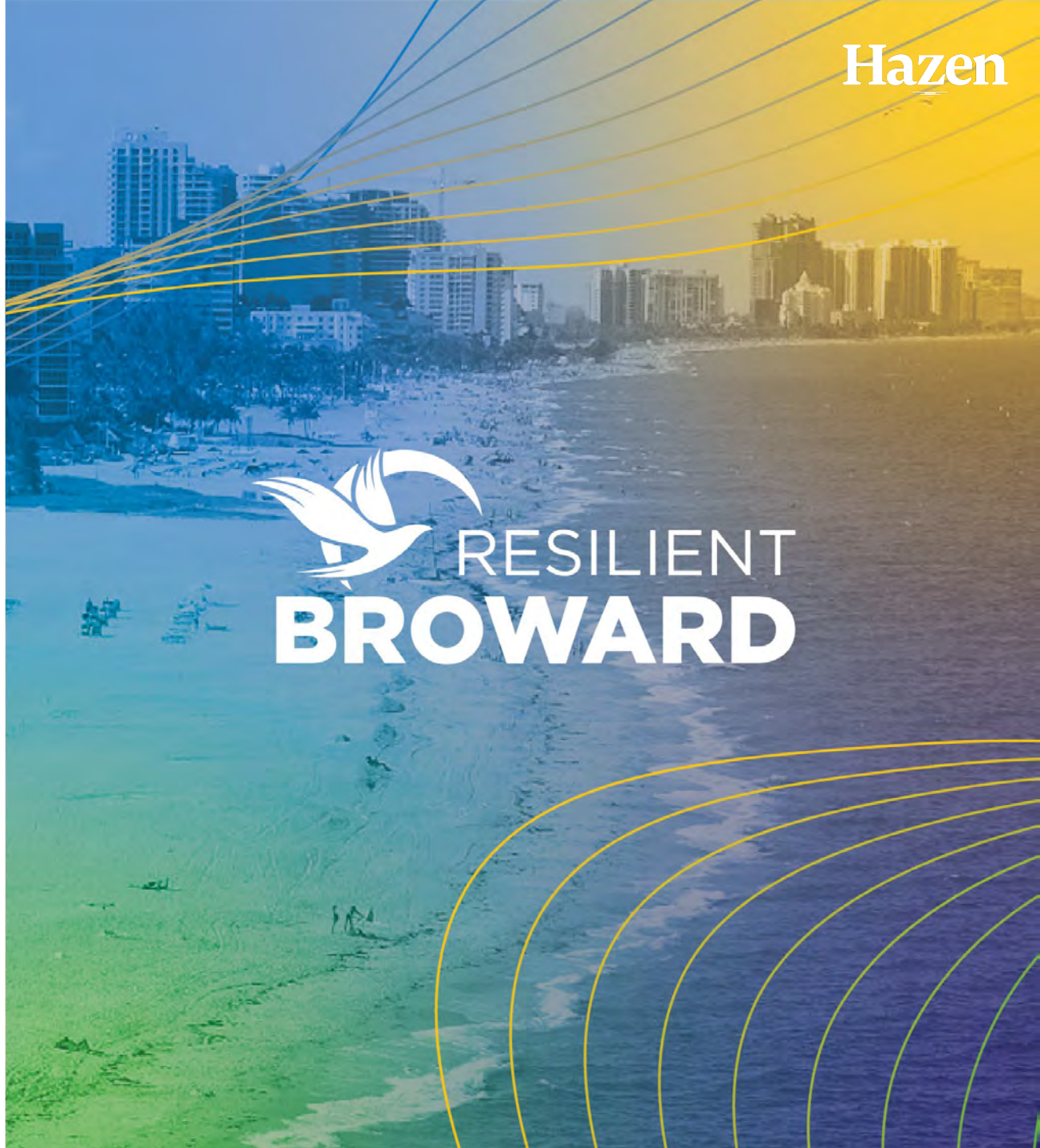
COUNTYWIDE RISK ASSESSMENT AND RESILIENCE PLAN

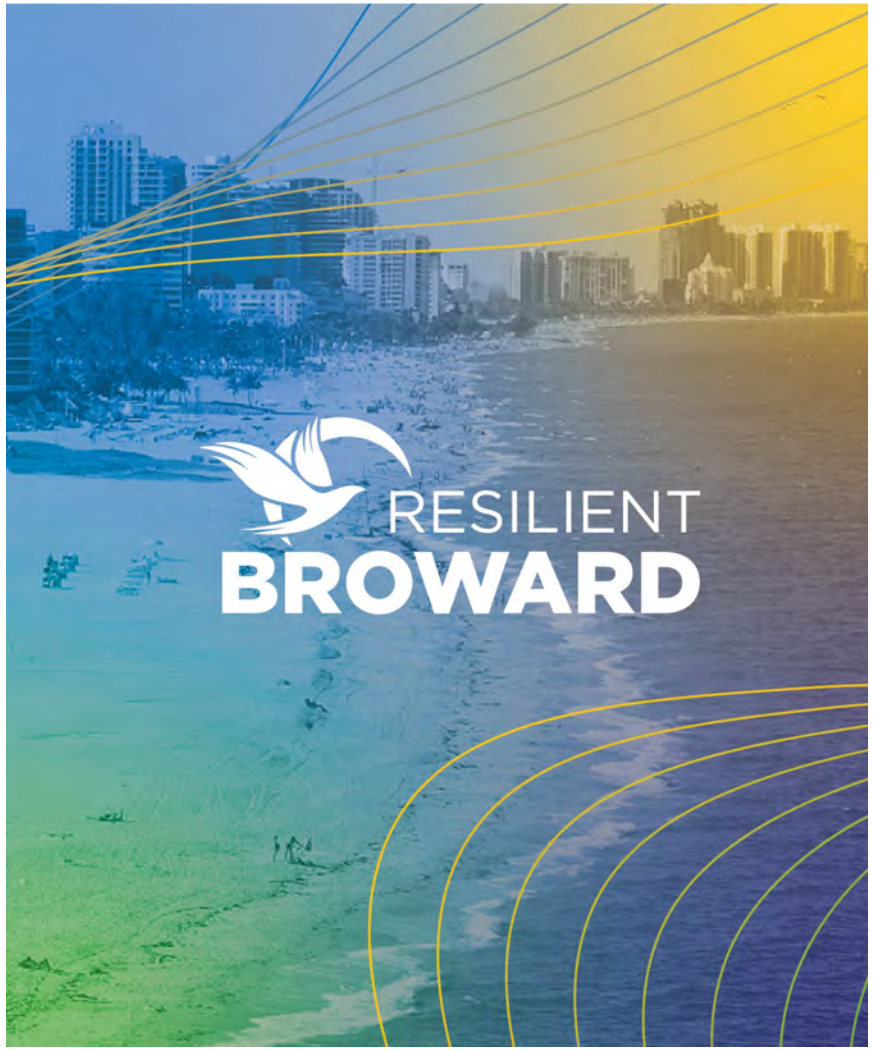
ADAPTATIONS RESULTS REVIEW - NORTH

March 25, 2024



Outline

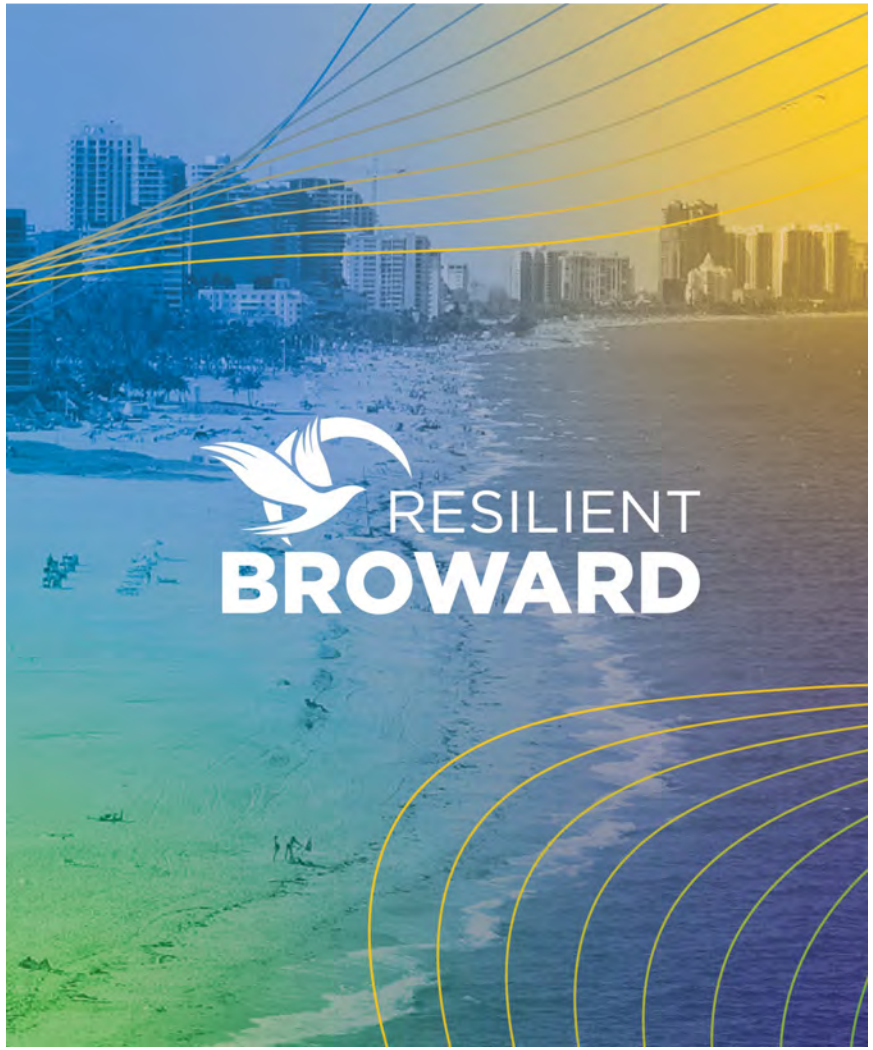
1. Introduction
2. Intent of Stakeholder Review
3. Overview of Adaptation Strategies and Results
4. Discussion
5. Concluding Thoughts/Next Steps



