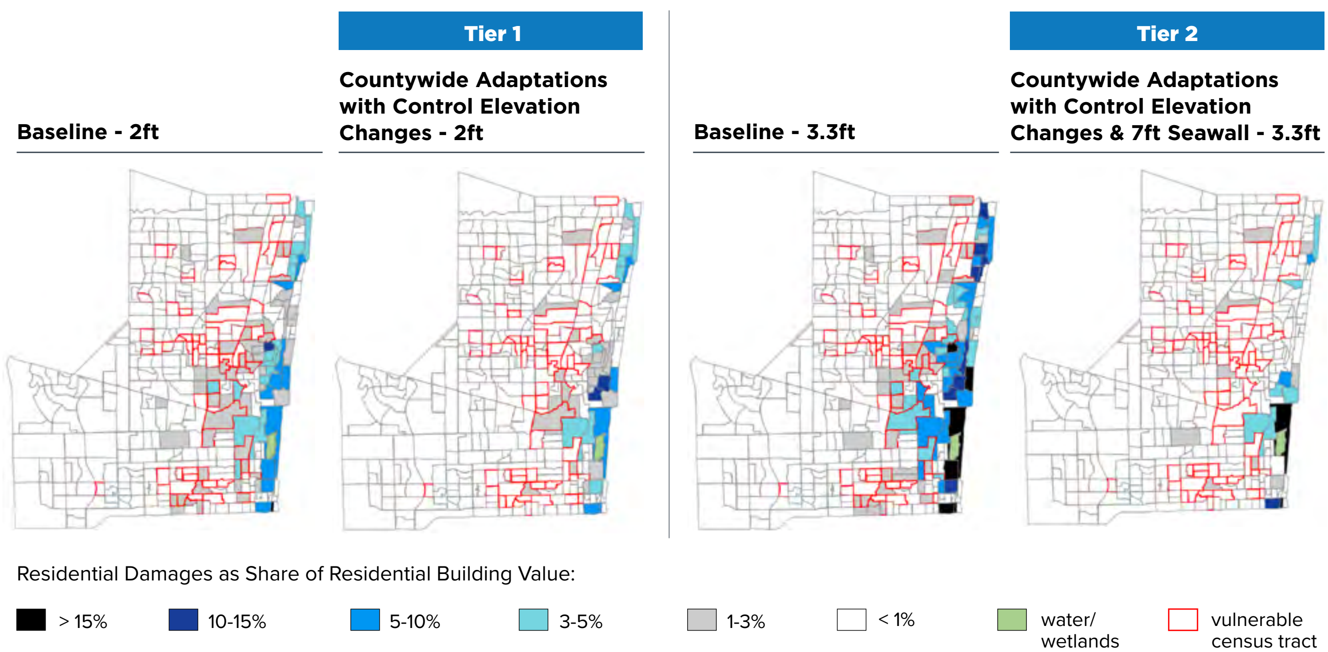


**Figure 5-15.** Number of NFIP Flood Insurance Policies

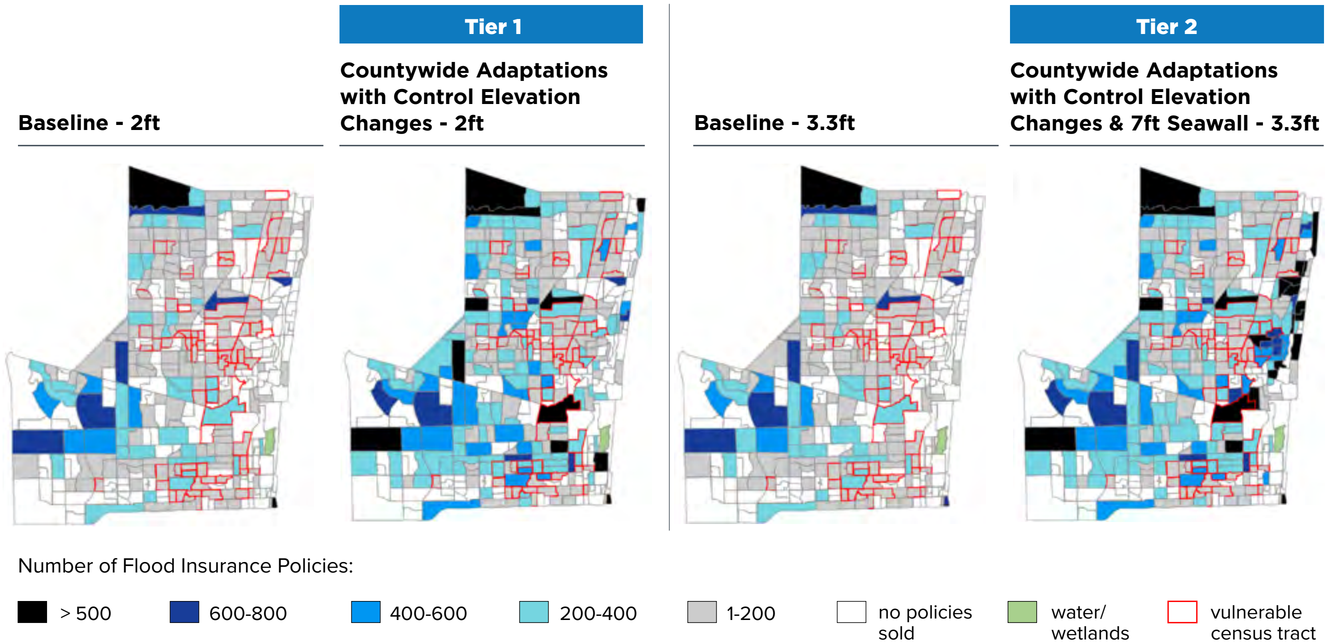



**Figure 5-16.** Single-family Home Annual Flood Insurance Premiums (Estimated Dollars)

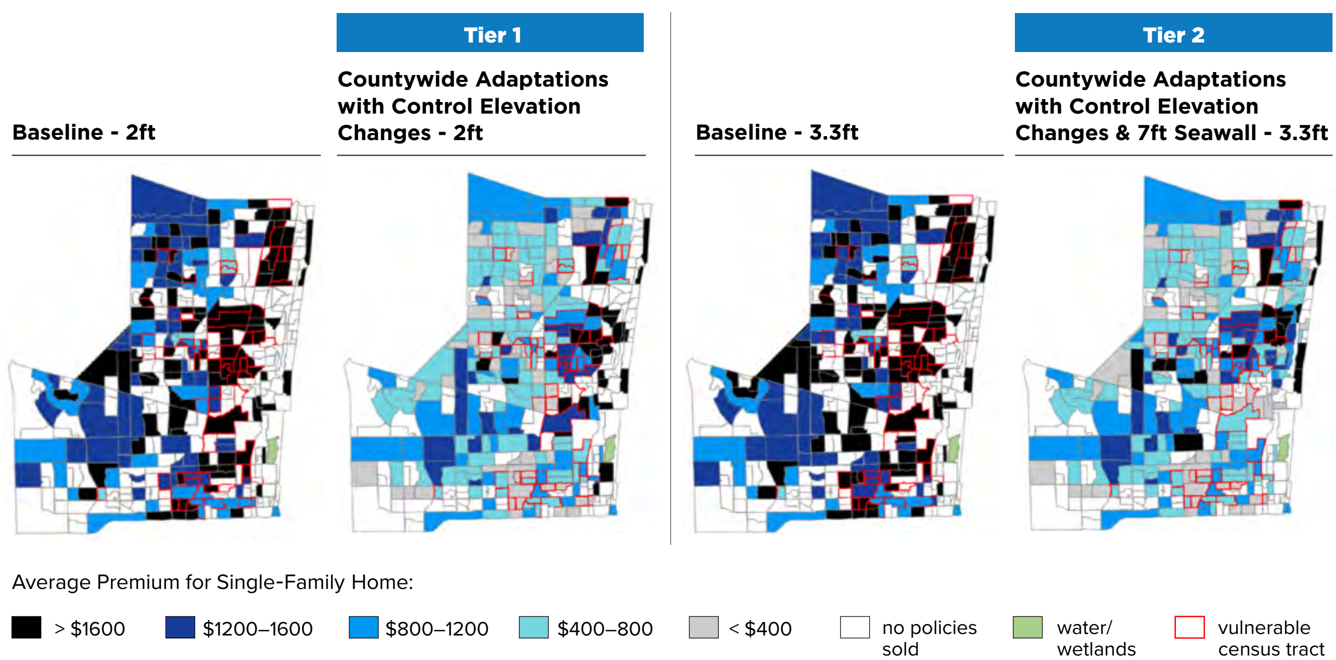
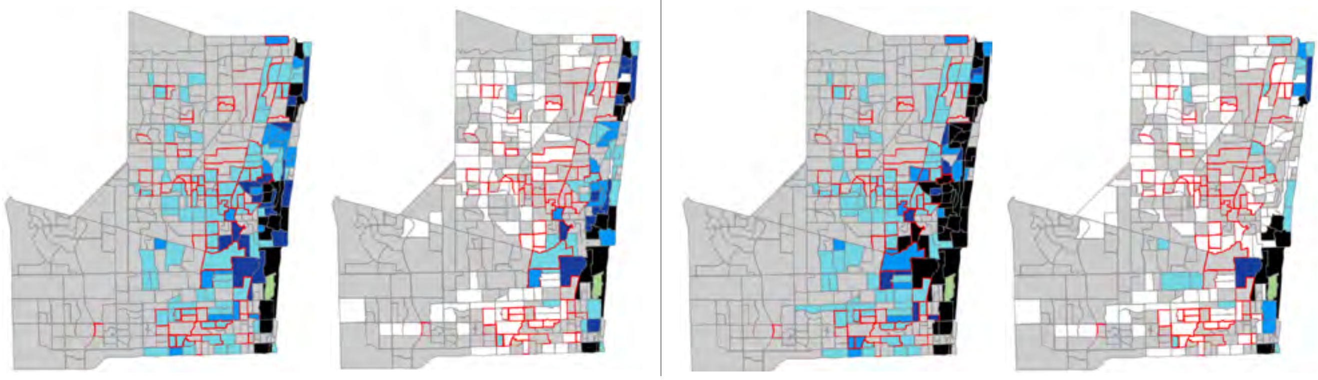


**Figure 5-17.** Real Estate Value Losses Across Broward County (Estimated Percent of Property Value)

| Baseline - 2ft | Tier 1<br>Countywide Adaptations with Control Elevation Changes - 2ft | Baseline - 3.3ft | Tier 2<br>Countywide Adaptations with Control Elevation Changes & 7ft Seawall - 3.3ft |
|---|---|---|---|



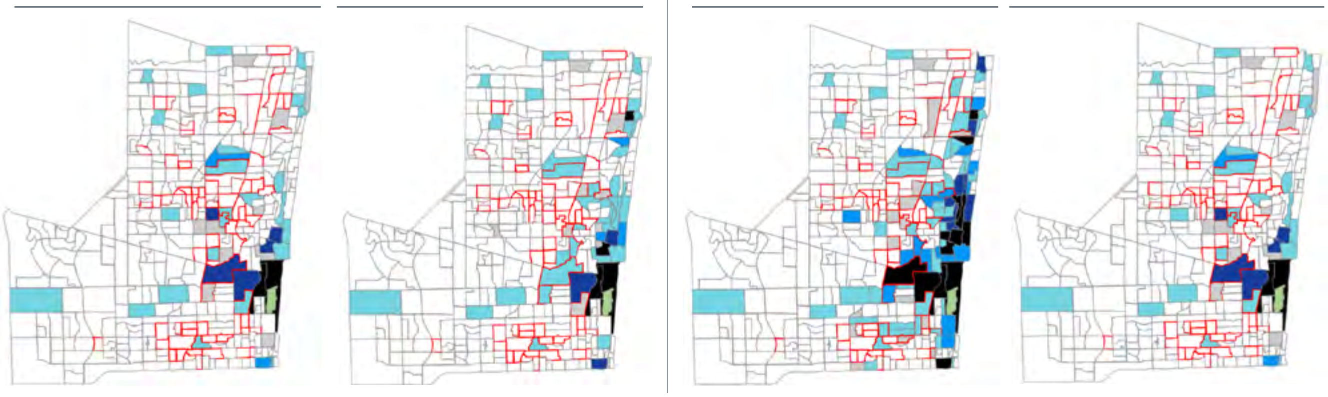
Residential Property Value Loss as Share of Residential Building Value:

> 80% | 40-80% | 10-40% | 1-10% | 0-1% | < 0% | water/ wetlands | vulnerable census tract

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)

| Baseline - 2ft | Tier 1<br>Countywide Adaptations with Control Elevation Changes - 2ft | Baseline - 3.3ft | Tier 2<br>Countywide Adaptations with Control Elevation Changes & 7ft Seawall - 3.3ft |
|---|---|---|---|



Millions in Sales Revenue Loss:

> $40M | $20-40M | $10-20M | $1-10M | $500K-1M | < $500K | water/ wetlands | vulnerable census tract

# 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, classified 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.

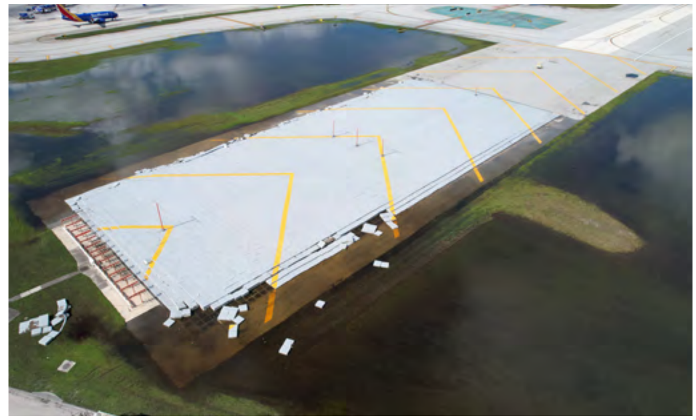


*Photo taken at Fort Lauderdale International Airport on April 13, 2023 of the damaged Engineered Materials Arresting System (EMAS) at the east end of the north airport runway.*

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.

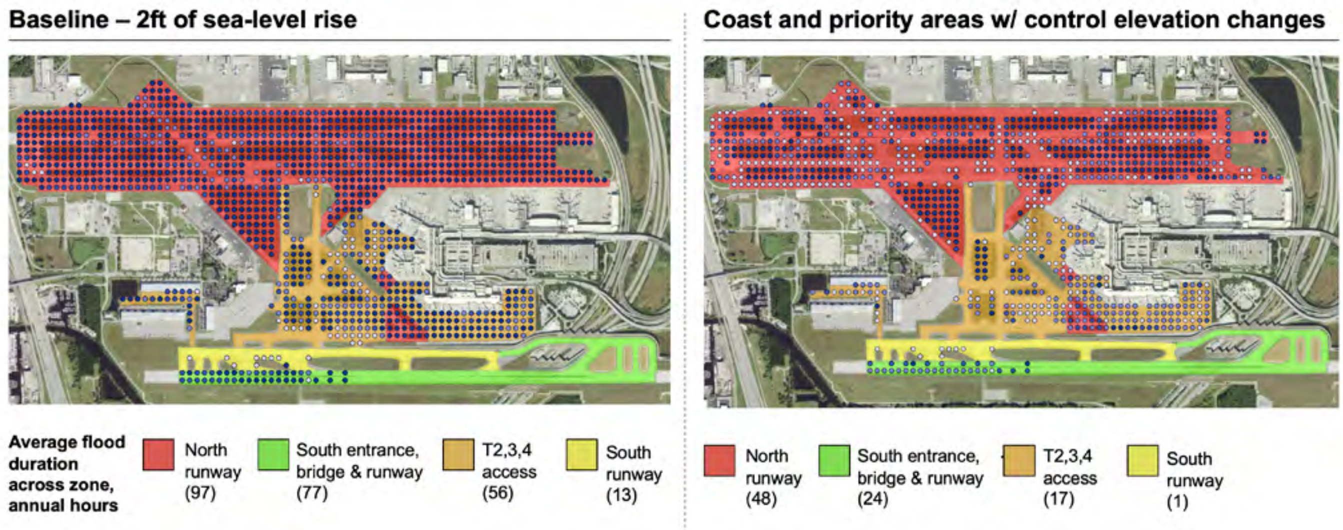
Estimating the annual average loss in airport sales and profits due to more frequent and severe flooding is challenging due to the complex nature of airport operations. For example, flooding in certain areas may only close one runway, or only selected taxiways or hangers. Flooding of access roads to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

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



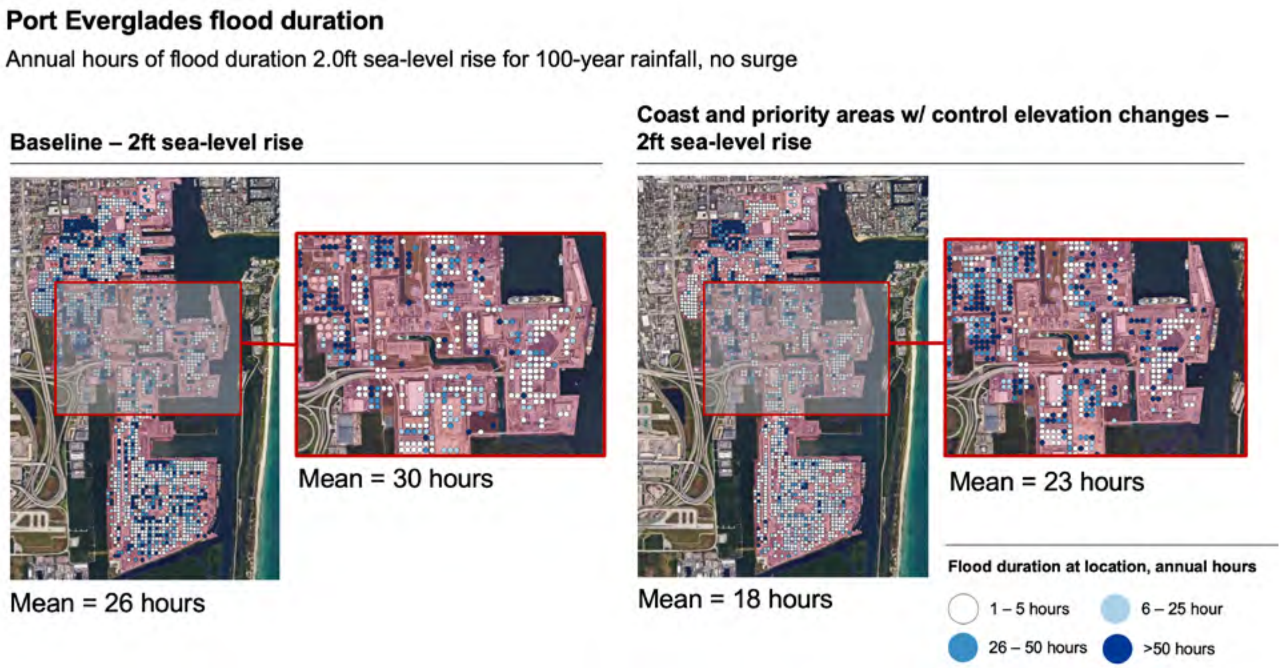

The figure shows that the area marked in red associated with the north runway could experience a significant reduction in flood duration of approximately 50% with the implementation of the Tier 1 adaptation strategy, decreasing from around 100 hours in the baseline to around 50 hours under adaptation. 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 the world works to decarbonize and limit the impacts of greenhouse gas emissions on the Earth's climate. 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 capital and annual costs incurred each year are provided in Appendix F. 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<br>(15 years) | 2070<br>(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 benefits 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 offset 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 = $\Sigma t{=}1{,}101$ $[(B_t - C_t) / (1+d)^t]$**

*where,*

- **$\Sigma$ 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. The annual benefits and costs used for each tier are provided in Appendix F. 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 a diverse array 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. The list of Resilience Steering Committee members is included in Appendix A.
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 sustainable 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.
6. **Equitable Community Engagement.** A key focus of Broward County's stakeholder engagement strategy is ensuring that all voices are heard, particularly those from historically underserved communities. The County strives to make the engagement process inclusive and equitable, recognizing that resilience planning must address the needs of all residents to be effective.

By fostering a collaborative and inclusive approach to stakeholder engagement, Broward County developed a Resilience Plan that is comprehensive, equitable, and reflective of the community's diverse needs and priorities.

The engagements completed under this study are described below in chronological order. Each engagement is included in Appendix G and includes the engagement date, target audience, description, key outcomes, and selected graphics.


*Photo of Broward County volunteers planting green infrastructure.*

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

## COUNTYWIDE RISK ASSESSMENT AND RESILIENCE PLAN

# ENGAGEMENT TIMELINE

**2022**

JUNE

06/08/2022
**Resilience Steering Committee Presentation #1**

1


AUGUST

08/10/2022
**Resilience Steering Committee Presentation #2**

SEPTEMBER

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

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

2


NOVEMBER

11/12/2022
**Resilience Steering Committee Presentation #3**

**Broward Resilience in the Making Project Update #2**

DECEMBER

12/14/2022
**Resilience Steering Committee Presentation #4**

**Broward Resilience in the Making Project Update #3**

**2023**

FEBRUARY

02/08/2023
**Resilience Steering Committee Presentation #5**

**Broward Resilience in the Making Project Update #4**

APRIL

04/09/2023
**Resilience Steering Committee Presentation #6**

**Broward Resilience in the Making Project Update #5**

MAY

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

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

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

AUGUST

08/23/2023
**Resilience Steering Committee Presentation #7**

2


OCTOBER

10/31/2023
**Community Foundation Listening Session**

**Broward Resilience in the Making Project Update #6**

Community Foundation of Broward

NOVEMBER

Urban League of Broward County

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**

2 11/14/2023 5PM
**Ecoexplorers Listening Session**

1 2 11/14/2023 7PM
**Urban League Listening Session**

Museum of Discovery & Science Autonation IMAX Theater

DECEMBER

Residents 4 Resilience

12/01/2023
**Residents for Resilience Listening Session**

12/13/2023
**Resilience Steering Committee Presentation #9**

12/20/2023
**Hispanic Unity Listening Session**

Hispanic Unity of Florida

**2024**

JANUARY

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

FEBRUARY

02/07/2024
**Resilience Steering Committee #10**

MARCH

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

06/12/2024
**Resilience Steering Committee #11**

AUGUST

08/28/2024
**Resilience Steering Committee #12**

# 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 Green Infrastructure

Improve stormwater absorption and reduce runoff through enhanced green 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 green 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 flood 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. The selection could include a neighborhood that would directly benefit from the flood reduction (Broward Municipal Services District, Chapel Trail, or Fort Lauderdale neighborhood, for example), a neighborhood that would not directly benefit but would significantly contribute to the area's flood control (e.g. Embassy Lakes), a neighborhood that can afford the conversion or at least provide a significant cost-share, and a neighborhood that cannot afford any cost-share (potentially in the mapped Zone 1).

## 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 green 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 significantly reduced over time as the size of the impervious area decreases. These fee structures would incentivize property owners to implement certain green 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 trading 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 green 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 sustainable 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. The parking lots could be constructed to include solar panel structures to promote the production and use of green energy.

**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 significant green infrastructure if a “net benefit” 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 significant green 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.

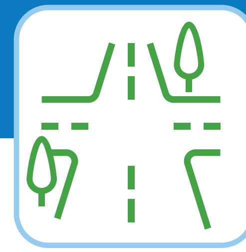
**Benefits:** The County would be prepared for the eventual increase in SLR to 3.3 feet or above. Analysis has demonstrated that increases in SLR to 3.3 feet would reduce the effectiveness of the 5.0-foot NAVD seawalls.

**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/reflective paving, and shade structures through resilient complete streets design standards. The NACTO urban street design guide is a good starting reference.

**Benefits:** Incorporating flood 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 sustainable 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 offset the additional costs of building to higher standards and to encourage infill 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 green 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 green 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 green 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 significant 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 modifications 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 Priority 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 for Social Resilience within the County's land use plan, providing for an additional level or review for water storage and green 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 and least resources for adaptation.

**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 Green Infrastructure**: Investments are focused on creating dedicated storage areas and expanding pervious surfaces across all zones to improve floodwater 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, offering additional protection against anticipated SLR and higher storm surges.

## Geographic Implementation Zones

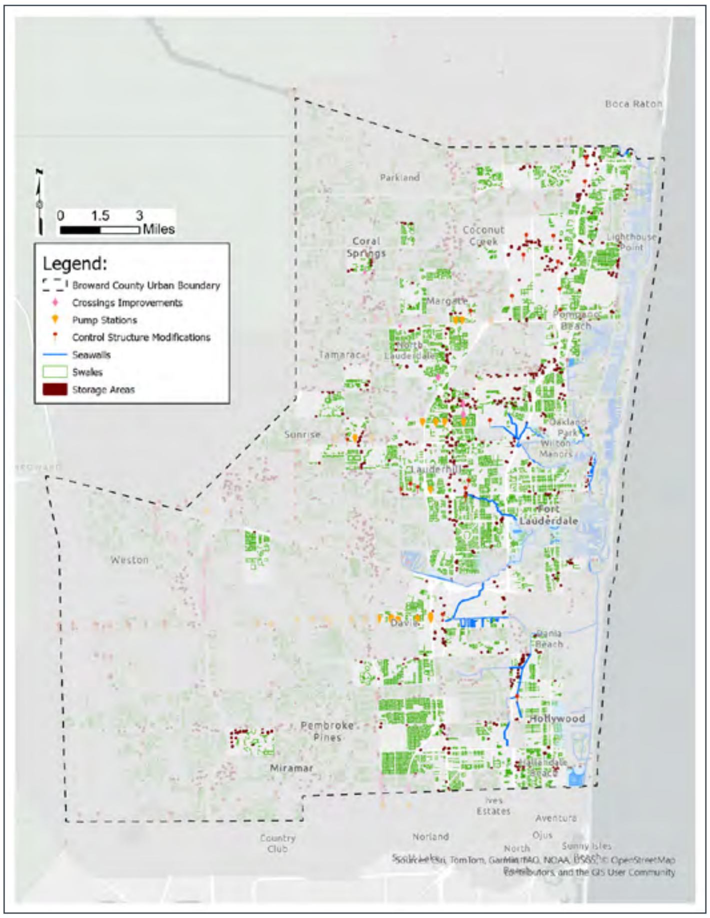
To ensure that adaptation measures are appropriately targeted, Broward County is divided into three geographic zones based on vulnerability and proximity to the coast. This zoning approach enables the County to deploy customized strategies to address the distinct resilience needs of each area.

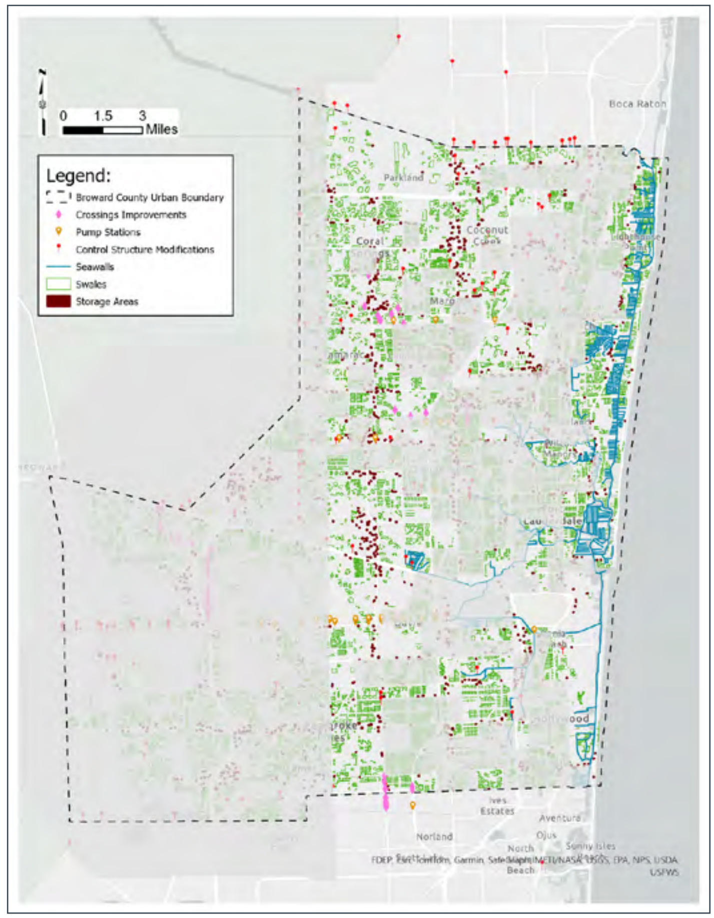
### Zone 1: Highly Vulnerable Areas

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

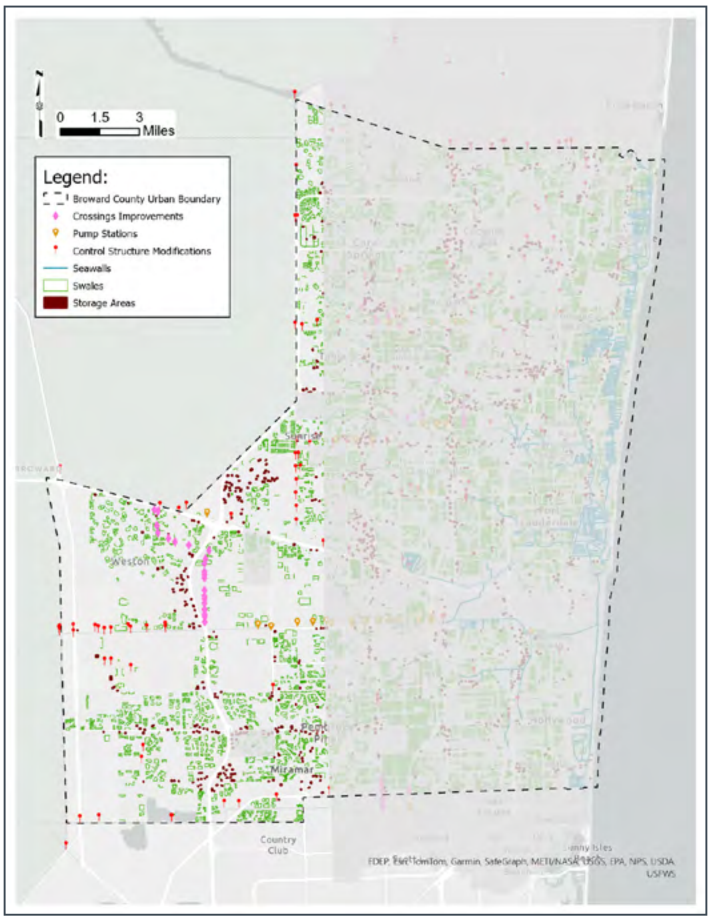
Eastern areas of the county are more influenced by SLR and storm surge.



## 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.

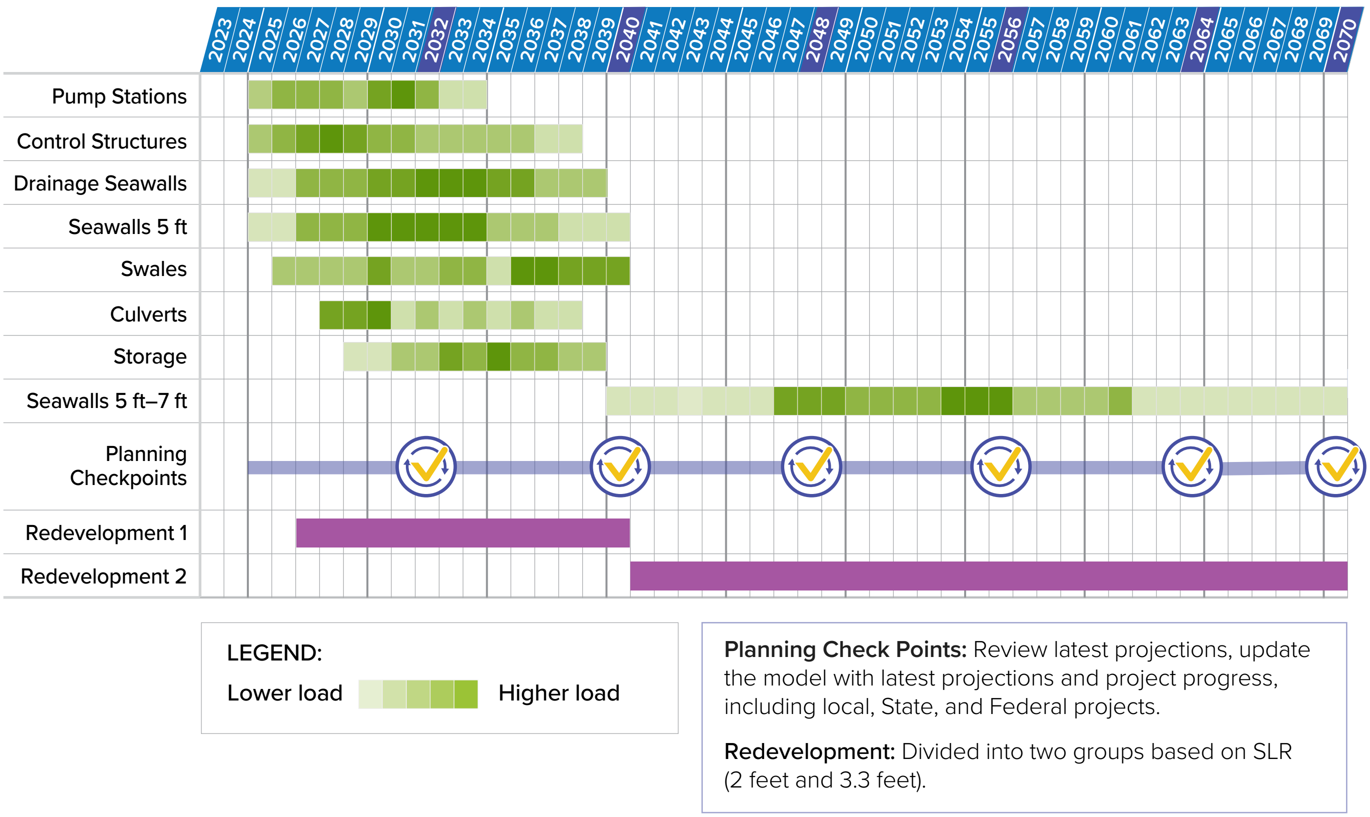
### Documentation and Reporting

- 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 configured 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 most vulnerable 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 specific 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 flood zones.

Elevating a building requires structural modifications to raise the foundation to the specified 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 offer 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 green 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 flow 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 flow. 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 sustainable 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 flood 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.

# GREEN INFRASTRUCTURE INCORPORATION

## Green Infrastructure Performance Targets

Green infrastructure (GI) 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 GI within the Resilience Plan ensures that these systems effectively contribute to the County's overall resilience. Clear performance targets for GI are especially important, as the sizing and design of GI to support flood mitigation and heat mitigation may differ from conventional GI sizing and design for water quality improvement.

Historically, GI 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 flood reduction, this runoff depth represents less than 15% of the current 10-year, 72-hour design storm. Consequently, conventional GI implementation will have limited utility in managing runoff from a tributary impervious area to relieve flooding. Conventional GI implementation can have a key impact on flood 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 GI designs. GI 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 GI 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 GI to manage a storm depth up to 2 inches can alleviate demands on existing drainage infrastructure with limited capacity.

GI 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. For GI that does not have capacity to manage runoff from at least 1 inch of rainfall, the cost and benefit of GI in relation to alternative approaches should be carefully considered.

Drainage relief provided by GI can be enhanced by providing adaptations to conventional GI design, particularly through implementation of a controlled drainage mechanism. Bioretention, a common GI 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 overflow structure. This configuration can be problematic for GI 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 from GI can be tailored to maximize the use of GI 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 GI. 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 other GI 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 specific 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.

GI 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 GI 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 GI. Creating metrics that apply to all GI projects will enable the County to compare their various choices and select the GI that best suits their needs and environment.

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

### Stormwater Management

- Volume of runoff absorbed by GI 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 floodplain 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 GI projects that create potential habitats for animals.
- Percentage of native plants used in GI project.

### Community Engagement and Education

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

### Economic and Social Benefits

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

# EVALUATION OF SOCIOECONOMIC STRATEGIES

Ensuring equitable treatment of diverse socioeconomic residences in Broward County requires a multifaceted approach that addresses the unique vulnerabilities and needs of different communities. This Plan considered hydrologic impacts to socially vulnerable communities and ensured that adaptations were specifically considered for these areas. Further, the Plan recommends the following continued strategies:

### Inclusive Community Engagement

- **Participatory Planning**: Involve residents from all socioeconomic 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 and culturally relevant materials to reach diverse communities.

### Equitable Infrastructure Investments

- **Targeted Funding**: Allocate resources to upgrade infrastructure in underserved areas, such as improving drainage systems, building flood barriers, and enhancing public transportation.
- **Green Infrastructure**: Implement GI projects like rain gardens, permeable pavements, and urban forests in low-income neighborhoods to reduce flood risks and improve environmental quality.

### 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 diverse communities. Ensure that shelters and emergency services are accessible to all residents.

### Economic Opportunities and Workforce Development

- **Job Training**: Offer training programs in green jobs and resilience-related fields to create economic opportunities for low-income 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.

### Policy and Advocacy

- **Equity-Focused Policies**: Advocate for local and State policies that prioritize equity in climate adaptation and resilience planning. This includes zoning laws, building codes, and funding allocations.
- **Community Representation**: Ensure that diverse communities are represented in decision-making bodies and advisory committees related to climate resilience.

By implementing these strategies, Broward County can promote equitable treatment of all residents, ensuring that the benefits of resilience planning are shared across diverse socioeconomic groups.

# POTENTIAL FUNDING STRATEGIES

Sustainable 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 offer 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 specific 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 sustainable 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 fish 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 specific 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.

#### Resilience Bond

This bond is a type of green bond because it would be pledged to finance specific climate resilient projects. Resilience bonds are attractive to investors who want to support certain impactful investments. The bond terms and processes are like traditional municipal bonds.

## 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 equitable 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 effectively to improve transportation infrastructure and enhance the overall resilience of the County.

# FINANCE PLAN

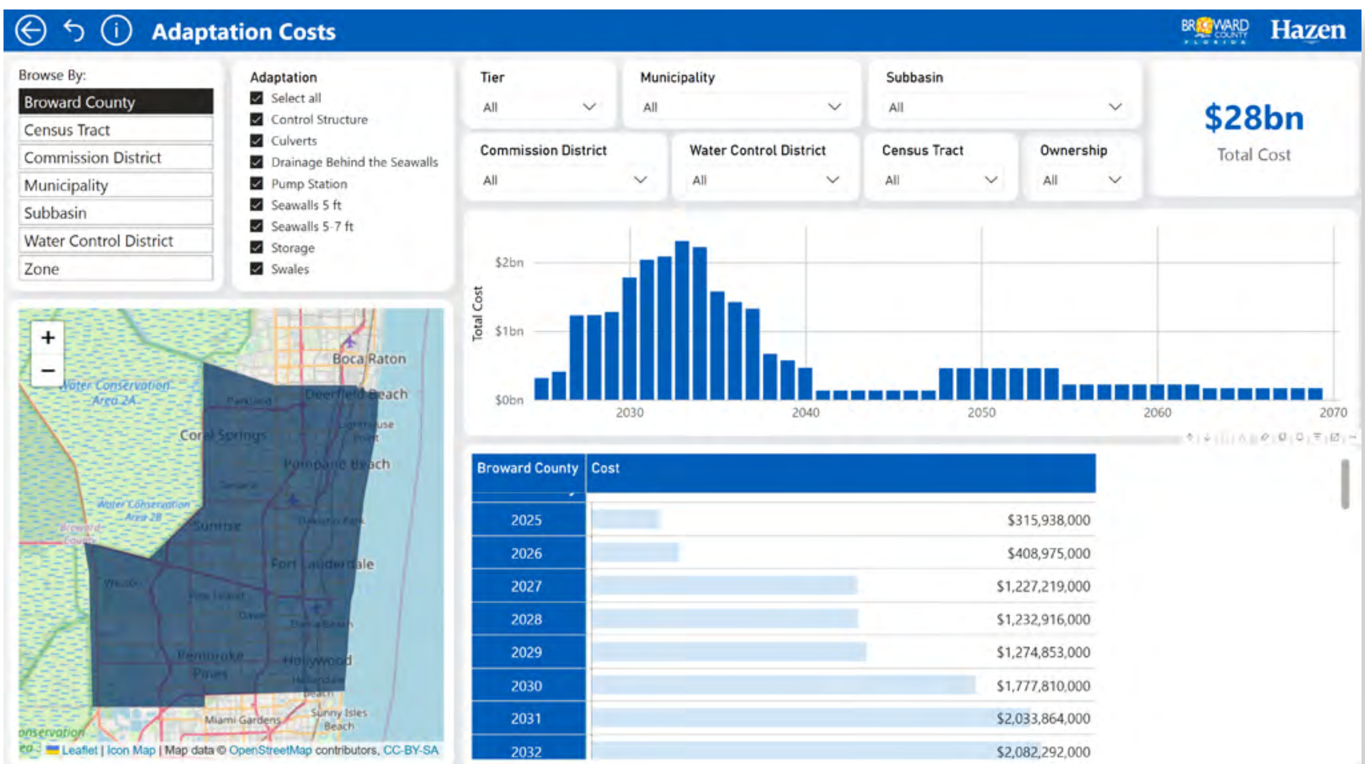
**The economic feasibility analysis demonstrated that the present value benefits of the County's Resilience Plan is greater than the present value of its costs.** The benefits included were avoided property damage, avoided reductions in economic activity within the county, and avoided reductions in property 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 sustainable 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 sustainable and 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.

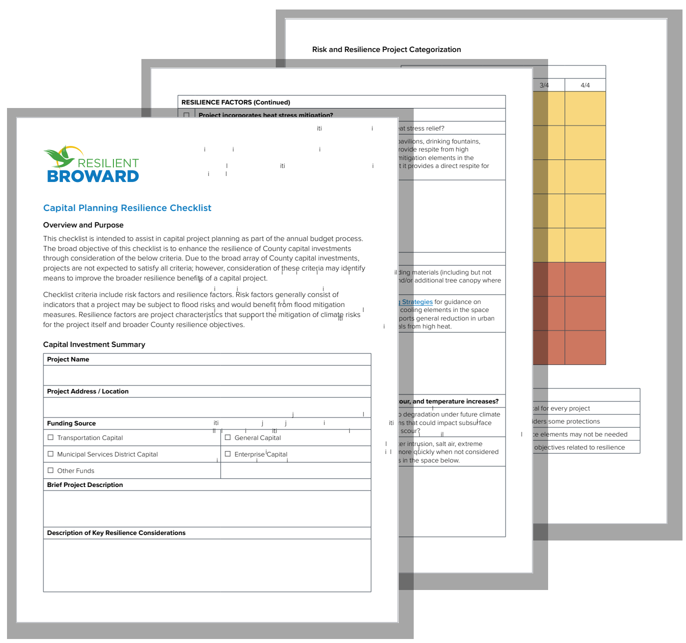
The checklist criteria include risk factors and resilience factors. Risk factors are indicators that a project may be subject to flood risks and would benefit from flood mitigation measures. Resilience factors are project characteristics that support the mitigation of climate risks for the project itself 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. |

See Appendix H for the Broward Resilience Capital Planning Checklist.



# 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, green 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 benefits to be worthwhile. The County will work to ensure that the investments are properly prioritized to achieve the highest possible benefits.

# 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 flood 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.

Flavelle (2021). Why Does Disaster Aid Often Favor White People? Available at: https://www.nytimes.com/2021/06/07/climate/FEMA-race-climate.html

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 effect 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

National Low Income Housing Coalition; FEMA Social Vulnerability Index

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 effects 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 Affect People of Low Socioeconomic Status. Available at: https://www.samhsa.gov/sites/default/files/dtac/srb-low-ses_2.pdf

Tellman et al., (2020). Using Disaster Outcomes to Validate Components of Social Vulnerability to Floods: Flood Deaths and Property Damage Across the USA. Available at: https://www.mdpi.com/2071-1050/12/15/6006

Urban Land Institute (2020) The Business Case for Resilience in Southeast Florida: Regional Benefits 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 effects 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/

# **Appendix A**: Resilience Steering Committee

The following individuals participated as Resilience Steering Committee members for the development of this Resilience Plan. The support, insight, and encouragement from these members was critical to the development of the Resilience Plan.

| | |
|---|---|
| Patty Archer | *President/CEO*<br>Miramar Pembroke Pines Regional Chamber of Commerce |
| Josie Bacallao | *President and CEO*<br>Hispanic Unity of Florida |
| Maribel Feliciano | *Assistant Director*<br>Office of Economic and Small Business Development |
| Shaheewa Jarrett Gelin | *Founder & President*<br>Broward County Black Chamber of Commerce |
| Keith Koenig | *Immediate Past Chair*<br>Broward Workshop |
| Dan Lindblade | *President and CEO*<br>Greater Fort Lauderdale Chamber of Commerce |
| Jean McIntyre | *President/CEO*<br>Greater Pompano Beach Chamber of Commerce |
| Julie Medley | *Executive Director*<br>Urban Land Institute - Southeast Florida/Caribbean |
| Ariadna Musarra | *Director*<br>Construction Management Division |
| Sheila Rose | *Deputy City Manager*<br>City of Coconut Creek |
| Jo Sesodia | *Director*<br>Urban Planning Division |
| Germaine Smith-Baugh, Ed.D. | *President and CEO*<br>Urban League of Broward County |
| Ken Stiles | *CEO and Board Director*<br>Stiles Corporation |
| Marie Suarez | *CEO/Executive Director*<br>Greater Hollywood Chamber of Commerce |
| Bob Swindell | *President and CEO*<br>Greater Fort Lauderdale Alliance |
| George Tablack | *Chief Financial Officer and Director*<br>Finance and Administrative Services Department |
| Richard Tornese | *Director*<br>Highway Construction and Engineering Division |
| Lenny Vialpando | *Chief Innovation Officer and Director*<br>Resilient Environment Department |

# **Appendix B**: Blue Ribbon Panel

The following individuals served as Blue Ribbon Panel members for internal reviews and input.  Their scientific feedback enhanced the development of the Resilience Plan.

| | |
|---|---|
| Jeffrey Hebert | HR&A Advisors |
| Jonathan Sandor Goldman | HR&A Advisors |
| Dr. Cheryl Holder | Florida International University, Florida Clinicians for Climate Action |
| Hugh Roberts | The Water Institute of the Gulf |
| Daniel Stander | Special Advisor to the United Nations / Good Alpha |
| Dr. Michael Sukop | Florida International University |

# **Appendix C**: Hydraulic Model Scenarios

| Scenario No. | Rainfall * | Sea Level Rise Scenario | Antecedent Condition | Tidal Condition |
|---|---|---|---|---|
| RP-1 | 25-yr | 2.0 ft | Variable GW | No Surge |
| RP-2 | 50-yr | 2.0 ft | Variable GW | No Surge |
| RP-3 | 100-yr | 2.0 ft | Saturated System* | No Surge |
| RP-4 | 25-yr | 2.0 ft | Variable GW | 20-yr Storm Surge |
| RP-5 | 50-yr | 2.0 ft | Variable GW | 20-yr Storm Surge |
| RP-6 | 100-yr | 2.0 ft | Saturated System | 20-yr Storm Surge |
| RP-7 | 25-yr | 2.0 ft | Variable GW | 100-yr Storm Surge |
| RP-8 | 50-yr | 2.0 ft | Variable GW | 100-yr Storm Surge |
| RP-9 | 100-yr | 2.0 ft | Saturated System | 100-yr Storm Surge |
| RP-10 | 25-yr | 3.3 ft | Variable GW | No Surge |
| RP-11 | 50-yr | 3.3 ft | Variable GW | No Surge |
| RP-12 | 100-yr | 3.3 ft | Saturated System* | No Surge |
| RP-13 | 25-yr | 3.3 ft | Variable GW | 20-yr Storm Surge |
| RP-14 | 50-yr | 3.3 ft | Variable GW | 20-yr Storm Surge |
| RP-15 | 100-yr | 3.3 ft | Saturated System | 20-yr Storm Surge |
| RP-16 | 25-yr | 3.3 ft | Variable GW | 100-yr Storm Surge |
| RP-17 | 50-yr | 3.3 ft | Variable GW | 100-yr Storm Surge |
| RP-18 | 100-yr | 3.3 ft | Saturated System* | 100-yr Storm Surge |
| RP-19 | 3-day 10-yr + 20% | 2.0 ft | Variable GW | No Surge |
| RP-20 | 3-day 10-yr + 20% | 2.0 ft | Variable GW | 20-yr Storm Surge |
| RP-21 | 3-day 10-yr + 20% | 2.0 ft | Variable GW | 100-yr Storm Surge |
| RP-22 | 3-day 10-yr + 20% | 3.3 ft | Variable GW | No Surge |
| RP-23 | 3-day 10-yr + 20% | 3.3 ft | Variable GW | 20-yr Storm Surge |
| RP-24 | 3-day 10-yr + 20% | 3.3 ft | Variable GW | 100-yr Storm Surge |
| RP-28 | 1-yr | Current | Variable GW | No Surge |

| Scenario No. | Rainfall * | Sea Level Rise Scenario | Antecedent Condition | Tidal Condition |
|---|---|---|---|---|
| RP-29 | 2-yr | Current | Variable GW | No Surge |
| RP-30 | 5-yr | Current | Variable GW | No Surge |
| RP-31 | 0 | 2.0 ft | Saturated | 100-yr Storm Surge |
| RP-32 | 0 | 3.3 ft | Saturated | 100-yr Storm Surge |
| RP-33 | 1-yr | 2.0 ft | Variable GW | No Surge |
| RP-34 | 2-yr | 2.0 ft | Variable GW | No Surge |
| RP-35 | 5-yr | 2.0 ft | Variable GW | No Surge |
| RP-36 | 1-yr | 3.3 ft | Variable GW | No Surge |
| RP-37 | 2-yr | 3.3 ft | Variable GW | No Surge |
| RP-38 | 5-yr | 3.3 ft | Variable GW | No Surge |
| RP-40 | 1-yr | Current | Variable GW | 20-yr Storm Surge |
| RP-41 | 10-yr | Current | Variable GW | 20-yr Storm Surge |
| RP-42 | 25-yr | Current | Variable GW | 20-yr Storm Surge |
| RP-43 | 50-yr | Current | Variable GW | 20-yr Storm Surge |
| RP-44 | 100-yr | Current | Saturated | 20-yr Storm Surge |
| RP-45 | 1-yr | Current | Variable GW | 100-yr Storm Surge |
| RP-46 | 10-yr | Current | Variable GW | 100-yr Storm Surge |
| RP-47 | 25-yr | Current | Variable GW | 100-yr Storm Surge |
| RP-48 | 50-yr | Current | Variable GW | 100-yr Storm Surge |
| RP-49 | 100-yr | Current | Saturated System* | 100-yr Storm Surge |
| RP-50 | 1-yr | 2.0 ft | Variable GW | 20-yr Storm Surge |
| RP-51 | 1-yr | 3.3 ft | Variable GW | 20-yr Storm Surge |

# **Appendix D**: Conceptual Representations

## Edgar Mills Multi-Purpose Center

***Concept Overview***




**Conceptual Solution**

The proposed concept design integrates a multi-faceted approach to enhance both flood and heat resiliency. A cool roof system helps mitigate heat, while a rainwater harvesting system captures and stores water for reuse, reducing runoff. Permeable pavement facilitates ground infiltration, easing stormwater management. Interconnecting existing ponds balances water levels to prevent flooding, and the installation of backflow preventers and larger outfall pipes ensures effective drainage during heavy rainfall and North Fork New River. Together, these solutions create a robust, resilient urban environment.

**Site Size:** 3.2 Acres
**SLR:** 2 ft
**Rain:** 25-yr/3-day
**Assumed FFE:** 8.2 ft (NAVD)
**SHGW:** 4.0 ft (NAVD)

**Site Characteristics:**
- 68% impervious
- Existing berm around property
- Outfall to water body
- Multi-level- Parking Structure

**Target Site Volume**
- 25-yr/ 3-day Rainfall: 0.80 MGal
- 100-yr/3-day Rainfall: 1.1 MGal

**Concept Elements**
- Rain harvesting system
- Cool Roof
- Permeable Pavement
- Backflow Preventor
- Bioretention
- Drainage resize

Countywide Risk Assessment and Resilience Plan (DRAFT)

Sheet 1 | May 2024

Conceptual Overview – Not for Construction

# Proposed Solution Details – Edgar Mills Multi-Purpose Center

## Site Description:

The Edgar Mills Multi-Purpose Center serves as a community hub, multi-purpose facility providing services such as health services, job training, and social support programs. The site is comprised of a multi-level main building and a multi-level parking structure, surrounded by paved access roads and additional parking areas. Existing stormwater management infrastructure includes a dry detention pond, infiltration trenches, and a perimeter berm. Runoff is directed to the North Fork New River through an outfall system.

Hydraulic models simulating a 25-year storm event, with a projected 2-foot sea level rise (SLR), indicate flooding risks on the northern part of the site near the parking structure and along the southern boundary adjacent to the North Fork New River. Additionally, the extensive concrete surfaces, parking lots, and dark roofs intensify the urban heat island effect by absorbing and retaining solar energy, leading to elevated temperatures around the site, especially during hot weather.

## Stormwater Management Solutions

**Rainwater harvesting system**

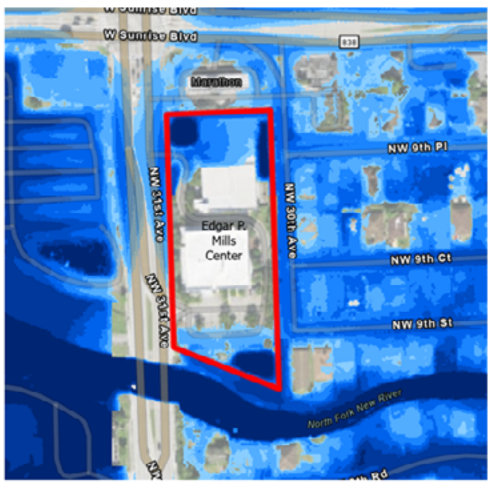
- Total Area: 22,000 ft$^2$
- Designed to manage 40,000 gal. of runoff volume

**Permeable Pavement**

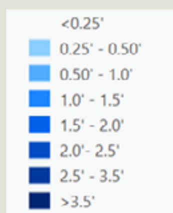
- Total Area: 20,000 ft$^2$
- Designed to manage up to 14% of the 25-year, 72-hour storm event.

**Storage Collection and Interconnectivity**

- Interconnect existing pond system and drainage for storage balance
- Increase outfall pipe size
- Add backflow preventor valve on outfall




Flood depth model results for a 25-yr. storm with a projection of 2 ft SLR




## Heat Impact Reduction Solutions

| | Cool Roofs |
|---|---|
| **Cooling Impact** | Reduces heat by reflecting solar radiation |
| **Energy Savings** | Immediate energy cost reduction |
| **Environmental Impact** | Limited to reducing heat island effect |
| **Maintenance** | Low (occasional cleaning) |
| **Structural Constraints** | Lighter, easier to implement |

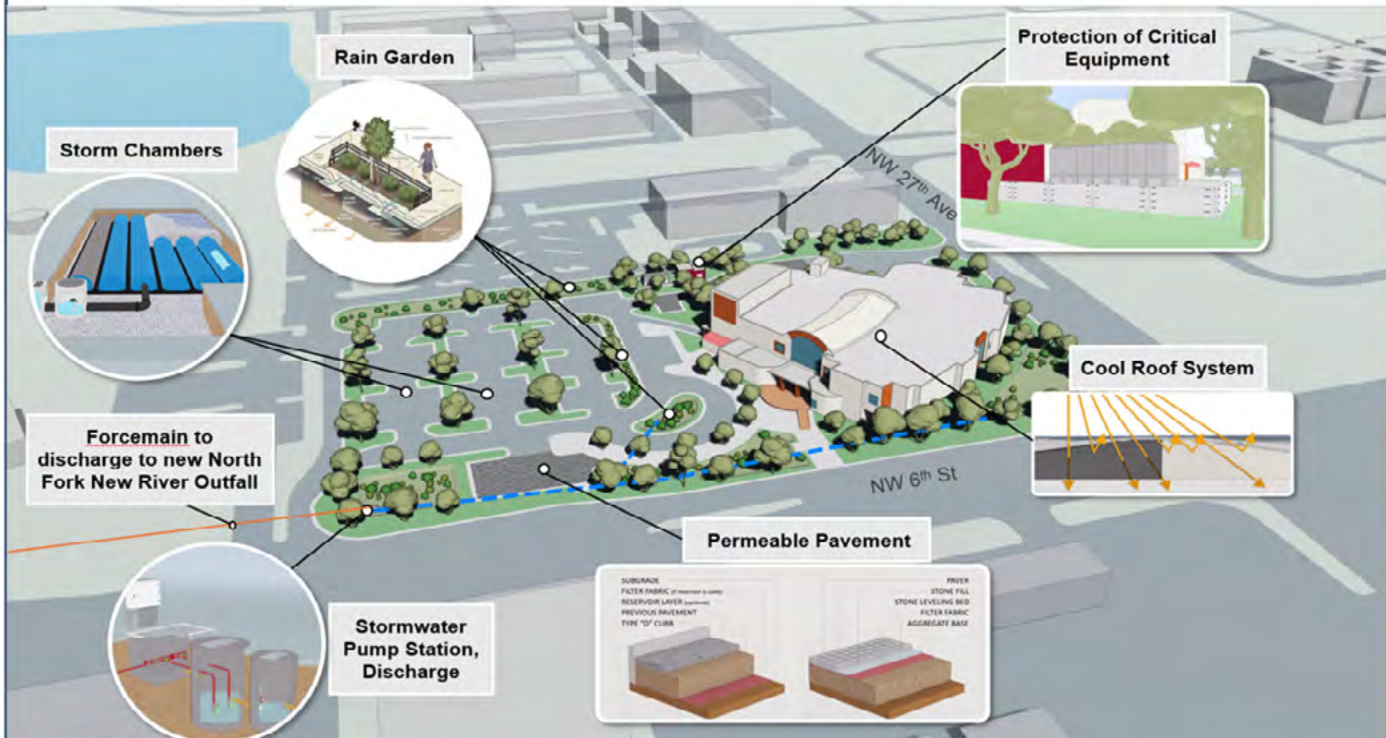
- Additional tree planting throughout the parking lot and around the building will provide shade to large impervious surfaces, further reducing heat buildup and enhancing site aesthetics.

**Total Roof Area** 18,000 ft$^2$

RESILIENT BROWARD Hazen 2

# African American Library

## *Concept Overview*





### Conceptual Solution

The proposed design for the African American Library enhances flood resilience and sustainability with a cool roof to reduce heat, permeable pavement for ground infiltration, and storm infiltration chambers with a pump station to manage excess water faster. Utilizing Delevoe Park as a retention area before discharging to the North Fork New River further supports flood control and water quality. Flood walls and elevated protection for critical equipment add resilience for larger, less frequent events.

**Site Size:** 4.2 Acres
**SLR:** 2 ft
**Rain:** 25-yr/72-hr
**Assumed FFE:** 7.2 ft (NAVD)
**SHGW:** 3.0 ft (NAVD)

**Site Characteristics:**
- 88% impervious
- Large asphalted parking area
- Proximity to Delevoe Park
- Two-level building

**Target Site Volume**
- 25-yr/72-hr Rainfall: 1.3 MGal
- 100-yr/72-hr Rainfall: 1.8 MGal

**Concept Elements**
- Cool Roof
- Permeable Pavement
- Pump Station
- Infiltration Chambers
- Bioretention
- Flood Walls

Countywide Risk Assessment and Resilience Plan (DRAFT)

Hazen

Sheet 3 | May 2024

Conceptual Overview – Not for Construction

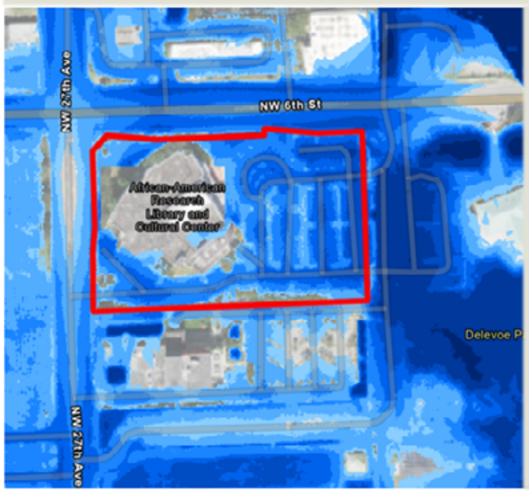
# Proposed Solution Details – African American Library

## Site Description:

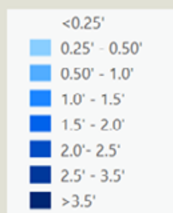
Located in Fort Lauderdale, the African American Library is a significant cultural resource, housing over 1 million items related to African, African-American, and Caribbean culture.

The site includes a two-story main building and an extensive, highly impervious parking area, which contributes to substantial runoff during rainfall events. Ground water levels are high in the site limiting the benefits of infiltration. Adjacent to Delevoe Park, the library could benefit from some additional flood management capacity.

Hydraulic models indicate that the entire parking lot is susceptible to flooding during a 25-year storm event. Additional flood protection measures will be necessary to safeguard the building and its valuable collections from larger or more intense storms. The extensive impervious surfaces, coupled with dark roofing and asphalt, exacerbate the urban heat island effect, leading to higher temperatures around the site during hot weather.




Flood depth model results for a 25-yr. storm with a projection of 2 ft SLR




## Stormwater Management Solutions

**Permeable Pavement**

- Convert Total Area: 13,800 $ft^2$
- Designed to manage up to 5% of the design storm event.

**Infiltration Chambers**

- Area of 5,000 ft2 of infiltration chambers were proposed to manage up to 5% of the design storm. Reduced benefit due to high GW levels.

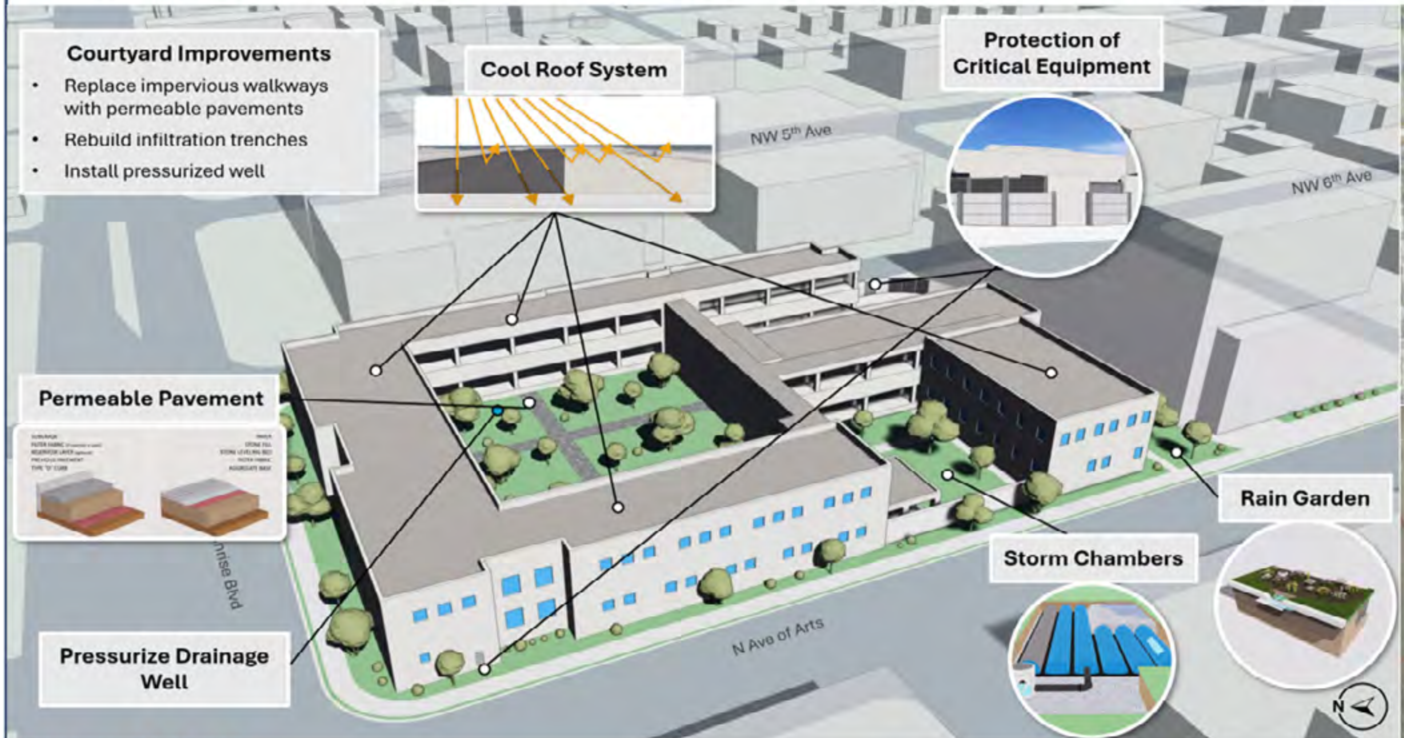
**Storage Collection and Interconnectivity**

- Interconnect existing retention system and drainage for storage balance and conveyance to new Pump Station.
- Convert 4,000 ft2 of parking to detention pond that convey to new PS.
- Add stormwater pump station to redirect excess runoff towards Delevoe Park with outfall to North Fork New River

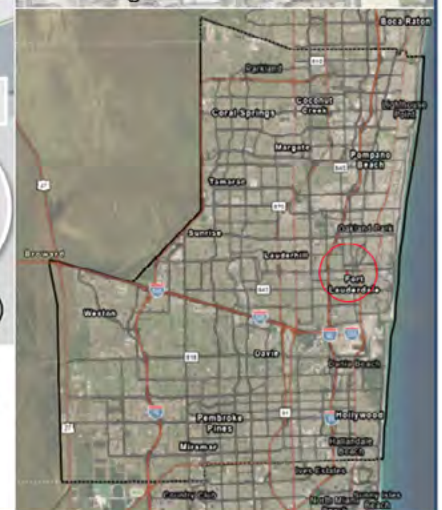
## Heat Impact Reduction Solutions

- A 20,000-square-foot cool roof is recommended on the main building, replacing the existing dark roofing. This cool roof will reduce heat absorption, lower the urban heat island effect. A structural assessment will be required to ensure the roof can support the additional load.
- Additional tree planting throughout the parking lot and around the building will provide shade to large impervious surfaces, further reducing heat buildup and enhancing site aesthetics.

# Central Homeless Assistance Center *Concept Overview*







**Conceptual Solution**

The proposed concept design for the Central Homeless Assistance Center enhances flood resilience and sustainability with a cool roof to reduce heat, permeable pavement and courtyard improvements for ground infiltration, and storm chambers to manage excess water. A pressurized drainage well further supports efficient water management, ensuring the site can withstand heavy rainfall. Modular floodproofing and elevated protection for critical equipment add resilience for larger, less frequent events.

**Site Size:** 2.4 Acres
**SLR:** 2 ft
**Rain:** 25-yr/72-yr
**Assumed FFE:** 7.2 ft (NAVD)
**SHGW:** 3.5 ft (NAVD)

**Site Characteristics:**
- 53% impervious
- Courtyard at center of the building.
- Two-level Structure
- Highly Urbanized Area

**Target Site Volume**
- 25-yr/72-hr Rainfall: 0.48 MGal
- 100-yr/72 hr Rainfall: 0.66 MGal

**Concept Elements**
- Cool Roof
- Storm Chambers
- Courtyard Improvements
- Pressurized Drainage Well
- Bioretention
- Drainage resize
- Modular floodproofing
- Permeable Pavement

Countywide Risk Assessment and Resilience Plan (DRAFT)

Broward County Florida | Hazen

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Conceptual Overview – Not for Construction

## Proposed Solution Details – Central Homeless Assistance Center

### Site Description:

The Central Homeless Assistance Center is a facility providing shelter, health services, and social support to the local homeless population. The site consists of a two-level, closed concrete building with an interior courtyard. Existing stormwater management infrastructure includes infiltration trenches and catch basins, which channel runoff to an adjacent property to the south. The system is old and require However, the limited outdoor space and the fully enclosed design increase the site's vulnerability to heat retention and potential runoff challenges.

Hydraulic models for a 25-year storm event indicate potential flooding risks around the property, mostly below 6" of flood depth concentrating in the courtyard area. Concrete surfaces of the building contribute to the urban heat island effect by absorbing and retaining solar energy, which raises temperatures within the site, especially during hot weather.


Flood depth model results for a 25-yr. storm with a projection of 2 ft SLR

### Stormwater Management Solutions

**Rainwater harvesting system**

- Total Area: 9,500 $ft^2$
- Designed to manage up to 40,000 gal. of runoff volume

**Storage Collection and Interconnectivity**

- Add pressurized drainage well in the courtyard area, re-grading
- Add infiltration chambers under the playground area.

**Bioswales and Rain Gardens**

- Total Area: 12,400 $ft^2$ around the property, including the entrance and courtyard areas.
- Designed to manage 17,000 gal. of runoff volume

- Dry proof Building with modular flood barriers at entrances.

### Heat Impact Reduction Solutions

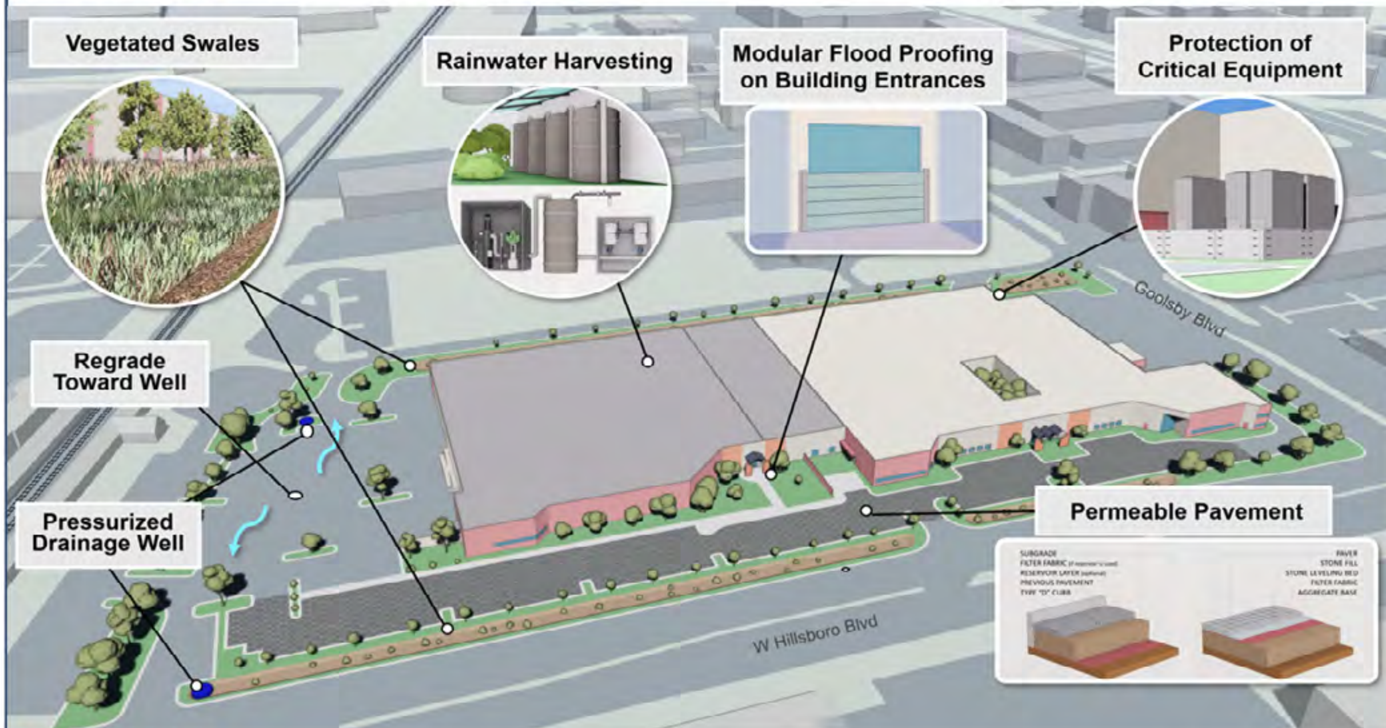
| | Cool Roofs |
|---|---|
| **Total Area** | 32,000 $ft^2$ |
| **Cooling Impact** | Reduces heat by reflecting solar radiation |
| **Energy Savings** | Immediate energy cost reduction |
| **Environmental Impact** | Limited to reducing heat island effect |
| **Maintenance** | Low (occasional cleaning) |
| **Structural Constraints** | Lighter, easier to implement |

- Additional tree planting throughout the parking lot and around the building will provide shade to large impervious surfaces, further reducing heat buildup and enhancing site aesthetics.

RESILIENT BROWARD Hazen 6

# North Regional Court House

## *Concept Overview*






**Conceptual Solution**

The proposed design for the North Regional Court House, a highly impervious area, emphasizes flood resilience and efficient stormwater management. Vegetated swales and regrading toward a pressurized drainage well facilitate water flow and infiltration, while a rainwater harvesting system captures runoff for reuse. Modular floodproofing at entrances and permeable pavement reduce flood risks and enhance resilience against heavy rains. Cool roofs mitigate heat, and protection for critical equipment ensures functionality during extreme weather.

**Site Size:** 10.0 Acres
**SLR:** 2 ft
**Rain:** 25-yr/72-hr
**Assumed FFE:** 15.5 ft (NAVD)
**SHGW:** 3.0 ft (NAVD)

**Site Characteristics:**
- 84% impervious
- Large roof area
- Urbanized Areas

**Target Site Volume**
- 25-yr/72-hr Rainfall: 3.1 MGal
- 100-yr/72-hr Rainfall: 4.3 MGal

**Concept Elements**
- Rain harvesting system
- Cool Roof
- Permeable Pavement
- Modular floodproofing
- Bioretention
- Pressurized Drainage Well

Countywide Risk Assessment and Resilience Plan (DRAFT)

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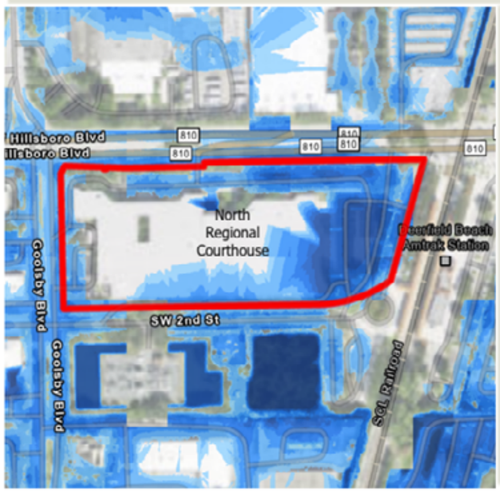
Conceptual Overview – Not for Construction

## Proposed Solution Details – North Regional Court House

### Site Description:

The North Regional Court House is a 189,414-square-foot facility (approximately 4.35 acres), situated on a 10-acre site with 84% impervious coverage. The large roof area presents an opportunity for stormwater and heat mitigation; however, structural assessments indicate that a green roof may not be feasible. Existing drainage challenges are evident, as hydraulic models for a 25-year storm event show flooding risks in the western parking lot. To address the urban heat island effect, alternative heat mitigation strategies are needed, focusing on reducing heat buildup across the extensive paved surfaces and parking areas. Enhancing on-site stormwater management and implementing targeted heat reduction measures will improve resilience and sustainability while minimizing impacts on the surrounding community.




Flood depth model results for a 25-yr storm with a projection of 2 ft SLR

- <0.25'
- 0.25' - 0.50'
- 0.50' - 1.0'
- 1.0' - 1.5'
- 1.5' - 2.0'
- 2.0'- 2.5'
- 2.5' - 3.5'
- >3.5'

### Stormwater Management Solutions

**Rainwater harvesting system**
- Total Area: 40,000 $ft^2$
- Designed to manage 40,000 gal. of runoff volume

**Permeable Pavement**
- Total Area: 13,800 $ft^2$
- Designed to manage up to 2% of the 25-year, 72-hour storm event

**Storage Collection and Interconnectivity**
- Interconnect existing pond system and outfall for storage balance
- Add two pressurized drainage wells

**Bioswales and Rain Gardens**
- Total Area: 14,000 $ft^2$
- Designed to manage 8,700 gal. of runoff

### Heat Impact Reduction Solutions

- A 20,000-square-foot cool roof system is recommended to be installed on the main building, replacing the existing dark roofing.
- Additional tree planting throughout the parking lot and around the building will provide shade to large impervious surfaces, further reducing heat buildup and enhancing site aesthetics.

RESILIENT BROWARD
Hazen
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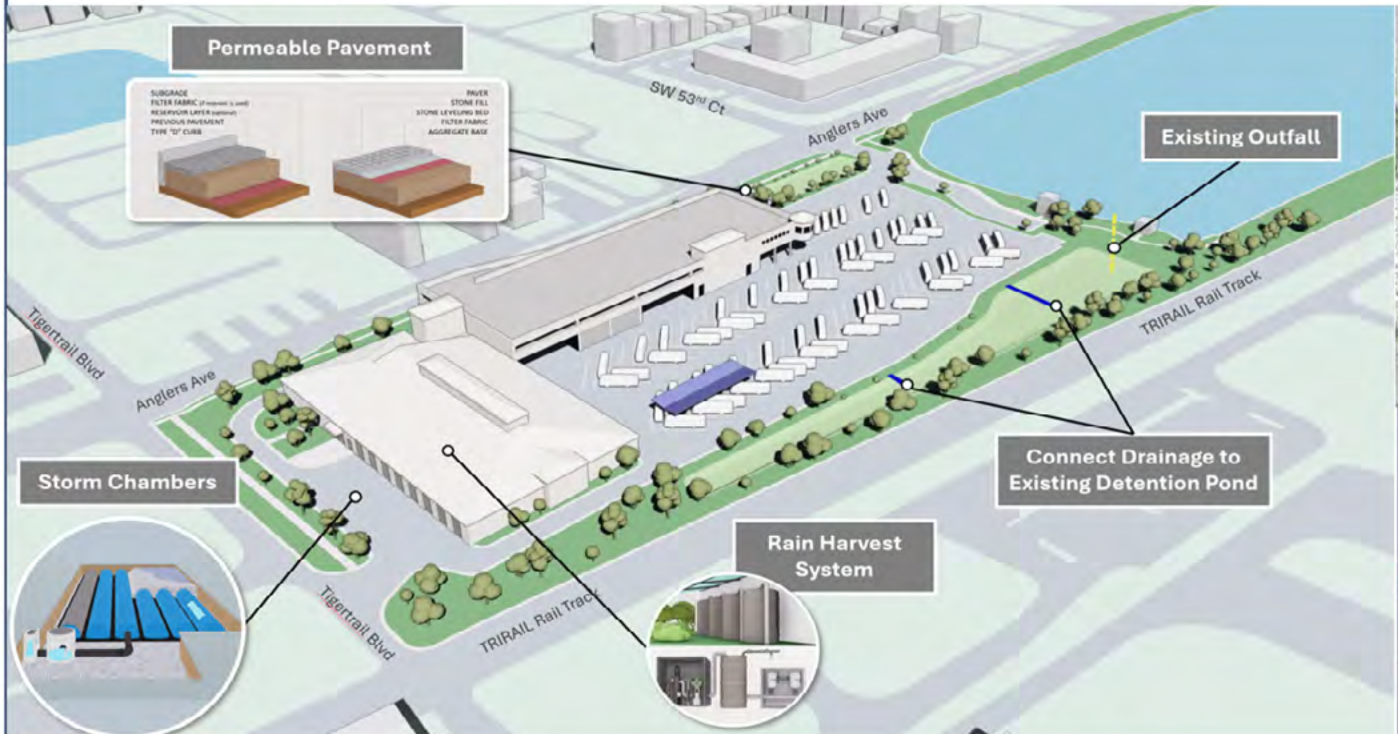
# South Mass Transit

## *Concept Overview*




**Conceptual Solution**

The proposed design for the South Mass Transit site incorporates resilient stormwater management and sustainability features to handle high impervious surfaces and potential contaminated runoff. Storm chambers manage runoff and promote infiltration, reducing flood risks. A rain harvesting system captures water for reuse, while connecting drainage to an existing detention pond and outfall enhances the site's water management capacity. These elements, along with strategic bioretention areas, support a robust system that mitigates flood risks and improves environmental sustainability for this high-traffic transit location.

**Site Size:** 9.1 Acres
**SLR:** 2 ft
**Rain:** 25-yr/72-hr
**Assumed FFE:** 7.6 ft (NAVD)
**SHGW:** 2.5 ft (NAVD)

**Site Characteristics:**

- 71% impervious
- Large Parking Area
- Possible Contaminated Runoff
- Multi-level- Parking Structure

**Target Site Volume**

- 25-yr/72-hr Rainfall: 2.3 MGal
- 100-yr/72-hr Rainfall: 3.4 MGal

**Concept Elements**

- Rain harvesting system
- Permeable Pavement
- Infiltration Chambers
- Maintenance/refurbish Bioretention area
- Drainage connectivity

Countywide Risk Assessment and Resilience Plan (DRAFT)

BROWARD COUNTY FLORIDA | Hazen

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Conceptual Overview – Not for Construction

## Proposed Solution Details – South Mass Transit

### Site Description:

The South Mass Transit site is a recently redeveloped bus maintenance facility designed to accommodate increased operational capacity. The facility includes a 60,000-square-foot maintenance building, a 13,000-square-foot fueling and washing area, and a three-story parking garage with 268 spaces. Existing stormwater management infrastructure consists of detention areas located in the northeast and northwest corners of the site on Florida Power & Light (FPL) right-of-way (ROW) land, with an outfall discharging toward Tigertail Lake.

Hydraulic models for a 25-year storm event indicate that the current detention areas may be adequate for typical rainfall, but additional measures may be needed to handle larger storm events and account for future climate impacts. The extensive impervious surfaces, including the parking garage and paved maintenance areas, contribute to the urban heat island effect, intensifying surrounding temperatures.

