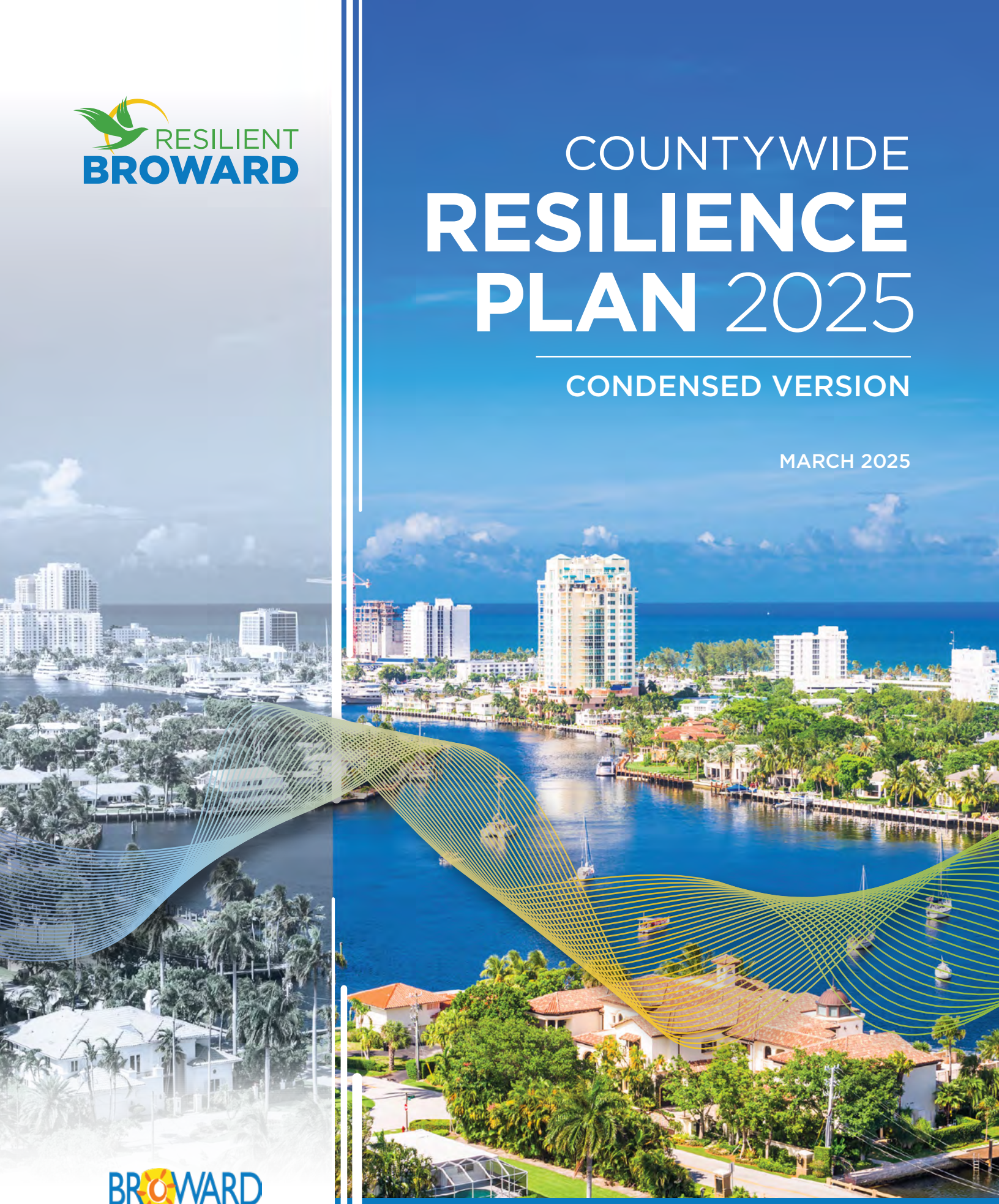
RESILIENT BROWARD

COUNTYWIDE RESILIENCE PLAN 2025

CONDENSED VERSION

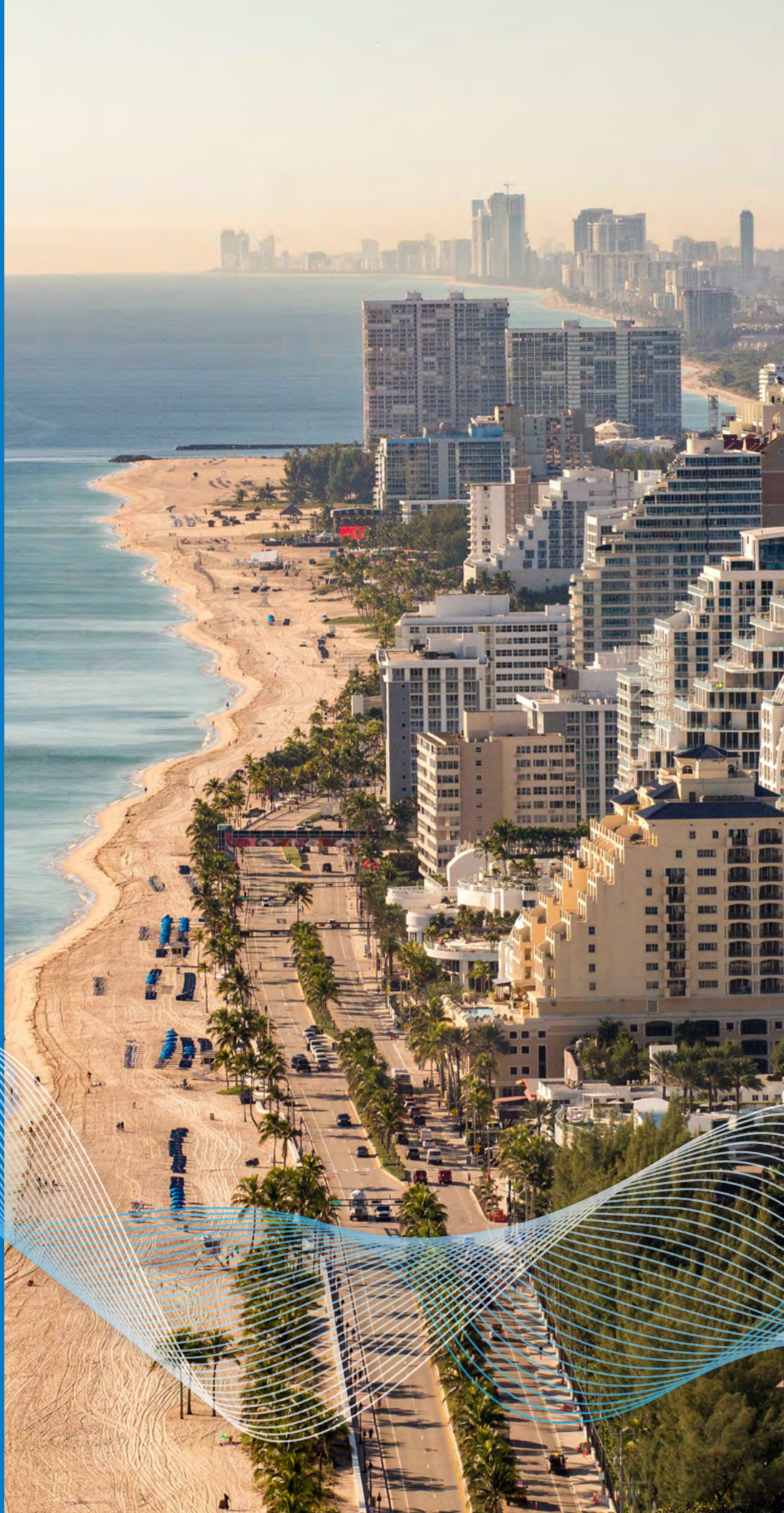
MARCH 2025



BROWARD COUNTY FLORIDA

BROWARD COUNTY, FLORIDA

Contents



BROWARD COUNTY FLORIDA

Hazen

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.

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.

Key Benefits of the Plan

Reduced Flood Risks

Protecting homes, businesses, and public spaces from water damage through advanced infrastructure and green solutions.

Stronger Economy

Reducing disruptions to business operations and maintaining economic stability.

Improved Public Health

Mitigating urban heat and enhancing overall wellbeing with expanded green spaces and cooler environments.