1

Introduction

Hazen



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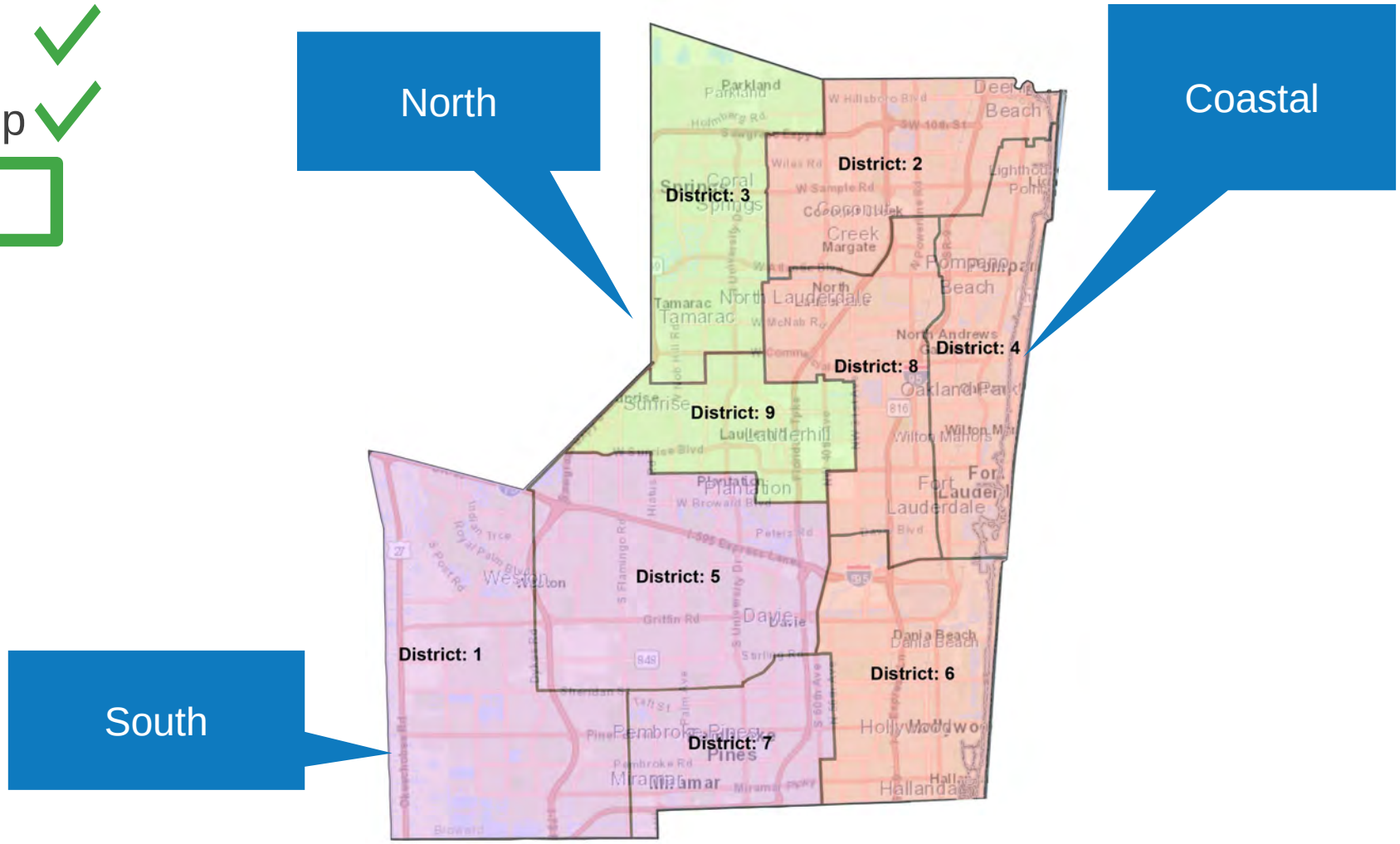
Intent of Stakeholder Review

Hazen

We will be meeting with Stakeholders in three separate group meetings

- March 14 – South Group ✓
- March 19 – Coastal Group ✓
- March 25 – North Group

Arrangement roughly by Commission District and general location/resilience challenges



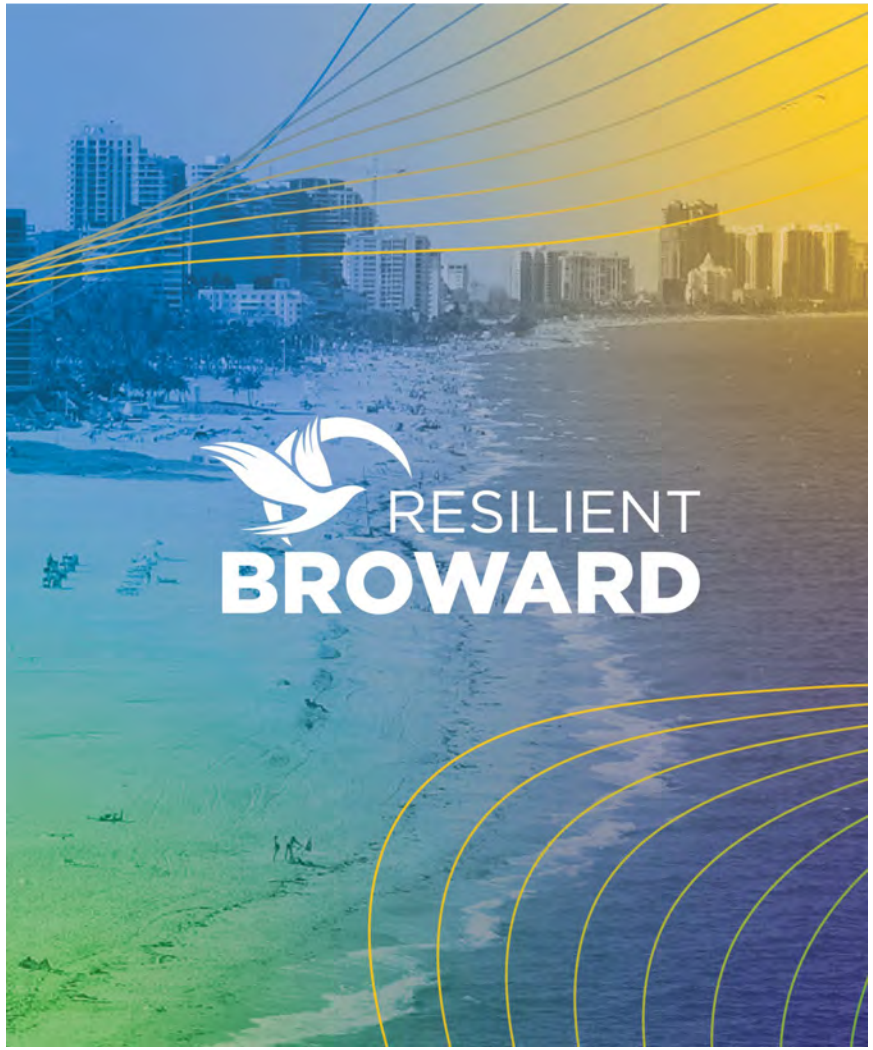
The intent of this engagement is to inform municipalities, water control districts, and other entities about possible adaptations (and receive their feedback).

- Unique local insight is critical
- Garnering community support is essential

Incorporation of the collective adaptations into the model will yield hydrologic results that feed the economic analyses.

As we review today's adaptations, consider the following:

- Specific practices will be more/less effective in certain areas
- Practices will be deployed in combination (suites of strategies)
- There will be a timing hierarchy regarding application of strategies
  - **Consideration of difficult/controversial implementation**
  - **Relative cost/benefit ratio**
- Some applications may have strong co-benefits (heat reduction/aesthetics/open space), which should be considered
- It is understood that some strategies have drawbacks, but are still worthy of consideration
- Some areas will require investment regardless of cost/benefit ratio



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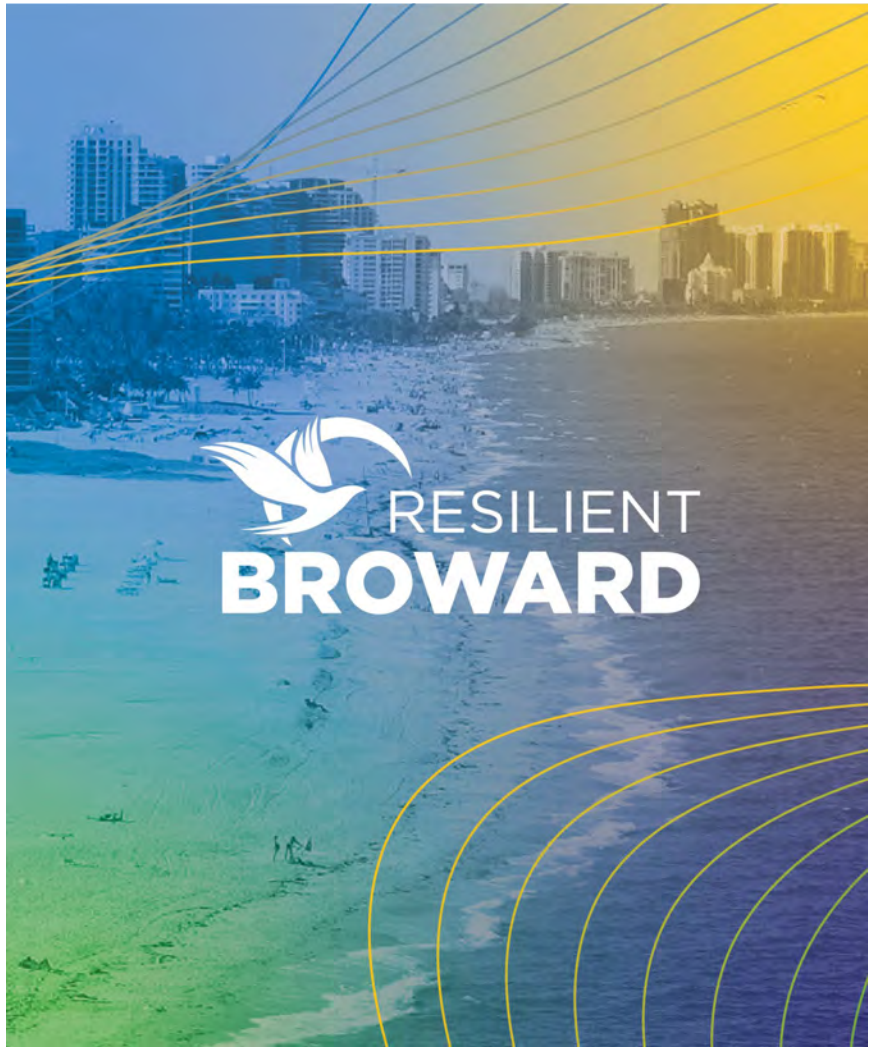
Overview of Adaptation Strategies and Results