### Stormwater Management Solutions

**Rainwater harvesting system**

- Total Area: 32,500 $ft^2$, designed to manage up to 40,000 gal. of runoff volume

**Storage Collection and Interconnectivity**

- Interconnect existing detention system and drainage for storage balance
- Add infiltration chambers to promote groundwater recharge.

**Bioswales and Rain Gardens**

- Total Area: 50,000 $ft^2$
- Designed to manage 31,000 gal. of runoff volume


Flood depth model results for a 25-yr. storm with a projection of 2 ft SLR

| |
|---|
| <0.25' |
| 0.25' - 0.50' |
| 0.50' - 1.0' |
| 1.0' - 1.5' |
| 1.5' - 2.0' |
| 2.0'- 2.5' |
| 2.5' - 3.5' |
| >3.5' |

### Heat Impact Reduction Solutions

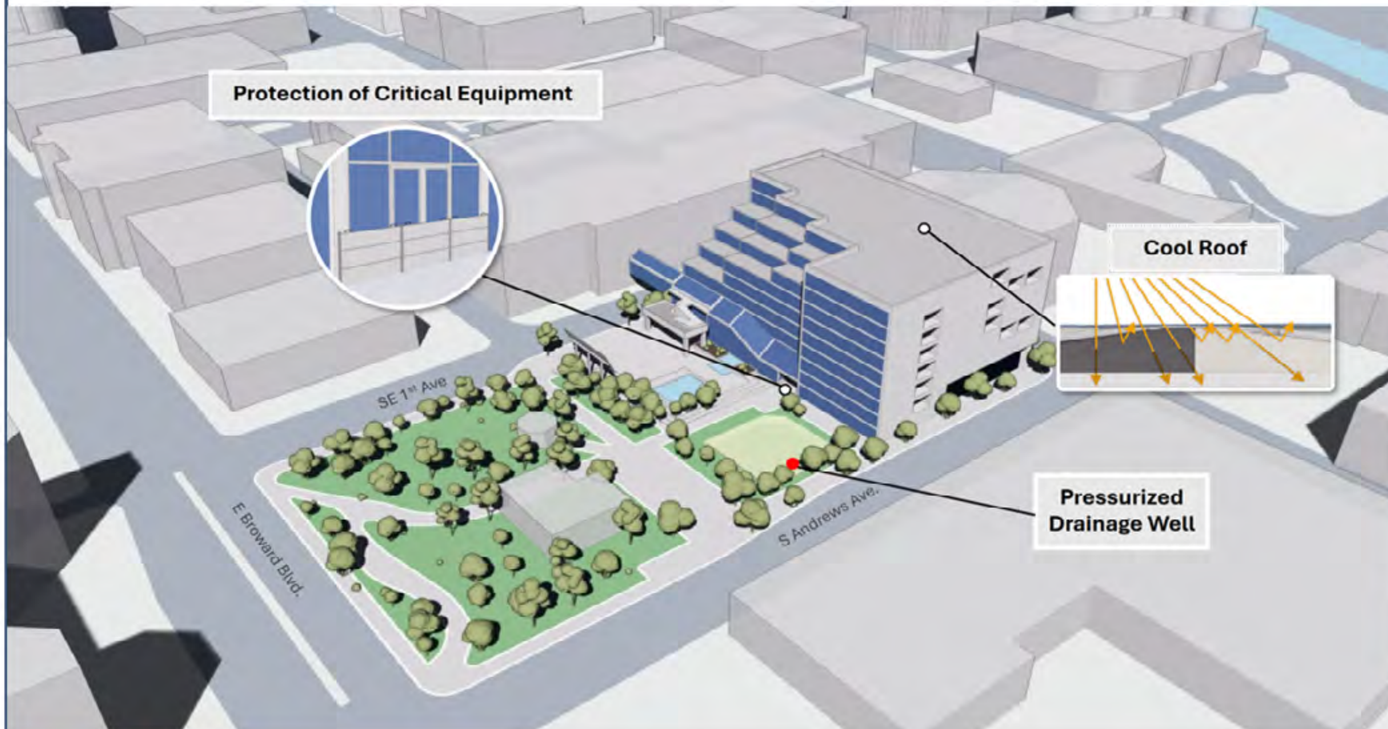
- Additional tree planting throughout the perimeter around the site building will provide shade to large impervious surfaces, further reducing heat buildup and enhancing site aesthetics.

RESILIENT BROWARD

Hazen

# Main Library

## *Concept Overview*




**Conceptual Solution**

The proposed concept for the Main Library enhances flood resilience and sustainability while preserving the existing design. A cool roof minimizes heat, and permeable pavement with a pressurized drainage well improves water management without significant alterations. Protection for critical equipment and modular floodproofing walls add further resilience, ensuring essential operations are safeguarded with minimal impact on the library's original layout.

**Site Size:** 1.8 Acres
**SLR:** 2 ft
**Rain:** 25-yr/72-hr
**Assumed FFE:** 6.1 ft (NAVD)
**SHGW:** 2.0 ft (NAVD)

**Site Characteristics:**
- 70% impervious
- Existing berm around property
- Highly Urban Setting
- Multi-level Structure

**Target Site Volume**
- 25-yr/72-hr Rainfall: 0.48 MGal
- 100-yr/72-hr Rainfall: 0.66 MGal

**Concept Elements**
- Cool Roof
- Pervious Pavement
- Backflow Preventor
- Modular floodproofing
- Bioretention
- Pressurized Drainage Well

Countywide Risk Assessment and Resilience Plan (DRAFT)

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Conceptual Overview – Not for Construction

## Proposed Solution Details – Main Library

### Site Description:

The Main Library, currently undergoing renovations, is in a highly urbanized area and serves as a major public resource and community space. The site consists of a multi-level building surrounded by paved surfaces, resulting in a high level of impervious coverage. Existing stormwater management infrastructure is limited, posing challenges for handling runoff effectively in this dense urban setting. Hydraulic models for a 25-year storm event indicate flooding risks around the site, and for larger flood elevations, dry proofing the building may be necessary to protect the structure and maintain accessibility. The recommendations for stormwater management and heat mitigation are designed to minimize disruption to the library's current design, focusing on targeted improvements that enhance resilience without altering the essential layout. Additionally, the extensive impervious surfaces and urban setting contribute to the heat island effect, increasing temperatures around the site, especially during hot weather

### Stormwater Management Solutions

**Storage Collection and Interconnectivity**

- Add pressurized drainage well
- Add berms to reduce sediment runoff

**Bioswales and Rain Gardens**

- Total Area: 10,000 $ft^2$
- Designed to manage 6,200 gal. of runoff volume.

**Dry Proof Building**

- Dry proof with modular flood barriers.

Site is currently undergoing renovations the proposed measures intent to not cause disruption to the site current design.


Flood depth model results for a 25-yr. storm with a projection of 2 ft SLR

| Legend |
|---|
| <0.25' |
| 0.25' - 0.50' |
| 0.50' - 1.0' |
| 1.0' - 1.5' |
| 1.5' - 2.0' |
| 2.0'- 2.5' |
| 2.5' - 3.5' |
| >3.5' |

### Heat Impact Reduction Solutions

| Total Area 29,000 $ft^2$ | Cool Roofs |
|---|---|
| Cooling Impact | Reduces heat by reflecting solar radiation |
| Energy Savings | Immediate energy cost reduction |
| Environmental Impact | Limited to reducing heat island effect |
| Maintenance | Low (occasional cleaning) |
| Structural Constraints | Lighter, easier to implement |

- Additional tree planting throughout the parking lot and around the building will provide shade to large impervious surfaces, further reducing heat buildup and enhancing site aesthetics.

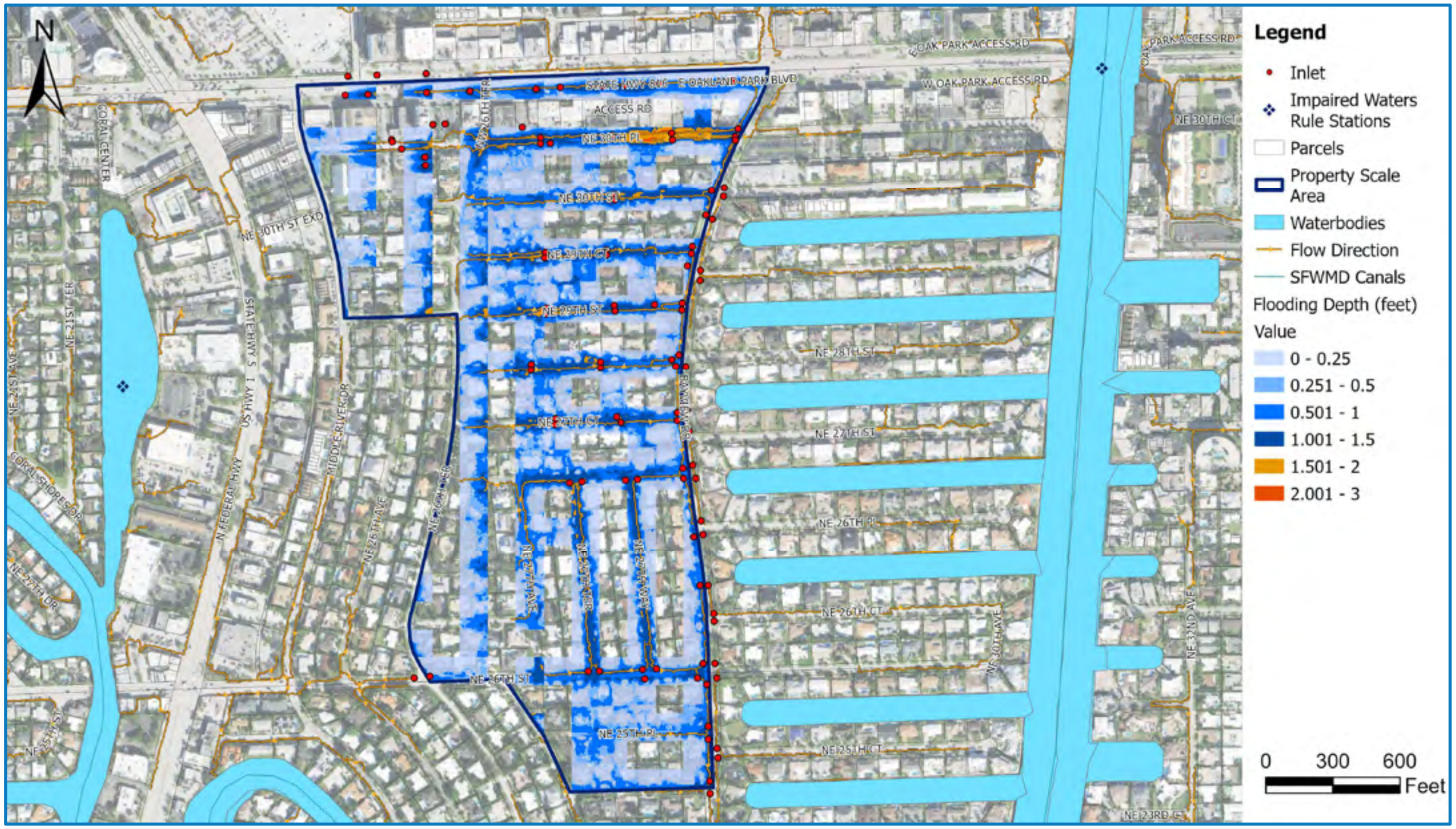
RESILIENT BROWARD  Hazen

# **Appendix E**: Property Scale Proposals

## #1

## Property Scale Proposal #1 – Fort Lauderdale

### Medium Density Residential and Commercial





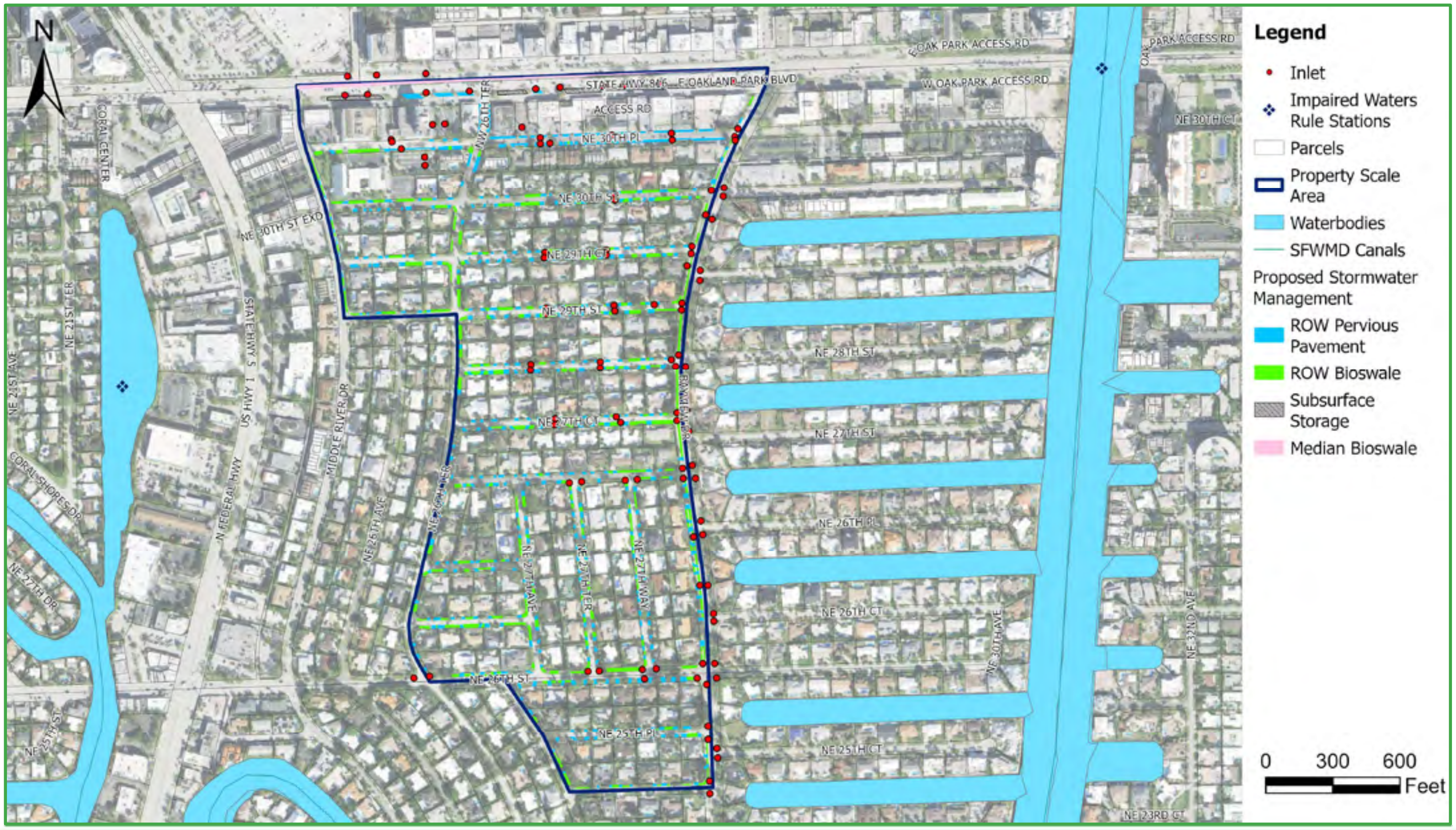
| Municipality | |
|---|---|
| Fort Lauderdale | |
| **Area** | |
| 96 acres | |
| **Imperviousness** | **Groundwater Depth** |
| 67% | 2.5 ft |
| **Target Design Storm Volume** | |
| 18.8 million gallons | |
| **Average Flooding Depth** | **Max Flooding Depth** |
| 0.5 ft | 2.4 ft |

**Existing Conditions**

This neighborhood is primarily single-family homes on large parcels. The northern portion of the neighborhood along E Oakland Park Boulevard and NE 30th Place has commercial property and multi-family homes. E Oakland Park Boulevard borders the neighborhood to the north and serves as a local thoroughfare road with a bus route. This community experiences frequent shallow flooding, and topography and drainage typically flows to the southeast. The 10-year, 72-hour storm event with a 2-foot level sea level rise condition creates wide-spread flooding through the neighborhood. Parcels typically experience <6 in of flooding while streets experience up to 3 feet of flooding in some pockets throughout the neighborhood.

# Property Solution Overview – Property Scale Proposal #1

## Short-Term Solution: Right-of-Way Green Infrastructure and Subsurface Storage





| Stormwater Volume Managed | |
|---|---|
| 2.0 million gallons | |
| **% Volume Reduction 10-yr, 72-hr** | **% Volume Reduction 10-yr, 24-hr** |
| 11% | 13% |
| **% Volume Reduction 5-yr, 24-hr** | **% Volume Reduction 2-yr, 2-hr** |
| 15% | 36% |
| **Conceptual Cost Estimate** | |
| $8,475,000 | |

**Proposed Solution Description**

This solution involves transforming current right-of-way (ROW) green space between the street and the sidewalk into shallow bioswales with a turf grass surface. Bioswales were sited to avoid major structures within the right-of-way (i.e. mailboxes, above ground utility boxes, trees, etc). Bioswales would have a shallow 3" depression in the middle to allow for short-term ponding. Driveways in-between the grassed bioswales are proposed as pervious pavement with opportunities to hydraulically connect systems with the underlying stone base and underdrains. A median bioswale along E Oakland Park Boulevard could be a good can be an ideal location for subsurface storage with stone layers created an increase in void space. Commercial parking lots that are in the ROW along E Oakland Boulevard could also provide an ideal location for subsurface storage and pervious pavement.

# Property Solution Details – Property Scale Proposal #1

## Short-Term Solution: Right-of-Way Green Infrastructure and Subsurface Storage



**Co-benefits**

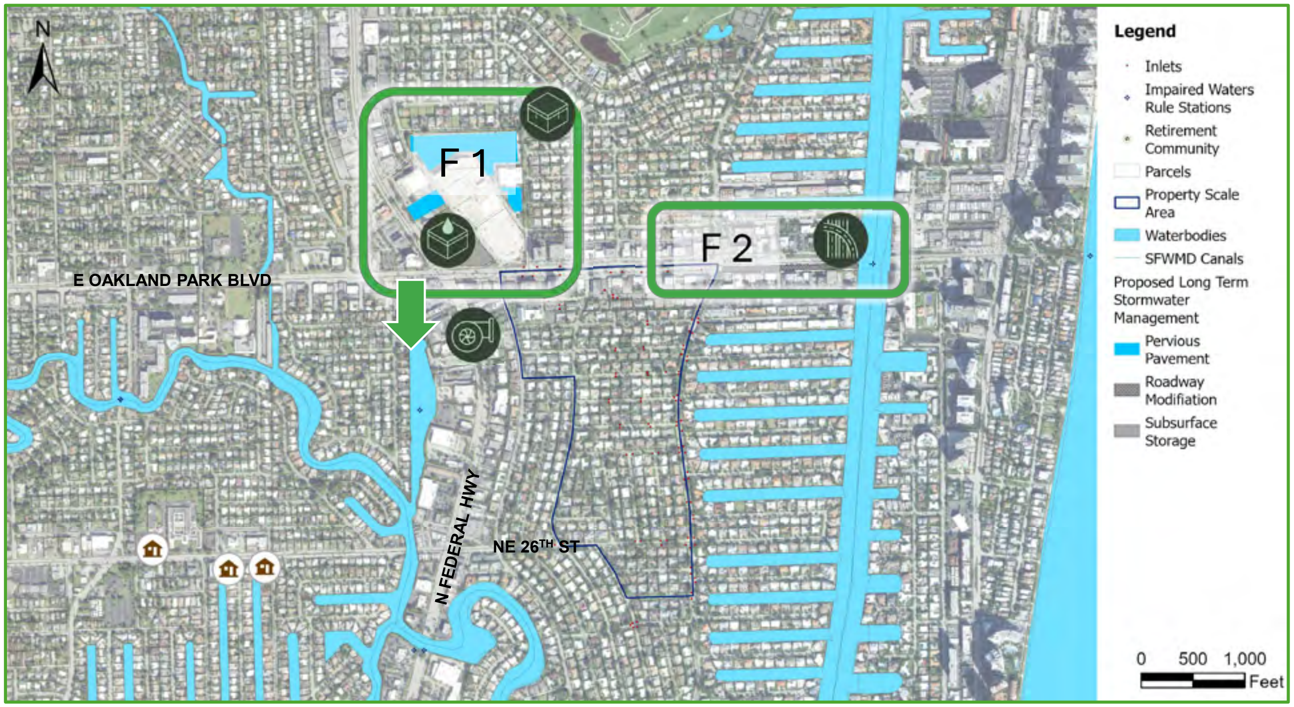
- Educational Outreach
- Improved Water Quality
- Neighborhood Enhancement

**Proposed Short-Term Solution**

Residential and commercial solutions considered options for addressing localized flooding, maximizing volume with limited space and reducing impacts to existing parking and neighborhood use. These concepts can be used in our parts of the County with similar right-of-way configurations and commercial areas and particularly in areas where impacts should be minimal in the short-term.

- Right-of-Way Bioswales
- Pervious Pavement
- Subsurface storage

# Proposed Solution Details - Property Scale Proposal #1
## Future Implementation Options




Pervious Pavement

Large Subsurface Storage

Pump Station

Roadway Modification

### Potential Additional Volume Managed
- ✓ F 1 – 3,443,803 gal
- ✓ F 2 – 1,091,762 gal

### Key Considerations
- ✓ Stakeholder Support
- ✓ Utility Relocation

### Future Implementation Strategy

*Additional stormwater management is necessary to mitigate larger flooding events and flooding. Future implementation strategies could provide centralized, large-scale stormwater management, which will require detailed feasibility analysis and coordination with stakeholders. These solutions would provide additional flood mitigation.*

**F 1**

One potential solution would be to construct subsurface retention/detention practices below the parking lot at Coral Ridge Mall at 3200 N Federal Highway. This solutions would require pump stations to route runoff from the project area, to the large-scale stormwater system, to then discharge to the canal south of E Oakland Park Boulevard. Additionally, pervious pavement could be implemented in the parking lot to reduce impervious area.

**F 2**

One solution northeast of the neighborhood would be to add an additional canal or stormwater management system, similar to the existing waterbodies. This would require removal of the green space along E Oakland Park Boulevard and within the median to shift the travel lanes of the roadway.

# Proposed Solution Details – Property Scale Proposal #1

## Metric Summary

### Rainfall and Coastal Conditions

*Multiple design storms were evaluated to illustrate the effectiveness of the water management adaptation conceptual strategies. The 10-year, 72-hour storm event is the basis for crown-of-road elevations. Smaller design storms were evaluated including the 2-year, 2-hour storm event, which FDOT frequently evaluates, to determine strategies' effectiveness during smaller, more frequent events.*

| Scenario | Rainfall Depth (in) | Storm Volume (gal) |
|---|---|---|
| 2-year, 2-hour | 3.19 | 5,539,481 |
| 5-year, 24-hour | 7.42 | 12,884,936 |
| 10-year, 24-hour | 9.07 | 15,750,185 |
| 10-year, 72-hour | 10.8 | 18,754,354 |

### Short-Term Solution Cost Estimate

| | Quantity | Unit Cost | Subtotal |
|---|---|---|---|
| Exfiltration/Bioswale | 119,278 ft² | $ 25.00 | $ 2,981,947.84 |
| Porous Pavement | 144,440 ft² | $ 30.00 | $ 4,333,204.54 |
| Subsurface Storage | 23,130 ft² | $ 50.00 | $ 1,156,489.18 |
| | | | **$ 8,471,641.56** |

*Conceptual cost estimate is variable depending on site conditions, utility constraints, additional restoration, improvements and design aspects including underdrains and expanded footprints.*

### Summary of Design

*Additional stormwater management is necessary to mitigate flooding. Long-term solutions could provide centralized, large-scale stormwater management, which will require detailed feasibility analysis and coordination with stakeholders.*

***Drainage Area*** 96 ac

***Percentage Impervious*** 67%

| System Type | System Area | System Volume | % of Tv Managed by Full Vol.* 2yr - 2hr | 5yr - 24hr | 10yr-24hr | 10yr - 72hr |
|---|---|---|---|---|---|---|
| ROW Systems | | | | | | |
| Exfiltration/Bioswale | 119,278 ft² | 907,190 gal | 16% | 7% | 6% | 5% |
| Porous Pavement | 144,440 ft² | 936,483 gal | 17% | 7% | 6% | 5% |
| Subsurface Storage | 23,130 ft² | 149,963 gal | 3% | 1% | 1% | 1% |
| ***SubTotal*** | ***286,848 ft²*** | ***1,993,635 gal*** | ***36%*** | ***15%*** | ***13%*** | ***11%*** |
| Long-term Systems | | | | | | |
| F1 (Coral Ridge Mall) | 531,161 ft² | 3,443,803 gal | 62% | 27% | 22% | 18% |
| F2 (E Oakland Park Boulevard) | 63,451 ft² | 1,091,762 gal | 20% | 8% | 22% | 6% |
| ***SubTotal*** | ***594,613 ft²*** | ***4,535,565 gal*** | ***82%*** | ***35%*** | ***44%*** | ***24%*** |
| ***Total*** | | ***6,529,200 gal*** | ***118%*** | ***51%*** | ***56%*** | ***35%*** |

**Tv = Storm Depth * % Impervious * Drainage Area*

### Green Infrastructure Sizing Assumptions

**Exfiltration/Bioswale Systems**

| Surface Volume Provided | |
|---|---|
| Ponding Depth | 3'' |
| ROW System Floor Area | 119,278 ft² |
| Area at Ponding Elevation | 119,278 ft² |
| Surface Ponding Volume | 29,819 ft³ |

| Full Storage Volume Provided | |
|---|---|
| Soil Depth | 1.0' |
| Soil Porosity | 30% |
| Stone Depth | 1.17' |
| Stone Porosity | 40% |
| Surface Volume | 29,819 ft³ |
| Soil Volume | 35,783 ft³ |
| Stone Volume | 55,663 ft³ |
| Total Storage Volume | 121,266 ft³ |
| Total Storage Volume (gal) | 907,190 gal |

**Porous Pavement Systems**

| Surface Volume Provided | |
|---|---|
| | - |
| ROW System Floor Area | 144,440 ft² |
| | - |
| | - |

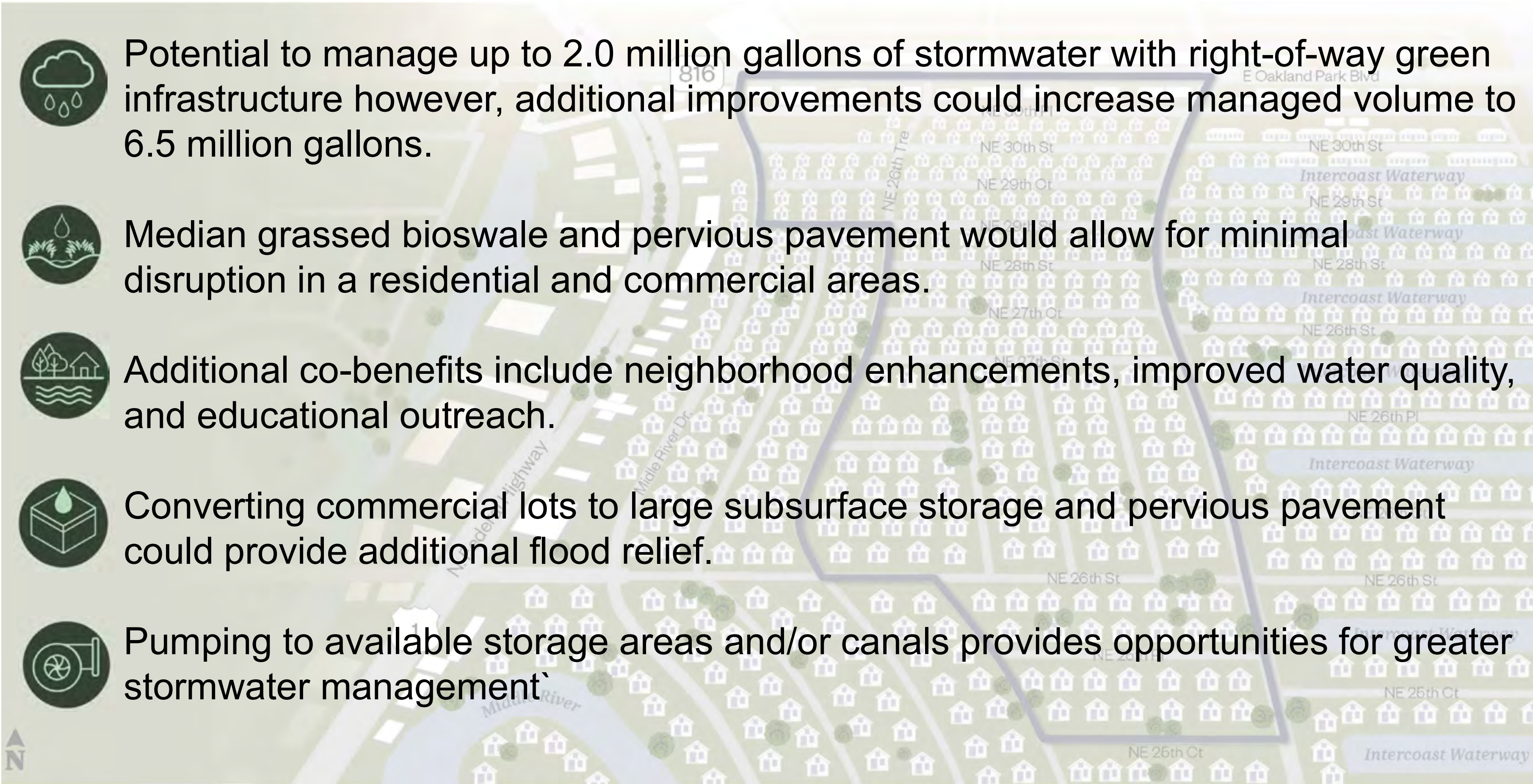
| Full Storage Volume Provided | |
|---|---|
| | - |
| | - |
| Stone Depth | 2.17' |
| Stone Porosity | 40% |
| | - |
| | - |
| Stone Volume | 125,181 ft³ |
| Total Storage Volume | 125,181 ft³ |
| Total Storage Volume (gal) | 936,483 gal |

**Subsurface Storage Systems**

| Surface Volume Provided | |
|---|---|
| | - |
| ROW System Floor Area | 23,130 ft² |
| | - |
| | - |

| Full Storage Volume Provided | |
|---|---|
| | - |
| | - |
| Stone Depth | 2.17' |
| Stone Porosity | 40% |
| | - |
| | - |
| Stone Volume | 20,046 ft³ |
| Total Storage Volume | 20,046 ft³ |
| Total Storage Volume (gal) | 149,963 gal |

**Property Solution Details – Property Scale Proposal #1**
Overall Summary




- Potential to manage up to 2.0 million gallons of stormwater with right-of-way green infrastructure however, additional improvements could increase managed volume to 6.5 million gallons.
- Median grassed bioswale and pervious pavement would allow for minimal disruption in a residential and commercial areas.
- Additional co-benefits include neighborhood enhancements, improved water quality, and educational outreach.
- Converting commercial lots to large subsurface storage and pervious pavement could provide additional flood relief.
- Pumping to available storage areas and/or canals provides opportunities for greater stormwater management`

# Property Scale Proposal #2 – Lauderhill

## Medium Density Residential and Commercial



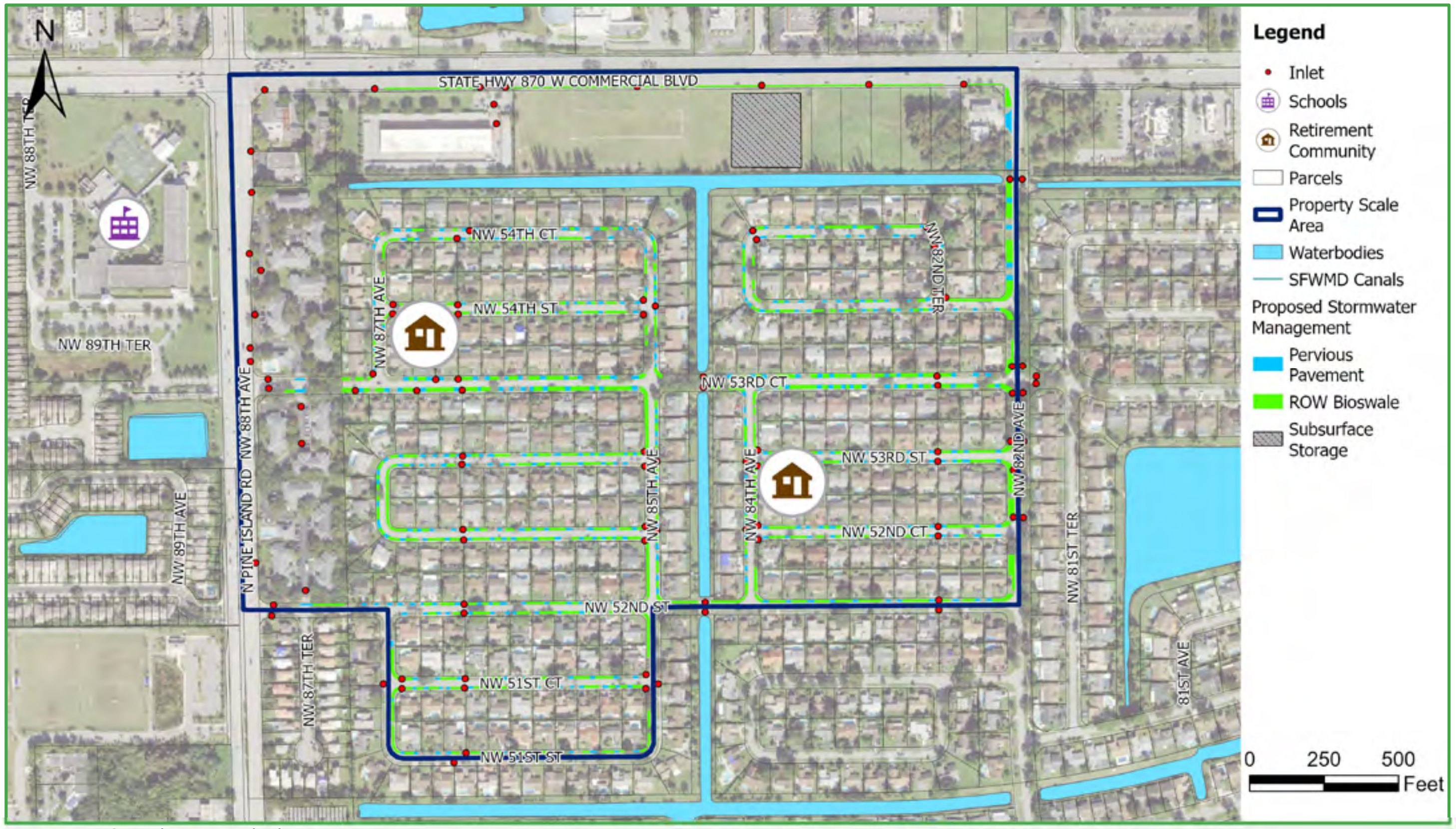
| Municipality | |
|---|---|
| Lauderhill | |
| Area | |
| 119 acres | |
| Imperviousness | Groundwater Depth |
| 60% | 3.5 ft |
| Target Design Storm Volume | |
| 20.8 million gallons | |
| Average Flooding Depth | Max Flooding Depth |
| 0.4 ft | 3.5 ft |

**Existing Conditions**

This medium density neighborhood is primarily single-family homes with residential streets. Developed and undeveloped commercial property border the neighborhood to the north and apartment buildings border the neighborhood to the west. Bus routes run along W Commercial Boulevard and N Pine Island Road. This community experiences frequent shallow flooding, and topography and drainage typically flows to the southeast. Critical infrastructure in the vicinity includes Discovery Elementary School southwest of the intersection of N Pine Island Rd and W Commercial Boulevard. The 10-year, 72-hour storm event with a 2-foot level sea level rise condition creates wide-spread flooding through the neighborhood. Parcels typically experience <6 in of flooding while streets experience up to 1.5 feet of flooding in some pockets throughout the neighborhood.

# Property Solution Overview – Property Scale Proposal #2

## Short-Term Solution: Right-of-Way Green Infrastructure and Subsurface Storage





| Stormwater Volume Managed | |
|---|---|
| 2.7 million gallons | |
| % Volume Reduction 10-yr, 72-hr | % Volume Reduction 10-yr, 24-hr |
| 13% | 15% |
| % Volume Reduction 5-yr, 24-hr | % Volume Reduction 2-yr, 2-hr |
| 19% | 44% |
| Conceptual Cost Estimate | |
| $9,130,000 | |

**Proposed Solution Description**

The proposed near-term solution involves transforming current right-of-way green space between the street and the sidewalk into shallow bioswales with a turf grass surface. Bioswales were sited to avoid major structures within the right-of-way (i.e. mailboxes, above ground utility boxes, etc). Bioswales would have a shallow 3" depression in the middle to allow for short-term ponding. Driveways in-between the grassed bioswales are proposed as pervious pavement with opportunities to hydraulically connect systems with the underlying stone base and underdrains. The vacant commercial lots along W Commercial Boulevard could provide an ideal location for large subsurface storage and pervious pavement. Shallow subsurface chambers or perforated pipes can be included within the stone layers to increase void space.

# Property Solution Details – Property Scale Proposal #2

## Short-Term Solution: Right-of-Way Green Infrastructure and Subsurface Storage



### Co-benefits

- Educational Outreach
- Improved Water Quality
- Neighborhood Enhancement

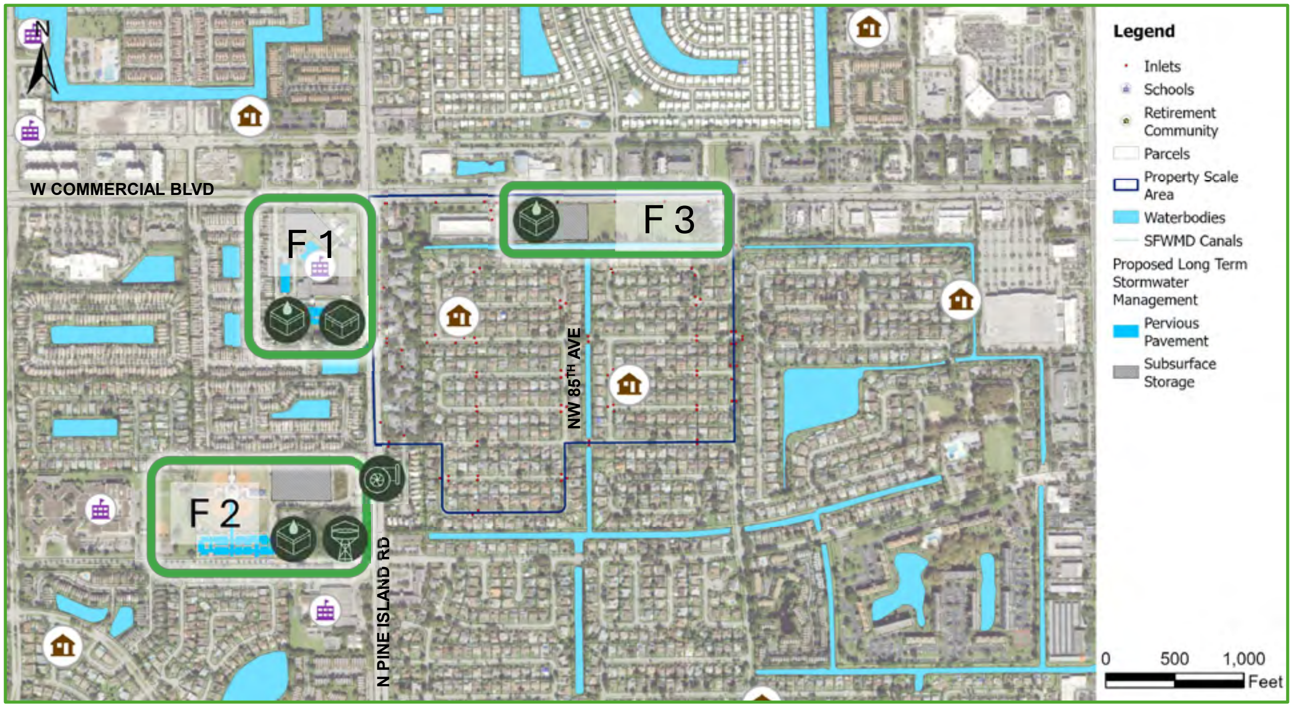
**Proposed Short-Term Solution**

Residential and commercial solutions considered options for addressing localized flooding, maximizing volume with limited space and reducing impacts to existing parking and retirement community use. These concepts can be used in our parts of the County with similar right-of-way configurations and commercial areas where impacts should be minimal in the short-term.

- Right-of-Way Bioswales
- Pervious Pavement
- Subsurface storage

# Proposed Solution Details - Property Scale Proposal #2

## Future Implementation Options




Pervious Pavement

Large Subsurface Storage

Above-ground Water Storage

Pump Station

### Potential Additional Volume Managed

- ✓ F 1 – 1,849,517 gal
- ✓ F 2 – 4,295,082 gal
- ✓ F 3 – 1,463,830 gal

### Key Considerations

- ✓ Stakeholder Support
- ✓ Utility Relocation

### Future Implementation Strategy

*Additional stormwater management is necessary to mitigate larger flooding events and flooding. Future implementation strategies could provide centralized, large-scale stormwater management, which will require detailed feasibility analysis and coordination with stakeholders. These solutions would provide additional flood mitigation.*

**F 1 & F 2**

A nearby school and sports facility have been identified as potential locations for stormwater solutions. In both locations, one potential solution would be to construct subsurface retention/detention practices below the parking lots and/or sport fields. Above ground retention/detention and/or stormwater storage tanks could be evaluated. These solutions would require pump stations to route runoff from the project area, to the large-scale stormwater system. Additionally, pervious pavement could be implemented in the parking lot to reduce impervious area.

**F 3**

In the vacant commercial lots to the north of the neighborhood, subsurface retention/detention practices could be constructed.

# Proposed Solution Details – Property Scale Proposal #2

## Metric Summary

RESILIENT BROWARD

### Rainfall and Coastal Conditions

*Multiple design storms were evaluated to illustrate the effectiveness of the water management adaptation conceptual strategies. The 10-year, 72-hour storm event is the basis for crown-of-road elevations. Smaller design storms were evaluated including the 2-year, 2-hour storm event, which FDOT frequently evaluates, to determine strategies' effectiveness during smaller, more frequent events.*

| Scenario | Rainfall Depth (in) | Storm Volume (gal) |
|---|---|---|
| 2-year, 2-hour | 3.19 | 6,146,701 |
| 5-year, 24-hour | 7.42 | 14,297,343 |
| 10-year, 24-hour | 9.07 | 17,476,671 |
| 10-year, 72-hour | 10.8 | 20,810,148 |

### Short-Term Solution Cost Estimate

| | Quantity | Unit Cost | Subtotal |
|---|---|---|---|
| Exfiltration/Bioswale | 160,110 ft² | $ 25.00 | $ 4,002,746.20 |
| Porous Pavement | 74,130 ft² | $ 30.00 | $ 2,223,902.03 |
| Subsurface Storage | 57,905 ft² | $ 50.00 | $ 2,895,250.34 |
| | | | **$ 9,121,898.57** |

*Conceptual cost estimate is variable depending on site conditions, utility constraints, additional restoration, improvements and design aspects including underdrains and expanded footprints.*

### Summary of Design

*Additional stormwater management is necessary to mitigate flooding. Long-term solutions could provide centralized, large-scale stormwater management, which will require detailed feasibility analysis and coordination with stakeholders.*

***Drainage Area*** 119 ac
***Percentage Impervious*** 60%

| | | | % of Tv Managed by Full Vol.* | | | |
|---|---|---|---|---|---|---|
| ***System Type*** | ***System Area*** | ***System Volume*** | ***2yr - 2hr*** | ***5yr - 24hr*** | ***10yr-24hr*** | ***10yr - 72hr*** |
| **ROW Systems** | | | | | | |
| Exfiltration/Bioswale | 160,110 ft² | 1,457,301 gal | 24% | 10% | 8% | 7% |
| Porous Pavement | 74,130 ft² | 702,452 gal | 11% | 5% | 4% | 3% |
| Subsurface Storage | 57,905 ft² | 548,704 gal | 9% | 4% | 3% | 3% |
| ***SubTotal*** | ***292,145 ft²*** | ***2,708,457 gal*** | ***44%*** | ***19%*** | ***15%*** | ***13%*** |
| **Long-term Systems** | | | | | | |
| F1 (Discovery Elementary School) | 195,180 ft² | 1,849,517 gal | 30% | 13% | 11% | 9% |
| F2 (Sunrise Sportsplex) | 163,387 ft² | 4,295,082 gal | 70% | 30% | 11% | 21% |
| F3 (Vacant Lots) | 154,479 ft² | 1,463,830 gal | 24% | 10% | 11% | 7% |
| ***SubTotal*** | ***358,568 ft²*** | ***6,144,599 gal*** | ***100%*** | ***43%*** | ***21%*** | ***30%*** |
| ***Total*** | | ***8,853,056 gal*** | ***144%*** | ***62%*** | ***37%*** | ***43%*** |

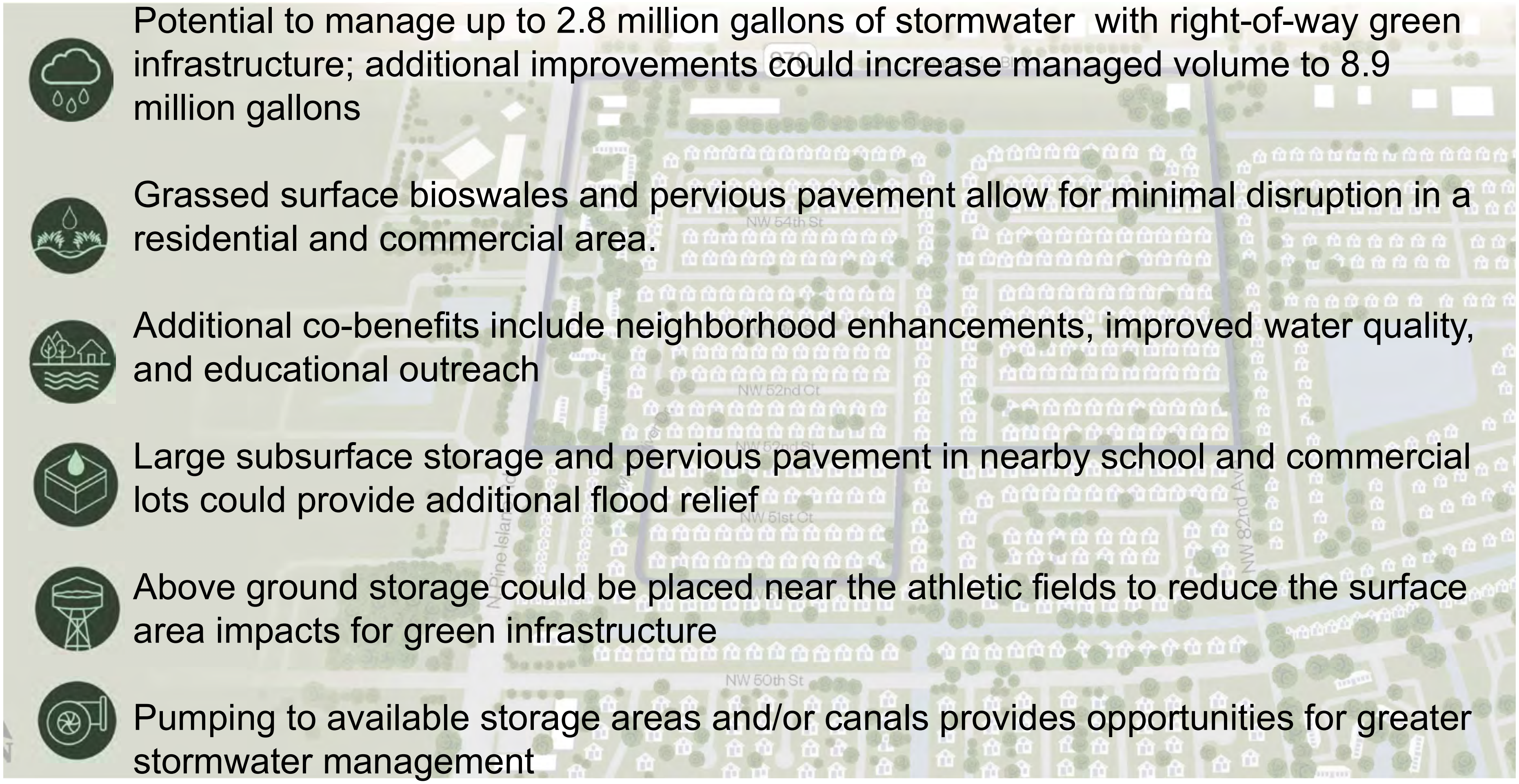
**Tv = Storm Depth * % Impervious * Drainage Area*

### Green Infrastructure Sizing Assumptions

| Exfiltration/Bioswale Systems | | Porous Pavement Systems | | Subsurface Storage Systems | |
|---|---|---|---|---|---|
| **Surface Volume Provided** | | **Surface Volume Provided** | | **Surface Volume Provided** | |
| Ponding Depth | 3'' | | - | | - |
| ROW System Floor Area | 160,110 ft$^2$ | ROW System Floor Area | 74,130 ft$^2$ | ROW System Floor Area | 57,905 ft$^2$ |
| Area at Ponding Elevation | 160,110 ft$^2$ | | - | | - |
| Surface Ponding Volume | 40,027 ft$^3$ | | - | | - |
| **Full Storage Volume Provided** | | **Full Storage Volume Provided** | | **Full Storage Volume Provided** | |
| Soil Depth | 1.0' | | - | | - |
| Soil Porosity | 30% | | - | | - |
| Stone Depth | 1.67' | Stone Depth | 3.17' | Stone Depth | 3.17' |
| Stone Porosity | 40% | Stone Porosity | 40% | Stone Porosity | 40% |
| Surface Volume | 40,027 ft$^3$ | | - | | - |
| Soil Volume | 48,033 ft$^3$ | | - | | - |
| Stone Volume | 106,740 ft$^3$ | Stone Volume | 93,898 ft$^3$ | Stone Volume | 73,346 ft$^3$ |
| Total Storage Volume | 194,800 ft$^3$ | Total Storage Volume | 93,898 ft$^3$ | Total Storage Volume | 73,346 ft$^3$ |
| Total Storage Volume (gal) | 1,457,301 gal | Total Storage Volume (gal) | 702,452 gal | Total Storage Volume (gal) | 548,704 gal |

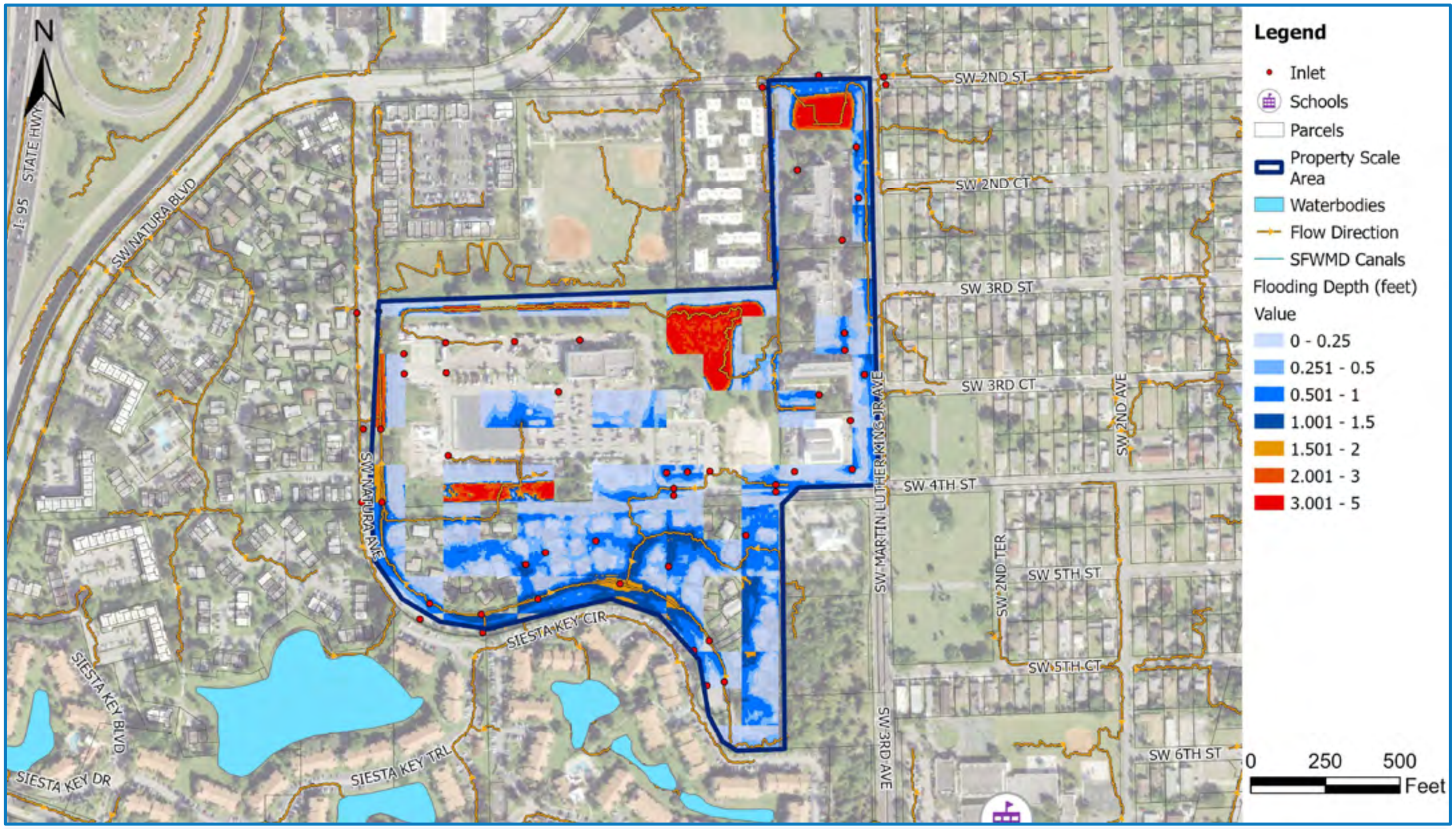
**Property Solution Details – Property Scale Proposal #2**

Overall Summary




- Potential to manage up to 2.8 million gallons of stormwater with right-of-way green infrastructure; additional improvements could increase managed volume to 8.9 million gallons
- Grassed surface bioswales and pervious pavement allow for minimal disruption in a residential and commercial area.
- Additional co-benefits include neighborhood enhancements, improved water quality, and educational outreach
- Large subsurface storage and pervious pavement in nearby school and commercial lots could provide additional flood relief
- Above ground storage could be placed near the athletic fields to reduce the surface area impacts for green infrastructure
- Pumping to available storage areas and/or canals provides opportunities for greater stormwater management

# Property Scale Proposal #3 – Deerfield Beach
## Industrial and Residential





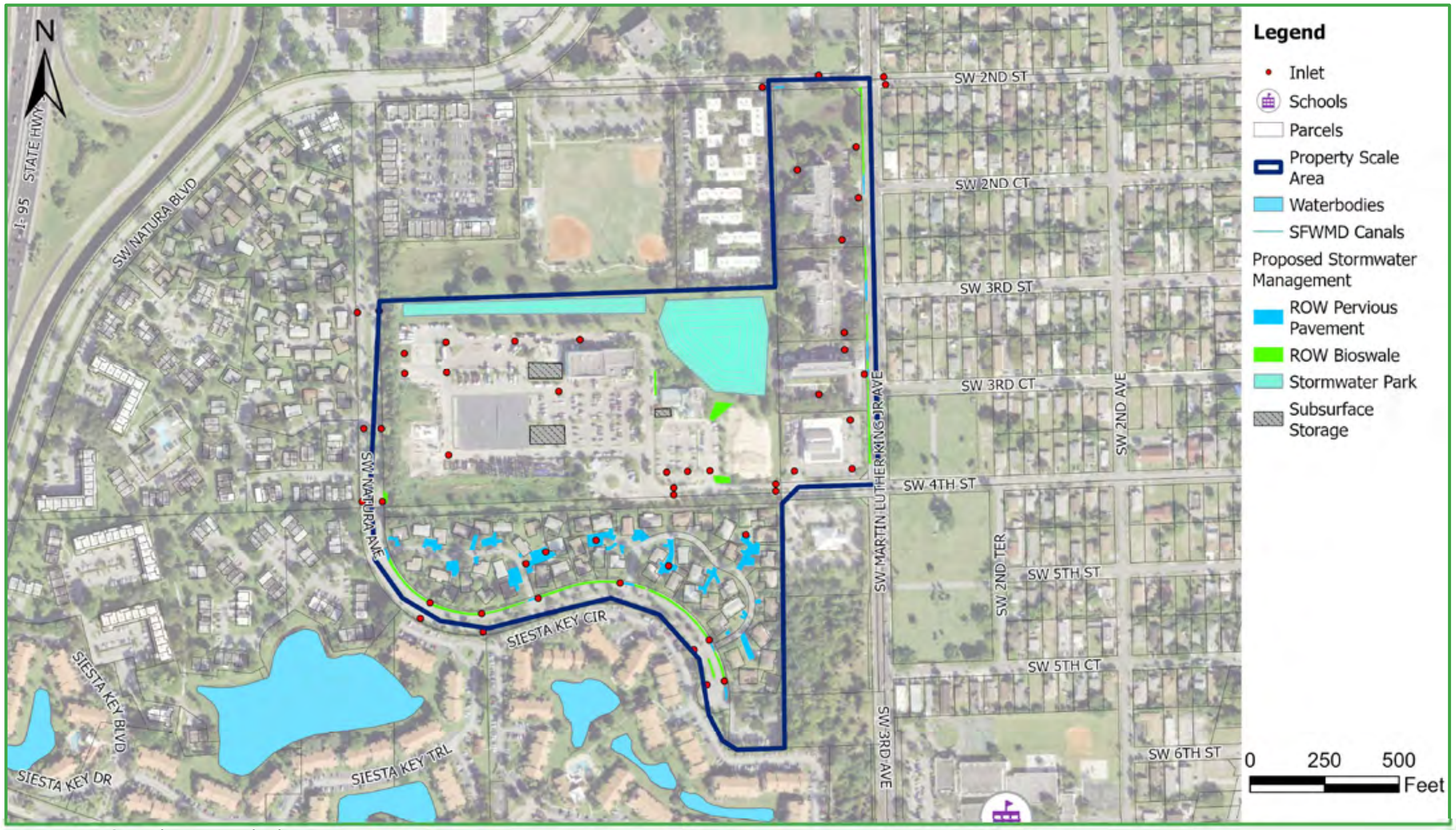
| Municipality | |
|---|---|
| Deerfield Beach | |
| **Area** | |
| 47 acres | |
| **Imperviousness** | **Groundwater Depth** |
| 57% | 4.5 ft |
| **Target Design Storm Volume** | |
| 7.9 million gallons | |
| **Average Flooding Depth** | **Max Flooding Depth** |
| 0.5 ft | 4.2 ft |

**Existing Conditions**

This neighborhood contains industrial and residential areas with large apartment buildings, an HOA, and the City's municipal center. This community experiences extreme flooding, and topography and drainage typically flows to the north. The 10-year, 72-hour storm event with a 2-foot level sea level rise condition creates wide-spread flooding through the neighborhood. Parcels typically experience <6 in of flooding while streets experience up to 2 feet of flooding in some pockets throughout the industrial areas.

# Property Solution Overview – Property Scale Proposal #3

## Short-Term Solution: Gray/Green Infrastructure





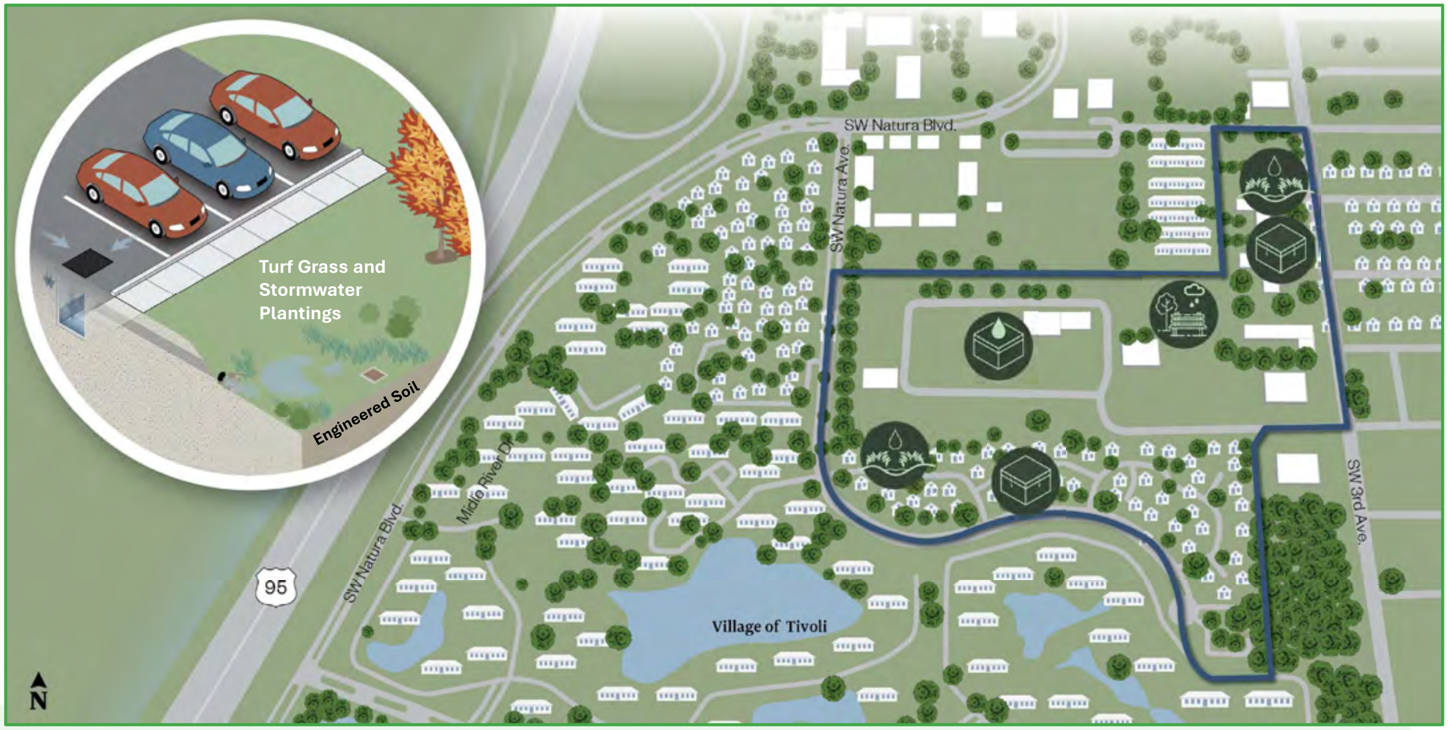
| Stormwater Volume Managed | |
|---|---|
| 2.2 million gallons | |
| % Volume Reduction 10-yr, 72-hr | % Volume Reduction 10-yr, 24-hr |
| 28% | 33% |
| % Volume Reduction 5-yr, 24-hr | % Volume Reduction 2-yr, 2-hr |
| 41% | 95% |
| Conceptual Cost Estimate | |
| $9,050,000 | |

**Proposed Solution Description**

The proposed near-term solution involves transforming current right-of-way green space between the street and the sidewalk into shallow bioswales with a turf grass surface. Bioswales were sited to avoid major structures within the right-of-way (i.e. mailboxes, above ground utility boxes, etc). Bioswales would have a shallow 3" depression in the middle to allow for short-term ponding. Driveways in the ROW and parking areas in the HOA along SW Natura Avenue are proposed as pervious pavement. Shallow subsurface chambers or perforated pipes can be included within the stone layers to increase void space. The existing stormwater management features on City property, adjacent to the athletic fields, can be retrofitted to stormwater parks to increase the capacity.

# Property Solution Details – Property Scale Proposal #3

## Short-Term Solution: Gray/Green Infrastructure





**Co-benefits**

- Educational Outreach
- Improved Water Quality
- Neighborhood Enhancement

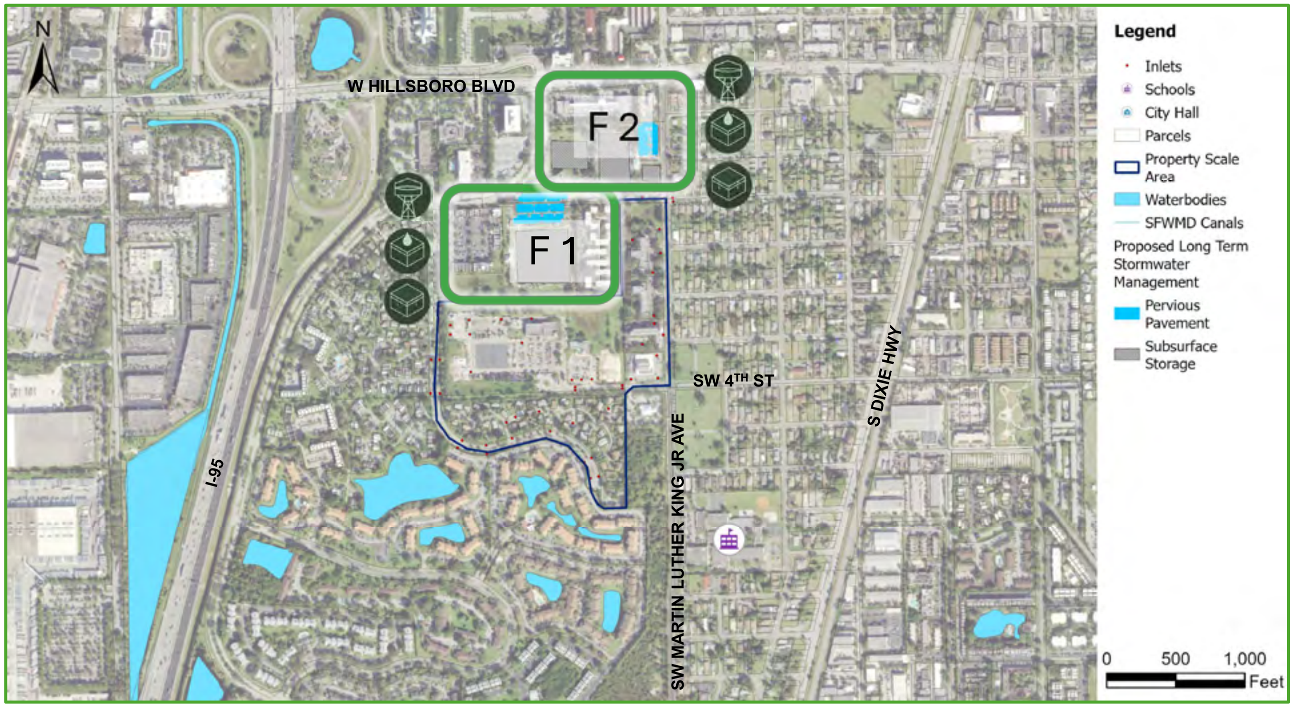
**Proposed Short-Term Solution**

Industrial and residential solutions considered options for addressing localized flooding, maximizing volume with limited space and reducing impacts to existing industrial and neighborhood use. These concepts can be used in other parts of the County with similar right-of-way configurations and particularly in industrial and residential areas where impacts should be minimal in the short-term.

- Right-of-Way Bioswales
- Pervious Pavement
- Stormwater Park
- Subsurface Storage

# Proposed Solution Details - Property Scale Proposal #3

## Future Implementation Options




Pervious Pavement

Large Subsurface Storage

Above-ground Water Storage

### Potential Additional Volume Managed

- ✓ F 1 – 5,967,191 gal
- ✓ F 2 – 4,704,849 gal

### Key Considerations

- ✓ Stakeholder Support
- ✓ Utility Relocation

### Future Implementation Strategy

*Additional stormwater management is necessary to mitigate larger flooding events and flooding. Future implementation strategies could provide centralized, large-scale stormwater management, which will require detailed feasibility analysis and coordination with stakeholders. These solutions would provide additional flood mitigation.*

**F 1 & F 2**

The Oveta McKeithen Recreational Complex to the northwest of the neighborhood has great protentional for numerous stormwater solutions. In both locations, one potential solution would be to construct subsurface retention/detention practices below the parking lots and/or sport fields. Above ground retention/detention and/or stormwater storage tanks could be evaluated. Additionally, pervious pavement could be implemented in the parking lots to reduce impervious area.

# Proposed Solution Details – Property Scale Proposal #3

## Metric Summary

RESILIENT BROWARD

### Rainfall and Coastal Conditions

*Multiple design storms were evaluated to illustrate the effectiveness of the water management adaptation conceptual strategies. The 10-year, 72-hour storm event is the basis for crown-of-road elevations. Smaller design storms were evaluated including the 2-year, 2-hour storm event, which FDOT frequently evaluates, to determine strategies' effectiveness during smaller, more frequent events.*

| Scenario | Rainfall Depth (in) | Storm Volume (gal) |
|---|---|---|
| 2-year, 2-hour | 3.19 | 2,327,535 |
| 5-year, 24-hour | 7.42 | 5,413,889 |
| 10-year, 24-hour | 9.07 | 6,617,787 |
| 10-year, 72-hour | 10.8 | 7,880,055 |

### Short-Term Solution Cost Estimate

| | Quantity | Unit Cost | Subtotal |
|---|---|---|---|
| Exfiltration/Bioswale | 18,763 ft² | $ 25.00 | $ 469,068.75 |
| Porous Pavement | 35,936 ft² | $ 30.00 | $ 1,078,078.92 |
| Subsurface Storage | 14,759 ft² | $ 50.00 | $ 737,952.57 |
| Subsurface Storage | 135,267 ft² | $ 50.00 | $ 6,763,344.06 |
| | | | **$ 9,048,444.29** |

*Conceptual cost estimate is variable depending on site conditions, utility constraints, additional restoration, improvements and design aspects including underdrains and expanded footprints.*

### Summary of Design

*Additional stormwater management is necessary to mitigate flooding. Long-term solutions could provide centralized, large-scale stormwater management, which will require detailed feasibility analysis and coordination with stakeholders.*

***Drainage Area*** 47 ac
***Percentage Impervious*** 57%

| System Type | System Area | System Volume | % of Tv Managed by Full Vol.* 2yr - 2hr | 5yr - 24hr | 10yr-24hr | 10yr - 72hr |
|---|---|---|---|---|---|---|
| ROW Systems | | | | | | |
| Exfiltration/Bioswale | 18,763 ft² | 198,849 gal | 9% | 4% | 3% | 3% |
| Porous Pavement | 35,936 ft² | 340,527 gal | 15% | 6% | 5% | 4% |
| Subsurface Storage | 14,759 ft² | 139,856 gal | 6% | 3% | 2% | 2% |
| Stormwater Park | 135,267 ft² | 1,534,763 gal | 66% | 28% | 23% | 19% |
| ***SubTotal*** | ***204,725 ft²*** | ***2,213,995 gal*** | ***95%*** | ***41%*** | ***33%*** | ***28%*** |
| Long-term Systems | | | | | | |
| F1 (SW - Rec Center) | 247,557 ft² | 5,967,191 gal | 256% | 110% | 90% | 76% |
| F2 (NE - Rec Center) | 204,253 ft² | 4,704,849 gal | 202% | 87% | 90% | 60% |
| ***SubTotal*** | ***451,810 ft²*** | ***10,672,040 gal*** | ***459%*** | ***197%*** | ***180%*** | ***135%*** |
| ***Total*** | | ***12,886,034 gal*** | ***554%*** | ***238%*** | ***214%*** | ***164%*** |

**Tv = Storm Depth * % Impervious * Drainage Area*

### Green Infrastructure Sizing Assumptions

**Exfiltration/Bioswale Systems**

| Surface Volume Provided | |
|---|---|
| Ponding Depth | 3'' |
| ROW System Floor Area | 18,763 ft² |
| Area at Ponding Elevation | 18,763 ft² |
| Surface Ponding Volume | 4,691 ft³ |

| Full Storage Volume Provided | |
|---|---|
| Soil Depth | 1.0' |
| Soil Porosity | 30% |
| Stone Depth | 2.17' |
| Stone Porosity | 40% |
| Surface Volume | 4,691 ft³ |
| Soil Volume | 5,629 ft³ |
| Stone Volume | 16,261 ft³ |
| Total Storage Volume | 26,581 ft³ |
| Total Storage Volume (gal) | 198,849 gal |

**Porous Pavement Systems**

| Surface Volume Provided | |
|---|---|
| | - |
| ROW System Floor Area | 35,936 ft² |
| | - |
| | - |

| Full Storage Volume Provided | |
|---|---|
| | - |
| | - |
| Stone Depth | 3.17' |
| Stone Porosity | 40% |
| | - |
| | - |
| Stone Volume | 45,519 ft³ |
| Total Storage Volume | 45,519 ft³ |
| Total Storage Volume (gal) | 340,527 gal |

**Subsurface Storage Systems**

| Surface Volume Provided | |
|---|---|
| | - |
| ROW System Floor Area | 14,759 ft² |
| | - |
| | - |

| Full Storage Volume Provided | |
|---|---|
| | - |
| | - |
| Stone Depth | 3.17' |
| Stone Porosity | 40% |
| | - |
| | - |
| Stone Volume | 18,695 ft³ |
| Total Storage Volume | 18,695 ft³ |
| Total Storage Volume (gal) | 139,856 gal |

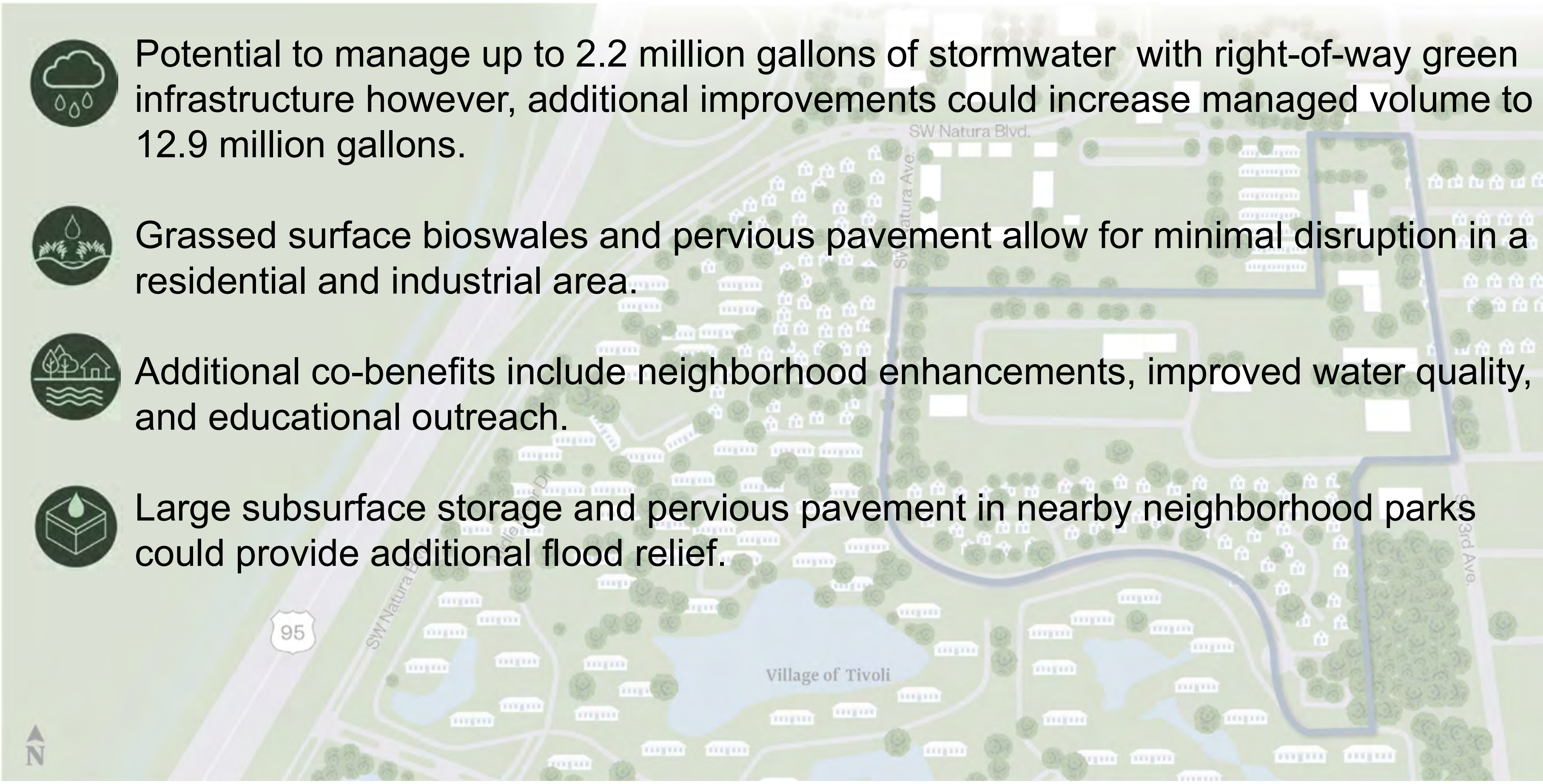
**Stormwater Park Systems**

| Surface Volume Provided | |
|---|---|
| Ponding Depth | 3'' |
| ROW System Floor Area | 135,267 ft² |
| Area at Ponding Elevation | 135,267 ft² |
| Surface Ponding Volume | 33,817 ft³ |

| Full Storage Volume Provided | |
|---|---|
| Soil Depth | 2.0' |
| Soil Porosity | 30% |
| Stone Depth | 1.67' |
| Stone Porosity | 40% |
| Surface Volume | 33,817 ft³ |
| Soil Volume | 81,160 ft³ |
| Stone Volume | 90,178 ft³ |
| Total Storage Volume | 205,155 ft³ |
| Total Storage Volume (gal) | 1,534,763 gal |

## Property Solution Details – Property Scale Proposal #3

Overall Summary

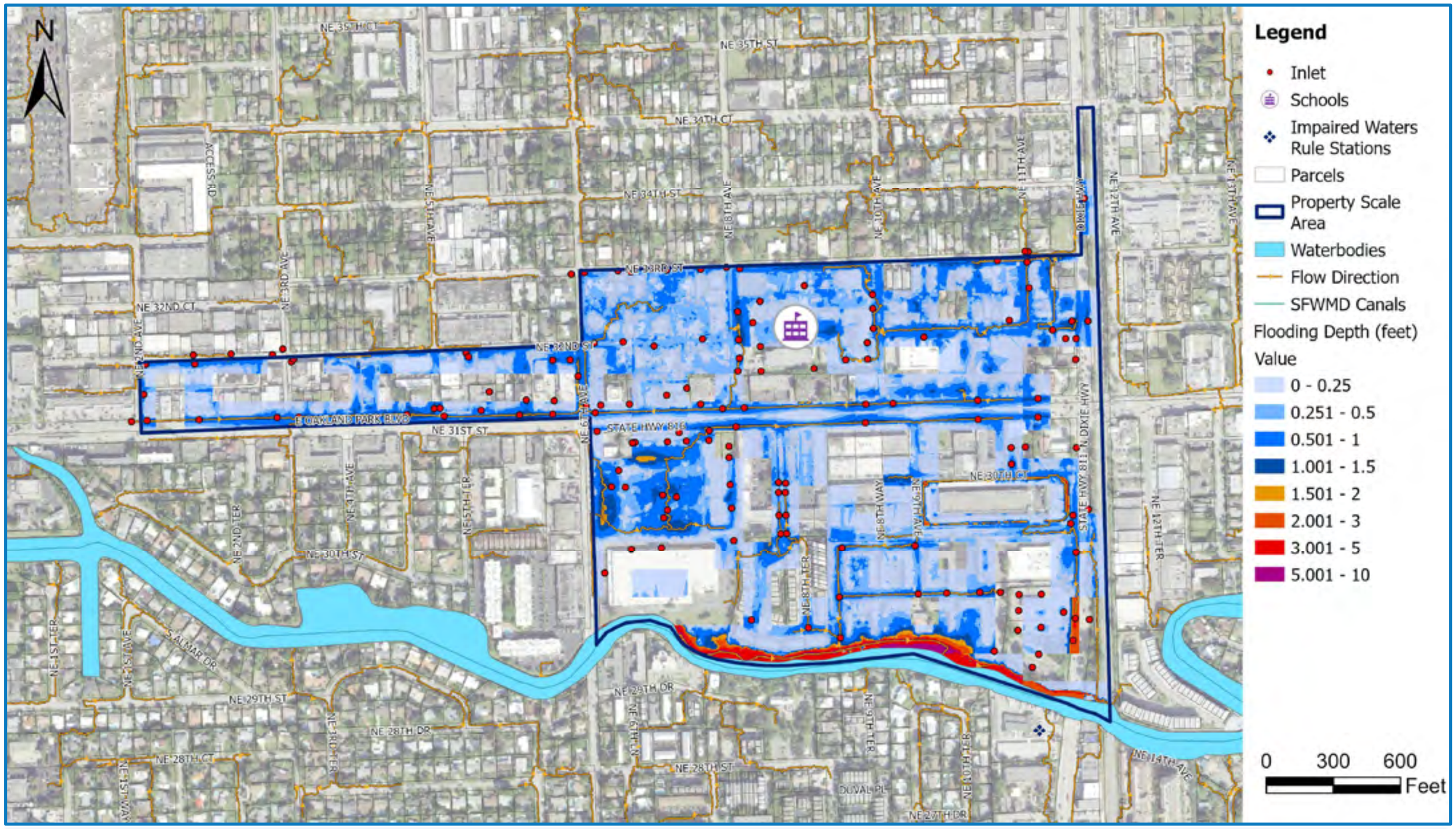



- Potential to manage up to 2.2 million gallons of stormwater with right-of-way green infrastructure however, additional improvements could increase managed volume to 12.9 million gallons.
- Grassed surface bioswales and pervious pavement allow for minimal disruption in a residential and industrial area.
- Additional co-benefits include neighborhood enhancements, improved water quality, and educational outreach.
- Large subsurface storage and pervious pavement in nearby neighborhood parks could provide additional flood relief.