Environmental Preservation

Protecting biodiversity, enhancing ecosystems, and promoting sustainable land use.

Community Preparedness

Strengthening the County's capacity to respond to and recover from extreme weather and climate impacts.

RESILIENCE IN ACTION

Approach

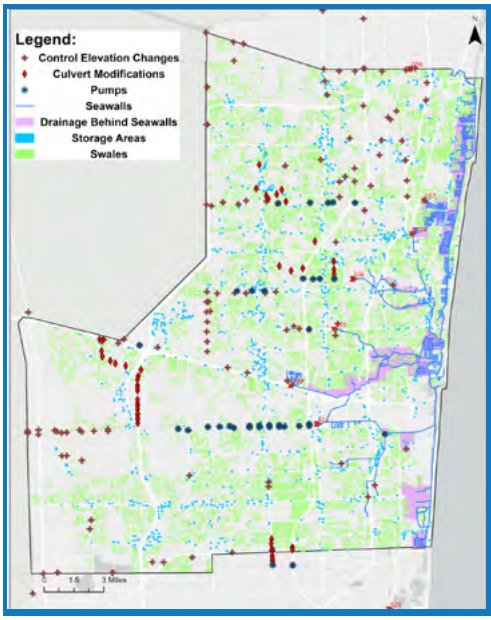
The Resilience Plan uses a structured and adaptive approach, employing detailed hydraulic and hydrologic modeling, to address evolving flood risk with climate change. By phasing strategies over time, the Plan prioritizes the adaptations to immediate risks while preparing for future challenges. The Plan 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 adaptations 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 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. In addition to the adaptations under Tier 1, this phase involves raising seawalls to 7 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.



Solutions have been tailored to meet the needs of

THE COUNTY'S THREE UNIQUE ZONES:

- Highly Vulnerable Areas
- Eastern Areas
- Inland Areas

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.

Summary of Tier 1 and Tier 2 Benefit Value Estimates

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

Overview

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 and over 300 miles of intracoastal waterway and navigable inland waterways. Due to its low elevation, flat topography, exposure to storm surge, and dense urban development, Broward County is particularly vulnerable to the impacts of climate change, including sea level rise (SLR), coastal erosion, more intense precipitation, and increased storm surge.

To mitigate the negative impacts of climate change to residents and businesses, the Countywide Resilience Plan provides adaptations and actionable investments that can be implemented through projects by the County, municipalities, water control districts, and individual residents. These adaptations address the most socioeconomically vulnerable areas of Broward County to ensure the socioeconomic fairness of the Plan.

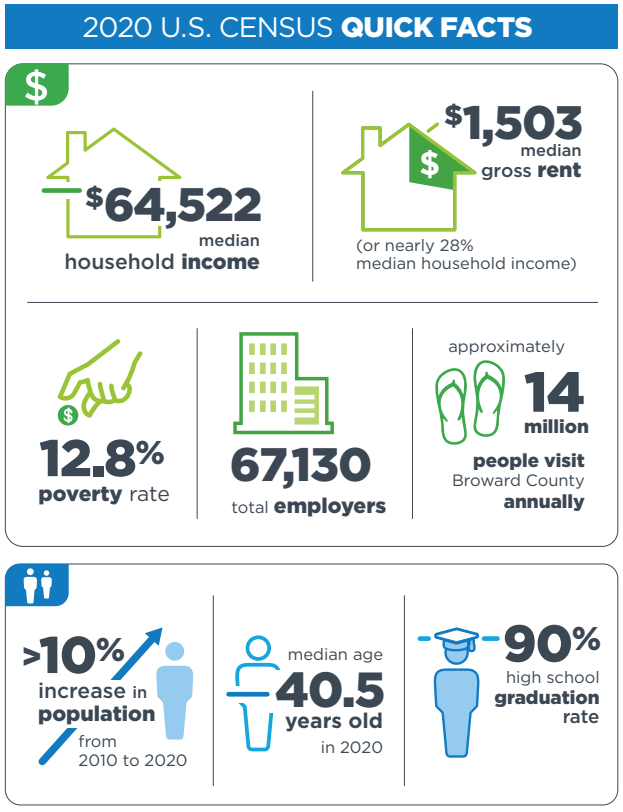
The County developed this Resilience Plan with a vision to protect the residents and businesses of Broward County while preserving and enhancing the economy and community wellbeing.

With over 67,000 employers, Broward County is a hub of economic and cultural activity. The Resilience Plan promotes a strong and stable economy, as measured by improvements in property values, property taxes, insurance premia, and Gross Value Added (GVA) compared to the baseline scenario (of not implementing adaptations).

Broward County is recognized for its unique natural resources. The Everglades and nearshore coastal reefs are systems with significant intrinsic value and are highly connected to the local economy. Urban adaptation, in response to evolving climate conditions, must be compatible and supportive of the preservation and protection of these resources and dependent ecosystems.

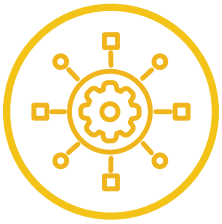
Broward County is heavily dependent on the highly interconnected canal network, drainage, and water conveyance system that must be adapted and managed in coordination with partner agencies across diverse basins and communities, necessitating use of hydrologic modeling in this effort.

The County developed this Resilience Plan with a vision to protect the residents and businesses of Broward County. The Plan focuses on strategies that are consistent with and further the County's environmental priorities to preserve and enhance the economy and community wellbeing.



Vision for Resilience

Integrate Robust Risk Analytics and Economic Analyses



Include Resilient County Infrastructure Improvement Strategies

Present Resilient Redevelopment Strategies

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

Encourage Opportunities and Partnerships Among Municipalities and Districts for Future Funding

Form the Foundation for the Collective Mitigation of Future Flooding

The Plan provides sufficient detail to serve as the basis for a multi-decade, coordinated, phased approach with planning-level detail to support refined outreach, conceptual design development, and financing. The Plan consists of adaptation strategies, particularly addressing the challenges of mitigation flood and heat risk where the lack of stormwater storage, dense development, and older infrastructure contribute to exposures.

The Resilience Plan focuses on climate change impacts anticipated over the next 50 years and the specific challenge of flood risk mitigation and the co-benefits of green infrastructure in addressing urban heat. The Plan includes new water management strategies, recommendations for increased water storage, considerations for future policy development, and green and gray infrastructure improvements.

The 50-year Plan focuses on climate change impacts—specifically, the challenge of mitigating flood risks with consideration of the co-benefits of green infrastructure to reduce urban heat.

Risks to Broward County

The Resilience Plan focuses on the baseline scenario: what would Broward County look like if we did nothing to protect and improve the resilience of the County over the next 50 years? To measure improvements, we must first understand the County's risk and vulnerabilities without implementing resilience measures.

What would Broward County look like if we did nothing to protect and improve the resilience of the County over the next 50 years?

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.

These risks are indicated for the purpose of developing strategies to improve the lifestyle of the residents and visitors to Broward County. Consideration of the attributes that residents and visitors care about primarily are addressed within the Plan.

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

These risks are based on a large set of assumptions for the future, which may be realized at a slower or faster pace than currently projected. The assumptions included estimates for SLR projections, more intense rainfall, surge events, King Tide events, and increased groundwater elevation.