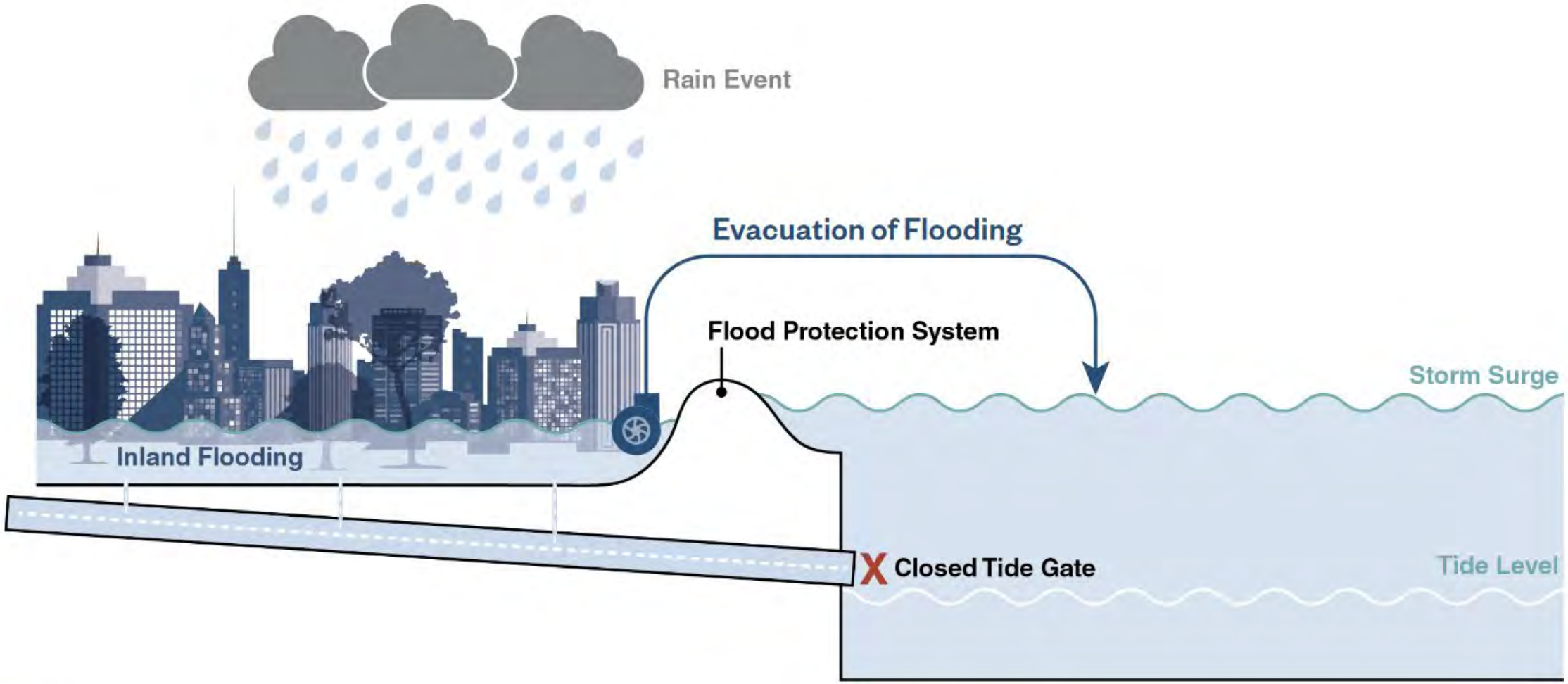
Hazen



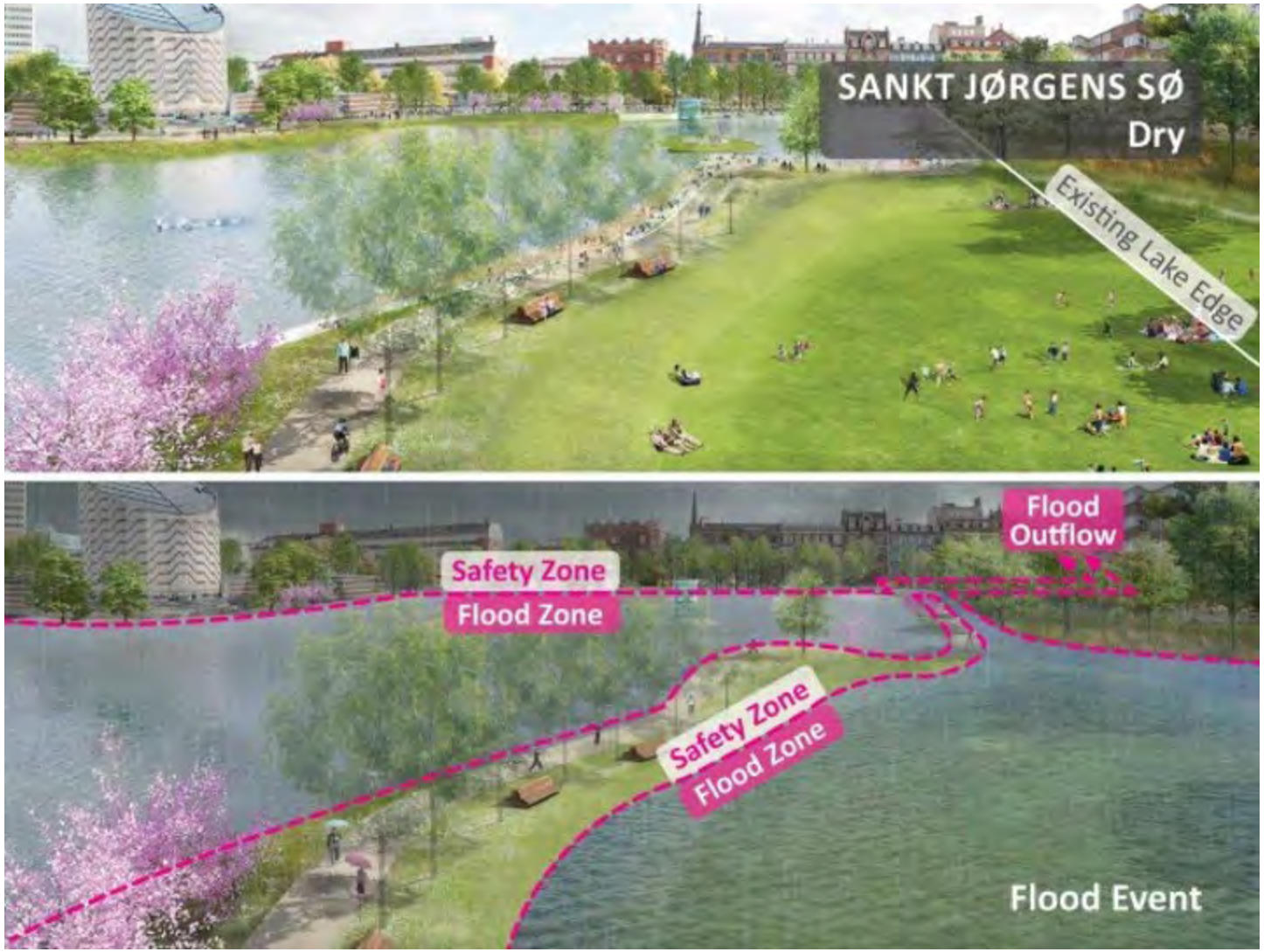
Adaptation Concepts

Hazen

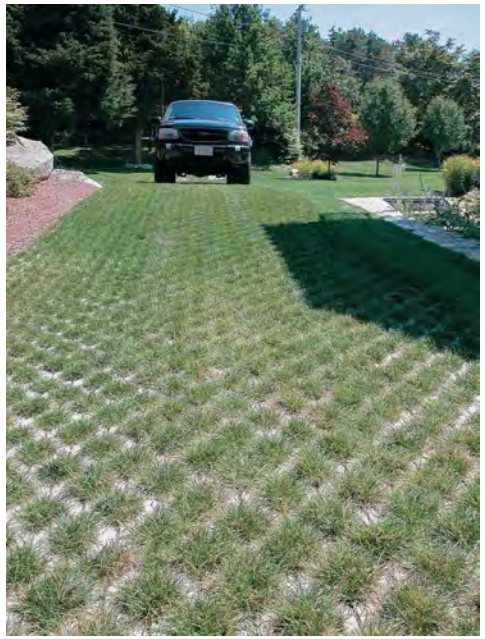
In big picture terms, we are protecting from storm surge and sea level rise with additional conveyance and strategic addition of system storage



Where possible, we will leverage existing landscapes for nature-based solutions and improved public access



A myriad of optional practices are being considered...



Increased Pervious Area

Swales

Bioswales

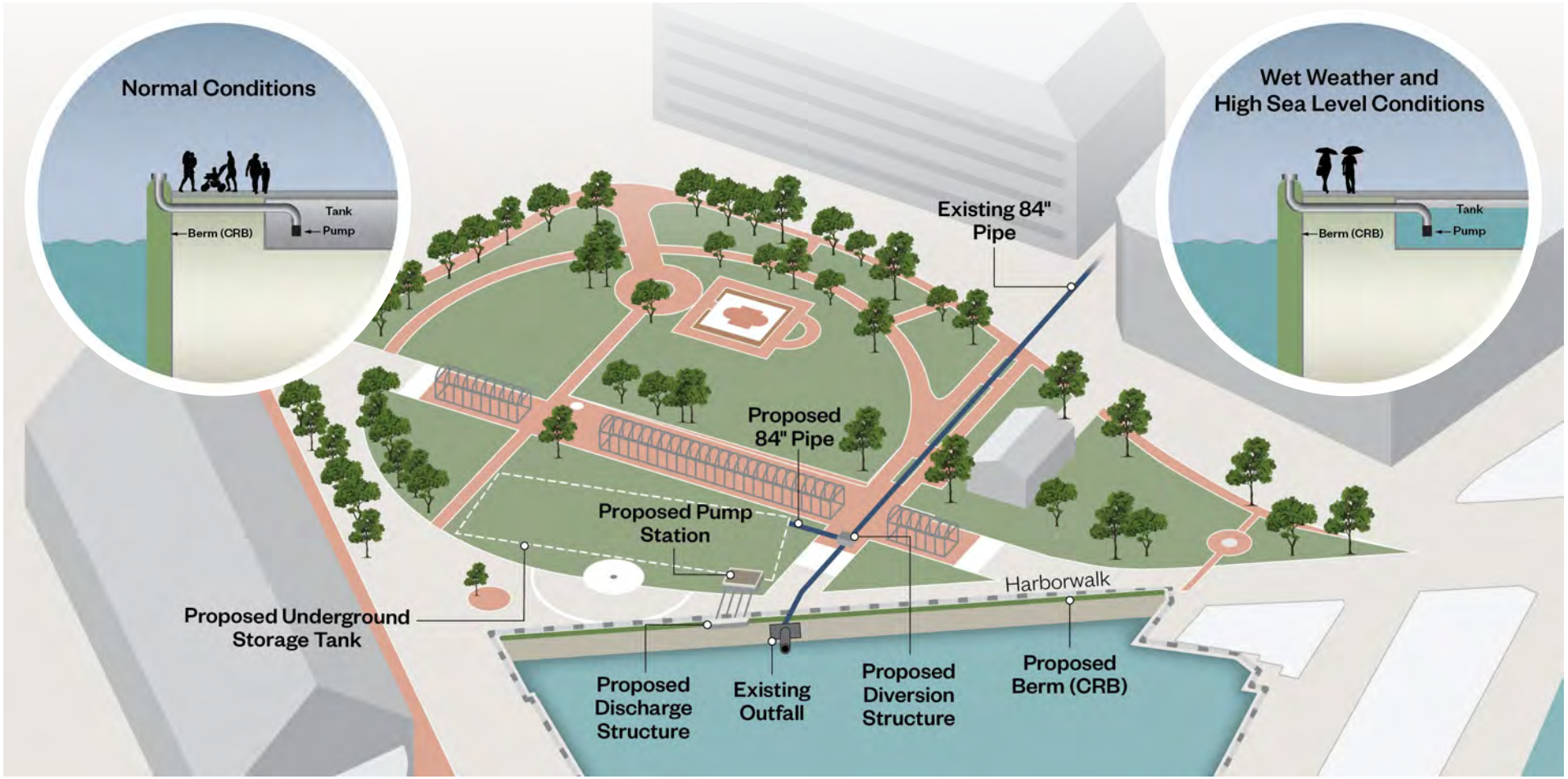
Elevated Roads and Infrastructure

Pumped Systems

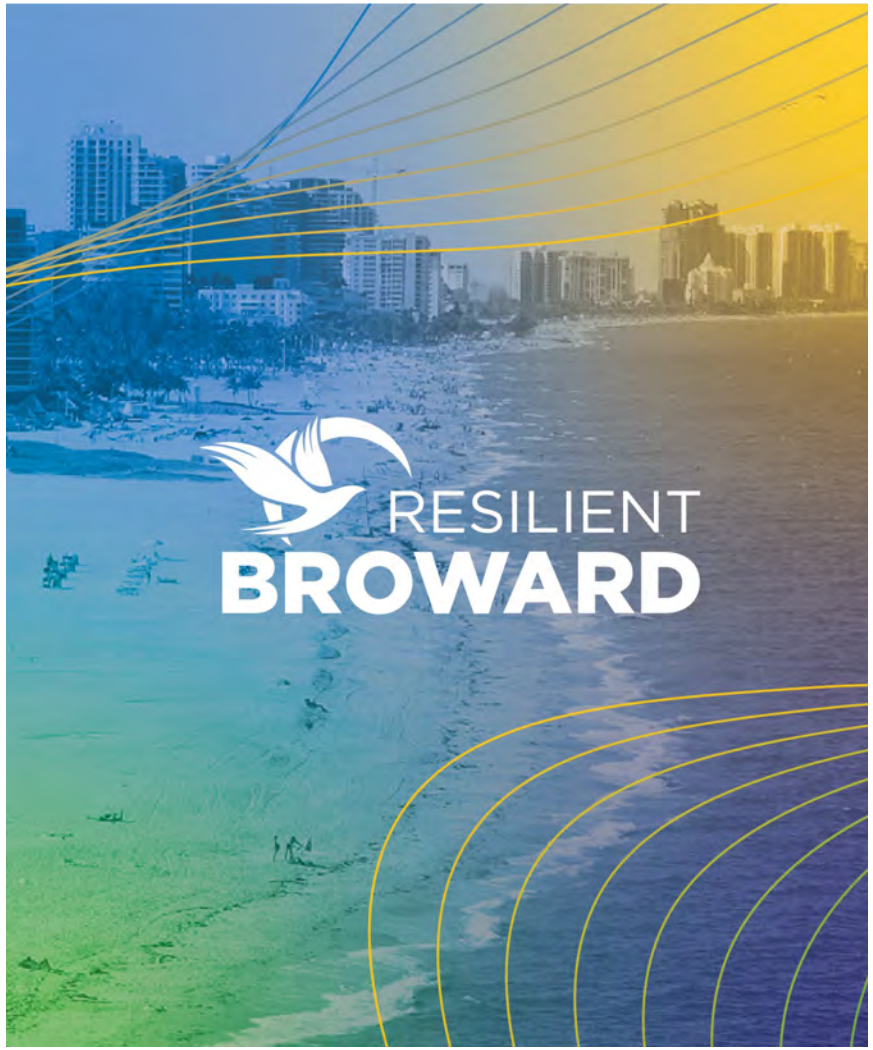
Seawalls

…the effectiveness of many will be enhanced by increasing groundwater storage.