#4

# Property Scale Proposal #4 – Oakland Park

## High Density Residential and Commercial





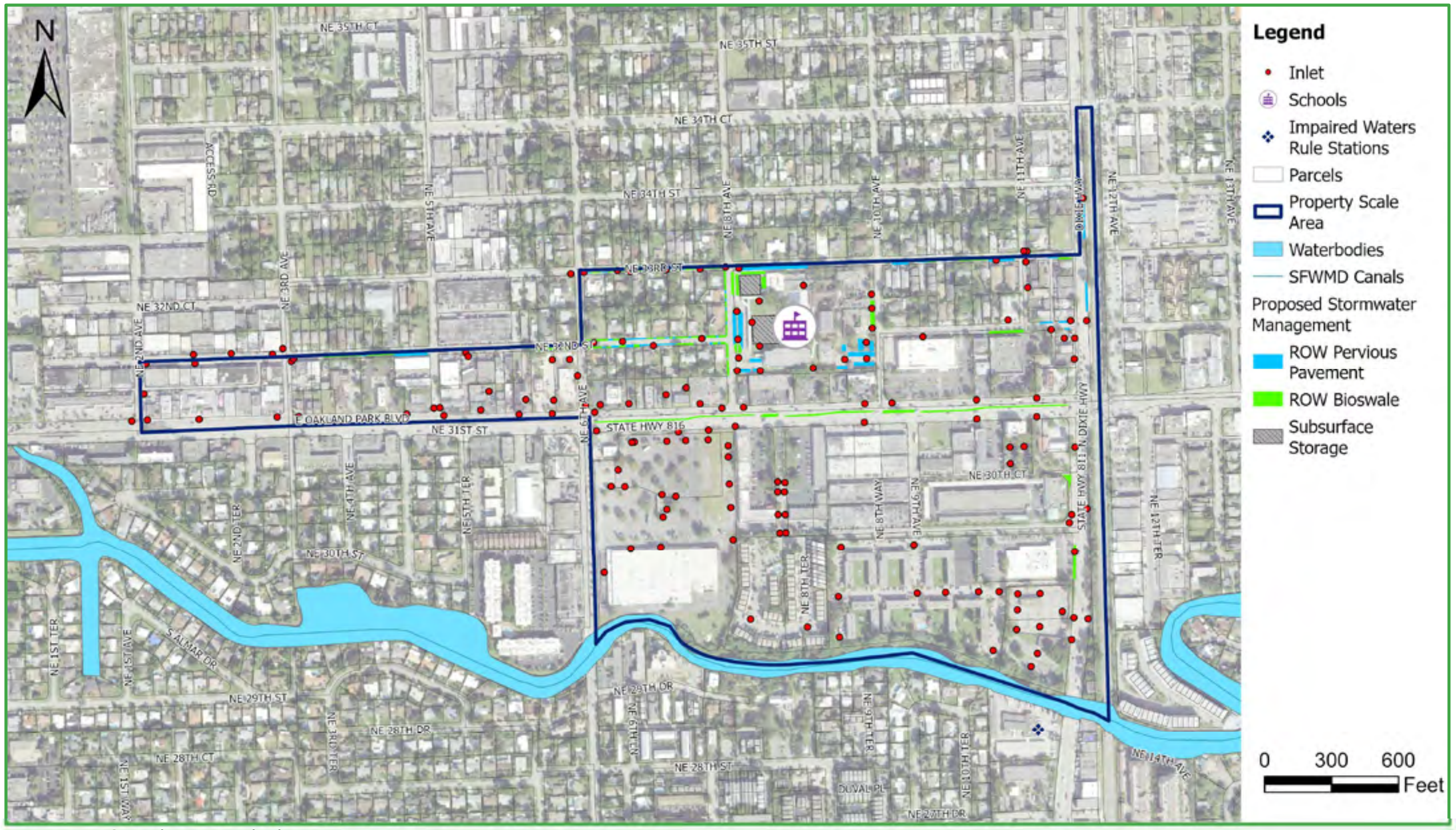
| Municipality | |
|---|---|
| Oakland Park | |
| **Area** | |
| 111 acres | |
| **Imperviousness** | **Groundwater Depth** |
| 77% | 3.0 ft |
| **Target Design Storm Volume** | |
| 25.02 million gallons | |
| **Average Flooding Depth** | **Max Flooding Depth** |
| 0.4 ft | 5.4 ft |

**Existing Conditions**

This high density neighborhood is an older development consisting of a mixture of single-family, multi-family, and commercial development. Critical infrastructure includes Oakland Park Elementary School. The community experiences frequent shallow flooding, and topography and drainage typically flows to the North Forks New River to the south. The 10-year, 72-hour storm event with a 2-foot sea level rise condition creates flooding in pockets of the neighborhood. The majority of parcels experience up 3 to 12 inches of flooding.

# Property Solution Overview: Property Scale Proposal #4

## Short-Term Solution: Right-of-Way Green Infrastructure and Subsurface Storage





| Stormwater Volume Managed | |
|---|---|
| 820,600 gallons | |
| **% Volume Reduction 10-yr, 72-hr** | **% Volume Reduction 10-yr, 24-hr** |
| 3% | 4% |
| **% Volume Reduction 5-yr, 24-hr** | **% Volume Reduction 2-yr, 2-hr** |
| 5% | 11% |
| **Conceptual Cost Estimate** | |
| $4,150,000 | |

**Proposed Solution Description**

This solution involves transforming current right-of-way (ROW) green space between the street and the sidewalk into shallow bioswales with a turf grass surface. Bioswales were sited to avoid major structures within the ROW (i.e. light poles, trees, above ground utility boxes, etc). Bioswales would have a shallow 3" depression to allow for short-term ponding. Driveways in-between the bioswales are proposed as pervious pavement with opportunities to hydraulically connect systems with the underlying stone base or underdrains. Oakland Park Elementary school provides an ideal location for subsurface detention/retention beneath grassed and paved play areas. Additional pervious pavement can be introduced the parking stall on school property and additional bioswales in linear grassed area interior to the site.

# Property Solution Details – Property Scale Proposal #4

## Short-Term Solution: Right-of-Way Green Infrastructure and Subsurface Storage



**Co-benefits**

- Educational Outreach
- Improved Water Quality
- Neighborhood Enhancement

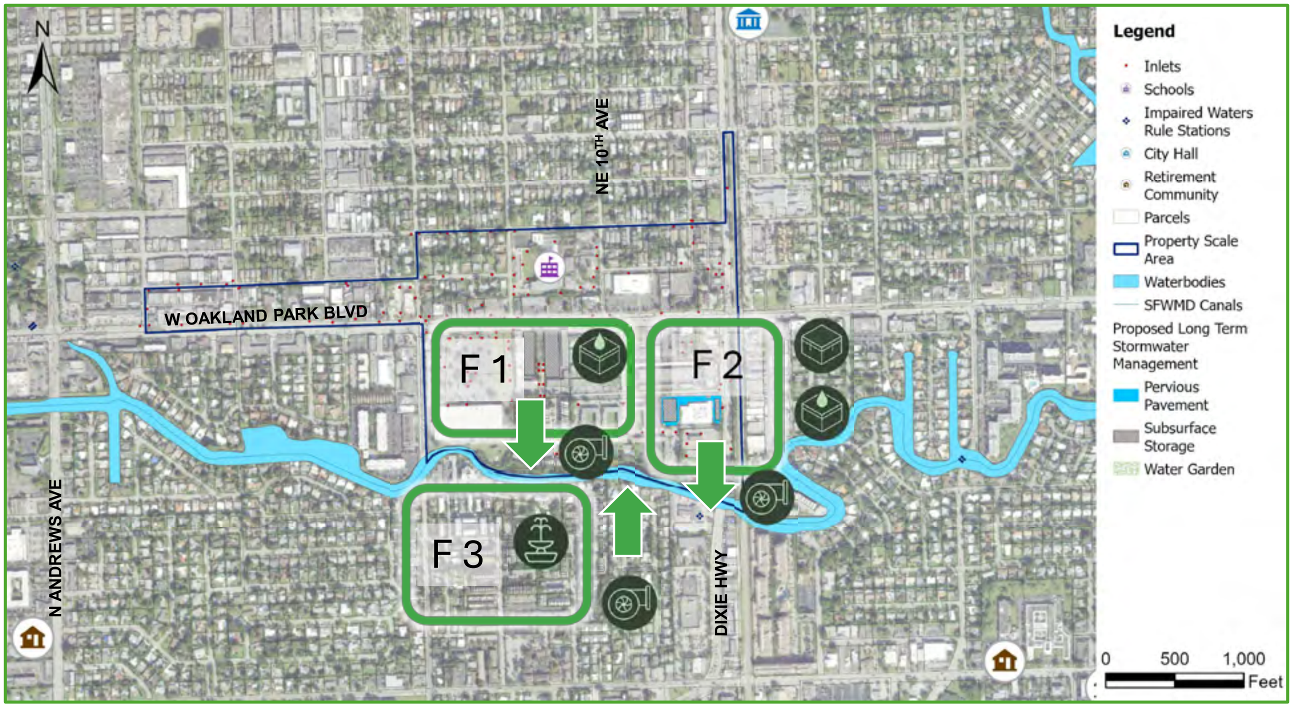
**Proposed Short-Term Solution**

Commercial and heavy density residential solutions considered options for addressing localized flooding, maximizing volume with limited space and reducing impacts to existing parking, school, and neighborhood use. These concepts can be used in other parts of the County with similar right-of-way configurations and particularly in heavy density residential and commercial areas where impacts should be minimal in the short-term.

- Right-of-Way Bioswales
- Pervious Pavement
- Subsurface Storage

# Proposed Solution Details - Property Scale Proposal #4

## Future Implementation Options




Pervious Pavement

On-Site Green Infrastructure

Large Subsurface Storage

Pump Station

Water Garden

**Potential Additional Volume Managed**

- ✓ F 1 – 383,452 gal
- ✓ F 2 – 426,695 gal
- ✓ F 3 – 26,495 gal

**Key Considerations**

- ✓ Stakeholder Support
- ✓ Utility Relocation

### Future Implementation Strategy

*Additional stormwater management is necessary to mitigate larger flooding events and flooding. Future implementation strategies could provide centralized, large-scale stormwater management, which will require detailed feasibility analysis and coordination with stakeholders. These solutions would provide additional flood mitigation.*

**F 1**

One potential solution would be to construct subsurface retention/detention practices below the parking lot of the 840 Plaza Shopping mall.

**F 2**

An additional potential solution would be to construct subsurface retention/detention under the parking lot of the Broward County Nancy J. Cotterman Center. An addition to subsurface storage, pervious pavement could be implemented as the parking lot surface to reduce impervious area.

There solutions would require pump stations to route runoff from the larger scale stormwater systems to discharge to the North Forks New River.

**F3**

A third potential solution would be to construct water gardens outside the Wilton Manors City Office at Island City Park Preserve.

# Proposed Solution Details – Property Scale Proposal #4

## Metric Summary

### Rainfall and Coastal Conditions

*Multiple design storms were evaluated to illustrate the effectiveness of the water management adaptation conceptual strategies. The 10-year, 72-hour storm event is the basis for crown-of-road elevations. Smaller design storms were evaluated including the 2-year, 2-hour storm event, which FDOT frequently evaluates, to determine strategies' effectiveness during smaller, more frequent events.*

| Scenario | Rainfall Depth (in) | Storm Volume (gal) |
|---|---|---|
| 2-year, 2-hour | 3.19 | 7,392,837 |
| 5-year, 24-hour | 7.42 | 17,195,878 |
| 10-year, 24-hour | 9.07 | 21,019,759 |
| 10-year, 72-hour | 10.8 | 25,029,040 |

### Short-Term Solution Cost Estimate

| | Quantity | | Unit Cost | | Subtotal |
|---|---|---|---|---|---|
| Exfiltration/Bioswale | 43,716 ft² | $ | 25.00 | $ | 1,092,898.65 |
| Porous Pavement | 35,455 ft² | $ | 30.00 | $ | 1,063,660.50 |
| Subsurface Storage | 39,825 ft² | $ | 50.00 | $ | 1,991,243.87 |
| | | | | **$** | **4,147,803.02** |

*Conceptual cost estimate is variable depending on site conditions, utility constraints, additional restoration, improvements and design aspects including underdrains and expanded footprints.*

### Summary of Design

*Additional stormwater management is necessary to mitigate flooding. Long-term solutions could provide centralized, large-scale stormwater management, which will require detailed feasibility analysis and coordination with stakeholders.*

***Drainage Area*** 111 ac
***Percentage Impervious*** 77%

| | | | *% of Tv Managed by Full Vol.** | | | |
|---|---|---|---|---|---|---|
| ***System Type*** | ***System Area*** | ***System Volume*** | ***2yr - 2hr*** | ***5yr - 24hr*** | ***10yr-24hr*** | ***10yr - 72hr*** |
| ROW Systems | | | | | | |
| Exfiltration/Bioswale | 43,716 ft² | 332,490 gal | 4% | 2% | 2% | 1% |
| Porous Pavement | 35,455 ft² | 229,876 gal | 3% | 1% | 1% | 1% |
| Subsurface Storage | 39,825 ft² | 258,206 gal | 3% | 2% | 1% | 1% |
| ***SubTotal*** | ***118,996 ft²*** | ***820,572 gal*** | ***11%*** | ***5%*** | ***4%*** | ***3%*** |
| Long-term Systems | | | | | | |
| F1 (840 Plaza Shopping Mall) | 59,142 ft² | 383,452 gal | 5% | 2% | 2% | 2% |
| F2 (Nancy J. Cotterman Center) | 65,812 ft² | 426,695 gal | 6% | 2% | 2% | 2% |
| F3 (Island City Park Preserve) | 4,087 ft² | 26,495 gal | 0% | 0% | 2% | 0% |
| ***SubTotal*** | ***129,041 ft²*** | ***836,642 gal*** | ***11%*** | ***5%*** | ***5%*** | ***3%*** |
| ***Total*** | | ***1,657,214 gal*** | ***22%*** | ***10%*** | ***9%*** | ***7%*** |

**Tv = Storm Depth * % Impervious * Drainage Area*

### Green Infrastructure Sizing Assumptions

| Exfiltration/Bioswale Systems | | Porous Pavement Systems | | Subsurface Storage Systems | |
|---|---|---|---|---|---|
| **Surface Volume Provided** | | **Surface Volume Provided** | | **Surface Volume Provided** | |
| Ponding Depth | 3" | | - | | - |
| ROW System Floor Area | 43,716 ft² | ROW System Floor Area | 35,455 ft² | ROW System Floor Area | 39,825 ft² |
| Area at Ponding Elevation | 43,716 ft² | | - | | - |
| Surface Ponding Volume | 10,929 ft³ | | - | | - |
| **Full Storage Volume Provided** | | **Full Storage Volume Provided** | | **Full Storage Volume Provided** | |
| Soil Depth | 1.0' | | - | | - |
| Soil Porosity | 30% | | - | | - |
| Stone Depth | 1.17' | Stone Depth | 2.17' | Stone Depth | 2.17' |
| Stone Porosity | 40% | Stone Porosity | 40% | Stone Porosity | 40% |
| Surface Volume | 10,929 ft³ | | - | | - |
| Soil Volume | 13,115 ft³ | | - | | - |
| Stone Volume | 20,401 ft³ | Stone Volume | 30,728 ft³ | Stone Volume | 34,515 ft³ |
| Total Storage Volume | 44,445 ft³ | Total Storage Volume | 30,728 ft³ | Total Storage Volume | 34,515 ft³ |
| Total Storage Volume (gal) | 332,490 gal | Total Storage Volume (gal) | 229,876 gal | Total Storage Volume (gal) | 258,206 gal |

## Property Solution Details – Property Scale Proposal #4

Overall Summary

- Potential to manage up to 0.8 million gallons of stormwater with right-of-way green infrastructure however, additional improvements could increase managed volume to 1.7 million gallons.
- Grassed surface bioswales, pervious pavement, and subsurface storage allow for minimal disruption in a residential and commercial area.
- Additional co-benefits include neighborhood enhancements, improved water quality, and educational outreach.
- Large subsurface storage in commercial lots could provide additional flood relief.
- Pumping to available storage areas and/or canals provides opportunities for greater stormwater management.

#5

# Property Scale Proposal #5 – Miramar

## Medium Density Residential



| Municipality | |
|---|---|
| Miramar | |
| Area | |
| 160 acres | |
| Imperviousness | Groundwater Depth |
| 36% | 2.5 ft |
| Target Design Storm Volume | |
| 16.8 million gallons | |
| Average Flooding Depth | Max Flooding Depth |
| 1.0 ft | 0.6 ft |

**Existing Conditions**

This medium density residential neighborhood is a newer development of single-family homes with residential streets. Critical infrastructure includes the adjacent Memorial Regional Hospital to the northwest. This community experiences frequent shallow flooding, and topography and drainage typically flows to the canals bordering the development perimeter. The 10-year, 72-hour storm event with a 2-foot sea level rise condition creates flooding in pockets of the neighborhood. Parcels experience <3-inches of flooding, while roadways experience up to 1 foot of flooding in some pockets.

# Property Solution Overview - Property Scale Proposal #5

## Short-Term Solution: Right-of-Way Green Infrastructure



| Stormwater Volume Managed | |
|---|---|
| 685,000 gallons | |
| % Volume Reduction 10-yr, 72-hr | % Volume Reduction 10-yr, 24-hr |
| 4% | 5% |
| % Volume Reduction 5-yr, 24-hr | % Volume Reduction 2-yr, 2-hr |
| 6% | 14% |
| Conceptual Cost Estimate | |
| $2,830,000 | |

**Proposed Solution Description**

Based on Miramar GIS, the roadways within the neighborhood are private streets with no public right-of-way. This solution involves transforming existing driveway aprons with pervious pavement with an underlying stone base. Additional pervious pavement is proposed within the parking stalls at the HOA community center. This solution also involves transforming the grassed area between the street and sidewalk into shallow bioswales with a turf grass. Bioswales were sited to avoid any existing trees, which significantly limits the number of bioswales feasible in this neighborhood. Additional bioswales are proposed to the south between the commercial development and Miramar Parkway. Bioswales were sited to avoid steeper slopes and above ground utilities. Bioswales would have a shallow 3" depression to allow for short-term ponding.

# Property Solution Details – Property Scale Proposal #5

## Proposed Short-Term: Right-of-Way Green Infrastructure



**Co-benefits**

- Educational Outreach
- Improved Water Quality
- Neighborhood Enhancement

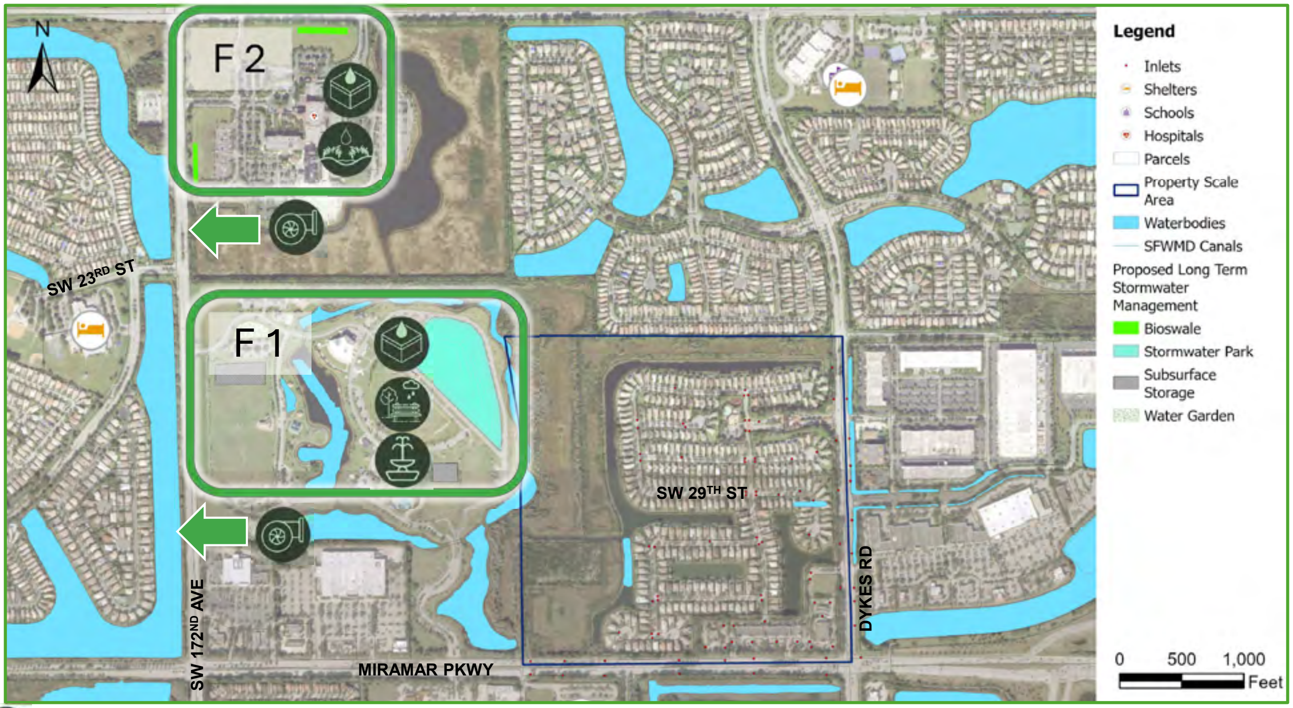
**Proposed Short-Term Solution**

Residential solutions considered options for addressing localized flooding, maximizing volume with limited space and reducing impacts to existing parking and neighborhood use. These concepts can be used in other parts of the County with similar right-of-way configurations and particularly in residential areas where impacts should be minimal in the short-term.

- Right-of-Way Bioswales
- Pervious Pavement

# Proposed Solution Details - Property Scale Proposal #5

## Future Implementation Options




- Stormwater Park
- On-Site Green Infrastructure
- Large Subsurface Storage
- Pump Station
- Water Gardens

### Potential Additional Volume Managed

✓ F 1 – 3,916,500 gal
✓ F 2 – 244,326 gal

### Key Considerations

✓ Stakeholder Support
✓ Utility Relocation

### Future Implementation Strategy

*Additional stormwater management is necessary to mitigate larger flooding events and flooding. Future implementation strategies could provide centralized, large-scale stormwater management, which will require detailed feasibility analysis and coordination with stakeholders. These solutions would provide additional flood mitigation.*

**F 1**

Within Miramar Regional Park, one potential solution would be to construct subsurface detention practices below the existing sport fields. An additional potential solution is to create a water garden at the project entrance adjacent to the playground and beach volleyball court. A third potential solution is to convert the grassed area to the rear of the park to a large stormwater park.

**F 2**

The Memorial Hospital Miramar is identified as a critical facility located to the northwest of the project area. Existing drainage swales run along the north and west property perimeter. Offline bioswales could be installed in the grassed area adjacent to the existing drainage features to provide additional flood mitigation and water quality benefits. Additional subsurface detention/retention could be provided in the grassed areas or below existing parking lots. Above ground detention/retention could also be evaluated. These solutions would require pump stations to route runoff from the project area, to the large-scale stormwater systems, to then discharge to the canal along SW 172nd Ave.

# Proposed Solution Details – Property Scale Proposal #5

## Metric Summary

### Rainfall and Coastal Conditions

*Multiple design storms were evaluated to illustrate the effectiveness of the water management adaptation conceptual strategies. The 10-year, 72-hour storm event is the basis for crown-of-road elevations. Smaller design storms were evaluated including the 2-year, 2-hour storm event, which FDOT frequently evaluates, to determine strategies' effectiveness during smaller, more frequent events.*

| Scenario | Rainfall Depth (in) | Storm Volume (gal) |
|---|---|---|
| 2-year, 2-hour | 3.19 | 4,946,706 |
| 5-year, 24-hour | 7.42 | 11,506,132 |
| 10-year, 24-hour | 9.07 | 14,064,773 |
| 10-year, 72-hour | 10.8 | 16,747,470 |

### Short-Term Solution Cost Estimate

| | Quantity | Unit Cost | Subtotal |
|---|---|---|---|
| Exfiltration/Bioswale | 32,513 ft² | $ 25.00 | $ 812,831.89 |
| Porous Pavement | 67,225 ft² | $ 30.00 | $ 2,016,749.74 |
| | | | **$ 2,829,581.63** |

*Conceptual cost estimate is variable depending on site conditions, utility constraints, additional restoration, improvements and design aspects including underdrains and expanded footprints.*

### Summary of Design

*Additional stormwater management is necessary to mitigate flooding. Long-term solutions could provide centralized, large-scale stormwater management, which will require detailed feasibility analysis and coordination with stakeholders.*

***Drainage Area*** 160 ac

***Percentage Impervious*** 36%

| System Type | System Area | System Volume | % of Tv Managed by Full Vol.* 2yr - 2hr | 5yr - 24hr | 10yr-24hr | 10yr - 72hr |
|---|---|---|---|---|---|---|
| ROW Systems | | | | | | |
| Exfiltration/Bioswale | 32,513 ft² | 247,286 gal | 5% | 2% | 2% | 1% |
| Porous Pavement | 67,225 ft² | 435,855 gal | 9% | 4% | 3% | 3% |
| ***SubTotal*** | ***99,738 ft²*** | ***683,141 gal*** | ***14%*** | ***6%*** | ***5%*** | ***4%*** |
| Long-term Systems | | | | | | |
| F1 (Miramar Regional Park) | 562,571 ft² | 3,916,500 gal | 79% | 34% | 28% | 23% |
| F2 (Memorial Hospital Miramar) | 32,124 ft² | 244,326 gal | 5% | 2% | 28% | 1% |
| ***SubTotal*** | ***594,695 ft²*** | ***4,160,826 gal*** | ***84%*** | ***36%*** | ***56%*** | ***25%*** |
| ***Total*** | | ***4,843,967 gal*** | ***98%*** | ***42%*** | ***61%*** | ***29%*** |

**Tv = Storm Depth * % Impervious * Drainage Area*

### Green Infrastructure Sizing Assumptions

| Exfiltration/Bioswale Systems | | Porous Pavement Systems | |
|---|---|---|---|
| **Surface Volume Provided** | | **Surface Volume Provided** | |
| Ponding Depth | 3" | | - |
| ROW System Floor Area | 32,513 ft² | ROW System Floor Area | 67,225 ft² |
| Area at Ponding Elevation | 32,513 ft² | | - |
| Surface Ponding Volume | 8,128 ft³ | | - |
| **Full Storage Volume Provided** | | **Full Storage Volume Provided** | |
| Soil Depth | 1.0' | | - |
| Soil Porosity | 30% | | - |
| Stone Depth | 1.17' | Stone Depth | 2.17' |
| Stone Porosity | 40% | Stone Porosity | 40% |
| Surface Volume | 8,128 ft³ | | - |
| Soil Volume | 9,754 ft³ | | - |
| Stone Volume | 15,173 ft³ | Stone Volume | 58,262 ft³ |
| Total Storage Volume | 33,055 ft³ | Total Storage Volume | 58,262 ft³ |
| Total Storage Volume (gal) | 247,286 gal | Total Storage Volume (gal) | 435,855 gal |

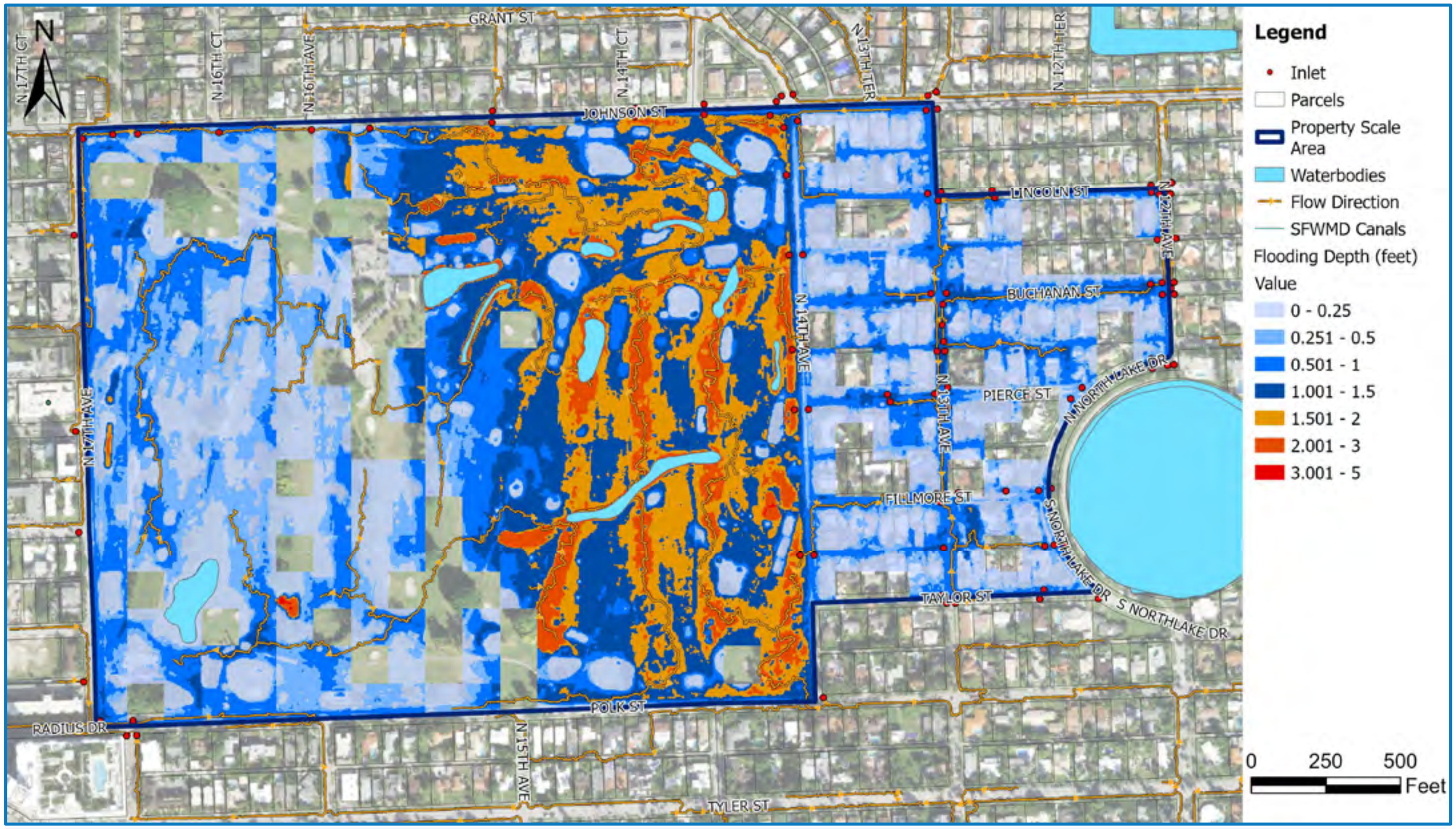
**Property Solution Details – Property Scale Proposal #5**

Overall Summary

- Potential to manage up to 0.7 million gallons of stormwater with right-of-way green infrastructure however, additional improvements could increase managed volume to 4.8 million gallons.
- Grassed surface bioswales and pervious pavement allow for minimal disruption in a residential area.
- Additional co-benefits include neighborhood enhancements, improved water quality, and educational outreach.
- A large stormwater park at a nearby park could provide additional flood relief.
- Pumping to available storage areas and/or canals provides opportunities for greater stormwater management.

# Property Scale Proposal #6 – Hollywood – North Lake

## Country Club and Residential





| Municipality | |
|---|---|
| Hollywood | |
| **Area** | |
| 146 acres | |
| **Imperviousness** | **Groundwater Depth** |
| 30% | 2.5 ft |
| **Target Design Storm Volume** | |
| 12.8 million gallons | |
| **Average Flooding Depth** | **Max Flooding Depth** |
| 0.8 ft | 3.8 ft |

**Existing Conditions**

This neighborhood contains single family homes and a private golf country club and golf course. North Lake is directly to the east of the neighborhood, which drains into the Stranahan River. This community experiences frequent moderate flooding, and topography and drainage typically flows to the west. The 10-year, 72-hour storm event with a 2-foot level sea level rise condition creates wide-spread flooding through the neighborhood. Parcels typically experience <6 in of flooding while the majority of the streets experience 1 to 2 feet of flooding.

# Property Solution Overview – Property Scale Proposal #6

## Short-Term Solution: Right-of-Way Green Infrastructure



| Stormwater Volume Managed | |
|---|---|
| 1.07 million gallons | |
| % Volume Reduction 10-yr, 72-hr | % Volume Reduction 10-yr, 24-hr |
| 8% | 10% |
| % Volume Reduction 5-yr, 24-hr | % Volume Reduction 2-yr, 2-hr |
| 12% | 28% |
| Conceptual Cost Estimate | |
| $4,000,000 | |

**Proposed Solution Description**

The proposed near-term solution involves transforming current right-of-way green space between the street and the sidewalk into shallow bioswales with a turf grass surface. Bioswales were sited to avoid major structures within the right-of-way (i.e. mailboxes, above ground utility boxes, etc). Bioswales would have a shallow 3" depression in the middle to allow for short-term ponding. Driveways in-between the grassed bioswales are proposed as pervious pavement with opportunities to hydraulically connect systems with the underlying stone base and underdrains. Shallow subsurface chambers or perforated pipes can be included within the stone layers to increase void space. Additionally, previous pavement is proposed in all on-street parking spaces throughout the neighborhood.

# Property Solution Details – Property Scale Proposal #6

## Short-Term Solution: Right-of-Way Green Infrastructure



**Co-benefits**

- Educational Outreach
- Improved Water Quality
- Neighborhood Enhancement

**Proposed Short-Term Solution**

Residential solutions considered options for addressing localized flooding, maximizing volume with limited space and reducing impacts to existing parking and neighborhood use. These concepts can be used in other parts of the County with similar right-of-way configurations and particularly in residential areas where impacts should be minimal in the short-term.

- Right-of-Way Bioswales
- Pervious Pavement

# Proposed Solution Details - Property Scale Proposal #6

## Future Implementation Options


- Pervious Pavement
- On-Site Green Infrastructure
- Stormwater Park
- Pump Station
- Above-ground Water Storage

### Potential Additional Volume Managed

✓ F 1 – 4,374,097 gal
✓ F 2 – 332,597 gal

### Key Considerations

✓ Stakeholder Support
✓ Utility Relocation

## Future Implementation Strategy

*Additional stormwater management is necessary to mitigate larger flooding events and flooding. Future implementation strategies could provide centralized, large-scale stormwater management, which will require detailed feasibility analysis and coordination with stakeholders. These solutions would provide additional flood mitigation.*

**F 1**

The Hollywood Beach Club is a public golf course with numerous opportunities for stormwater management. The existing ponds can be expanded to provide additional above ground water storage. Additional stormwater features can be added with stormwater parks and on-site green infrastructure. Each of these features can increase the stormwater storage capacity in the neighborhood while increasing the complexity and appeal of the course. These solutions would require a pump station to route the stormwater to the canal to the east.

**F 2**

The alleys within the neighborhood can be converted to pervious pavement to increase the storage capacity. Additionally, stormwater from the neighborhood can be directed into the solutions proposed in F1 via a pump station.

# Proposed Solution Details – Property Scale Proposal #6

## Metric Summary

### Rainfall and Coastal Conditions

*Multiple design storms were evaluated to illustrate the effectiveness of the water management adaptation conceptual strategies. The 10-year, 72-hour storm event is the basis for crown-of-road elevations. Smaller design storms were evaluated including the 2-year, 2-hour storm event, which FDOT frequently evaluates, to determine strategies' effectiveness during smaller, more frequent events.*

| Scenario | Rainfall Depth (in) | Storm Volume (gal) |
|---|---|---|
| 2-year, 2-hour | 3.19 | 3,759,430 |
| 5-year, 24-hour | 7.42 | 8,744,504 |
| 10-year, 24-hour | 9.07 | 10,689,037 |
| 10-year, 72-hour | 10.8 | 12,727,850 |

### Short-Term Solution Cost Estimate

| | Quantity | Unit Cost | Subtotal |
|---|---|---|---|
| Exfiltration/Bioswale | 93,155 ft² | $ 25.00 | $ 2,328,876.95 |
| Porous Pavement | 54,622 ft² | $ 30.00 | $ 1,638,649.75 |
| | | | **$ 3,967,526.70** |

*Conceptual cost estimate is variable depending on site conditions, utility constraints, additional restoration, improvements and design aspects including underdrains and expanded footprints.*

### Summary of Design

*Additional stormwater management is necessary to mitigate flooding. Long-term solutions could provide centralized, large-scale stormwater management, which will require detailed feasibility analysis and coordination with stakeholders.*

***Drainage Area*** 146 ac

***Percentage Impervious*** 30%

| System Type | System Area | System Volume | % of Tv Managed by Full Vol.* 2yr - 2hr | 5yr - 24hr | 10yr-24hr | 10yr - 72hr |
|---|---|---|---|---|---|---|
| **ROW Systems** | | | | | | |
| Exfiltration/Bioswale | 93,155 ft² | 708,508 gal | 19% | 8% | 7% | 6% |
| Porous Pavement | 54,622 ft² | 354,141 gal | 9% | 4% | 3% | 3% |
| ***SubTotal*** | ***147,777 ft²*** | ***1,062,649 gal*** | ***28%*** | ***12%*** | ***10%*** | ***8%*** |
| **Long-term Systems** | | | | | | |
| F1 (Hollywood Beach Club) | 492,734 ft² | 4,374,097 gal | 116% | 50% | 41% | 34% |
| F2 (Neighborhood) | 51,299 ft² | 332,597 gal | 9% | 4% | 41% | 3% |
| ***SubTotal*** | ***544,033 ft²*** | ***4,706,694 gal*** | ***125%*** | ***54%*** | ***82%*** | ***37%*** |
| ***Total*** | | ***5,769,343 gal*** | ***153%*** | ***66%*** | ***92%*** | ***45%*** |

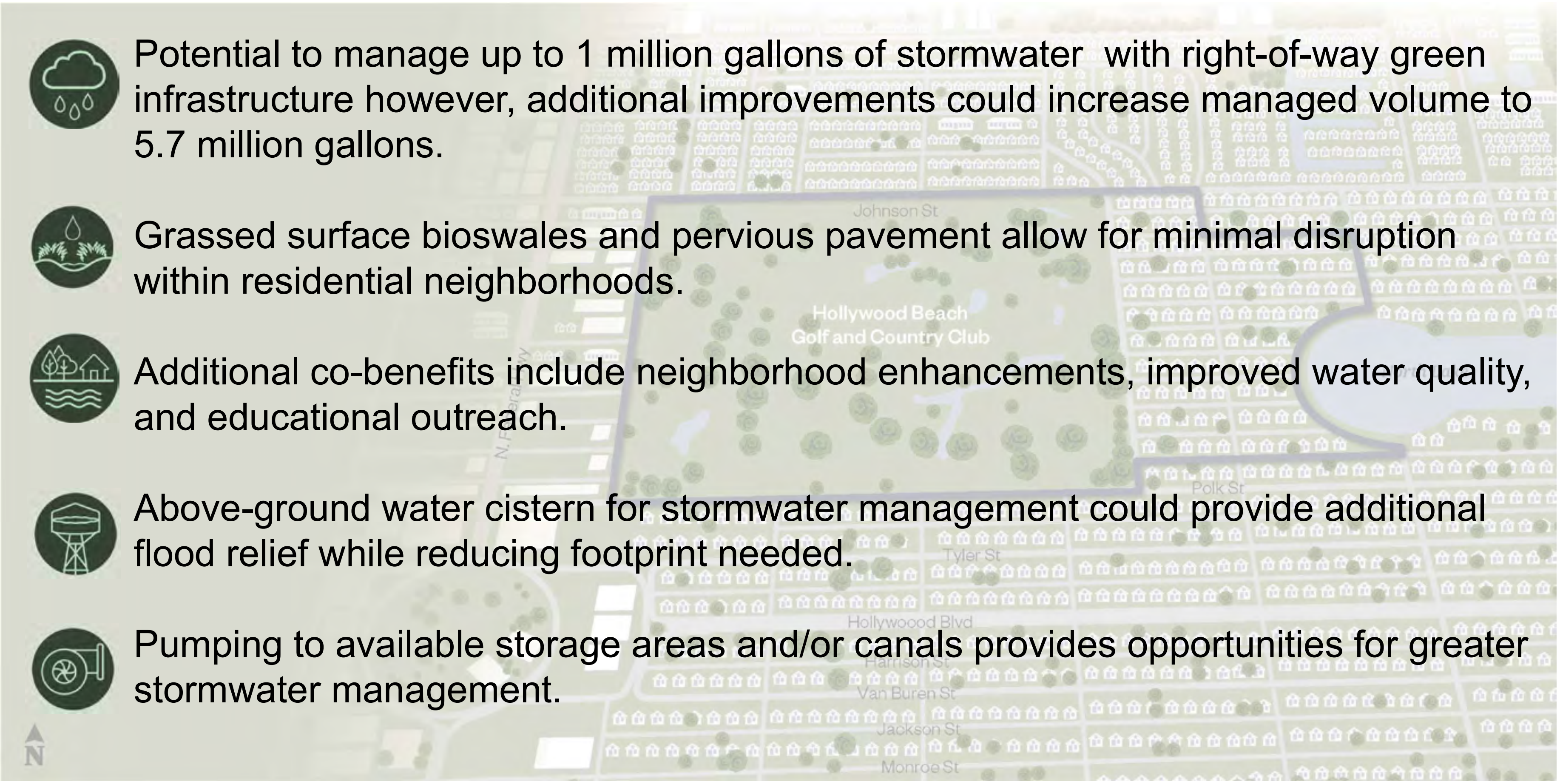
**Tv = Storm Depth * % Impervious * Drainage Area*

### Green Infrastructure Sizing Assumptions

| Exfiltration/Bioswale Systems | | Porous Pavement Systems | |
|---|---|---|---|
| **Surface Volume Provided** | | **Surface Volume Provided** | |
| Ponding Depth | 3" | | - |
| ROW System Floor Area | 93,155 ft² | ROW System Floor Area | 54,622 ft² |
| Area at Ponding Elevation | 93,155 ft² | | - |
| Surface Ponding Volume | 23,289 ft³ | | - |
| **Full Storage Volume Provided** | | **Full Storage Volume Provided** | |
| Soil Depth | 1.0' | | - |
| Soil Porosity | 30% | | - |
| Stone Depth | 1.17' | Stone Depth | 2.17' |
| Stone Porosity | 40% | Stone Porosity | 40% |
| Surface Volume | 23,289 ft³ | | - |
| Soil Volume | 27,947 ft³ | | - |
| Stone Volume | 43,472 ft³ | Stone Volume | 47,339 ft³ |
| Total Storage Volume | 94,708 ft³ | Total Storage Volume | 47,339 ft³ |
| Total Storage Volume (gal) | 708,508 gal | Total Storage Volume (gal) | 354,141 gal |

**Property Solution Details – Property Scale Proposal #6**

Overall Summary

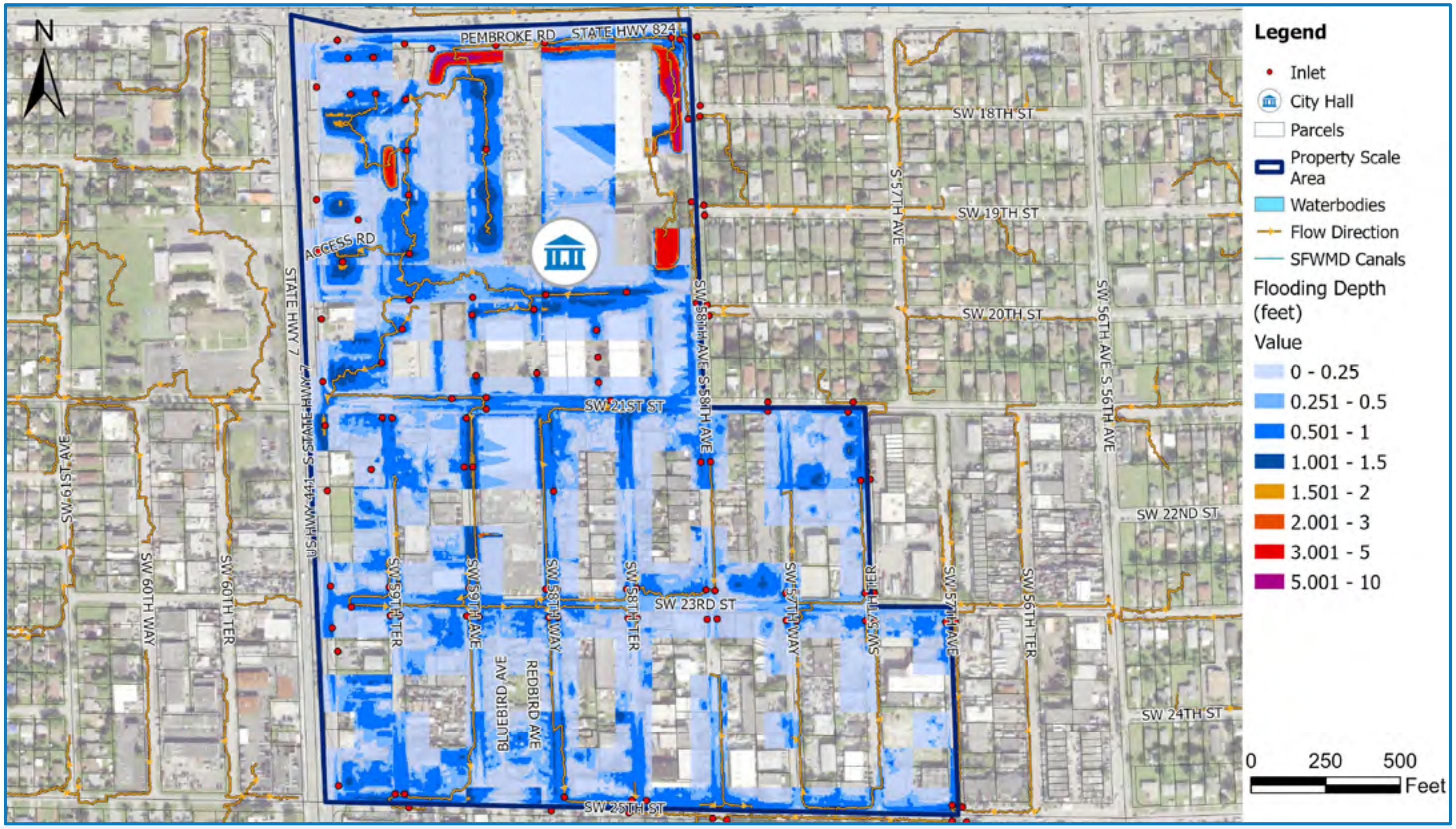



- Potential to manage up to 1 million gallons of stormwater with right-of-way green infrastructure however, additional improvements could increase managed volume to 5.7 million gallons.
- Grassed surface bioswales and pervious pavement allow for minimal disruption within residential neighborhoods.
- Additional co-benefits include neighborhood enhancements, improved water quality, and educational outreach.
- Above-ground water cistern for stormwater management could provide additional flood relief while reducing footprint needed.
- Pumping to available storage areas and/or canals provides opportunities for greater stormwater management.

## #7

# Property Scale Proposal #7 – West Park

## Country Club and Residential





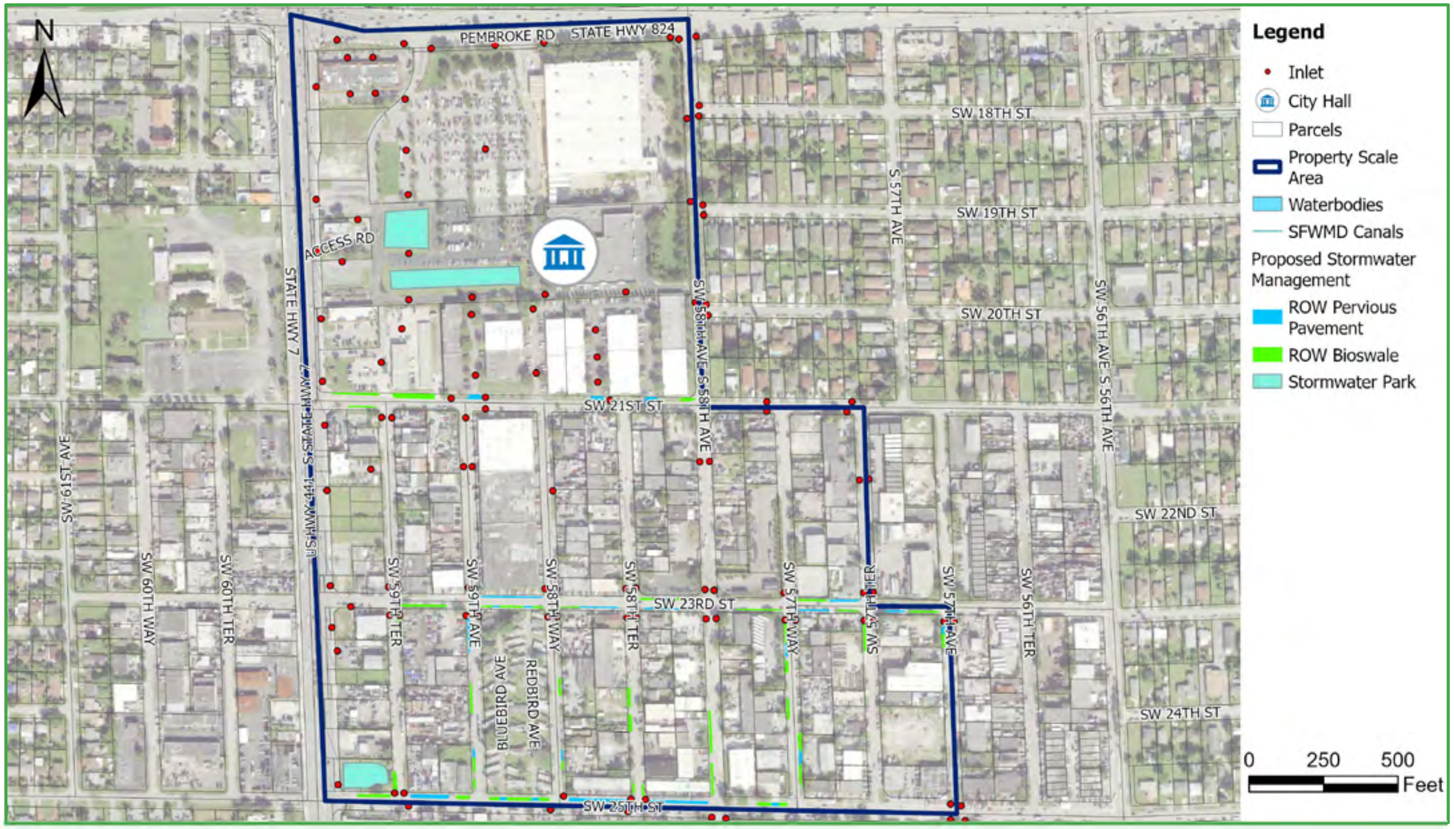
| Municipality | |
|---|---|
| West Park | |
| **Area** | |
| 101 acres | |
| **Imperviousness** | **Groundwater Depth** |
| 80% | 2.5 ft |
| **Target Design Storm Volume** | |
| 23.6 million gallons | |
| **Average Flooding Depth** | **Max Flooding Depth** |
| 0.4 ft | 6.0 ft |

**Existing Conditions**

This mixed-use property area is a combination of modular homes, primarily older, single-family homes, and commercial lots. State Highway 7 borders the west side of the property area and State Highway 824 borders the north side, with bus routes on both roads. Home Depot and West Park City Hall along with other commercial properties make up the upper half of the property area and contain some existing stormwater management features. This area experiences frequent shallow flooding, and topography and drainage typically flows to the south. Critical infrastructure in the vicinity includes West Park City Hall. The 10-year, 72-hour storm event with a 2-foot level sea level rise condition creates wide-spread flooding through the area. Parcels typically experience <6 in of flooding while some streets and parcels experience up to 2 feet of flooding.

# Property Solution Overview – Property Scale Proposal #7

## Short-Term Solution: Gray/Green Infrastructure





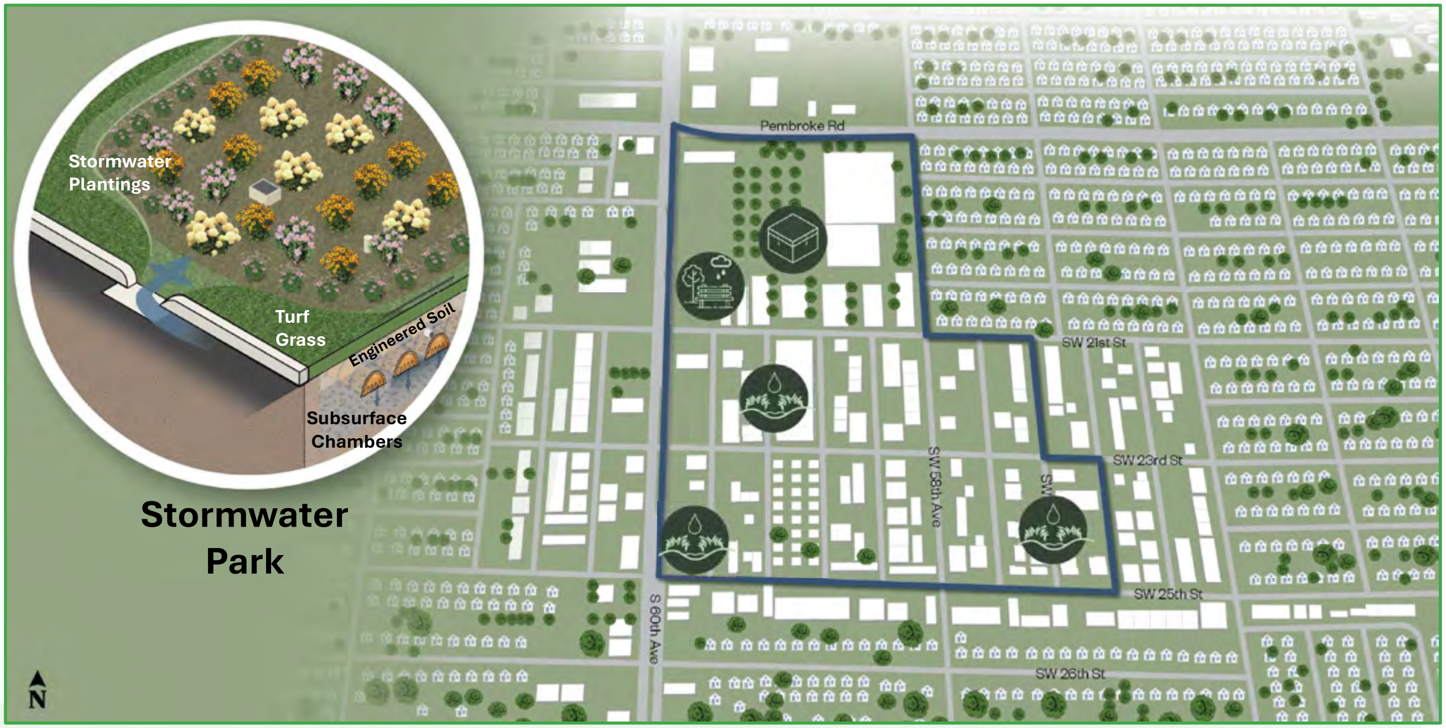
| Stormwater Volume Managed | |
|---|---|
| 682,000 gallons | |
| **% Volume Reduction 10-yr, 72-hr** | **% Volume Reduction 10-yr, 24-hr** |
| 3% | 3% |
| **% Volume Reduction 5-yr, 24-hr** | **% Volume Reduction 2-yr, 2-hr** |
| 4% | 10% |
| **Conceptual Cost Estimate** | |
| $3,985,000 | |

**Proposed Solution Description**

The proposed near-term solution involves transforming current right-of-way green space between the street and the sidewalk into shallow bioswales with a turf grass surface. Bioswales were sited to avoid major structures within the right-of-way (i.e. mailboxes, above ground utility boxes, etc). Bioswales would have a shallow 3" depression in the middle to allow for short-term ponding. Pervious pavement is proposed in driveways in the ROW. Underground stone areas can be expanded within the street to accommodate shallow ground water while maximizing volume capture. Shallow subsurface chambers or perforated pipes can be included within the stone layers to increase void space. A stormwater park is proposed on the vacant parcels located in the southwest corner of the neighborhood.

# Property Solution Details – Property Scale Proposal #7

## Short-Term Solution: Gray/Green Infrastructure





**Co-benefits**

- Educational Outreach
- Improved Water Quality
- Neighborhood Enhancement

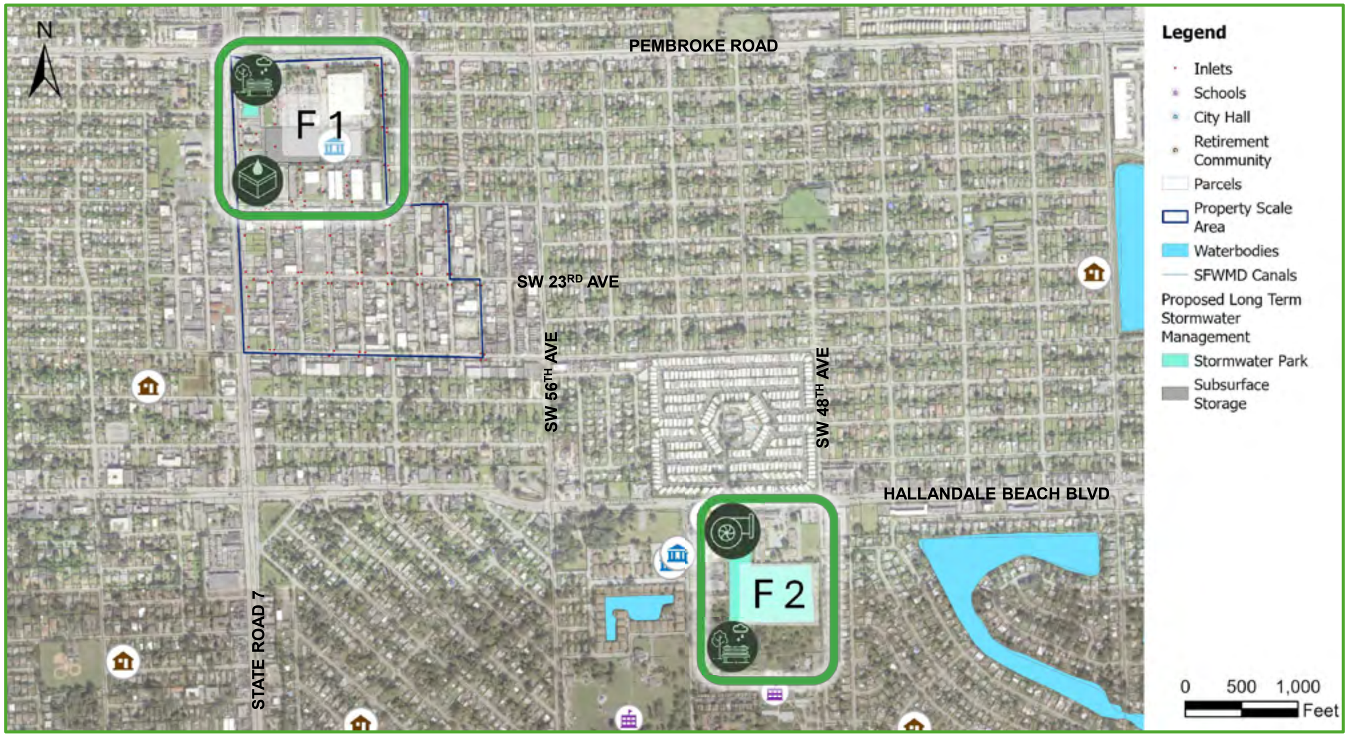
**Proposed Short-Term Solution**

Industrial solutions considered options for addressing localized flooding, maximizing volume with limited space and reducing impacts to existing parking and industrial use. These concepts can be used in other parts of the County with similar right-of-way configurations and particularly in industrial areas where impacts should be minimal in the short-term.

- Right-of-Way Bioswales
- Pervious Pavement
- Stormwater Park

# Proposed Solution Details – Property Scale Proposal #7

## Future Implementation Options




Stormwater Park

Large Subsurface Storage

Pump Station

### Potential Additional Volume Managed

- ✓ F 1 – 1,179,500 gal
- ✓ F 2 – 3,341,296 gal

### Key Considerations

- ✓ Stakeholder Support
- ✓ Utility Relocation

## Future Implementation Strategy

*Additional stormwater management is necessary to mitigate larger flooding events and flooding. Future implementation strategies could provide centralized, large-scale stormwater management, which will require detailed feasibility analysis and coordination with stakeholders. These solutions would provide additional flood mitigation and would work*

**F 1**

To the southeast of the intersection of State Road 7 and Pembroke Boulevard, there is a large commercial shopping plaza that is a good opportunity for stormwater facilities. A stormwater park could be constructed in the vacant lot along State Road 7. Additionally, large-scale subsurface detention systems could be constructed underneath parking lots to manage nearby runoff.

**F 2**

The Pembroke Park Perserve is located to the southeast of the project area. A stormwater park is proposed in a portion of the park. The stormwater park could be expanded to manage additional runoff. This solution would require pump stations to route runoff from the project area.

# Proposed Solution Details – Property Scale Proposal #7

## Metric Summary

### Rainfall and Coastal Conditions

*Multiple design storms were evaluated to illustrate the effectiveness of the water management adaptation conceptual strategies. The 10-year, 72-hour storm event is the basis for crown-of-road elevations. Smaller design storms were evaluated including the 2-year, 2-hour storm event, which FDOT frequently evaluates, to determine strategies' effectiveness during smaller, more frequent events.*

| Scenario | Rainfall Depth (in) | Storm Volume (gal) |
|---|---|---|
| 2-year, 2-hour | 3.19 | 6,986,935 |
| 5-year, 24-hour | 7.42 | 16,251,743 |
| 10-year, 24-hour | 9.07 | 19,865,675 |
| 10-year, 72-hour | 10.8 | 23,654,827 |

### Short-Term Solution Cost Estimate

| | Quantity | Unit Cost | Subtotal |
|---|---|---|---|
| Exfiltration/Bioswale | 27,905 ft² | $ 25.00 | $ 697,618.76 |
| Porous Pavement | 16,657 ft² | $ 30.00 | $ 499,707.92 |
| Subsurface Storage | 55,741 ft² | $ 50.00 | $ 2,787,048.65 |
| | | | **$ 3,984,375.33** |

*Conceptual cost estimate is variable depending on site conditions, utility constraints, additional restoration, improvements and design aspects including underdrains and expanded footprints.*

### Summary of Design

*Additional stormwater management is necessary to mitigate flooding. Long-term solutions could provide centralized, large-scale stormwater management, which will require detailed feasibility analysis and coordination with stakeholders.*

***Drainage Area*** 101 ac

***Percentage Impervious*** 80%

| System Type | System Area | System Volume | % of Tv Managed by Full Vol.* 2yr - 2hr | 5yr - 24hr | 10yr-24hr | 10yr - 72hr |
|---|---|---|---|---|---|---|
| **ROW Systems** | | | | | | |
| Exfiltration/Bioswale | 27,905 ft² | 212,235 gal | 3% | 1% | 1% | 1% |
| Porous Pavement | 16,657 ft² | 107,996 gal | 2% | 1% | 1% | 0% |
| Subsurface Storage | 55,741 ft² | 361,398 gal | 5% | 2% | 2% | 2% |
| ***SubTotal*** | ***100,303 ft²*** | ***681,629 gal*** | ***10%*** | ***4%*** | ***3%*** | ***3%*** |
| **Long-term Systems** | | | | | | |
| F1 (Adjacent to State HWY 7) | 179,068 ft² | 1,179,500 gal | 17% | 7% | 6% | 5% |
| F2 (SW 52nd Avenue) | 470,145 ft² | 3,341,296 gal | 48% | 21% | 6% | 14% |
| ***SubTotal*** | ***649,213 ft²*** | ***4,520,795 gal*** | ***65%*** | ***28%*** | ***12%*** | ***19%*** |
| ***Total*** | | ***5,202,424 gal*** | ***74%*** | ***32%*** | ***15%*** | ***22%*** |

**Tv = Storm Depth * % Impervious * Drainage Area*

### Green Infrastructure Sizing Assumptions

**Exfiltration/Bioswale Systems**

| Surface Volume Provided | |
|---|---|
| Ponding Depth | 3" |
| ROW System Floor Area | 27,905 ft² |
| Area at Ponding Elevation | 27,905 ft² |
| Surface Ponding Volume | 6,976 ft³ |
| **Full Storage Volume Provided** | |
| Soil Depth | 1.0' |
| Soil Porosity | 30% |
| Stone Depth | 1.17' |
| Stone Porosity | 40% |
| Surface Volume | 6,976 ft³ |
| Soil Volume | 8,371 ft³ |
| Stone Volume | 13,022 ft³ |
| Total Storage Volume | 28,370 ft³ |
| Total Storage Volume (gal) | 212,235 gal |

**Porous Pavement Systems**

| Surface Volume Provided | |
|---|---|
| Ponding Depth | - |
| ROW System Floor Area | 16,657 ft² |
| Area at Ponding Elevation | - |
| Surface Ponding Volume | - |
| **Full Storage Volume Provided** | |
| Soil Depth | - |
| Soil Porosity | - |
| Stone Depth | 2.17' |
| Stone Porosity | 40% |
| Surface Volume | - |
| Soil Volume | - |
| Stone Volume | 14,436 ft³ |
| Total Storage Volume | 14,436 ft³ |
| Total Storage Volume (gal) | 107,996 gal |

**Subsurface Storage Systems**

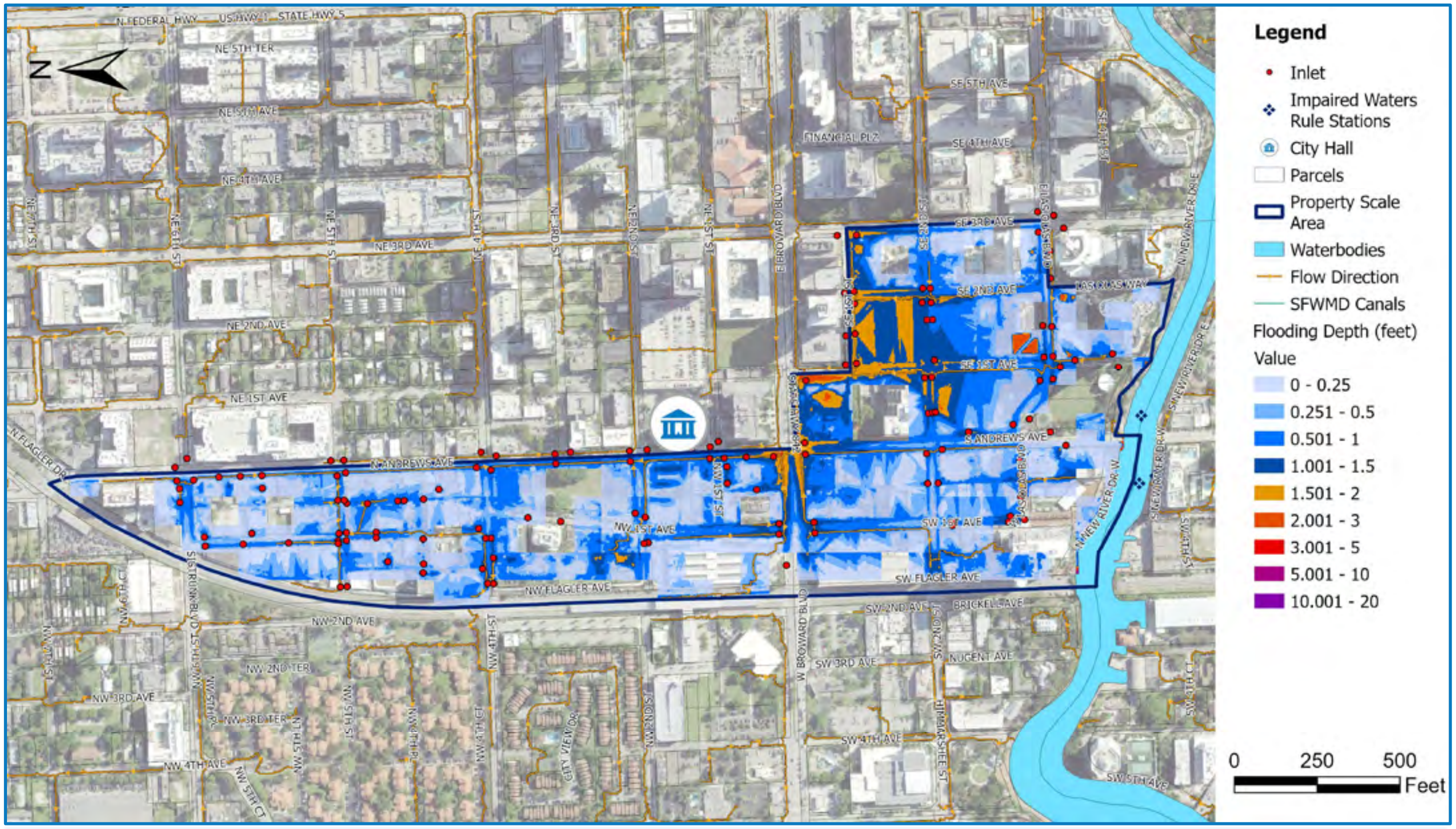
| Surface Volume Provided | |
|---|---|
| Ponding Depth | - |
| ROW System Floor Area | 55,741 ft² |
| Area at Ponding Elevation | - |
| Surface Ponding Volume | - |
| **Full Storage Volume Provided** | |
| Soil Depth | - |
| Soil Porosity | - |
| Stone Depth | 2.17' |
| Stone Porosity | 40% |
| Surface Volume | - |
| Soil Volume | - |
| Stone Volume | 48,309 ft³ |
| Total Storage Volume | 48,309 ft³ |
| Total Storage Volume (gal) | 361,398 gal |

**Property Solution Details – Property Scale Proposal #7**
Overall Summary

- Potential to manage up to 0.7 million gallons of stormwater with right-of-way green infrastructure however, additional improvements could increase managed volume to 5.2 million gallons.
- Grassed surface bioswales and pervious pavement allow for minimal disruption in a residential, commercial, industrial areas.
- Additional co-benefits include neighborhood enhancements, improved water quality, and educational outreach.
- Large subsurface storage underneath parking lots and stormwater parks adjacent to the subsurface storage could provide additional flood relief.
- Pumping to available storage areas and/or canals provides opportunities for greater stormwater management.

# Property Scale Proposal #8 – Downtown Fort Lauderdale

## Commercial and Services/Institutional





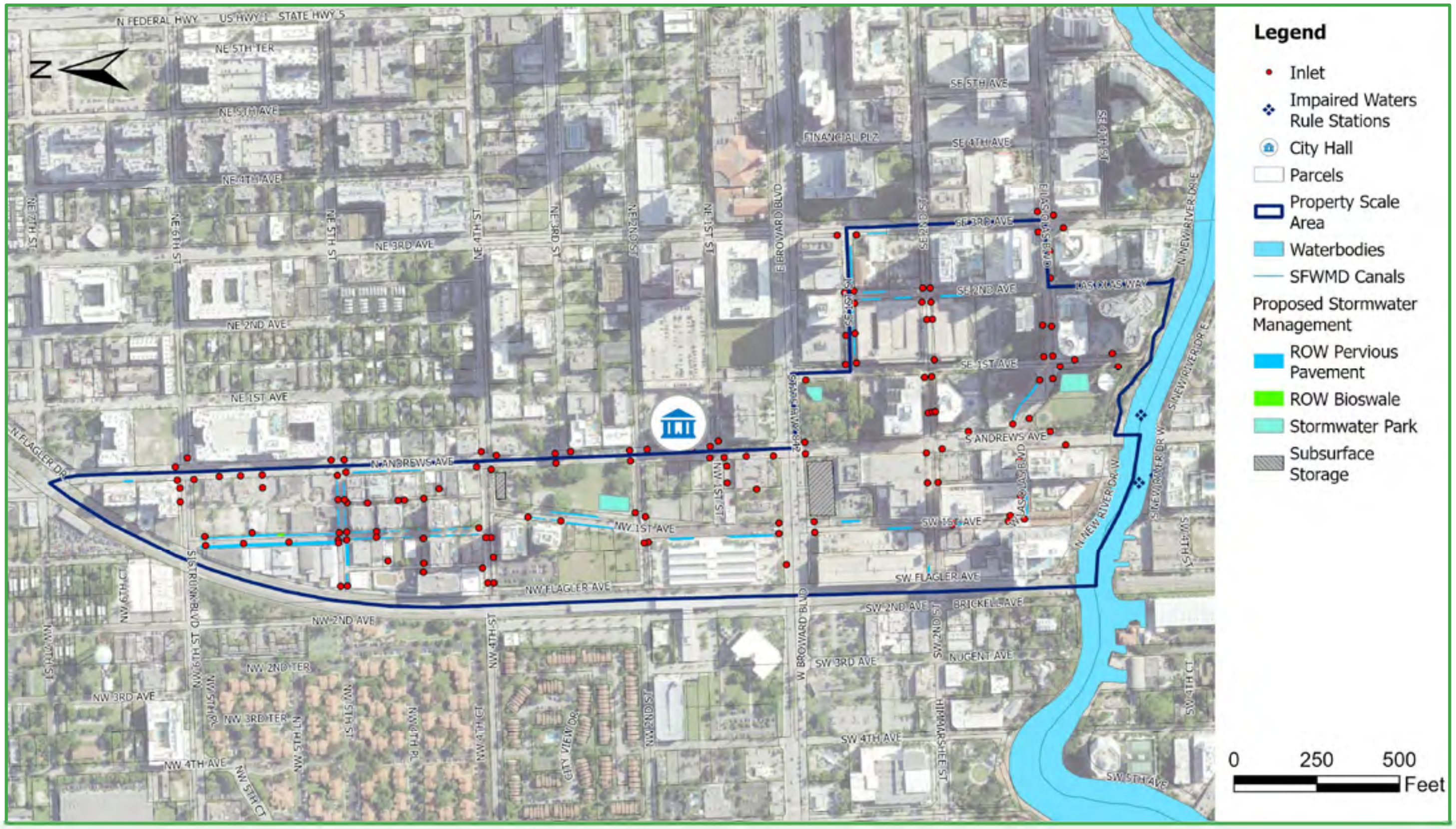
| Municipality | |
|---|---|
| Fort Lauderdale | |
| **Area** | |
| 92 acres | |
| **Imperviousness** | **Groundwater Depth** |
| 84% | 3.0 ft |
| **Target Design Storm Volume** | |
| 22.7 million gallons | |
| **Average Flooding Depth** | **Max Flooding Depth** |
| 0.5 ft | 2.9 ft |

**Existing Conditions**

Downtown Fort Lauderdale is highly urbanized with many commercial and high-rise apartment buildings. There are numerous bus routes through the neighborhood since the Broward County Bus Terminal is located at the intersection of W Broward Boulevard and SW 1st Avenue. This community experiences moderate to extreme flooding, and topography and drainage typically flows to the south. Fort Lauderdale City Hall is located at 100 N Andrews Avenue and is critical infrastructure. The 10-year, 72-hour storm event with a 2-foot level sea level rise condition creates wide-spread flooding through the downtown area. Parcels typically experience <6 in of flooding with some parcels experiencing up to 1.5 feet. Streets typically experience up to 1.5 feet of flooding with some areas experiencing up to 3 feet.

# Property Solution Overview – Property Scale Proposal #8

## Short-Term Solution: Gray/Green Infrastructure





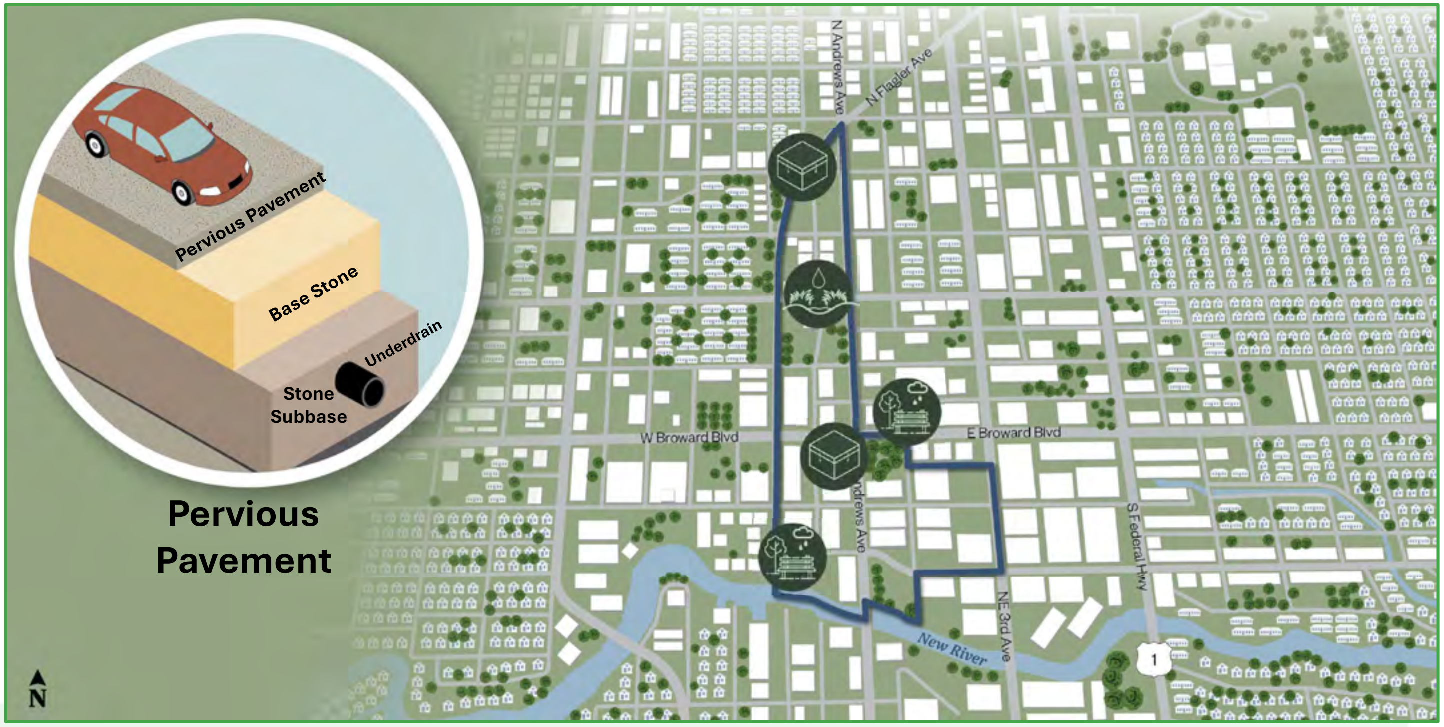
| Stormwater Volume Managed | |
|---|---|
| 670,500 gallons | |
| **% Volume Reduction 10-yr, 72-hr** | **% Volume Reduction 10-yr, 24-hr** |
| 3% | 4% |
| **% Volume Reduction 5-yr, 24-hr** | **% Volume Reduction 2-yr, 2-hr** |
| 4% | 10% |
| **Conceptual Cost Estimate** | |
| $4,145,000 | |

**Proposed Solution Description**

The proposed near-term solution involves transforming on street parking in pervious pavement and current right-of-way green spaces into shallow bioswales. Pervious pavement and bioswales were sited to avoid major structures within the right-of-way (i.e. above ground utility boxes, landscaping etc). Bioswales would have a shallow 3” depression in the middle to allow for short-term ponding. Underground stone areas can be expanded within the street to accommodate shallow ground water while maximizing volume capture. Shallow subsurface chambers or perforated pipes can be included within the stone layers to increase void space. Stormwater parks are proposed in public parks throughout the downtown area. Subsurface storage is proposed in city parking lots. Water gardens are proposed in open walking commercial areas.

# Property Solution Details – Property Scale Proposal #8

## Short-Term Solution: Gray/Green Infrastructure





**Co-benefits**

Educational Outreach

Improved Water Quality

Neighborhood Enhancement

**Proposed Short-Term Solution**

Commercial solutions considered options for addressing localized flooding, maximizing volume with limited space and reducing impacts to existing parking and commercial use. These concepts can be used in other parts of the County with similar right-of-way configurations and particularly in commercials areas where impacts should be minimal in the short-term.