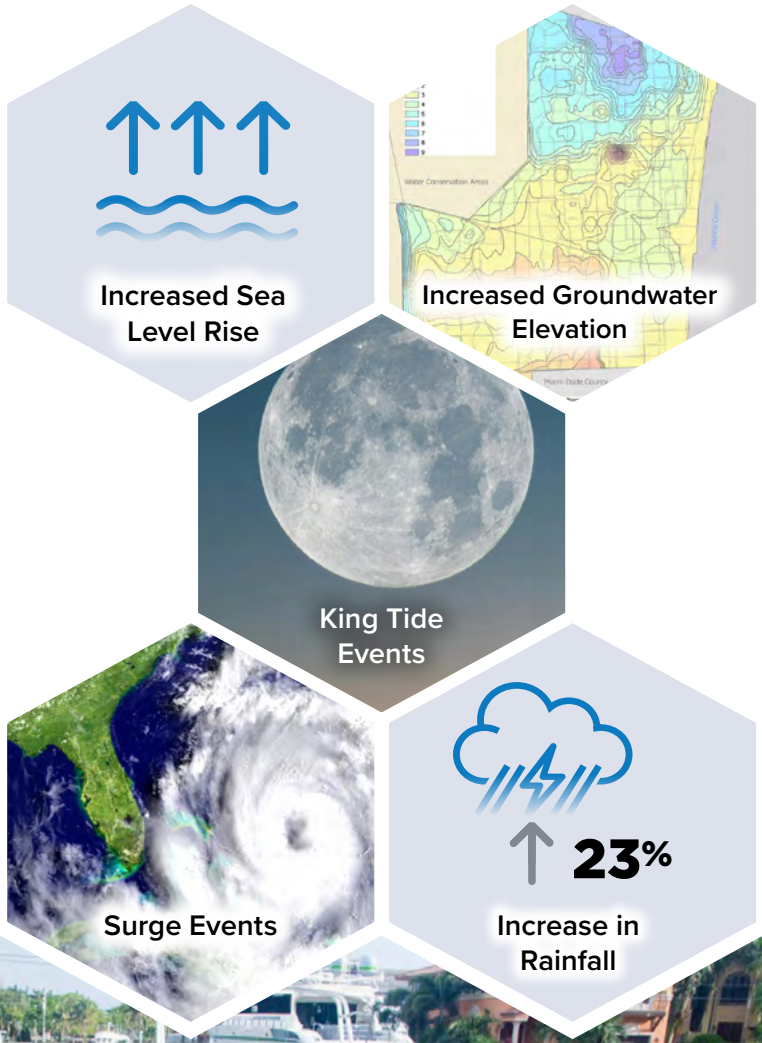


Photo below: Example of King Tide flooding.

Flood Modeling Results

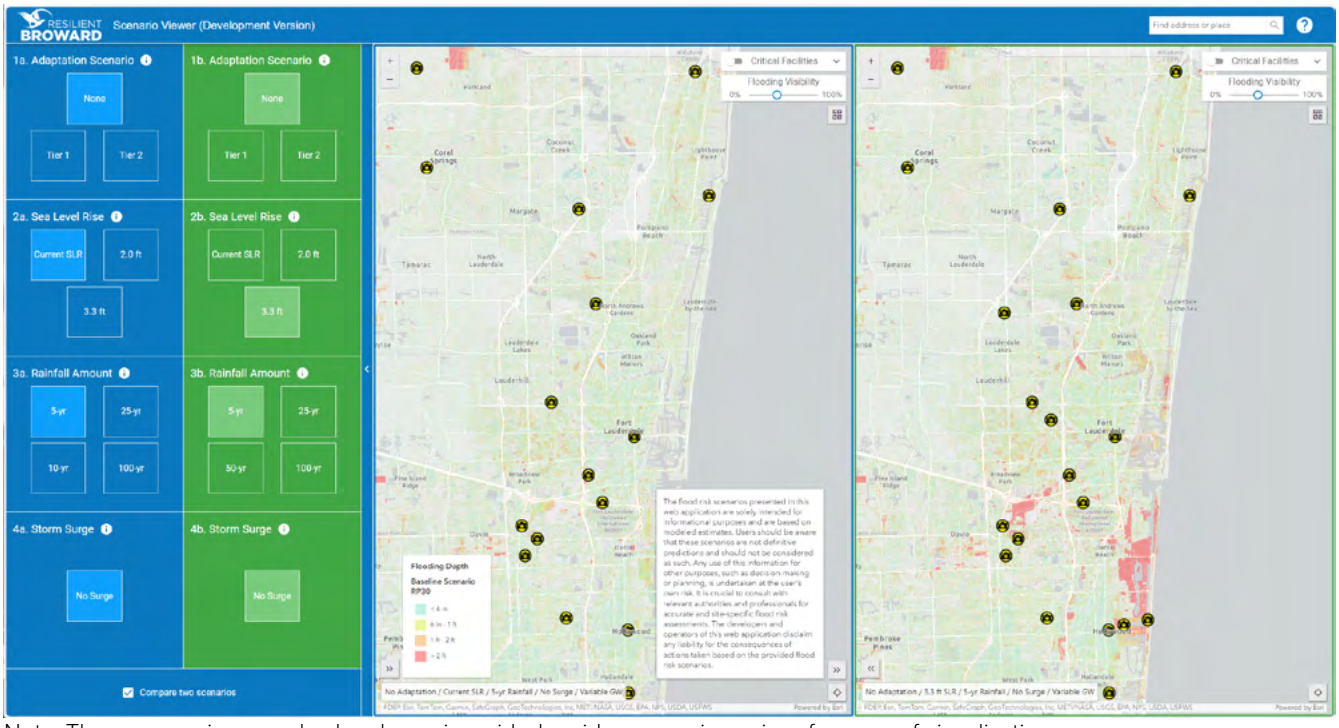
Extensive hydraulic and hydrologic (H&H) modeling was performed to evaluate flood exposure and risk under varying combinations of contributing flood conditions. The risks are not just future projections, but playing out in real time, as Broward County is already being impacted by sudden, intense rainfall and King Tide events. Residents, businesses, and visitors are increasingly challenged by surprise inundation events, which are forecast to be even more extreme and frequent in the future. Adaptations are necessary for today's conditions and even more necessary for the projected future. The Resilience Plan focuses on building community resilience to flood hazards, which are anticipated to be exacerbated by future climatological issues (specifically SLR, more intense rainfall, higher groundwater, and increasing heat) predicted over the next half-century, with a primary focus on flood mitigation. The ancillary benefit of heat mitigation is also expressed in terms of how the adaptation strategies reduce the heat effect.

The Plan focuses on building community resilience to flood hazards exacerbated by climatological issues predicted over the next half-century.

Notable to this effort is the Plan's building upon several decades of ongoing investment in the development, calibration, and refinement of the County's H&H model, a tool that has been collectively used and updated in its application by local, State, and Federal partners.

The flood model runs were captured in a Scenario Viewer, allowing users to select various combinations of SLR, rainfall, and storm surge scenarios to view associated future flood conditions. These scenarios can also be shown in a comparison view or side by side for ease of visualization. This Scenario Viewer, shown in **Figure 1**, is accessible through the Resilience Plan dashboard.

Figure 1. Scenario Viewer for Broward County



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. **Figures 2** and **3** 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 2. Long Key Natural Area 360-degree Photo with Flood Renderings