One such example is underground storage chambers



- Storage chambers under pervious pavement or similar surfaces provide a more direct access to the storage.
- Structures will be more effective in areas of lower groundwater table



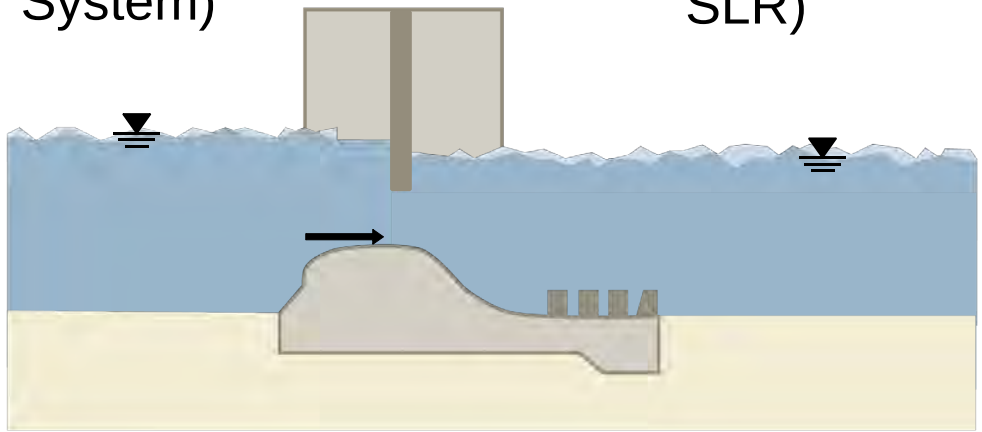
Adaptation Specifics

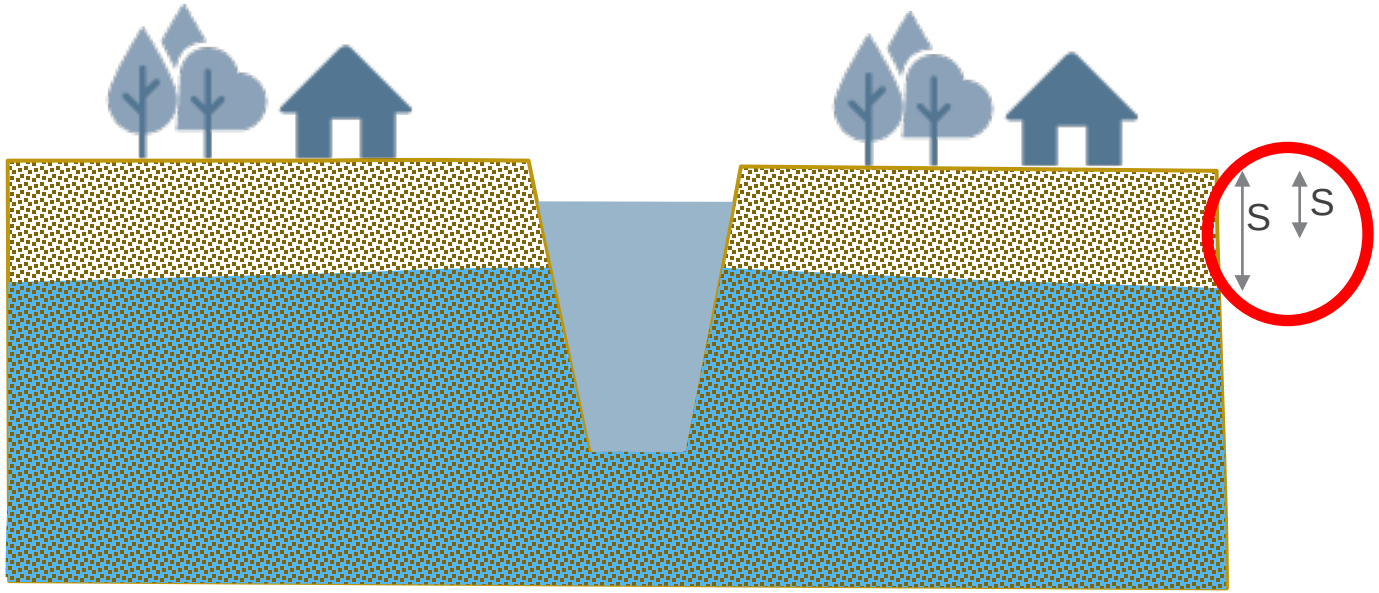
Hazen

Sea Level Rise will cause an increase in Groundwater Levels, which translates to reduced storage

Headwater (controls water levels in Primary System)

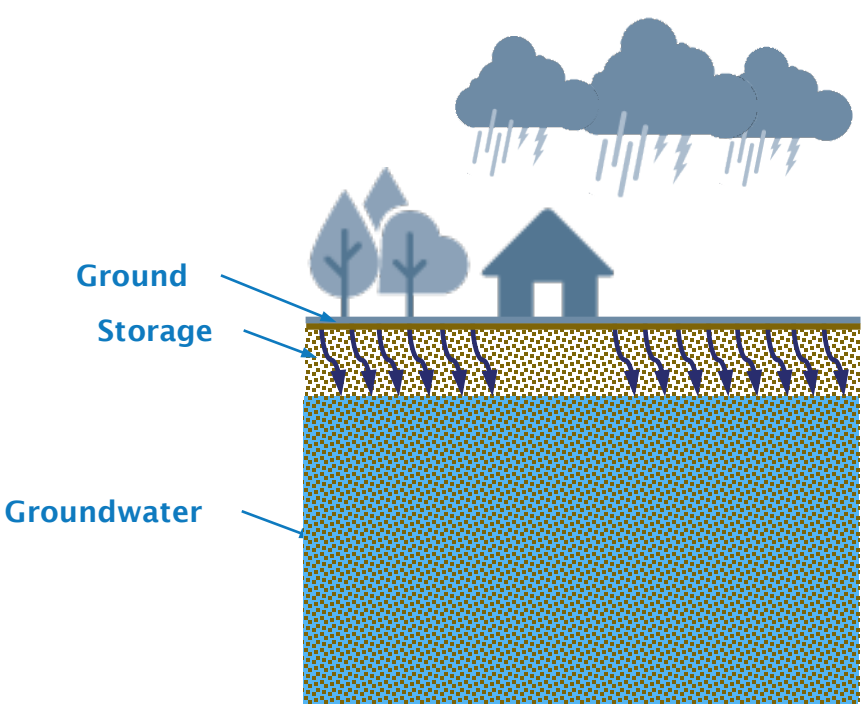
Tailwater (tidal, influenced by SLR)

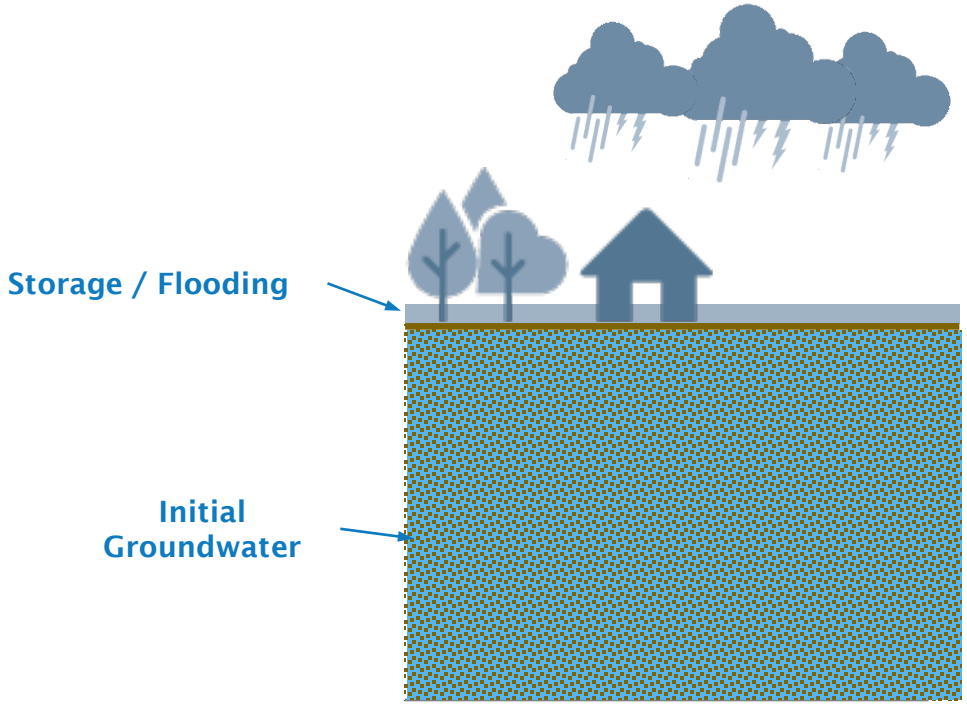




The storage capacity will be reduced as the headwater elevation increases to limit saltwater intrusion as the sea level rises over time.

The Stormwater Management System is dependent on Ground Storage



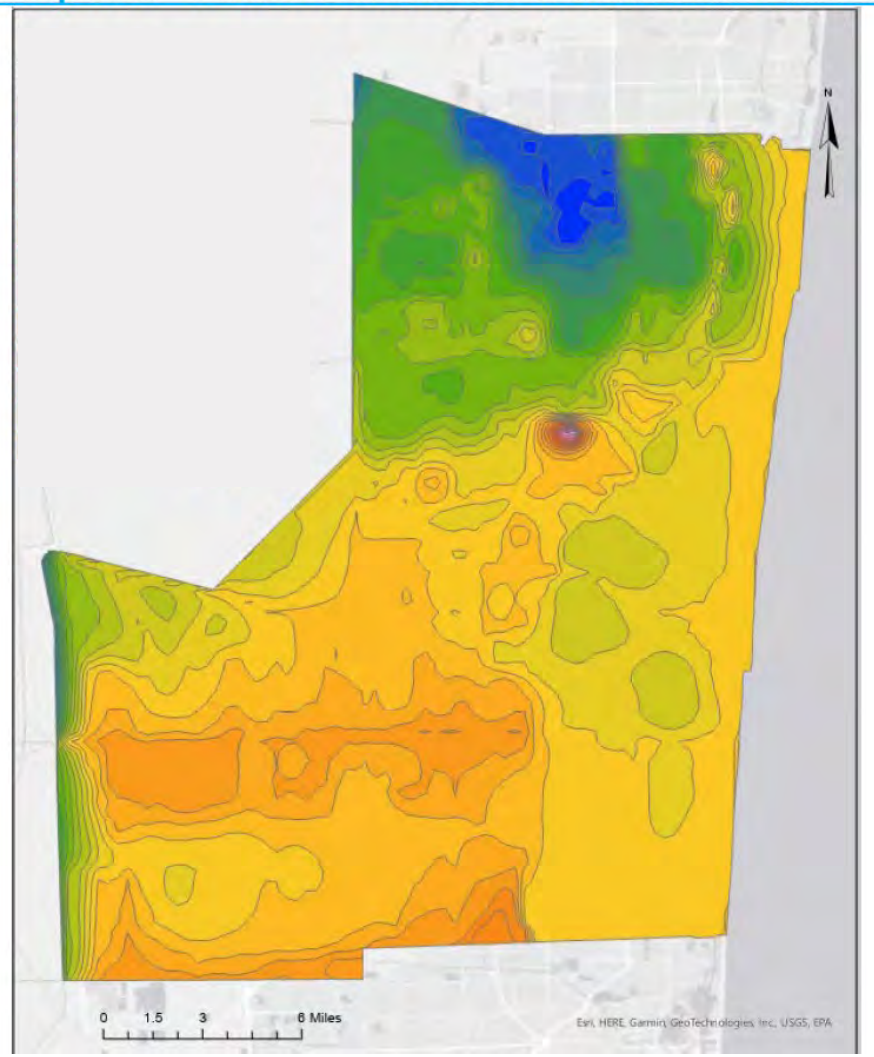


Groundwater Level at the beginning of the storm largely affects how much storage is available, and how much flooding the storms will cause