Right-of-Way Bioswales

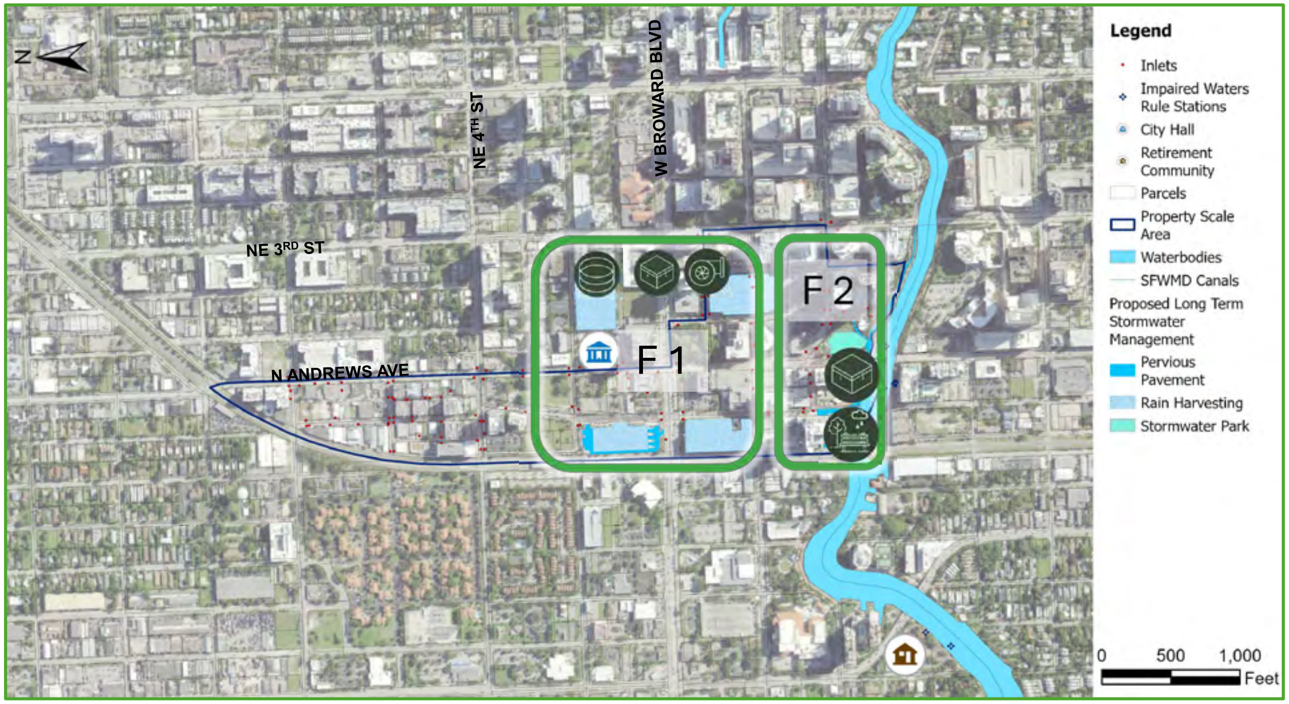
Pervious Pavement

Stormwater Park

Subsurface Storage

# Proposed Solution Details - Property Scale Proposal #8

## Future Implementation Options




Rainwater Harvesting

Stormwater Park

Pump Station

Pervious Pavement

### Potential Additional Volume Managed

- ✓ F 1 – 2,990,755 gal
- ✓ F 2 – 518,826 gal

### Key Considerations

- ✓ Stakeholder Support
- ✓ Utility Relocation

### Future Implementation Strategy

*Additional stormwater management is necessary to mitigate larger flooding events and flooding. Future implementation strategies could provide centralized, large-scale stormwater management, which will require detailed feasibility analysis and coordination with stakeholders. These solutions would provide additional flood mitigation.*

**F 1**

There are multiple parking garages in the area along with a large bus terminal. In these areas, water tanks can collect runoff during large storm events from the elevated impervious surfaces. The harvested rainwater can be used for landscaping. Alternatively, the water can be routed to the New River via a pump station. Additionally, pavement surrounding the parking garages and bus terminal can be converted to pervious pavement.

**F 2**

Huizenga Plaza is a prime location for a stormwater park. The entire area in front of the stage can be converted to a stormwater park. Since the park is in downtown Fort Laudedale, the stormwater park could also serve as an educational opportunity. All of the pavement along the Riverwalk can be converted to pervious pavement to increase the storage capacity and water quality benefits.

# Proposed Solution Details – Property Scale Proposal #8

## Metric Summary

RESILIENT BROWARD

### Rainfall and Coastal Conditions

*Multiple design storms were evaluated to illustrate the effectiveness of the water management adaptation conceptual strategies. The 10-year, 72-hour storm event is the basis for crown-of-road elevations. Smaller design storms were evaluated including the 2-year, 2-hour storm event, which FDOT frequently evaluates, to determine strategies' effectiveness during smaller, more frequent events.*

| Scenario | Rainfall Depth (in) | Storm Volume (gal) |
|---|---|---|
| 2-year, 2-hour | 3.19 | 6,701,844 |
| 5-year, 24-hour | 7.42 | 15,588,615 |
| 10-year, 24-hour | 9.07 | 19,055,085 |
| 10-year, 72-hour | 10.8 | 22,689,628 |

### Short-Term Solution Cost Estimate

| | Quantity | Unit Cost | Subtotal |
|---|---|---|---|
| Exfiltration/Bioswale | 379 ft² | $ 25.00 | $ 9,467.92 |
| Porous Pavement | 45,198 ft² | $ 30.00 | $ 1,355,943.25 |
| Subsurface Storage | 32,919 ft² | $ 50.00 | $ 1,645,958.64 |
| Stormwater Park | 22,665 ft² | $ 50.00 | $ 1,133,258.94 |
| | | | **$ 4,144,628.74** |

*Conceptual cost estimate is variable depending on site conditions, utility constraints, additional restoration, improvements and design aspects including underdrains and expanded footprints.*

### Summary of Design

*Additional stormwater management is necessary to mitigate flooding. Long-term solutions could provide centralized, large-scale stormwater management, which will require detailed feasibility analysis and coordination with stakeholders.*

***Drainage Area*** 92 ac
***Percentage Impervious*** 84%

| System Type | System Area | System Volume | % of Tv Managed by Full Vol.* 2yr - 2hr | 5yr - 24hr | 10yr-24hr | 10yr - 72hr |
|---|---|---|---|---|---|---|
| ROW Systems | | | | | | |
| Exfiltration/Bioswale | 379 ft² | 2,880 gal | 0% | 0% | 0% | 0% |
| Porous Pavement | 45,198 ft² | 293,043 gal | 4% | 2% | 2% | 1% |
| Subsurface Storage | 32,919 ft² | 213,433 gal | 3% | 1% | 1% | 1% |
| Stormwater Park | 22,665 ft² | 161,080 gal | 2% | 1% | 1% | 1% |
| ***SubTotal*** | ***101,161 ft²*** | ***670,437 gal*** | ***10%*** | ***4%*** | ***4%*** | ***3%*** |
| Long-term Systems | | | | | | |
| F1 (Bus Terminal) | 461,285 ft² | 2,990,755 gal | 45% | 19% | 16% | 13% |
| F2 (Riverwalk) | 76,765 ft² | 518,826 gal | 8% | 3% | 16% | 2% |
| ***SubTotal*** | ***538,050 ft²*** | ***3,509,580 gal*** | ***52%*** | ***23%*** | ***31%*** | ***15%*** |
| ***Total*** | | ***4,180,017 gal*** | ***62%*** | ***27%*** | ***35%*** | ***18%*** |

**Tv = Storm Depth * % Impervious * Drainage Area*

### Green Infrastructure Sizing Assumptions

| | Exfiltration/Bioswale Systems | Porous Pavement Systems | Subsurface Storage Systems | Stormwater Park Systems |
|---|---|---|---|---|
| **Surface Volume Provided** | | | | |
| Ponding Depth | 3'' | - | - | 3'' |
| ROW System Floor Area | 379 ft² | 45,198 ft² | 32,919 ft² | 22,665 ft² |
| Area at Ponding Elevation | 379 ft² | - | - | 22,665 ft² |
| Surface Ponding Volume | 95 ft³ | - | - | 5,666 ft³ |
| **Full Storage Volume Provided** | | | | |
| Soil Depth | 1.0' | - | - | 1.0' |
| Soil Porosity | 30% | - | - | 30% |
| Stone Depth | 1.17' | 2.17' | 2.17' | 1.00' |
| Stone Porosity | 40% | 40% | 40% | 40% |
| Surface Volume | 95 ft³ | - | - | 5,666 ft³ |
| Soil Volume | 114 ft³ | - | - | 6,800 ft³ |
| Stone Volume | 177 ft³ | 39,172 ft³ | 28,530 ft³ | 9,066 ft³ |
| Total Storage Volume | 385 ft³ | 39,172 ft³ | 28,530 ft³ | 21,532 ft³ |
| Total Storage Volume (gal) | 2,880 gal | 293,043 gal | 213,433 gal | 161,080 gal |

## Property Solution Details – Property Scale Proposal #8

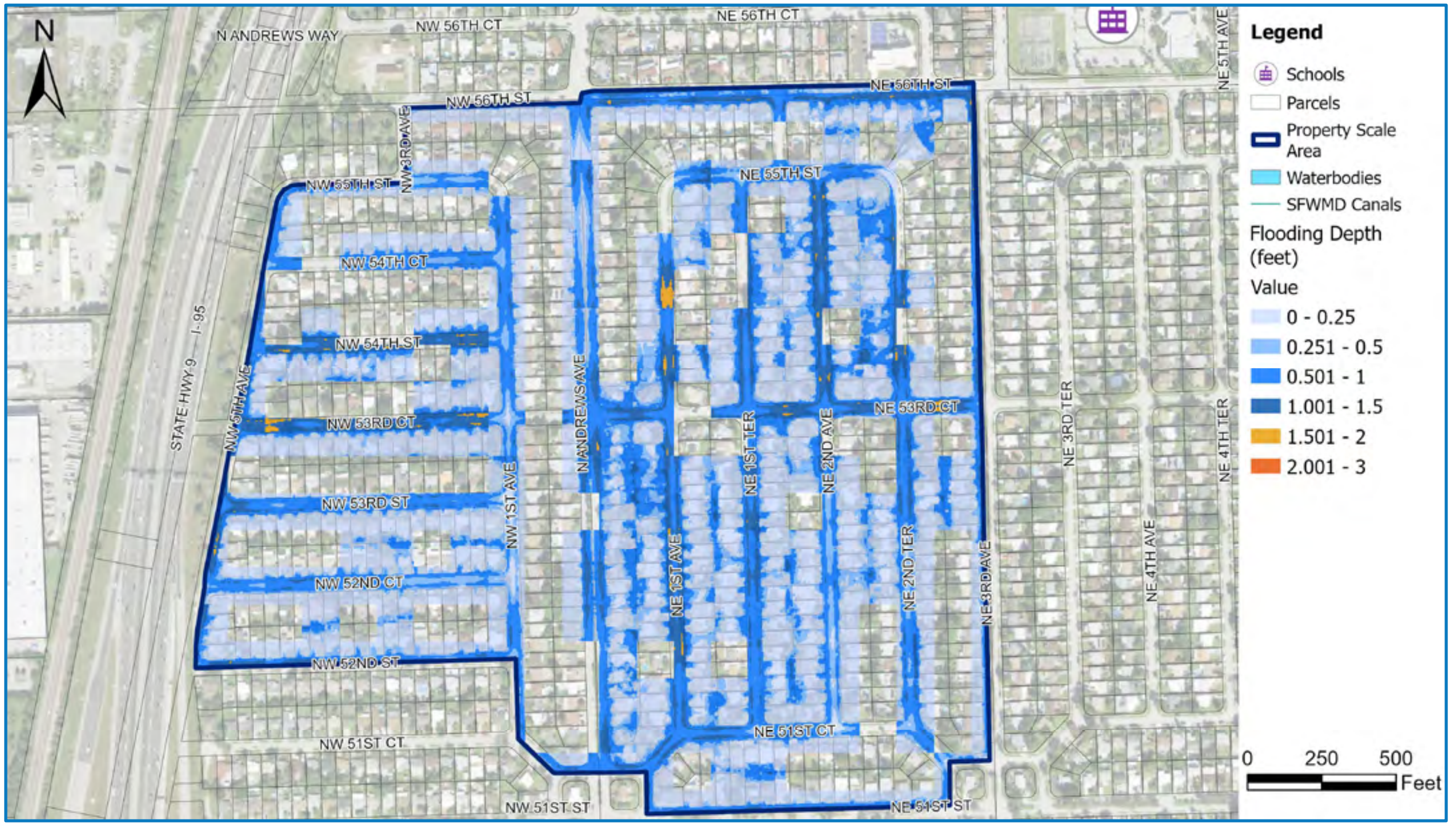
Overall Summary

- Potential to manage up to 0.7 million gallons of stormwater with right-of-way green infrastructure however, additional improvements could increase managed volume to 4.2 million gallons.
- Grassed surface bioswales and pervious pavement allow for minimal disruption within commercial areas.
- Additional co-benefits include neighborhood enhancements, improved water quality, and educational outreach.
- Water gardens for stormwater management with runoff storage from commercial areas could provide additional flood relief as well as aesthetic benefits.
- Pumping to available storage areas and/or canals provides opportunities for greater stormwater management.

## #9

# Property Scale Proposal #9 – Oakland Park/North Andrews

## Medium Density Residential





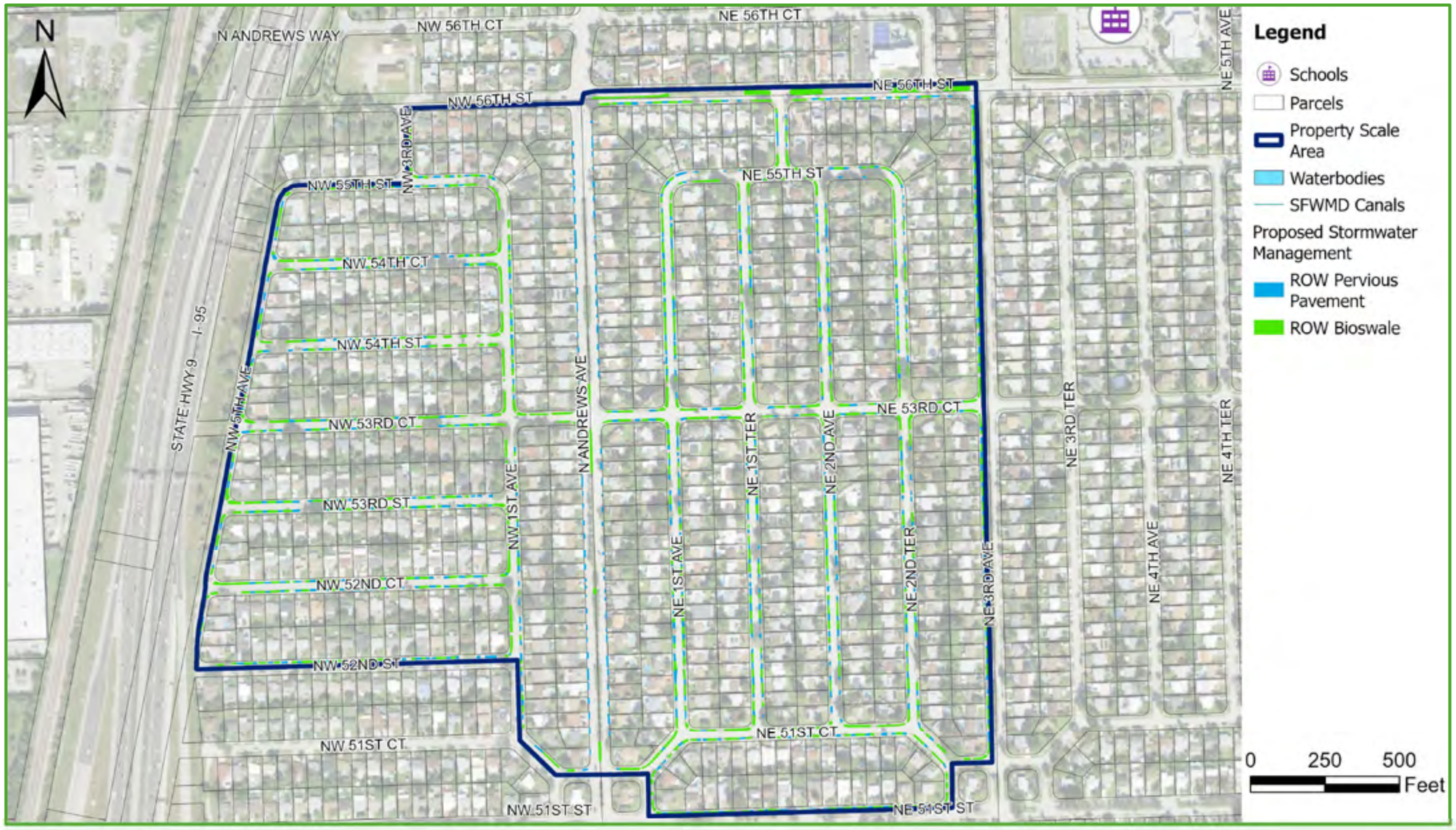
| Municipality | |
|---|---|
| Oakland Park, North Andrews | |
| **Area** | |
| 123 acres | |
| **Imperviousness** | **Groundwater Depth** |
| 65% | 3.5 ft |
| **Target Design Storm Volume** | |
| 23.3 million gallons | |
| **Average Flooding Depth** | **Max Flooding Depth** |
| 0.4 ft | 2.1 ft |

### Existing Conditions

This medium density residential neighborhood is primarily older, single-family homes with residential streets. N. Andrews Avenue is a local thoroughfare road with a bus route intersecting the neighborhood. This community experiences frequent shallow flooding, and topography and drainage typically flows to the southwest. Critical infrastructure in the vicinity includes two nearby schools, North Andrews Garden Elementary school to the north of NE 56$^{th}$ and Northeast High School to the east of NE 6$^{th}$ Avenue. The 10-year, 72-hour storm event with a 2-foot level sea level rise condition creates wide-spread flooding through the neighborhood. Parcels typically experience <6 in of flooding while streets experience up to 2 ft of flooding in some areas.

# Property Solution Overview – Property Scale Proposal #9

## Short-Term Solution: Right-of-Way Green Infrastructure





| Stormwater Volume Managed | |
|---|---|
| 2.5 million gallons | |
| **% Volume Reduction 10-yr, 72-hr** | **% Volume Reduction 10-yr, 24-hr** |
| 11% | 13% |
| **% Volume Reduction 5-yr, 24-hr** | **% Volume Reduction 2-yr, 2-hr** |
| 16% | 37% |
| **Conceptual Cost Estimate** | |
| $6,730,000 | |

**Proposed Solution Description**

To help mitigate localized flooding the proposed short-term solution involves transforming current right-of-way green space between the street and the sidewalk into shallow bioswales with a turf grass surface. Bioswales were sited to avoid major structures within the right-of-way (i.e. mailboxes, above ground utility boxes, etc). Bioswales would have a shallow 3" depression in the middle to allow for short-term ponding. Driveways in-between the grassed bioswales are proposed as pervious pavement with opportunities to connect systems with the underlying stone base and underdrains. Underground stone areas can be expanded within the street to maximize stormwater capture.

# Property Solution Details – Property Scale Proposal #9

## Short-Term Solution: Right-of-Way Green Infrastructure

RESILIENT BROWARD



**Co-Benefits**

- Educational Outreach
- Improved Water Quality
- Neighborhood Enhancement

Right-of-Way Bioswales

Pervious Pavement

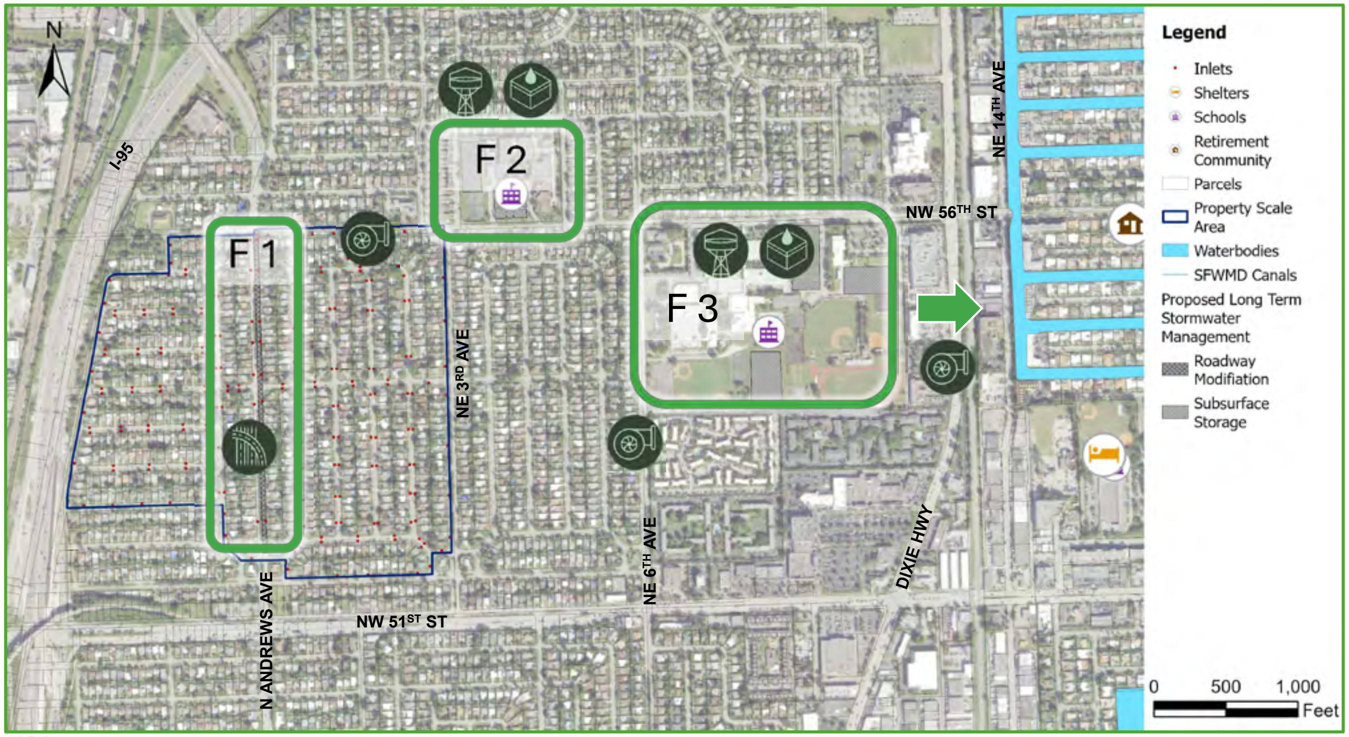
**Proposed Short-Term Solutions**

Residential solutions considered options for addressing localized flooding, maximizing volume with limited space and reducing impacts to existing parking and neighborhood use. These concepts can be used in other parts of the County with similar right-of-way configurations and particularly in residential areas where impacts should be minimal in the short-term.

The **Proposed Solution Concept** (right), illustrates how the residential neighborhood would not be drastically different from what is existing. The grass strips in between the sidewalk and street would be modified with engineered soil underneath and a stone bed which would absorb stormwater faster than what is currently there. That stone bed would also be under the porous pavement sections that are shown within the driveway sections, all of which would allow for significant stormwater capture and reduce flooding.

# Proposed Solution Details – Property Scale Proposal #9

## Future Implementation Options




Roadway Modification

Above-ground Water Storage

Large Subsurface Storage

Pump Station

### Potential Additional Volume Managed

✓ F 1 – 1,179,302 gal
✓ F 2 – 1,000,000 gal
✓ F 3 – 8,239,049 gal

### Key Considerations

✓ Stakeholder Support
✓ Utility Relocation

### Future Implementation Strategy

*Additional stormwater management is necessary to mitigate larger flooding events and flooding. Future implementation strategies could provide centralized, large-scale stormwater management, which will require detailed feasibility analysis and coordination with stakeholders.*

**F 1**

Within the Oakland Park neighborhood, solutions include:

- Converting N. Andrews Avenue from a 4-lane arterial road to 2-lane and dedicate the exterior abandoned lane into a stormwater management system
- Alternatively, elevating the road to create a bypass and convert all 4 lanes into stormwater detention beneath road.

**F 2 & F 3**

Adjacent to the neighborhood solutions include:

- Two nearby schools are located to the east of the project area that could serve as stormwater facilities. Large-scale subsurface detention systems could be constructed underneath parking lots and/or sports fields to manage nearby runoff.
- Above ground retention/detention and/or stormwater storage tanks could also be evaluated. These solutions would require pump stations to route runoff from the project area, to the large-scale stormwater systems, to then discharge to the canal along NE 14th Avenue.

# Proposed Solution Details – Property Scale Proposal #9
## Metric Summary

### Rainfall and Coastal Conditions

*Multiple design storms were evaluated to illustrate the effectiveness of the water management adaptation conceptual strategies. The 10-year, 72-hour storm event is the basis for crown-of-road elevations. Smaller design storms were evaluated including the 2-year, 2-hour storm event, which FDOT frequently evaluates, to determine strategies' effectiveness during smaller, more frequent events.*

| Scenario | Rainfall Depth (in) | Storm Volume (gal) |
|---|---|---|
| 2-year, 2-hour | 3.19 | 6,875,971 |
| 5-year, 24-hour | 7.42 | 15,993,638 |
| 10-year, 24-hour | 9.07 | 19,550,175 |
| 10-year, 72-hour | 10.8 | 23,279,149 |

### Short-Term Solution Cost Estimate

| | Quantity | Unit Cost | Subtotal |
|---|---|---|---|
| Exfiltration/Bioswale | 158,223 ft² | $ 25.00 | $ 3,955,579.67 |
| Porous Pavement | 92,194 ft² | $ 30.00 | $ 2,765,824.15 |
| | | | **$ 6,721,403.83** |

*Conceptual cost estimate is variable depending on site conditions, utility constraints, additional restoration, improvements and design aspects including underdrains and expanded footprints.*

### Summary of Design

*Additional stormwater management is necessary to mitigate flooding. Long-term solutions could provide centralized, large-scale stormwater management, which will require detailed feasibility analysis and coordination with stakeholders.*

***Drainage Area*** 123 ac

***Percentage Impervious*** 65%

| | | | % of Tv Managed by Full Vol.* | | | |
|---|---|---|---|---|---|---|
| ***System Type*** | ***System Area*** | ***System Volume*** | ***2yr - 2hr*** | ***5yr - 24hr*** | ***10yr-24hr*** | ***10yr - 72hr*** |
| ROW Systems | | | | | | |
| Exfiltration/Bioswale | 158,223 ft² | 1,676,863 gal | 24% | 10% | 9% | 7% |
| Porous Pavement | 92,194 ft² | 873,626 gal | 13% | 5% | 4% | 4% |
| ***SubTotal*** | ***250,417 ft²*** | ***2,550,488 gal*** | ***37%*** | ***16%*** | ***13%*** | ***11%*** |
| Long-term Systems | | | | | | |
| F1 (N Andrews Ave) | 68,539 ft² | 1,179,302 gal | 17% | 7% | 6% | 5% |
| F2 (North Gardens Elementary School) | 87,664 ft² | 1,000,001 gal | 15% | 6% | 6% | 4% |
| F3 (Northeast High School) | 291,402 ft² | 8,239,049 gal | 120% | 52% | 6% | 35% |
| ***SubTotal*** | ***447,605 ft²*** | ***10,418,352 gal*** | ***152%*** | ***65%*** | ***18%*** | ***45%*** |
| ***Total*** | | ***12,968,840 gal*** | ***189%*** | ***81%*** | ***31%*** | ***56%*** |

**Tv = Storm Depth * % Impervious * Drainage Area*

### Green Infrastructure Sizing Assumptions

| Exfiltration/Bioswale Systems | | Porous Pavement Systems | |
|---|---|---|---|
| **Surface Volume Provided** | | **Surface Volume Provided** | |
| Ponding Depth | 3" | | - |
| ROW System Floor Area | 158,223 ft² | ROW System Floor Area | 92,194 ft² |
| Area at Ponding Elevation | 158,223 ft² | | - |
| Surface Ponding Volume | 39,556 ft³ | | - |
| **Full Storage Volume Provided** | | **Full Storage Volume Provided** | |
| Soil Depth | 1.0' | | - |
| Soil Porosity | 30% | | - |
| Stone Depth | 2.17' | Stone Depth | 3.17' |
| Stone Porosity | 40% | Stone Porosity | 40% |
| Surface Volume | 39,556 ft³ | | - |
| Soil Volume | 47,467 ft³ | | - |
| Stone Volume | 137,127 ft³ | Stone Volume | 116,779 ft³ |
| Total Storage Volume | 224,150 ft³ | Total Storage Volume | 116,779 ft³ |
| Total Storage Volume (gal) | 1,676,863 gal | Total Storage Volume (gal) | 873,626 gal |

## Property Solution Details – Property Scale Proposal #9

Overall Summary

There is a potential to manage up to 2.5 million gallons of stormwater with right-of-way green infrastructure. Additional improvements could increase managed volume to 13.0 million gallons.

Grassed surface bioswales and pervious pavement would allow for minimal disruption within this residential neighborhood.

Additional co-benefits of these improvements include neighborhood enhancements, improved water quality, and educational outreach.

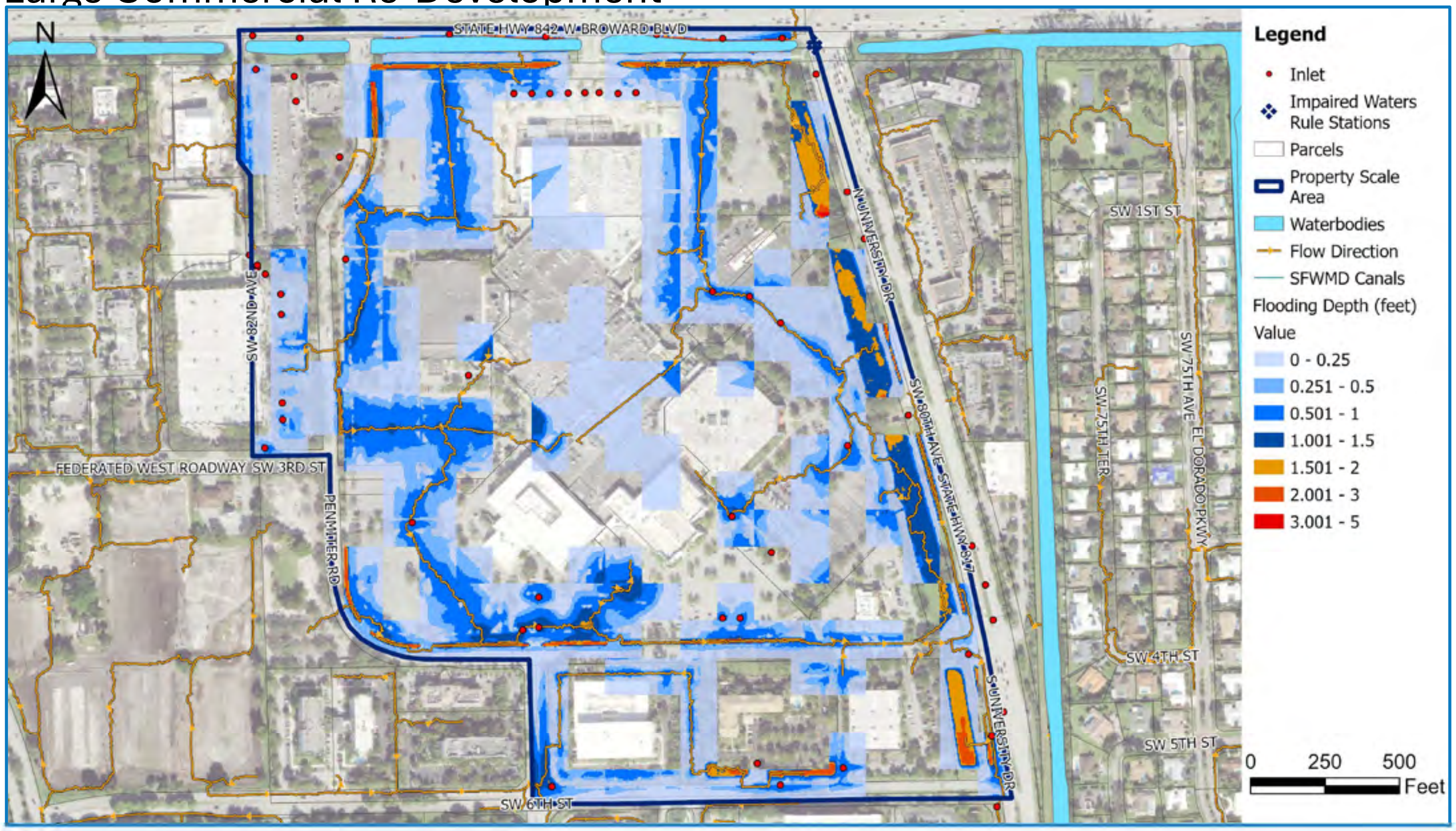
Driving lane removal for stormwater management or raising roads within the neighborhood could provide additional flood relief as a future solution.

Pumping to available storage areas, schools and/or canals provides opportunities for greater stormwater management as a future solution.

## #10

# Property Scale Proposal #10 – Plantation – Broward Mall

## Large Commercial Re-Development





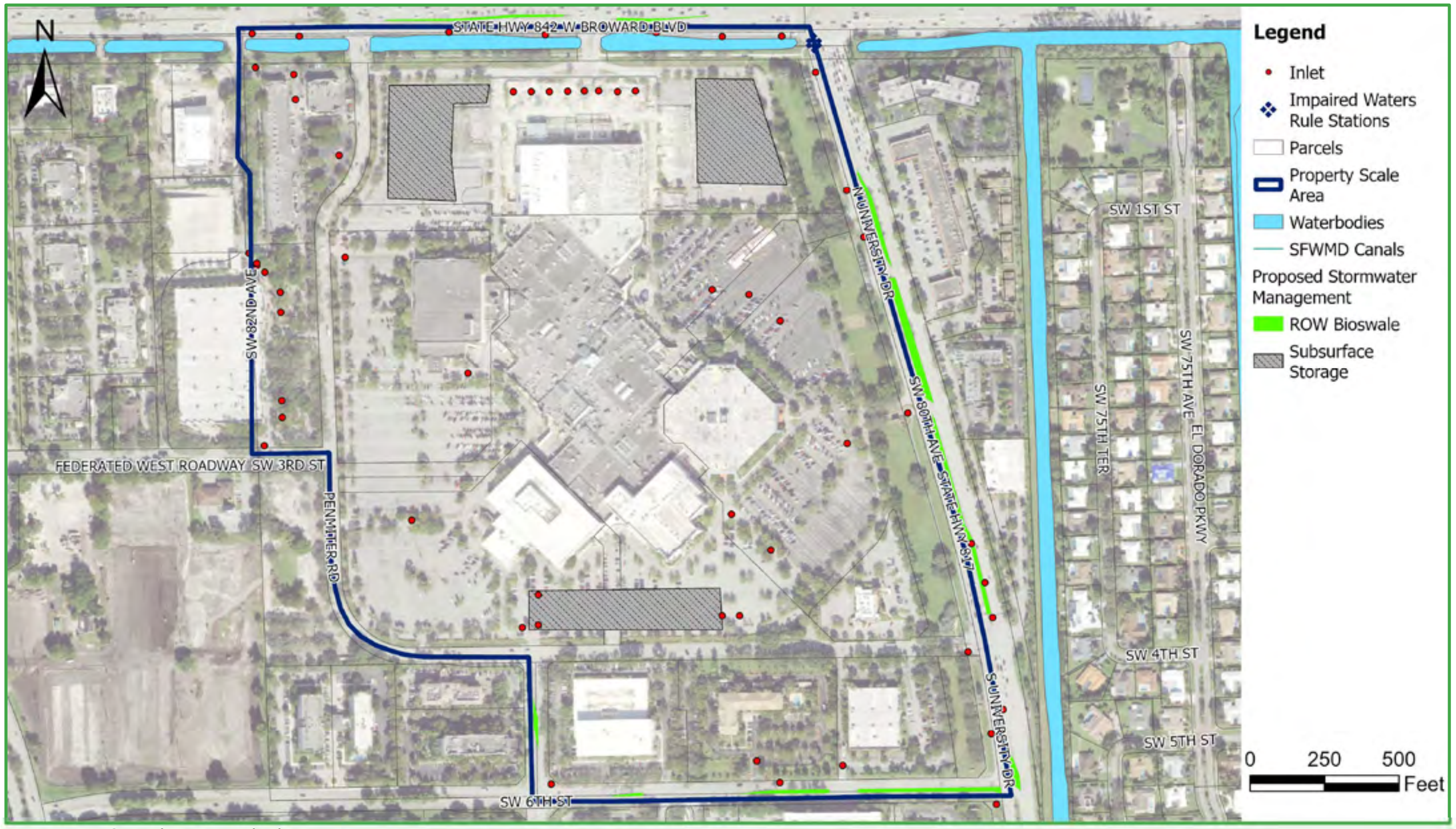
| Municipality | |
|---|---|
| City of Plantation | |
| **Area** | |
| 119 acres | |
| **Imperviousness** | **Groundwater Depth** |
| 75% | 2.5 ft |
| **Target Design Storm Volume** | |
| 26.3 million gallons | |
| **Average Flooding Depth** | **Max Flooding Depth** |
| 0.4 ft | 3.8 ft |

**Existing Conditions**

This commercial area contains the Broward Mall and surrounding commercial areas. S University Drive boards the east side of the property area and W Broward Blvd borders the north side. Existing waterbodies are located between the Broward Mall and W Broward Blvd on the north. Existing stormwater management features border the property to the east and south, which are located adjacent to S University Drive and SW 6$^{th}$ Street. The Plantation Fire Department Station #4 is located west of the project area. This area experiences frequent shallow flooding, and topography and drainage typically flows to the outer perimeter of the mall area. No critical infrastructure exists in area. The 10-yr, 72-hour storm with a 2-foot sea level rise condition creates wide-spread flooding through the area. Parking lots and streets typically experience <6in of flooding, while some areas of the parking lots experience up to 1 foot of flood.

# Proposed Solution Details - Property Scale Proposal #10

## Short-Term Solution: Right-of-Way Green Infrastructure and Subsurface Storage





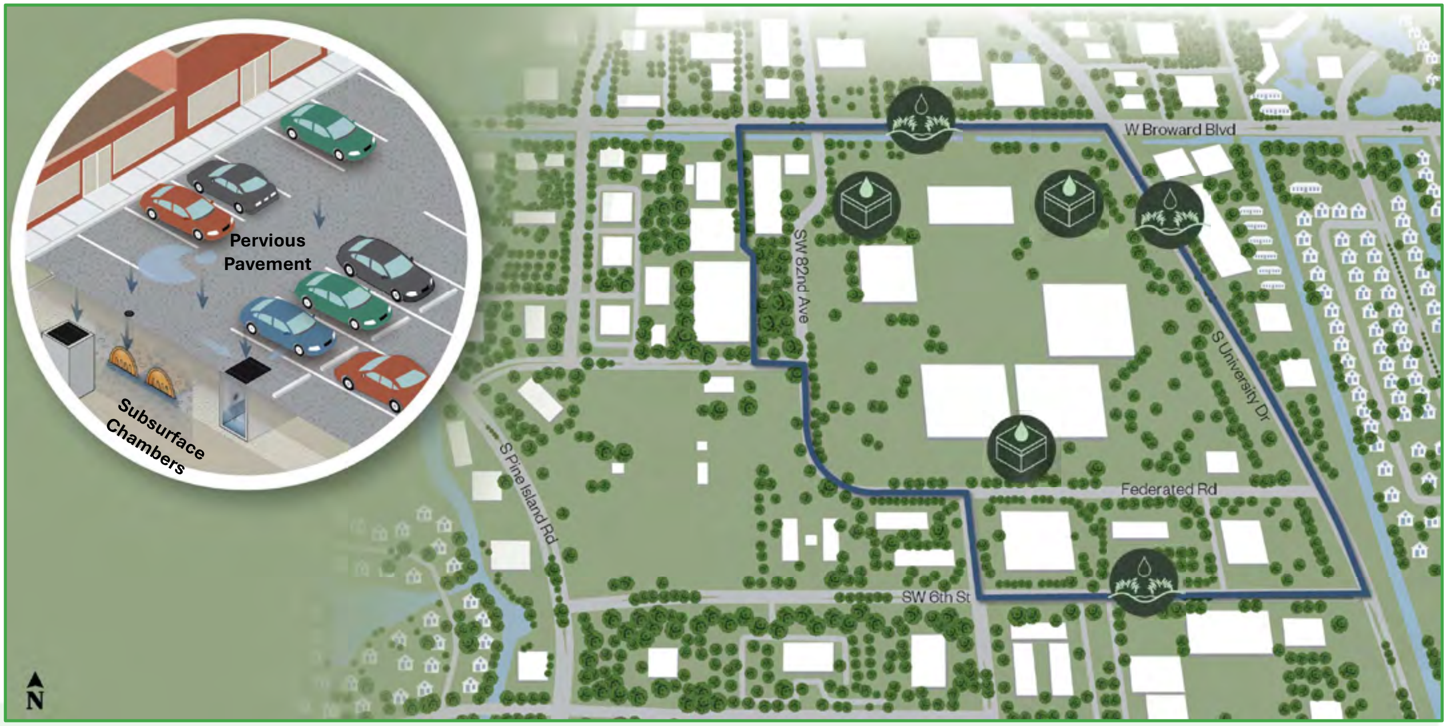
| Stormwater Volume Managed | |
|---|---|
| 2.06 million gallons | |
| **% Volume Reduction 10-yr, 72-hr** | **% Volume Reduction 10-yr, 24-hr** |
| 8% | 9% |
| **% Volume Reduction 5-yr, 24-hr** | **% Volume Reduction 2-yr, 2-hr** |
| 11% | 27% |
| **Conceptual Cost Estimate** | |
| $14,385,000 | |

**Proposed Solution Description**

The proposed near-term solution involves transforming the current center medians within the right-of-way into shallow bioswales. Bioswales would have a shallow 3” ponding surface. Additionally near-term solution involves constructing shallow subsurface chambers beneath the mall parking lot to provide additional detention.

# Property Solution Details – Property Scale Proposal #10

## Short-Term Solution: Right-of-Way Green Infrastructure and Subsurface Storage





**Co-benefits**

- Educational Outreach
- Improved Water Quality
- Neighborhood Enhancement

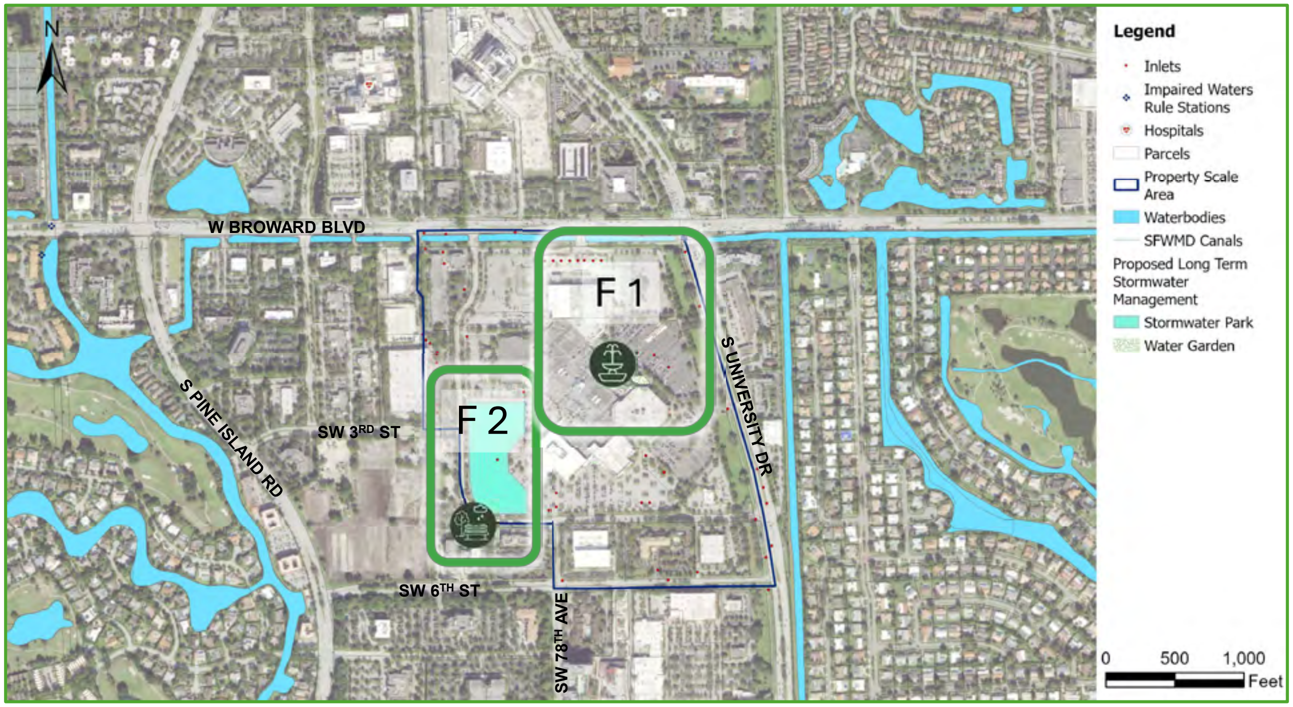
**Proposed Short-Term Solution**

Commercial solutions considered options for addressing localized flooding, maximizing volume with limited space and reducing impacts to existing parking and commercial use. These concepts can be used in other parts of the County with similar right-of-way configurations and particularly in commercial areas where impacts should be minimal in short-term.

- Right-of-Way Bioswales
- Subsurface Storage

# Proposed Solution Details - Property Scale Proposal #10

## Future Implementation Options




Water Garden

Stormwater Park

### Potential Additional Volume Managed

- ✓ F 1 – 97,932 gal
- ✓ F 2 – 2,052,626 gal

### Key Considerations

- ✓ Stakeholder Support
- ✓ Utility Relocation

### Future Implementation Strategy

*Additional stormwater management is necessary to mitigate larger flooding events and flooding. Future implementation strategies could provide centralized, large-scale stormwater management, which will require detailed feasibility analysis and coordination with stakeholders. These solutions would provide additional flood mitigation.*

**F 1**

One potential solution on the Broward Mall property is to construct water gardens at outside varies mall entrances.

**F 2**

An additional potential solution is to re-analyze the number of parking spaces required at the mall given the shift to eCommerce. Excess parking area on the east could be purchased by the City and converted to a stormwater park. Benefits would include additional flood mitigation, water quality improvements, public education, and drawing residents to the surrounding retail and dining establishments.

# Proposed Solution Details – Property Scale Proposal #10

## Metric Summary

### Rainfall and Coastal Conditions

*Multiple design storms were evaluated to illustrate the effectiveness of the water management adaptation conceptual strategies. The 10-year, 72-hour storm event is the basis for crown-of-road elevations. Smaller design storms were evaluated including the 2-year, 2-hour storm event, which FDOT frequently evaluates, to determine strategies' effectiveness during smaller, more frequent events.*

| Scenario | Rainfall Depth (in) | Storm Volume (gal) |
|---|---|---|
| 2-year, 2-hour | 3.19 | 7,771,531 |
| 5-year, 24-hour | 7.42 | 18,076,728 |
| 10-year, 24-hour | 9.07 | 22,096,486 |
| 10-year, 72-hour | 10.8 | 26,311,141 |

### Short-Term Solution Cost Estimate

| | Quantity | Unit Cost | Subtotal |
|---|---|---|---|
| Exfiltration/Bioswale | 44,617 ft² | $ 25.00 | $ 1,115,436.53 |
| Subsurface Storage | 265,305 ft² | $ 50.00 | $ 13,265,264.27 |
| | | | **$ 14,380,700.79** |

*Conceptual cost estimate is variable depending on site conditions, utility constraints, additional restoration, improvements and design aspects including underdrains and expanded footprints.*

### Summary of Design

*Additional stormwater management is necessary to mitigate flooding. Long-term solutions could provide centralized, large-scale stormwater management, which will require detailed feasibility analysis and coordination with stakeholders.*

***Drainage Area*** 119 ac

***Percentage Impervious*** 75%

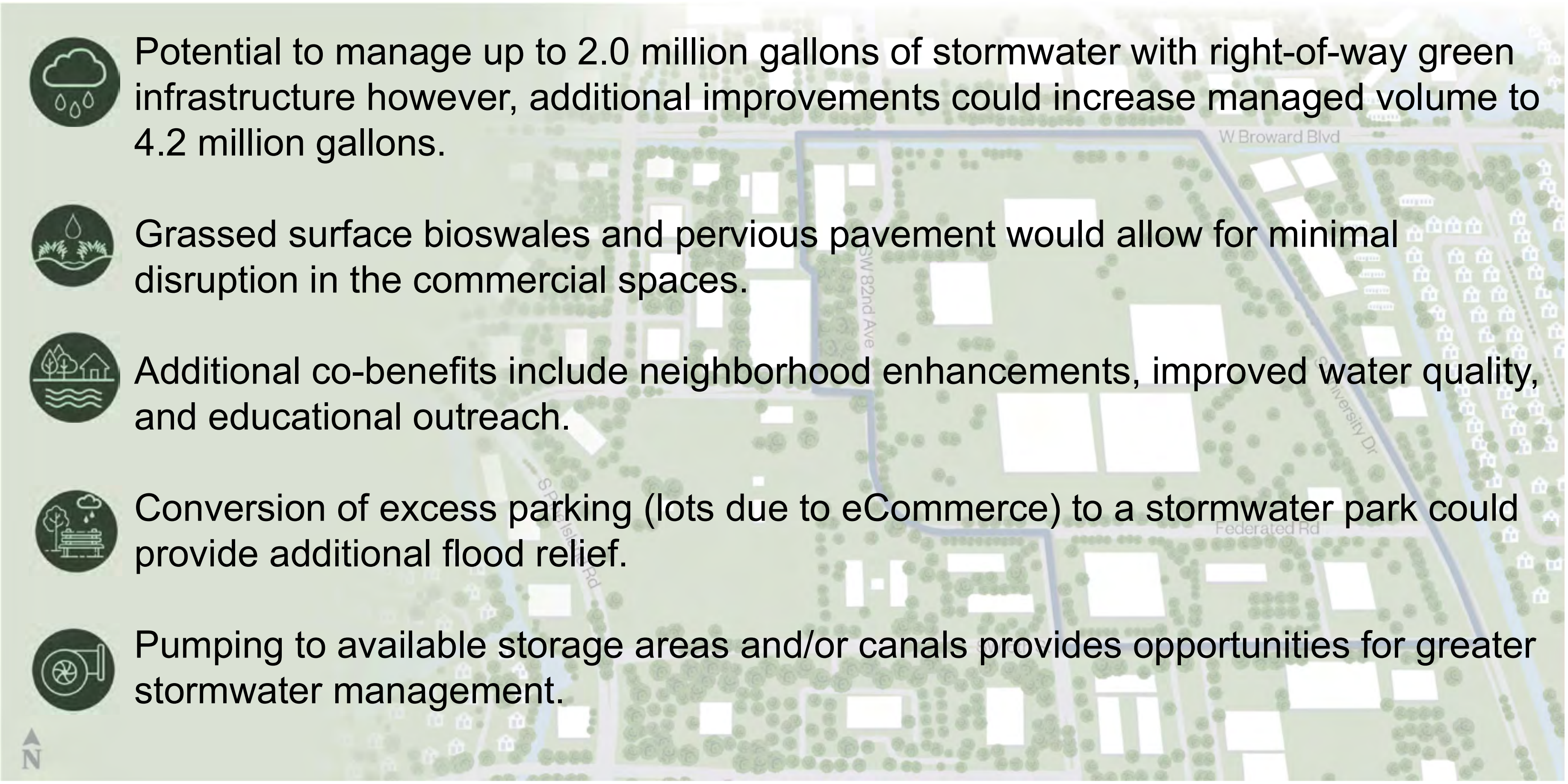
| *System Type* | *System Area* | *System Volume* | % of Tv Managed by Full Vol.* 2yr - 2hr | 5yr - 24hr | 10yr-24hr | 10yr - 72hr |
|---|---|---|---|---|---|---|
| ROW Systems | | | | | | |
| Exfiltration/Bioswale | 44,617 ft² | 339,346 gal | 4% | 2% | 2% | 1% |
| Subsurface Storage | 265,305 ft² | 1,720,116 gal | 22% | 10% | 8% | 7% |
| ***SubTotal*** | ***309,923 ft²*** | ***2,059,462 gal*** | ***27%*** | ***11%*** | ***9%*** | ***8%*** |
| Long-term Systems | | | | | | |
| F1 (Broward Mall Water Gardens) | 15,021 ft² | 97,392 gal | 1% | 1% | 0% | 0% |
| F2 (eCommerce of Broward Wall) | 288,820 ft² | 2,052,626 gal | 26% | 11% | 0% | 8% |
| ***SubTotal*** | ***303,841 ft²*** | ***2,150,018 gal*** | ***28%*** | ***12%*** | ***1%*** | ***8%*** |
| ***Total*** | | ***4,209,480 gal*** | ***54%*** | ***23%*** | ***10%*** | ***16%*** |

**Tv = Storm Depth * % Impervious * Drainage Area*

### Green Infrastructure Sizing Assumptions

| Exfiltration/Bioswale Systems | | Subsurface Storage Systems | |
|---|---|---|---|
| **Surface Volume Provided** | | **Surface Volume Provided** | |
| Ponding Depth | 3" | | - |
| ROW System Floor Area | 44,617 ft² | ROW System Floor Area | 265,305 ft² |
| Area at Ponding Elevation | 44,617 ft² | | - |
| Surface Ponding Volume | 11,154 ft³ | | - |
| **Full Storage Volume Provided** | | **Full Storage Volume Provided** | |
| Soil Depth | 1.0' | | - |
| Soil Porosity | 30% | | - |
| Stone Depth | 1.17' | Stone Depth | 2.17' |
| Stone Porosity | 40% | Stone Porosity | 40% |
| Surface Volume | 11,154 ft³ | | - |
| Soil Volume | 13,385 ft³ | | - |
| Stone Volume | 20,821 ft³ | Stone Volume | 229,931 ft³ |
| Total Storage Volume | 45,361 ft³ | Total Storage Volume | 229,931 ft³ |
| Total Storage Volume (gal) | 339,346 gal | Total Storage Volume (gal) | 1,720,116 gal |

**Property Solution Details – Property Scale Proposal #10**
Overall Summary




- Potential to manage up to 2.0 million gallons of stormwater with right-of-way green infrastructure however, additional improvements could increase managed volume to 4.2 million gallons.
- Grassed surface bioswales and pervious pavement would allow for minimal disruption in the commercial spaces.
- Additional co-benefits include neighborhood enhancements, improved water quality, and educational outreach.
- Conversion of excess parking (lots due to eCommerce) to a stormwater park could provide additional flood relief.
- Pumping to available storage areas and/or canals provides opportunities for greater stormwater management.

# **Appendix F**: Economic Analysis Memoranda and Economic Feasibility Analysis

# Appendix F-1:
# Memorandum for Task 4.1 - Economic Modeling Methodology and Data Sources – FINAL

Hazen *Memorandum*

December 20, 2023

To: Broward County

From: Hazen and Sawyer
McKinsey & Company

Project: Broward County Risk Assessment and Resilience Plan (44500-001)

# Subject: Task 4.1 - Economic Modeling Methodology and Data Sources - FINAL

### Authorization

This memorandum is delivered to Broward County under "Task 4.1 Economic Modeling Methodology" of the Agreement between Broward County and Hazen and Sawyer, PC for Consultant Services for a Countywide Flood Risk Assessment and Resilience Plan (RFP #TEC2120637P1). This memorandum was prepared primarily by McKinsey as a subconsultant to Hazen and Sawyer for this project.

## 1. Introduction

**This memorandum outlines the economic analysis methodology and data sources that the consultancy team has relied upon to model the socioeconomic impacts of flooding in Broward County under different climate change adaptation scenarios.** The purpose of this analysis is to quantify the expected reduction in socioeconomic risks that can be delivered through the County's preferred Resilience Plan, relative to a "do nothing" approach referred to as the "baseline". This analysis will be a core component of the team's economic feasibility analysis of the proposed Resilience Plan.[1] The analysis will also inform the prioritization and implementation of interventions, be a critical input into the preparation of financing proposals (such as FEMA grant applications) and support communication with stakeholders, particularly the business community in Broward County.

This memorandum focuses on the methodology and data sources associated with estimating the baseline economic impacts from future anticipated sea level rise-induced flooding as modeled under this study and assuming that no actions are taken to mitigate these impacts. Similar methods and data will be used to model the impact of County adaptation scenarios on the extent to which baseline impacts can be mitigated.

The memorandum's structure is as follows.

Section 1 introduced this economic modeling methods and data sources memorandum.

[1] Other inputs to the economic feasibility analysis will include economic analysis of: (1) the reduction in environmental and amenity risks; (2) the broader economic, social, and environmental co-benefits of adaptation interventions (not related to risk reduction); and (3) the capital and operating costs of adaptation interventions.

- Section 2 outlines the mechanisms by which increasing flood risk from sea level rise could impact Broward County's economy.
- Section 3 describes the inputs to the analysis that was obtained from the hydraulic modeling workstream.
- Sections 4 through 7 outline the methodology and data sources being used for each of the four impact areas that are being quantitatively analyzed.
- Section 8 discusses what will be completed during the adaptation phase of the economic modeling effort.

## 2. Socioeconomic impacts of climate-induced increasing flood risk

**The Baseline Results Memorandum outlines a comprehensive set of socioeconomic impacts from anticipated increases in Broward County's flood risk when no adaptation strategies are implemented to mitigate flooding.** Through literature review and engagement with stakeholders in Broward County, the Memorandum explains the mechanisms by which flood risks can lead to different socioeconomic impacts and the potential scale of those impacts. Through discussions with Broward County and preliminary literature review, the Hazen team identified nine key socioeconomic impact areas:

**Short-term economic losses**. Flooding directly damages buildings, infrastructure, and other productive assets, causing both direct and indirect economic impacts. The short-term economic losses modeled include revenue loss from business downtime, economic losses generated through transport system disruption, and indirect impacts to the County's economy through changes in gross value added (GVA)[2], employment, and tax revenue.

**Increased insurance premia / reduced insurance affordability**. With the adoption of risk-reflective pricing as per Risk Rating 2.0, increasing flood risk is expected to increase NFIP premia. The analysis quantifies the impact of increased flood insurance cost on affordability, policy take-up rate, total purchased coverage, and rates of underinsurance. The consequent impact on uninsured damages is computed to inform the size of the protection gap as flood risk intensifies.

**Lowered real estate values**. Increasing flood risk reduces the value of properties, as prospective buyers will expect to face higher property management costs such as repair and insurance, disruption to property use, higher insurance cost, and disruption to local amenities and services. The quantitative analysis considers impacts from property downtime due to flooding, increased cost of flood insurance and increased annual uncovered damages and translates these losses into expected loss in property value.

**Heightened fiscal risks to the County**. The public sector has an important role in flood relief and recovery, the costs of which are shared across local, state, and federal governments. Increases in the frequency and extent of flooding may increase these costs to the County. Meanwhile, ad valorem tax

[2] Gross Value Added (GVA) is a standard international and national metric of economic activity. Specifically, it 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. GVA includes the income that residents receive, company profits, depreciation, interest payments and net subsidies (subsidies minus taxes).

collections may fall as the value and number of properties decrease. This analysis quantifies the short-run ad valorem tax impact from loss of sales and business activities. In addition, the impact from property devaluation on ad valorem property tax revenue is also analyzed.

**Disruption to public services**. Flood can directly damage critical infrastructure networks such as power grids and road networks. These failures can propagate to other systems (e.g., power outage can disrupt communication system), with cascading effects onthe health and wellbeing of the recipients of public services in Broward County.

**Reduced investment**. In the longer-term, increasing flood risk could lower expected returns on investments and raise perceptions of the riskiness of investments in the County. This could increase the cost of borrowing and reduce inward investment, with consequential impacts on the County's economic growth and economic structure.

**Demographic change**. Increased flood risk and the associated impact on quality of life, safety of assets and the prospect of employment opportunities can increase out-migration (especially after severe flood events), reduce in-migration and incentivize people to move away from high-risk zones within the County. The consequent decline in population could reduce the labour force and the consumer base, with knock-on impact on consumer demand, house price, employment, and the County's tax base.

**Reduced tourism**. Flooding can temporarily reduce tourism capacity through damaging tourism and transportation infrastructure. Increased flood risk can also reduce the attractiveness of the County as a vacation destination. Reduced tourism could directly impact businesses and jobs in the tourism sector and indirectly reduce the overall level of economic activities. Moreover, the County's finances can be negatively affected through lower revenue collected from the Tourism Development Tax.

**Human capital impacts.** Flood events can cause both physical (e.g., drowning, spread of water-borne diseases) and mental (e.g., anxiety) health issues, negatively impacting people's development and productive capacity. Moreover, disruptions to education and health facilities as well as the flood events' negative impact on household finances can have far-reaching consequences on the community's education and health outcomes. Recovery and reconstruction efforts from flood events could also divert public finances away from investing other public services (e.g., green space, art, vocational training), negatively impacting human capital in the long term.

These nine socioeconomic impact areas are non-exhaustive and closely interrelated. For example, demographic changes will have fiscal consequences for the County from potential changes in tax revenue. Four of these impact areas were selected for quantitative analysis: (1) short-run economic losses, (2) increased insurance premia, (3) lowered real estate values, and (4) lowered ad valorem property tax revenue from Broward County residents and businesses. These impact areas were selected due to the importance of these risks to the County and the feasibility of conducting quantitative analysis. For areas (5) to (8), we conducted qualitative research to analyze the expected scale of these risks to Broward County.

## 3. Inputs to quantitative analysis of socioeconomic impacts from the hydraulic modeling workstream

The core inputs to the quantitative socioeconomic analysis are the estimates of the dollar value of damages to properties and assets calculated within the hydraulic modeling workstream. One product of the hydraulic modeling workstream is a set of flood scenarios characterized by rainfall, sea level rise, groundwater saturation and tidal conditions. The sea level rise indicator suggests whether it is an event that would occur under current conditions (2022), or under scenarios of 2.0 feet of sea level rise (SLR) (potentially reached by 2050 according to the 2017 NOAA Intermediate High projection) and 3.3 feet of SLR (potentially reached by 2070 following the same projection). For each of these flood scenarios the hydraulic workstream modeled flood depth and duration and the probability of occurrence.

The hydraulic modeling team estimated the expected dollar value of damage to property and other assets for those flood scenarios using Broward County property appraiser data on market values of the individual properties in Broward County and damage functions from the South Florida Water Management District. The hydrologic analysis assumed that future land use would be the land use adopted by the County for runoff calculations. The dollar damage estimates assume there is no change in land use or property value from current conditions (2022) to 2070. The hydraulic modelling workstream provided the following inputs to the economics workstream:

- The probability of each flood scenario occurring under current conditions, in 2050, and in 2070
- Flood extent depth-duration maps for each of the flood scenarios
- The expected damages from each flood event for each building, categorized by land use type, expressed in US dollars (USD) and as a share of value, disaggregated between property and other asset damage
- Market value of every building (in the absence of flooding).

For the flood events envisioned from each sea level rise scenario (current, 2050 and 2070), the economic workstream produced the estimated average annual dollar value of flood damage by geographic area and land use.[3]

Throughout the socioeconomic analysis, a key assumption used in the economic workstream is that there is no change in the economy of Broward County – including no changes in land use, gross domestic product, employment, or population. The results are best interpreted as the socioeconomic impacts of flooding that would occur today if Broward County experienced the flood conditions that are possible in 2050 and 2070.

[3] Calculating the average annual dollar value of flood damage under a given SLR scenario (current, 2050 and 2070) involves: (1) inferring a damage-probability curve from the data points provided by the hydraulic modeling workstream and (2) taking the integral of the curve over the range of possible flood scenarios.

## 4. Short term economic losses

The short-term economic losses modeled in this workstream include revenue loss through business downtime; economic losses generated through transport system disruption; and indirect economic impacts of flooding.

### 4.1 Motivation for quantitative analysis

**Flooding has both direct and indirect short-term economic impacts.** Flooding directly damages buildings, infrastructure, and other assets, with losses felt by the businesses relying on those assets. These losses can propagate through supply chains and the financial sector to have indirect impacts across the County's economy, including changes in GVA, employment, and tax revenue.

The scale of these short-run economic losses can be significant. Examples of the magnitude of these losses associated with hurricanes can be found in the literature: Hurricane Irma (2017) incurred an estimated total cost of $59.5B and caused a significant outflow of more than 75,000 jobs, Hurricane Michael (2018) led to an estimated total cost of $18.4B, with direct damages to more than 40,000 homes, and Hurricane Ian (2022) is expected to cost insurers $67B in direct property damages.[4,5]

### 4.2 Methodology of quantitative analysis

The costs associated with the anticipated flood damage over time were provided by the hydraulic modeling workstream. For the economic modeling effort, the quantitative analysis of short-run economic losses had three additional components:

- Revenue loss through business downtime;
- Economic losses generated through transport system disruption; and,
- Indirect impacts of flooding.

#### 4.2.1 Revenue loss through business downtime

| | |
|---|---|
| **Flood risk inputs:** | Damages from individual flood scenarios at the land parcel level (% value) |
| **Other data inputs:** | FEMA damage-downtime curves, ESRI business analyst revenue data, Social Vulnerability Index |
| **Raw outputs:** | Expected maximum loss in sales revenue for individual flood scenarios, by business building |
| **Outputs:** | Average annual maximum loss of sales revenue, in 2050 and 2070 |

**Summary of approach:** We estimated the maximum days of business downtime (being unable to open due to repair needs) for each flood scenario by each business building. By estimating the average daily revenue of each land use parcel, we estimated the maximum loss in revenue for each flood event.

**Steps in analysis:**

[4] Wright (2017), Jobs numbers feel the effects 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/

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

1. The Office of Economic and Small Business Development shared ESRI Business Analyst data for Broward County,[6] which includes data about total sales, total number of employees, and number of businesses for a geographic area for specified NAICS and SIC code categories[7]. We matched this data to the building map shared by the hydraulic modelling team[8].
2. We used the ESRI Business Analyst data to estimate the average daily sales revenue for each business building.
3. We matched the land use categories used in this project with the land use categories used in the FEMA curves for estimating the maximum days of functional downtime for a given proportion of damage.
4. We applied the FEMA curves to the hydraulic modelling team's results on the building-level property damage (expressed as a share of total value) to estimate the maximum days of functional downtime by business building for each flood scenario.
5. We multiplied the estimate of maximum days of functional downtime by the estimated daily sales revenue to estimate the maximum expected loss in sales revenue by land use parcel for each flood scenario.
6. We aggregated the results to estimate the average annual maximum loss of sales revenue by census tract.
7. We analyzed whether areas of higher social vulnerability experience higher rates of sales revenue loss (see **Exhibit 1**).

**Key assumptions within the approach:**

- For consistency with the hydraulic modeling workstream's approach of estimating damages, we assumed the annual revenue for each business building remains constant over time.
- We assumed that there is a linear relationship between days of being open and sales revenue. It is possible that the annual impact on sales revenue would be less than this (for example, if customers delay purchase until the business reopens), or greater than this (for example, if a customer permanently switches suppliers).
- The limitations are the following: the analysis does not consider if a business can still operate when there is no access to the building, if it must wait for repairs to be fully completed, or if it is really affected by a flood (e.g., located on the second floor of a building).

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

[7] The North American Industry Classification System (NAICS) is the standard used by Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy. NAICS was developed under the auspices of the Office of Management and Budget (OMB), and adopted in 1997 to replace the Standard Industrial Classification (SIC) system.

[8] Businesses are not all geospatially located on buildings. To match them with the buildings provided by Hazen we spatially joined them to the nearest commercial building (use_code >10).

**Exhibit 1 - Analyzing the equity impacts of flood risk**

**Four reasons why increased flood risk may have disproportionate impacts on marginalized communities:**

**Socially vulnerable populations can face disproportionate exposure to flood risk.** Due to structural inequities in practices such as redlining, marginalized communities typically face greater exposure to flood risk.

**Socially vulnerable populations can face location-specific structural barriers to flood resilience.** Areas with high concentration of low-income and/or minority communities have traditionally benefited less from flood prevention infrastructure. Racial minorities and lower-income groups typically live in older, more fragile homes and have less access to credit or funds to upgrade and retrofit these homes.[9,10]

**Communities of color and low-income communities can receive less public assistance and services post-disaster.** Lower home ownership and lower flood insurance uptake among these communities cause them to receive less relief and recovery assistance – low and moderate-income multi-family housing is rarely replaced after disasters. Bureaucratic processes and eligibility requirements in FEMA post-disaster aid processes often lead to individual assistance aid denials for low-income individuals who might not have the ability to take off from hourly-wage jobs, prove homeownership in family homes, and other bureaucratic issues. A study showed that nationally FEMA awarded homeowners in areas with predominantly Black populations 5-10% less money.[11]

**Minority and low-income communities have lower access to inclusive early warning systems.** Early warning systems tend to be designed in non-inclusive ways, for example: warnings sent in English might be less accessible to non-native English speakers or to people have poor access to the internet (e.g., homeless people, ethnic minorities, and lower-income communities, etc.).[12]

We have identified census tracts where high flood risk converges with areas of high social vulnerability, using the data provided through the Social Vulnerability Index. The Social Vulnerability Index uses U.S. Census data to determine the social vulnerability of every census tract. It ranks each tract on 16 social factors, including poverty, lack of vehicle access, and crowded housing, and groups them into four themes: socioeconomic status, household characteristics, racial & ethnic minority status and housing type/transportation. Each tract receives a separate ranking for each of the 16 metrics, each of the four themes, as well as a total SVI ranking, derived as an average across all themes.

[9] Tellman et al., (2020). Using Disaster Outcomes to Validate Components of Social Vulnerability to Floods: Flood Deaths and Property Damage Across the USA. Available at: https://www.mdpi.com/2071-1050/12/15/6006

[10] National Low Income Housing Coalition; FEMA Social Vulnerability Index

[11] Flavelle (2021). Why Does Disaster Aid Often Favor White People? Available at: https://www.nytimes.com/2021/06/07/climate/FEMA-race-climate.html

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

### 4.2.2 Transport disruption

| | |
|---|---|
| **Flood risk inputs:** | Maps outlining the duration of flooding above elevations |
| **Other data inputs:** | USGS National Transportation Dataset; ESRI Broward Business revenue and Employment Database |
| **Raw outputs:** | Assessment of whether commercial buildings are stranded, by flood scenarios |
| **Outputs:** | Number of stranded businesses, for each 24h period, by flood scenarios |

**Summary of approach:** We identified 196 business centers through mapping business hotspots. For every 24-hour period following peak flooding, we identified areas of the road network where the flood depth exceeds 0.5 feet, for each flood scenario. We calculated for each business the share of business centers they were no longer able to access due to this flooding to identify which businesses were stranded. Businesses are considered stranded if they cannot reach 90% of business centers via the County's road network.

**Steps in analysis:**

1. We used the ESRI business analyst data to geolocate businesses, enabling us to locate them on the Broward County road network. We also used the ESRI business analyst data to identify the NAICS sector for each business.
2. We identified 196 business centers by mapping hotspots of high concentration of businesses in Broward County.
3. The hydraulic modelling team shared maps which showed the duration of flooding above certain thresholds for each flood scenario. Using this data, we created maps showing the areas of the County's road network where the flood depth exceeds 0.5ft, for every 24 hours following peak flooding for each flood scenario.
4. We computed the share of connections for each business to all business centers which were no longer viable due to roads being impassable.
5. For each NAICS sector we computed the share of completely stranded business (more than 90% of business centers unreachable), for each flood scenario, for every 24-hour time-stepped period following peak flooding, to input into the V-ARIO model.

**Key assumptions within the approach:**

- Roads are impassable where the flood depth exceeds 0.5 feet.
- A business can be defined as stranded if more than 90% of its connections to business centers are not available. We tested the robustness of our results to this specific threshold by conducting robustness checks at 85% and 95%.
- The disruption from workers commuting to businesses is expected to be the same as the disruption in business-to-business travel.

- We assumed that transport disruptions are limited to the impacts of road inundations and assume that no debris or permanent damage to roads occur, given the relatively low flood depth and the build of the County's roads.

### 4.2.3 Indirect economic impacts from flooding

| | |
|---|---|
| **Flood risk inputs:** | Damages from individual flood scenarios by building (USD), sectoral shares of stranded businesses for each 24-hr period (%) |
| **Other data inputs:** | IMPLAN Broward County input-output table, estimated feasibility to work from home, ESRI business analyst data, Census Bureau's Public Use Microdata Sample (PUMS), 2021 |
| **Raw outputs:** | Time path of sector GVA (USD), employment (number of jobs) firm profits (USD) and tax revenue (USD, by tax category) recovery time (days), all at the Broward County level for all flood scenarios |
| **Outputs:** | Output indicators above for all flood scenarios and expressed as an average annual value for current conditions, 2050, 2070 |

**Summary of approach:** We used the Vivid Adaptive Regional Input Output model (V-ARIO) to model the economy-wide impact of flood events. This approach is very similar to the methodology adopted in the Urban Land Institute's Business Case for Resilience in South-East Florida.[13] The model simulates the path of economic activity from a "shock" (a flood scenario), until the economy returns to equilibrium. It captures the impact of disrupted economic activity across the supply chain, as businesses impacted by flooding demand less from upstream suppliers and are less able to provide inputs to downstream consumers. Transport disruptions resulting from temporary road inundations during peak flooding events further constrain the economy.

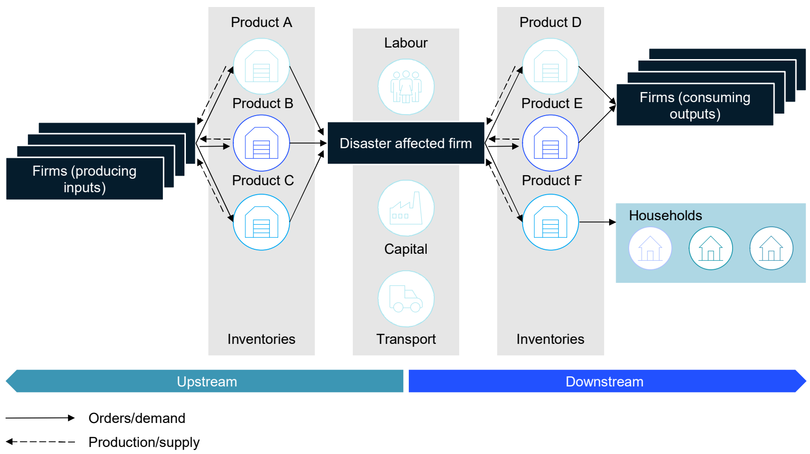
We incorporated these impacts through a road disruption index. The model also captures the boost in economic activity from repair and reconstruction expected in future years. We used the model to estimate the expected recovery time from flood events, as well as the impact of the changes in economic activity on labor market and tax variables. **Exhibit 2** provides more detail on the model.

[13] Urban Land Institute (2020) The business case for resilience in southeast Florida. Available at: https://southeastfloridaclimatecompact.org/wp-content/uploads/2020/10/The-Business-Case-for-Resilience-in-Southeast-Florida_reduced.pdf

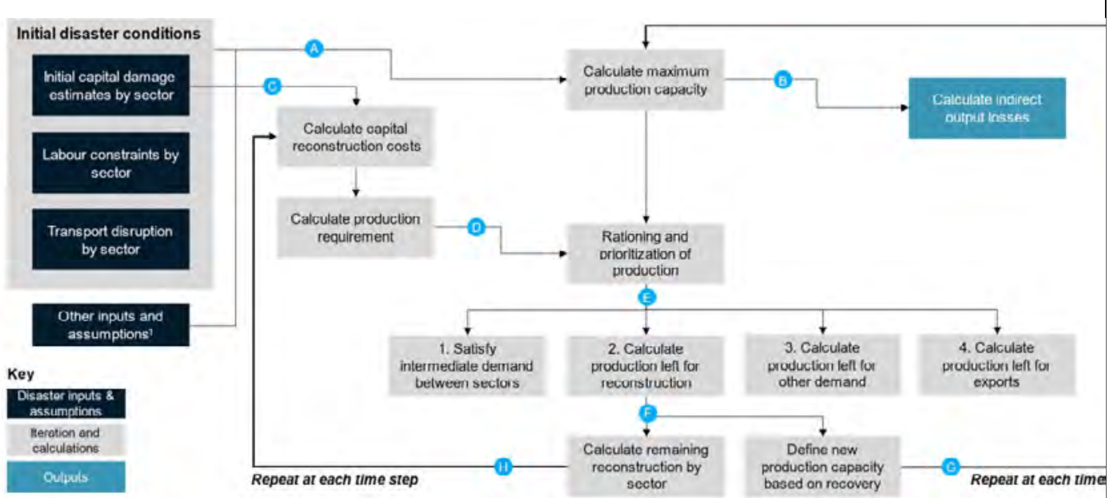
**Exhibit 2 - Summary of V-ARIO model**

**The Vivid Adaptive Regional Input Output model (V-ARIO) simulates the post-disaster economy to analyze the indirect impacts of shocks.** The model is adapted from academic models estimating the impacts of disasters by accounting for upstream and downstream economic linkages, as well as reduced production capacity due to damages to capital, infrastructure, and labor productivity losses.[14][15]

The diagram below summarizes how V-ARIO captures the impact of a flood on the upstream and downstream sectors of a firm impacted by flooding:




The diagram below summarizes the steps in the model, which occur for each sector and each period following a disaster:




[14] 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/

[15] 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

**Steps in analysis:**

1. We assigned the IMPLAN list of industry sectors to the buildings provided by the hydraulic modeling workstream analysis to determine the list of sectors to be used in the analysis. We categorized each building by NAICS industry sector and then used the "IMPLAN sector to NAICS sector bridge" obtained from IMPLAN.com. Buildings had been matched to NAICS industry sector using the land use dataset (by building) and the business dataset (which had business type and address). If a commercial building could not be matched to a business type using the business dataset, then the land use dataset was used to classify the building based on the parcel land use type.

2. We calibrated the V-ARIO model using the IMPLAN Broward County input-output table – a matrix which describes the sale and purchase relationships between producers and consumers within an economy.

3. For each flood scenario, we estimated the total damage to capital by industry sector, expressed in USD and as a share of total capital. For each flood scenario, we estimated a sectoral transport disruption index at daily timesteps. Each index represents an industry sector and is defined as the product of:

    - The share of businesses stranded by NAICS code (e.g., share of all restaurants, share of all bank branches); and,

    - The maximum value of these two parameters:

    *1)* The ratio of transport sector input as a share of total input into a sector *(This ratio describes how much of an industry sector's value comes from the transport sector. This ratio is larger for industries that need a substantial value of materials to be trucked compared to industries that only need the internet to operate.)*

    *2)* The share of work in the sector (and therefore value creation) that must be performed at the business location, therefore requiring employees to travel to the business (versus being able to work from home)[16].

4. We inputted the damage estimates as a shock to the model which provide the following model outputs: time path of sector Gross Value Added (GVA in USD, employment (number); firm profits (USD) and tax revenue (USD); and recovery time (days). These outputs are for individual flood scenarios, expressed at the Broward County level. Impacts to sales tax revenues and vulnerable populations was performed separately.

5. We estimated the average annual values for the above indicators, for current flood conditions, 2050, and 2070.

**Key assumptions within the of approach:**

- For consistency with the hydraulic modelling workstream's approach of estimating damages, we assumed the economic activity and the structure of the economy remain constant over time.

[16] The data used to calculate this work share for each sector is from: Dingel and Neiman (2020). How many jobs can be done at home? Available at: https://www.sciencedirect.com/science/article/pii/S0047272720300992

- The only shocks that V-ARIO captures are the damage to economic capital and transport disruption, focusing only on the direct damage within Broward County. The analysis does not capture:
  - Losses attributable to other network-based infrastructure disruption (e.g., electricity grids)
  - Flood damages outside the county
  - Reduction in household expenditure due to a loss in household wealth from uninsured flood damages
- The V-ARIO model assumes the economy returns to pre-disaster conditions following a shock, but evidence suggests that high-severity events can cause permanent out-migration and other permanent changes in local economies which are not included in the quantified socioeconomic baseline results.
- The V-ARIO model assumes that the production system is fixed (i.e. that there is no substitutability between production inputs), and that there are no changes in prices. This is an accepted assumption for short-term economic modelling.

### 4.3 Limitations to the analysis

The analysis will not capture the risk of household or business bankruptcy triggered by large uninsured losses, with associated knock-on impacts for the financial sector.

## 5. Increased flood insurance premia

The impacts of future flood conditions on residential NFIP insurance premia, the coverage of flood insurance and the value of the uninsured property damages were estimated as described below.

### 5.1 Motivation for quantitative analysis

Increasing flood risk will lead to increasing insurance premia – both in the private insurance market and under the FEMA National Flood Insurance Program.[17] Lower insurance affordability may result in lower coverage and increased rates of underinsurance, reducing households' and business' ability to recover from flood events and increasing the burden on other post-event safety nets, including FEMA's Individual and Households Program. This is of critical importance to Broward County as Florida already experiences difficulties with the cost and availability of flood insurance,[18] resulting in high rates of uninsurance and underinsurance.[19,20]

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[17] Under Risk Rating 2.0, NFIP premia are moving towards more risk-based pricing by incorporating flood risk variables and property characteristics to reflect each building's unique flood risk. Even in the absence of climate change, NFIP premia are expected to increase due to Risk Rating 2.0, which is projected to lead to premium increases for 77% of NFIP policyholders. Source: UNDRR (2021) Risk Rating 2.0: A First Look At FEMA'S New Flood Insurance System. Available at: https://www.preventionweb.net/news/risk-rating-20-first-look-femas-new-flood-insurance-system#:~:text=Roughly%2077%25%20of%20customers%20of,in%20on%20April%201%2C%202022.

[18] Accessible at: https://floridaphoenix.com/2022/12/14/on-top-of-rising-homeowner-premiums-policyholders-face-a-new-tab-coming-soon-flood-insurance/Perry (2022), "On top of homeowner premiums, policyholders could face a new tab coming soon: Flood insurance".

[19] Only 18% of homes in Florida have flood insurance. 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

[20] Uninsurance is the state of not having any insurance, whereas underinsurance is having insufficient insurance for their needs.

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### 5.2 Methodology of quantitative analysis

The quantitative analysis of the flood insurance premia has three components:

- Expected increase in flood insurance premia;
- Expected reduction in flood insurance coverage due to increased premia; and,
- Expected uninsured property damages due to lower insurance coverage.

Across this analysis, we limited our focus to the NFIP.

#### 5.2.1 Expected increase in flood insurance premia

| | |
|---|---|
| **Flood risk inputs:** | Average annual damages (USD), aggregated to census tract level |
| **Other data inputs:** | Average NFIP costs of flood insurance, policy count, and purchased building and content coverage by zip code and census tract (USD, available from NFIP Open FEMA open data, disaggregated by occupancy type), Risk Rating 2.0 costs of flood insurance at the zip code level for single- family homes (SFH), property values, Social Vulnerability Index data |
| **Raw outputs:** | Average NFIP premia in 2050 and 2070 for single family and multiple family homes, by census tract (USD) |
| **Outputs:** | Insurance affordability (ratio between costs of flood insurance and coverage value) by census tract |

**Summary of approach:** We assumed that NFIP costs of flood insurance will increase linearly with average annual damages, in line with the Risk Rating 2.0 ambition of risk reflective pricing.