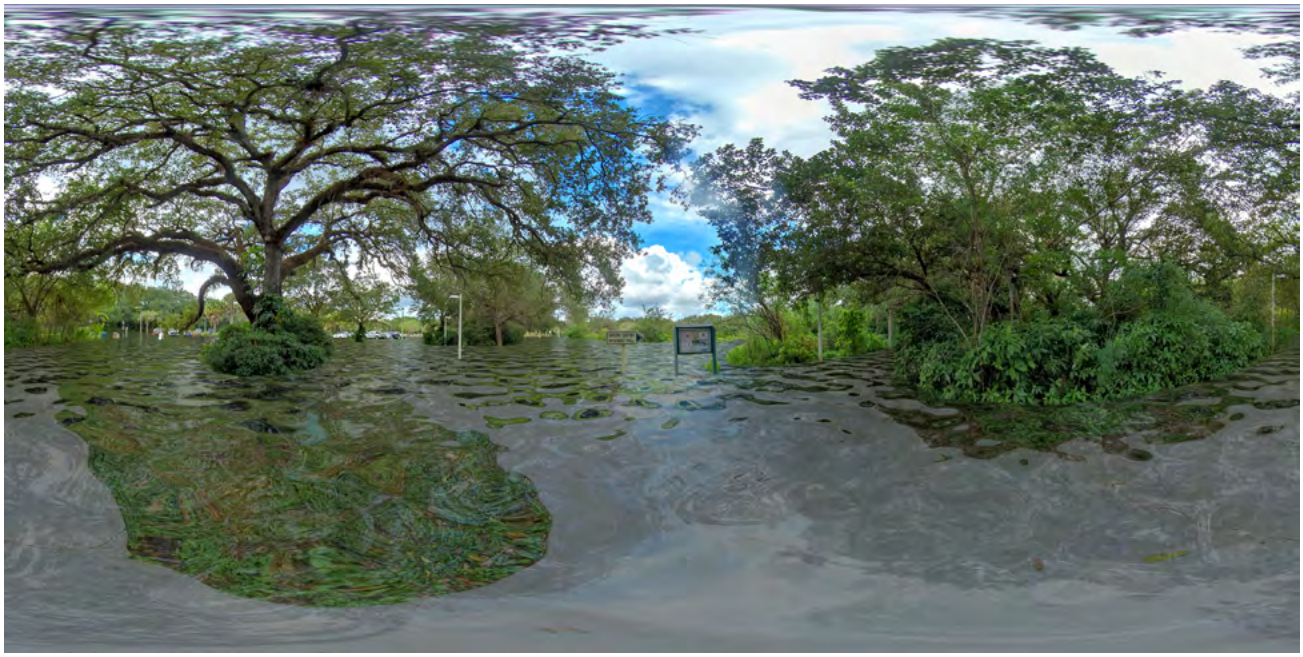
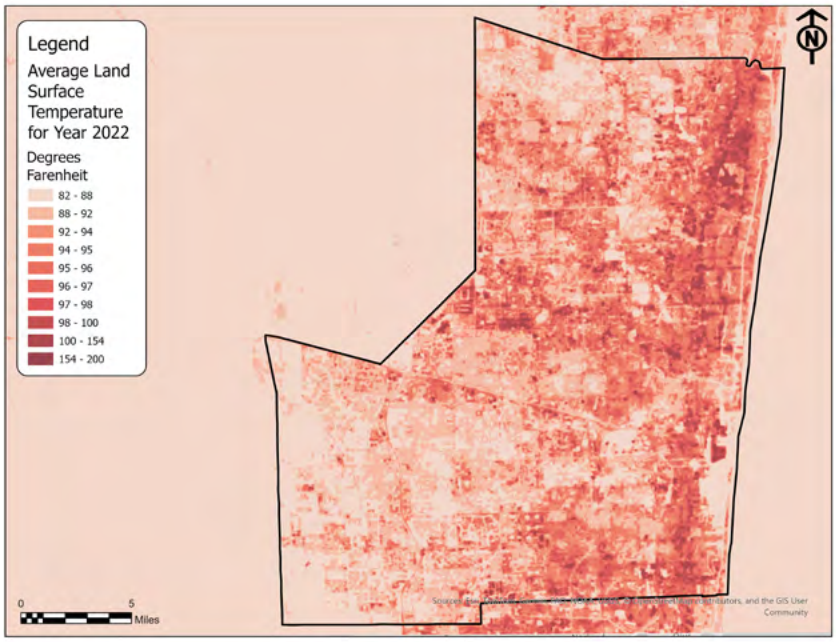


Figure 3. Memorial Regional Hospital 360-degree Photo with Flood Renderings

Heat Analysis Results

The average land surface temperature (LST) for Broward County is shown in **Figure 4** and ranged from 74–112° F for the year 2022.

Figure 4. Average 2022 Land Surface Temperature (°F)



The County's socially vulnerable populations are within or near areas that experience high LSTs, making them more susceptible to heat-related deaths and illnesses. **Figure 5** on the following page 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. 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).

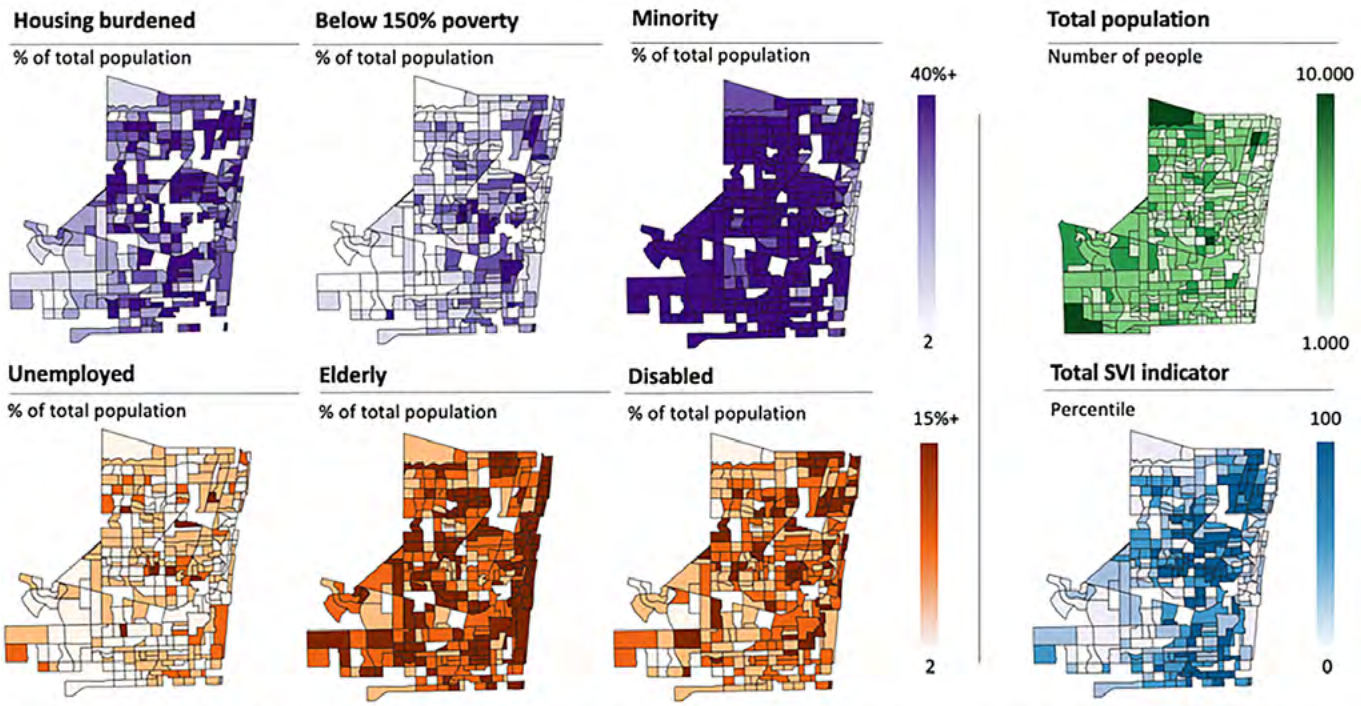
The analysis confirmed a correlation between the imperviousness of a cell and the LST in areas around that cell. Based on these analyses, a distance of 1,000 feet was used as the radius of influence that green infrastructure best management practices have on lowering temperature. This radius of influence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

> South Florida has unique geographical attributes and several environmental factors that contribute to the temperature felt by residents of Broward County.

The development of this Resilience Plan included adaptations that would benefit the hotspots identified in **Figure 6**, 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.

Figure 5. Vulnerable Populations per Social Vulnerability Index (SVI) Database

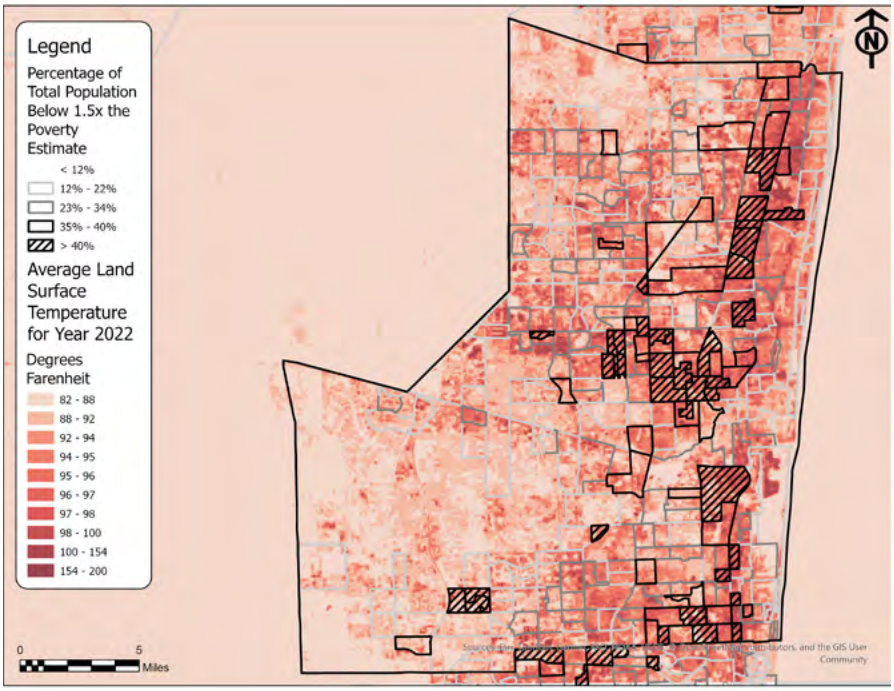


Note: This figure is taken from the Economic Evaluation of the Base Line. The darker areas have more population because the polygon is larger. Map shows population and not density.