The County has analyzed the effect of SLR on Groundwater Level

- The County is updating the map that shows the effect of 3.3 ft Sea Level Rise (shown in this slide).
- The map shows Future Groundwater Levels for **Average** Conditions
- During High Tides and other events, the operation of the water management system creates even higher Groundwater Levels than those shown in the map

2023 Update – Future Conditions Groundwater Elevation



Fundamental to the efficacy of most of the strategies is managing the Groundwater Level

Adaptation Strategies Evaluated

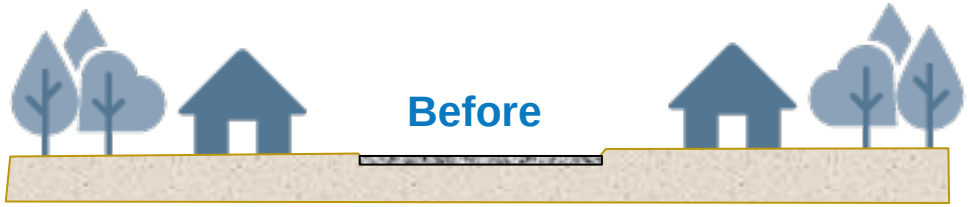
- Storage
  - Above ground storage
  - Recovering underground storage
- **Green Infrastructure**
  - Reducing Impervious Area
    - *Adding localized surface storage*
- Conveyance
  - Improving existing conveyance structures (canals, culverts, etc.)
  - Additional Pumping
- Barriers
  - Property level seawalls
  - Nature-based and/or engineered structures
  - Large scale levees and other surge barriers
- Redevelopment

This adaption strategy is linked to the development of Green Infrastructure. In addition to promoting **Evapotranspiration,** most Green Infrastructure solutions are based on the idea of increasing **Infiltration** by reducing impervious area. Infiltration can only be increased if there is available ground storage to receive rainwater.

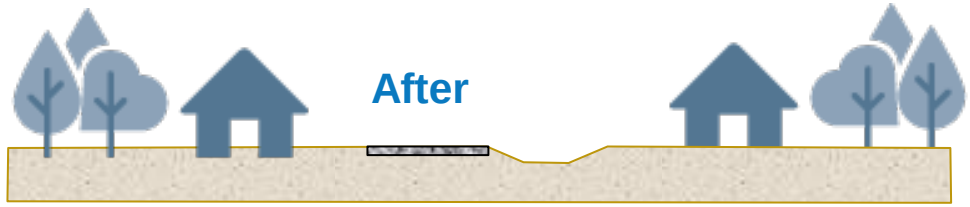
: Potential **HEAT** reduction benefits

Green Infrastructure – Reducing Impervious Area and Adding Storage

Local roads in the County were reviewed to analyze the potential conversion from two-way roads to one-way road.



- Local roads were evaluated to assess their suitability for conversion.
- Evaluated factors included:
  - Depth to Groundwater
  - Fire Department Access
  - Traffic
  - Increase in Travel Time (1 minute Increase, ½ mile)
  - Number of Entrances

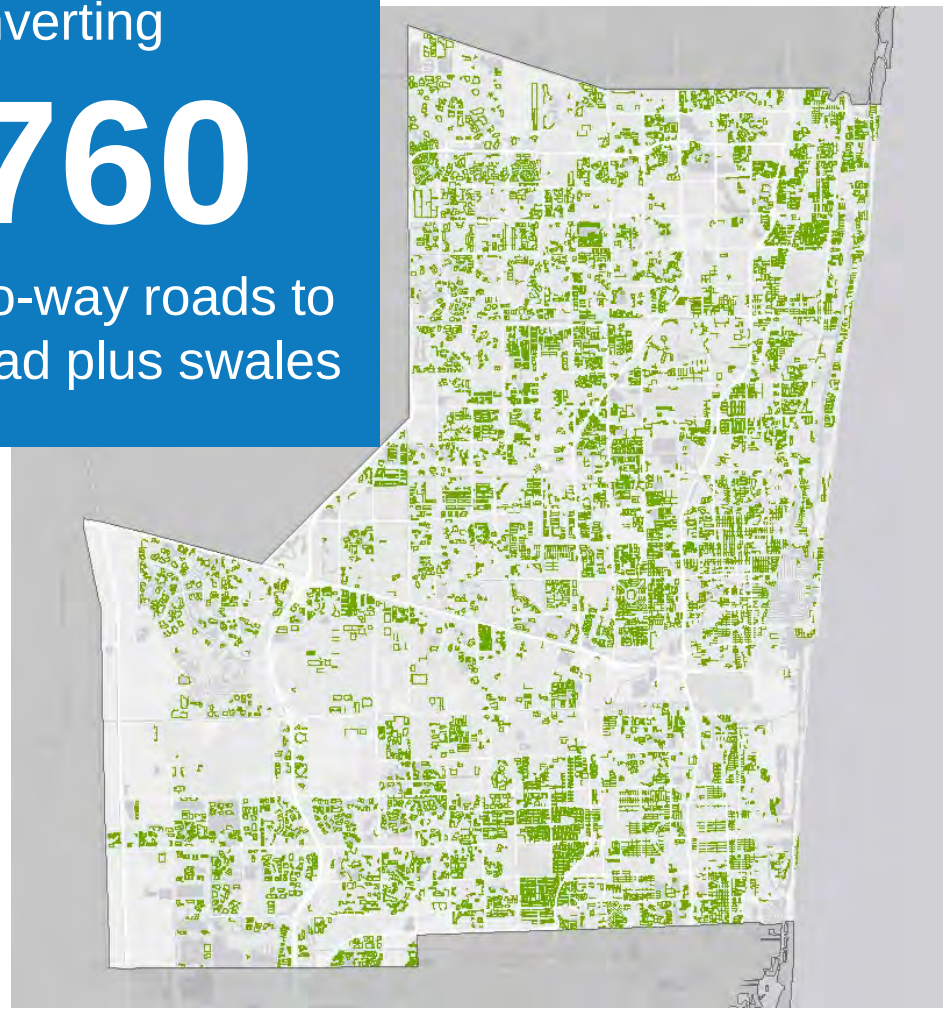


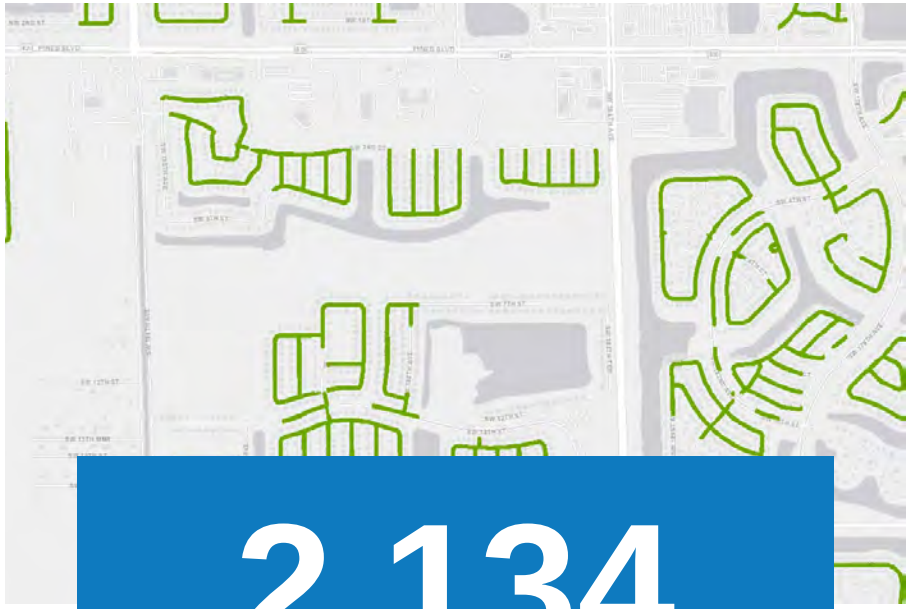
Green Infrastructure – Reducing Impervious Area and Adding Storage

Converting

1,760

Miles of two-way roads to one-way road plus swales





2,134

Acres created

1,247

Acres-ft of storage

Recovering Underground Storage

Modify Control Structures to add the capability of reducing control elevation ahead of the storms

Modifications Required in

169

Controls Structures

- Control Structures in Secondary system to be modified to allow a change on control elevation
- Most Structures are fixed. The proposed Adaptation Strategy will require modification of structures by adding a movable element (gate or weir crest)
- It is desirable to add telemetry to allow for easier operation of the structure and facilitate SFWMD enforcement of return to normal levels.

Conveyance Improvements

Upsize Culverts or Crossings in areas identified as bottlenecks,
addition of Pumping Stations

- Several model runs were executed under “uncorked” conditions to identify the performance of the systems under “unrestricted” conditions
- Unrestricted conditions in the case of the culvert analysis correspond to a condition with no culverts or canals constrictions
- Unrestricted conditions in the case of the pump stations correspond to addition with “free fall” (no downstream restriction) in all canal connections.
- Evaluated the areas in the system that showed significant improvements in the unrestricted runs as compared to the baseline
- Define improvements needed in those areas based on local conditions