**Steps in analysis:**

1. Over the next few years, NFIP premia are expected to increase in Broward County due to Risk Rating 2.0. FEMA has released example data on risk-based costs of flood insurance under Risk Rating 2.0 at zip-code level for SFH for current risk-level. Assuming same risk pass-through for multi-family homes (MFH), we estimated zip-code level risk-based costs of flood insurance for MFH.
2. We then computed census-tract level risk-based costs of flood insurance in current sea level conditions by allocating zip-code level values to census tracts, weighted by area of intersection.
3. We calculated the increase in average annual damages from the current climate conditions to 2050 and 2070.
4. Assuming that NFIP costs of insurance will increase linearly with average annual damages, we applied the expected increases to the NFIP costs of insurance under current climate conditions, to estimate the average 2050 and 2070 NFIP costs of insurance by census tract (USD).
5. We then estimated the change in insurance affordability for each census tract by dividing the average NFIP costs of insurance by the average building and content coverage value.

6. We also analyzed whether areas of social vulnerability coincide with those which experience significant changes in NFIP insurance affordability by intersecting the SVI data and insurance analysis results.

**Key assumptions within the approach:**

- We assumed the percentage difference between average paid versus risk-based costs of flood insurance for SFH policies in each zip code is the same as that for MFH policies.
- We assumed that NFIP premium scales linearly with the change in average annual damages.
- We assumed that there are no changes to NFIP risk-rating methodology, pricing, or policy in the future, or any other factors which would increase NFIP premia.

### 5.2.2 Expected reduction in flood insurance coverage

| | |
|---|---|
| **Flood risk inputs:** | n/a [as drawing on inputs from other stages in the analysis] |
| **Other data inputs:** | Expected increased in NFIP premia by 2050 and 2070 by census tract, (USD, see 5.2.1), average NFIP coverage by zip code, disaggregated by occupancy type (USD), price elasticity of flood insurance[21], property value |
| **Raw outputs:** | Total NFIP coverage under current climate conditions, 2050 and 2070 by census tract (USD) |
| **Outputs:** | Rates of underinsurance (ratio of NFIP coverage to replacement value) and policy count as a percentage of housing units by census tract |

**Summary of approach:** We applied the price elasticity of flood insurance to the expected increases in NFIP premia to estimate the expected reduction in NFIP policy count and coverage.

**Steps in analysis:**

1. We applied the price elasticity of flood insurance to the average increase in NFIP costs of insurance relative to current levels (pre-Risk Rating 2.0 adjustment) in 2050 and 2070 to estimate the reduction in policy count, and the expected level of coverage by census tract in 2050 and 2070. The elasticity is the weighted average between -0.290% (in non-SFHA) and -0.327% (in SFHA), with the weight being the proportion of existing policies in non-SFHA vs in SFHA in each census tract.
2. For each census tract, we estimated the expected rate of underinsurance in 2050 and 2070 by calculating the ratio between the total expected level of coverage and the total building and content replacement value.
3. For each census tract, we estimated policy count as a percentage of housing units in 2050 and 2070.
4. As a sensitivity analysis, we computed the expected percentage increase in the number of buildings in Special Flood Hazard Area (SFHA), proxied by the number of buildings flooded in a 100-yr flood

[21] Bradt et al., 2021, "Voluntary purchases and adverse selection in the market for flood insurance" Accessible at: https://www.sciencedirect.com/science/article/abs/pii/S0095069621000826. Elasticity in non-SFHA is -0.290% and elasticity in SFHA is -0.327%.

event, in 2050 and 2070. We then calculated the difference in NFIP take-up in SFHA (79% take-up rate) and non-SFHA (10% take-up rate) to arrive at the projected policy count if properties get re-zoned into SFHA areas where flood insurance is mandatory for properties that are federally funded or funded by a federally insured mortgage. This policy count was used as the base for price elasticity analysis.

**Key assumptions within the approach:**

- We assumed the price elasticity for each census tract is the weighted average of SFHA elasticity and non-SFHA elasticity, with the proportion of policies in SFHA and non-SFHA as weights.
- We assumed that in response to premium increase, policy count decreases whereas purchased coverage per policy remains constant.
- We assumed uniform NFIP insurance penetration rate in SFHA and non-SFHA across census tracts (i.e., the penetration rates in SFHA and non-SFHA in each census tract is assumed to be equal to County-level penetration rates in SFHA and non-SFHA). We computed housing units count for each census tract as the number of NFIP policies in SFHA and non-SFHA divided by the respective county-level penetration rates and summed together.
- We assumed that building replacement value is 80% of building just value[22] and content replacement value is 17% of building replacement value[23].
- We assumed that there would be no changes to the FEMA SFHA zones or other NFIP policies in the future, or any other factors which would increase NFIP take-up. Changes in SFHA zones, where flood insurance is compulsory if the structure is federally funded or funded by a federally insured mortgage, are considered in a sensitivity analysis.

### 5.2.3 Expected uninsured property damages

| | |
|---|---|
| **Flood risk inputs:** | Aggregate residential property damages from individual flood events by census tract (USD) |
| **Other data inputs:** | Expected aggregate NFIP coverage by census tract (USD), Social Vulnerability Index data |
| **Raw outputs:** | Expected uninsured property damages by census tract for individual flood events (USD) |
| **Outputs:** | Average annual uninsured property damages, by census tract, in 2050 and 2070 |

[22] This assumption was based on average rebuild cost for a single-family home in Florida compared to the average single family home building just value in Broward

[23] This assumption was based on the ratio between total content coverage and total building coverage for all residential NFIP policies in Broward in 2022

**Summary of approach:** We estimated the uninsured damages for each census tract for the individual flood events by subtracting aggregate NFIP coverage from expected damages.

**Steps in analysis:**

1. For each census tract, for each flood event, we subtracted the expected NFIP coverage from the expected damage to compute uncovered damages.
2. We then computed the annual average uncovered damage under current, 2050 and 2070 risk-levels by considering the probability of each flood event.
3. We analyzed whether areas of higher social vulnerability experience higher rates of uninsured damages. High social vulnerability was defined as being above the 75$^{th}$ percentile for the overall Social Vulnerability Index within Broward County. High uninsured damage was determined as being above the 75$^{th}$ percentile for uninsured damages within the county.

**Key assumptions within the approach:**

We assumed that within a census tract, NFIP coverage and flood damages are uniformly distributed.

### 5.3 Limitations to the analysis

We excluded private flood insurance from the analysis due to data limitations. Private flood insurance providers will also be expected to increase premia in response to increasing flood risk and may withdraw from the market. Severe events may cause insurance providers to experience major losses, which could discourage growth of the sector and limit reinsurance capacity.

## 6. Lowered real estate value

Increased flooding over time could be significant enough to reduce property values. The methods and data to be used to estimate this impact is described below.

### 6.1 Motivation for quantitative analysis

Increasing flood risk reduces the value of residential and commercial properties, as prospective buyers expect to face higher repair and other costs (e.g., insurance premia), disruption to property use, and disruption to local amenities and services. Flood risk and flood history are important factors in determining a residential property's real estate value, a phenomenon that has been growing in importance and magnitude in southeastern Florida.[24] Properties exposed to flooding are on average sold for 3% less than similar unexposed properties, while properties that have had more severe flood experience (either on the lot or on nearby roads) lose on average 11% of their value.[25] This has already resulted in a total devaluation today of $5 billion of affected residential properties in Florida compared with prices of unexposed homes, which is estimated to increase to $10B to $30B of affected homes by 2030, rising to $30B to $80B by 2050 in Florida.[26]

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[24] 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.

[25] Ibid.

[26] Ibid.

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This loss in income could cause financial distress for property owners, as real estate makes up a significant portion of household wealth in Florida: a majority of Florida residents are homeowners, with real estate representing a large portion of economic assets in the state.[27] Furthermore, lower property values could also reduce County property ad valorem tax revenue (see Section 7).

### 6.2 Methodology of quantitative analysis

The quantitative analysis of the impact of the real estate market has two components:

- Expected loss in net operating income attributable to property downtime for property owners
- Expected reduction in real estate value

#### 6.2.1 Expected loss in net operating income attributable to property downtime for property owners

| | |
|---|---|
| **Flood risk inputs:** | n/a [as drawing on inputs from other stages in the analysis] |
| **Other data inputs:** | Property value by land use parcel (shared by the hydraulic modelling workstream), CBRE capitalization rates[28], days of functional downtime (see 4.2.1) |
| **Raw outputs:** | Expected annual average reduction in Net Operating Income (NOI) attributable to property downtime by land use parcel (USD) |
| **Outputs:** | Expected annual average reduction attributable to property downtime in residential NOI by census tract, in 2050 and 2070 |

**Summary of approach:** We assumed that property owners cannot collect rent on a property while it is non-operational due to a flood event, and that this risk of loss is one of the drivers of lower property values. We did not distinguish between owner-occupied properties and rented properties, as we assumed a competitive property market with no market segmentation – i.e., Property A can be purchased by people looking to live in the property or rent it out, those who would rent it out would pay $X less for Property A due to the risk of lost rental income, the market value for Property A is $X less than it would be in the absence of flood events regardless of the purchaser. In the analysis, we estimated the potential NOI for each land parcel[29] and reduced it in line with the proportion of the year it is non-operational due to a flood event (days of functional downtime/365).

**Steps in analysis:**

1. We computed the average capitalization rate for residential properties based on H1 2023 CBRE capitalization rates survey.

2. For each residential land parcel, we multiplied the property just value by the capitalization rate to estimate the annual NOI.

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[27] Ibid.

[28] CBRE Group, Inc. is an American commercial real estate services and investment firm. The abbreviation CBRE stands for Coldwell Banker Richard Ellis. It is the world's largest commercial real estate services and investment firm (based on 2021 revenue).

[29] Note, if the property is owner-occupied this will be a hypothetical Net Operating Income.

3. We estimated days of functional downtime (estimated using approach described in 4.2.1) for each residential land parcel for individual flood events and computed the annual average functional downtime for current, 2050 and 2070 risk-levels.

4. We then estimated annual average NOI losses due to the days of functional downtime and aggregated to census tract level and the corresponding increases in 2050 and 2070 compared to current risk-level.

**Key assumptions within the approach:**

- Capitalization rate used for both single-family and multi-family residential properties was the average capitalization rate for multi-family residential properties in 4 Florida cities, as single-family residential property capitalization rate was unavailable.
- For consistency with the hydraulic modelling team's approach of estimating damages, we assumed property capitalization rates and the net operating income associated with each land parcel would remain constant over time if not for the increase in flood risk.
- We assumed the current NOI and insurance-related losses are already reflected in current property just value.
- We assumed a direct and linear relationship between days of functional downtime and loss in NOI. It is possible that the impact on net operating income is less than this (for example, if rent is not suspended while the building is non-functional), or greater than this (for example, if tenants do not return to the building).

#### 6.2.2 Expected reduction in real estate value

| | |
|---|---|
| **Flood risk inputs:** | n/a [as drawing on inputs from other stages in the analysis] |
| **Other data inputs:** | Increase in NFIP premia, by census tract, in 2050 and 2070 (see 5.2.1); increase in annual average uninsured property damages, by census tract, in 2050 and 2070 (see 5.2.3); increase in annual average loss in NOI attributable to property downtime, by census tract, in 2050 and 2070 (see 6.2.1); aggregate property value by census tract (shared by the hydraulic modelling workstream); CBRE capitalization rates; Social Vulnerability Index data |
| **Raw outputs:** | n/a |
| **Outputs:** | Expected loss in property value by census tract relative to current climate conditions in 2050 and 2070 (USD) |

**Summary of approach:** we estimated the expected annual loss for each property due to increased flood risk, considering: (1) increased NFIP premia; (2) uninsured damages; and (3) losses in NOI attributable to property downtime. We converted the expected annual loss to property value reduction using capitalization rate.

**Steps in analysis:**

1. For each year 2050 and 2070 and for each census tract, we summed (1) the expected change in total purchased NFIP premia relative to current premia, (2) the expected increase in average annual

uninsured damages, and (3) the expected increase in average annual NOI loss attributable to property downtime.

2. For each census tract, we applied the CBRE capitalization rate to the total change in losses within the census tract as estimated in step 1 to estimate the decrease in aggregate property value in 2050 and 2070. i.e.,
3. 2050 Devaluation in Census Tract A = (2050 Change in insurance premium in Census Tract A + Increase in Uncovered Damages in 2050 + Increase in NOI Loss Attributable to Downtime in 2050) / Capitalization Rate
4. The CBRE capitalization rate used was 4.94% per year. This value was based on the average CBRE capitalization rate across multifamily properties in 4 Florida cities and counties (Jacksonville, Orlando, Tampa, and West Palm Beach) as provided in the CBRE cap rates survey H1 2023.
5. We analyzed whether areas of higher social vulnerability experience higher rates of property devaluation. A census tract is defined as having high social vulnerability if its total SVI ranking is in the top quartile all census tracts in Broward. A census tract is defined as having a high rate of property devaluation if its projected rate of property devaluation is in the 75$^{th}$ percentile across all census tracts in Broward.

**Key assumptions within the approach:**

- For consistency with the hydraulic modeling workstream's approach of estimating damages, we assumed capitalization rates and property value would remain constant over time, aside from a flood's impact on property value (e.g., there are no other changes to property values due to economic changes).
- We assumed there is no distinction between owner-occupied and rented residential property.
- We did not account for other mechanisms by which increased flood risk might lower property values, for example the increased risk of loss in local amenities might also reduce property attractiveness, other increases in costs (such as expenditure on risk mitigation, hotel stays in the event of evacuation etc.), or risk aversion.
- This approach assumed that property owners are informed about property flood risk, however residential real estate markets systematically underestimate flood risk – as evidenced by the drop in real estate prices which occur when a property is rezoned or when it is flooded.[30]

## 7. Fiscal risks to the County

This section focuses on the methods and data that were used to estimate the impact of expected future flooding on ad valorem property tax revenue although the fiscal risks also include estimates of the short-term impacts to sales tax and tourist development tax collections. The greatest fiscal risk to the County that was quantitatively evaluated is the long-term impact of property values on ad valorem tax revenue to

[30] See for example: Hino and Burke (2021) The effect of information about climate risk on property values. Available at: https://www.pnas.org/doi/full/10.1073/pnas.2003374118;

the County, its municipalities, its hospital districts, its drainage districts, its school districts, and the South Florida Water Management District. The methodology is described as follows.

### 7.1 Motivation for quantitative analysis

The public sector has an important role in flood relief and recovery, the costs of which are shared across local, state, and federal government. Flood-related economic disruption can also have temporary impacts on sales, tourism development and other tax revenue. Studies of municipal government in 21 US Atlantic and Gulf states found that major hurricanes reduce local tax revenue by an estimated 7.2% in the decade following a hurricane.[31] Longer term trends that can emerge from increased flood risk, such as reduced resident population and tourism, could also erode the County's tax base. Perceived reductions in the sustainability of the County's finances could result in lower credit ratings and increased borrowing costs. On average, a 1% increase in climate risk for a county is associated with a statistically significant 23.4 basis point increase in annualized issuance costs for long-term maturity bonds.[32,33]

### 7.2 Methodology for quantitative analysis

The quantitative analysis of the fiscal risk impacts on the County has two components:

- The short-run losses in Taxes on Production & Imports, Net of Subsidies (TOPI) revenue – This impact was measured using the results of the methodology described in Section 4.2.3 – Indirect Economic Impact as it relates to the sales revenue of businesses and transient boarding facilities that pay sales taxes and the tourist development tax.
- The expected reduction in ad valorem property tax revenue

#### 7.2.1 Expected reduction in ad valorem property tax revenue

| | |
|---|---|
| **Flood risk inputs:** | n/a |
| **Other data inputs:** | Expected loss in residential property value by census tract relative to current climate conditions in 2050 and 2070 (USD, see section 6.2.2); property just value by land parcel; Broward County property tax paid in 2022 at land parcel level; Social Vulnerability Index data |
| **Raw outputs:** | Expected loss in ad valorem property tax revenue by census tract relative to current climate conditions in 2050 and 2070 (USD) |
| **Outputs:** | Expected loss in ad valorem property tax revenue by census tract relative to current climate conditions in 2050 and 2070 (USD) |

**Summary of approach:** The total ad valorem property tax (including residential and non-residential properties) was computed for each census tract considering different government services (e.g., School Board, Children's Service Council). For each census tract, the total 2022 ad valorem tax revenue of all

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

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

[33] A basis point is a change equivalent to 0.01%. So, if a mortgage interest rate is 4.00%, then a 23.4 basis point increase would increase the interest rate to 4.234% (4.00 + 23.4 x 0.01).

residential and commercial properties was calculated. Then the estimated percentage reduction in residential property value in 2050 and 2070 was multiplied by the total 2022 ad valorem tax revenue to obtain estimates of the expected changes in property tax revenue in 2050 and 2070, respectively.

**Steps in analysis:**

1. For each census tract, we computed the aggregate ad valorem property tax paid by residential and non-residential properties in 2022.
2. We then multiplied the estimated proportional reduction in the just (or market) value of residential properties in each census tract in 2050 and 2070 by the aggregate 2022 ad valorem property tax to estimate the total expected loss in ad valorem property tax revenue from residences and businesses in 2050 and 2070, respectively. To do this, the following equation was applied:

$$\Delta Ad\ Valorem\ Tax\ Revenue = Ad\ Valorem\ Tax\ Revenue_{2022}\ x\ \frac{\Delta\ Residential\ Just\ Property\ Value}{Residential\ Just\ Property\ Value_{2022}}$$

3. This equation is the reduced form of the equation that includes the estimated average change in the just value of commercial and residential properties in the census tract, as follows:

   Change in Ad Valorem Tax = (Total Ad Valorem Tax in 2022 / Total Property Market Value in 2022) x (Average Change in Residential Market Value + Average Change in Non-Residential Market Value) where,

   The Average Change in Non-Residential Market Value = Non-Residential Market Value in 2022 x (Average Change in Residential Market Value / Residential Market Value in 2022); and,

   Total Property Market Value and Total Ad Valorem Tax in 2022 include both residential and non-residential values.

   The change in ad valorem property tax revenue at the census tract includes all residential and commercial properties. Note that residential property value accounts for 70% of total property value and properties in the same census tract are subject to similar flood risk level.

4. The changes in ad valorem property tax loss were then aggregated to the County level by adding all census-tract level changes together.

**Key assumptions within the approach:**

- The equation used to compute the change in ad valorem tax revenue provided above, includes consideration of the average dollar value of exemptions across all residential and commercial properties in the census tract (Ad valorem tax revenue in 2022 / Just Property Value in 2022). We computed percentage reduction using just value (rather than assessed value), as the assessed value depends on occupier-specific characteristics (e.g., homestead exemptions, military service, disability, low-income seniors) that are not possible to accurately assess as properties change ownership over time. Therefore, the exemptions on the properties as they existed in 2022 was used to estimate the change in ad valorem tax revenue.

- We assumed the millage rates remain at their 2022 values in 2050 and 2070 such that the changes in tax revenue are solely driven by changes in property value.

### 7.3 Limitations to the analysis

There are other impacts increased flood risk can have on the County's fiscal position not captured by our analysis:

- County expenditure on disaster relief and recovery – the costs of which are typically shared between Federal, State, and local government.
- Longer-term impacts of flood risk on investment, economic structure and demographics can impact public service needs and tax receipts.
- Changes in perceived County fiscal sustainability could impact the County's credit rating.

## 8. Adjustments to methodology for adaptation phase

In the adaptation phase, based on feedback from the Steering Committee, we will include a focused analysis of the Fort Lauderdale-Hollywood International Airport, Port Everglades, and the Convention Center Hotel, due to their strategic importance to Broward County. This analysis will look at disruption and downtime from flood events, as well as high-level quantification of potential financial impacts.

Additionally, tables of impacts will be provided for each municipality by aggregating census tracts. This aggregation will be based on US Census Bureau's and Broward County's mappings of census tracts to municipalities. Where possible, the vulnerability analysis will also look at the potential compounding intersections of vulnerabilities and/or gender splits by vulnerability driver.

# Appendix F-2:
# Memorandum for Task 5.2.5 - Calculation of Risk Reduction Benefits

Hazen *Memorandum*

December 5, 2024

To: Broward County

From: Hazen and Sawyer
McKinsey & Company

Project: Broward County Risk Assessment and Resilience Plan

**Subject: Task 5.2.5 Calculation of Risk Reduction Benefits -FINAL**

## Authorization

This memorandum is provided as the deliverable under "Task 5.2.5 Calculation of Risk Reduction Benefits" of the Agreement between Broward County and Hazen and Sawyer, PC for Consultant Services for a Countywide Risk Assessment and Resilience Plan. The memorandum was prepared primarily by McKinsey as a subconsultant to Hazen and Sawyer.

## 1. Results summary

This memorandum summarizes the benefits of conceptual adaptation suites for the Broward County Risk Assessment and Resilience Plan effort. The economic impacts under each suite were compared to the impacts from the baseline (no action) condition to understand how effective the adaptation suites would be in mitigating the economic losses from flooding.

The future flood projections for the baseline (no action) and the adaptation suites incorporate sea-level rise, in addition to expected rainfall and storm surge. The future sea-level rise conditions evaluated during this study are 2.0 feet assumed to be reached by 2050 and 3.3 feet assumed to be reached by 2070.

The key findings are as follows.

- **Flood damage to residential and productive assets would be avoided** and the avoided damage, as measured by the repair and replacement cost savings, will vary depending on the measures pursued. With 2 feet of sea-level rise, adaptation suites could yield average annual savings of $500 million (M) to $2.0 billion (B) which would mitigate from 20% to 80% of baseline damages, respectively.

  Under 3.3 feet of sea-level rise, the average annual savings ranges from $126M to $4.3B which mitigates from 3% to 88% of baseline damages. These savings would be realized throughout the county, are concentrated in coastal areas, and represent flood events triggered by the most extreme rainfall levels as well as the more frequent, less extreme rainfall levels.

- **Lost economic production from flooding would be avoided**. The economic benefit modeled here is the increased gross value added (GVA) from avoided direct flooding impacts to businesses and reduced disruption to roads. Both types of flood impacts reduce the sales of goods and services as businesses are forced to close or reduce operations and customers are unable to access these businesses.

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Under 2 feet of sea-level rise, GVA is estimated to be from $81M to $186M higher under the adaptation suites relative to baseline. Under 3.3 feet of sea-level rise GVA is estimated to be $77M to $660M higher, depending on the adaptation suite.

Not fully included in this measure are all the benefits of protecting critical infrastructure because only the short term direct effects were assessed. For example, flooding at the County's port and airport could slow or prevent the movement of people and goods with corresponding negative impacts to the economy. The adaptation suites were found to reduce downtime by at least 50% in key locations of the Fort Lauderdale-Hollywood International Airport and by 25% to 30% at Port Everglades potentially resulting in significant economic benefits to County residents and businesses.

- **More homes would be able to maintain their flood insurance.** All adaptation suites are expected to increase the number of NFIP (flood insurance) policies under 2 feet and 3.3 feet of sea-level rise relative to baseline. Under 2 feet of sea-level rise, the number of policies would be at least 60% higher than under the baseline. Under 3.3 feet of sea-level rise, the number of policies would be at least 70% higher than under the baseline. Premiums would be comparable to what they are today.

  However, none of the adaptation suites would maintain the number of policies that are currently held. While total flood insurance coverage is expected to be significantly higher than baseline under all suites when sea-level rise is 2 feet or 3.3 feet, only the most expensive suites can come close to maintaining today's current coverage of $44B.

- **Property values would be higher than under the baseline.** Under 2 feet of sea-level rise, only about $8B of the $24B in lost residential property value can be recovered under the less expensive adaptation suites. If more investment is made to increase drainage or create large flood control structures, almost all the $24B reduction can be recovered. Under 3.3 feet of sea-level rise, only about $3B in lost residential property value can be recovered unless additional drainage or flood control investments are made. This greater level of investment is expected to recover $30B of the $40B in lost residential property value.

- **Protect the county's fiscal position**. The County, its municipalities, and government agencies rely on property tax revenue and production-related tax revenue to finance public goods and services. Under 2 feet of sea-level rise, average annual property tax revenue is estimated to be $200M to $700M higher than under baseline depending on the adaptation suite. Under 3.3 feet of sea-level rise, average annual property tax revenue is estimated to be $100M to $1.0B higher than under baseline, depending on the suite. The adaptation suites are expected to reduce average annual production tax losses by $8M to $21M under 2 feet of sea-level rise and by $6M to $62M under 3.3 feet of sea-level rise, depending on the adaptation suite.

- **Reduce the flood impacts in vulnerable areas** as presented in this memorandum.

Taken together, the estimated benefit values demonstrate that the adaptation suites would be expected to materially mitigate the economic impacts of flooding caused by sea-level rise. However, as sea-level rise increases to 3.3ft, only the most ambitious adaptation suites provide substantial economic benefits.

Other benefits were not quantitatively estimated during this study but are important considerations. They include the increased economic activity (GVA) generated from the following flood-related impacts.

a) Avoided disruption to public services
b) Avoided population exodus
c) Avoided reduction in tourism
d) Increased investment
e) Favorable human capital impacts

Human capital impacts include improved physical and mental health, greater household wealth, and better education opportunities. These unmeasured benefits should be considered in future research related to quantifying the benefits of adaptation strategies.

These findings are described in detail herein, with methodology information contained in the *Task 4.1 Economic Modeling Methodology and Data Sources* memorandum, dated December 20 2023.

## 2. Introduction

The first phase of economic modeling in preparation for the Broward County Risk Assessment and Resilience Plan focused on the socioeconomic impacts of flooding given anticipated sea-level rise, ***assuming that no additional actions would be taken to mitigate these impacts***.

To facilitate the economic feasibility assessment of the proposed Resilience Plan, ***the economic benefits of adaptation suites were quantitatively estimated by examining the extent to which the baseline socioeconomic impacts could be mitigated within the county***. Seven different unique combinations of adaptation strategies were explored – each representing a different 'suite' of measures introduced to manage the effects of flooding.

The valuation of economic benefits presented in this memorandum assumes 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 socioeconomic impacts of flooding that would occur today if faced with the flood conditions expected in 2050 and 2070. ***All dollar values are in 2022 dollars.***

This assessment can inform strategic and developmental planning, prioritization and implementation of interventions, and serve as critical input to 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.

**As outlined in the *Economic Modeling Methodology and Data Sources* memorandum, analysis of the effects of the adaptation measures focused on quantitative modeling of four socioeconomic impact areas**, including:

1. **Reducing short-term economic losses.** Adaptation measures could reduce transport disruption and damage to productive assets. This analysis quantifies the short-term reduction (e.g. less than 1 year) in direct impacts to business downtime, including the indirect impacts to the county's sales, income, employment and tax revenue.

2. **Reducing property insurance impacts.** Under Risk Rating 2.0 property insurance could still be affected as flood risk increases. This analysis quantifies how adaptation measures could mitigate the negative impacts of sea-level rise on flood insurance affordability, insurance penetration rate, total purchased coverage, and rates of underinsurance.
3. **Reducing the impact on real estate values.** Increasing flood risk reduces the value of properties, as prospective buyers can expect to face higher repair and insurance costs, disruption to property use and higher insurance cost. This analysis quantifies how the flood adaptation suites could reduce these impacts.
4. **Reducing the fiscal risks to the County.** Ad valorem tax collections may fall as the value of properties decrease. This analysis quantifies how adaptation measures could mitigate downside impacts to tax collection.

In addition, the adaptation measures could also have benefits of reducing five other risks that were qualitatively assessed in the previous phase, including avoiding disruption to public services and critical infrastructure, lowering county investment risk, reducing demographic change such as out-migration, preserving tourism and avoiding physical and mental health impacts.

The memorandum's structure is as follows:

Section 1 describes the purpose of this memorandum.

Section 2 provides an introduction.

Section 3 provides definitions of frequently used terms used throughout this report.

Section 4 summarizes the key inputs to the socioeconomic modeling of adaptation, including outputs of the hydrologic modeling workstream and the adaptation suites.

Section 5 discusses the reductions in property-level flood damage under the adaptation suites.

Section 6 discusses the benefits of the adaptation suites as they mitigate short-term economic losses.

Section 7 discusses the benefits of the adaptation suites on NFIP insurance in Broward County.

Section 8 discusses the benefits of the adaptation suites on residential real estate value.

Section 9 discusses the benefits of the adaptation suites on tax revenue collection in Broward County.

Section 10 considers how impacts are distributed geographically across Broward County, including in vulnerable areas.

Section 11 assesses how adaptation can protect the operation of the Fort Lauderdale-Hollywood International Airport and Port Everglades.

Section 12 discusses uncertainties within the modeling effort and how they may affect the results contained in this memorandum.

Unless otherwise stated, all changes described in this memorandum are relative to impacts in the baseline.

## 3. Definitions

The following terms are used throughout this memorandum. Their definitions are provided below.

| | |
|---|---|
| Adaptation suite | Adaptation Suite (or strategy) is the bundle of adaptation measures intended to mitigate the socioeconomic impacts from flooding under baseline conditions of no action. |
| Adaptation measure | Adaptation measure refers to a single type of adaptation investment. The measures explored in this Resilience Study include converting two-lane roads to one-lane roads with storage areas, pumping stations, culvert improvements, seawalls, control-stations in canals and tidal barriers. |
| Average Annual Damage (AAD) | Average Annual Damage is the expected annual *financial loss from repairing or replacing physical damage* from flooding, accounting for the likelihood and severity of all the flood scenarios considered in the modeling process. |
| Average Annual Loss (AAL) | Average Annual Loss is the expected annual *macroeconomic loss* that would occur in any given year accounting for the likelihood and severity of all the scenarios considered in the modeling process. Macroeconomic losses the lost value of production resulting from damage to productive assets, business interruption caused by flooding of the road network, and indirect impacts to other businesses in the County. |
| Gross Value Added (GVA) | Gross Value Added 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). |
| High vulnerability census tract | Vulnerability data were obtained from the US Center for Disease Control's Social Vulnerability Index (CDC's SVI) dataset, at the census tract level. High vulnerability tracts were identified as those in the top quartile for a given vulnerability metric (e.g., elderly, disabled, housing burdened population) across Broward County. |
| 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[1]. |
| 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 property assets in the event of a flood that damages the property. |
| Insurance penetration rate | Ratio between National Flood Insurance Program policy count and total number of housing units at the census-tract level |
| NFIP | The National Flood Insurance Program, administered by the Federal Emergency Management Agency, provides affordable insurance to property owners and encourages communities to adopt and enforce floodplain management regulations. |
| 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 actuarily sound, equitable, easier to understand and better reflect a property's flood risk. |
| SFHA | Special Flood Hazard Areas (SFHA) are defined by FEMA as areas that will be inundated by flood events having a 1% annual chance of occurring. Residences within SFHAs typically are required to have NFIP flood insurance policies. |
| Sales | As used in this memorandum, "sales" is the commercial sales revenue by business type. |
| Stranded business | A stranded business is a business which is not physically connected to most of its consumers and suppliers (90%) via road, due to flooded roads being impractical to use for transportation (defined as roads with flood depths above 0.5ft). |
| SVI | The Social Vulnerability Index consolidates information on 16 vulnerability indicators in CDC/ATSDR's SVI database at the census track level, covering 4 key dimensions of |

[1] As per Affordability of National Flood Insurance Program Premiums Report 1, 2015; accessible at: https://nap.nationalacademies.org/read/21709/chapter/7#80

| | |
|---|---|
| | vulnerability: socioeconomic status, household characteristics, racial & ethnic minority status and housing type/transportation. |
| Underinsurance rate | Ratio between non-insured replacement costs and total replacement value. |

## 4. Key inputs to the socioeconomic modeling of adaptation

**Introduction to the inputs**. Outputs from the hydrologic modeling workstream were the core inputs into the socioeconomic modeling of adaptation. The hydrologic modeling workstream developed seven adaptation suites characterized by different combinations of measures and levels of protection offered.

Future flood projections for the baseline (no action) and the adaptation strategies incorporate sea-level rise, in addition to expected rainfall and storm surge. Sea-level rise scenarios of 2.0 feet (based on the 2017 NOAA Intermediate High Sea-Level Rise (SLR) projection) and 3.3 feet (using the same projection) were used. For each sea-level rise scenario, the hydrologic workstream provided the socioeconomic workstream with the following data:

1. Probability of the scenario occurring – same as the baseline in all adaptation suites
2. Maximum flood depth for each building – influenced by the adaptation suite
3. Duration of flooding above elevation thresholds for each building – influenced by the adaptation suite
4. Expected damages to each building, disaggregated between structural and content damages – influenced by the adaptation suite

The economics modeling team used these data to prepare two key inputs: (1) an analysis of road network disruption, and (2) damages to residential and productive assets.

**Adaptation suites explored in this effort.** Seven different unique combinations of adaptation suites were explored – each representing a different 'suite' of measures to manage the effects of flooding. In general, the level of protection (and associated required investment) was designed to increase from the first to the last strategy. However, as can be seen in the results, this is not uniformly the case given the complex ways in which different types of measures, implemented in different parts of the county, afford different levels of protection in different flood conditions. The assumptions in each adaptation suite are summarized in **Exhibit 1**. Only the suite titled "Countywide with 7 foot walls and control elevation changes" includes drainage systems behind and through the seawalls to move stormwater away from the properties.

Hazen

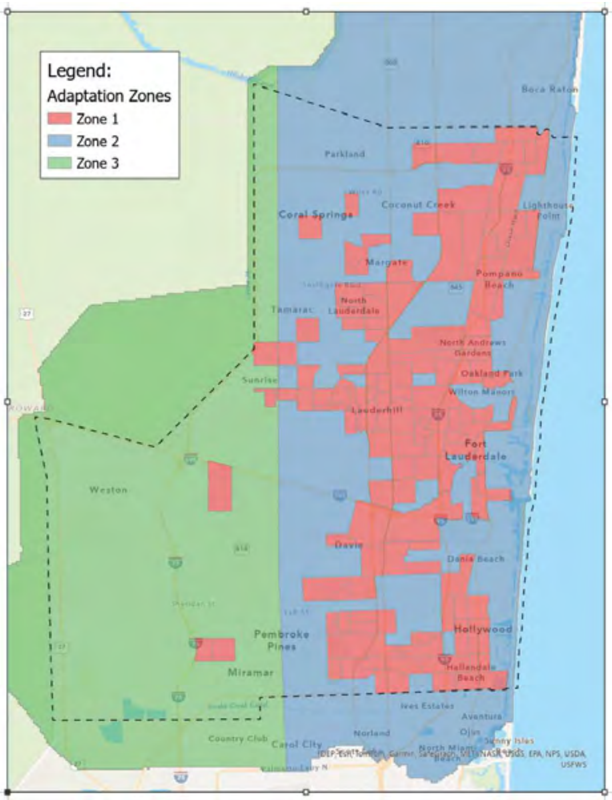
December 5, 2024

**Exhibit 1: Overview of the adaptation suites**

✗ Existing conditions ✓ Additional measures

| Adaptation suite | County area where measures implemented, % | Two-way roads converted | Pumping stations | Storage areas | Control elevation changes | Sea walls | Surge & tidal coastal barriers |
|---|---|---|---|---|---|---|---|
| Baseline | ~0% | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| Priority areas | ~30% (Zone 1) | ✓ | ✓ | ✓ | ✗ | 5ft | ✗ |
| Coastal areas | ~60% (Zone 1&2) | ✓ | ✓ | ✓ | ✗ | 5ft | ✗ |
| Coastal areas w/ control elevation changes | ~60% (Zone 1&2) | ✓ | ✓ | ✓ | ✓ | 5ft | ✗ |
| Countywide | ~100% (Zones 1-3) | ✓ | ✓ | ✓ | ✗ | 5ft | ✗ |
| Countywide w/control elevation changes | ~100% (Zones 1-3) | ✓ | ✓ | ✓ | ✓ | 5ft | ✗ |
| Countywide w/7ft walls & control elevation changes | ~100% (Zones 1-3) | ✓ | ✓ | ✓ | ✓ | 7ft | ✗ |
| Large flood control structures | ~100% (Zones 1-3) | ✓ | ✓ | ✓ | ✓ | 5ft | ✓ |

The adaptation zones referenced in **Exhibit 1** refer to different parts of the county where certain measures – two-way road conversion to one-way roads, pumping stations, stormwater pumps, green infrastructure, culvert improvements and distributed storage (above and below ground) – would be implemented. Three zones were identified as follows and are depicted in **Exhibit 2**.:




- **Zone 1:** Census tracts identified as having the highest vulnerability
- **Zone 2**: Eastern portion of Broward County
- **Zone 3**: Western portion of Broward County

**Exhibit 2: Adaptation zones in Broward County**

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December 5, 2024

**Flood scenarios evaluated.** The flood scenarios described in **Table 2** were modeled by Hazen and served as the base inputs to this economic modeling effort.

**Table 2. Flood scenarios used to estimate the economic benefits of adaptation suites**

| Scenario No. | Rainfall frequency | Sea-level Rise scenario | Antecedent Conditions | Tidal Conditions | Rainfall probability | Surge probability | Joint probability |
|---|---|---|---|---|---|---|---|
| RP-1 | 25-yr | 2.0 ft | Variable GW | No Surge | 4.00% | 100.00% | 4.00% |
| RP-2 | 50-yr | 2.0 ft | Variable GW | No Surge | 2.00% | 100.00% | 2.00% |
| RP-3 | 100-yr | 2.0 ft | Saturated System | No Surge | 1.00% | 100.00% | 1.00% |
| RP-4 | 25-yr | 2.0 ft | Variable GW | 20-yr Storm Surge | 4.00% | 5.00% | 0.20% |
| RP-5 | 50-yr | 2.0 ft | Variable GW | 20-yr Storm Surge | 2.00% | 5.00% | 0.10% |
| RP-6 | 100-yr | 2.0 ft | Saturated System | 20-yr Storm Surge | 1.00% | 5.00% | 0.05% |
| RP-7 | 25-yr | 2.0 ft | Variable GW | 100-yr Storm Surge | 4.00% | 1.00% | 0.04% |
| RP-8 | 50-yr | 2.0 ft | Variable GW | 100-yr Storm Surge | 2.00% | 1.00% | 0.02% |
| RP-9 | 100-yr | 2.0 ft | Saturated System | 100-yr Storm Surge | 1.00% | 1.00% | 0.01% |
| RP-10 | 25-yr | 3.3 ft | Variable GW | No Surge | 4.00% | 100.00% | 4.00% |
| RP-11 | 50-yr | 3.3 ft | Variable GW | No Surge | 2.00% | 100.00% | 2.00% |
| RP-12 | 100-yr | 3.3 ft | Saturated System | No Surge | 1.00% | 100.00% | 1.00% |
| RP-13 | 25-yr | 3.3 ft | Variable GW | 20-yr Storm Surge | 4.00% | 5.00% | 0.20% |
| RP-14 | 50-yr | 3.3 ft | Variable GW | 20-yr Storm Surge | 2.00% | 5.00% | 0.10% |
| RP-15 | 100-yr | 3.3 ft | Saturated System | 20-yr Storm Surge | 1.00% | 5.00% | 0.05% |
| RP-16 | 25-yr | 3.3 ft | Variable GW | 100-yr Storm Surge | 4.00% | 1.00% | 0.04% |
| RP-17 | 50-yr | 3.3 ft | Variable GW | 100-yr Storm Surge | 2.00% | 1.00% | 0.02% |
| RP-18 | 100-yr | 3.3 ft | Saturated System | 100-yr Storm Surge | 1.00% | 1.00% | 0.01% |
| RP-28 | 1-yr | Current | Variable GW | No Surge | 100.0% | 100.0% | 100.0% |
| RP-29 | 2-yr | Current | Variable GW | No Surge | 50.0% | 100.0% | 50.0% |
| RP-30 | 5-yr | Current | Variable GW | No Surge | 20.0% | 100.0% | 20.0% |
| RP-31 | 0 | 2.0 ft | Saturated | 100-yr Storm Surge | 100.00% | 1.00% | 1.00% |
| RP-32 | 0 | 3.3 ft | Saturated | 100-yr Storm Surge | 100.00% | 1.00% | 1.00% |
| RP-33 | 1-yr | 2.0 ft | Variable GW | No Surge | 100.00% | 100.00% | 100.00% |
| RP-34 | 2-yr | 2.0 ft | Variable GW | No Surge | 50.00% | 100.00% | 50.00% |
| RP-35 | 5-yr | 2.0 ft | Variable GW | No Surge | 20.00% | 100.00% | 20.00% |
| RP- 36 | 1-yr | 3.3 ft | Variable GW | No Surge | 100.00% | 100.00% | 100.00% |
| RP- 37 | 2-yr | 3.3 ft | Variable GW | No Surge | 50.00% | 100.00% | 50.00% |
| RP- 38 | 5-yr | 3.3 ft | Variable GW | No Surge | 20.00% | 100.00% | 20.00% |
| RP-40 | 1-yr | Current | Variable GW | 20-yr Storm Surge | 100.0% | 5.0% | 5.000% |
| RP-41 | 10-yr | Current | Variable GW | 20-yr Storm Surge | 10.0% | 5.0% | 0.500% |
| RP-42 | 25-yr | Current | Variable GW | 20-yr Storm Surge | 4.0% | 5.0% | 0.200% |
| RP-43 | 50-yr | Current | Variable GW | 20-yr Storm Surge | 2.0% | 5.0% | 0.100% |
| RP-44 | 100-yr | Current | Saturated | 20-yr Storm Surge | 1.0% | 5.0% | 0.050% |
| RP-45 | 1-yr | Current | Variable GW | 100-yr Storm Surge | 100.0% | 1.0% | 1.000% |
| RP-46 | 10-yr | Current | Variable GW | 100-yr Storm Surge | 10.0% | 1.0% | 0.100% |
| RP-47 | 25-yr | Current | Variable GW | 100-yr Storm Surge | 4.0% | 1.0% | 0.040% |
| RP-48 | 50-yr | Current | Variable GW | 100-yr Storm Surge | 2.0% | 1.0% | 0.020% |
| RP-49 | 100-yr | Current | Saturated | 100-yr Storm Surge | 1.0% | 1.0% | 0.010% |
| RP-50 | 1-yr | 2.0 ft | Variable GW | 20-yr Storm Surge | 100.00% | 5.00% | 5.00% |
| RP-51 | 1-yr | 3.3 ft | Variable GW | 20-yr Storm Surge | 100.00% | 5.00% | 5.00% |

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.

Hazen

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## 5. Property damage avoided


**Property-level damage.** The hydrologic modeling team modeled the average annual property damage associated with each flood scenario with and without each adaptation suite. In the baseline, average annual damage to residential assets could increase from close to $600M today to $1.8B with 2 feet of sea-level rise as indicated by the pink bars on the left hand side of **Exhibit 3a**.

Under 3.3 feet of sea-level rise, average annual baseline damage grows to an estimated $3.6B as indicated by the pink bar on the right hand side of **Exhibit 3a**. Damages to productive assets could increase from $240M today, to $645M with 2 feet of sea-level rise, and $1.4B with 3 feet of sea-level rise as indicated by the pink bars in **Exhibit 3b**.

**All but one adaptation suite would reduce property damage relative to the baseline**. For example, with 2 feet of sea-level rise, implementing measures in priority areas could avoid $400M to $1.5B in residential real estate damages, 21% to 82% of baseline damages (**Exhibit 3a**), and $100M-$400M in productive asset damages, 13%-63% of baseline damages (**Exhibit 3b**). The lower figure represents savings from implementing measures in priority areas, while the higher figure would involve implementing measures countywide with 7-foot NAVD seawalls and control-elevation changes.

**Exhibit 3a: Average annual damages to residential assets ($M damages)**

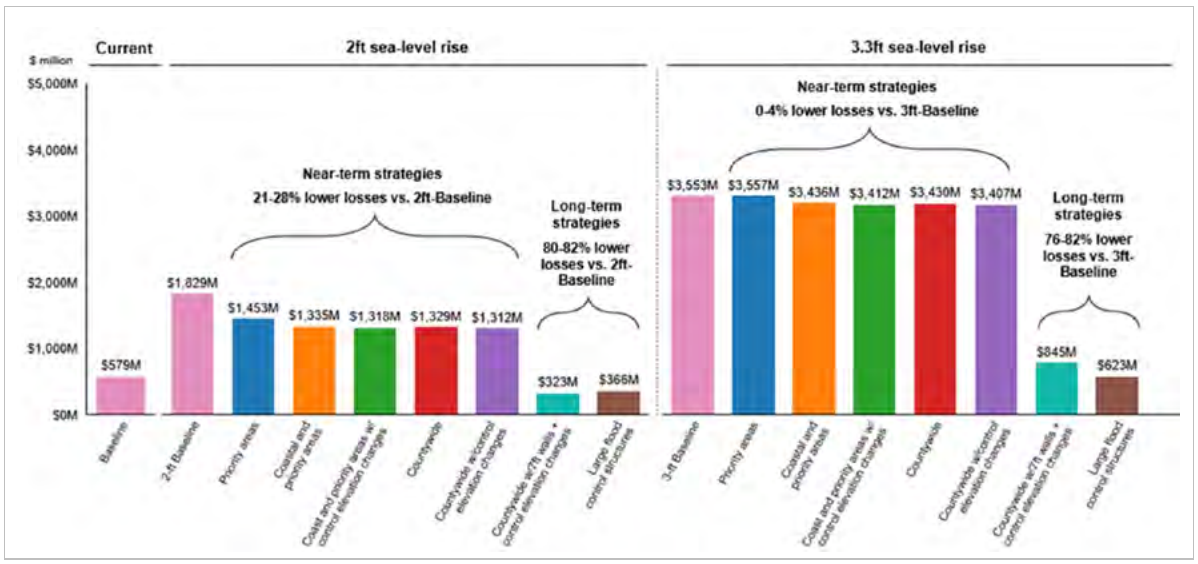

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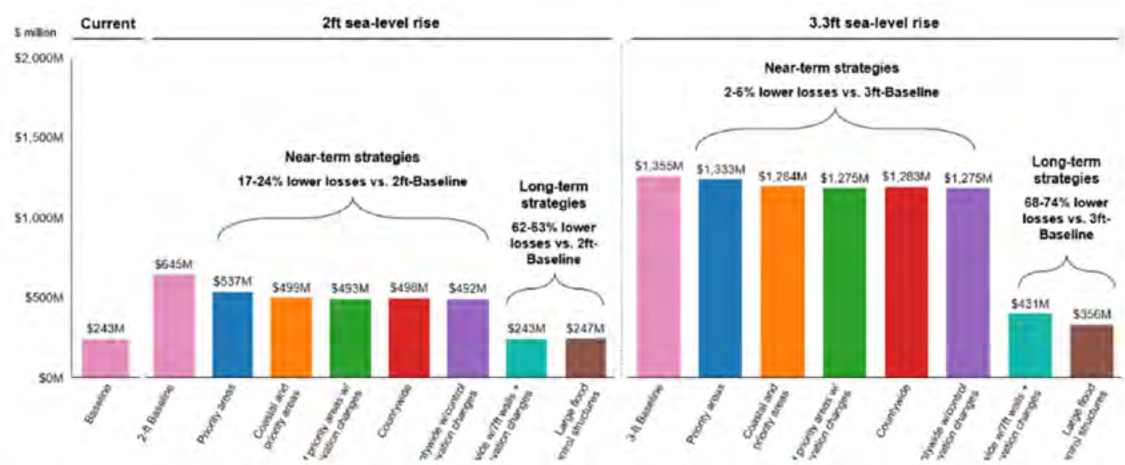
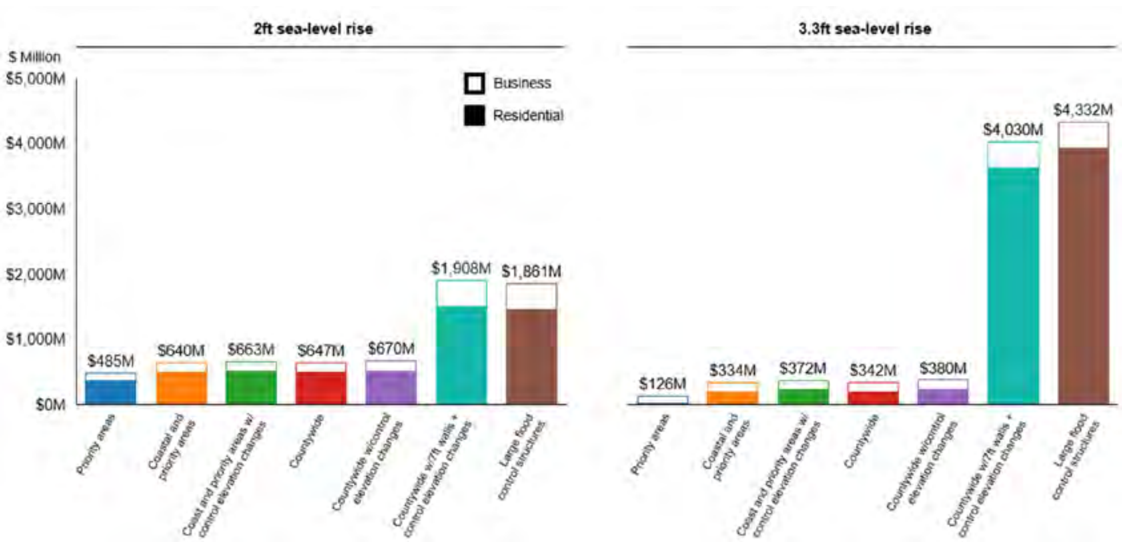
**Exhibit 3b: Average annual damages to productive assets ($M damages)**




With 3.3 feet of sea-level rise, higher seawalls and large flood control structures more materially mitigate flooding and the associated economic costs. The overall average annual savings associated with introducing these measures across residential and business assets would be $4.0B to 4.3B relative to the 3.3 foot baseline. The overall benefits of reduced asset damage associated with the adaptation suites are presented in **Exhibit 4.**

**Exhibit 4: Savings in average annual avoided flood damage to residential and productive assets relative to baseline ($M)**

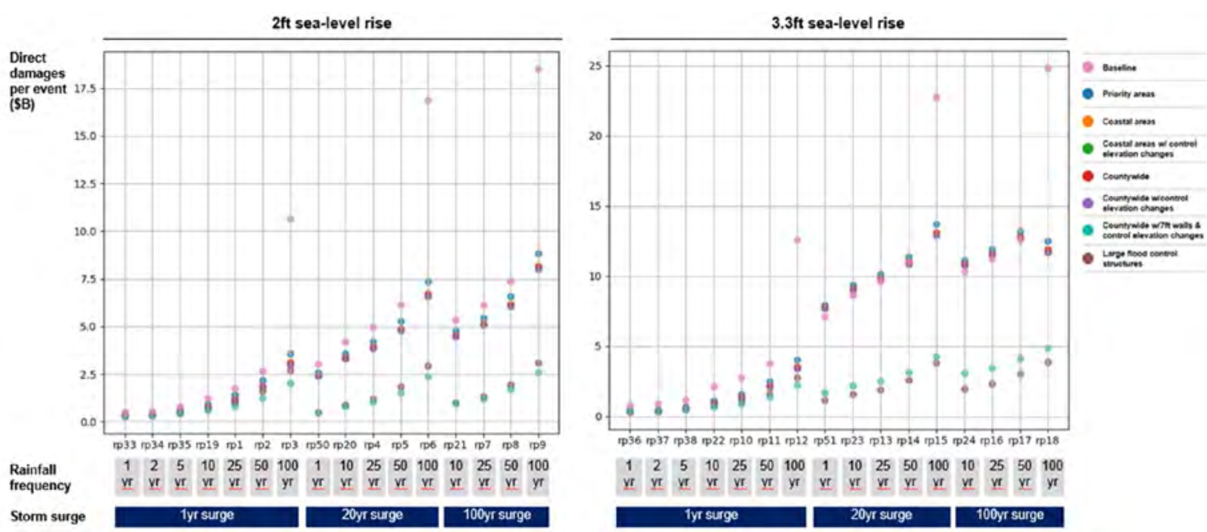



**Damages across different flood events.** Damages were calculated as the average annual damage based on probability weighted impacts of a range of rainfall and storm surge scenarios. This section considers how overall averages are built up from scenario-level impacts. Damages are highest for the scenarios that include a 100-year rainfall event and a 100-year storm surge event (See Table 2 - Scenarios RP9 and RP18 under 2 feet and 3.3 feet of sea-level rise, respectively). However, because they are relatively rare, they contribute a small amount to the overall average annual damage.

**Exhibit 5** presents the extent to which each adaptation suite mitigates flood damage under each rainfall event / storm surge scenario. For 2 feet of sea-level rise, all adaptation suites reduce damages under all scenarios, but with mitigation benefits most pronounced for the most extreme rainfall events as indicated under the scenarios RP3, RP6, and RP9 in the left hand graph of **Exhibit 5**. Under 3.3 feet of sea-level rise, some adaptation suites do not mitigate flood damage under some of the scenarios while the two adaptation suites with the most comprehensive investments reduce damages under all scenarios. This is evident by examining the right hand graph of **Exhibit 5**.

Furthermore, the most comprehensive adaptation suites provide the greatest flood protection compared to the other suites under all rainfall and storm surge scenarios and they offer the greatest level of avoided flood damage benefits in scenarios involving 20-or 100-year storm surge events. Under 3.3 feet of sea-level rise, the other adaptation suites become ineffective at reducing flood damages in scenarios with 20- or 100-year storm surge events.

**Exhibit 5: Direct residential property damages across different rainfall and storm surge probabilities ($M)** ***(not probability weighted)***




**Damages across different cities. Table 3a and Table 3b** present the benefits by city of two adaptation strategies, assuming the adoption of a near-term adaptation suite under 2 feet of sea-level rise and a longer-term approach under 3.3 feet of sea-level rise. In this table the near-term strategy would be implementation of the adaptation measures listed in **Exhibit 1** under “Countywide with Control Elevation Changes” and the longer-term approach would be the Countywide approach with an increase in seawall height from 5 foot NAVD to 7 foot NAVD.

For these 29 cities, property damages are lower when the adaptation strategies are adopted versus the baseline for both the near-term and longer-term strategies. The amount of savings increases when sea-level rise increases to 3.3 feet given the larger expected property damages that can be mitigated under the 3.3 feet sea-level rise baseline scenario. The largest benefits in reduced property damage are concentrated in the coastal cities and the lowest damages are in the cities that are in the more western portions of the County.

**Table 3a - Residential property damage avoided under two selected adaptation strategies among cities, sorted by $M in avoided property damage, average annual 2024 dollars**

| Average Annual Avoided Damage Range | Property Damage Avoided - Countywide with w/ control elevation changes at 2ft SLR | | | Property Damage Avoided - Countywide w/7ft NAVD seawalls + control elevation changes at 3.3ft SLR | | |
|---|---|---|---|---|---|---|
| | Number of Cities and Unincorporated County | $M / Year | % of Total Avoided Damage | Number of Cities and Unincorporated County | $M / Year | % of Total Avoided Damage |
| Greater than $100M | 2 | $337 | 54% | 5 | $2,436 | 85% |
| $20M to $100M | 4 | $145 | 23% | 5 | $342 | 12% |
| $10M to $20M | 6 | $81 | 13% | 3 | $32 | 1% |
| $5M to $10M | 5 | $36 | 6% | 5 | $49 | 2% |
| >$1 to <$5M | 8 | $19 | 3% | 8 | $20 | 1% |
| >$0 to $1M | 4 | $3 | 0.4% | 3 | $2 | 0.1% |
| **Total** | **29** | **$622** | **100%** | **29** | **$2,881** | **100%** |

*Note: Damages and savings by city were estimated as closely as possible because the analysis was conducted at the Census Tract level and the Census tracts mostly, but not completely, align with city boundaries.

**Table 3b - Residential property damage avoided under two selected adaptation strategies among cities, sorted by percentage of avoided property damage relative to baseline, average annual 2024 dollars**

| Average Annual Damage Avoided Range as percentage of baseline | Property Damage Avoided - Countywide with w/ control elevation changes at 2ft SLR | | | Property Damage Avoided - Countywide w/7ft NAVD seawalls + control elevation changes at 3.3ft SLR | | |
|---|---|---|---|---|---|---|
| | Number of Cities and Unincorporated County | $M / Year | % of Total Annual Avoided Damage | Number of Cities and Unincorporated County | $M / Year | % of Total Annual Avoided Damage |
| 70-99% reduction | 5 | $67 | 11% | 11 | $2,666 | 93% |
| 60-70% reduction | 6 | $53 | 9% | 7 | $87 | 3% |
| 40-60% reduction | 8 | $266 | 43% | 6 | $111 | 4% |
| 20-40% reduction | 6 | $77 | 12% | 3 | $12 | 0% |
| >0-20%reduction | 4 | $158 | 25% | 2 | $4 | 0% |
| **Total** | **29** | **$622** | **100%** | **29** | **$2,881** | **100%** |

*Note: Damages and savings by city were estimated as closely as possible because the analysis was conducted at the Census Tract level and the Census tracts mostly, but not completely, align with city boundaries.

The tables include all municipalities in Broward County except Lighthouse Point, which will experience a 112% increase in flooding under the near-term strategy relative to baseline conditions with 2.0 feet of sea-level rise. This amounts to an additional $66 million increase in average annual property damage above baseline conditions.

This increase in flooding occurs at the locations close to the Hillsboro Inlet where the water stages of the Intracoastal Waterway are more sensitive to sea-level rise than elsewhere. This sensitivity will be exacerbated by the effects of the adaptation strategies implemented upstream of the inlet (mainly the installation of 5 foot seawalls). Under the 2.0 foot sea-level rise baseline, in areas with low or no seawalls, the excess water would flow outside of channel banks during heavy rainfall or flood events. Once 5-foot seawalls are constructed under the near team adaptation strategy, more water will stay inside the channels, creating higher channel water depths downstream. These higher water depths would impede the proper drainage of the residential areas in Lighthouse Point and result in greater flooding than under baseline.

Once the drainage systems behind and through the seawalls are implemented under the long-term strategy, the city's drainage would significantly improve such that the property damage within the city would be expected to fall by 91% which amounts to $160 million in avoided average annual damages.

To counter the city's flood problem under the near-term approach, the economic analysis includes drainage improvements behind and through the seawalls in the City of Lighthouse Point in the near-term such that $106 million in property damages would be avoided in the near-term compared to the baseline which is a 70% reduction in damages under baseline.

The condition described here may also be present in other downstream areas. Although the economic effects in those areas are not expected to be significant enough to make a difference in the results presented in this document, the increased flooding that might occur in certain areas under the near-term strategy will be addressed during the formulation of the Resilience Plan.

The average annual avoided property damages for the individual cities in Broward County under the near-term strategy that includes the Lighthouse Point drainage features (later referred to as Tier 1) and under the longer-term strategy (later referred to as Tier 2) are provided in Appendix A-1.

## 6. Increased short-term economic activity

**Summary of key findings.** Gross Value Added (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 each adaptation suite were assessed as 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 key findings of the short-term economic activity evaluation are as follows.

- The adaptation suites materially reduce modeled losses to economic production. Savings as measured by the avoided reduction in average annual GVA range from $81M to $186M under 2 feet of sea-level rise and between $77M and $660M under 3.3 feet of sea-level rise, depending on the adaptation suite. These suites could protect 1,000 to 2,500 jobs that would otherwise be at risk under 2 feet of sea-level rise, and as many as 8,300 jobs protected under 3.3 feet of sea-level rise.
- The avoided reduction in average annual GVA as a percentage of baseline GVA loss ranges from 19% to 43% while the avoided property damage as a percentage of baseline damage is higher at 21% to 82%, depending on the adaptation suite. The GVA losses are mitigated to a lesser extent because interruptions to the movement of goods and services are persistent over time.
- Outside of economic analysis, a more commonly used economic metric to residents and businesses is the "value of sales" or "sales" of a good, a service, or the total sales in an economy. Estimated county-wide average annual avoided sales loss is estimated to range from $310M and $850M under 2 feet of sea-level rise (31% to 83% of baseline sales losses) and $175M to $2.4B under 3.3 feet of sea-level rise (7% to 88% of baseline sales losses).

**Discussion of key findings.** The short-term economic loss modeling included two analyses:

- **Input-output modeling** – which provides estimates of the *expected* economy-wide impacts of flood damage and transport disruption.
- **Sales disruption** – which provides an estimate of a more familiar measure of economic activity.

**Mitigating expected economic losses (Input-output modeling).** The baseline analysis found the effects of flooding on economic production to be material, at $435M in average annual losses to GVA with 2 feet of sea-level rise, increasing to $947M with 3.3 feet of sea-level rise. This reflects business outages that result from damage to assets and interruptions to the road network, as well as the compounding impacts on other businesses in the county that trade with those that experience outages. Compared to the assessment of property damages, more extreme flooding scenarios cause proportionally greater losses to production, as large disruptions create bottlenecks in supply chains, increasing recovery times.

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**All the adaptation suites substantively reduce short term losses to gross value added, profits, and jobs as risk. Exhibits 6a, 6b and 6c** demonstrate that, for all three economic measures, reductions could range from around 19% to 43% of the total expected baseline losses under 2 feet of sea-level rise, increasing to around 8% to 70% of the baseline when sea-level rise reaches 3.3 feet.

**Exhibit 6a: Average annual gross value added loss, $M, under the baseline and the adaptation strategies**

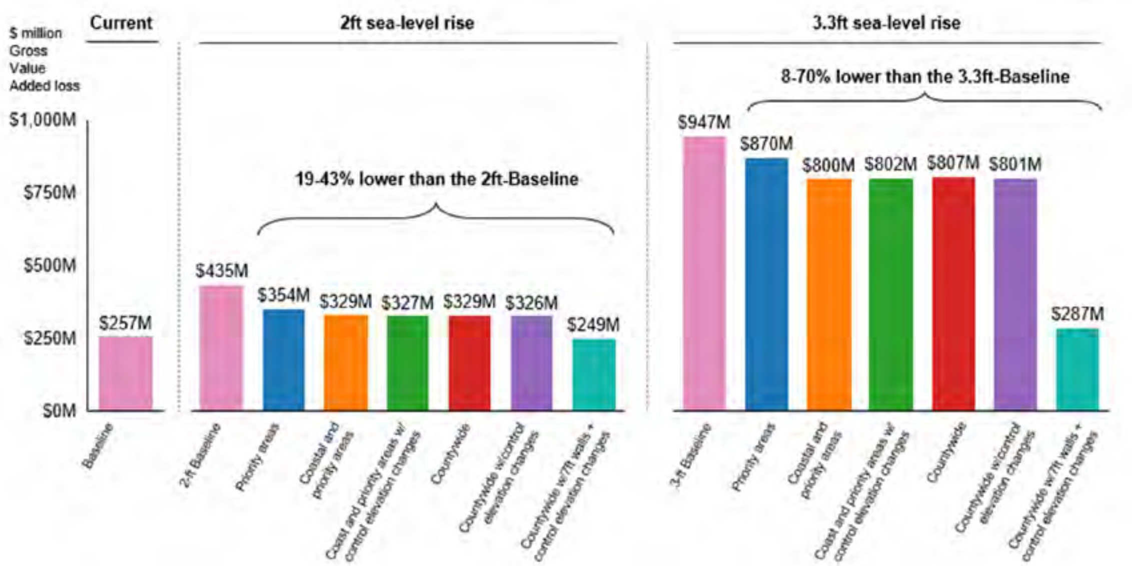


**Exhibit 6b: Average annual Profit loss, $M, under the baseline and the adaptation strategies**

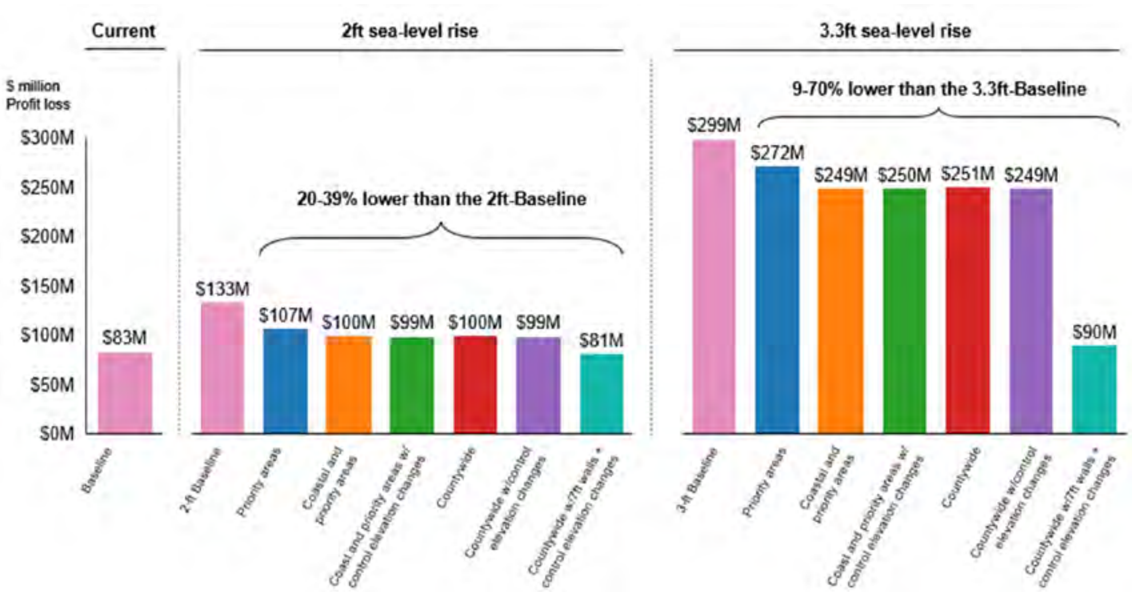

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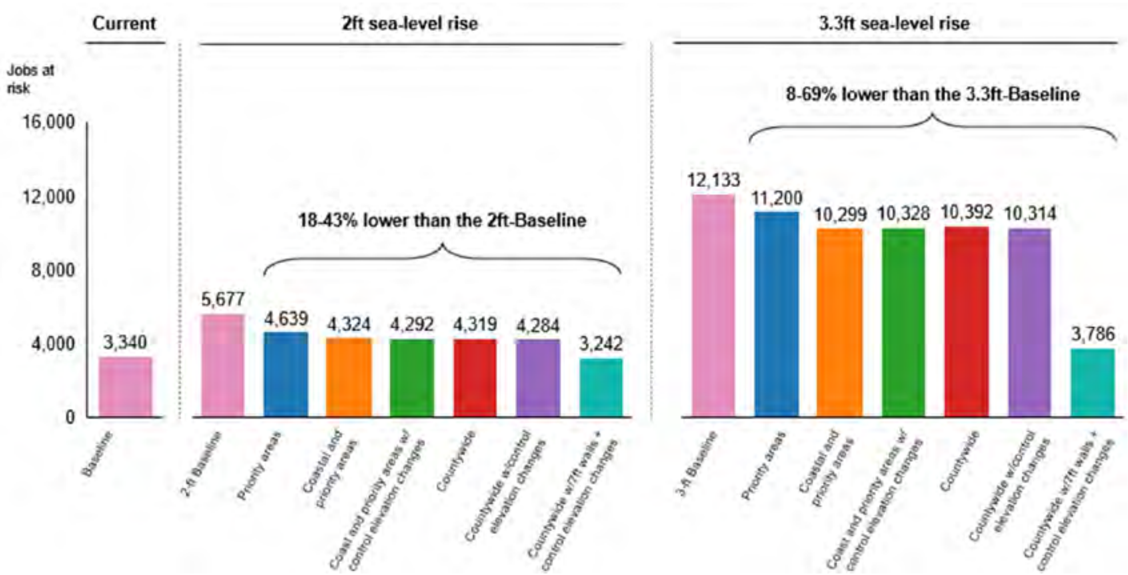
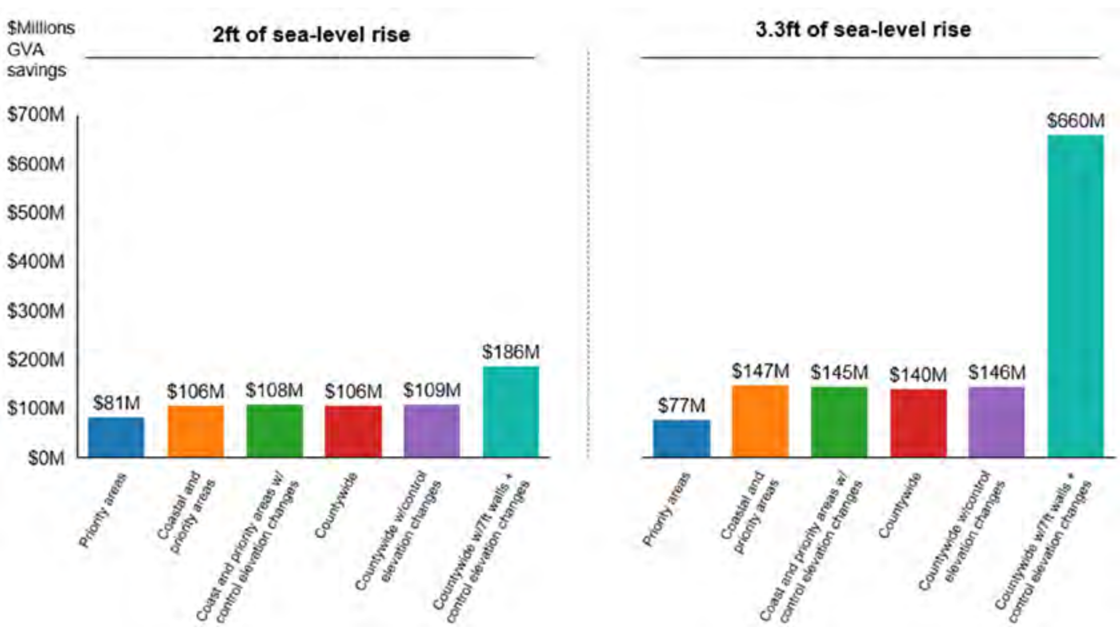
**Exhibit 6c: Average annual jobs at risk under baseline and the adaptation strategies**




The average annual increase in GVA from the adaptation strategies is provided in **Exhibit 7**. The benefits of the adaptation strategies as they mitigate short term economic losses range between an increase of $81M to $186M in GVA under 2 feet of sea-level rise, and $77M to $660M under 3.3 feet of sea-level rise.

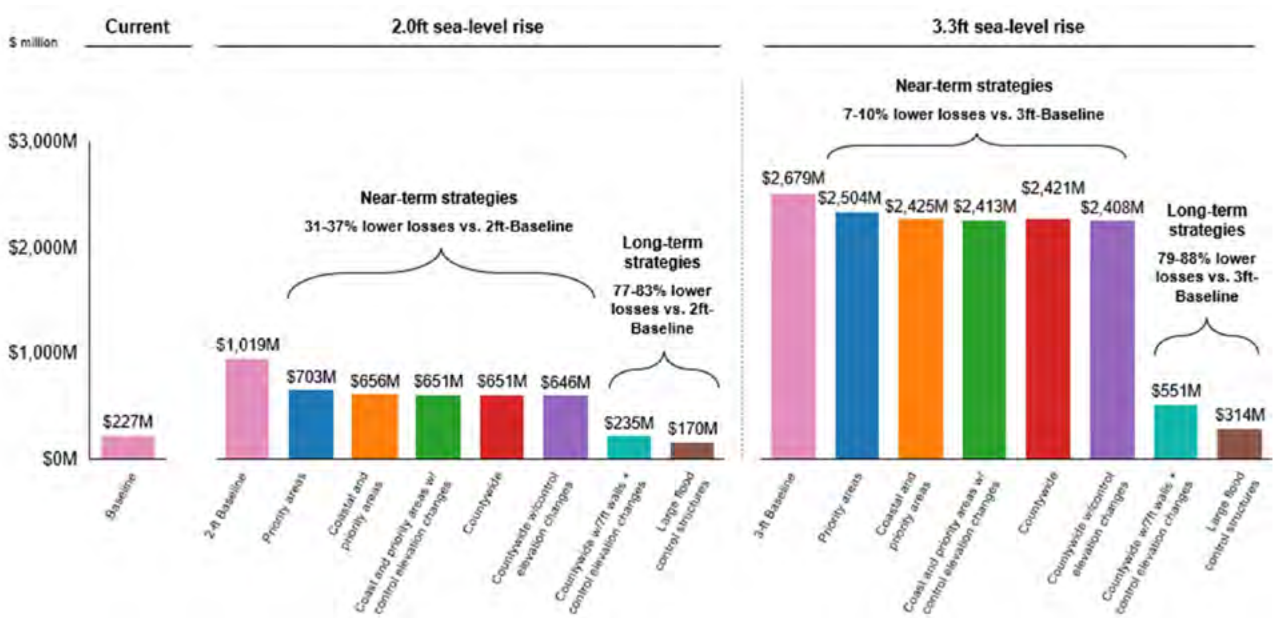
**Exhibit 7: Average annual increase in gross value added from the adaptation strategies, $M**



**Mitigating maximum potential sales losses.** Sales revenue is a metric that is routinely collected and reported by government agencies and private firms. The baseline analysis concluded that the average annual sales loss could increase between 4.5x and 11.8x the current sales losses from flooding absent adaptation actions with 2 feet and 3.3 feet of sea-level rise, respectively.

**Exhibit 8** demonstrates that under 2 feet of sea-level rise, the first five adaptation suites would still result in lower sales than today, but the loss would be between 31% to 37% lower than under baseline. The last two adaptation strategies, involving the construction of higher seawalls or large flood control structures would keep future losses at today's levels under 2 feet of sea-level rise. While sales loss under 3.3 feet of sea-level rise could not be kept at today's levels, the loss reduction would be high at 79% to 88% of baseline sales loss.

**Exhibit 8: Average annual sales loss across the baseline and the adaptation strategies, $M**



## 7. Greater flood insurance coverage


**Summary of key findings**. The key findings of the flood insurance market evaluation are as follows.

- **The number of NFIP policies in Broward County is expected to fall at a lower rate over time when adaptations suites are implemented relative to baseline.** Re-pricing of risk and growing damages from floods would still reduce the number of homes holding NFIP policies from the current level of 175,000 policies. However, assuming current NFIP policy criteria continue to be in place, from 1.6x to 3.3x as many people could maintain insurance where adaptation strategies are pursued. This represents an additional 32,000 to 113,000 additional policies relative to the baseline under the 2 foot sea-level rise scenario and 30,000 to 88,000 additional policies under 3.3 feet of sea-level rise, depending on the adaptation suite.

- **Premia for remaining policies could remain at levels more like today:** While some homes with higher risk profiles could still exit the market, premia for remaining homes could be the same, if not lower, with the adaptation suites in place.

- **Total NFIP coverage would still fall overall (because of changes in policy count and premia) but much less than in the baseline:** Current flood insurance coverage in Broward County is about $44B. Under 2 feet of sea-level rise with no adaptation (baseline), the amount of flood insurance coverage is expected to fall to $13B. The adaptation suites increase coverage to $21B to $41B relative to baseline, with the two most comprehensive suites facilitating the high end of this range at $38B and $41B. These two suites are expected to bring NFIP coverage close to its current level.

  Under 3.3 feet of sea-level rise with no adaptation, Countywide NFIP coverage falls to $11B from the current $44B level. The adaptation suites mitigate this drop resulting in $19B to $33B of coverage, with the two most comprehensive suites recovering to $31B and $33B or 70% to 75% of current coverage levels.

- **As a result, uninsured damages could be at 20% to 90% lower than under the baseline,** depending on which adaptation suite is pursued. The two most comprehensive suites provide the greatest benefits under both sea-level rise scenarios.

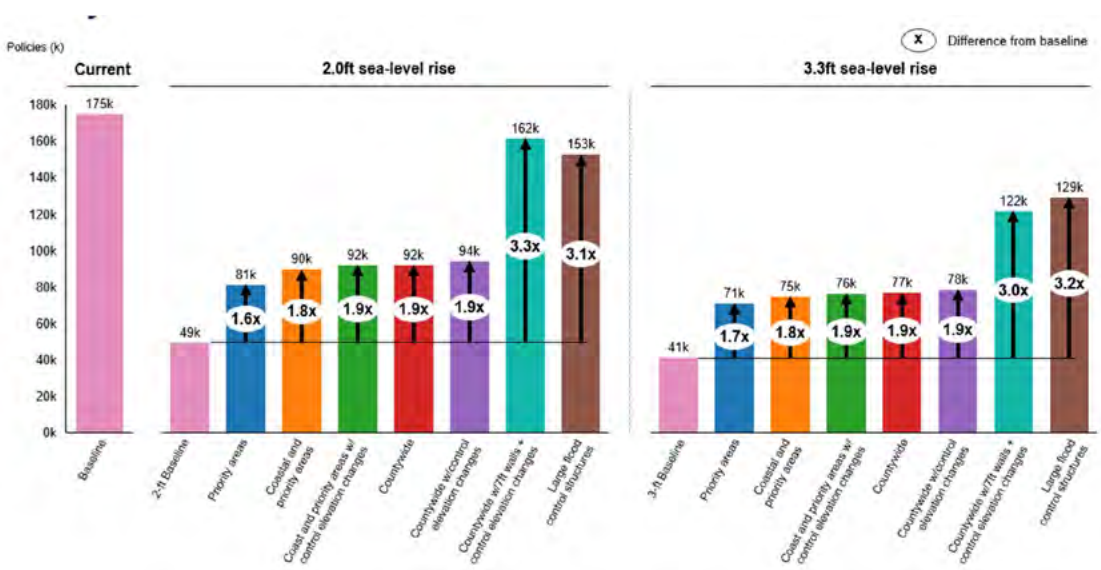
**Discussion of key findings.** All adaptation strategies would increase the number of residential housing units with NFIP policies relative to the baseline.

**With 2 feet and 3.3 feet of sea-level rise, respectively, the higher average annual damages per housing unit under baseline conditions could reduce the Countywide NFIP policy count by 70% to 75% relative to current conditions.** This assumes NFIP premia would increase in line with AAD (given the ambition of Risk Rating 2.0) which makes purchasing insurance less affordable absent adaptation measures. **Exhibit 9** presents the estimated NFIP policy count under current conditions and the estimated policy counts for the baseline and adaptation suites under each sea-level rise projection (2 feet and 3.3 feet). The exhibit shows how the Countywide NFIP policy count is expected to decrease from 175,000 policies currently to 49,000 policies under 2.0 feet of sea-level rise, and to 41,000 policies under 3.3 feet of sea-level rise.

**Implementing adaptation strategies could mean 1.6x to 3.3x times more residential homes would maintain their NFIP policies in 2050 and 2070.** This is primarily because each of the suites would lower a housing unit's average annual damage. This translates into a lower rise in risk-adjusted premiums, and a greater share of policies that remain affordable. The following observations are of note.

- While the adaptation suites result in higher NFIP policy counts relative to the baseline, they do not completely mitigate the reduction in the insurance penetration rate, and the policy count still falls overall. This is because the risk-adjusted premiums would be higher under the sea-level rise scenarios than they are currently, even if they would be significantly lower than under the baseline.
- Insurance penetration rates are much higher in the last two strategies depicted in **Exhibit 9** than in the baseline or the other adaptation suites. The adaptation measures implemented with higher seawalls (7ft) and/or large flood control structures offer increased flood protection in the longer term.

**Exhibit 9: Total NFIP policy count could fall less over time than the baseline if adaptation measures are pursued**




NFIP premia for the remaining policies could remain much closer to the current premia. After accounting for policy exits, premia for purchased NFIP policies may only rise modestly or even fall slightly in real terms. On the county level, **Exhibits 10a and 10b** demonstrate how the increase in premia due to 2 feet of sea-level rise could be significantly mitigated. Instead of the 1.9x increase from today's current premia, single-family home policy costs could range between 0.8x (lower) and 1.3x (higher) compared to current costs. Multi-family home policy costs range between 0.7x (lower) and 1.6x (higher) compared to current costs.

In some instances, 2050 costs (in 2025 dollars) for the remaining policies could be lower than they are today for both single and multi-family homes. This is because properties that face high average annual damages drop out of the market under the baseline and under the adaptation suites, thus reducing the premia charged to those who keep their policies. This feature results in relatively modest differences in average premia between the adaptation suites.

To illustrate: for single-family homes, the average premia *among those households that buy insurance* is only 22% higher for the adaptation suite that introduces county-wide control elevation changes with 5 foot NAVD seawalls (purple bar in **Exhibit 10a**) versus the same suite but with 7 foot NAVD seawalls (aqua bar in **Exhibit 10a**) ([$766M - $627M] / $627M = 0.22). However, because insurance is more expensive in general, 42% fewer households can afford insurance with the former adaptation suite than the latter.