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 6. Most Vulnerable Areas Overlain with Average Land Surface Temperature



Recommended Adaptations

Broward County is part of an overall southeast Florida drainage network operated by the South Florida Water Management District (SFWMD). Improvements made within Broward County will affect how the overall SFWMD system works. Similarly, improvements made to the SFWMD primary canals will directly impact how well Broward County can adapt.

The Resilience Plan considers these inter-connectivities and 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 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 local water control districts, the SFWMD, and other outside agencies continue to work together to maximize the benefits of the Countywide Resilience Plan.

Figure 7. Adaptations Modeled

The adaptations labeled "Tier 1" include the conversion of selected two-way roads into one-way 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. All seawalls represented must comply with this minimum elevation, 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.

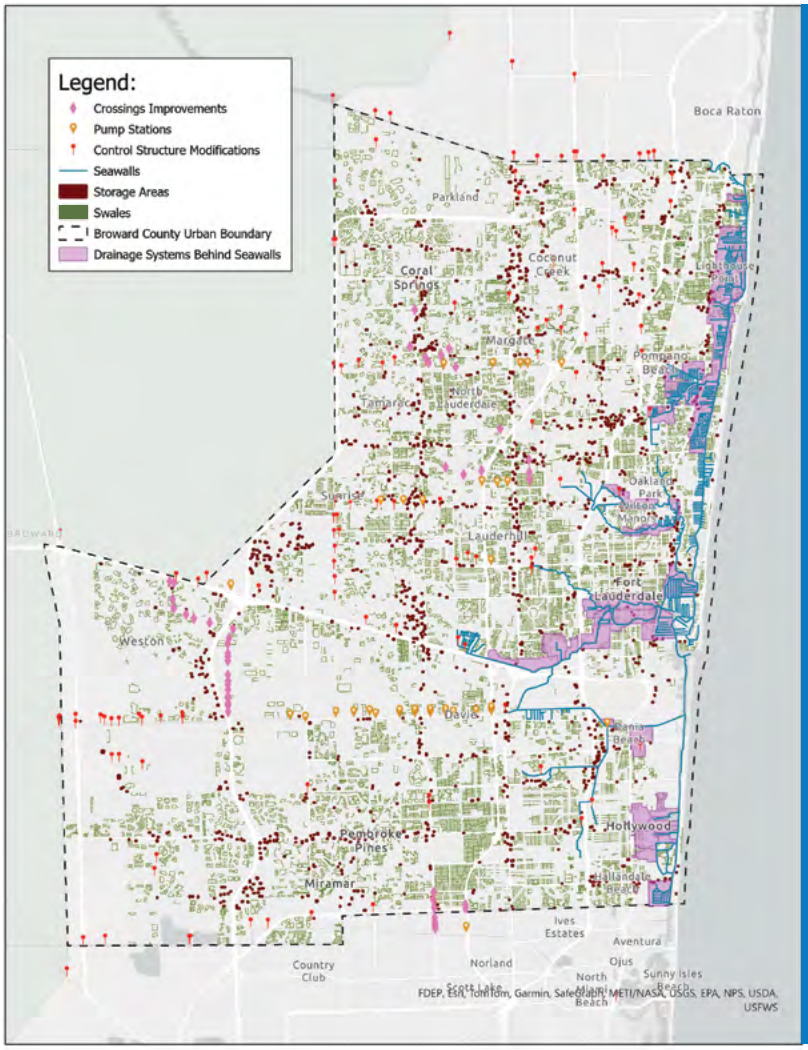
The adaptations labeled "Tier 2" include all the investments under Tier 1 plus upgrade of all seawall heights by an additional 2 feet, from 5 feet NAVD to 7 feet NAVD. Modeling showed this increased height was driven by coastal flooding under various storm surge conditions and increases in sea level, but also requires additional drainage, and pumping systems behind the seawalls to ensure adequate water management with rainfall.

Figure 8. Summary of the Adaptations Under Tier 1 and Tier 2

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

The flood mitigation effects of the Tier 1 and Tier 2 adaptations can be viewed in the Scenario Viewer alongside the base model runs without adaptations included.

Figure 9. Summary of Modeled 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 would not significantly impact the hydrologic modeling results.

Benefits of Adaptations

AVOIDED PROPERTY DAMAGE

Implementing resilience adaptations in Broward County is critical for ensuring a sustainable and thriving future. These adaptations address the County's unique vulnerabilities to climate change and environmental stressors, delivering numerous near- and long-term benefits. Enhanced flood protection will protect homes, businesses, and critical infrastructure from water damage. Under the Tier 1 investments with 2.0 feet of SLR, the average annual avoided property damage, as measured by the avoided cost of repair and replacement, is expected to be $0.78 billion. Under the Tier 2 investments with 3.3 feet of SLR, the average annual avoided property damage is expected to be $3.6 billion.

Property Damage Avoided 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 **Annual Dollars**	$0.78 Billion	$3.6 Billion
Change from Baseline	31% reduction	83% reduction

Economic stability and growth will be supported by safeguarding key economic sectors and attracting new businesses.

INCREASED SHORT-TERM ECONOMIC ACTIVITY

GVA measures the contribution of local businesses to the County's overall economic activity and includes the income produced from all sources.

The economic benefits modeled here were based on the increased GVA from:

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

The average annual avoided reduction in GVA from the Tier 1 adaptations is the difference between the baseline impact under 2.0 feet of SLR and the impacts measured following implementation of Tier 1. This avoided reduction, one of the benefits of Tier 1, is $0.11 billion. Likewise, the average annual avoided reduction in GVA from the Tier 2 adaptations is the difference between the baseline

Increased Economic Activity Countywide (Gross Value Added)

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 **Annual Dollars**	$0.11 Billion	$0.66 Billion
Change from Baseline	24% reduced loss	69% reduced loss

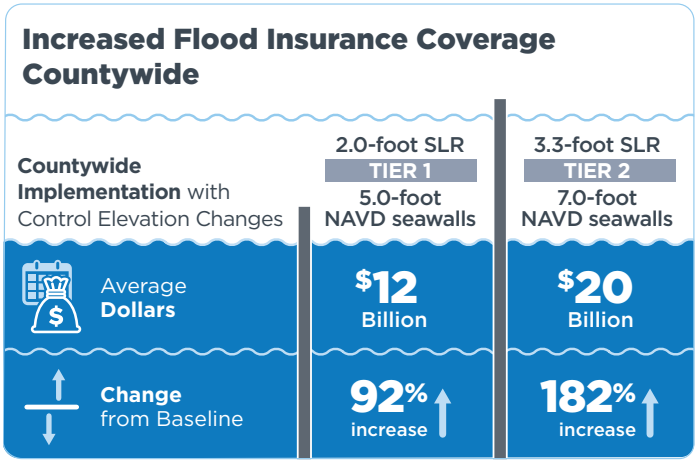
impact under 3.3 feet of SLR and the impacts measured following implementation of Tier 2 adaptations with the same 3.3 feet of SLR. The avoided reduction under Tier 2 is $0.66 billion and is one of the benefits of Tier 2.

GREATER FLOOD INSURANCE COVERAGE

Relative to the baseline conditions of no adaptation, 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 and thus reduction in uninsured losses.

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.