28

New Pump Stations

50

Upgraded Crossings

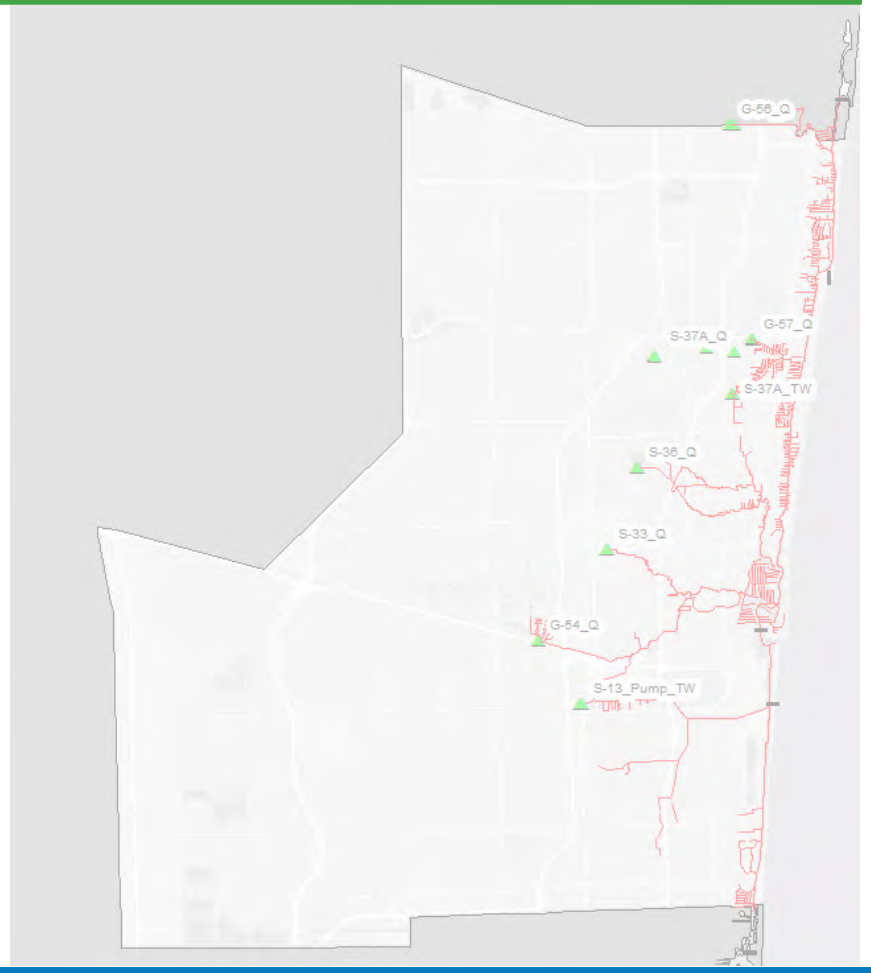
Barriers

Countywide (Coastal Areas) implementation of Sea Wall Ordinance

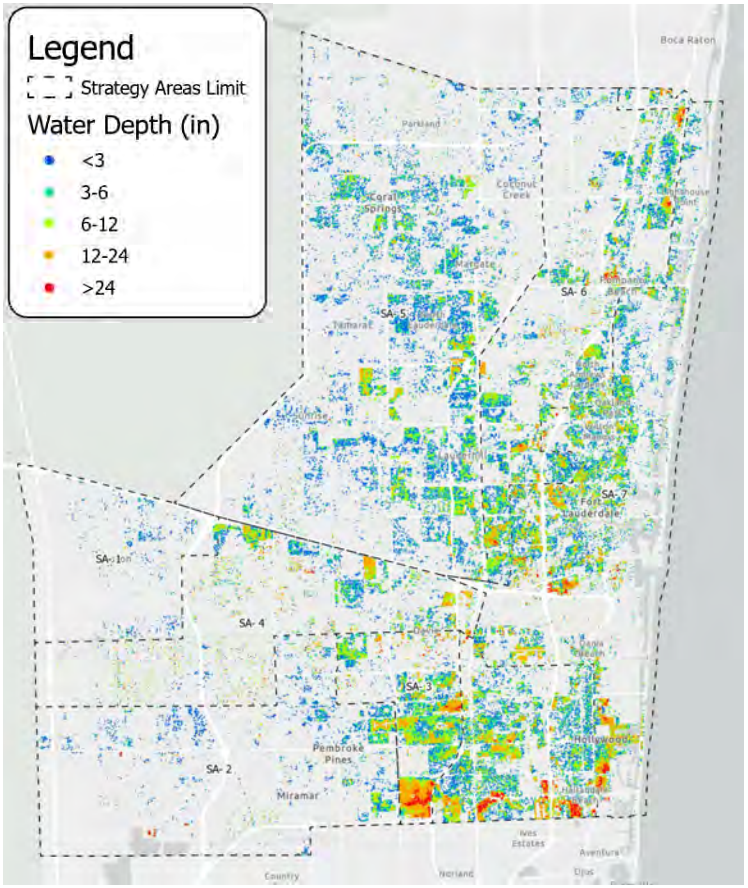
190

Miles of Seawall and Enhanced Natural Barriers

- 5 ft. NAVD Seawalls were added to the coastal line in the model
- Seawalls were added to the cross-sections that are used to model the water bodies.
- To obtain complete protection via seawalls after SLR has taken place, these walls will also need to be extended downwards to reduce the groundwater flow under them.

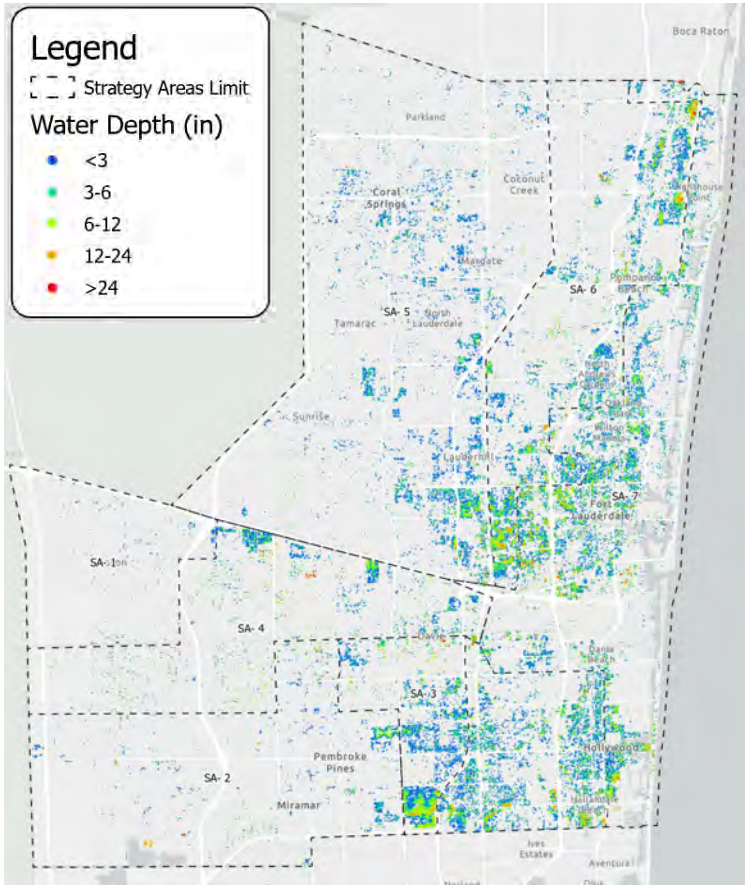


Increasing Groundwater storage (1ft) – Properties Flooded



Base Scenario Water Depth

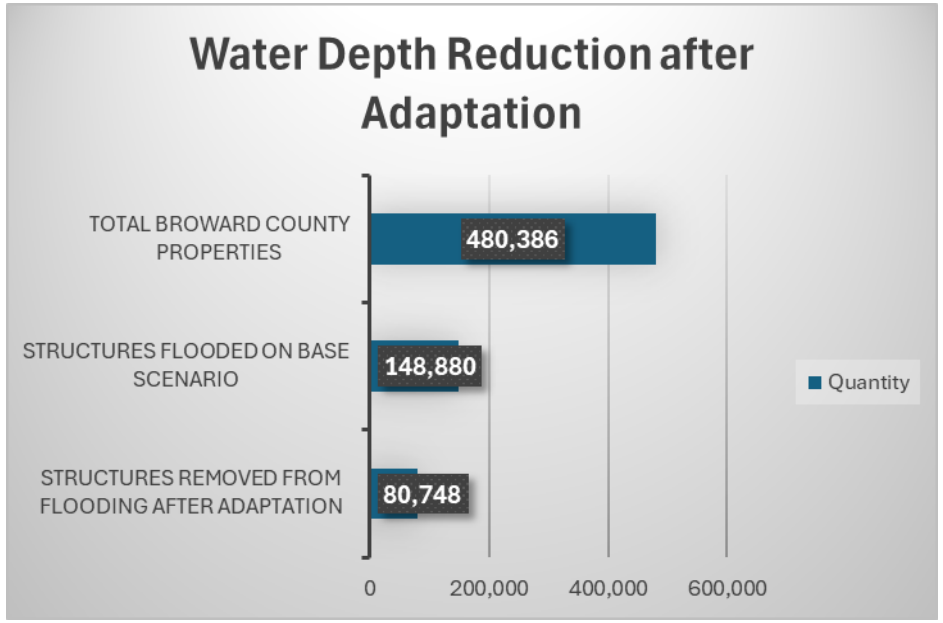
Rain	SLR	Tidal
100-yr. 3d	2 ft	King Tide

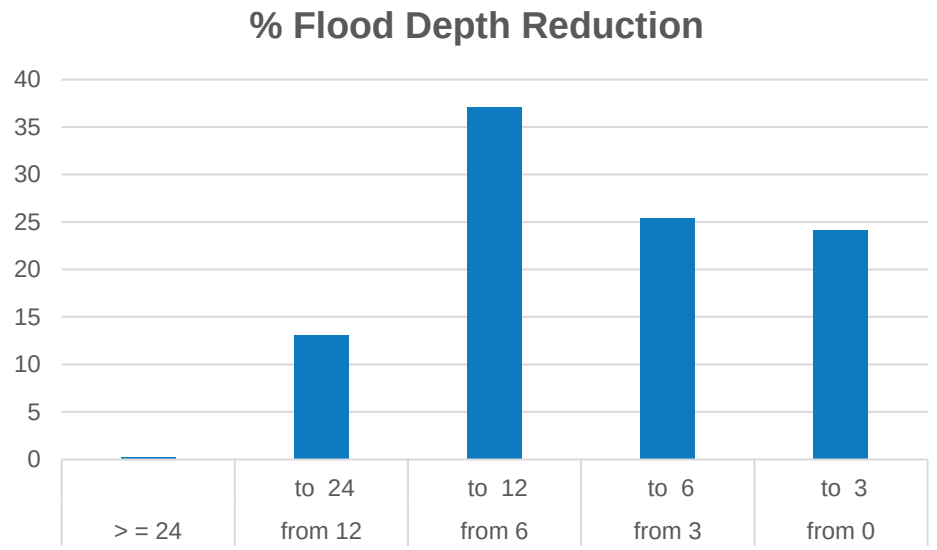


Adaptation Strategy Water Depth

All secondary structures have the control elevation (CE) reduced by 1'

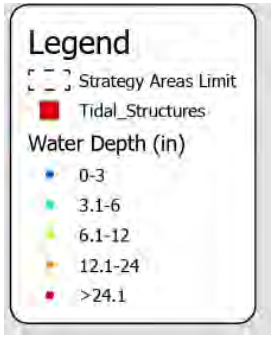
Increasing Groundwater storage (1ft) – Properties Flooded

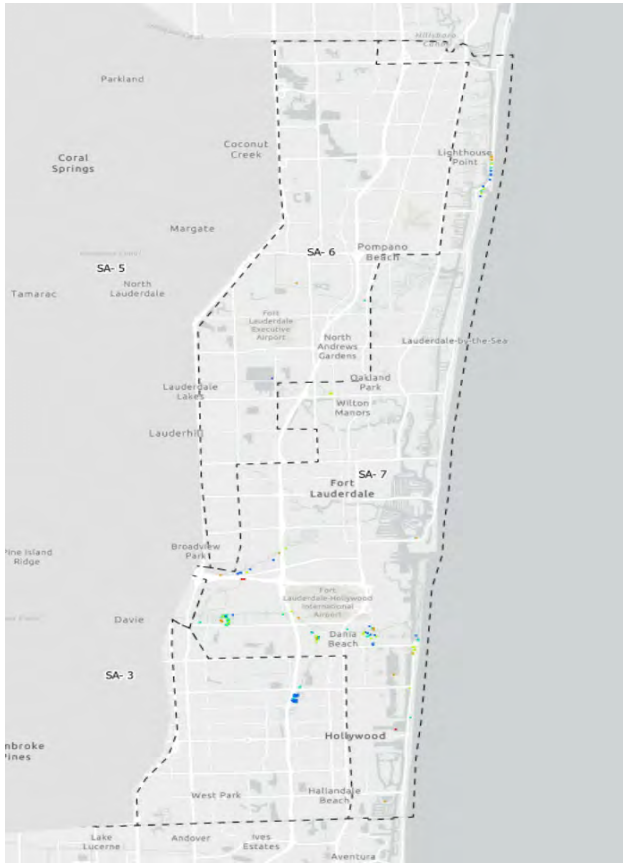




Water Depth Reduction
(136,000 Structures)