**Exhibit 10a: Average NFIP premia in Broward County – Single-Family**

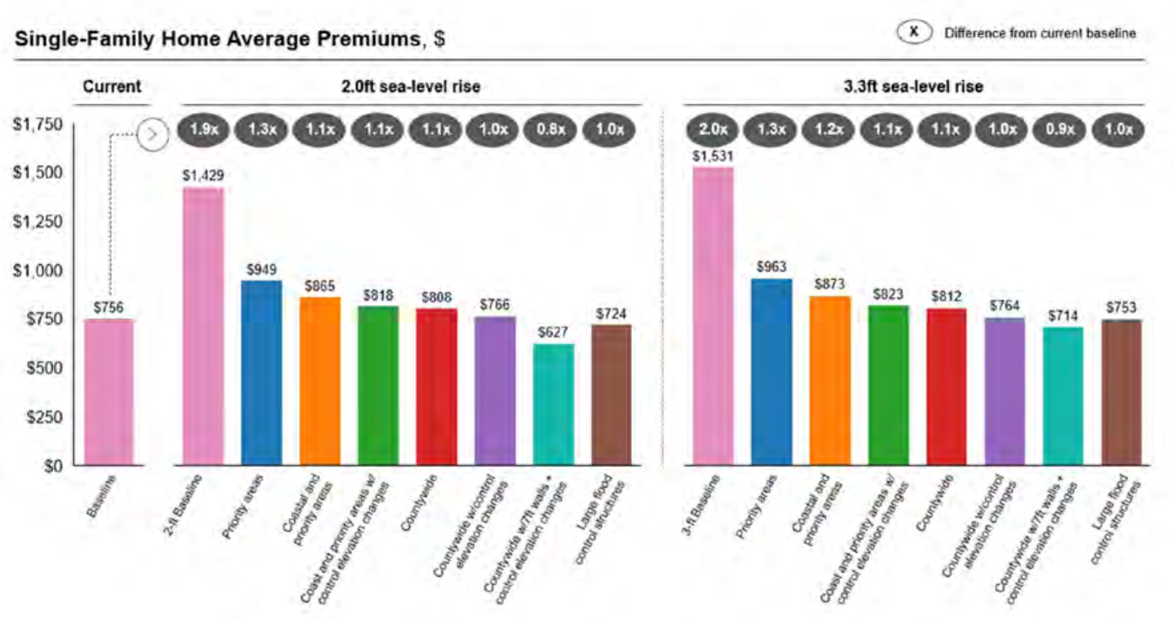
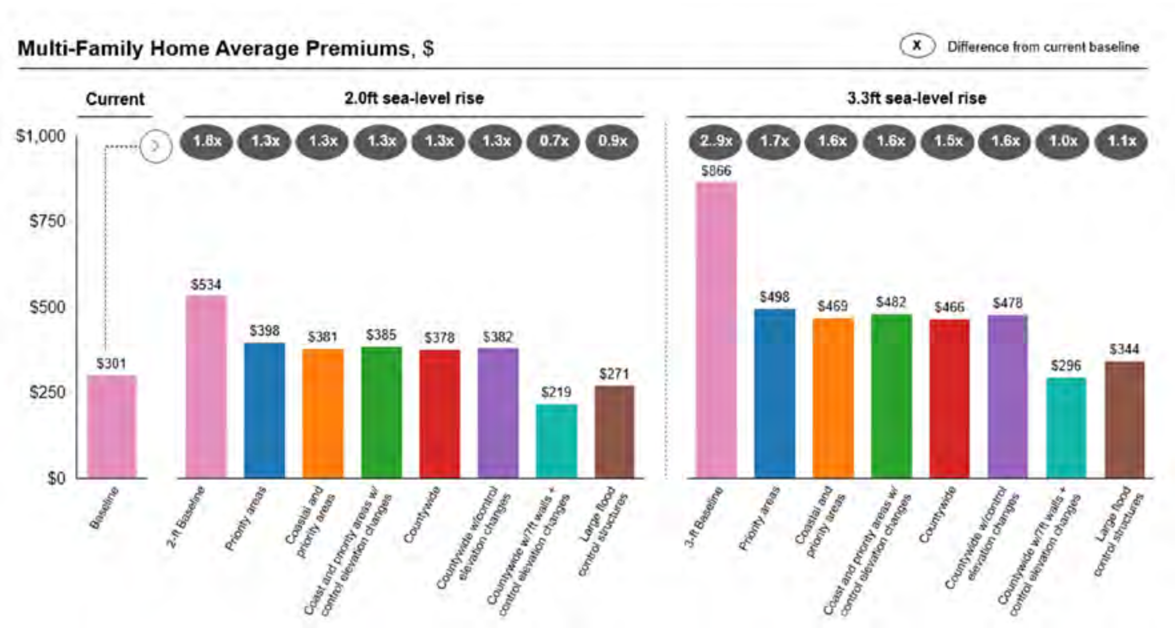


**Exhibit 10b: Average NFIP premia in Broward County – Multi-Family**




Compared to current conditions, total NFIP insurance coverage is expected to decrease under most adaptation suites but would still be higher than under the 2.0 foot and 3.3 foot baseline conditions. As a result of shifts in policy count and premia, total coverage could still decrease from $44B but with a wider range of potential outcomes. For example, in **Exhibit 11a**, total purchased coverage with 2.0 feet of sea-level rise could fall to between $21B and $41B but this would still be higher than under the baseline coverage of $13B.

Total insurance coverage, however, does not provide the full picture. Under the baseline, the share of census tracts with a 100% underinsurance rate (a measure of the amount of coverage relative to replacement value) is estimated to rise from the current 0% to about 30% under both sea-level rise scenarios. In all adaptation suites, the increase would be from 0% currently to no more than 15% and, correspondingly, the number of homes with at least 75% coverage would be higher.

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**Exhibit 11a: Total flood insurance coverage under baseline and adaptation strategies**

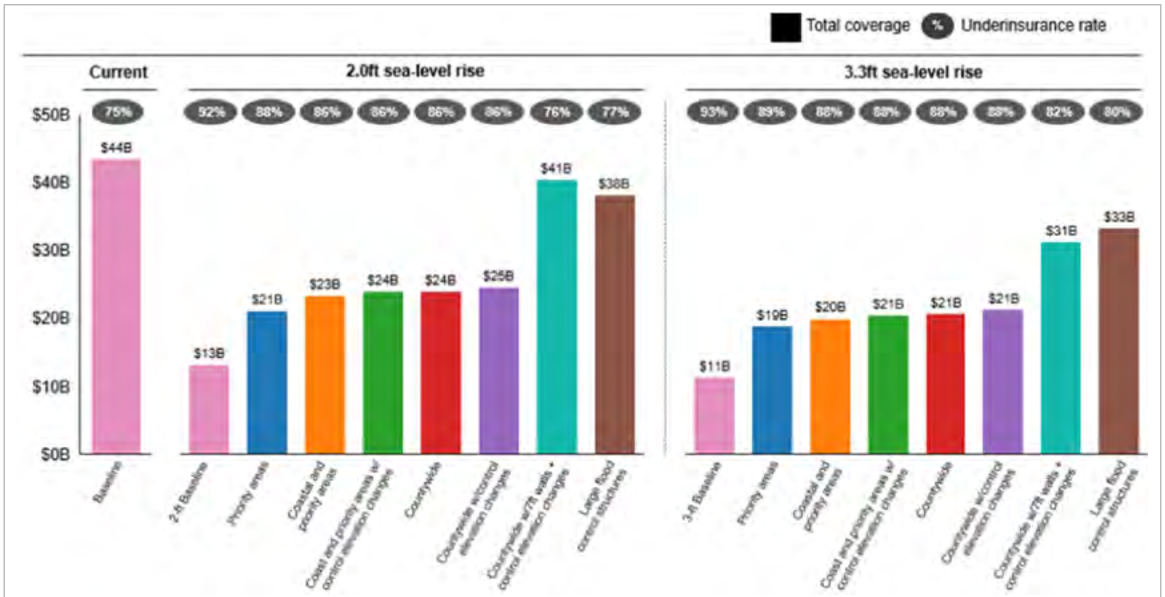
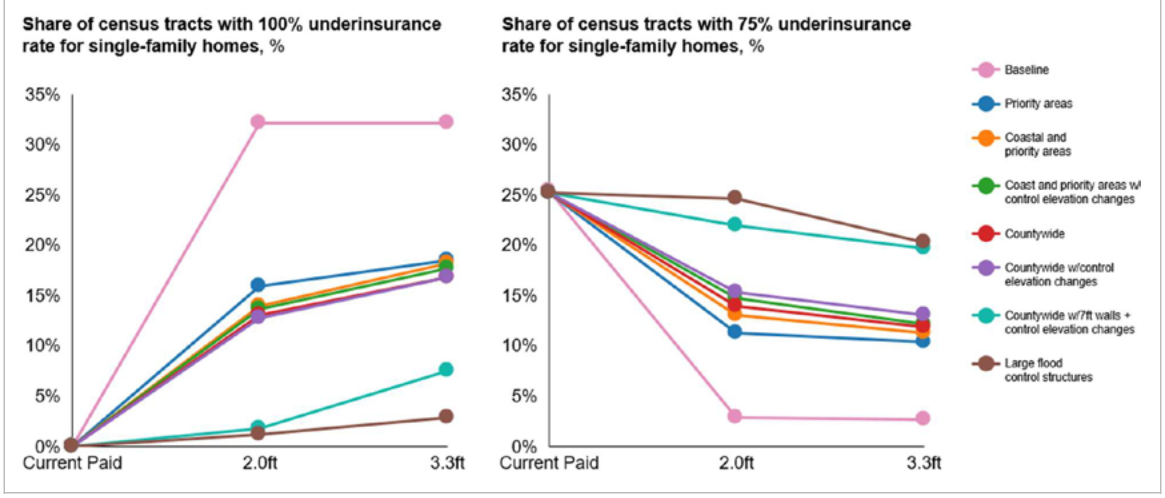


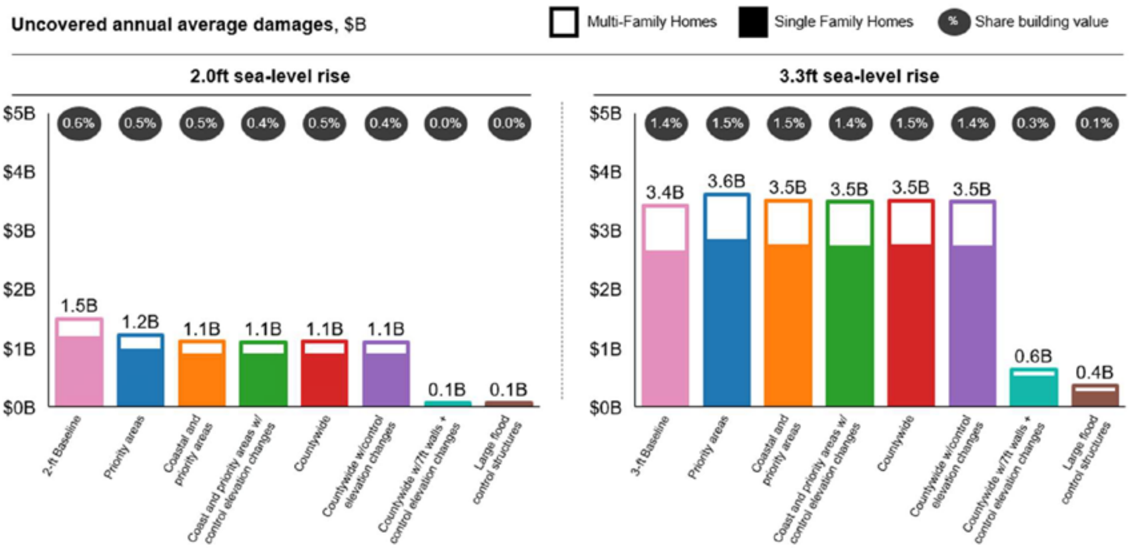

**Exhibit 11b: Underinsurance rates, defined as the value of uninsured assets as a proportion of the replacement value of assets**




As a result of higher insurance coverage, annual uninsured damages are expected to be lower under the adaptation suites than under the baseline. As presented in **Exhibit 12**, annual uninsured damage in the baseline is estimated to be $1.5B by 2050 under 2 feet of sea-level rise and $3.4B under 3.3 feet of sea-level rise.

Under 2.0 feet of sea-level rise, most of the adaptation suites could reduce the uninsured damages by about 20% to 25% relative to baseline. The last two more comprehensive strategies mostly eliminate the uninsured damages under baseline. Under 3.3 feet of sea-level rise, only the last two more comprehensive adaptation suites can reduce uninsured property damage but the reduction is an 80% elimination of the baseline uninsured damage (**Exhibit 12**).

**Exhibit 12: Average annual uninsured property damages assuming no re-mapping of special flood hazard areas**




## 8. Increased real estate values


**Summary of key findings**. The key findings of the real estate benefits evaluation are as follows.

The real estate analysis assessed the benefits of adaptation on the valuations of homes and the associated fiscal tax impacts to the county. This is a first order analysis that focuses on the real estate directly affected by floods and does not consider market effects. For example, losses in certain parts of neighborhoods that are affected could depress real estate prices 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 baseline and adaptation strategies on real estate values is summarized in **Exhibit 13**. The estimated increase in real estate values 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 sea-level rise.

The previous baseline analysis found that the increased flood risk relative to current conditions could reduce the value of a residential property in Broward County by 18% under 2.0 feet of sea-level rise if no adaptation actions are taken. This could amount to $24B in dollar terms, with the primary driver being the

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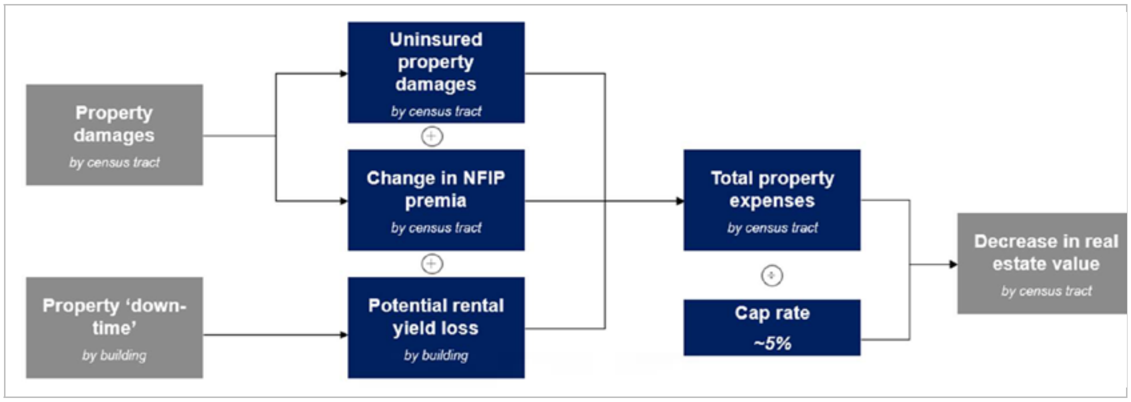
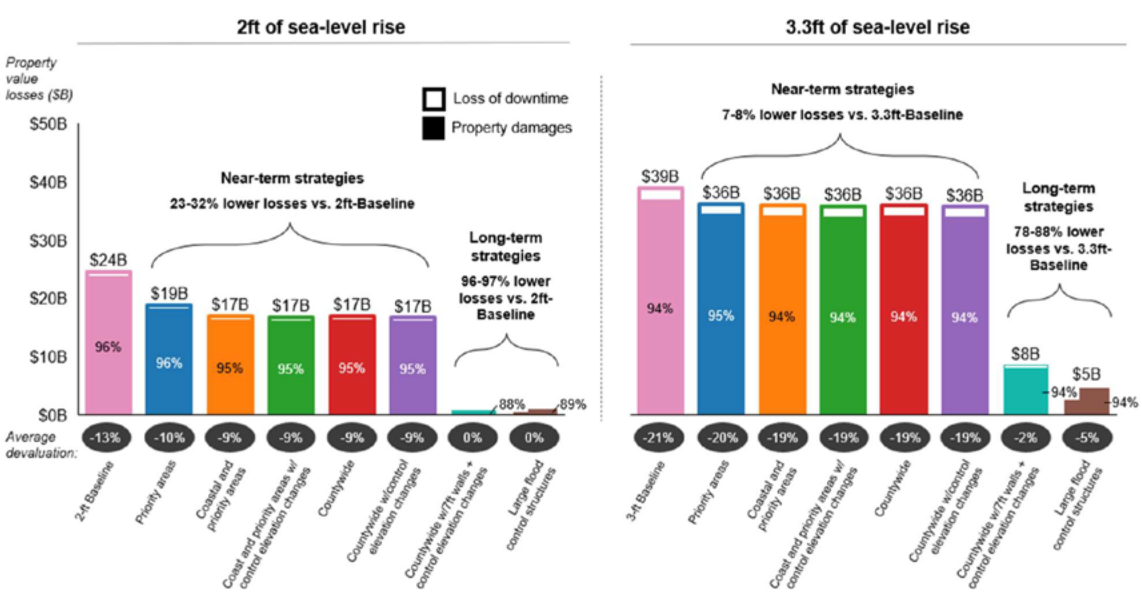
direct effect of uninsured property damages (see **Exhibit 13**). Changes in policy premia costs and loss of use are also factored into the analysis but tend to play a smaller role (**Exhibit 13**).

**Exhibit 13: Costs of Increased Flooding are Expected to Devalue Residential Properties**




As presented in **Exhibit 14**, five of the adaptation suites could mitigate the baseline reduction in residential real estate prices by 23% to 32% under 2 feet of sea-level rise, with the two more ambitious adaptation suites all but eliminating the baseline reduction in property value. Under 3.3 feet of sea-level rise, only about 7% to 8% of the baseline real estate value reduction under baseline be mitigated when five of the adaptation suites are implemented. When the last two more comprehensive suites are implemented, then about 78% to 88% of the baseline real estate value losses could be mitigated.

**Exhibit 14: Residential real estate property value losses across adaptation suites**
Inside each bar is the % of the property value reduction driven by average annual property damage



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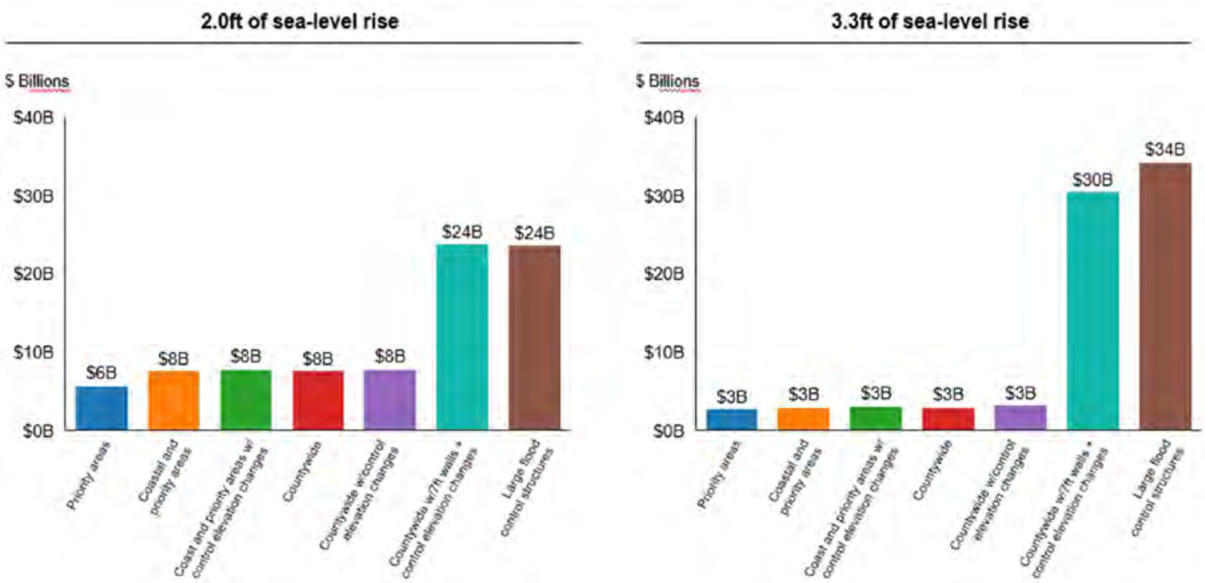
As with the baseline results, property value reductions are primarily driven by uninsured property damage (about 95%+ of the damages) and this impact on household cost is assumed to affect the valuation of the property. These potential losses under the baseline and under the adaptation suites are not evenly distributed across the county – they are particularly concentrated in areas that could be subject to higher flood risk under any conditions.

This evaluation found that the adaptations suites are expected to save about $6B to $24B in residential real estate value under 2feet of sea-level rise, and $3B-$34B in value under 3.3 feet of sea-level rise. **Exhibit 15** presents the potential savings for each adaptation suite. The losses broadly reflect the same trend as the direct flood damages (which are the key input) and are sensitive to assumptions regarding the capitalization rate.

**Exhibit 15: Savings in residential real estate property values across adaptation suites**



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## 9. Increased tax collections

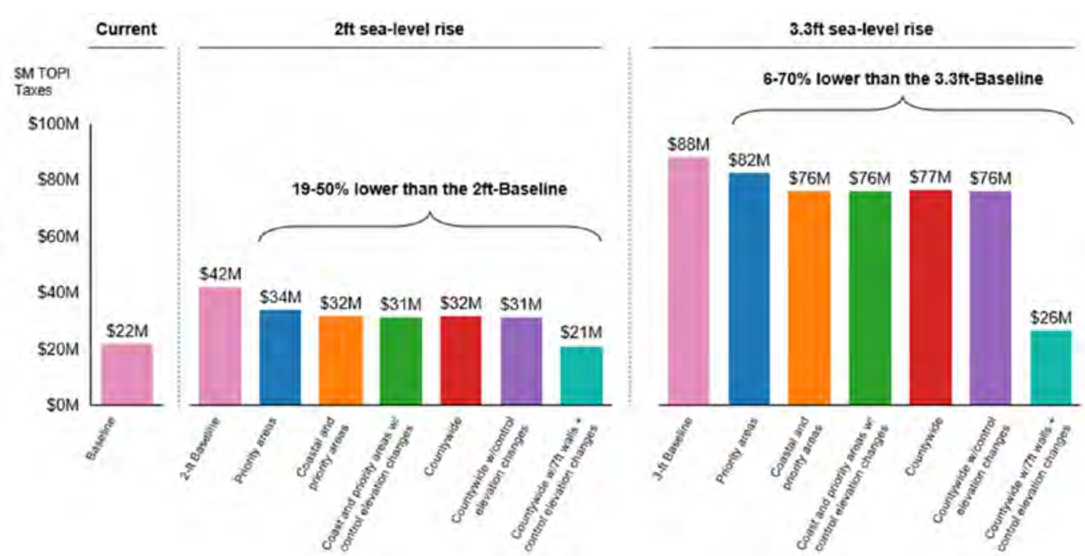

**Summary of key findings**. The reduction in tax revenue collected in Broward County due to increased flood risk was estimated. This tax revenue includes the reduction in production-related tax revenue associated with disrupted economic activity, and the reduction in ad valorem tax revenue associated with reduced real estate values. Production-related taxes include sales and excise taxes, customs duties, property taxes, motor vehicle licenses, severance taxes, other taxes, and assessments.

Currently, average annual production-related tax revenue loss from flooding is estimated to be $22M countywide. Under the baseline condition with 2 feet of sea-level rise, the average annual tax revenue loss is $42M which is an additional loss of $20M relative to current conditions. The adaptation suites would mitigate the baseline loss of production-related tax revenue by $8M to $21M under 2 feet of sea-level rise and by $6M to $62M under 3.3 feet of sea-level rise, depending on the suite, with the more comprehensive suites providing the most savings in production tax revenue.

Under 2 feet of sea-level rise, average annual ad valorem tax revenue could be $200M to $800M higher than under baseline, depending on the adaptation measures pursued, with the most comprehensive suites maintaining tax revenue at current levels (in 2022 dollars). The results are similar under 3.3 feet of sea-level rise, where average annual property tax revenue would be $100M to $1.0B higher than baseline, with the two most comprehensive suites maintaining almost all (94%) of today's property tax revenue.

**Production-related tax revenue.** The average annual production-related tax revenue losses currently and under baseline and the adaptation suites for both sea-level rise scenarios are provided in **Exhibit 16**. The baseline assessment found that the average annual production tax revenue loss could increase from $22M to $42M under 2 feet of sea-level rise. The baseline average annual revenue loss increases to $88M under 3.3 feet of sea-level rise.

**Exhibit 16: Production-related tax revenue losses, average annual in 2022 dollars**



The adaptation suites are expected to reduce average annual production-related tax revenue losses by about $8M to $21M at 2 feet of sea-level rise, and about $6M to $62M at 3.3 feet of sea-level rise. The change in tax revenue is directly related to the change in economic activity caused by flood damage and transport disruption.

**Impacts on ad valorem tax revenue.** The ad valorem tax collected in the County is based on the assessed value of the property which is based on its market value. Also, other factors determine a property's ad valorem tax bill including existence of a Homestead Exemption and 13 other exemptions that provide tax advantages to homeowners, military veterans, seniors, active military and the disabled.

Homestead Exemptions are provided to residential property owners who permanently live in their homes and apply for the exemption. For properties with a Homestead Exemption, the Save Our Homes (SOH) provision under Florida Statutes limits the annual increase in the assessed value of a property to no more than 3% of the home's assessed value in the previous year (called the SOH value).

If the home's value falls from one year to the next, the home's SOH value is increased by 3% per year until the SOH value is equal to its market value. This is called the "recapture" rule. Once the assessed value reaches the market value of the home, the recapture rule no longer applies and the assessed value is adjusted downward when its market value falls resulting in a lower tax bill.

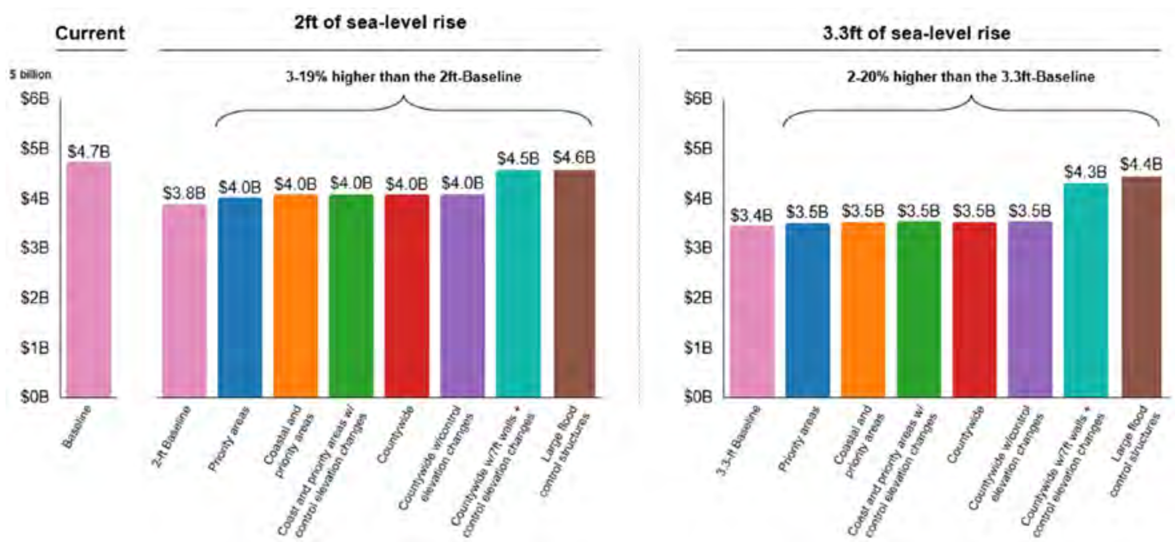
The method used to calculate the impact of sea-level rise on market value captures the distribution of the exemptions countywide but does not account for the impact of the SOH statute on ad valorem taxes when property values fall for Homesteaded properties. Thus, in the short-term, the estimated impacts of sea-level rise on ad valorem tax revenue will be lower than reported in this memorandum.

The average annual ad valorem tax revenue collected currently and under the baseline and adaptation suites with 2 feet and 3.3 feet of sea-level rise is presented in **Exhibit 17**. Without the adaptation suites, the current annual ad valorem tax revenue of $4.7B could fall to an average annual revenue of $3.8B, a 19% reduction, under 2 feet of sea-level rise. Under 3.3 feet of sea-level rise, average annual revenue could fall to $3.4B, a 27% reduction. Ad valorem tax revenue is an important source of government revenue, accounting for 37% of the County's total revenue in FY22.[2]

Under the adaptation suites, most of the ad valorem tax revenue losses can be recovered under the two most comprehensive suites. Under 2 feet of sew-level rise, average annual ad valorem tax revenue increases by $200M to $800M relative to the baseline tax revenue, with the most significant mitigation provided by the two more comprehensive suites. Under 3.3 feet of sea-level rise, average annual ad valorem tax revenue increases by $100M to $1.0B, with the more comprehensive suites providing the largest tax revenue savings.

2 Based on Broward County's FY22 Annual Comprehensive Financial Report, page 7, total property tax revenue received by the County, most of which includes ad valorem tax revenue, was $1.2 billion. This amount is 37% of the $3.3 billion in total Broward County government revenue collected in FY22. This amount does include the $3.6 billion of property tax revenue allocated to the County's municipalities, school board, and other state and local government agencies.

**Exhibit 17: County-wide average annual ad valorem tax revenue across adaptation suites**




## 10. Benefits across the county, including vulnerable areas

In general, adaptation strategies reduce impacts in vulnerable areas as well as other parts of the county. The charts in **Exhibit 18** present these results through the lens of four types of impacts including residential damages, sales revenue loss, average premiums for single-family homes, and impacts on property values. Vulnerable areas are outlined in black and include census tracts with higher socio-economic vulnerability and census tracts located in areas of high flood risk.

For the 2-foot sea-level rise scenario, the baseline map can be compared to the adaptation suite that includes countywide adaptations with control elevation changes under the current 5-foot NAVD seawalls requirement. For the 3.3-foot sea-level rise scenario, the baseline map can be compared to the county-wide coverage with 7-foot NAVD seawalls.

Across the county, impacts are lower for all four metrics when moving from the baseline map to the adaptation suite map. The impacts are lower across the Zone 1 priority areas for vulnerability analysis and across the county more generally. The benefits tend to be more pronounced in the Zone 1 priority areas (as shown by the number of black outlined squares that are no longer shaded).

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**Exhibit 18a: Average annual damages to residential assets as share of property value across the county – Direct residential damages**

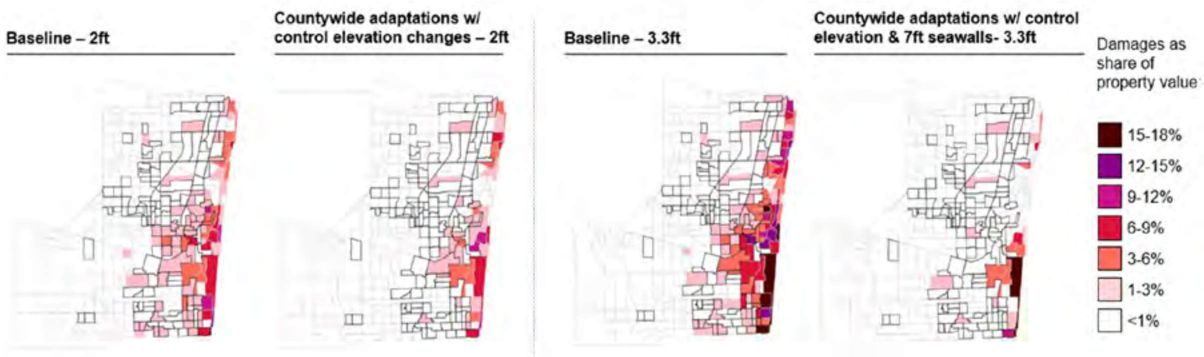


**Exhibit 18b: Average annual sales revenue loss ($M)**

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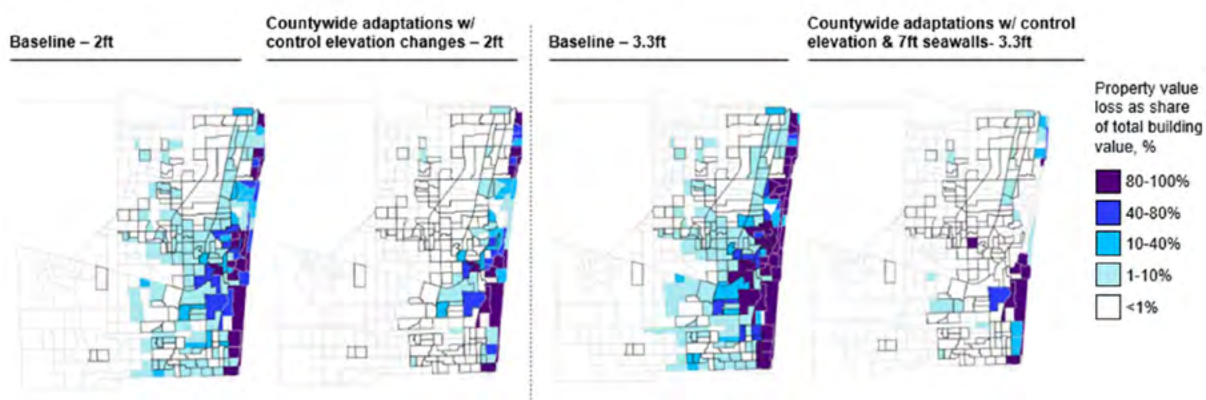
**Exhibit 18c: Initial single-family home premiums across the County before considering their impact on affordability and the corresponding adjustments to coverage and premia**


**Exhibit 18d: Real estate value losses across the County ($M losses)**

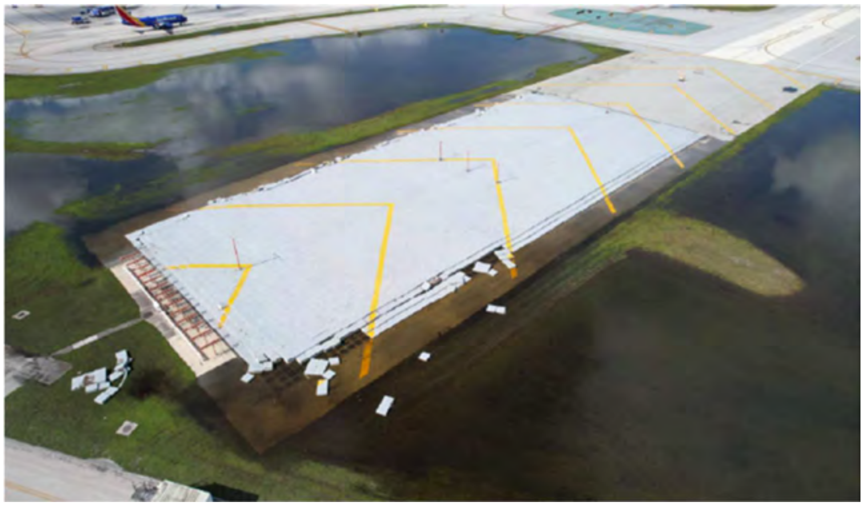



## 11. Sea-level Rise impacts on the County's airport and port

**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, classified 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 was $17.5 million, primarily attributed to the extensive damage sustained by the EMAS (Engineered Materials Arrestor System) beds.

**Photo taken at FLL International Airport on April 13th 2023 (View of East end EMAS)**



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 profits 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 five percent reduction in commercial operations could result in about a $12 million annual reduction in revenue and a fifteen percent reduction could result in about a $35 million annual revenue reduction.

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 **Exhibit 19**, the impacts of the adaptation strategies were compared to the baseline for an RP-3 flood event (2.0 feet of sea-level rise and 100-year rainfall with no storm surge). The metric is the number of hours of annual flood duration above 6 inches.

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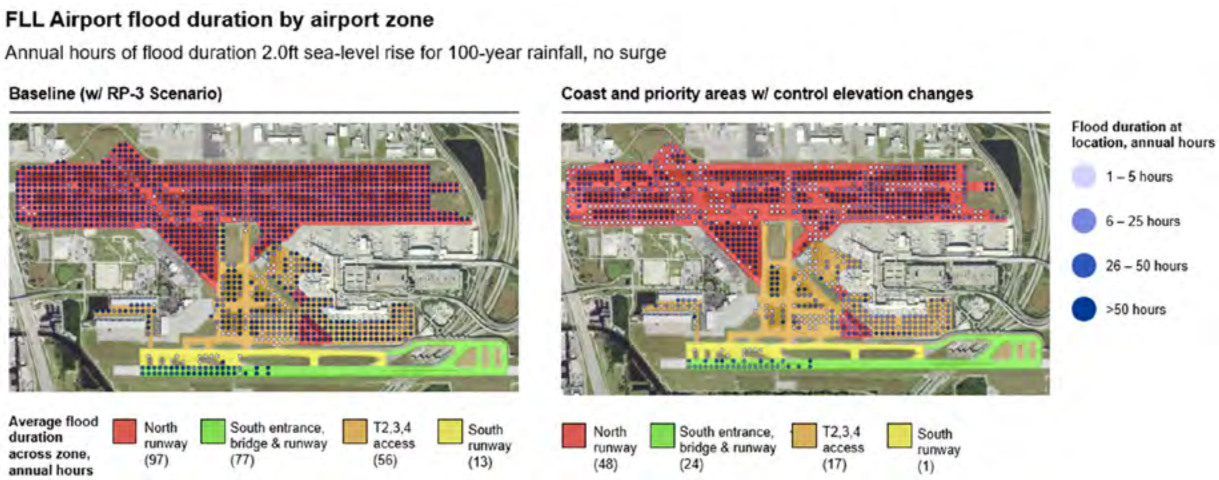
**Exhibit 19: Fort Lauderdale-Hollywood International Airport average annual hours of maximum flood duration by airport zone**



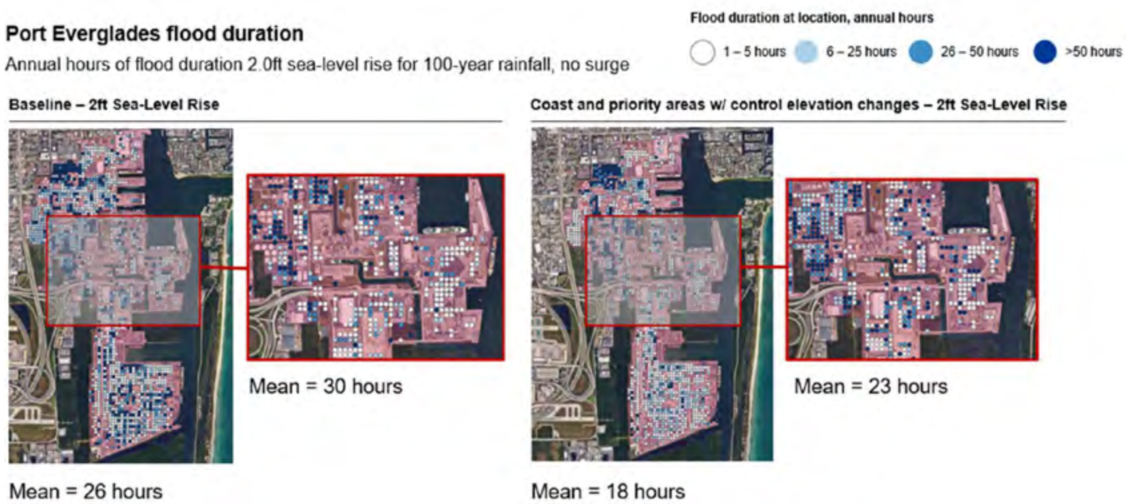

The exhibit shows that the area marked in red associated with the north runway could experience a significant reduction in flood duration of approximately 50% with the implementation of adaptation measures in *Coastal and Priority Areas w/Control Elevation Changes*, decreasing from around 100 hours in the baseline to around 50 hours under adaptation. The south runway is relatively less affected. In the baseline only the eastern edges are flooded, and this is mostly mitigated using the same adaptation strategy.

**Port Everglades.** Port Everglades is also at risk of flooding events due to its coastal position. During the 1-in-1000 year flood occurrence 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.

**Exhibit 20** presents the results of a similar analysis conducted for Port Everglades under a 100-year rainfall event with no storm surge at 2.0 feet of sea-level rise. The annual number of hours flooded in the baseline at 2.0 feet of sea-level rise could be about 30 hours at the main access, and 26 hours across all port facilities including storage areas.

Under 2 feet of sea-level rise, annual flood duration would be approximately 25% to 30% lower if adaptation measures were pursued in the adaptation suite called "Coastal and Priority Areas w/ Control Elevation Changes". The average annual number of hours flooded could be reduced from 30 hours to 23 hours at the main access and from 26 hours to 18 hours across all port facilities.

**Exhibit 20: Port Everglades annual hours of max flood duration**




## 12. Discussion of uncertainty

Climate change is an ongoing process with a variety of outcomes possible in the 21st century and beyond, as the world works to decarbonize and limit the impacts of greenhouse gas emissions on the Earth's climate. 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 sea-level rise scenarios of 2.0 feet and 3.3 feet were chosen, which correspond approximately with 2050 and 2070 estimates using NOAA's 2017 sea-level rise projections under the medium-high emissions scenario. Under other emission scenarios, these sea-level rise scenarios could occur at different times in the future. Uncertainty around timing and magnitude of sea-level rise is the largest uncertainty included in this analysis.

This analysis used a case study of 2.0-foot sea-level rise by 2050 and 3.3-foot sea-level rise by 2070. Significant deviations in sea-level rise will affect the need for and timing of the measures that comprise each Adaptation Strategy. Given these sea-level rise scenarios, the best available information was used to assess the benefits of the adaptation strategies.

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

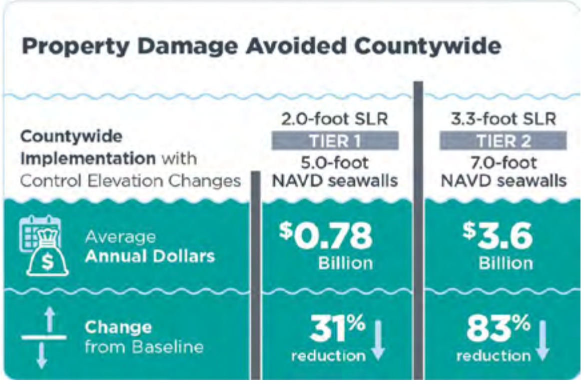
- Land uses, economic conditions and drainage infrastructure existing at the time of this study could be different during engineering design and construction of the adaptation suites resulting in differences in benefits and costs than those reported during this study.
- While the data used to assess 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 behaviour 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 being contemplated.

The estimated economic benefit values reported in this memorandum 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 analysis.

## 13. Benefit values of the Tier 1 and Tier 2 adaptation strategies

Given the benefit values presented in this memorandum, the adaptation suites with the greatest total benefits are the Countywide measures with control elevation changes. This adaptation strategy, where the current seawall height requirement of 5 feet NAVD is maintained but additional drainage features behind the seawalls in Lighthouse Point are added, is called Tier 1 and for the purposes of this study would be fully implemented by the year 2050 when sea-level rise is expected to be 2.0 feet higher than today.




By 2070, sea-level rise is expected to be 3.3 feet higher than it is today. To mitigate the increased flooding impacts, the flood control capabilities of Tier 1 would be enhanced by adding an additional 2 feet to the existing seawalls to achieve 7 foot NAVD seawalls in place of the 5 foot NAVD seawalls reflected in the Tier 1 strategy.

In addition, additional drainage features would be added, as needed, to protect property behind the seawalls from additional flooding caused by the higher sea levels. This adaptation strategy is referred to as Tier 2 and, for the purposes of this study, would be fully implemented by 2070.

Another adaptation strategy that includes large flood control structures delivered even greater benefit values. However, these structures would be relatively expensive and intrusive to the natural and aesthetic environment and are not further considered at this time.

A summary of the benefit values estimated during this study are provided in **Table 4**.

**Table 4 Summary Countywide Tier 1 and Tier 2 Benefit Estimates in 2022 Dollars**

| Benefit Category | Tier 1 Adaptation Strategy to Mitigate 2-foot SLR | Tier 2 Adaptation Strategy to Mitigate 3.3-foot SLR |
|---|---|---|
| Property Damage Avoided, average annual | $776,000,000 | $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 | $8,000,000,000 | $30,000,000,000 |
| Increased Flood Insurance Coverage | $12,000,000,000 | $20,000,000,000 |

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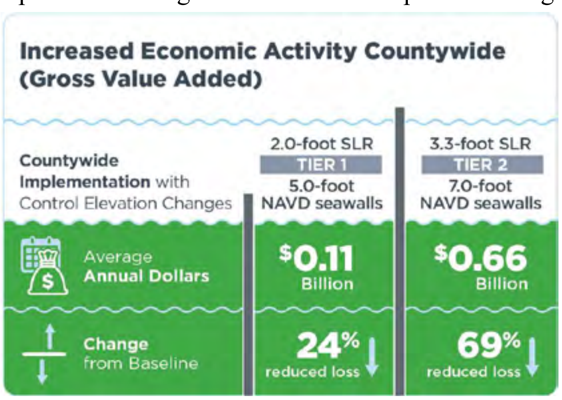
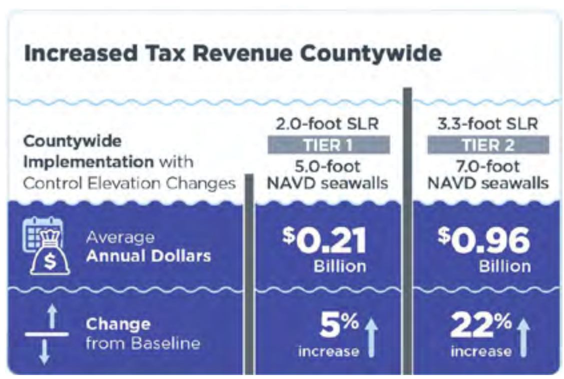
The average annual benefits of the Tier 1 adaptation strategy when sea-level rise is 2.0 feet include an estimated $776 million in avoided property damage, $109 million in short term economic activity (gross value added), and a $211 million increase in property taxes collected. Property values are estimated to be $8 billion higher and flood insurance coverage is expected to be $12 billion larger than the baseline strategy of no action.

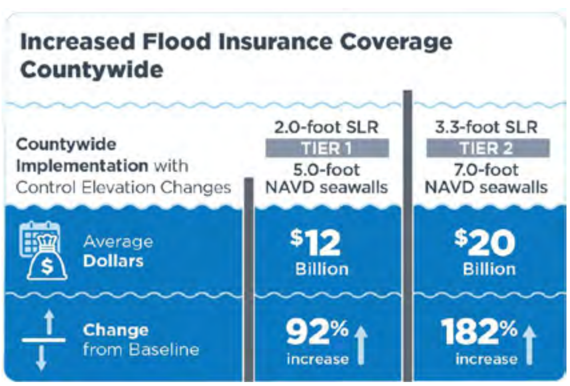
The average annual benefits of the Tier 2 adaptation strategy when sea-level rise is 3.3 feet include an estimated $3.6 billion in avoided property damage, $660 million in short term economic activity (gross value added), and a $962 million increase in property taxes collected. Property values are expected to be $30 billion higher and flood insurance coverage is expected to be $20 billion larger than in the absence of flood mitigation action.

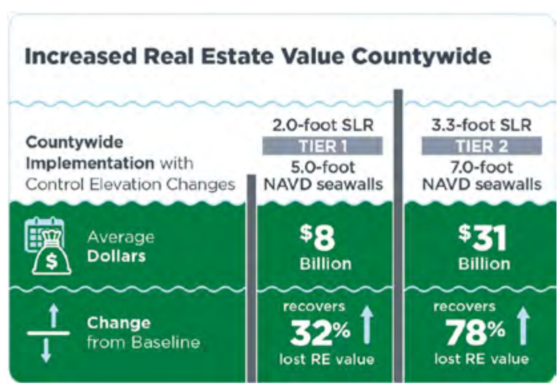
The values for property damage avoided, increased economic activity, and increased real estate value will be included along with the capital and annual cost of Tier 1 and Tier 2 to assess the economic feasibility and economic internal rate of return of these two suites of adaptation strategies.

Other benefits whose dollar values were estimated will not be included in the economic feasibility evaluation because they would be double counting the benefits. These benefit values are the increased flood insurance coverage and the reduced flood insurance premia which are included in the estimated property damages and the increased property tax revenue which is included in the real estate benefit value. However, these other benefits do have meaning to residents and businesses as the cost of everyday expenses are mitigated when flood adaptation strategies are implemented.



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 would further stabilize the County's wellbeing and economy by reducing the negative impacts of sea-level rise. Many of these impacts would increase economic activity as measured by gross value added 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.
- **Avoided demographic disruptions.** Decreases in the frequency and extent of flooding caused by sea-level rise could improve the quality of life and public safety that 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.

The estimated economic benefit values reported in this memorandum provide actionable information for the County to conduct resiliency planning. These benefit values were based on certain assumptions and circumstances that could change over time, including future drainage investments by other entities, changes in economic conditions, and future climate change and its effects. For these reasons, the benefit values and economic feasibility of adaptation measures and strategies should be revisited on a regular basis as investment decisions are being contemplated.

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**Appendix A-1: Average annual percentage change in flood damage to residential properties relative to baseline under Tier 1 and Tier 2 adaptation strategies by municipality**

| Municipality | Baseline average annual flood damages and Tier 1 and Tier 2 percentage changes Relative to Baseline (negative % means reduction in property damage) | | | |
|---|---|---|---|---|
| | Baseline under 2ft SLR ($M in damages to residential homes) | Tier 1 % change - Countywide w/ control elevation changes under 2ft SLR | Baseline under 3.3ft SLR ($M in damages to residential homes) | Tier 2 % change - County-wide measures, w/ control elevation changes and 7ft seawalls under 3.3ft 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% |

# Appendix F-3:

# Economic Feasibility Model - Economic Feasibility of Tier 1 and Tier 2 Investments

**Appendix F-3, Item I:** Summary of Benefits and Costs Used

**Appendix F-3, Item II:** Tier 1 and 2 - Adaptation Strategy - Countywide Investments with Control Elevation Changes over time as sea-level rise reaches 2.0 feet by 2050 and 3.3 feet by 2070

**Appendix F-3, Item III:** Tier 1 Adaptation Strategy - Countywide Investments with Control Elevation Changes over time as sea-level rise reaches 2.0 feet by 2050 and thereafter

Appendix F-3: Economic Feasibility Model - Economic Feasibility of Tier 1 and Tier 2 Investments

# **Appendix F-3, Item I:** Summary of Benefits and Costs Used

**Costs of Tier 1 and Tier 2 Investments in 2024 dollars**

| Tier | Capital Cost | Annual Cost | Years to Completion |
|---|---|---|---|
| 1 | $20,133,000,000 | $201,330,000 | 15 |
| 2 | $28,001,000,000 | $280,010,000 | 30 |

**Time Sensitive Parameters, Nominal Annual**

| | |
|---|---|
| Discount Rate | 5.00% |
| Inflation Rate | 2.53% |

**Benefits of Tier 1 and Tier 2 Investments in 2024 dollars**

| **GDP Implicit Price Deflator ratio to convert 2022 dollars to 2024 dollars:** | | | **1.074** |
|---|---|---|---|
| **Investments / Sea Level Rise / Year Level Attained** | **Average Annual Avoided Damages** | **Gross Value Added (Short Term Avoided Loss)** | **Avoided Loss in Property Value (60% of estimated avoided value)** |
| Tier 1 - 2ft sea-level rise - 2050 | $833,000,000 | $117,000,000 | $5,038,200,000 |
| Tier 2 - 3.3ft sea-level rise - 2070 | $4,295,000,000 | $709,000,000 | $19,548,000,000 |

| | |
|---|---|
| **Percentage of Estimated Real Estate Value Loss Included in Economic Feasibiliity Model:** | 60% |

## Appendix F-3, Item I: Summary of Benefits and Costs Used

**Timing of Capital Costs Expended for the Economic Feasibility Analysis**

| Year | Tier 1 and 2 Capital Cost Spent that Year | Tier 1 Only Capital Cost Spent that Year | Tier 1 and 2 Annual Cost Spent that Year | Tier 1 Only Annual Cost Spent that Year | Tier 2 Additional Capital Cost |
|---|---|---|---|---|---|
| 2025 | $331,206,661 | $331,206,661 | $0 | $0 | $0 |
| 2026 | $425,603,998 | $425,603,998 | $4,256,040 | $4,256,040 | $0 |
| 2027 | $1,209,105,702 | $1,209,105,702 | $7,568,107 | $7,568,107 | $0 |
| 2028 | $1,225,224,256 | $1,225,224,256 | $19,659,164 | $19,659,164 | $0 |
| 2029 | $1,277,118,908 | $1,277,118,908 | $31,911,406 | $31,911,406 | $0 |
| 2030 | $1,775,496,081 | $1,775,496,081 | $44,682,595 | $44,682,595 | $0 |
| 2031 | $2,046,134,176 | $2,046,134,176 | $62,437,556 | $62,437,556 | $0 |
| 2032 | $2,279,169,009 | $2,279,169,009 | $82,898,898 | $82,898,898 | $0 |
| 2033 | $1,905,897,170 | $1,905,897,170 | $105,690,588 | $105,690,588 | $0 |
| 2034 | $2,075,595,410 | $2,075,595,410 | $124,749,560 | $124,749,560 | $0 |
| 2035 | $1,531,911,568 | $1,531,911,568 | $145,505,514 | $145,505,514 | $0 |
| 2036 | $1,341,269,596 | $1,341,269,596 | $160,824,629 | $160,824,629 | $0 |
| 2037 | $1,243,567,717 | $1,243,567,717 | $174,237,325 | $174,237,325 | $0 |
| 2038 | $572,024,211 | $572,024,211 | $186,673,003 | $186,673,003 | $0 |
| 2039 | $566,272,256 | $566,272,256 | $192,393,245 | $192,393,245 | $0 |
| 2040 | $437,480,899 | $327,043,538 | $198,055,967 | $198,055,967 | $110,437,361 |
| 2041 | $110,437,361 | $0 | $202,430,776 | $201,326,403 | $110,437,361 |
| 2042 | $110,437,361 | $0 | $203,535,150 | $201,326,403 | $110,437,361 |
| 2043 | $110,437,361 | $0 | $204,639,523 | $201,326,403 | $110,437,361 |
| 2044 | $110,437,361 | $0 | $205,743,897 | $201,326,403 | $110,437,361 |
| 2045 | $110,437,361 | $0 | $206,848,271 | $201,326,403 | $110,437,361 |
| 2046 | $110,437,361 | $0 | $207,952,644 | $201,326,403 | $110,437,361 |
| 2047 | $488,555,490 | $0 | $209,057,018 | $201,326,403 | $488,555,490 |
| 2048 | $488,555,490 | $0 | $213,942,573 | $201,326,403 | $488,555,490 |
| 2049 | $488,555,490 | $0 | $218,828,128 | $201,326,403 | $488,555,490 |
| 2050 | $378,118,129 | $0 | $223,713,683 | $201,326,403 | $378,118,129 |
| 2051 | $378,118,129 | $0 | $227,494,864 | $201,326,403 | $378,118,129 |
| 2052 | $378,118,129 | $0 | $231,276,045 | $201,326,403 | $378,118,129 |
| 2053 | $378,118,129 | $0 | $235,057,226 | $201,326,403 | $378,118,129 |
| 2054 | $604,975,612 | $0 | $238,838,408 | $201,326,403 | $604,975,612 |
| 2055 | $604,975,612 | $0 | $244,888,164 | $201,326,403 | $604,975,612 |
| 2056 | $604,975,612 | $0 | $250,937,920 | $201,326,403 | $604,975,612 |
| 2057 | $226,857,483 | $0 | $256,987,676 | $201,326,403 | $226,857,483 |
| 2058 | $226,857,483 | $0 | $259,256,251 | $201,326,403 | $226,857,483 |
| 2059 | $226,857,483 | $0 | $261,524,826 | $201,326,403 | $226,857,483 |
| 2060 | $226,857,483 | $0 | $263,793,401 | $201,326,403 | $226,857,483 |
| 2061 | $343,607,367 | $0 | $266,061,975 | $201,326,403 | $343,607,367 |
| 2062 | $116,749,884 | $0 | $269,498,049 | $201,326,403 | $116,749,884 |
| 2063 | $116,749,884 | $0 | $270,665,548 | $201,326,403 | $116,749,884 |
| 2064 | $116,749,884 | $0 | $271,833,047 | $201,326,403 | $116,749,884 |
| 2065 | $116,749,884 | $0 | $273,000,546 | $201,326,403 | $116,749,884 |

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**Timing of Capital Costs Expended for the Economic Feasibility Analysis**

| Year | Tier 1 and 2 Capital Cost Spent that Year | Tier 1 Only Capital Cost Spent that Year | Tier 1 and 2 Annual Cost Spent that Year | Tier 1 Only Annual Cost Spent that Year | Tier 2 Additional Capital Cost |
|---|---|---|---|---|---|
| 2066 | $116,749,884 | $0 | $274,168,044 | $201,326,403 | $116,749,884 |
| 2067 | $116,749,884 | $0 | $275,335,543 | $201,326,403 | $116,749,884 |
| 2068 | $116,749,884 | $0 | $276,503,042 | $201,326,403 | $116,749,884 |
| 2069 | $116,749,884 | $0 | $277,670,541 | $201,326,403 | $116,749,884 |
| 2070 | $116,749,884 | $0 | $278,838,040 | $201,326,403 | $116,749,884 |
| 2071 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2072 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2073 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2074 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2075 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2076 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2077 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2078 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2079 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2080 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2081 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2082 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2083 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2084 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2085 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2086 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2087 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2088 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2089 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2090 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2091 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2092 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2093 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2094 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2095 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2096 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2097 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2098 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2099 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2100 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2101 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2102 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2103 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2104 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2105 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2106 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |

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**Timing of Capital Costs Expended for the Economic Feasibility Analysis**

| Year | Tier 1 and 2 Capital Cost Spent that Year | Tier 1 Only Capital Cost Spent that Year | Tier 1 and 2 Annual Cost Spent that Year | Tier 1 Only Annual Cost Spent that Year | Tier 2 Additional Capital Cost |
|---|---|---|---|---|---|
| 2107 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2108 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2109 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2110 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2111 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2112 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2113 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2114 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2115 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2116 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2117 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2118 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2119 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2120 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2121 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2122 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2123 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2124 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| 2125 | $0 | $0 | $280,005,539 | $201,326,403 | $0 |
| **Total** | **$28,000,553,863** | **$20,132,640,255** | **$24,242,169,038** | **$18,654,287,812** | **$7,867,913,608** |

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Appendix F-3: Economic Feasibility Model - Economic Feasibility of Tier 1 and Tier 2 Investments

# **Appendix F-3, Item II:** Tier 1 and 2 Adaptation Strategies - Countywide Investments with Control Elevation Changes over time as sea-level rise reaches 2.0 feet by 2050 and 3.3 feet by 2070

Appendix F-3, Item II: Tier 1 and 2 - Adaptation Strategy - Countywide Investments with Control Elevation Changes over time as sea-level rise reaches 2.0 feet by 2050 and 3.3 feet by 2070

## Appendix F-3, Item II - Economic Feasibility of Broward County Flood Adaptation Strategies

### Tier 1 and Tier 2 Adaptation - Countywide Investments with Control Elevation Changes as sea-level rises 2ft by 2050 and 3.3ft by 2070

| Year Number | Tier 1 Benefits Realized | Tier 2 Benefits Realized | Year | Dollar Value of Benefits in 2024 dollars (real) | | | | Dollar Value of Costs in 2024 dollars (real) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Flood Damage Avoided | Gross Value Added | Increased Property Value | Total Benefits | Capital Cost | Annual O&M and R&R Cost | Total Cost |
| 1 | 0.00 | 0.00 | 2025 | $0 | $0 | $0 | $0 | $331,206,661 | $0 | $331,206,661 |
| 2 | 0.02 | 0.00 | 2026 | $0 | $0 | $0 | $0 | $425,603,998 | $4,256,040 | $429,860,038 |
| 3 | 0.04 | 0.00 | 2027 | $31,312,933 | $4,398,095 | $0 | $35,711,028 | $1,209,105,702 | $7,568,107 | $1,216,673,808 |
| 4 | 0.10 | 0.00 | 2028 | $81,339,509 | $11,424,637 | $0 | $92,764,146 | $1,225,224,256 | $19,659,164 | $1,244,883,420 |
| 5 | 0.16 | 0.00 | 2029 | $132,032,987 | $18,544,849 | $0 | $150,577,837 | $1,277,118,908 | $31,911,406 | $1,309,030,314 |
| 6 | 0.22 | 0.00 | 2030 | $184,873,600 | $25,966,640 | $0 | $210,840,240 | $1,775,496,081 | $44,682,595 | $1,820,178,676 |
| 7 | 0.31 | 0.00 | 2031 | $258,334,497 | $36,284,677 | $491,962,440 | $786,581,614 | $2,046,134,176 | $62,437,556 | $2,108,571,732 |
| 8 | 0.41 | 0.00 | 2032 | $342,993,006 | $48,175,488 | $306,607,304 | $697,775,798 | $2,279,169,009 | $82,898,898 | $2,362,067,907 |
| 9 | 0.52 | 0.00 | 2033 | $437,293,298 | $61,420,547 | $319,593,726 | $818,307,571 | $1,905,897,170 | $105,690,588 | $2,011,587,758 |
| 10 | 0.62 | 0.00 | 2034 | $516,149,521 | $72,496,391 | $444,310,553 | $1,032,956,465 | $2,075,595,410 | $124,749,560 | $2,200,344,969 |
| 11 | 0.72 | 0.00 | 2035 | $602,026,985 | $84,558,412 | $512,036,617 | $1,198,622,014 | $1,531,911,568 | $145,505,514 | $1,677,417,081 |
| 12 | 0.80 | 0.00 | 2036 | $665,409,607 | $93,460,893 | $570,352,620 | $1,329,223,121 | $1,341,269,596 | $160,824,629 | $1,502,094,225 |
| 13 | 0.87 | 0.00 | 2037 | $720,904,445 | $101,255,486 | $476,942,886 | $1,299,102,818 | $1,243,567,717 | $174,237,325 | $1,417,805,042 |
| 14 | 0.93 | 0.00 | 2038 | $772,356,882 | $108,482,299 | $519,409,169 | $1,400,248,350 | $572,024,211 | $186,673,003 | $758,697,213 |
| 15 | 0.96 | 0.00 | 2039 | $796,024,302 | $111,806,535 | $383,354,535 | $1,291,185,372 | $566,272,256 | $192,393,245 | $758,665,500 |
| 16 | 0.98 | 0.01 | 2040 | $868,047,831 | $123,406,906 | $335,647,170 | $1,327,101,907 | $437,480,899 | $198,055,967 | $635,536,867 |
| 17 | 1.00 | 0.03 | 2041 | $930,188,191 | $133,619,125 | $311,197,679 | $1,375,004,995 | $110,437,361 | $202,430,776 | $312,868,138 |
| 18 | 1.00 | 0.04 | 2042 | $978,782,287 | $141,928,687 | $143,146,693 | $1,263,857,667 | $110,437,361 | $203,535,150 | $313,972,511 |
| 19 | 1.00 | 0.06 | 2043 | $1,027,376,382 | $150,238,249 | $345,372,977 | $1,522,987,608 | $110,437,361 | $204,639,523 | $315,076,885 |
| 20 | 1.00 | 0.07 | 2044 | $1,075,970,478 | $158,547,811 | $285,597,004 | $1,520,115,293 | $110,437,361 | $205,743,897 | $316,181,258 |
| 21 | 1.00 | 0.08 | 2045 | $1,124,564,573 | $166,857,374 | $203,665,687 | $1,495,087,633 | $110,437,361 | $206,848,271 | $317,285,632 |
| 22 | 1.00 | 0.10 | 2046 | $1,173,158,669 | $175,166,936 | $203,665,687 | $1,551,991,291 | $110,437,361 | $207,952,644 | $318,390,006 |
| 23 | 1.00 | 0.16 | 2047 | $1,388,130,412 | $211,926,980 | $203,665,687 | $1,803,723,079 | $488,555,490 | $209,057,018 | $697,612,508 |
| 24 | 1.00 | 0.22 | 2048 | $1,603,102,156 | $248,687,024 | $203,665,687 | $2,055,454,867 | $488,555,490 | $213,942,573 | $702,498,063 |
| 25 | 1.00 | 0.28 | 2049 | $1,818,073,900 | $285,447,068 | $203,665,687 | $2,307,186,654 | $488,555,490 | $218,828,128 | $707,383,618 |
| 26 | 1.00 | 0.33 | **2050** | **$1,984,451,548** | **$313,897,550** | $900,981,227 | **$3,199,330,325** | $378,118,129 | $223,713,683 | **$601,831,812** |
| 27 | 1.00 | 0.38 | **2051** | **$2,150,829,196** | **$342,348,031** | $900,981,227 | **$3,394,158,455** | $378,118,129 | $227,494,864 | **$605,612,993** |

BC Analysis of Tier 1 and 2 12_17_2024 Qcd Formatted / NPV Tier 1 and Tier 2

Present Value of Net Benefits - Tier 1 and Tier 2 Investments

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Appendix F-3, Item II: Tier 1 and 2 - Adaptation Strategy - Countywide Investments with Control Elevation Changes over time as sea-level rise reaches 2.0 feet by 2050 and 3.3 feet by 2070

## Appendix F-3, Item II - Economic Feasibility of Broward County Flood Adaptation Strategies

### Tier 1 and Tier 2 Adaptation - Countywide Investments with Control Elevation Changes as sea-level rises 2ft by 2050 and 3.3ft by 2070

| Year Number | Tier 1 Benefits Realized | Tier 2 Benefits Realized | Year | Dollar Value of Benefits in 2024 dollars (real) | | | | Dollar Value of Costs in 2024 dollars (real) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Flood Damage Avoided | Gross Value Added | Increased Property Value | Total Benefits | Capital Cost | Annual O&M and R&R Cost | Total Cost |
| 28 | 1.00 | 0.43 | 2052 | $2,317,206,845 | $370,798,513 | $900,981,227 | $3,588,986,585 | $378,118,129 | $231,276,045 | $609,394,174 |
| 29 | 1.00 | 0.48 | 2053 | $2,483,584,493 | $399,248,995 | $697,315,540 | $3,580,149,028 | $378,118,129 | $235,057,226 | $613,175,355 |
| 30 | 1.00 | 0.55 | 2054 | $2,749,782,836 | $444,768,758 | **$697,315,540** | $3,891,867,134 | $604,975,612 | $238,838,408 | $843,814,020 |
| 31 | 1.00 | 0.63 | 2055 | $3,015,981,180 | $490,288,521 | **$697,315,540** | $4,203,585,241 | $604,975,612 | $244,888,164 | $849,863,776 |
| 32 | 1.00 | 0.71 | 2056 | $3,282,179,523 | $535,808,284 | $697,315,540 | $4,515,303,347 | $604,975,612 | $250,937,920 | $855,913,532 |
| 33 | 1.00 | 0.74 | 2057 | $3,382,000,218 | $552,877,565 | $1,115,680,163 | $5,050,557,946 | $226,857,483 | $256,987,676 | $483,845,159 |
| 34 | 1.00 | 0.77 | 2058 | $3,481,820,914 | $569,946,846 | $1,115,680,163 | $5,167,447,922 | $226,857,483 | $259,256,251 | $486,113,734 |
| 35 | 1.00 | 0.79 | 2059 | $3,581,641,609 | $587,016,127 | $1,115,680,163 | $5,284,337,899 | $226,857,483 | $261,524,826 | $488,382,309 |
| 36 | 1.00 | 0.82 | 2060 | $3,681,462,304 | $604,085,408 | $418,364,622 | $4,703,912,335 | $226,857,483 | $263,793,401 | $490,650,883 |
| 37 | 1.00 | 0.87 | 2061 | $3,832,654,699 | $629,939,221 | $418,364,622 | $4,880,958,542 | $343,607,367 | $266,061,975 | $609,669,342 |
| 38 | 1.00 | 0.88 | 2062 | $3,884,026,399 | $638,723,752 | $418,364,622 | $4,941,114,773 | $116,749,884 | $269,498,049 | $386,247,933 |
| 39 | 1.00 | 0.90 | 2063 | $3,935,398,099 | $647,508,283 | $418,364,622 | $5,001,271,004 | $116,749,884 | $270,665,548 | $387,415,432 |
| 40 | 1.00 | 0.91 | 2064 | $3,986,769,799 | $656,292,814 | $633,671,698 | $5,276,734,311 | $116,749,884 | $271,833,047 | $388,582,931 |
| 41 | 1.00 | 0.93 | 2065 | $4,038,141,500 | $665,077,345 | $215,307,075 | $4,918,525,919 | $116,749,884 | $273,000,546 | $389,750,430 |
| 42 | 1.00 | 0.94 | 2066 | $4,089,513,200 | $673,861,876 | $215,307,075 | $4,978,682,151 | $116,749,884 | $274,168,044 | $390,917,928 |
| 43 | 1.00 | 0.96 | 2067 | $4,140,884,900 | $682,646,407 | $215,307,075 | $5,038,838,382 | $116,749,884 | $275,335,543 | $392,085,427 |
| 44 | 1.00 | 0.97 | 2068 | $4,192,256,600 | $691,430,938 | $215,307,075 | $5,098,994,613 | $116,749,884 | $276,503,042 | $393,252,926 |
| 45 | 1.00 | 0.99 | 2069 | $4,243,628,300 | $700,215,469 | $215,307,075 | $5,159,150,844 | $116,749,884 | $277,670,541 | $394,420,425 |
| 46 | 1.00 | 1.00 | **2070** | **$4,295,000,000** | **$709,000,000** | $215,307,075 | **$5,219,307,075** | $116,749,884 | $278,838,040 | **$395,587,924** |
| 47 | 1.00 | 1.00 | 2071 | **$4,295,000,000** | **$709,000,000** | $215,307,075 | $5,219,307,075 | $0 | $280,005,539 | $280,005,539 |
| 48 | 1.00 | 1.00 | 2072 | $4,295,000,000 | $709,000,000 | $215,307,075 | $5,219,307,075 | $0 | $280,005,539 | $280,005,539 |
| 49 | 1.00 | 1.00 | 2073 | $4,295,000,000 | $709,000,000 | $215,307,075 | $5,219,307,075 | $0 | $280,005,539 | $280,005,539 |
| 50 | 1.00 | 1.00 | 2074 | $4,295,000,000 | $709,000,000 | **$0** | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 51 | 1.00 | 1.00 | 2075 | $4,295,000,000 | $709,000,000 | **$0** | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 52 | 1.00 | 1.00 | 2076 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 53 | 1.00 | 1.00 | 2077 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 54 | 1.00 | 1.00 | 2078 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 55 | 1.00 | 1.00 | 2079 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |

BC Analysis of Tier 1 and 2 12_17_2024 Qcd Formatted /
NPV Tier 1 and Tier 2

Present Value of Net Benefits - Tier 1 and Tier 2 Investments

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Appendix F-3, Item II: Tier 1 and 2 - Adaptation Strategy - Countywide Investments with Control Elevation Changes over time as sea-level rise reaches 2.0 feet by 2050 and 3.3 feet by 2070

## Appendix F-3, Item II - Economic Feasibility of Broward County Flood Adaptation Strategies

**Tier 1 and Tier 2 Adaptation - Countywide Investments with Control Elevation Changes as sea-level rises 2ft by 2050 and 3.3ft by 2070**

| Year Number | Tier 1 Benefits Realized | Tier 2 Benefits Realized | Year | Dollar Value of Benefits in 2024 dollars (real) | | | | Dollar Value of Costs in 2024 dollars (real) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Flood Damage Avoided | Gross Value Added | Increased Property Value | Total Benefits | Capital Cost | Annual O&M and R&R Cost | Total Cost |
| 56 | 1.00 | 1.00 | | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 57 | 1.00 | 1.00 | 2081 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 58 | 1.00 | 1.00 | 2082 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 59 | 1.00 | 1.00 | 2083 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 60 | 1.00 | 1.00 | 2084 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 61 | 1.00 | 1.00 | 2085 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 62 | 1.00 | 1.00 | 2086 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 63 | 1.00 | 1.00 | 2087 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 64 | 1.00 | 1.00 | 2088 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 65 | 1.00 | 1.00 | 2089 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 66 | 1.00 | 1.00 | | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 67 | 1.00 | 1.00 | 2091 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 68 | 1.00 | 1.00 | 2092 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 69 | 1.00 | 1.00 | 2093 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 70 | 1.00 | 1.00 | 2094 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 71 | 1.00 | 1.00 | 2095 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 72 | 1.00 | 1.00 | 2096 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 73 | 1.00 | 1.00 | 2097 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 74 | 1.00 | 1.00 | 2098 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 75 | 1.00 | 1.00 | 2099 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 76 | 1.00 | 1.00 | | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 77 | 1.00 | 1.00 | 2101 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 78 | 1.00 | 1.00 | 2102 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 79 | 1.00 | 1.00 | 2103 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 80 | 1.00 | 1.00 | 2104 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 81 | 1.00 | 1.00 | 2105 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 82 | 1.00 | 1.00 | 2106 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 83 | 1.00 | 1.00 | 2107 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |

Appendix F-3, Item II: Tier 1 and 2 - Adaptation Strategy - Countywide Investments with Control Elevation Changes over time as sea-level rise reaches 2.0 feet by 2050 and 3.3 feet by 2070

## Appendix F-3, Item II - Economic Feasibility of Broward County Flood Adaptation Strategies

**Tier 1 and Tier 2 Adaptation - Countywide Investments with Control Elevation Changes as sea-level rises 2ft by 2050 and 3.3ft by 2070**

| Year Number | Tier 1 Benefits Realized | Tier 2 Benefits Realized | Year | Dollar Value of Benefits in 2024 dollars (real) | | | | Dollar Value of Costs in 2024 dollars (real) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Flood Damage Avoided | Gross Value Added | Increased Property Value | Total Benefits | Capital Cost | Annual O&M and R&R Cost | Total Cost |
| 84 | 1.00 | 1.00 | 2108 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 85 | 1.00 | 1.00 | 2109 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 86 | 1.00 | 1.00 | 2110 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 87 | 1.00 | 1.00 | 2111 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 88 | 1.00 | 1.00 | 2112 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 89 | 1.00 | 1.00 | 2113 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 90 | 1.00 | 1.00 | 2114 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 91 | 1.00 | 1.00 | 2115 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 92 | 1.00 | 1.00 | 2116 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 93 | 1.00 | 1.00 | 2117 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 94 | 1.00 | 1.00 | 2118 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 95 | 1.00 | 1.00 | 2119 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 96 | 1.00 | 1.00 | 2120 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 97 | 1.00 | 1.00 | 2121 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 98 | 1.00 | 1.00 | 2122 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 99 | 1.00 | 1.00 | 2123 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 100 | 1.00 | 1.00 | 2124 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| 101 | 1.00 | 1.00 | 2125 | $4,295,000,000 | $709,000,000 | $0 | $5,004,000,000 | $0 | $280,005,539 | $280,005,539 |
| Remaining Useful Value | | | | $0 | $0 | $0 | $0 | $0 | $0 | $0 |

BC Analysis of Tier 1 and 2 12_17_2024 Qcd Formatted /
NPV Tier 1 and Tier 2

Present Value of Net Benefits - Tier 1 and Tier 2 Investments

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Appendix F-3, Item II: Tier 1 and 2 - Adaptation Strategy - Countywide Investments with Control Elevation Changes over time as sea-level rise reaches 2.0 feet by 2050 and 3.3 feet by 2070

## Appendix F-3, Item II - Economic Feasibility of Broward County Flood Adaptation Strategies

**Tier 1 and Tier 2 Adaptation - Countywide Investments with Control Elevation Changes as sea-level rises 2ft by 2050 and 3.3ft by 2070**

| Year Number | Tier 1 Benefits Realized | Tier 2 Benefits Realized | Year | Net Benefits in 2024 dollars | Values are in nominal dollars (2.53% annual inflation used) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Total Benefits | Total Costs | Net Benefits |
| 1 | 0.00 | 0.00 | 2025 | -$331,206,661 | $0 | $339,586,190 | -$339,586,190 |
| 2 | 0.02 | 0.00 | 2026 | -$429,860,038 | $0 | $451,886,105 | -$451,886,105 |
| 3 | 0.04 | 0.00 | 2027 | -$1,180,962,780 | $38,490,648 | $1,311,375,395 | -$1,272,884,747 |
| 4 | 0.10 | 0.00 | 2028 | -$1,152,119,274 | $102,514,188 | $1,375,727,796 | -$1,273,213,608 |
| 5 | 0.16 | 0.00 | 2029 | -$1,158,452,477 | $170,614,462 | $1,483,216,304 | -$1,312,601,842 |
| 6 | 0.22 | 0.00 | | -$1,609,338,436 | $244,939,736 | $2,114,558,801 | -$1,869,619,065 |
| 7 | 0.31 | 0.00 | 2031 | -$1,321,990,118 | $936,915,648 | $2,511,568,812 | -$1,574,653,165 |
| 8 | 0.41 | 0.00 | 2032 | -$1,664,292,109 | $852,164,741 | $2,884,695,905 | -$2,032,531,163 |
| 9 | 0.52 | 0.00 | 2033 | -$1,193,280,187 | $1,024,649,154 | $2,518,822,711 | -$1,494,173,557 |
| 10 | 0.62 | 0.00 | 2034 | -$1,167,388,504 | $1,326,146,770 | $2,824,882,241 | -$1,498,735,471 |
| 11 | 0.72 | 0.00 | 2035 | -$478,795,067 | $1,577,766,682 | $2,208,012,828 | -$630,246,146 |
| 12 | 0.80 | 0.00 | 2036 | -$172,871,105 | $1,793,946,038 | $2,027,256,329 | -$233,310,291 |
| 13 | 0.87 | 0.00 | 2037 | -$118,702,224 | $1,797,653,442 | $1,961,909,465 | -$164,256,023 |
| 14 | 0.93 | 0.00 | 2038 | $641,551,137 | $1,986,636,786 | $1,076,420,332 | $910,216,454 |
| 15 | 0.96 | 0.00 | 2039 | $532,519,872 | $1,878,248,099 | $1,103,607,634 | $774,640,465 |
| 16 | 0.98 | 0.01 | | $691,565,041 | $1,979,336,309 | $947,885,907 | $1,031,450,401 |
| 17 | 1.00 | 0.03 | 2041 | $1,062,136,857 | $2,102,667,253 | $478,440,144 | $1,624,227,109 |
| 18 | 1.00 | 0.04 | 2042 | $949,885,156 | $1,981,597,292 | $492,276,222 | $1,489,321,069 |
| 19 | 1.00 | 0.06 | 2043 | $1,207,910,723 | $2,448,299,590 | $506,506,162 | $1,941,793,428 |
| 20 | 1.00 | 0.07 | 2044 | $1,203,934,035 | $2,505,507,319 | $521,141,035 | $1,984,366,284 |
| 21 | 1.00 | 0.08 | 2045 | $1,177,802,001 | $2,526,601,526 | $536,192,223 | $1,990,409,302 |
| 22 | 1.00 | 0.10 | 2046 | $1,233,601,285 | $2,689,120,987 | $551,671,425 | $2,137,449,563 |
| 23 | 1.00 | 0.16 | 2047 | $1,106,110,570 | $3,204,364,279 | $1,239,328,048 | $1,965,036,231 |
| 24 | 1.00 | 0.22 | 2048 | $1,352,956,803 | $3,743,957,602 | $1,279,581,959 | $2,464,375,643 |
| 25 | 1.00 | 0.28 | 2049 | $1,599,803,036 | $4,308,803,266 | $1,321,079,436 | $2,987,723,830 |
| 26 | 1.00 | 0.33 | | **$2,597,498,513** | $6,126,098,482 | $1,152,391,461 | $4,973,707,021 |
| 27 | 1.00 | 0.38 | **2051** | **$2,788,545,462** | $6,663,585,314 | $1,188,970,373 | $5,474,614,941 |

BC Analysis of Tier 1 and 2 12_17_2024 Qcd Formatted / NPV Tier 1 and Tier 2

Present Value of Net Benefits - Tier 1 and Tier 2 Investments

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Appendix F-3, Item II: Tier 1 and 2 - Adaptation Strategy - Countywide Investments with Control Elevation Changes over time as sea-level rise reaches 2.0 feet by 2050 and 3.3 feet by 2070

## Appendix F-3, Item II - Economic Feasibility of Broward County Flood Adaptation Strategies

### Tier 1 and Tier 2 Adaptation - Countywide Investments with Control Elevation Changes as sea-level rises 2ft by 2050 and 3.3ft by 2070

| Year Number | Tier 1 Benefits Realized | Tier 2 Benefits Realized | Year | Net Benefits in 2024 dollars | Values are in nominal dollars (2.53% annual inflation used) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Total Benefits | Total Costs | Net Benefits |
| 28 | 1.00 | 0.43 | 2052 | $2,979,592,410 | $7,224,347,725 | $1,226,662,544 | $5,997,685,181 |
| 29 | 1.00 | 0.48 | 2053 | $2,966,973,673 | $7,388,884,347 | $1,265,500,891 | $6,123,383,456 |
| 30 | 1.00 | 0.55 | 2054 | $3,048,053,115 | $8,235,438,466 | $1,785,564,151 | $6,449,874,315 |
| 31 | 1.00 | 0.63 | 2055 | $3,353,721,465 | $9,120,098,673 | $1,843,864,475 | $7,276,234,198 |
| 32 | 1.00 | 0.71 | 2056 | $3,659,389,815 | $10,044,251,264 | $1,903,971,874 | $8,140,279,390 |
| 33 | 1.00 | 0.74 | 2057 | $4,566,712,787 | $11,519,163,738 | $1,103,539,781 | $10,415,623,956 |
| 34 | 1.00 | 0.77 | 2058 | $4,681,334,188 | $12,083,942,754 | $1,136,764,341 | $10,947,178,413 |
| 35 | 1.00 | 0.79 | 2059 | $4,795,955,590 | $12,669,926,287 | $1,170,963,699 | $11,498,962,588 |
| 36 | 1.00 | 0.82 | 2060 | $4,213,261,451 | $11,563,616,624 | $1,206,165,912 | $10,357,450,712 |
| 37 | 1.00 | 0.87 | 2061 | $4,271,289,200 | $12,302,419,776 | $1,536,667,052 | $10,765,752,724 |
| 38 | 1.00 | 0.88 | 2062 | $4,554,866,840 | $12,769,130,401 | $998,165,485 | $11,770,964,916 |
| 39 | 1.00 | 0.90 | 2063 | $4,613,855,573 | $13,251,581,928 | $1,026,512,527 | $12,225,069,401 |
| 40 | 1.00 | 0.91 | 2064 | $4,888,151,380 | $14,335,192,277 | $1,055,655,013 | $13,279,537,264 |
| 41 | 1.00 | 0.93 | 2065 | $4,528,775,490 | $13,700,115,126 | $1,085,615,049 | $12,614,500,078 |
| 42 | 1.00 | 0.94 | 2066 | $4,587,764,222 | $14,218,527,117 | $1,116,415,348 | $13,102,111,769 |
| 43 | 1.00 | 0.96 | 2067 | $4,646,752,954 | $14,754,401,448 | $1,148,079,251 | $13,606,322,197 |
| 44 | 1.00 | 0.97 | 2068 | $4,705,741,687 | $15,308,289,883 | $1,180,630,741 | $14,127,659,142 |
| 45 | 1.00 | 0.99 | 2069 | $4,764,730,419 | $15,880,760,928 | $1,214,094,463 | $14,666,666,465 |
| 46 | 1.00 | 1.00 | **2070** | **$4,823,719,151** | $16,472,400,325 | $1,248,495,739 | $15,223,904,586 |
| 47 | 1.00 | 1.00 | 2071 | $4,939,301,537 | $16,889,152,053 | $906,069,723 | $15,983,082,330 |
| 48 | 1.00 | 1.00 | 2072 | $4,939,301,537 | $17,316,447,600 | $928,993,287 | $16,387,454,313 |
| 49 | 1.00 | 1.00 | 2073 | $4,939,301,537 | $17,754,553,724 | $952,496,818 | $16,802,056,907 |
| 50 | 1.00 | 1.00 | 2074 | $4,723,994,461 | $17,452,802,322 | $976,594,987 | $16,476,207,335 |
| 51 | 1.00 | 1.00 | 2075 | $4,723,994,461 | $17,894,358,221 | $1,001,302,840 | $16,893,055,381 |
| 52 | 1.00 | 1.00 | 2076 | $4,723,994,461 | $18,347,085,484 | $1,026,635,802 | $17,320,449,682 |
| 53 | 1.00 | 1.00 | 2077 | $4,723,994,461 | $18,811,266,747 | $1,052,609,688 | $17,758,657,059 |
| 54 | 1.00 | 1.00 | 2078 | $4,723,994,461 | $19,287,191,796 | $1,079,240,713 | $18,207,951,083 |
| 55 | 1.00 | 1.00 | 2079 | $4,723,994,461 | $19,775,157,748 | $1,106,545,503 | $18,668,612,245 |