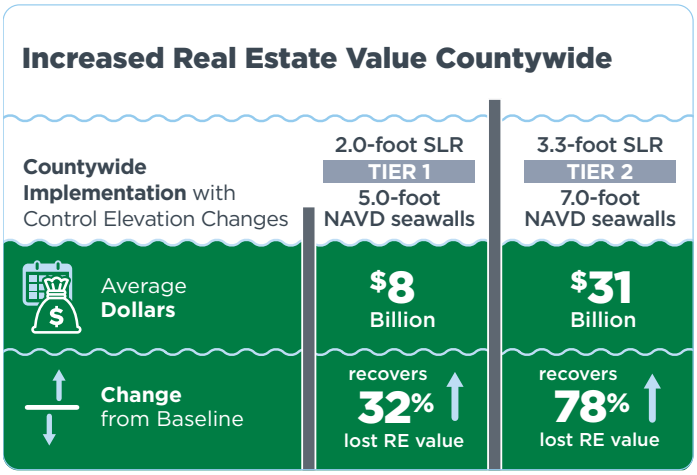
Under Tier 1 with a 2-foot SLR, approximately $12 billion in additional insurance coverage will be purchased. Under Tier 2 with a 3.3-foot SLR, insurance coverage will increase by an estimated $20 billion.



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 to other neighborhoods. For example, losses in neighborhoods affected by increased flooding could depress the real estate values of other properties in the vicinity. On the flip side, migration from the impacted areas to other parts of the county could increase prices in these neighborhoods.

Under Tier 1, countywide real estate value is estimated to be $8 billion higher than it would be under the baseline of no action. Under Tier 2, countywide real estate value is estimated to be $31 billion higher than under the baseline.

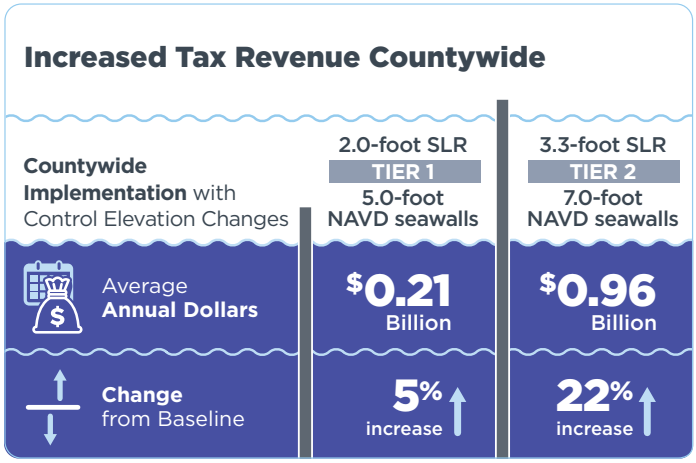


INCREASED TAX REVENUE

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 property tax, which is based on the market value of real estate. As real estate values become lower than they would be if sea levels remained stable, this loss eventually translates into lower taxable values of real estate and lower property tax revenue.

Given the millage rates assessed by the County, municipalities, and government agencies, ad valorem tax revenue would be expected to fall as flooding increases with 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 tax revenue losses under the baseline of "no action." The benefit of the Tier 2 investments is a countywide average annual tax revenue that would be $0.96 billion higher than the baseline, which recovers 22% of the baseline losses.

SUMMARY OF BENEFITS

The average annual countywide benefits of the Tier 1 adaptation strategy when SLR is 2 feet include an estimated $780 million in avoided property damage, $109 million in short-term economic activity GVA, and a $211 million 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 adaptation strategy when SLR is 3.3 feet include an estimated $3.6 billion in avoided property damage, $660 million in short-term economic activity (GVA), and a $962 million 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 actions that mitigate flood impacts.

Figure 10. 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

Costs of Adaptations

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 feet NAVD to 7 feet NAVD and the cost of the additional drainage features behind the seawalls. The additional cost was estimated to be $7.9 billion for the incremental Tier 2 capital cost with a combined total capital cost of $28.0 billion in 2024 dollars. The annual operation, maintenance, renewal, and replacement cost of Tier 1 is estimated to be $201 million, and the annual cost of Tier 2 is estimated to be $280 million.

Figure 11. Estimated Capital Cost of the Tier 1 and Tier 2 Investments in 2024 Dollars

Figure 11A. Public and Private Capital Costs of the Tier 1 Investments

Investment Types	Public Cost	Private Cost	Total Cost
Control Structures	$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 Stations	$575,000,000	$0	$575,000,000
Seawalls	$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
Swales	$771,000,000	$426,000,000	$1,197,000,000
Seawalls 5–7ft	$0	$0	$0
Grand Total	**$8,145,000,000**	**$11,988,000,000**	**$20,133,000,000**

Figure 11B. Additional Public and Private Capital Costs of the Tier 2 Investments

Investment Types	Public Cost	Private Cost	Total Cost
Control Structures	$0	$0	$0
Crossings	$0	$0	$0
Drainage Behind Seawalls	$0	$0	$0
Pump Stations	$0	$0	$0
Seawalls	$0	$0	$0
Storage	$0	$0	$0
Swales	$0	$0	$0
Seawalls 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**

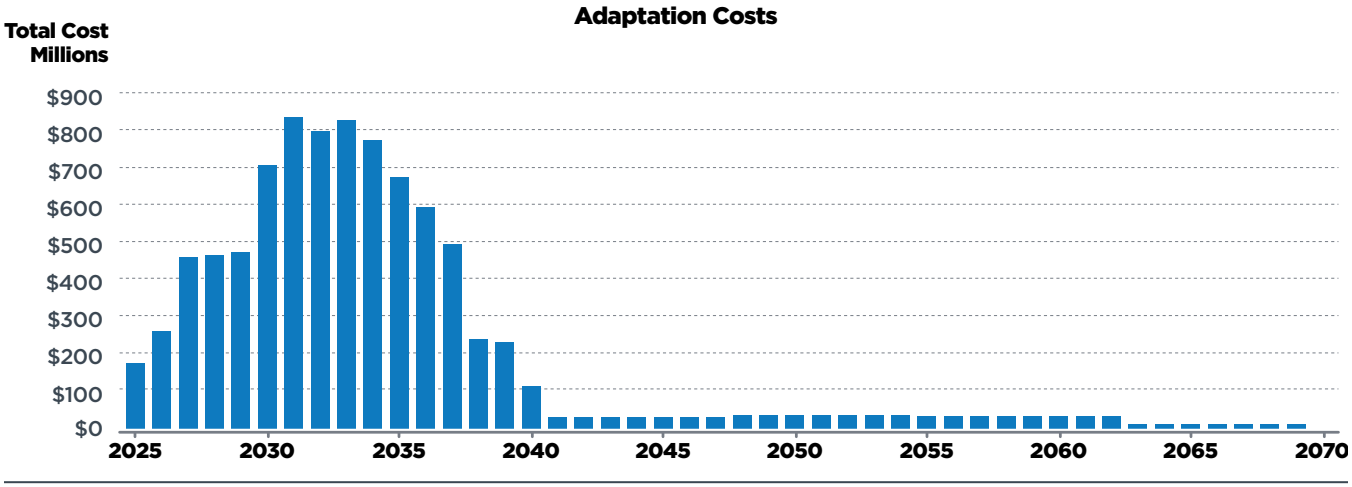
Figure 11C. Public and Private Capital Costs of the Tier 2 Investments

Investment Types	Public Cost	Private Cost	Total Cost
Control Structures	$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 Stations	$575,000,000	$0	$575,000,000
Seawalls	$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
Swales	$771,000,000	$426,000,000	$1,197,000,000
Seawalls 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**

The total cost of Tier 1 and Tier 2 adaptations is $28 billion. The public portion of that total cost is $9 billion and should be split between the County and the municipalities and water control districts.

Figure 12 below shows the projected expenditure per year for the County's portion of the Tier 1 and Tier 2 investments.

Figure 12. Projected Expenditures for the Public's Portion of Tier 1 and Tier 2 Adaptations



Note: This is the baseline projected expenditure for the public if the projects were to start immediately. It is recognized that the expenditures likely will not start until at least two years from present.

Economic Feasibility of Adaptations

The economic feasibility evaluation included 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. The IRR is the discount rate that equates the present value of benefits to the present value of costs.

The Tier 1 and Tier 2 benefits included were the dollar value of the avoided property damage, the increased short-term economic activity (GVA), and the increased real estate value. These benefits were compared to the capital and annual cost of the Tier 1 and Tier 2 investments. The other benefits estimated in this study were either included in, or are byproducts of, these three major benefits.

Additional benefits of Tier 1 and Tier 2 also contribute to the economic feasibility evaluation but were not estimated during this study. They include the GVA created from: avoided disruption to public services, avoided reduction in private investment, and avoided demographic disruption. As a result, the overall economic feasibility metrics are at least as large as those reported in this study.