Construct Seawalls – Surge Event





Base Scenario Water Depth

Rain	SLR	Tidal

Adaptation Strategy Water Depth

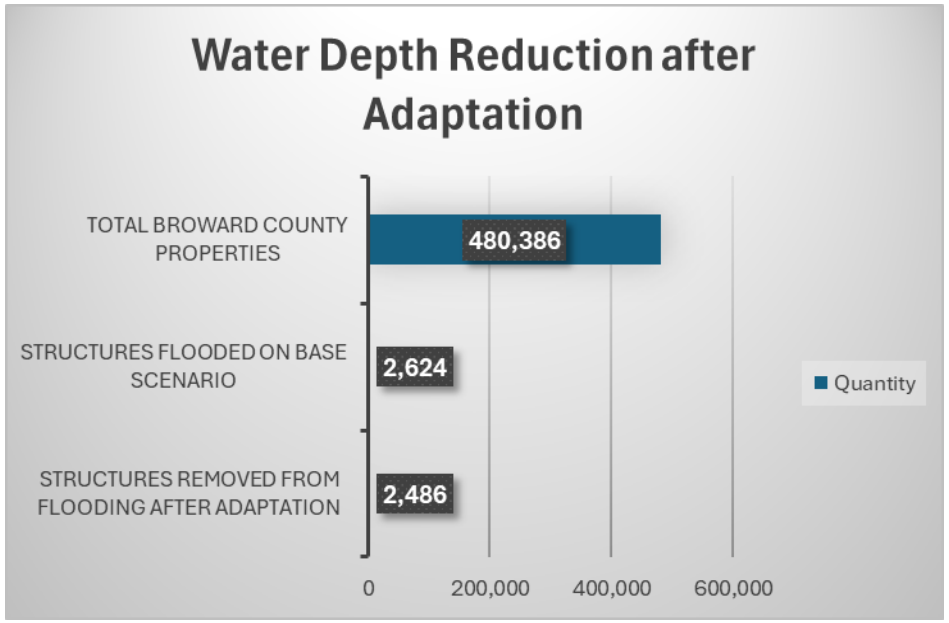
Seawalls 5 ft. NAVD

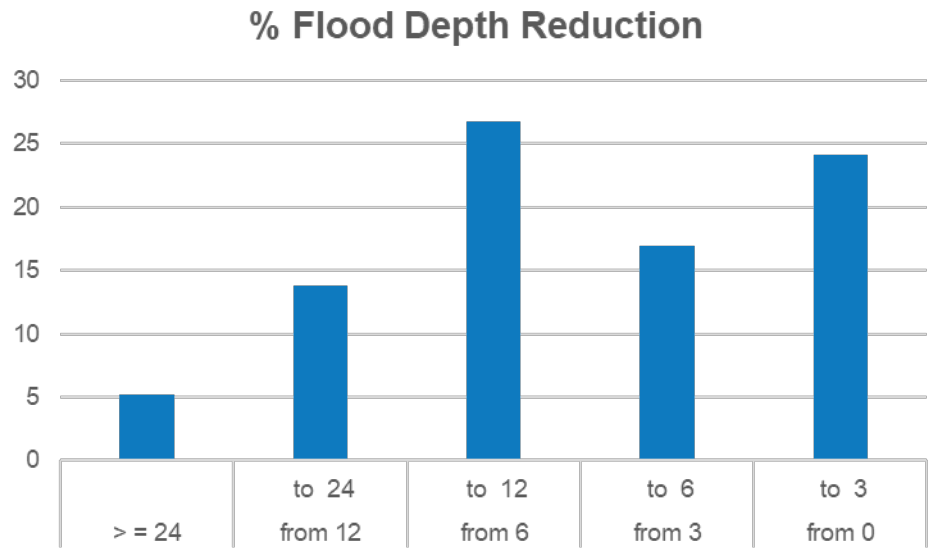
Structures removed from flooding after Adaptation	2,486
Total BC	480,386

Delta Flood Depth (inches)		%
> = 24		5.20%
from 12	to 24	13.76%
from 6	to 12	26.73%
from 3	to 6	16.95%
from 0	to 3	37.35%

Water Depth Reduction
(2,500 Structures)

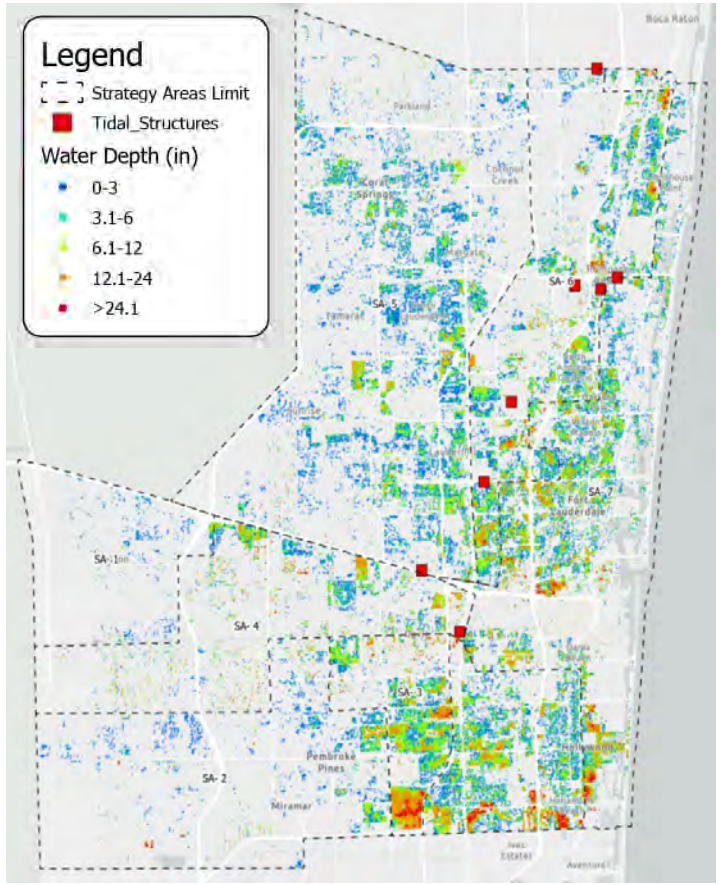
Construct Seawalls – Surge Event





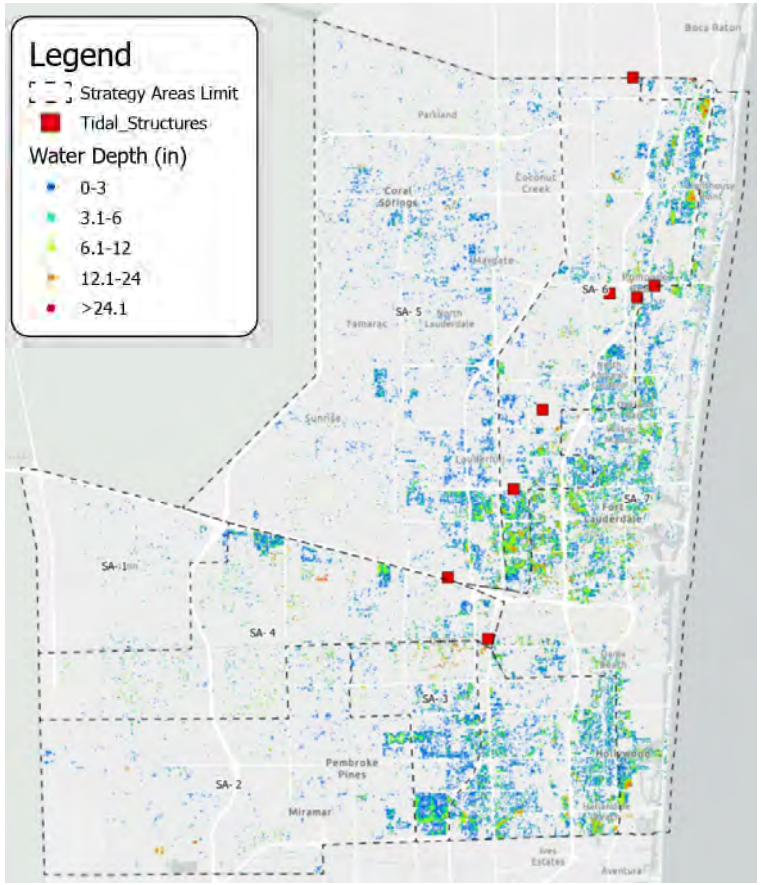
Water Depth Reduction
(2,500 Structures)

All Adaptation Strategies Working in Combination



Base Scenario Water Depth

Rain	SLR	Tidal
100-yr 3-day	2 ft	King Tide



Adaptation Strategy Water Depth

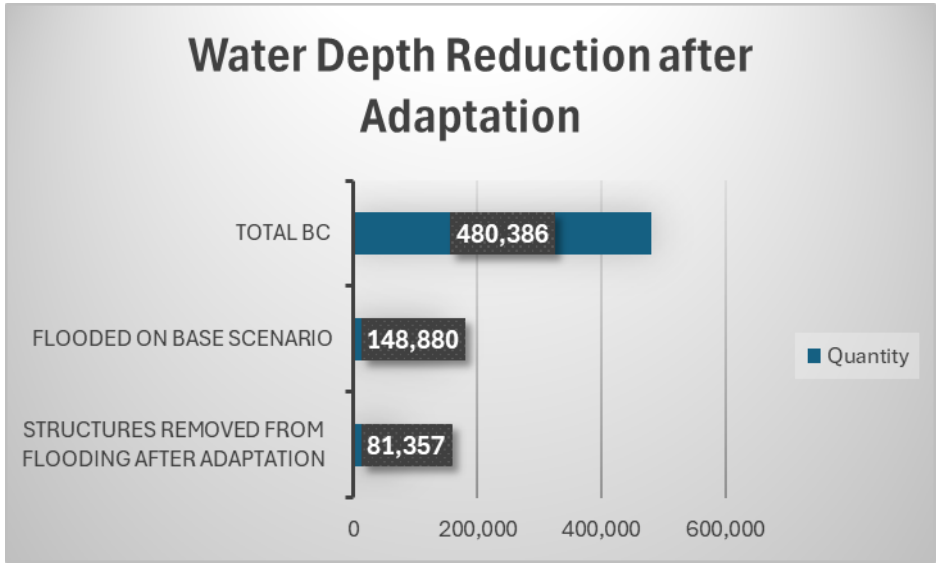
All secondary structures have the control elevation (CE) reduced by 1'.
Includes also: Pumps, Crossings, Seawalls.