BC Analysis of Tier 1 and 2 12_17_2024 Qcd Formatted /
NPV Tier 1 and Tier 2

Present Value of Net Benefits - Tier 1 and Tier 2 Investments

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Appendix F-3, Item II: Tier 1 and 2 - Adaptation Strategy - Countywide Investments with Control Elevation Changes over time as sea-level rise reaches 2.0 feet by 2050 and 3.3 feet by 2070

## Appendix F-3, Item II - Economic Feasibility of Broward County Flood Adaptation Strategies

**Tier 1 and Tier 2 Adaptation - Countywide Investments with Control Elevation Changes as sea-level rises 2ft by 2050 and 3.3ft by 2070**

| Year Number | Tier 1 Benefits Realized | Tier 2 Benefits Realized | Year | Net Benefits in 2024 dollars | Values are in nominal dollars (2.53% annual inflation used) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Total Benefits | Total Costs | Net Benefits |
| 56 | 1.00 | 1.00 | | $4,723,994,461 | $20,275,469,239 | $1,134,541,104 | $19,140,928,135 |
| 57 | 1.00 | 1.00 | 2081 | $4,723,994,461 | $20,788,438,611 | $1,163,244,994 | $19,625,193,617 |
| 58 | 1.00 | 1.00 | 2082 | $4,723,994,461 | $21,314,386,108 | $1,192,675,092 | $20,121,711,015 |
| 59 | 1.00 | 1.00 | 2083 | $4,723,994,461 | $21,853,640,076 | $1,222,849,772 | $20,630,790,304 |
| 60 | 1.00 | 1.00 | 2084 | $4,723,994,461 | $22,406,537,170 | $1,253,787,872 | $21,152,749,299 |
| 61 | 1.00 | 1.00 | 2085 | $4,723,994,461 | $22,973,422,561 | $1,285,508,705 | $21,687,913,856 |
| 62 | 1.00 | 1.00 | 2086 | $4,723,994,461 | $23,554,650,151 | $1,318,032,075 | $22,236,618,076 |
| 63 | 1.00 | 1.00 | 2087 | $4,723,994,461 | $24,150,582,800 | $1,351,378,286 | $22,799,204,514 |
| 64 | 1.00 | 1.00 | 2088 | $4,723,994,461 | $24,761,592,545 | $1,385,568,157 | $23,376,024,388 |
| 65 | 1.00 | 1.00 | 2089 | $4,723,994,461 | $25,388,060,836 | $1,420,623,031 | $23,967,437,805 |
| 66 | 1.00 | 1.00 | | $4,723,994,461 | $26,030,378,776 | $1,456,564,794 | $24,573,813,981 |
| 67 | 1.00 | 1.00 | 2091 | $4,723,994,461 | $26,688,947,359 | $1,493,415,883 | $25,195,531,475 |
| 68 | 1.00 | 1.00 | 2092 | $4,723,994,461 | $27,364,177,727 | $1,531,199,305 | $25,832,978,422 |
| 69 | 1.00 | 1.00 | 2093 | $4,723,994,461 | $28,056,491,423 | $1,569,938,648 | $26,486,552,776 |
| 70 | 1.00 | 1.00 | 2094 | $4,723,994,461 | $28,766,320,656 | $1,609,658,095 | $27,156,662,561 |
| 71 | 1.00 | 1.00 | 2095 | $4,723,994,461 | $29,494,108,569 | $1,650,382,445 | $27,843,726,124 |
| 72 | 1.00 | 1.00 | 2096 | $4,723,994,461 | $30,240,309,516 | $1,692,137,121 | $28,548,172,395 |
| 73 | 1.00 | 1.00 | 2097 | $4,723,994,461 | $31,005,389,346 | $1,734,948,190 | $29,270,441,156 |
| 74 | 1.00 | 1.00 | 2098 | $4,723,994,461 | $31,789,825,697 | $1,778,842,380 | $30,010,983,317 |
| 75 | 1.00 | 1.00 | 2099 | $4,723,994,461 | $32,594,108,287 | $1,823,847,092 | $30,770,261,195 |
| 76 | 1.00 | 1.00 | | $4,723,994,461 | $33,418,739,227 | $1,869,990,423 | $31,548,748,804 |
| 77 | 1.00 | 1.00 | 2101 | $4,723,994,461 | $34,264,233,329 | $1,917,301,181 | $32,346,932,148 |
| 78 | 1.00 | 1.00 | 2102 | $4,723,994,461 | $35,131,118,432 | $1,965,808,901 | $33,165,309,532 |
| 79 | 1.00 | 1.00 | 2103 | $4,723,994,461 | $36,019,935,729 | $2,015,543,866 | $34,004,391,863 |
| 80 | 1.00 | 1.00 | 2104 | $4,723,994,461 | $36,931,240,103 | $2,066,537,126 | $34,864,702,977 |
| 81 | 1.00 | 1.00 | 2105 | $4,723,994,461 | $37,865,600,477 | $2,118,820,515 | $35,746,779,962 |
| 82 | 1.00 | 1.00 | 2106 | $4,723,994,461 | $38,823,600,169 | $2,172,426,674 | $36,651,173,495 |
| 83 | 1.00 | 1.00 | 2107 | $4,723,994,461 | $39,805,837,254 | $2,227,389,069 | $37,578,448,185 |

BC Analysis of Tier 1 and 2 12_17_2024 Qcd Formatted /
NPV Tier 1 and Tier 2

Present Value of Net Benefits - Tier 1 and Tier 2 Investments

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Appendix F-3, Item II: Tier 1 and 2 - Adaptation Strategy - Countywide Investments with Control Elevation Changes over time as sea-level rise reaches 2.0 feet by 2050 and 3.3 feet by 2070

## Appendix F-3, Item II - Economic Feasibility of Broward County Flood Adaptation Strategies

**Tier 1 and Tier 2 Adaptation - Countywide Investments with Control Elevation Changes as sea-level rises 2ft by 2050 and 3.3ft by 2070**

| Year Number | Tier 1 Benefits Realized | Tier 2 Benefits Realized | Year | Net Benefits in 2024 dollars | Values are in nominal dollars (2.53% annual inflation used) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Total Benefits | Total Costs | Net Benefits |
| 84 | 1.00 | 1.00 | 2108 | $4,723,994,461 | $40,812,924,936 | $2,283,742,012 | $38,529,182,924 |
| 85 | 1.00 | 1.00 | 2109 | $4,723,994,461 | $41,845,491,937 | $2,341,520,685 | $39,503,971,252 |
| 86 | 1.00 | 1.00 | 2110 | $4,723,994,461 | $42,904,182,883 | $2,400,761,159 | $40,503,421,724 |
| 87 | 1.00 | 1.00 | 2111 | $4,723,994,461 | $43,989,658,710 | $2,461,500,416 | $41,528,158,294 |
| 88 | 1.00 | 1.00 | 2112 | $4,723,994,461 | $45,102,597,075 | $2,523,776,376 | $42,578,820,699 |
| 89 | 1.00 | 1.00 | 2113 | $4,723,994,461 | $46,243,692,781 | $2,587,627,919 | $43,656,064,863 |
| 90 | 1.00 | 1.00 | 2114 | $4,723,994,461 | $47,413,658,209 | $2,653,094,905 | $44,760,563,304 |
| 91 | 1.00 | 1.00 | 2115 | $4,723,994,461 | $48,613,223,761 | $2,720,218,206 | $45,893,005,555 |
| 92 | 1.00 | 1.00 | 2116 | $4,723,994,461 | $49,843,138,323 | $2,789,039,727 | $47,054,098,596 |
| 93 | 1.00 | 1.00 | 2117 | $4,723,994,461 | $51,104,169,722 | $2,859,602,432 | $48,244,567,290 |
| 94 | 1.00 | 1.00 | 2118 | $4,723,994,461 | $52,397,105,216 | $2,931,950,373 | $49,465,154,843 |
| 95 | 1.00 | 1.00 | 2119 | $4,723,994,461 | $53,722,751,978 | $3,006,128,718 | $50,716,623,260 |
| 96 | 1.00 | 1.00 | 2120 | $4,723,994,461 | $55,081,937,603 | $3,082,183,774 | $51,999,753,829 |
| 97 | 1.00 | 1.00 | 2121 | $4,723,994,461 | $56,475,510,624 | $3,160,163,024 | $53,315,347,600 |
| 98 | 1.00 | 1.00 | 2122 | $4,723,994,461 | $57,904,341,043 | $3,240,115,148 | $54,664,225,895 |
| 99 | 1.00 | 1.00 | 2123 | $4,723,994,461 | $59,369,320,872 | $3,322,090,062 | $56,047,230,810 |
| 100 | 1.00 | 1.00 | 2124 | $4,723,994,461 | $60,871,364,690 | $3,406,138,940 | $57,465,225,749 |
| 101 | 1.00 | 1.00 | 2125 | $4,723,994,461 | $62,411,410,216 | $3,492,314,255 | $58,919,095,961 |
| Remaining Useful Value | | | | $0 | $0 | $0 | $0 |
| | | | | **Present Value at 5% annual discount rate:** | **$109,625,688,622** | **$27,910,744,939** | **$81,714,943,683** |
| | | | | | | **Rate of Return on Investment (IRR), nominal (includes inflation):** | **11.95%** |
| | | | | | | **B/C Ratio** | **3.93** |

BC Analysis of Tier 1 and 2 12_17_2024 Qcd Formatted / NPV Tier 1 and Tier 2

Present Value of Net Benefits - Tier 1 and Tier 2 Investments

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Page 8 of 8

Appendix F-3: Economic Feasibility Model - Economic Feasibility of Tier 1 and Tier 2 Investments

# **Appendix F-3, Item III:** Tier 1 Adaptation Strategy - Countywide Investments with Control Elevation Changes over time as sea-level rise reaches 2.0 feet by 2050 and thereafter

## Appendix F-3, Item III: Tier 1 Adaptation Strategy - Countywide Investments with Control Elevation Changes over time as sea-level rise reaches 2.0 feet by 2050 and thereafter

**Appendix F-3, Item III - Economic Feasibility Analysis of Broward County Flood Adaptation Strategies**
**Tier 1 - Countywide Investments with Control Elevation Changes over time as sea level rises to 2 feet by 2050 and beyond**

| Year Number | Tier 1 Benefits Realized | Tier 2 Benefits Realized | Year | Dollar Value of Benefits in 2024 dollars (real) | | | | Dollar Value of Costs in 2024 dollars (real) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Flood Damage Avoided | Gross Value Added | Increased Property Value | Total Benefits | Capital Cost | Annual O&M and R&R Cost | Total Cost |
| 1 | 0.00 | 0.00 | 2025 | $0 | $0 | $0 | $0 | $331,206,661 | $0 | $331,206,661 |
| 2 | 0.02 | 0.00 | 2026 | $0 | $0 | $0 | $0 | $425,603,998 | $4,256,040 | $429,860,038 |
| 3 | 0.04 | 0.00 | 2027 | $31,312,933 | $4,398,095 | $0 | $35,711,028 | $1,209,105,702 | $7,568,107 | $1,216,673,808 |
| 4 | 0.10 | 0.00 | 2028 | $81,339,509 | $11,424,637 | $0 | $92,764,146 | $1,225,224,256 | $19,659,164 | $1,244,883,420 |
| 5 | 0.16 | 0.00 | 2029 | $132,032,987 | $18,544,849 | $0 | $150,577,837 | $1,277,118,908 | $31,911,406 | $1,309,030,314 |
| 6 | 0.22 | 0.00 | 2030 | $184,873,600 | $25,966,640 | $0 | $210,840,240 | $1,775,496,081 | $44,682,595 | $1,820,178,676 |
| 7 | 0.31 | 0.00 | 2031 | $258,334,497 | $36,284,677 | $491,962,440 | $786,581,614 | $2,046,134,176 | $62,437,556 | $2,108,571,732 |
| 8 | 0.41 | 0.00 | 2032 | $342,993,006 | $48,175,488 | $306,607,304 | $697,775,798 | $2,279,169,009 | $82,898,898 | $2,362,067,907 |
| 9 | 0.52 | 0.00 | 2033 | $437,293,298 | $61,420,547 | $319,593,726 | $818,307,571 | $1,905,897,170 | $105,690,588 | $2,011,587,758 |
| 10 | 0.62 | 0.00 | 2034 | $516,149,521 | $72,496,391 | $444,310,553 | $1,032,956,465 | $2,075,595,410 | $124,749,560 | $2,200,344,969 |
| 11 | 0.72 | 0.00 | 2035 | $602,026,985 | $84,558,412 | $512,036,617 | $1,198,622,014 | $1,531,911,568 | $145,505,514 | $1,677,417,081 |
| 12 | 0.80 | 0.00 | 2036 | $665,409,607 | $93,460,893 | $570,352,620 | $1,329,223,121 | $1,341,269,596 | $160,824,629 | $1,502,094,225 |
| 13 | 0.87 | 0.00 | 2037 | $720,904,445 | $101,255,486 | $476,942,886 | $1,299,102,818 | $1,243,567,717 | $174,237,325 | $1,417,805,042 |
| 14 | 0.93 | 0.00 | 2038 | $772,356,882 | $108,482,299 | $519,409,169 | $1,400,248,350 | $572,024,211 | $186,673,003 | $758,697,213 |
| 15 | 0.96 | 0.00 | 2039 | $796,024,302 | $111,806,535 | $383,354,535 | $1,291,185,372 | $566,272,256 | $192,393,245 | $758,665,500 |
| 16 | 0.98 | 0.00 | 2040 | $819,453,736 | $115,097,343 | $335,647,170 | $1,270,198,250 | $327,043,538 | $198,055,967 | $525,099,505 |
| 17 | 1.00 | 0.00 | 2041 | $832,985,116 | $116,997,909 | $311,197,679 | $1,261,180,704 | $0 | $201,326,403 | $201,326,403 |
| 18 | 1.00 | 0.00 | 2042 | $832,985,116 | $116,997,909 | $143,146,693 | $1,093,129,718 | $0 | $201,326,403 | $201,326,403 |
| 19 | 1.00 | 0.00 | 2043 | $832,985,116 | $116,997,909 | $141,707,290 | $1,091,690,315 | $0 | $201,326,403 | $201,326,403 |
| 20 | 1.00 | 0.00 | 2044 | $832,985,116 | $116,997,909 | $81,841,293 | $1,031,824,318 | $0 | $201,326,403 | $201,326,403 |
| 21 | 1.00 | 0.00 | 2045 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 22 | 1.00 | 0.00 | 2046 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 23 | 1.00 | 0.00 | 2047 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 24 | 1.00 | 0.00 | 2048 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 25 | 1.00 | 0.00 | 2049 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 26 | 1.00 | **0.00** | **2050** | **$832,985,116** | **$116,997,909** | $0 | **$949,983,025** | $0 | $201,326,403 | **$201,326,403** |
| 27 | 1.00 | **0.00** | **2051** | **$832,985,116** | **$116,997,909** | $0 | **$949,983,025** | $0 | $201,326,403 | **$201,326,403** |
| 28 | 1.00 | 0.00 | 2052 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 29 | 1.00 | 0.00 | 2053 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 30 | 1.00 | 0.00 | 2054 | $832,985,116 | $116,997,909 | **$0** | **$949,983,025** | $0 | $201,326,403 | $201,326,403 |
| 31 | 1.00 | 0.00 | 2055 | $832,985,116 | $116,997,909 | **$0** | **$949,983,025** | $0 | $201,326,403 | $201,326,403 |
| 32 | 1.00 | 0.00 | 2056 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 33 | 1.00 | 0.00 | 2057 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 34 | 1.00 | 0.00 | 2058 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 35 | 1.00 | 0.00 | 2059 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 36 | 1.00 | 0.00 | 2060 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |

BC Analysis of Tier 1 and 2 12_17_2024 Qcd Formatted /
NPV Tier 1 2ft SLR over time

Present Value of Net Benefits - Tier 1 Investments

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Appendix F-3, Item III: Tier 1 Adaptation Strategy - Countywide Investments with Control Elevation Changes over time as sea-level rise reaches 2.0 feet by 2050 and thereafter

**Appendix F-3, Item III - Economic Feasibility Analysis of Broward County Flood Adaptation Strategies**
**Tier 1 - Countywide Investments with Control Elevation Changes over time as sea level rises to 2 feet by 2050 and beyond**

| Year Number | Tier 1 Benefits Realized | Tier 2 Benefits Realized | Year | Dollar Value of Benefits in 2024 dollars (real) | | | | Dollar Value of Costs in 2024 dollars (real) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Flood Damage Avoided | Gross Value Added | Increased Property Value | Total Benefits | Capital Cost | Annual O&M and R&R Cost | Total Cost |
| 37 | 1.00 | 0.00 | 2061 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 38 | 1.00 | 0.00 | 2062 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 39 | 1.00 | 0.00 | 2063 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 40 | 1.00 | 0.00 | 2064 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 41 | 1.00 | 0.00 | 2065 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 42 | 1.00 | 0.00 | 2066 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 43 | 1.00 | 0.00 | 2067 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 44 | 1.00 | 0.00 | 2068 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 45 | 1.00 | 0.00 | 2069 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 46 | 1.00 | 0.00 | 2070 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 47 | 1.00 | 0.00 | 2071 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 48 | 1.00 | 0.00 | 2072 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 49 | 1.00 | 0.00 | 2073 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 50 | 1.00 | 0.00 | 2074 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 51 | 1.00 | 0.00 | 2075 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 52 | 1.00 | 0.00 | 2076 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 53 | 1.00 | 0.00 | 2077 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 54 | 1.00 | 0.00 | 2078 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 55 | 1.00 | 0.00 | 2079 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 56 | 1.00 | 0.00 | 2080 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 57 | 1.00 | 0.00 | 2081 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 58 | 1.00 | 0.00 | 2082 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 59 | 1.00 | 0.00 | 2083 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 60 | 1.00 | 0.00 | 2084 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 61 | 1.00 | 0.00 | 2085 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 62 | 1.00 | 0.00 | 2086 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 63 | 1.00 | 0.00 | 2087 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 64 | 1.00 | 0.00 | 2088 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 65 | 1.00 | 0.00 | 2089 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 66 | 1.00 | 0.00 | 2090 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 67 | 1.00 | 0.00 | 2091 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 68 | 1.00 | 0.00 | 2092 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 69 | 1.00 | 0.00 | 2093 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 70 | 1.00 | 0.00 | 2094 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 71 | 1.00 | 0.00 | 2095 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 72 | 1.00 | 0.00 | 2096 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 73 | 1.00 | 0.00 | 2097 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |

Appendix F-3, Item III: Tier 1 Adaptation Strategy - Countywide Investments with Control Elevation Changes over time as sea-level rise reaches 2.0 feet by 2050 and thereafter

**Appendix F-3, Item III - Economic Feasibility Analysis of Broward County Flood Adaptation Strategies**
**Tier 1 - Countywide Investments with Control Elevation Changes over time as sea level rises to 2 feet by 2050 and beyond**

| Year Number | Tier 1 Benefits Realized | Tier 2 Benefits Realized | Year | Dollar Value of Benefits in 2024 dollars (real) | | | | Dollar Value of Costs in 2024 dollars (real) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Flood Damage Avoided | Gross Value Added | Increased Property Value | Total Benefits | Capital Cost | Annual O&M and R&R Cost | Total Cost |
| 74 | 1.00 | 0.00 | 2098 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 75 | 1.00 | 0.00 | 2099 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 76 | 1.00 | 0.00 | 2100 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 77 | 1.00 | 0.00 | 2101 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 78 | 1.00 | 0.00 | 2102 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 79 | 1.00 | 0.00 | 2103 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 80 | 1.00 | 0.00 | 2104 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 81 | 1.00 | 0.00 | 2105 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 82 | 1.00 | 0.00 | 2106 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 83 | 1.00 | 0.00 | 2107 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 84 | 1.00 | 0.00 | 2108 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 85 | 1.00 | 0.00 | 2109 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 86 | 1.00 | 0.00 | 2110 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 87 | 1.00 | 0.00 | 2111 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 88 | 1.00 | 0.00 | 2112 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 89 | 1.00 | 0.00 | 2113 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 90 | 1.00 | 0.00 | 2114 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 91 | 1.00 | 0.00 | 2115 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 92 | 1.00 | 0.00 | 2116 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 93 | 1.00 | 0.00 | 2117 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 94 | 1.00 | 0.00 | 2118 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 95 | 1.00 | 0.00 | 2119 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 96 | 1.00 | 0.00 | 2120 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 97 | 1.00 | 0.00 | 2121 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 98 | 1.00 | 0.00 | 2122 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 99 | 1.00 | 0.00 | 2123 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 100 | 1.00 | 0.00 | 2124 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| 101 | 1.00 | 0.00 | 2125 | $832,985,116 | $116,997,909 | $0 | $949,983,025 | $0 | $201,326,403 | $201,326,403 |
| **Remaining Useful Value:** | | | | $0 | $0 | $0 | $0 | $0 | $0 | $0 |

## Appendix F-3, Item III: Tier 1 Adaptation Strategy - Countywide Investments with Control Elevation Changes over time as sea-level rise reaches 2.0 feet by 2050 and thereafter

### Appendix F-3, Item III - Economic Feasibility Analysis of Broward County Flood Adaptation Strategies
**Tier 1 - Countywide Investments with Control Elevation Changes over time as sea level rises to 2 feet by 2050 and beyond**

| Year Number | Tier 1 Benefits Realized | Tier 2 Benefits Realized | Year | Net Benefits in 2024 dollars | Values are in nominal dollars (2.53% annual inflation) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Total Benefits | Total Costs | Net Benefits |
| 1 | 0.00 | 0.00 | 2025 | -$331,206,661 | $0 | $339,586,190 | -$339,586,190 |
| 2 | 0.02 | 0.00 | 2026 | -$429,860,038 | $0 | $451,886,105 | -$451,886,105 |
| 3 | 0.04 | 0.00 | 2027 | -$1,180,962,780 | $38,490,648 | $1,311,375,395 | -$1,272,884,747 |
| 4 | 0.10 | 0.00 | 2028 | -$1,152,119,274 | $102,514,188 | $1,375,727,796 | -$1,273,213,608 |
| 5 | 0.16 | 0.00 | 2029 | -$1,158,452,477 | $170,614,462 | $1,483,216,304 | -$1,312,601,842 |
| 6 | 0.22 | 0.00 | | -$1,609,338,436 | $244,939,736 | $2,114,558,801 | -$1,869,619,065 |
| 7 | 0.31 | 0.00 | 2031 | -$1,321,990,118 | $936,915,648 | $2,511,568,812 | -$1,574,653,165 |
| 8 | 0.41 | 0.00 | 2032 | -$1,664,292,109 | $852,164,741 | $2,884,695,905 | -$2,032,531,163 |
| 9 | 0.52 | 0.00 | 2033 | -$1,193,280,187 | $1,024,649,154 | $2,518,822,711 | -$1,494,173,557 |
| 10 | 0.62 | 0.00 | 2034 | -$1,167,388,504 | $1,326,146,770 | $2,824,882,241 | -$1,498,735,471 |
| 11 | 0.72 | 0.00 | 2035 | -$478,795,067 | $1,577,766,682 | $2,208,012,828 | -$630,246,146 |
| 12 | 0.80 | 0.00 | 2036 | -$172,871,105 | $1,793,946,038 | $2,027,256,329 | -$233,310,291 |
| 13 | 0.87 | 0.00 | 2037 | -$118,702,224 | $1,797,653,442 | $1,961,909,465 | -$164,256,023 |
| 14 | 0.93 | 0.00 | 2038 | $641,551,137 | $1,986,636,786 | $1,076,420,332 | $910,216,454 |
| 15 | 0.96 | 0.00 | 2039 | $532,519,872 | $1,878,248,099 | $1,103,607,634 | $774,640,465 |
| 16 | 0.98 | 0.00 | | $745,098,745 | $1,894,466,055 | $783,171,594 | $1,111,294,461 |
| 17 | 1.00 | 0.00 | 2041 | $1,059,854,301 | $1,928,606,352 | $307,869,743 | $1,620,736,609 |
| 18 | 1.00 | 0.00 | 2042 | $891,803,316 | $1,713,913,636 | $315,658,847 | $1,398,254,789 |
| 19 | 1.00 | 0.00 | 2043 | $890,363,913 | $1,754,961,719 | $323,645,016 | $1,431,316,704 |
| 20 | 1.00 | 0.00 | 2044 | $830,497,915 | $1,700,689,015 | $331,833,235 | $1,368,855,780 |
| 21 | 1.00 | 0.00 | 2045 | $748,656,622 | $1,605,409,949 | $340,228,616 | $1,265,181,333 |
| 22 | 1.00 | 0.00 | 2046 | $748,656,622 | $1,646,026,820 | $348,836,400 | $1,297,190,421 |
| 23 | 1.00 | 0.00 | 2047 | $748,656,622 | $1,687,671,299 | $357,661,961 | $1,330,009,338 |
| 24 | 1.00 | 0.00 | 2048 | $748,656,622 | $1,730,369,383 | $366,710,808 | $1,363,658,574 |
| 25 | 1.00 | 0.00 | 2049 | $748,656,622 | $1,774,147,728 | $375,988,592 | $1,398,159,136 |
| 26 | 1.00 | **0.00** | | **$748,656,622** | $1,819,033,666 | $385,501,103 | $1,433,532,562 |
| 27 | 1.00 | **0.00** | **2051** | **$748,656,622** | $1,865,055,217 | $395,254,281 | $1,469,800,936 |
| 28 | 1.00 | 0.00 | 2052 | $748,656,622 | $1,912,241,114 | $405,254,214 | $1,506,986,900 |
| 29 | 1.00 | 0.00 | 2053 | $748,656,622 | $1,960,620,814 | $415,507,146 | $1,545,113,669 |
| 30 | 1.00 | 0.00 | 2054 | $748,656,622 | $2,010,224,521 | $426,019,477 | $1,584,205,044 |
| 31 | 1.00 | 0.00 | 2055 | $748,656,622 | $2,061,083,201 | $436,797,769 | $1,624,285,432 |
| 32 | 1.00 | 0.00 | 2056 | $748,656,622 | $2,113,228,606 | $447,848,753 | $1,665,379,853 |
| 33 | 1.00 | 0.00 | 2057 | $748,656,622 | $2,166,693,290 | $459,179,326 | $1,707,513,964 |
| 34 | 1.00 | 0.00 | 2058 | $748,656,622 | $2,221,510,630 | $470,796,563 | $1,750,714,067 |
| 35 | 1.00 | 0.00 | 2059 | $748,656,622 | $2,277,714,849 | $482,707,716 | $1,795,007,133 |
| 36 | 1.00 | 0.00 | | $748,656,622 | $2,335,341,035 | $494,920,222 | $1,840,420,813 |

BC Analysis of Tier 1 and 2 12_17_2024 Qcd Formatted / NPV Tier 1 2ft SLR over time

Present Value of Net Benefits - Tier 1 Investments

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Appendix F-3, Item III: Tier 1 Adaptation Strategy - Countywide Investments with Control Elevation Changes over time as sea-level rise reaches 2.0 feet by 2050 and thereafter

## Appendix F-3, Item III - Economic Feasibility Analysis of Broward County Flood Adaptation Strategies

### Tier 1 - Countywide Investments with Control Elevation Changes over time as sea level rises to 2 feet by 2050 and beyond

| Year Number | Tier 1 Benefits Realized | Tier 2 Benefits Realized | Year | Net Benefits in 2024 dollars | Values are in nominal dollars (2.53% annual inflation) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Total Benefits | Total Costs | Net Benefits |
| 37 | 1.00 | 0.00 | 2061 | $748,656,622 | $2,394,425,163 | $507,441,703 | $1,886,983,460 |
| 38 | 1.00 | 0.00 | 2062 | $748,656,622 | $2,455,004,120 | $520,279,978 | $1,934,724,141 |
| 39 | 1.00 | 0.00 | 2063 | $748,656,622 | $2,517,115,724 | $533,443,062 | $1,983,672,662 |
| 40 | 1.00 | 0.00 | 2064 | $748,656,622 | $2,580,798,752 | $546,939,171 | $2,033,859,581 |
| 41 | 1.00 | 0.00 | 2065 | $748,656,622 | $2,646,092,960 | $560,776,732 | $2,085,316,228 |
| 42 | 1.00 | 0.00 | 2066 | $748,656,622 | $2,713,039,112 | $574,964,384 | $2,138,074,729 |
| 43 | 1.00 | 0.00 | 2067 | $748,656,622 | $2,781,679,002 | $589,510,983 | $2,192,168,019 |
| 44 | 1.00 | 0.00 | 2068 | $748,656,622 | $2,852,055,481 | $604,425,610 | $2,247,629,870 |
| 45 | 1.00 | 0.00 | 2069 | $748,656,622 | $2,924,212,484 | $619,717,578 | $2,304,494,906 |
| 46 | 1.00 | 0.00 | 2070 | $748,656,622 | $2,998,195,060 | $635,396,433 | $2,362,798,627 |
| 47 | 1.00 | 0.00 | 2071 | $748,656,622 | $3,074,049,395 | $651,471,963 | $2,422,577,432 |
| 48 | 1.00 | 0.00 | 2072 | $748,656,622 | $3,151,822,845 | $667,954,204 | $2,483,868,641 |
| 49 | 1.00 | 0.00 | 2073 | $748,656,622 | $3,231,563,963 | $684,853,445 | $2,546,710,518 |
| 50 | 1.00 | 0.00 | 2074 | $748,656,622 | $3,313,322,531 | $702,180,237 | $2,611,142,294 |
| 51 | 1.00 | 0.00 | 2075 | $748,656,622 | $3,397,149,591 | $719,945,397 | $2,677,204,194 |
| 52 | 1.00 | 0.00 | 2076 | $748,656,622 | $3,483,097,476 | $738,160,016 | $2,744,937,460 |
| 53 | 1.00 | 0.00 | 2077 | $748,656,622 | $3,571,219,842 | $756,835,464 | $2,814,384,378 |
| 54 | 1.00 | 0.00 | 2078 | $748,656,622 | $3,661,571,704 | $775,983,401 | $2,885,588,303 |
| 55 | 1.00 | 0.00 | 2079 | $748,656,622 | $3,754,209,468 | $795,615,781 | $2,958,593,687 |
| 56 | 1.00 | 0.00 | 2080 | $748,656,622 | $3,849,190,967 | $815,744,860 | $3,033,446,107 |
| 57 | 1.00 | 0.00 | 2081 | $748,656,622 | $3,946,575,499 | $836,383,205 | $3,110,192,293 |
| 58 | 1.00 | 0.00 | 2082 | $748,656,622 | $4,046,423,859 | $857,543,701 | $3,188,880,158 |
| 59 | 1.00 | 0.00 | 2083 | $748,656,622 | $4,148,798,383 | $879,239,556 | $3,269,558,826 |
| 60 | 1.00 | 0.00 | 2084 | $748,656,622 | $4,253,762,982 | $901,484,317 | $3,352,278,665 |
| 61 | 1.00 | 0.00 | 2085 | $748,656,622 | $4,361,383,185 | $924,291,870 | $3,437,091,315 |
| 62 | 1.00 | 0.00 | 2086 | $748,656,622 | $4,471,726,180 | $947,676,454 | $3,524,049,725 |
| 63 | 1.00 | 0.00 | 2087 | $748,656,622 | $4,584,860,852 | $971,652,669 | $3,613,208,183 |
| 64 | 1.00 | 0.00 | 2088 | $748,656,622 | $4,700,857,832 | $996,235,481 | $3,704,622,350 |
| 65 | 1.00 | 0.00 | 2089 | $748,656,622 | $4,819,789,535 | $1,021,440,239 | $3,798,349,296 |
| 66 | 1.00 | 0.00 | 2090 | $748,656,622 | $4,941,730,210 | $1,047,282,677 | $3,894,447,533 |
| 67 | 1.00 | 0.00 | 2091 | $748,656,622 | $5,066,755,984 | $1,073,778,929 | $3,992,977,056 |
| 68 | 1.00 | 0.00 | 2092 | $748,656,622 | $5,194,944,911 | $1,100,945,536 | $4,093,999,375 |
| 69 | 1.00 | 0.00 | 2093 | $748,656,622 | $5,326,377,017 | $1,128,799,458 | $4,197,577,559 |
| 70 | 1.00 | 0.00 | 2094 | $748,656,622 | $5,461,134,356 | $1,157,358,084 | $4,303,776,272 |
| 71 | 1.00 | 0.00 | 2095 | $748,656,622 | $5,599,301,055 | $1,186,639,244 | $4,412,661,811 |
| 72 | 1.00 | 0.00 | 2096 | $748,656,622 | $5,740,963,371 | $1,216,661,216 | $4,524,302,155 |
| 73 | 1.00 | 0.00 | 2097 | $748,656,622 | $5,886,209,745 | $1,247,442,745 | $4,638,767,000 |

BC Analysis of Tier 1 and 2 12_17_2024 Qcd Formatted /
NPV Tier 1 2ft SLR over time

Present Value of Net Benefits - Tier 1 Investments

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Appendix F-3, Item III: Tier 1 Adaptation Strategy - Countywide Investments with Control Elevation Changes over time as sea-level rise reaches 2.0 feet by 2050 and thereafter

**Appendix F-3, Item III - Economic Feasibility Analysis of Broward County Flood Adaptation Strategies**
**Tier 1 - Countywide Investments with Control Elevation Changes over time as sea level rises to 2 feet by 2050 and beyond**

| Year Number | Tier 1 Benefits Realized | Tier 2 Benefits Realized | Year | Net Benefits in 2024 dollars | Values are in nominal dollars (2.53% annual inflation) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Total Benefits | Total Costs | Net Benefits |
| 74 | 1.00 | 0.00 | 2098 | $748,656,622 | $6,035,130,851 | $1,279,003,047 | $4,756,127,805 |
| 75 | 1.00 | 0.00 | 2099 | $748,656,622 | $6,187,819,662 | $1,311,361,824 | $4,876,457,838 |
| 76 | 1.00 | 0.00 | 2100 | $748,656,622 | $6,344,371,499 | $1,344,539,278 | $4,999,832,221 |
| 77 | 1.00 | 0.00 | 2101 | $748,656,622 | $6,504,884,098 | $1,378,556,122 | $5,126,327,977 |
| 78 | 1.00 | 0.00 | 2102 | $748,656,622 | $6,669,457,666 | $1,413,433,591 | $5,256,024,074 |
| 79 | 1.00 | 0.00 | 2103 | $748,656,622 | $6,838,194,945 | $1,449,193,461 | $5,389,001,483 |
| 80 | 1.00 | 0.00 | 2104 | $748,656,622 | $7,011,201,277 | $1,485,858,056 | $5,525,343,221 |
| 81 | 1.00 | 0.00 | 2105 | $748,656,622 | $7,188,584,669 | $1,523,450,265 | $5,665,134,405 |
| 82 | 1.00 | 0.00 | 2106 | $748,656,622 | $7,370,455,861 | $1,561,993,556 | $5,808,462,305 |
| 83 | 1.00 | 0.00 | 2107 | $748,656,622 | $7,556,928,395 | $1,601,511,993 | $5,955,416,401 |
| 84 | 1.00 | 0.00 | 2108 | $748,656,622 | $7,748,118,683 | $1,642,030,247 | $6,106,088,436 |
| 85 | 1.00 | 0.00 | 2109 | $748,656,622 | $7,944,146,086 | $1,683,573,612 | $6,260,572,474 |
| 86 | 1.00 | 0.00 | 2110 | $748,656,622 | $8,145,132,982 | $1,726,168,024 | $6,418,964,957 |
| 87 | 1.00 | 0.00 | 2111 | $748,656,622 | $8,351,204,846 | $1,769,840,075 | $6,581,364,771 |
| 88 | 1.00 | 0.00 | 2112 | $748,656,622 | $8,562,490,329 | $1,814,617,029 | $6,747,873,299 |
| 89 | 1.00 | 0.00 | 2113 | $748,656,622 | $8,779,121,334 | $1,860,526,840 | $6,918,594,494 |
| 90 | 1.00 | 0.00 | 2114 | $748,656,622 | $9,001,233,104 | $1,907,598,169 | $7,093,634,935 |
| 91 | 1.00 | 0.00 | 2115 | $748,656,622 | $9,228,964,301 | $1,955,860,403 | $7,273,103,898 |
| 92 | 1.00 | 0.00 | 2116 | $748,656,622 | $9,462,457,098 | $2,005,343,671 | $7,457,113,427 |
| 93 | 1.00 | 0.00 | 2117 | $748,656,622 | $9,701,857,263 | $2,056,078,866 | $7,645,778,397 |
| 94 | 1.00 | 0.00 | 2118 | $748,656,622 | $9,947,314,251 | $2,108,097,661 | $7,839,216,590 |
| 95 | 1.00 | 0.00 | 2119 | $748,656,622 | $10,198,981,302 | $2,161,432,532 | $8,037,548,770 |
| 96 | 1.00 | 0.00 | 2120 | $748,656,622 | $10,457,015,529 | $2,216,116,775 | $8,240,898,754 |
| 97 | 1.00 | 0.00 | 2121 | $748,656,622 | $10,721,578,022 | $2,272,184,530 | $8,449,393,492 |
| 98 | 1.00 | 0.00 | 2122 | $748,656,622 | $10,992,833,946 | $2,329,670,798 | $8,663,163,148 |
| 99 | 1.00 | 0.00 | 2123 | $748,656,622 | $11,270,952,645 | $2,388,611,469 | $8,882,341,175 |
| 100 | 1.00 | 0.00 | 2124 | $748,656,622 | $11,556,107,746 | $2,449,043,340 | $9,107,064,407 |
| 101 | 1.00 | 0.00 | 2125 | $748,656,622 | $11,848,477,272 | $2,511,004,136 | $9,337,473,136 |
| Remaining Useful Value: | | | | $0 | $0 | $0 | $0 |
| | | | | Present Value at 5% annual discount rate: | $32,624,296,812 | $22,682,017,514 | $9,942,279,298 |
| | | | | | | Rate of Return on Investment (IRR), nominal (includes inflation): | 7.27% |
| | | | | | | B/C Ratio | 1.44 |

BC Analysis of Tier 1 and 2 12_17_2024 Qcd Formatted /
NPV Tier 1 2ft SLR over time

Present Value of Net Benefits - Tier 1 Investments

F-3, Item III, Page 6 of 6

# **Appendix G**: Stakeholder Engagement and Public Outreach

## 1. Resilience Plan Steering Committee Presentation

**DATE:** June 8, 2022

**TARGET AUDIENCE:**

Resilience Plan Steering Committee and regional stakeholders involved in resilience planning, policy, and infrastructure development.

This presentation provides an overview of Broward County's Risk Assessment and Resilience Plan, developed over 16 years of resilience policy and planning. It addresses the County's increasing vulnerability to climate change, focusing on SLR, flood risks, and groundwater rise. The presentation discusses the need for resilient infrastructure, including drainage systems, shoreline management, and GI. The team also discussed the economic value of resilience investments, showing a clear return on investment for both building-level and community-wide adaptation strategies. Stakeholder engagement and a phased implementation plan were highlighted as critical components of the strategy to ensure the success of these resilience measures.

**KEY OUTCOMES:**

- Agreement on the need for infrastructure improvements and resilient land use planning.
- Presentation of unified SLR projections for Southeast Florida.
- Economic analysis showing the financial benefits of adaptation strategies.
- Emphasis on the importance of phased implementation and stakeholder engagement.
- Clarification on the need for new resilience standards, flood risk management, and integration of GI.


**ULTIMATE OBJECTIVE:**

**A foundational plan which will benefit our community for decades.**

## 2. Resilient Broward: One Community, A Shared Strategy

**DATE:** June 8, 2022

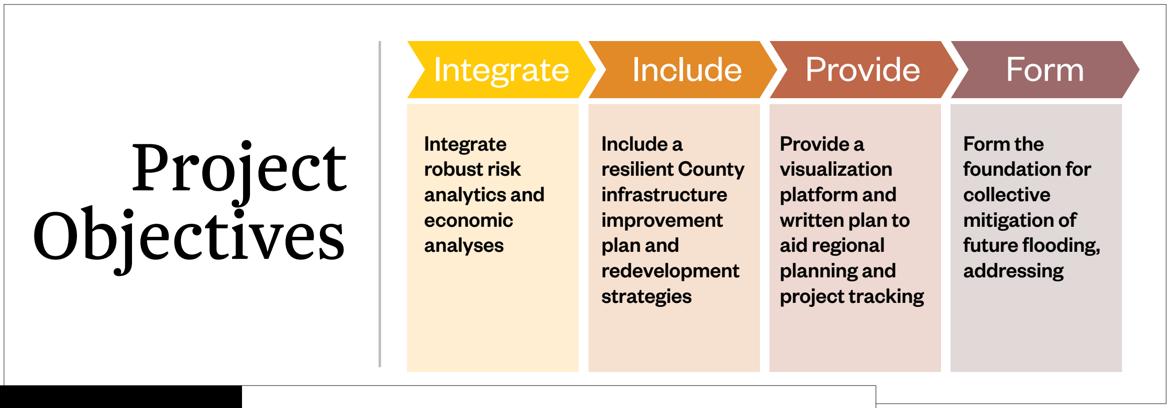
**TARGET AUDIENCE:**

Resilience Steering Committee and other stakeholders involved in county-level climate resilience planning, including public officials, technical experts, and community representatives.

This presentation outlines Broward County's Countywide Risk Assessment and Resilience Plan. It introduces the project objectives, scope of services, and deliverables over a two-year period. The focus is on climate risk assessments, hydrologic modeling, asset analysis, economic modeling, and the development of a resilience adaptation plan. The presentation also highlights the importance of stakeholder engagement and outreach to ensure a successful resilience strategy. The plan is structured to address flooding, SLR, and other climate risks, while providing tools and visualizations to guide infrastructure and policy decisions.

**KEY OUTCOMES:**

- Clear project objectives and scope for developing a comprehensive resilience plan for Broward County.
- Introduction of nine specific tasks, including hydrologic modeling, asset analysis, economic modeling, and resilience adaptation planning.
- Highlighting the importance of stakeholder engagement and the role of the Blue-Ribbon Panel in providing expert guidance.
- Detailed schedule for project milestones and expected deliverables over a two-year period.




# 3. Resilience Steering Committee Presentation

**DATE:** August 10, 2022

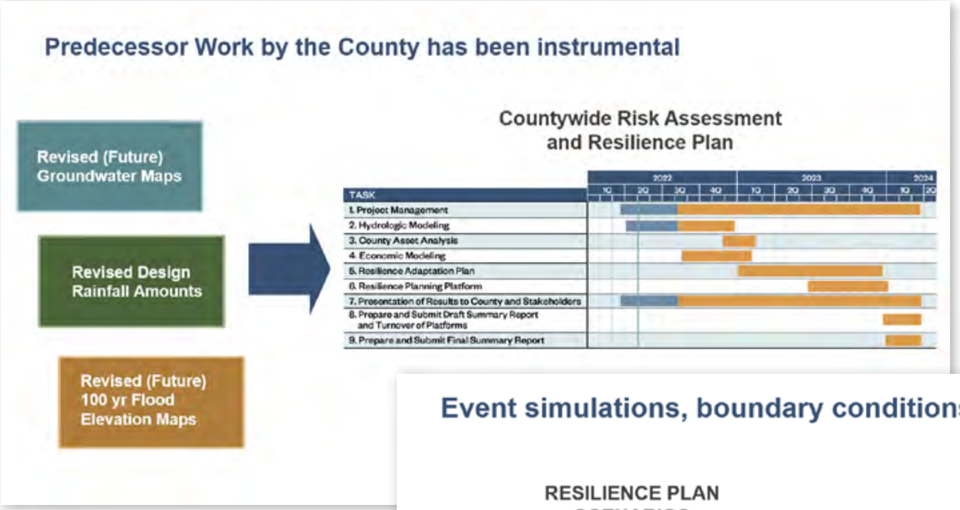
**TARGET AUDIENCE:**

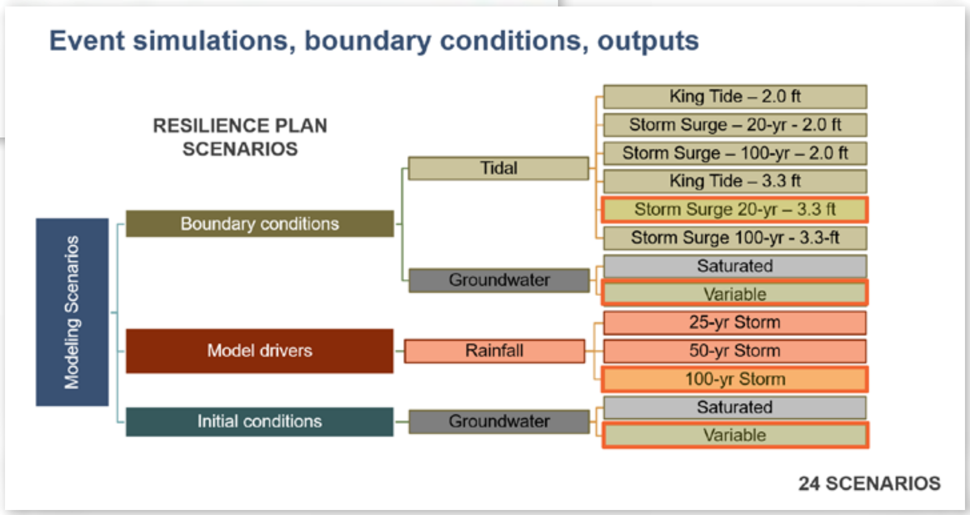
Resilience Steering Committee and other stakeholders involved in regional planning, infrastructure development, and economic modeling for climate resilience.

This presentation provides an update on Broward County's Countywide Risk Assessment and Resilience Plan, with a focus on the progress of hydrologic modeling and economic modeling methodologies. It outlines key elements of South Florida water management, future conditions for the 100-year flood elevation map, and model adaptation strategies. The presentation also introduces the methodology for economic benefits modeling, detailing how adaptation strategies will be assessed for their financial and societal impacts. The goal is to build resilience through improved water management, infrastructure planning, and economic analysis that guides cost-effective adaptation measures.

**KEY OUTCOMES:**

- Progress on hydrologic modeling, including model adaptation to integrate future conditions, increased canal density, and updated boundary conditions for SLR.
- Future conditions 100-year flood elevation map developed to inform flood protection standards.
- Introduction of the economic modeling methodology that will assess adaptation strategy benefits, including avoided costs and financial impacts on residents, businesses, and local governments.
- Focus on the continued refinement of resilience strategies based on hydrologic and economic models.



# 4. Broward Resilience in the Making Project Update

**DATE:** September 2022

**TARGET AUDIENCE:**

Broward County residents, public officials, stakeholders in climate resilience planning, and members of the Steering Committee.

This update provides an overview of Broward County's two-year Resilience Plan, which aims to build community resilience to climate change impacts, focusing on flooding and extreme heat. It highlights the use of hydrologic modeling to assess future flood conditions, including SLR, rainfall, and storm surge. The plan incorporates economic analyses to evaluate the direct and indirect impacts of flood risks and adaptation investments. It also emphasizes the importance of GI solutions for water management and urban cooling, particularly in areas where extreme heat and vulnerable populations intersect. The document mentions the role of the project Steering Committee in providing oversight and outlines a commitment to provide quarterly progress updates.

**KEY OUTCOMES:**

- Introduction of hydrologic modeling for evaluating future flood conditions and informing adaptation strategies.
- Inclusion of economic analyses to understand the impacts of flooding on different sectors and inform investment decisions.
- Emphasis on GI solutions to address both flood and heat risks, particularly in vulnerable areas.
- Establishment of a Steering Committee for planning oversight and a commitment to provide regular progress updates.

## 5. Planning and Utility Directors Roundtable – Stakeholder Workshop Presentation

**DATE:** September 15, 2022

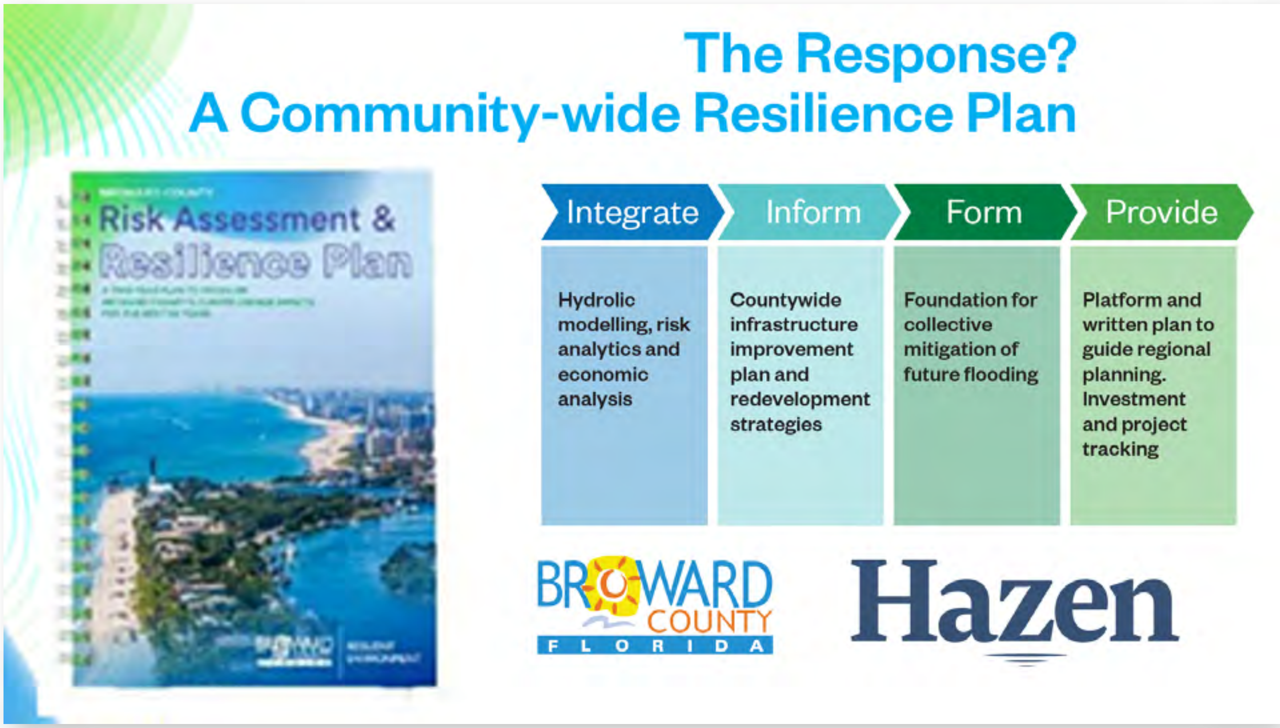
**TARGET AUDIENCE:**

Broward County stakeholders, public officials, and community leaders involved in resilience planning and climate adaptation strategies.

This presentation outlines Broward County's two-year Resilience Plan, which focuses on building community resilience to climate change impacts, specifically flooding and SLR. It presents SLR projections and discusses the County's historical efforts in resilience policy and planning. Key components of the plan include hydrologic modeling, risk analytics, and economic analyses to support infrastructure improvements, redevelopment strategies, and coordinated water management. The plan emphasizes stakeholder engagement through workshops and a dedicated 20-member Steering Committee. The presentation also highlights the business case for resilience, showing a strong return on investment for both building-level and community-wide adaptation strategies.

**KEY OUTCOMES:**

- Introduction to the County's updated SLR projections and flood maps, indicating the necessity for a comprehensive resilience strategy.
- Development of an infrastructure improvement plan and strategies for countywide resilience.
- Promotion of a business case for resilience.
- Emphasis on community-wide coordination and input as vital components of planning.



# 6. Resilience Steering Committee Presentation

**DATE:** October 12, 2022

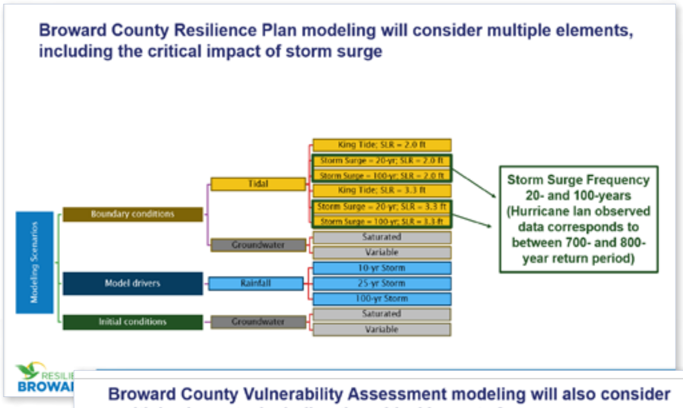
**TARGET AUDIENCE:**

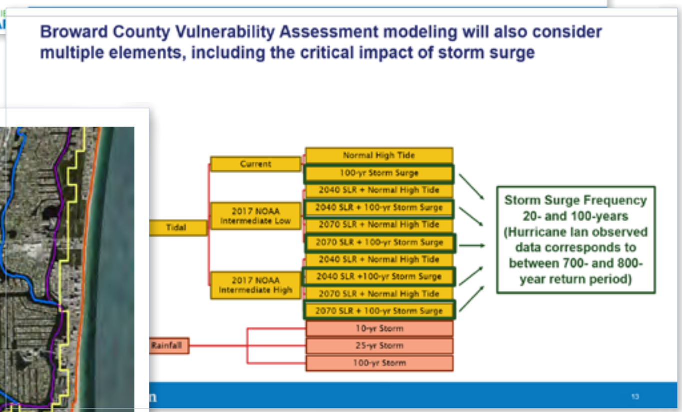
Broward County Resilience Steering Committee, public officials, stakeholders in climate resilience, and infrastructure planning professionals.

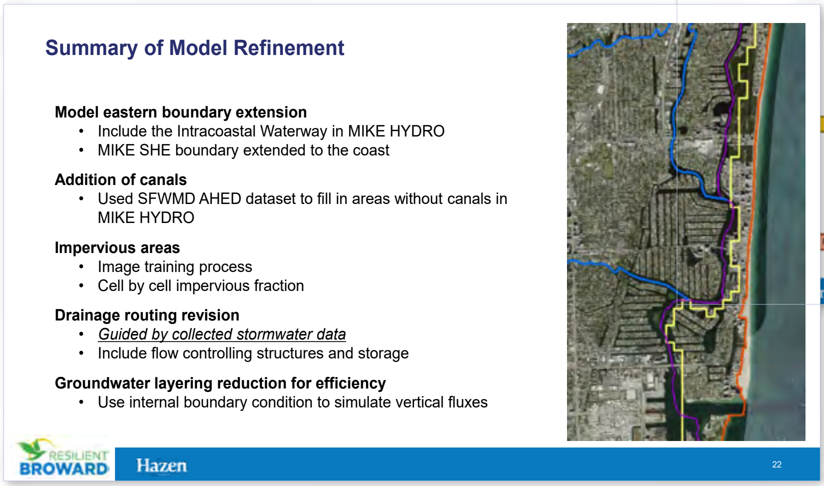
This presentation, given during the Resilience Steering Committee meeting on October 12, 2022, provides updates on Broward County's Countywide Risk Assessment and Resilience Plan. It begins with a reflection on Hurricane Ian, emphasizing the importance of evaluating compound flood risks. The presentation then reviews the ongoing data collection efforts from stakeholders and the incorporation of this data into the hydrologic model. Updates on the economic modeling process are also discussed, focusing on how the plan will measure the benefits of adaptation strategies in terms of avoided losses and costs. Additionally, the presentation introduces "the Platform," a tool to visualize flood scenarios, track progress, and showcase adaptation strategies. The presentation concludes by outlining next steps, including further stakeholder engagement and the development of the Resilience Adaptation Plan with actionable countywide strategies.

**KEY OUTCOMES:**

- Reflection on Hurricane Ian's impacts, highlighting the need to consider compound flood factors in resilience planning.
- Updates on data collection and integration into the hydrologic model to improve flood risk assessments.
- Progress in economic modeling, with an emphasis on measuring the financial benefits of various adaptation strategies.
- Introduction of "the Platform," which will support scenario visualization and stakeholder engagement.
- Preparation for further stakeholder engagement to guide the development of countywide adaptation and mitigation strategies.



# 7. Broward Resilience in the Making Project Update

**DATE:** November 2022

**TARGET AUDIENCE:**

Broward County Resilience Steering Committee, municipal stakeholders, water management professionals, and other parties involved in climate resilience planning.

This document provides updates on Broward County's Resilience Plan as of November 2022. It covers the latest developments in the hydrologic model, which has been updated to include current pervious/impervious cover data and detailed stormwater information. The third meeting of the Resilience Plan Steering Committee, held on October 12, 2022, focused on reviewing project model scenarios, including SLR, storm surge, and rainfall, in light of events like Hurricane Ian. The importance of compound flood factors and the focus on higher frequency return period events for resilient infrastructure design were emphasized. Additionally, the document mentions stakeholder coordination efforts, including a recent kick-off workshop for municipalities and the water management community. Upcoming steps involve moving into adaptation planning and economic modeling phases, with updates on the development of the online platform for presenting flood risk and adaptation projects.

**KEY OUTCOMES:**

- Completion of the hydrologic model updates with current stormwater data and land cover information.
- Review of model scenarios to incorporate SLR, storm surge, and rainfall impacts.
- Emphasis on the need to focus on compound flood factors and high-frequency events for infrastructure resilience.
- Introduction of a template for an online platform to display flood risks and adaptation project performance.
- Announcement of upcoming workshops to review preliminary model results and begin adaptation planning.

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BROWARD COUNTY: A RESILIENCE PLAN IN THE MAKING

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#ResilientBroward

November 2022

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**Progress Update:**

The County's base hydrologic model has been updated to incorporate current pervious/impervious cover county-wide and detailed stormwater data, information that will improve model performance and guide adaptation strategies. Local data and insights will continue to be solicited to support model validation and adaptation plan development.

The Resilience Plan Steering Committee held its third meeting on October 12, 2022, with a detailed review of project model scenarios, including sea level rise, storm surge and rainfall in the context of Hurricane Ian and observed impacts. Presentations reinforced the importance of accounting for compound flood factors, but also the plan's emphasis on higher frequency return period events needed for resilient infrastructure design as opposed to low-frequency high-impact events that provide the basis for evacuation planning.

The Steering Committee was provided an initial glimpse of the anticipated features of a template Resilience Plan on-line platform with localized visuals to present flood risk and performance of preferred adaptation projects.

**Stakeholder Coordination:**

The County recently held a stakeholder kick-off workshop (Sept 15) for municipalities and the water management community, with nearly 100 attendees. The next several workshops (into January) will include preliminary model results and sub-regional in-person workshops to review model results and identify flood locations and water management issues of local concern. Additional opportunities for formal engagement will be posted on the plan website as efforts progress.

**Next Steps:**

We anticipate moving into the preliminary phases of adaptation planning and evaluation of the economic modelling toward the end of the first quarter of 2023 and will be sharing updates about the platform as it is developed.

*NOAA Estimates for the Surge Produced by a Category 4 Hurricane - Sea, Lakes and Overland Surges*

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# 8. Resilience Steering Committee Presentation

**DATE:** December 14, 2022

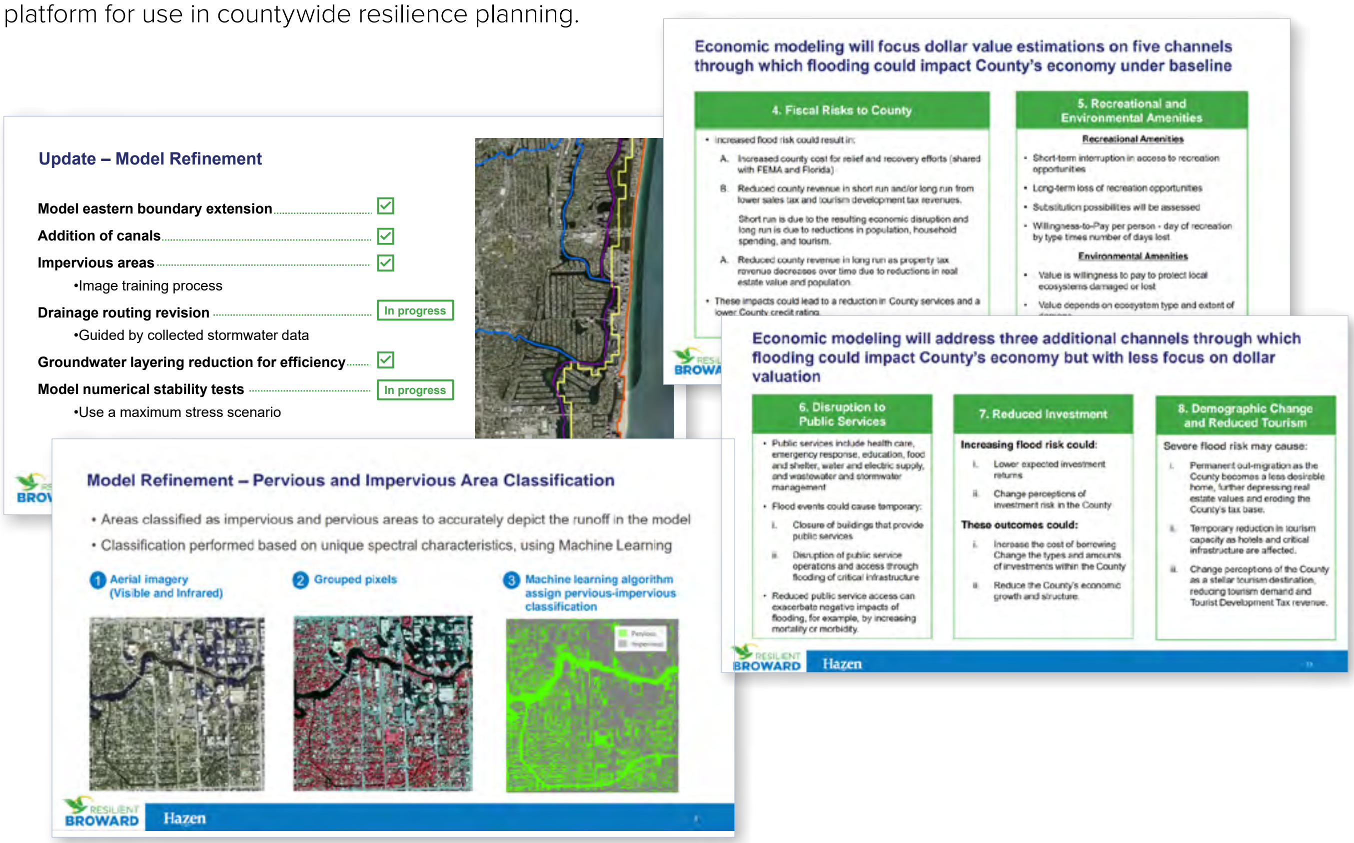
**TARGET AUDIENCE:**

Broward County Resilience Steering Committee, public officials, local governments, and stakeholders involved in climate resilience and infrastructure planning.

This presentation, delivered at the Resilience Steering Committee meeting on December 14, 2022, provides updates on Broward County's Countywide Risk Assessment and Resilience Plan. It highlights the recent data collection efforts, the progress in refining the hydrologic model, and updates on economic modeling that focuses on evaluating the direct and indirect impacts of flooding. The presentation introduces the "Platform" development for visualizing risk assessment data and outlines the County Asset Analysis, which involves assessing the risk to county-owned assets and conceptualizing site-specific adaptations. Additionally, the presentation discusses next steps, including engaging stakeholders, further developing the economic model, and completing the platform for use in countywide resilience planning.

**KEY OUTCOMES:**

- Completion of the stormwater data collection phase to inform the hydrologic model.
- Continued refinement of the hydrologic model to include detailed assessments of pervious and impervious areas.
- Focus on economic modeling to estimate the dollar value impacts of flooding on the County's economy, including building damage, business downtime, fiscal risks, and changes in real estate values.
- Introduction of the County Asset Analysis, which aims to assess risks and develop a standard methodology for reviewing future Capital Improvement Plan projects.
- Overview of next steps, including stakeholder engagement through the Blue Ribbon Panel and platform development to support ongoing resilience efforts.



# 9. Broward Resilience in the Making Project Update

**DATE:** December 2022

**TARGET AUDIENCE:**

Broward County Resilience Steering Committee, public officials, local governments, and stakeholders involved in climate resilience planning and infrastructure management.

This document provides updates from the fourth meeting of the Broward County Resilience Plan Steering Committee held on December 14, 2022. Key progress includes updates on hydrologic and economic modeling, the readiness of the hydrologic model to run no-action flood-risk scenarios, and data collection efforts completed in coordination with water managers and municipalities. The County Asset Analysis is set to begin, focusing on risk assessment and ranking of County-owned assets. The development of adaptation strategies and a standardized review methodology for future Capital Improvements Plan projects is also underway. Additionally, insights gained from the Regional Climate Leadership Summit will inform the County's communication and engagement strategies.

**KEY OUTCOMES:**

- Hydrologic model updates, including the ability to run no-action flood-risk scenarios for future evaluations.
- County Asset Analysis to assess flood risks to County-owned properties and develop adaptation strategies.
- Integration of feedback from the 14th Regional Climate Leadership Summit to inform communication and engagement strategies.
- Development of a methodology for reviewing future Capital Improvements Plan projects.

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BROWARD COUNTY: A RESILIENCE PLAN IN THE MAKING

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December 2022

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**Progress Update:**

The Resilience Plan Steering Committee held its fourth meeting on December 14, 2022, with progress reports on hydrologic and economic modeling advancements and development of the Resilience Platform. Staff shared updates on the approach to economic and community engagement strategies based on insights gained from the County's hosting of the 14th Regional Climate Leadership Summit on December 8-9, 2022 with panelists and attendees that included several members of the Blue Ribbon Panel supporting development of the Resilience Plan.

The County's hydrologic model has been fully updated, including refinement of canal features, impervious/pervious data reflective of land use, and expansion of the land-based model to better integrate with the coastal component for storm surge analyses. Data collection in coordination with water managers and municipalities is also complete. The model is now ready to run the no-action flood-risk scenarios for individual and compound flood conditions. Results are expected to be shared at the February Steering Committee meeting.

**County Asset Analysis:**

The Hazen and Sawyer team is ready to begin analysis of County-owned assets and development of a risk assessment and ranking feature to define the exposure and potential opportunities for adaptation strategies. They will also work with County staff to assess projects in the design phase and work to conceptualize site adaptations. This activity will culminate in the development of a standard methodology for the review of future Capital Improvements Plan projects, whether county- or municipally-owned.

**Next Steps:**

County staff is coordinating with the consultant team to convene the Blue Ribbon Panel members in early 2022 while we work alongside the communication specialists and the outreach team to develop the communications plan framework. The Blue Ribbon Panel will be asked to advise on the overall economics and communications, and engagement strategies prior to finalizing and advancing an approved plan.

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# 10. Resilience Steering Committee Presentation

**DATE:** February 8, 2023

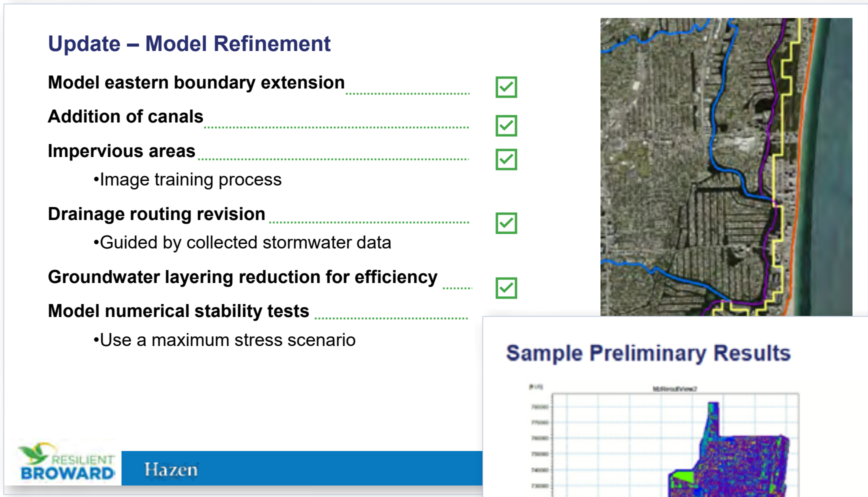
**TARGET AUDIENCE:**

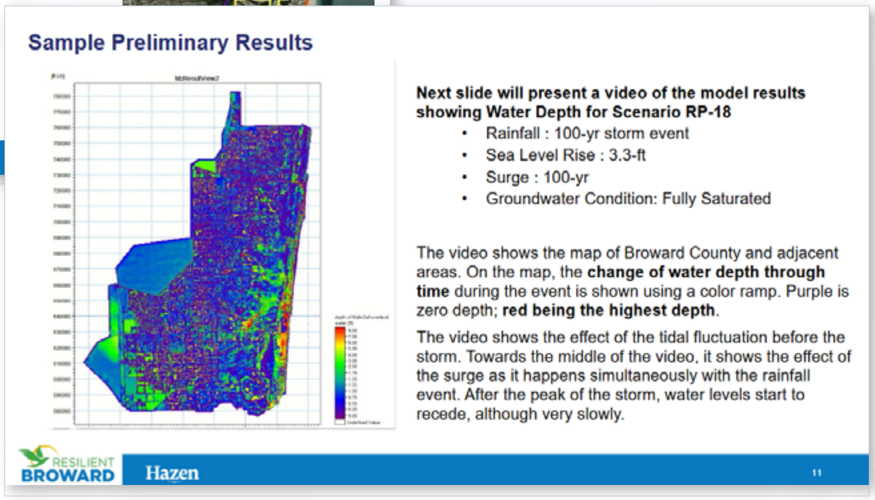
Broward County Resilience Steering Committee, public officials, stakeholders, and experts involved in the Resilience Plan, including hydrologic and economic modeling specialists.

This presentation provides updates on Broward County's Resilience Plan progress as of the February 8, 2023, Steering Committee meeting. Key areas covered include economic modeling, hydrologic modeling, County asset analysis, and coordination with the Blue-Ribbon Panel. The economic modeling update introduces the Vivid Adaptive Regional Input-Output (V-ARIO) model, which simulates post-disaster economic impacts. Hydrologic modeling refinements were made, including updates to groundwater layers, impervious areas, and stormwater data. The County asset analysis includes identifying critical infrastructure and developing adaptation strategies. Stakeholder engagement and feedback from experts continue to guide these efforts.

**KEY OUTCOMES:**

- Introduction of the V-ARIO model to assess the economic impacts of flooding and recovery efforts.
- The hydrologic model was refined to simulate multiple scenarios, including SLR, storm surge, and groundwater conditions.
- Progress on the County Asset Analysis, identifying critical assets and developing site-specific adaptation plans.
- Continued coordination with the Blue-Ribbon Panel on risk modeling, social equity, and equitable redevelopment.



# 11. Broward Resilience in the Making Project Update

**DATE:** February/March 2023

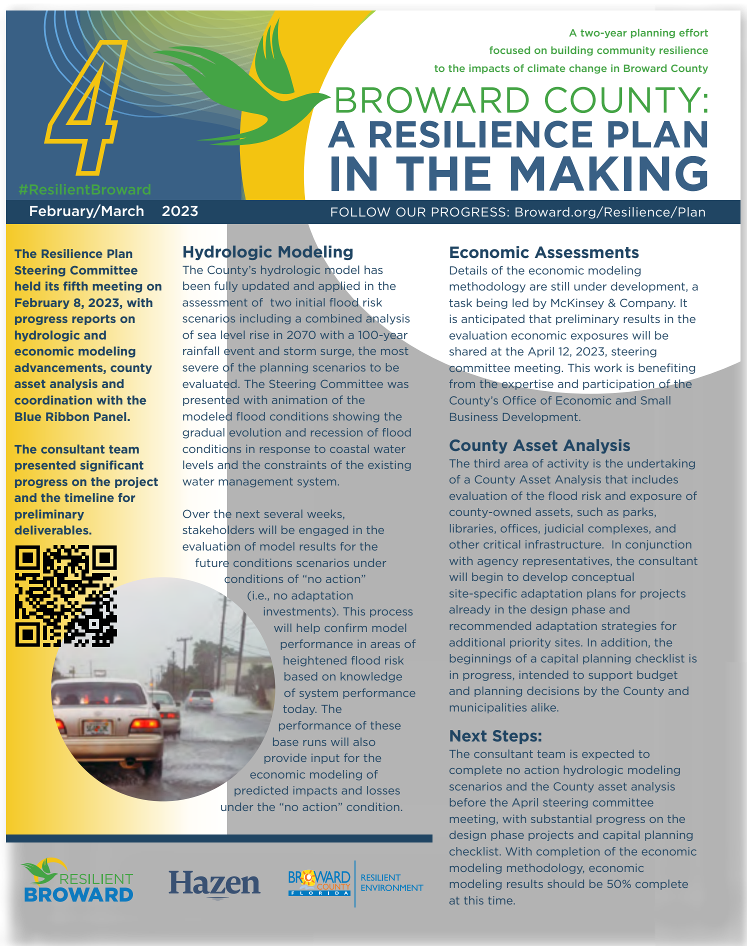
**TARGET AUDIENCE:**

Broward County Resilience Steering Committee, public officials, local governments, and stakeholders involved in climate resilience planning and infrastructure management.

This report provides updates from the fifth meeting of the Broward County Resilience Plan Steering Committee, held on February 8, 2023. It highlights advancements in hydrologic modeling, economic assessments, and County asset analysis. The hydrologic model was applied to assess future flood risks under severe conditions, including SLR in 2070 combined with a 100-year rainfall event and storm surge. Stakeholders will be engaged to evaluate these model results. The economic modeling methodology, led by McKinsey & Company, is still under development, with preliminary results expected by April. The County Asset Analysis focuses on assessing flood risks to County-owned infrastructure and developing adaptation strategies. A capital planning checklist is also in progress to guide future budget and planning decisions for resilience investments.

**KEY OUTCOMES:**

- Hydrologic modeling will be applied to future flood risk scenarios, including SLR and severe storm events, and stakeholder engagement will be planned to evaluate the results.
- Economic modeling methodology is still in progress, with preliminary results expected in April 2023.
- Ongoing County Asset Analysis to assess flood risks to critical infrastructure and develop site-specific adaptation strategies.
- Development of a capital planning checklist to support future resilience investments and budget planning.



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BROWARD COUNTY: A RESILIENCE PLAN IN THE MAKING

February/March 2023

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**The Resilience Plan Steering Committee held its fifth meeting on February 8, 2023, with progress reports on hydrologic and economic modeling advancements, county asset analysis and coordination with the Blue Ribbon Panel.**

**The consultant team presented significant progress on the project and the timeline for preliminary deliverables.**

**Hydrologic Modeling**

The County's hydrologic model has been fully updated and applied in the assessment of two initial flood risk scenarios including a combined analysis of sea level rise in 2070 with a 100-year rainfall event and storm surge, the most severe of the planning scenarios to be evaluated. The Steering Committee was presented with animation of the modeled flood conditions showing the gradual evolution and recession of flood conditions in response to coastal water levels and the constraints of the existing water management system.

Over the next several weeks, stakeholders will be engaged in the evaluation of model results for the future conditions scenarios under conditions of "no action" (i.e., no adaptation investments). This process will help confirm model performance in areas of heightened flood risk based on knowledge of system performance today. The performance of these base runs will also provide input for the economic modeling of predicted impacts and losses under the "no action" condition.

**Economic Assessments**

Details of the economic modeling methodology are still under development, a task being led by McKinsey & Company. It is anticipated that preliminary results in the evaluation economic exposures will be shared at the April 12, 2023, steering committee meeting. This work is benefiting from the expertise and participation of the County's Office of Economic and Small Business Development.

**County Asset Analysis**

The third area of activity is the undertaking of a County Asset Analysis that includes evaluation of the flood risk and exposure of county-owned assets, such as parks, libraries, offices, judicial complexes, and other critical infrastructure. In conjunction with agency representatives, the consultant will begin to develop conceptual site-specific adaptation plans for projects already in the design phase and recommended adaptation strategies for additional priority sites. In addition, the beginnings of a capital planning checklist is in progress, intended to support budget and planning decisions by the County and municipalities alike.

**Next Steps:**

The consultant team is expected to complete no action hydrologic modeling scenarios and the County asset analysis before the April steering committee meeting, with substantial progress on the design phase projects and capital planning checklist. With completion of the economic modeling methodology, economic modeling results should be 50% complete at this time.

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# 12. Resilience Steering Committee Presentation

**DATE:** April 12, 2023

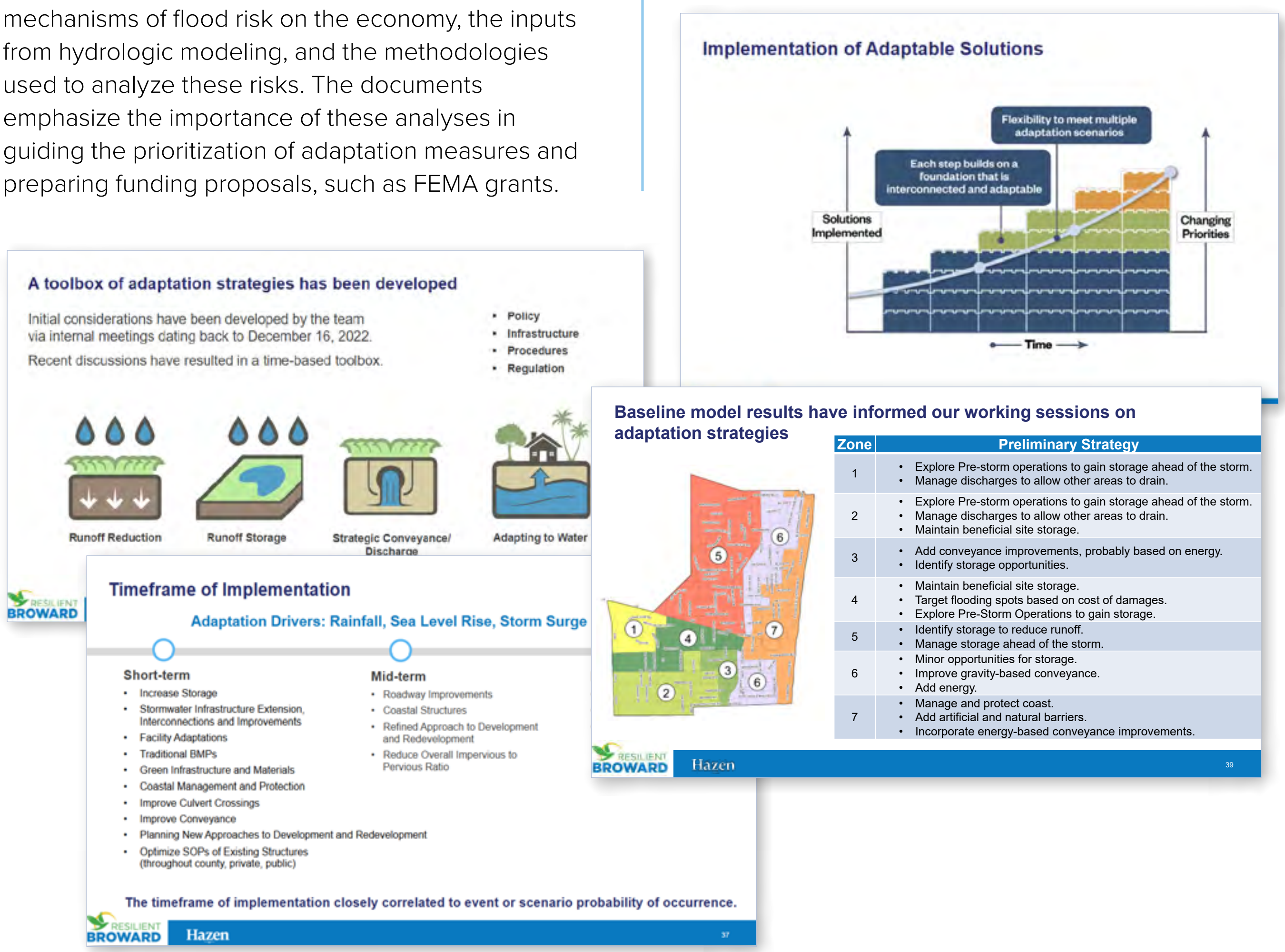
**TARGET AUDIENCE:**

Broward County Resilience Steering Committee, public officials, and stakeholders involved in resilience planning, economic modeling, and climate adaptation.

In this presentation, a PowerPoint and Economic Modeling Memorandum was used to provide an overview of the economic modeling methodology and progress updates for Broward County's Countywide Risk Assessment and Resilience Plan. The economic modeling focuses on quantifying the socioeconomic impacts of flooding and the benefits of climate adaptation strategies. The modeling covers various areas, including short-term economic losses, increased flood insurance premiums, reduced real estate values, and fiscal risks to the County. Additionally, the presentation outlines the key mechanisms of flood risk on the economy, the inputs from hydrologic modeling, and the methodologies used to analyze these risks. The documents emphasize the importance of these analyses in guiding the prioritization of adaptation measures and preparing funding proposals, such as FEMA grants.