For this Resilience Plan, and in general, a project is deemed economically feasible if the present value of net benefits is greater than zero. When this happens, the project's rate of return on investment (IRR) will be greater than the 5% annual discount rate used, and the project's benefit-cost ratio will be greater than 1.0.

For this Plan, the economic feasibility was evaluated for two SLR scenarios. Scenario 1 assumes that SLR will be 2 feet by 2050 and continue to rise to 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 results is provided in **Figure 13**.

Figure 13. 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 (IRR)	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.

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.

Implementation Plan

The Resilience Plan is intended to be implemented over several decades in coordination with other ongoing infrastructure projects where possible. Certain adaptations, such as the conversion to one-way roads, may require public education and public relations to successfully implement. All strategies will require proper funding and coordination with other ongoing efforts.

The Resilience Plan is intended to be implemented over a long period of time and in coordination with other ongoing infrastructure projects where possible.

PHASED PROJECT TIERS DETAILS

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

Tier 1 (Completion by 2040)

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

- **Seawalls up to 5 feet NAVD**: Assumes seawall or equivalent tidal flood barriers would 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 would be converted to one-way or single lane roads, increasing pervious surfaces to improve stormwater absorption. Additional pumping stations, improved crossings, and larger culverts would be added to strengthen the drainage system.
- **Storage Areas and Green Infrastructure**: Investments would be 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 would be 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 feet NAVD. This will provide additional protection against anticipated SLR and higher storm surges.

- **Seawalls up to 7 feet NAVD**: In this phase, seawalls in Zones 1 and 2 would be raised to 7 feet NAVD, offering additional protection against anticipated SLR and higher storm surges.
- **Enhanced Drainage and Pumping Capacity**: Tier 2 projects would require expanded drainage infrastructure with additional pumping stations, larger culverts, and control structures to manage the stormwater on the landward side of seawalls.
- **Continued Expansion of Green Infrastructure**: Additional swales, pervious surfaces, and storage areas would be implemented in inland areas, especially Zone 3, where these solutions are essential for sustainable flood management.

GEOGRAPHIC IMPLEMENTATION ZONES

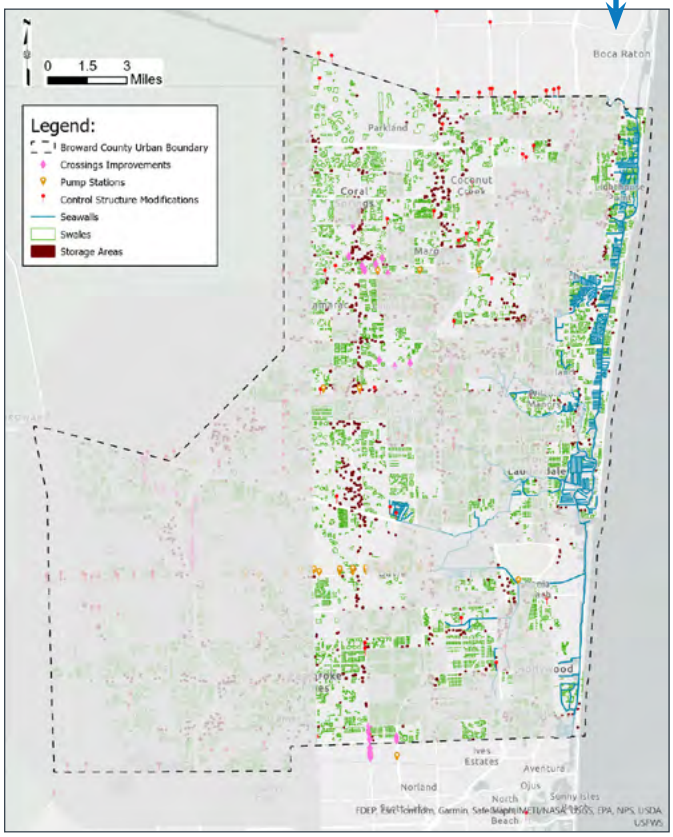
To ensure that adaptation measures are appropriately targeted, Broward County is divided into three geographic zones based on vulnerability and proximity to the coast. This zoning approach enables the County to deploy customized strategies to address the distinct resilience needs of each area.

Zone 1: Highly Vulnerable Areas

The vulnerable areas are characterized by overlapping challenges, including high flood risks, and extreme heat impacts. The presence of low- and moderate-income (LMI) communities is also considered in Zone 1.

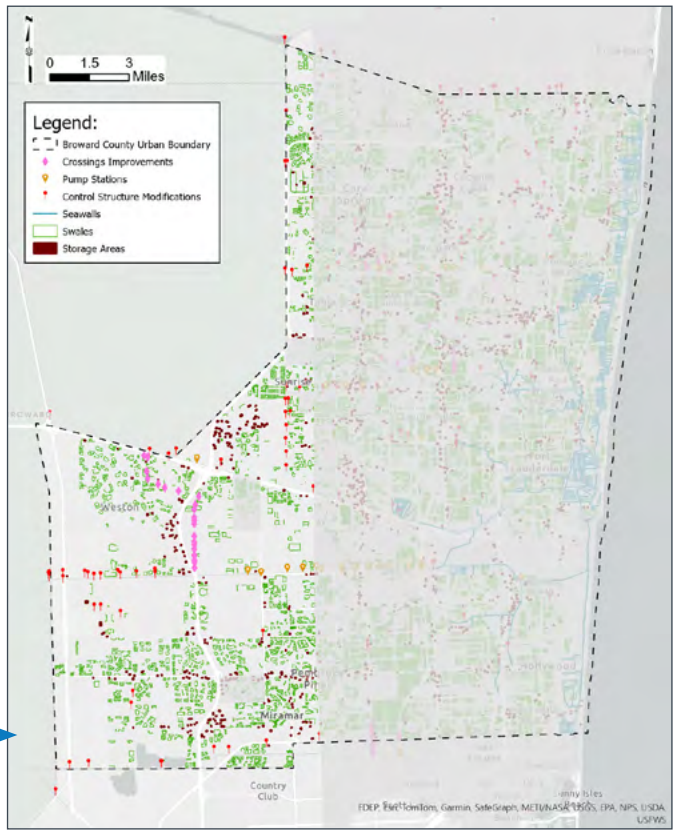
Zone 2: Eastern Areas

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.



Prioritization

The criteria for assigning start dates to projects as presented in **Figure 14** 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 eastern 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.

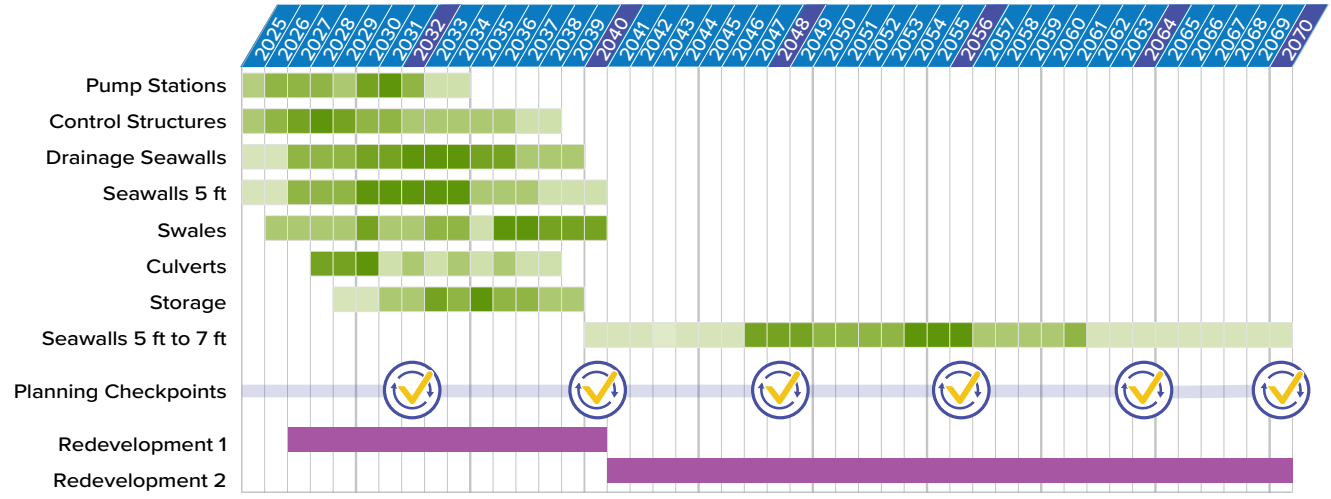
When sequencing projects, downstream effects were evaluated to ensure execution progressed from downstream to upstream (or east to west), minimizing the risk of unintended impacts during implementation.