**KEY OUTCOMES:**

- Clear methodology for economic analysis focusing on flood risks and potential mitigation benefits.
- Detailed inputs from hydrologic modeling, such as flood depth, damage estimates, and economic losses.
- Analysis of four primary areas: short-term economic losses, insurance premiums, real estate values, and fiscal risks.
- Emphasis on adaptation strategies, stakeholder engagement, and use of data to inform policy decisions and grant applications.



# 13. Broward Resilience in the Making Project Update

**DATE:** April/May 2023

**TARGET AUDIENCE:**

Broward County Resilience Steering Committee, public officials, local governments, and stakeholders involved in resilience planning and infrastructure development.

This report provides updates from the sixth meeting of the Broward County Resilience Plan Steering Committee held on April 12, 2023. It focuses on key milestones, including the completion of the economic modeling methodology, initial results from the hydrologic modeling, and the County asset analysis. The economic modeling methodology will integrate data from small businesses to assess the impacts of flooding, while the hydrologic model results viewer allows stakeholders to compare flood risks under different scenarios. The report also introduces ongoing efforts to develop adaptation strategies aimed at reducing stormwater runoff, improving water conveyance, and managing future hydrologic challenges. The next steps include stakeholder engagement through regional meetings and the continued development of cost-benefit analyses for adaptation investments.

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## BROWARD COUNTY: A RESILIENCE PLAN IN THE MAKING

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April/May 2023

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**The Resilience Plan Steering Committee held its sixth meeting on April 12, 2023, with progress reports on the Economic Methodology Memorandum, the initial hydrologic modeling results viewer and the County asset analysis.**

### Economic Modeling

Economic Modeling Methodology: The economic consulting team provided a presentation on the final economic modeling methodology that has been accepted by the County. This represents the completion of a significant milestone and brings us closer to combining the hydrologic model results as an input to the economic model. County staff are currently engaged with delivering small business economic data to the consultants in support of this task. This effort is expected to continue through the summer and updates will be provided at future meetings.

### County Asset Analysis

Hazen representatives held two meetings with agency staff to support the County asset analysis including the ranking and weighting criteria and methodology. Next steps will include a facilitated group exercise to refine the approach with application to selection of county sites. It is anticipated that experiences from the April 2023 rain event will inform this exercise (a timely misfortune). This task has broader community relevance as a capital project planning checklist will be developed in parallel to the analysis and shared with Broward municipalities for use in review of facility and infrastructure investments.

### Hydrologic Model Results Viewer

The consultant team shared the model results viewer with the Committee and gave a brief demonstration on how the tool works and will be used in the engagement with local governments to explore the validity of the model results and aid in the identification of adaptation priorities and opportunities. The viewer allows comparison of model outputs across scenarios and location-specific estimates of flood depth under compound flood conditions. The model results themselves will be useful in comparing to flood depths measured in April 2023. The Hazen team will be holding 6 sub-regional stakeholder meetings to review the results and solicit feedback during the months of May and June (to be announced shortly).

### Adaptation Approaches

The Hazen team has begun to look at potential adaptation strategies that include changes to policy, infrastructure, procedures, and regulations to support a toolbox or pool of potential options. The main goals are to reduce and store stormwater runoff, improve conveyance and manage discharges in adapting to future hydrologic conditions and land use changes. A timeline for implementation, ranging from short- to long-term, will be developed for a variety of potential adaptations that correspond to the type of event, and the probability of occurrence. The adaptation investments will need to be sequenced so as to build upon previous investments, allowing for modification, and while providing a base for longer-term solutions.

### Next Steps

The consultant is working to finalize the hydrologic model viewer and will be scheduling the stakeholder meetings for early summer. The no action hydrologic model results will be used by the economic modeling team to develop the cost-benefit scenarios for different investment decisions and outcomes. The next Resilience Plan Steering Committee Meeting will be held on June 14, 2023.

*Photo: Street flooding along Riverland Road, Davie, 4/13/2023. Inset: Rescue vehicle, Fort Lauderdale.*

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**KEY OUTCOMES:**

- Completion of the economic modeling methodology, with integration of hydrologic model results to assess flood impacts.
- Progress on the County asset analysis, with a focus on ranking and prioritization for capital planning.
- Demonstration of the hydrologic model results viewer to aid local governments in understanding flood risks and identifying adaptation opportunities.
- Initiation of adaptation strategies aimed at stormwater management and future land use challenges.
- Announcement of upcoming stakeholder meetings to gather feedback on flood model results and adaptation strategies.

# 14. Subregional Stakeholder Meetings – Meeting 1/Group 1

**DATE:** May 22, 2023

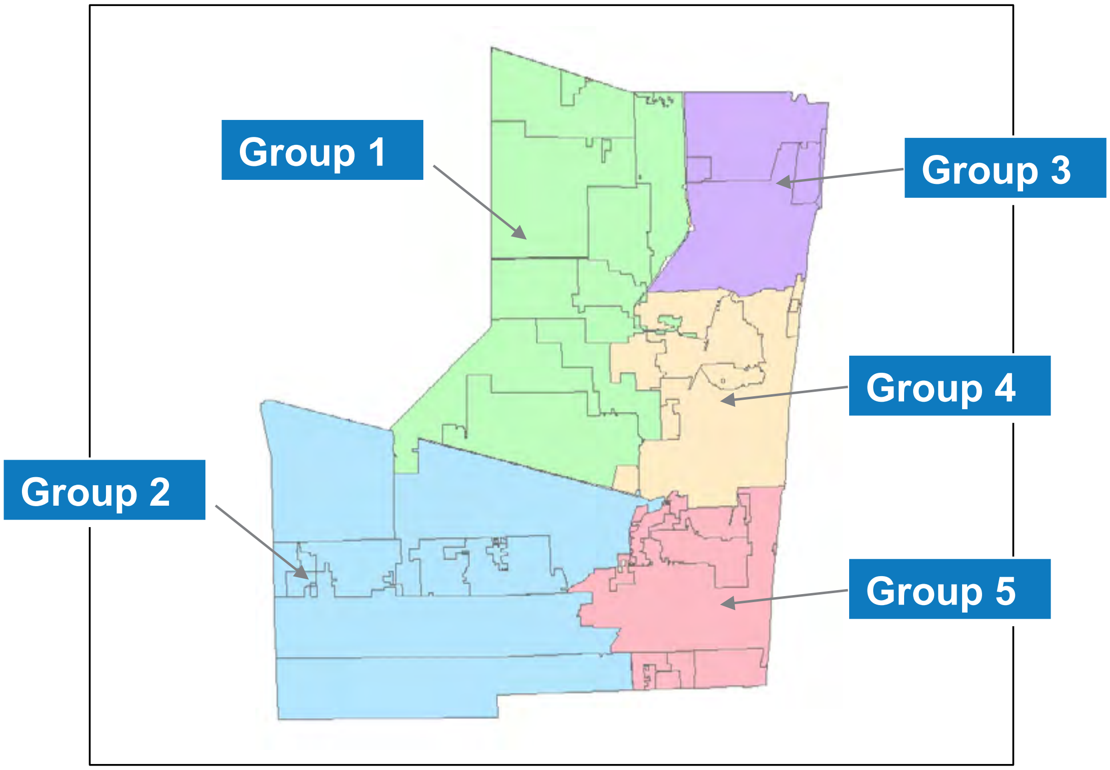
**TARGET AUDIENCE:**

Countywide stakeholders, including local municipalities, water control districts, and other regional entities.

This presentation discusses the baseline hydrologic model results as part of Broward County's Countywide Risk Assessment and Resilience Plan. The Hazen team led sub-regional stakeholder workshops in May and June 2023 to refine the model and inform adaptation strategies. The presentation covers the model's evolution, various scenarios analyzed (including rainfall and storm surge impacts), and future steps for stakeholder involvement. It also highlights tools like the review platform and breakout sessions for in-depth analysis.

**KEY OUTCOMES:**

- Refinement of hydrologic models based on stakeholder input.
- Enhanced understanding of flood risk and resilience strategies.
- Planned adaptation strategies informed by model results.



# 15. Subregional Stakeholder Meetings – Meeting 2/Group 2

**DATE:** May 22, 2023

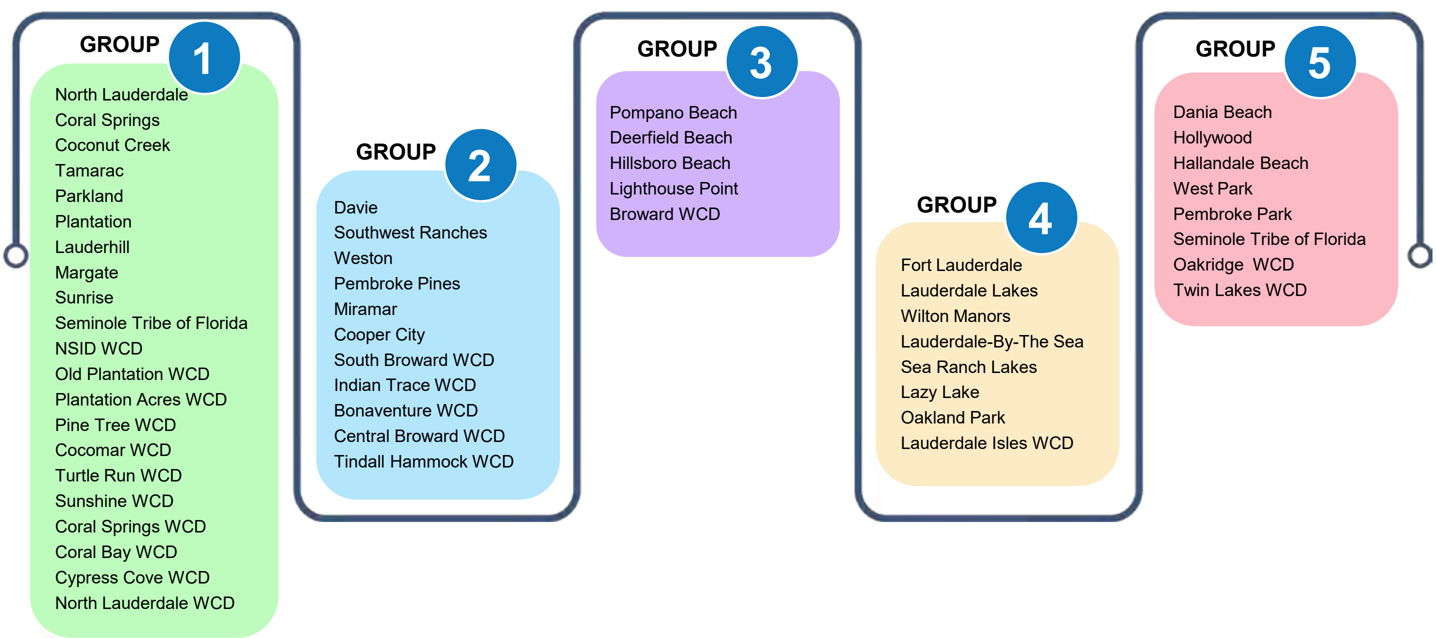
**TARGET AUDIENCE:**

Countywide stakeholders, including municipalities, water control districts, and regional entities.

The presentation provides baseline hydrologic model results for Broward County's Countywide Risk Assessment and Resilience Plan. It outlines the model's evolution and details the scenarios analyzed, which focus on varying conditions of rainfall, SLR, and storm surge impacts. Stakeholder review workshops were held in May and June 2023 to refine the model and inform adaptation strategies. The presentation also introduced tools for reviewing model results and facilitated breakout sessions for in-depth discussions.

**KEY OUTCOMES:**

- Refinement of hydrologic models based on stakeholder input.
- Detailed analysis of flood risks and adaptation strategies.
- Development of tools to visualize and compare flood scenarios.



## 16. Subregional Stakeholder Meetings – Meeting 3/Group 3

**DATE:** May 22, 2023

**TARGET AUDIENCE:**

Countywide stakeholders, including municipalities, water control districts, and regional entities.

The presentation provides baseline hydrologic model results for Broward County's Countywide Risk Assessment and Resilience Plan. It outlines the model's evolution and details the scenarios analyzed, which focus on varying conditions of rainfall, SLR, and storm surge impacts. Stakeholder review workshops were held in May and June 2023 to refine the model and inform adaptation strategies. The presentation also introduced tools for reviewing model results and facilitated breakout sessions for in-depth discussions.

**KEY OUTCOMES:**

- Refinement of hydrologic models based on stakeholder input.
- Detailed analysis of flood risks and adaptation strategies.
- Development of tools to visualize and compare flood scenarios.

## 17. Subregional Stakeholder Meetings – Meeting 4/Group 4

**DATE:** May 22, 2023

**TARGET AUDIENCE:**

Countywide stakeholders, including municipalities, water control districts, and regional entities.

The presentation provides baseline hydrologic model results for Broward County's Countywide Risk Assessment and Resilience Plan. It outlines the model's evolution and details the scenarios analyzed, which focus on varying conditions of rainfall, SLR, and storm surge impacts. Stakeholder review workshops were held in May and June 2023 to refine the model and inform adaptation strategies. The presentation also introduced tools for reviewing model results and facilitated breakout sessions for in-depth discussions.

**KEY OUTCOMES:**

- Refinement of hydrologic models based on stakeholder input.
- Detailed analysis of flood risks and adaptation strategies.
- Development of tools to visualize and compare flood scenarios.

## 18. Subregional Stakeholder Meetings – Meeting 5/Group 5

**DATE:** May 22, 2023

**TARGET AUDIENCE:**

Countywide stakeholders, including municipalities, water control districts, and regional entities.

The presentation provides baseline hydrologic model results for Broward County's Countywide Risk Assessment and Resilience Plan. It outlines the model's evolution and details the scenarios analyzed, which focus on varying conditions of rainfall, SLR, and storm surge impacts. Stakeholder review workshops were held in May and June 2023 to refine the model and inform adaptation strategies. The presentation also introduced tools for reviewing model results and facilitated breakout sessions for in-depth discussions.

**KEY OUTCOMES:**

- Refinement of hydrologic models based on stakeholder input.
- Detailed analysis of flood risks and adaptation strategies.
- Development of tools to visualize and compare flood scenarios.

# 19. Resilience Steering Committee Presentation

**DATE:** August 23, 2023

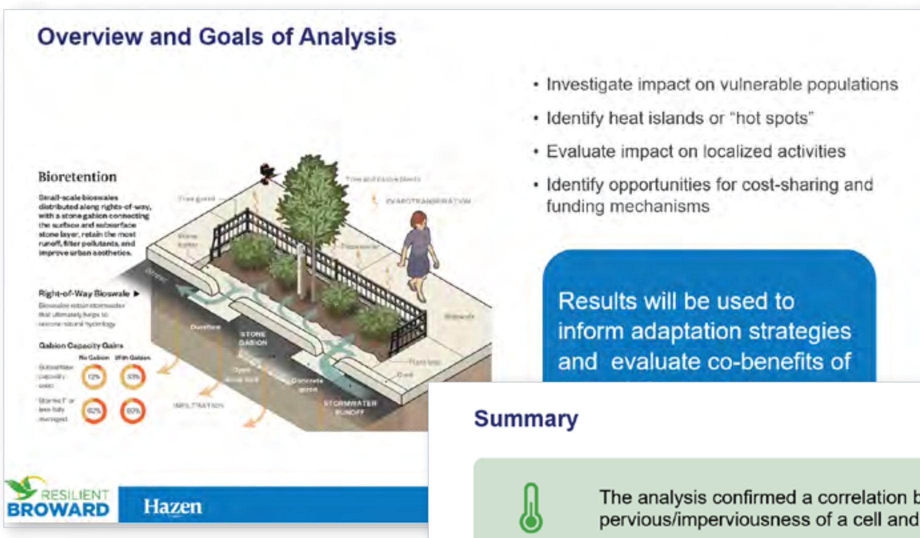
**TARGET AUDIENCE:**

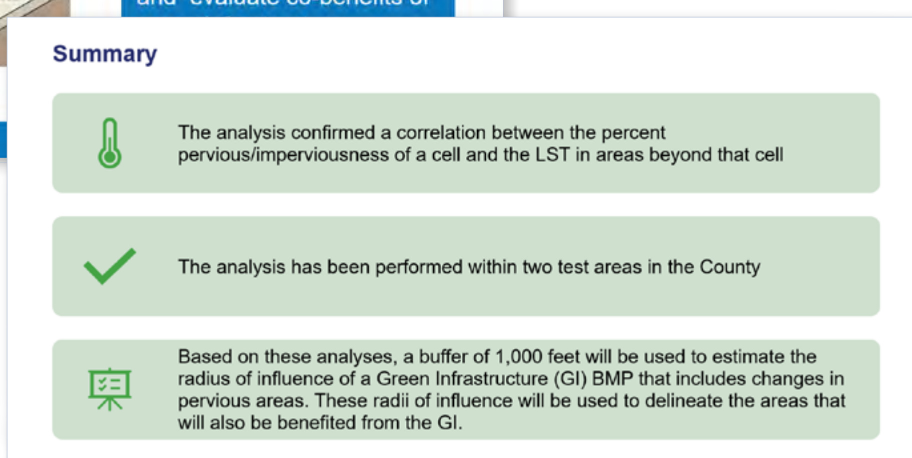
Broward County Steering Committee members, local government officials, municipal planners, and key stakeholders involved in resilience planning, climate adaptation, and infrastructure development.

This presentation outlines the progress of Broward County's Countywide Risk Assessment and Resilience Plan as of August 23, 2023. Key topics included the analysis of land surface temperatures, the identification of urban heat islands, and the impact of extreme temperatures on vulnerable populations. Stakeholder input informed the modeling results and adaptation strategies, which include water runoff reduction, enhanced storage, and strategic conveyance improvements. The presentation also discussed ongoing economic modeling, a risk analysis of critical assets, and a new roadway risk assessment methodology. Adaptation strategies focus on balancing infrastructure and policy-based solutions to address rising sea levels, storm surges, and groundwater management challenges.

**KEY OUTCOMES:**

- Land surface temperature analysis identified key hotspots in coastal areas, prompting discussions on GI solutions.
- Stakeholder feedback corroborated the model results, leading to adjustments in adaptation strategies, particularly for flood-prone and economically vulnerable areas.
- Risk assessment methodology was developed for critical assets, scoring them on factors like service impact and asset value.
- A new roadway risk analysis identified key roadways vulnerable to flooding, prioritizing evacuation routes and areas with high traffic volumes for adaptation.



# 20. Community Foundation Listening Session

**DATE:** October 31, 2023

**TARGET AUDIENCE:**

Broward County Resilience Steering Committee and the Community Foundation of Broward.

The Broward Countywide Risk Assessment and Resilience Plan Listening Session with the Community Foundation was held on October 31, 2023. The virtual session began with an introduction to the Resilience Plan, focusing on its multi-faceted goals, including risk analytics, economic analyses, infrastructure improvement, and strategies for mitigating flooding and heat impacts. The discussion emphasized the role of community engagement and targeted adaptations. Sheri Brown Grosvenor from the Community Foundation shared insights on how flooding and heat impact nonprofits, highlighting the need for better advocacy, funding, and infrastructure support. The session explored ways to involve and educate nonprofits in climate resilience efforts, address building and homeowner needs, and improve communication and disaster response. It concluded with suggestions for potential partners and neighborhoods for future outreach.

**KEY OUTCOMES:**

- Recognition of the critical role nonprofits play in disaster response and the challenges they face, including funding gaps and infrastructure deficiencies.
- Emphasis on the need for targeted advocacy and community communication to address the concerns of low-income and marginalized neighborhoods.
- Suggestions for partnerships, including working with local nonprofits like the Youth Environmental Alliance and exploring ways to incorporate climate resilience into nonprofit missions.
- Identification of specific neighborhoods impacted by flooding and areas requiring infrastructure and support services.
- A call for increased community education and awareness about disaster resources and the importance of climate resilience.

# 21. Broward Resilience in the Making Project Update

**DATE:** September/October 2023

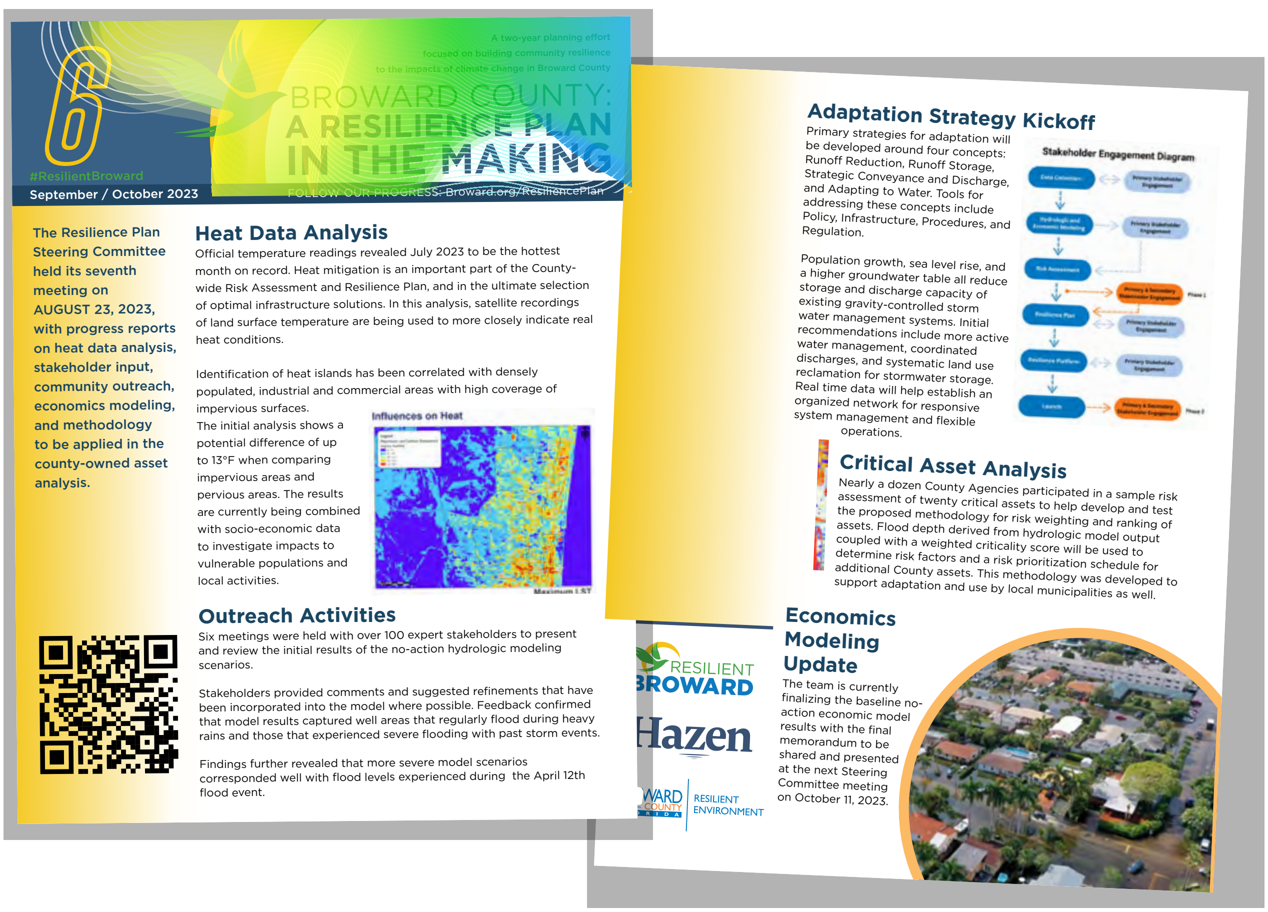
**TARGET AUDIENCE:**

Broward County stakeholders, County agencies, community members, and planners involved in resilience and climate adaptation initiatives.

This update highlights Broward County's ongoing two-year resilience planning efforts, focusing on building resilience to climate change impacts. The report details heat data analysis that identifies urban heat islands, community outreach activities involving expert stakeholders, and the kickoff of adaptation strategies aimed at runoff management and flood mitigation. Additionally, a risk assessment methodology for critical County assets is being tested, and baseline economic modeling is being finalized for future presentations.

**KEY OUTCOMES:**

- Initial analysis identified significant heat islands in urbanized areas with impervious surfaces.
- Stakeholder feedback on no-action hydrologic models confirmed accuracy in predicting flood-prone areas.
- Adaptation strategies focus on runoff reduction and enhanced water management.
- A risk assessment methodology for critical County assets is being tested.
- Finalization of baseline economic modeling results to be presented in October 2023.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BROWARD COUNTY: A RESILIENCE PLAN IN THE MAKING

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September / October 2023

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The Resilience Plan Steering Committee held its seventh meeting on AUGUST 23, 2023, with progress reports on heat data analysis, stakeholder input, community outreach, economics modeling, and methodology to be applied in the county-owned asset analysis.

**Heat Data Analysis**

Official temperature readings revealed July 2023 to be the hottest month on record. Heat mitigation is an important part of the County-wide Risk Assessment and Resilience Plan, and in the ultimate selection of optimal infrastructure solutions. In this analysis, satellite recordings of land surface temperature are being used to more closely indicate real heat conditions.

Identification of heat islands has been correlated with densely populated, industrial and commercial areas with high coverage of impervious surfaces.

The initial analysis shows a potential difference of up to 13°F when comparing impervious areas and pervious areas. The results are currently being combined with socio-economic data to investigate impacts to vulnerable populations and local activities.

Influences on Heat

**Outreach Activities**

Six meetings were held with over 100 expert stakeholders to present and review the initial results of the no-action hydrologic modeling scenarios.

Stakeholders provided comments and suggested refinements that have been incorporated into the model where possible. Feedback confirmed that model results captured well areas that regularly flood during heavy rains and those that experienced severe flooding with past storm events.

Findings further revealed that more severe model scenarios corresponded well with flood levels experienced during the April 12th flood event.

**Adaptation Strategy Kickoff**

Primary strategies for adaptation will be developed around four concepts: Runoff Reduction, Runoff Storage, Strategic Conveyance and Discharge, and Adapting to Water. Tools for addressing these concepts include Policy, Infrastructure, Procedures, and Regulation.

Population growth, sea level rise, and a higher groundwater table all reduce storage and discharge capacity of existing gravity-controlled storm water management systems. Initial recommendations include more active water management, coordinated discharges, and systematic land use reclamation for stormwater storage. Real time data will help establish an organized network for responsive system management and flexible operations.

Stakeholder Engagement Diagram

**Critical Asset Analysis**

Nearly a dozen County Agencies participated in a sample risk assessment of twenty critical assets to help develop and test the proposed methodology for risk weighting and ranking of assets. Flood depth derived from hydrologic model output coupled with a weighted criticality score will be used to determine risk factors and a risk prioritization schedule for additional County assets. This methodology was developed to support adaptation and use by local municipalities as well.

**Economics Modeling Update**

The team is currently finalizing the baseline no-action economic model results with the final memorandum to be shared and presented at the next Steering Committee meeting on October 11, 2023.

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# 22. Broward Social Media Post Regarding Climate Change Threats

**DATE:** November 7, 2023

**TARGET AUDIENCE:**

Broward County residents, local governments, community organizations, stakeholders, and social media followers.

This social media post focuses on the climate change threats that Broward County faces. It aims to raise public awareness about key risks, such as rising sea levels, flooding, extreme heat, and storm surges, while highlighting the County's proactive efforts to address these challenges through its Resilience Plan. The accompanying video emphasizes these climate threats and their potential impacts on infrastructure, communities, and the environment. Viewers are directed to the Broward Resilience Plan webpage for more information, reinforcing the County's commitment to long-term planning and community involvement in building a safer, more resilient future.

**KEY OUTCOMES:**

- Inform the public about the specific climate threats facing Broward County, such as flooding, SLR, and extreme heat.
- Highlight Broward County's efforts in developing a Resilience Plan to address these threats and reduce future risks.
- Encourage community engagement and direct viewers to learn more about the Resilience Plan at Broward.org/ResiliencePlan.

# 23. Broward Resilience in the Making Project Update

**DATE:** November 2023

**TARGET AUDIENCE:**

Broward County residents, stakeholders, community partners, and resilience planners involved in climate adaptation and economic impact assessments.

This update provides an overview of Broward County's ongoing two-year resilience planning effort, focusing on the impacts of climate change, particularly flooding, by 2070. The baseline economic modeling indicates potential flood damages of $5 billion annually and a 0.7% loss in the Broward economy if no action is taken. The plan outlines initial adaptation strategies, such as enhancing GI, storage improvements, and updates to development codes. Additionally, the outreach plan seeks community input on desired mitigation strategies, and further adaptation model results will be refined through workshops in early 2024.

**KEY OUTCOMES:**

- Baseline modeling predicts severe economic consequences under a no-action scenario.
- Adaptation strategies have been identified and are undergoing initial modeling.
- Community outreach efforts are underway to incorporate public insights into resilience planning.
- Further stakeholder workshops will be held to refine strategies in 2024.

A two-year planning effort focused on building community resilience to the impacts of climate change in Broward County

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## Baseline Economic Modeling

The County's consultant team has completed the "no-action" or "business as usual" evaluation of economic outcomes under various future conditions scenarios. The model approach offers a collective view of isolated and compound flood conditions for two and three foot sea level rise scenarios relative to today, assuming no notable change in overall adaptation investments, economics or demographics.

Initial findings point to potential average annual flood damages to property and contents of $5 billion annually by 2070, and losses in production equal to 0.7% of the Broward economy. In a no-action scenario, increasing flood risk coupled with risk-reflective pricing could drive a doubling in the average flood insurance premium.

These early findings reinforce the importance of early and coordinated adaptation efforts to mitigate major flood impacts and losses across all sectors.

**Substantial flood damage could affect 41% more vulnerable people by 2050**

Census tracts with substantial flood damage and vulnerable population, total SVI metric.

*High-risk areas under current SLR*

*Additional high-risk areas under 2.0ft SLR*

*Interim Results (Baseline/No adaptation actions considered)*

*Storm floods in downtown Fort Lauderdale, 2023.*

## Outreach Plan Efforts

An inclusive outreach strategy is being implemented to engage different voices and perspectives as we advance resilience in Broward County. Listening sessions are being scheduled with community partners and representative stakeholder groups to gain insight on how flooding and heat already impact people, property, and work, and what mitigation strategies are most desired across our communities.

## Adaptation Kickoff

An initial internal workshop with the consultant team was hosted on August 28th to finalize the first-cut strategies to be evaluated in the first round of adaptation modeling. The strategies were developed based on sub-regional considerations, such as storage opportunities vs. limitations, extent of water conveyance systems, and the presence or absence of infrastructure for active water management. Additional strategies for adaptation include distributed storage, shared infrastructure, operational changes, removal of pervious surfaces, enhanced green infrastructure, updates to development codes and design standards. Initial adaptation model results will be available by the end of the year, with additional stakeholder workshops conducted in January/February 2024 to seek further input and refine the next phase of modeling.

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# 24. Broward Social Post on Infrastructure Resilience

**DATE:** November 7, 2023

**TARGET AUDIENCE:**

Broward County Resilience Plan stakeholders, Steering Committee members, local governments, partners, Climate Change Task Force, consultant team members, and the general public.

Posted on November 14, 2023, the goal is to introduce the County's flood infrastructure and raise awareness about climate change challenges. The post highlights the importance of infrastructure, such as stormwater pumps, canals, dunes, lakes, and storm drains, and mentions Broward County's efforts to create a roadmap for flood risk reduction and urban cooling. The accompanying video emphasizes the various types of flood infrastructure and directs viewers to learn more on the Resilience Plan webpage. The document also provides detailed instructions for reposting the video, including recommended comments for key promoters, such as local governments, partners, and committee members. Additionally, an email template is provided to encourage the community to engage and share the content on their social media platforms.

**KEY OUTCOMES:**

- Introduction of Broward County's flood infrastructure and its challenges due to climate change.
- Promotion of the Resilience Plan and the Broward County Resilience webpage.
- Instructions for reposting the video on social media, including suggested comments for individuals, partners, and municipalities.
- Encouragement for community involvement and information sharing through social media platforms.

# 25. Resilience Steering Committee Presentation

**DATE:** October 11, 2023

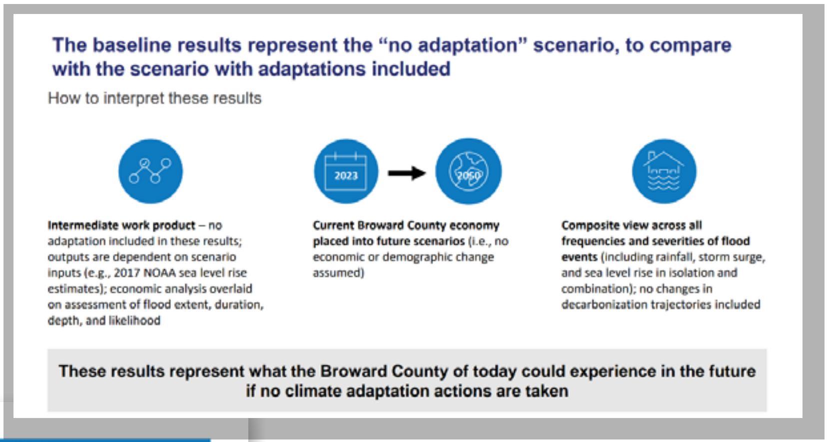
**TARGET AUDIENCE:**

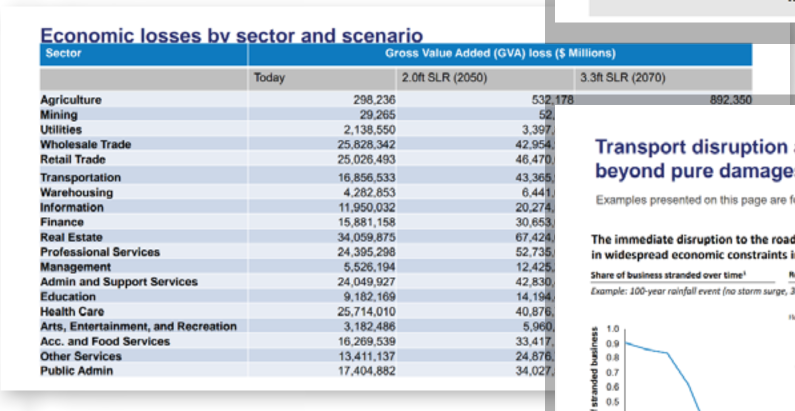
Stakeholders and technical experts involved in resilience, flood risk management, and climate adaptation.

This presentation covers the October 11, 2023, Resilience Steering Committee meeting for Broward County's Countywide Risk Assessment and Resilience Plan. The session focused on baseline economic modeling results without adaptation, which predict the potential impact of climate change and flooding on the County's economy, infrastructure, and vulnerable populations by 2050 and 2070. Key findings show that flood damages to residential and productive assets could increase significantly without intervention, leading to higher insurance premiums, a decrease in property values, and a reduction in property tax revenues. The presentation also highlighted the importance of adaptation strategies to mitigate these risks and detailed ongoing work in asset analysis, flood risk modeling, and outreach efforts to engage the community and stakeholders in the resilience planning process.

**KEY OUTCOMES:**

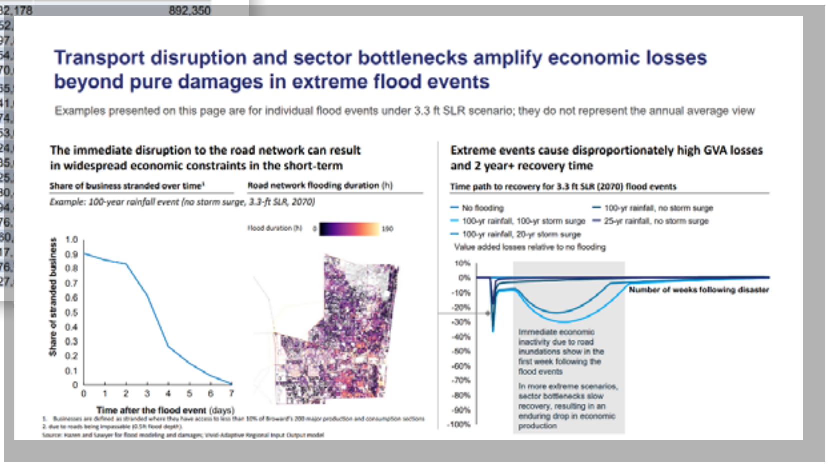
- Baseline economic results indicate significant future flood-related damages if no adaptation actions are taken.
- Residential properties could experience a 13% decrease in value by 2050, which would affect insurance premiums and property tax revenues.
- Adaptation strategies under consideration include improving conveyance systems, adding storage capacity, and implementing GI solutions.
- Stakeholder engagement is ongoing to incorporate feedback into the Resilience Plan, and critical assets have been scored for risk and vulnerability to help prioritize interventions.



Economic losses by sector and scenario

| Sector | Gross Value Added (GVA) loss ($ Millions) | | |
|---|---|---|---|
| | Today | 2.0ft SLR (2050) | 3.3ft SLR (2070) |
| Agriculture | 298,236 | 532,178 | 892,350 |
| Mining | 29,265 | 52, | |
| Utilities | 2,138,550 | 3,397, | |
| Wholesale Trade | 25,828,342 | 42,954, | |
| Retail Trade | 25,026,493 | 46,470, | |
| Transportation | 16,856,533 | 43,365, | |
| Warehousing | 4,282,853 | 6,441, | |
| Information | 11,950,032 | 20,274, | |
| Finance | 15,881,158 | 30,653, | |
| Real Estate | 34,059,875 | 67,424, | |
| Professional Services | 24,395,298 | 52,735, | |
| Management | 5,526,194 | 12,425, | |
| Admin and Support Services | 24,049,927 | 42,830, | |
| Education | 9,182,169 | 14,194, | |
| Health Care | 25,714,010 | 40,876, | |
| Arts, Entertainment, and Recreation | 3,182,486 | 5,960, | |
| Acc. and Food Services | 16,269,539 | 33,417, | |
| Other Services | 13,411,137 | 24,876, | |
| Public Admin | 17,404,882 | 34,027, | |



# 26. EcoExplorers Listening Session

**DATE:** November 14, 2024

**TARGET AUDIENCE:**

Broward County Resilience Steering Committee, EcoExplorers, and youth representatives.

The EcoExplorers Listening Session for the Broward County Risk Assessment and Resilience Plan was held at the Museum of Discovery and Science on November 14, 2023. The session gathered input from youth representatives on the impacts of flooding and extreme heat. Participants shared their experiences, discussed neighborhood challenges, and proposed solutions like improved drainage systems, planting more greenery, and implementing heat-mitigation measures at bus stops. The group also explored ideas for policy changes, the need for sustainable building practices, and ways to address climate change on a community-wide scale. The session ended with a discussion about future changes in Broward County's environment and infrastructure and how to foster long-term community resilience.

**KEY OUTCOMES:**

- Shared firsthand accounts of how flooding and extreme heat affect daily life and the built environment in Broward County.
- Suggested solutions, including improved drainage, wetland restoration, heat-friendly bus stops, tree planting, and more sustainable building practices.
- Emphasized the importance of youth involvement and education in addressing climate resilience challenges.
- Discussed the need for policy changes to limit new development and promote environmentally friendly practices.
- Raised awareness of community-wide issues and the importance of a balanced approach between urban infrastructure and green spaces.

# 27. Urban League Listening Session

**DATE:** November 14, 2023

**TARGET AUDIENCE:**

Broward County Resilience Steering Committee and Urban League of Broward County, community stakeholders.

The Urban League of Broward County Resilience Plan Listening Session was held on November 14, 2023, at Harris Chapel United Methodist in Fort Lauderdale. The session gathered community input on flooding and heat-related challenges, discussing potential solutions across four groups. Suggestions included infrastructure improvements, prioritizing assistance for low-income and senior residents, green landscaping, tax incentives, and better community education on climate resilience. The discussion also emphasized community engagement, with calls for City accountability, partnerships with officials, and improved communication of ongoing climate initiatives. The session highlighted the need for collaborative efforts and innovative solutions to address Broward County's flooding and heat issues.

**KEY OUTCOMES:**

- Identified various solutions for flooding, such as infrastructure upgrades, green space expansion, and better city accountability for funding.
- Explored heat mitigation strategies, including improved insulation, green landscaping, and educating residents.
- Highlighted the importance of prioritizing low-income and senior populations in resilience planning.
- Discussed community involvement in advocating for flood and heat solutions and the potential for partnerships with local officials and organizations.


# 28. Residents for Resilience Listening Session

**DATE:** December 1, 2023

**TARGET AUDIENCE:**

Broward County Resilience Steering Committee and Residents for Resilience

Residents for Resilience Listening Session for the Broward County Risk Assessment and Resilience Plan was held virtually on December 1, 2023. The meeting began with an overview of the plan, focusing on flood and heat mitigation in Broward County. Participants, including representatives from various organizations, discussed community concerns like water quality, seawall heights, storm resilience, and tree management. Suzee Bailey from Residents for Resilience emphasized the need for proactive measures, community involvement, and better communication regarding ongoing projects. Discussions also included nature-based solutions, policy recommendations, and collaboration efforts. The meeting covered specific solutions, such as creating water quality dashboards, raising public awareness about flood and heat impacts, and addressing insurance challenges in flood-prone areas. The session concluded with a call for long-term resilience strategies and continued collaboration.

**KEY OUTCOMES:**

- Highlighted community concerns around water quality, storm resilience, seawall heights, and tree management.
- Advocated for proactive education, communication, and community involvement in addressing climate challenges.
- Suggested the development of tools like water quality dashboards to inform residents about environmental risks.
- Discussed insurance issues in high-risk flood zones and proposed a collaborative approach to address long-term consequences.
- Explored nature-based solutions, policy recommendations, and the need for regional and global collaboration on climate resilience.

# 29. Resilience Steering Committee Presentation

**DATE:** February 7, 2024

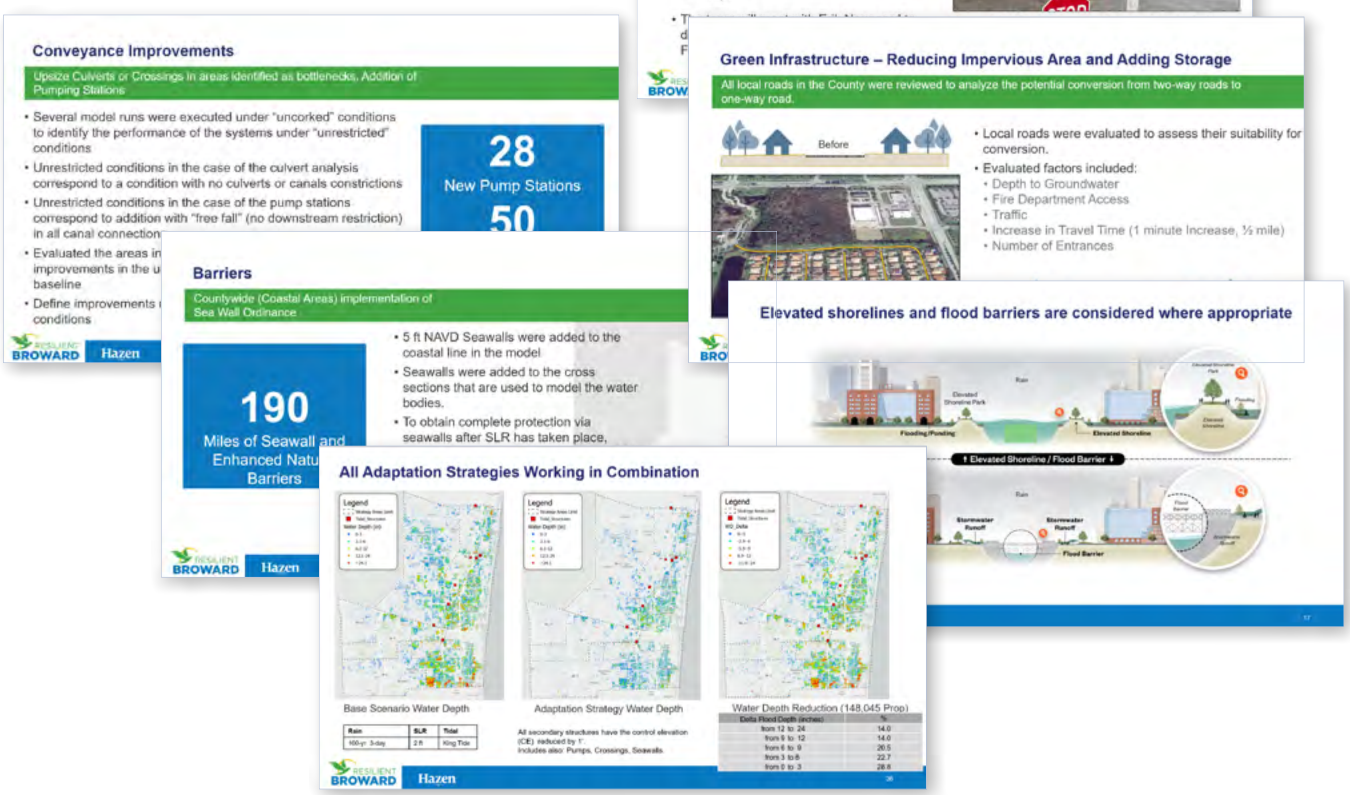
**TARGET AUDIENCE:**

Broward County Steering Committee members, local government officials, infrastructure planners, and community stakeholders interested in climate adaptation, flood risk management, and resilience planning.

This presentation from the Resilience Steering Committee on February 7, 2024, discusses the latest updates on Broward County's Countywide Risk Assessment and Resilience Plan. The meeting covered adaptation strategies to mitigate flood risks due to storm surge, SLR, and increased rainfall, with specific attention given to high-priority assets like Fort Lauderdale–Hollywood International Airport and Port Everglades. Stakeholder engagement updates emphasized community involvement and input from students, residents, and technical experts on GI, nature-based solutions, and adaptive strategies. The presentation also reviewed the results from modeling various flood scenarios and analyzed the effectiveness of different adaptation strategies to reduce flood impacts across the County.

**KEY OUTCOMES:**

- Updates on economic modeling, particularly for the Fort Lauderdale–Hollywood International Airport and Port Everglades, where recent flood events have caused significant disruptions.
- Engagement with stakeholders and students has led to the identification of innovative solutions, including GI and flood mitigation strategies.
- Modeling results showed improvements in flood risk reduction with the use of elevated shorelines, additional pumping, and underground storage tanks.
- Adaptation strategies evaluated include seawall construction, conveyance improvements, and groundwater storage management to reduce the impact of SLR and stormwater flooding.

# 30. Broward Resilience in the Making Project Update

**DATE:** February 2024

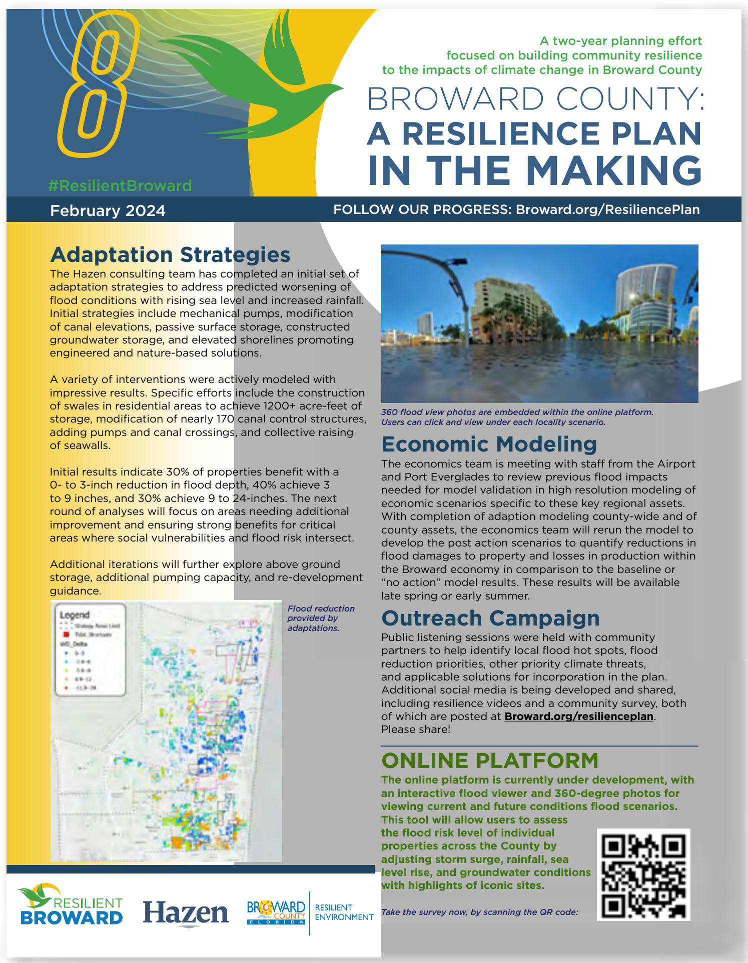
**TARGET AUDIENCE:**

Broward County community members, stakeholders, and regional planners, particularly those involved in resilience planning and climate change adaptation efforts.

This is an update on the Broward County Resilience Plan, detailing a two-year effort to enhance community resilience to climate change impacts, particularly focusing on flood mitigation strategies. Initial adaptation measures include installing mechanical pumps, adjusting canal elevations, and creating both natural and engineered water storage solutions. Early results show significant flood depth reductions for properties across the county. The plan also incorporates public outreach, economic modeling for critical assets like the airport and port, and an interactive online platform with flood risk assessment tools and community engagement features like surveys.

**KEY OUTCOMES:**

- Initial adaptation strategies led to measurable reductions in flood depths across various properties.
- Ongoing economic modeling aims to quantify flood damage reductions.
- Public listening sessions contributed to identifying local flood priorities, which will inform further plan development.
- Development of an online platform for flood risk assessment and public engagement featuring interactive tools and surveys is in progress.



A two-year planning effort focused on building community resilience to the impacts of climate change in Broward County

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## Adaptation Strategies

The Hazen consulting team has completed an initial set of adaptation strategies to address predicted worsening of flood conditions with rising sea level and increased rainfall. Initial strategies include mechanical pumps, modification of canal elevations, passive surface storage, constructed groundwater storage, and elevated shorelines promoting engineered and nature-based solutions.

A variety of interventions were actively modeled with impressive results. Specific efforts include the construction of swales in residential areas to achieve 1200+ acre-feet of storage, modification of nearly 170 canal control structures, adding pumps and canal crossings, and collective raising of seawalls.

Initial results indicate 30% of properties benefit with a 0- to 3-inch reduction in flood depth, 40% achieve 3 to 9 inches, and 30% achieve 9 to 24-inches. The next round of analyses will focus on areas needing additional improvement and ensuring strong benefits for critical areas where social vulnerabilities and flood risk intersect.

Additional iterations will further explore above ground storage, additional pumping capacity, and re-development guidance.

*Flood reduction provided by adaptations.*

*360 flood view photos are embedded within the online platform. Users can click and view under each locality scenario.*

## Economic Modeling

The economics team is meeting with staff from the Airport and Port Everglades to review previous flood impacts needed for model validation in high resolution modeling of economic scenarios specific to these key regional assets. With completion of adaption modeling county-wide and of county assets, the economics team will rerun the model to develop the post action scenarios to quantify reductions in flood damages to property and losses in production within the Broward economy in comparison to the baseline or "no action" model results. These results will be available late spring or early summer.

## Outreach Campaign

Public listening sessions were held with community partners to help identify local flood hot spots, flood reduction priorities, other priority climate threats, and applicable solutions for incorporation in the plan. Additional social media is being developed and shared, including resilience videos and a community survey, both of which are posted at **Broward.org/resilienceplan**. Please share!

## ONLINE PLATFORM

**The online platform is currently under development, with an interactive flood viewer and 360-degree photos for viewing current and future conditions flood scenarios. This tool will allow users to assess the flood risk level of individual properties across the County by adjusting storm surge, rainfall, sea level rise, and groundwater conditions with highlights of iconic sites.**

*Take the survey now, by scanning the QR code:*

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## 31. Hispanic Unity Listening Session

**DATE:** December 20, 2023

**TARGET AUDIENCE:**

Broward County Resilience Steering Committee and Hispanic Unity of Broward County.

The Broward Resilience Plan Listening Session with Hispanic Unity of Broward County was held on December 20, 2023. The session covered an introduction to the Broward County Risk Assessment and Resilience Plan, highlighting the importance of community input in addressing flood and heat challenges. Hispanic Unity introduced its mission, focusing on economic development and support for diverse communities. During the Q&A, discussions revolved around the impact of flooding on residents, workforce support, advocacy, infrastructure challenges, and potential partnerships to address climate issues. Hispanic Unity expressed willingness to support focus groups and further engagement, and the conversation underscored the importance of community involvement and education in resilience efforts.

**KEY OUTCOMES:**

- Hispanic Unity emphasized the impact of flooding on residents and highlighted the need for more capital grants to address infrastructure issues.
- Discussion on workforce support and advocacy, focusing on how climate-related challenges affect economic stability for families.
- Importance of community involvement, with Hispanic Unity offering to facilitate focus groups for further input.
- Identification of partnerships, including schools and other organizations, to promote climate education and awareness.
- Agreement to continue collaboration and explore additional ways Hispanic Unity can support the project.

## 32. Broward Social Post Dr. Jurado Survey Invitation

**DATE:** January 22, 2024

**TARGET AUDIENCE:**

Broward County residents, stakeholders, social media followers, community organizations, and partners in climate resilience efforts.

The third post in a social media campaign aimed at gathering public input for Broward County's Resilience Plan. Posted on November 27, 2023, the goal is to introduce a welcome message from Dr. Jennifer Jurado, the Chief Resilience Officer for Broward County, and invite residents to participate in a survey. The video features Dr. Jurado explaining the purpose of the Countywide Risk Assessment and Resilience Plan, highlighting its importance in addressing flooding and heat issues. She calls on residents to share their input, emphasizing community involvement in creating a more resilient Broward. The post and video direct viewers to the survey and the Resilience Plan webpage for more information. Detailed instructions for reposting and recommended post details are forthcoming.

**KEY OUTCOMES:**

- Introduction of the Resilience Plan and its long-term impact on flood risk reduction and urban resilience.
- Dr. Jurado personally invited residents to participate in a survey and contribute input to the Countywide plan.
- Promotion of community involvement and awareness of Broward County's efforts in developing a resilience strategy.
- Directs viewers to Broward.org/ResiliencePlan to take the survey and learn more.

# 33. Broward Resilience Plan Adaptation Results Review Meeting – South Inland

**DATE:** March 14, 2024

**TARGET AUDIENCE:**

Municipal stakeholders, water control districts, and community members from South Inland regions of South Florida, particularly those in low-lying and flood-prone areas.

This document reviews the adaptation strategies for coastal communities in South Florida as part of Broward County's Countywide Risk Assessment and Resilience Plan. The primary focus is on mitigating flood risks from storm surges, SLR, and tidal flooding. Coastal-specific strategies include the construction of elevated seawalls, natural barriers, and pumping systems. The meeting emphasized the role of GI and additional water storage solutions to protect against increased groundwater levels due to SLR. Key adaptations for these regions include enhanced drainage systems, underground storage chambers, and coastal surge barriers to reduce flood risks in both high and low tides. Feedback from stakeholders highlighted the importance of addressing long-term sustainability while maintaining critical infrastructure.

**KEY OUTCOMES:**

- Adaptation strategies, such as elevating seawalls to 5 feet NAVD and creating natural coastal barriers, are crucial for reducing storm surge impacts.
- Coastal adaptations such as surge barriers and improved drainage systems significantly reduced flood depths, benefiting property protection.
- Stakeholders stressed the need for long-term solutions that incorporate federal and state support, particularly for large-scale tide management infrastructure.
- GI and underground storage chambers will provide additional protection, particularly in low-lying coastal areas prone to tidal flooding and high groundwater levels.

# 34. Broward Resilience Plan Adaptation Results Review Meeting – Coastal

**DATE:** March 19, 2024

**TARGET AUDIENCE:**

Coastal municipalities, water management districts, and community stakeholders, particularly in regions vulnerable to storm surges, SLR, and tidal flooding.

This document reviews the adaptation strategies for South Inland communities in South Florida as part of Broward County's Countywide Risk Assessment and Resilience Plan. The focus is on mitigating flood risks from SLR, storm surges, and groundwater levels. Strategies include bioswales, elevated roads, underground storage chambers, and seawalls to manage stormwater. Stakeholders provided valuable feedback on each adaptation strategy's potential effectiveness and challenges. Localized adaptation strategies are being developed specifically for low- and moderate-income areas and FEMA Disaster Resilience Zones, with a particular focus on improving flood conditions and reducing urban heat through GI.

**KEY OUTCOMES:**

- Stakeholders emphasized the need for cost-effective and adaptable strategies to changing flood conditions.
- Adaptations such as GI, underground storage, and seawall improvements show promise in reducing flood depths and improving groundwater storage capacity.
- Localized strategies for low- and moderate-income areas are under evaluation, and further adaptation models show a reduction in flood risk for these vulnerable communities.

# 35. Broward Resilience Plan Adaptation Results Review Meeting – North Inland

**DATE:** March 25, 2024

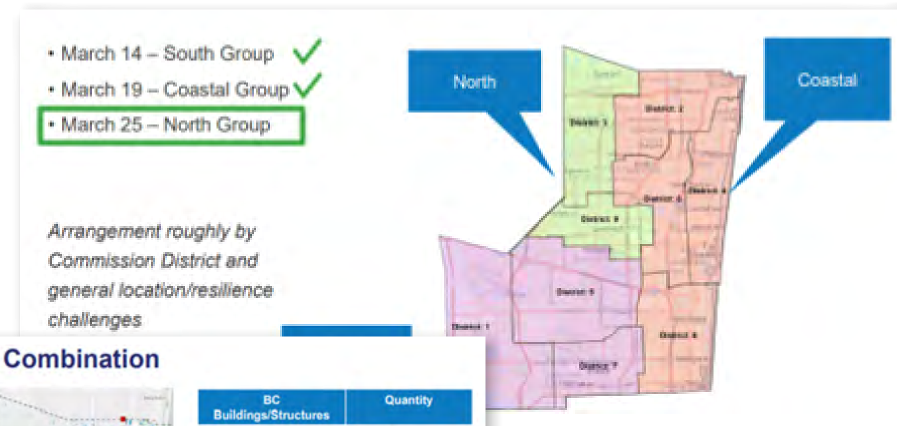
**TARGET AUDIENCE:**

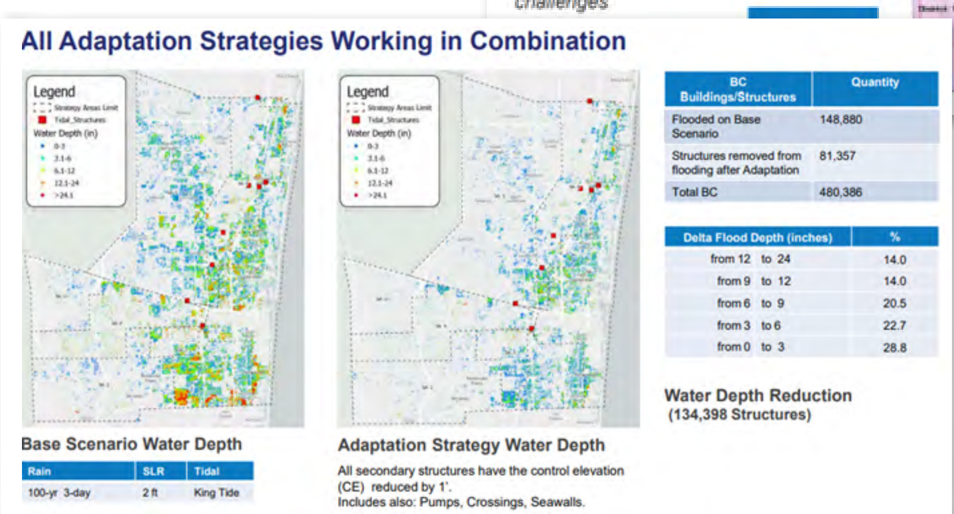
North Inland communities in South Florida - Municipalities, water control districts, regional stakeholders, and community members involved in resilience planning and flood mitigation efforts.

This document provides an overview of the adaptation results for Broward County's Countywide Risk Assessment and Resilience Plan, with a focus on the northern region. The review discusses various adaptation strategies being considered to address flood risks from storm surges, SLR, and increased groundwater levels. Strategies include nature-based solutions, underground storage chambers, elevation of roads, and modifications to water control structures. The meeting gathered feedback from stakeholders, which is critical to refining these strategies. Modeling and further evaluation of localized adaptation strategies are ongoing, especially in areas with vulnerable populations, low-income zones, and FEMA disaster resilience zones.

**KEY OUTCOMES:**

- Adaptation strategies include a mix of nature-based solutions, infrastructure upgrades, and water management improvements.
- Stakeholder input was key in evaluating the feasibility of different strategies and identifying areas needing further adaptation.
- Flood reduction modeling shows significant improvements in low- and moderate-income zones.
- Future work will continue to focus on localized adaptations, economic analysis, and strategy refinement based on ongoing stakeholder engagement.



# 36. Resilience Steering Committee Presentation

**DATE:** August 28, 2024

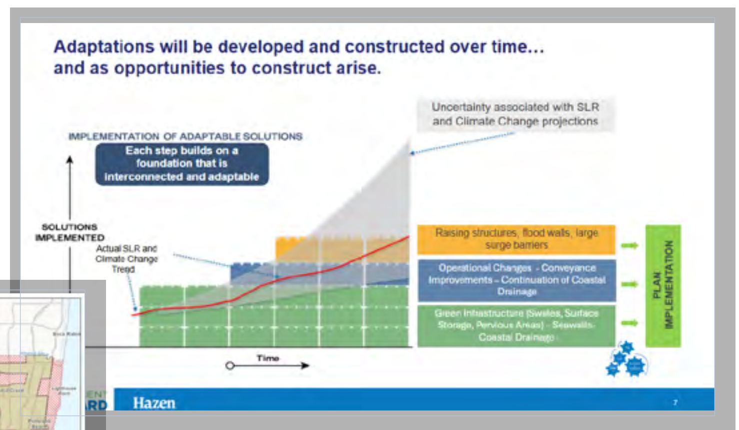
**TARGET AUDIENCE:**

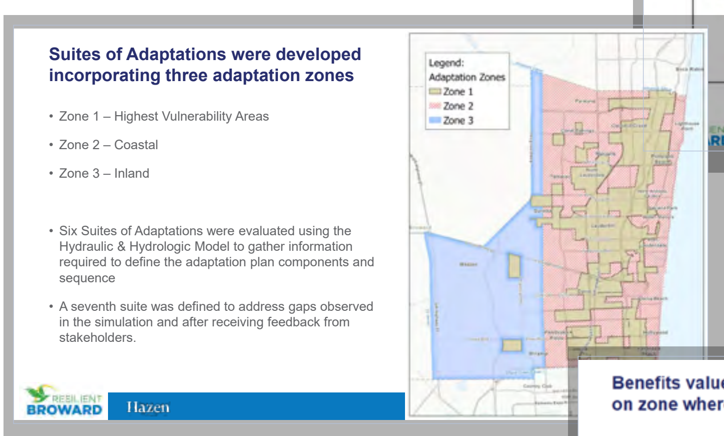
Broward County Resilience Plan Steering Committee members, regional stakeholders, municipal planners, and engineers involved in climate resilience and flood mitigation efforts.

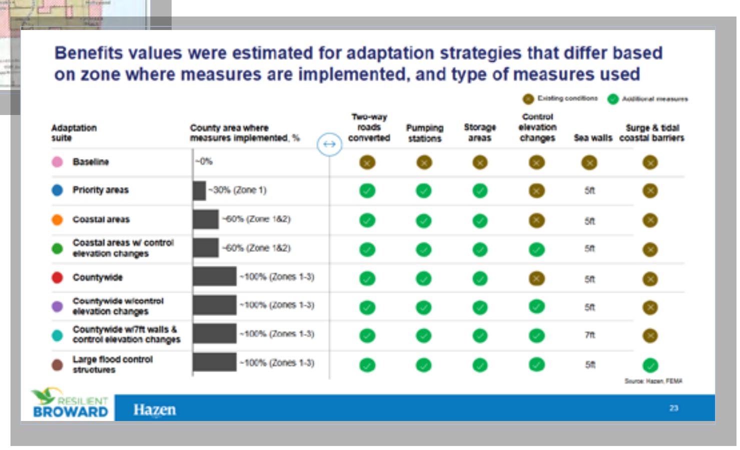
This presentation outlines the progress of Broward County's Countywide Risk Assessment and Resilience Plan. The meeting discussed adaptation strategies to mitigate SLR and storm surges by implementing multiple infrastructure improvements. Six suites of adaptation strategies, including seawall elevation, storage areas, and control structure modifications, were evaluated. The economic analysis highlighted significant benefits of these adaptations, such as reduced property damage, increased economic activity, enhanced flood insurance coverage, and higher property values. The presentation also emphasized the long-term return on investment and overall improvement in flood resilience across the County.

**KEY OUTCOMES:**

- Adaptation strategies reduce flood risks and property damage by 21% under a 2-foot SLR and by up to 82% under a 3.3-foot SLR.
- Economic activity and real estate values are projected to increase as a result of these investments.
- Implementation of flood insurance reforms and higher seawall elevation will significantly reduce flood-related losses.
- Adaptation measures will provide substantial Countywide benefits, preserving property and infrastructure while improving flood resilience across Broward County.



# 37. Broward Resilience in the Making Project Update

**DATE:** May 2024

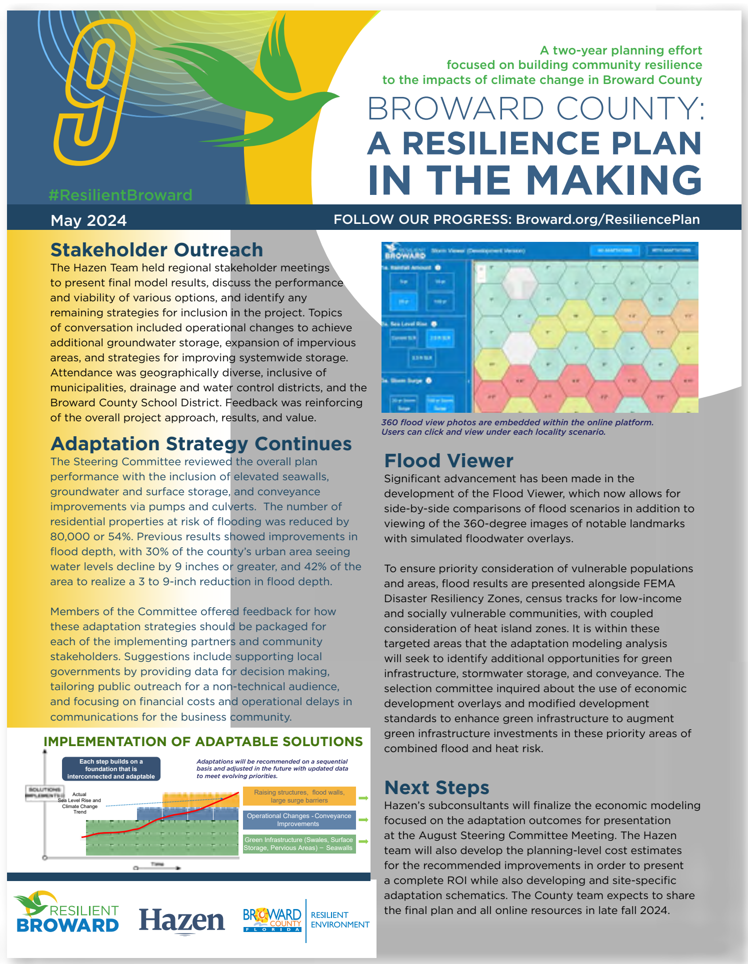
**TARGET AUDIENCE:**

Local governments, water control districts, the Broward County School District, businesses, and vulnerable communities.

The Broward County Resilience Plan is a two-year initiative aimed at enhancing community resilience to climate change. The Hazen Team conducted regional stakeholder meetings to discuss climate adaptation strategies, including operational changes, groundwater storage, and elevated seawalls. The goal is to reduce flood risks, with results showing significant flood depth reductions. The Flood Viewer tool has been enhanced to allow comparison of flood scenarios and overlay flood data with socially vulnerable communities. Upcoming steps include finalizing economic models and adaptation schematics, with the final plan set for release in fall 2024.

**KEY OUTCOMES:**

- Reduced flood risks (54% decrease in residential properties at risk).
- Improved public engagement through tailored outreach and data tools.
- Strategic plans for adaptive infrastructure in vulnerable zones.



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**Stakeholder Outreach**

The Hazen Team held regional stakeholder meetings to present final model results, discuss the performance and viability of various options, and identify any remaining strategies for inclusion in the project. Topics of conversation included operational changes to achieve additional groundwater storage, expansion of impervious areas, and strategies for improving systemwide storage. Attendance was geographically diverse, inclusive of municipalities, drainage and water control districts, and the Broward County School District. Feedback was reinforcing of the overall project approach, results, and value.

**Adaptation Strategy Continues**

The Steering Committee reviewed the overall plan performance with the inclusion of elevated seawalls, groundwater and surface storage, and conveyance improvements via pumps and culverts. The number of residential properties at risk of flooding was reduced by 80,000 or 54%. Previous results showed improvements in flood depth, with 30% of the county's urban area seeing water levels decline by 9 inches or greater, and 42% of the area to realize a 3 to 9-inch reduction in flood depth.

Members of the Committee offered feedback for how these adaptation strategies should be packaged for each of the implementing partners and community stakeholders. Suggestions include supporting local governments by providing data for decision making, tailoring public outreach for a non-technical audience, and focusing on financial costs and operational delays in communications for the business community.

**IMPLEMENTATION OF ADAPTABLE SOLUTIONS**

Each step builds on a foundation that is interconnected and adaptable

*Adaptations will be recommended on a sequential basis and adjusted in the future with updated data to meet evolving priorities.*

Raising structures, flood walls, large surge barriers

Operational Changes - Conveyance Improvements

Green Infrastructure (Swales, Surface Storage, Pervious Areas) – Seawalls

*360 flood view photos are embedded within the online platform. Users can click and view under each locality scenario.*

**Flood Viewer**

Significant advancement has been made in the development of the Flood Viewer, which now allows for side-by-side comparisons of flood scenarios in addition to viewing of the 360-degree images of notable landmarks with simulated floodwater overlays.

To ensure priority consideration of vulnerable populations and areas, flood results are presented alongside FEMA Disaster Resiliency Zones, census tracks for low-income and socially vulnerable communities, with coupled consideration of heat island zones. It is within these targeted areas that the adaptation modeling analysis will seek to identify additional opportunities for green infrastructure, stormwater storage, and conveyance. The selection committee inquired about the use of economic development overlays and modified development standards to enhance green infrastructure to augment green infrastructure investments in these priority areas of combined flood and heat risk.

**Next Steps**

Hazen's subconsultants will finalize the economic modeling focused on the adaptation outcomes for presentation at the August Steering Committee Meeting. The Hazen team will also develop the planning-level cost estimates for the recommended improvements in order to present a complete ROI while also developing and site-specific adaptation schematics. The County team expects to share the final plan and all online resources in late fall 2024.

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# **Appendix H**: Capital Planning Resilience Checklist

## Capital Planning Resilience Checklist

### Overview and Purpose

This checklist is intended to assist in capital project planning as part of the annual budget process. The broad objective of this checklist is to enhance the resilience of County capital investments through consideration of the below criteria. Due to the broad array of County capital investments, projects are not expected to satisfy all criteria; however, consideration of these criteria may identify means to improve the broader resilience benefits of a capital project.

Checklist criteria include risk factors and resilience factors. Risk factors generally consist of 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 and broader County resilience objectives.

### Capital Investment Summary

| **Project Name** | |
|---|---|
| | |
| **Project Address / Location** | |
| | |
| **Funding Source** | |
| ☐ Transportation Capital | ☐ General Capital |
| ☐ Municipal Services District Capital | ☐ Enterprise Capital |
| ☐ Other Funds | |
| **Brief Project Description** | |
| | |
| **Description of Key Resilience Considerations** | |
| | |

### Resilience Checklist

| RISK FACTORS | |
|---|---|
| ☐ | **Project located within Broward priority planning area?** |
| | *Criteria:* Is the project located within a priority planning area for sea level rise? These areas are defined as areas near tidal water bodies at increased risk of inundation under a 3.3-foot sea level rise and can be found on a generalized map in Attachment A. |
| | *Additional Guidance:* If the capital investment covers multiple locations, consider whether the majority of those locations are within a priority planning area and include, in the space below, a note on why the criterion should apply to this project. This criterion does not apply to county-wide investments. |
| | *Notes:* |
| ☐ | **Project located within a FEMA flood zone?** |
| | *Criteria:* Is the project located within one of the following FEMA flood zone designations: AO, AE, AH, or VE? |
| | *Additional Guidance:* If the capital investment covers multiple locations, consider whether the majority of those locations are within a FEMA flood zone and include, in the space below, a note on why the criterion should apply to this project. This criterion does not apply to county-wide investments. The Broward Interactive Tool for Current Flood Zones Maps can be used to evaluate presence of a flood zone at the project location. |
| | *Notes:* |

| RISK FACTORS (Continued) | |
|---|---|
| ☐ | **Known history of localized flooding?** |
| | *Criteria:* Is the project located within an area where anecdotal evidence of flooding concerns exists? Localized flooding may be attributed to tidal conditions, undersized stormwater infrastructure, or a lack of stormwater infrastructure under existing conditions prior to capital project implementation. |
| | *Additional Guidance:* Localized flooding should occur multiple times in a typical year to qualify for this criterion. Standing water at least 6-inches in depth along the centerline of an adjacent roadway qualifies as localized flooding. Standing water in a yard or localized depression outside the roadway does not qualify for this criterion. The nature of localized flooding should be noted below. |
| | *Notes:* |
| ☐ | **Long expected lifespan** |
| | *Criteria:* Is the capital project expected to remain in place until 2070 or beyond? |
| | *Additional Guidance:* For projects with long expected lifespans, it will be more important to consider future climate risks and potential resilience measures so they can maintain their intended function throughout their full life. |
| | *Notes:* |

| RESILIENCE FACTORS | |
|---|---|
| ☐ | **Project integrates future compound flood conditions.** |
| | *Criteria:* How does the project account for future flood conditions consistent with the Countywide Risk Assessment and Resilience Plan? |
| | *Additional Guidance:* The future compound flood conditions modeling results can be found here: Resilient Broward Storm Viewer |
| | *Notes:* |
| ☐ | **Project accounts for change factors on onsite stormwater management?** |
| | *Criteria:* How does the project account for rainfall intensification as part of stormwater storage, conveyance, and management? Does this include a minimum 20% change factor for design storms? |
| | *Additional Guidance:* Rainfall adjustment factors can be found in "Adoption of Future Extreme Rainfall Change Factors for Flood Resiliency Planning in South Florida," published by the SFWMD in April 2022. Applicant is also guided to the Future Conditions Map series (Broward Future Conditions Map Series) as applicable. |
| | *Notes:* |
| ☐ | **Project integrates green infrastructure?** |
| | *Criteria:* Does the project incorporate natural processes into stormwater controls to effectively manage stormwater runoff and provide additional co-benefits? |
| | *Additional Guidance:* Green infrastructure may include stormwater controls like bioswales, habitat restoration, coastal buffers, wetland mitigation, dune rehabilitation, and urban reforestation. List the green infrastructure included with the project in the space below. |
| | *Notes:* |

| RESILIENCE FACTORS (Continued) | |
|---|---|
| ☐ | **Project incorporates heat stress mitigation?** |
| | *Criteria:* Does the project incorporate mitigations that provide for heat stress relief? |
| | *Additional Guidance:* Intentional shade areas may be tree canopy, pavilions, drinking fountains, misting stations, or other natural or artificial structures intended to provide respite from high temperatures when outdoors. Briefly describe included heat stress mitigation elements in the space below. Heat stress mitigation differs from urban cooling in that it provides a direct respite for individuals from high heat. |
| | *Notes:* |
| ☐ | **Project aids urban cooling?** |
| | *Criteria:* Does the project utilize light-colored or solar reflective building materials (including but not limited to roofing, structure, and pavements), green infrastructure, and/or additional tree canopy where practical to aid in urban heat island reduction? |
| | *Additional Guidance:* Consult EPA guidance on Heat Island Cooling Strategies for guidance on practices that may be implemented. Briefly describe included urban cooling elements in the space below. Urban cooling differs from heat stress mitigation in that it supports general reduction in urban temperatures even if it does not provide a direct respite for individuals from high heat. |
| | *Notes:* |
| ☐ | **Materials resilient to saltwater and salt air corrosion, sediment scour, and temperature increases?** |
| | *Criteria:* Does design of the project incorporate materials resistant to degradation under future climate conditions? Is the project subject to changing groundwater conditions that could impact subsurface installations or tidal conditions that could lead to bridge or sediment scour? |
| | *Additional Guidance:* Sea level rise, ground water table rise, saltwater intrusion, salt air, extreme temperatures, and sediment scour may degrade building materials more quickly when not considered in design efforts. Briefly describe the degradation-resistant materials in the space below. |
| | *Notes:* |

| RESILIENCE FACTORS (Continued) | |
|---|---|
| ☐ | **Materials resilient to saltwater and salt air corrosion, sediment scour, and temperature increases?** |
| | *Criteria:* Does design of the project incorporate materials resistant to degradation under future climate conditions? Is the project subject to changing groundwater conditions that could impact subsurface installations or tidal conditions that could lead to bridge or sediment scour? |
| | *Additional Guidance:* Sea level rise, ground water table rise, saltwater intrusion, salt air, extreme temperatures, and sediment scour may degrade building materials more quickly when not considered in design efforts. Briefly describe the degradation-resistant materials in the space below. |
| | *Notes:* |
| ☐ | **Supports emergency response and recovery operations and technological advancements?** |
| | *Criteria:* Does the project directly aid in the County's response to an emergency situation? |
| | *Additional Guidance:* Example supporting characteristics include improving safe access for emergency vehicles, staging areas for emergency operations, on-site real-time data collection and relay, and gathering areas for evacuated residents. Briefly describe the supporting characteristics in the space below. |
| | *Notes:* |

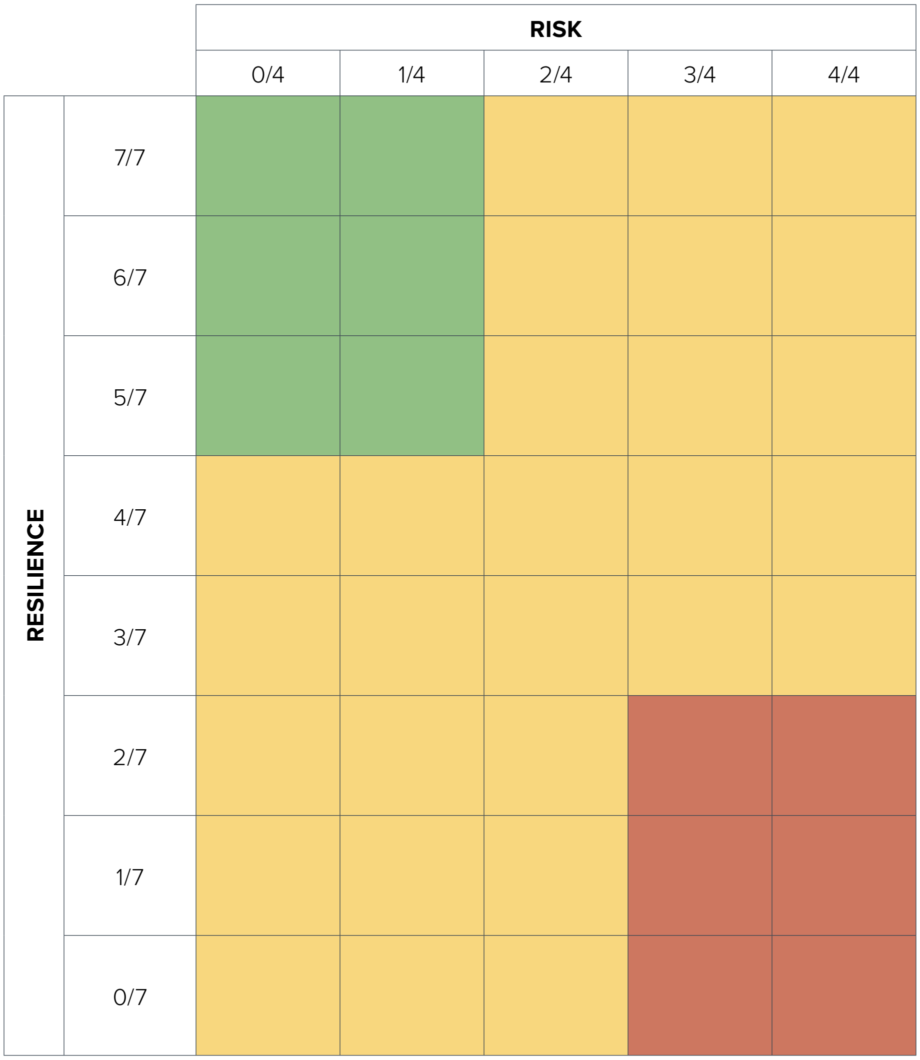
### Risk and Resilience Evaluation

Tabulate the number of applicable risk and resilience factors in the table below and plot the resultant position on the chart on the following page. The resultant position provides an indication of whether a project is subject to climate risks and the extent to which the project includes climate resiliency aspects. County capital projects have diverse characteristics and it is understood why some risks may be unavoidable and resilience measures not practical or needed. Especially in these cases, space is provided below to briefly share context on why the capital investment appropriately belongs in the assigned category.

| | |
|---|---|
| __/4 | Number of applicable risk factors |
| __/7 | Number of applicable resilience factors |

| **Additional Project Categorization Context** |
|---|
| |

### Risk and Resilience 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 |

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Hazen

Brizaga, Inc.
Climate Resilience Consulting
Collective Water Resources, LLC
Craven Thompson & Associates, Inc.
Cummins Cederberg, Inc
Good Alpha LTD
HR&A Advisors
McKinsey & Company, Inc
RJ Behar & Company, Inc
The Water Institute of the Gulf

**This study is a service of the Broward County Board of Commissioners.**