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 will be prioritized and budgeted in parallel with the Resilience Plan. The implementation of these projects will be tracked by the County against this prioritization schedule.

Figure 14. Implementation Plan for Tier 1 and Tier 2 Investments



Planning Check Points: Review latest projections, update the model with latest projections and project progress, including local, State, and Federal projects.

Redevelopment: Divided into two groups based on SLR (2 feet and 3.3 feet).

LEGEND:

Lower load — Higher load

Note: This is the baseline implementation plan for the County if the projects were to start immediately. It is recognized that the expenditures likely will not start until at least two years from present.

Finance Plan

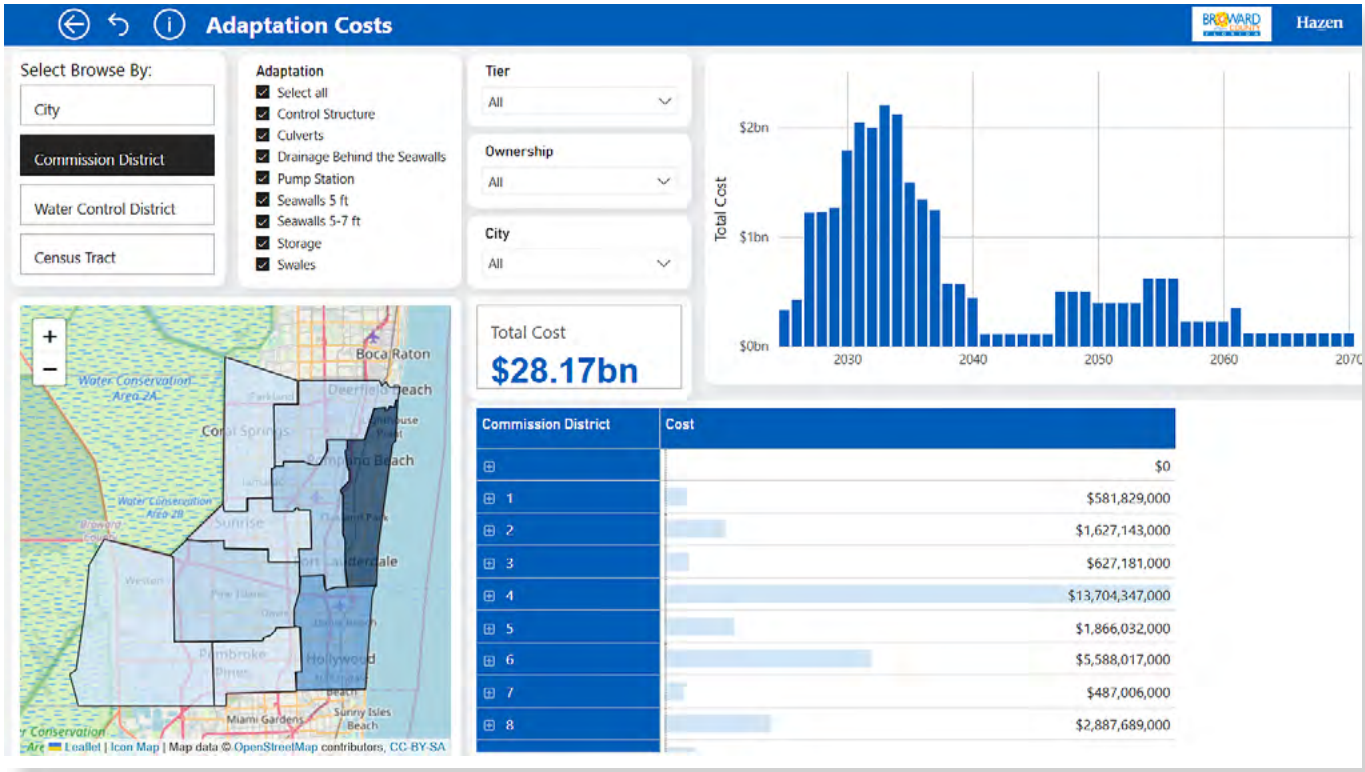
The economic feasibility analysis demonstrated that the present value benefits of the County's Resilience Plan is greater than the present value of its costs. The benefits included were avoided property damage, avoided reductions in economic activity within the county, and avoided reductions in property values. These benefits would be realized by residents and businesses throughout the county, and there would be additional benefits with monetary values that 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 Plan investments. They fall into the categories of Federal funding, State funding, community-based funding, and regional collaboration. A mix of these sources will likely provide sustainable funding. Care should be taken to ensure that the Plan is sufficiently funded throughout the 45-year investment period to achieve the intended outcomes.

Implementation will require that the County work with its municipalities, local water control districts, State and Federal governments, and private sector to identify sustainable and sufficient funding sources. Leveraging those opportunities would enable the County to develop an appropriate finance plan.

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



County Policies for Consideration

The Resilience Plan recommends several policies for the County's consideration to support how the adaptations are implemented. These policies include updating building codes and land use regulations to incorporate resilience measures, incentivizing the use of green infrastructure, promoting public awareness and education on climate change and resilience, and encouraging community engagement in the resilience planning process.

Policy Strategy 1

Develop Green Streets Program

Policy/Action: Increase available green space for drainage along roadways, including bioswales, by providing guidance and incentives to convert selected neighborhoods from two-way to one-way or one-lane roads and widen the drainage areas along the right-of-way (ROW).

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 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 Strategy 4

Reduce Parking Minimums

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

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 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 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 Strategy 8

Incorporate Resilience into Complete Streets Design Standards

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

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 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 Strategy 11

Promote Resilient Home Construction and Retrofits

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

Policy Strategy 12

Mitigate Rising Insurance Costs

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

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 Strategy 14

Utilize Technology to Enhance Flood Protection

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

Policy Strategy 15

Establish Overlay Districts to Enhance Resilience

Policy/Action: Provide incentives for redevelopment in overlay areas where additional storage will improve flooding and reduce heat.

Policy Strategy 16

Develop Cleaning and Maintenance Program for Infrastructure

Policy/Action: Require routine cleaning and maintenance of stormwater infrastructure.

Policy Strategy 17

Improve Resilient Development Requirements

Policy/Action: Develop a resilient land development code to document requirements for compliance with the Resilience Plan.

Policy Strategy 18

Document Future Seawall Requirements Post 2070

Policy/Action: Provide information to prepare for future modifications to the seawall ordinance.

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 redevelopments deliver optimized heat and flood mitigation benefits.

Stakeholder Engagement and Outreach

This Resilience Plan was developed with the direct involvement of the local municipalities and water control districts. The Plan kicked off with a stakeholder roundtable discussion in which most of the municipalities and water control districts participated and provided data for incorporation into the development of the model. The municipalities and water control districts then participated in geographic review meetings to review both initial model results (for the baseline scenario) as well as results from the modeled adaptations.

Plan development was further supported by a Resilience Steering Committee consisting of diverse private-sector and community representatives. The SFWMD and the US Army Corps of Engineers (USACE) also participated in discussions throughout plan development. Additionally, the team solicited input from the general public, including the local youth, through listening sessions with the Community Foundation, Hispanic Unity, Residents 4 Resilience, and the Eco Explorers at the Museum of Discovery and Science.

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 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's Unified Regional Sea Level Rise Projection, but recognizes 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 will be dynamic, with technological improvements incorporated within future investment strategies.

The Plan is intended to be implemented in parallel with improvements to the Central and Southern Florida (C&SF) Flood Control Project by the USACE and SFWMD. Additionally, each municipality is anticipated to implement, in parallel, improvements to its stormwater management capital infrastructure to address localized and frequent flooding.

Through implementation of the Plan and 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 Plan's investments are proven by the calculated benefits to be worthwhile. As resilience initiatives advance, the County is committed to working countywide to ensure that resilience investments are properly coordinated and prioritized for the greatest possible impacts and benefits.

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.

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

WWW.BROWARD.ORG/RESILIENCE

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.