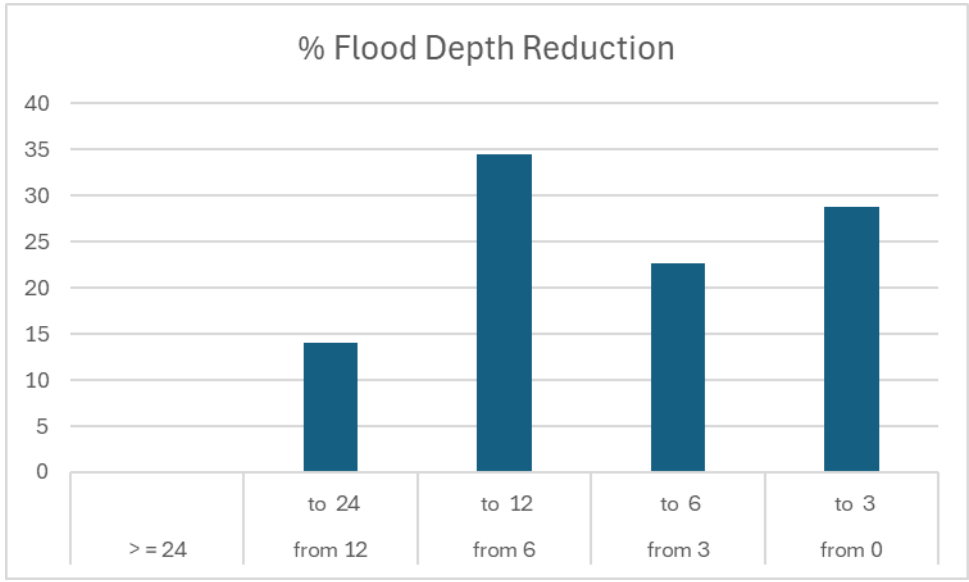
BC Buildings/Structures	Quantity
Flooded on Base Scenario	148,880
Structures removed from flooding after Adaptation	81,357
Total BC	480,386

Delta Flood Depth (inches)		%
from 12	to 24	14.0
from 9	to 12	14.0
from 6	to 9	20.5
from 3	to 6	22.7
from 0	to 3	28.8

Water Depth Reduction
(134,398 Structures)

All Adaptation Strategies Working in Combination



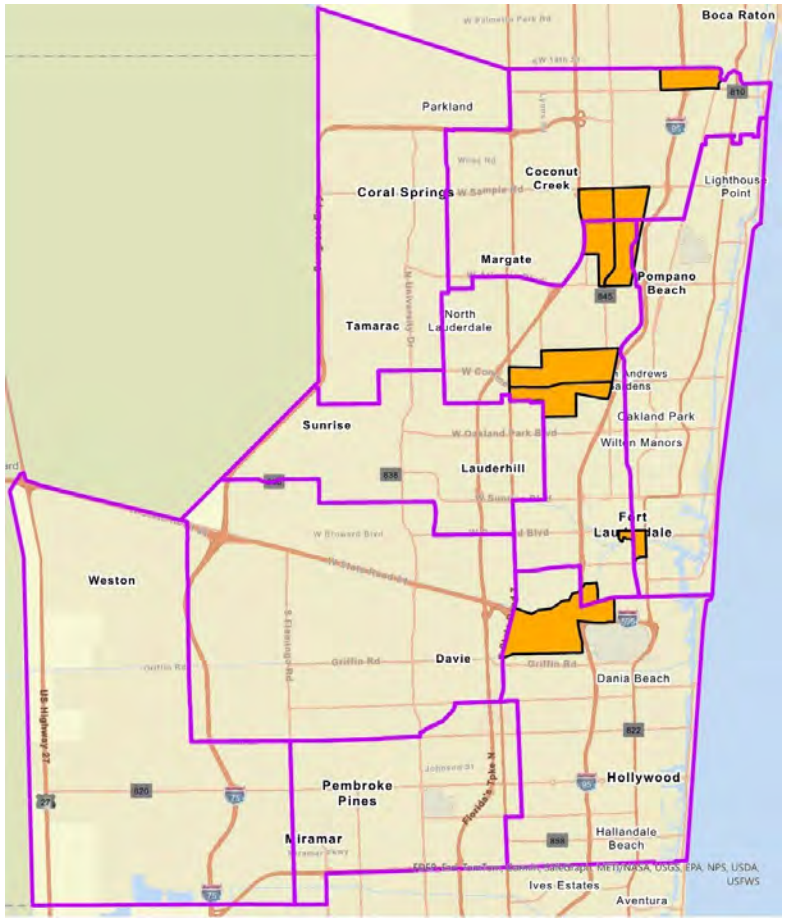


Water Depth Reduction
(134,398 Structures)

We are currently evaluating localized adaptation strategies in areas of Low and Moderate Income (LMI) and FEMA Disaster Resilience zones

FEMA Community Disaster Resilience Zones

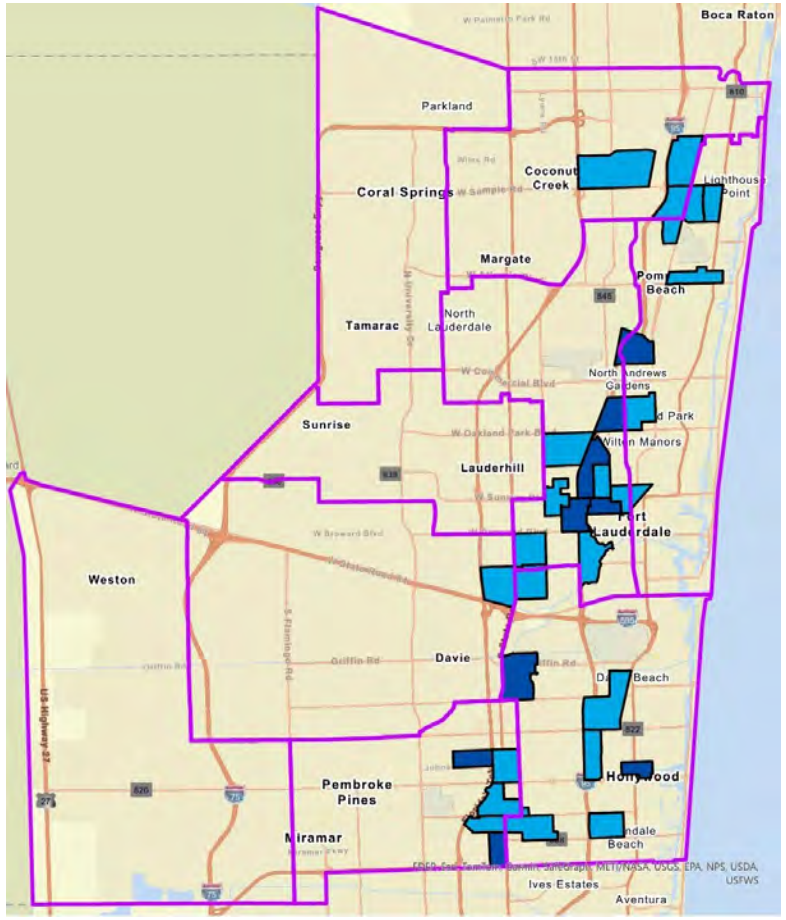
Broward County Commissioner District



High-risk areas under **current** SLR

Additional high-risk areas under **2.0ft** SLR

Broward County Commission District

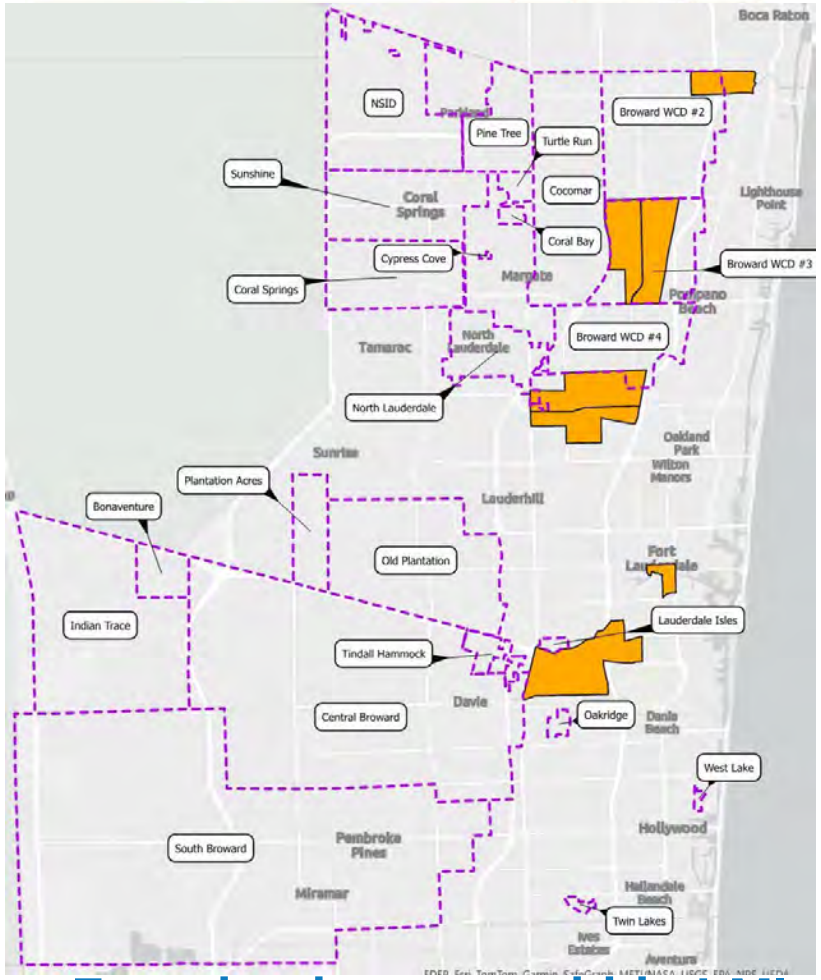


Zooming in areas within LMI and FEMA Disaster Resilience.
Will define strategies specific for this areas.

We are currently evaluating localized adaptation strategies in areas of Low and Moderate Income (LMI) and FEMA Disaster Resilience zones

FEMA Community Disaster Resilience Zones

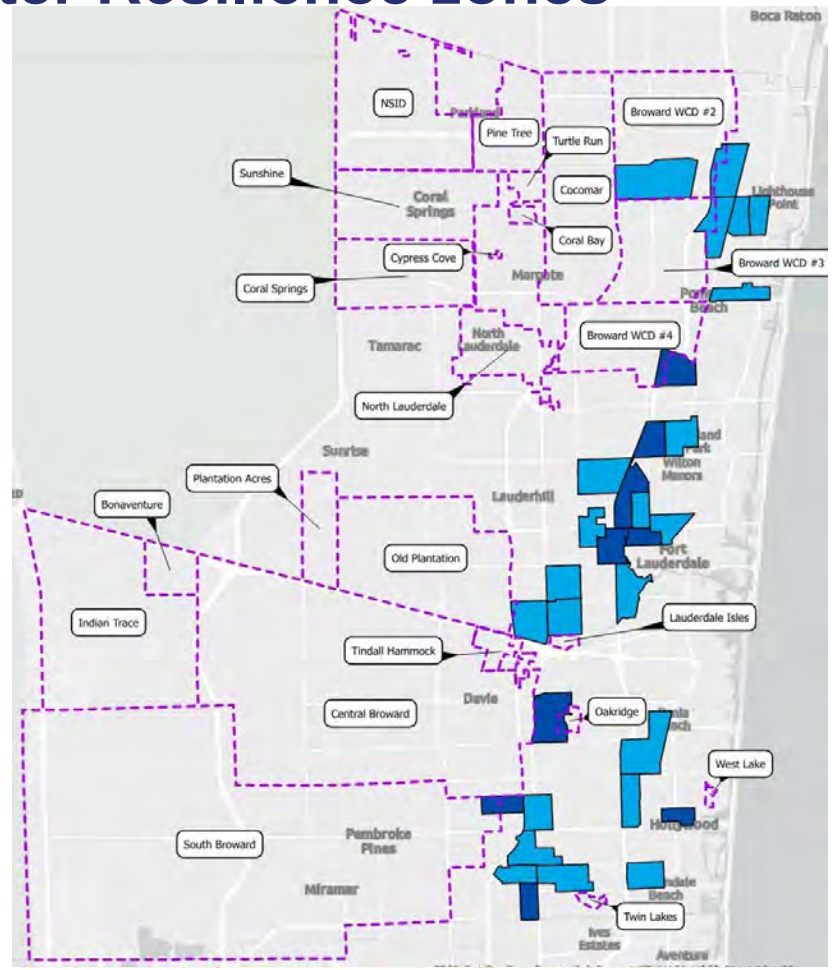
Drainage District



High-risk areas under **current** SLR

Additional high-risk areas under **2.0ft** SLR

Drainage District



Zooming in areas within LMI and FEMA Disaster Resilience.
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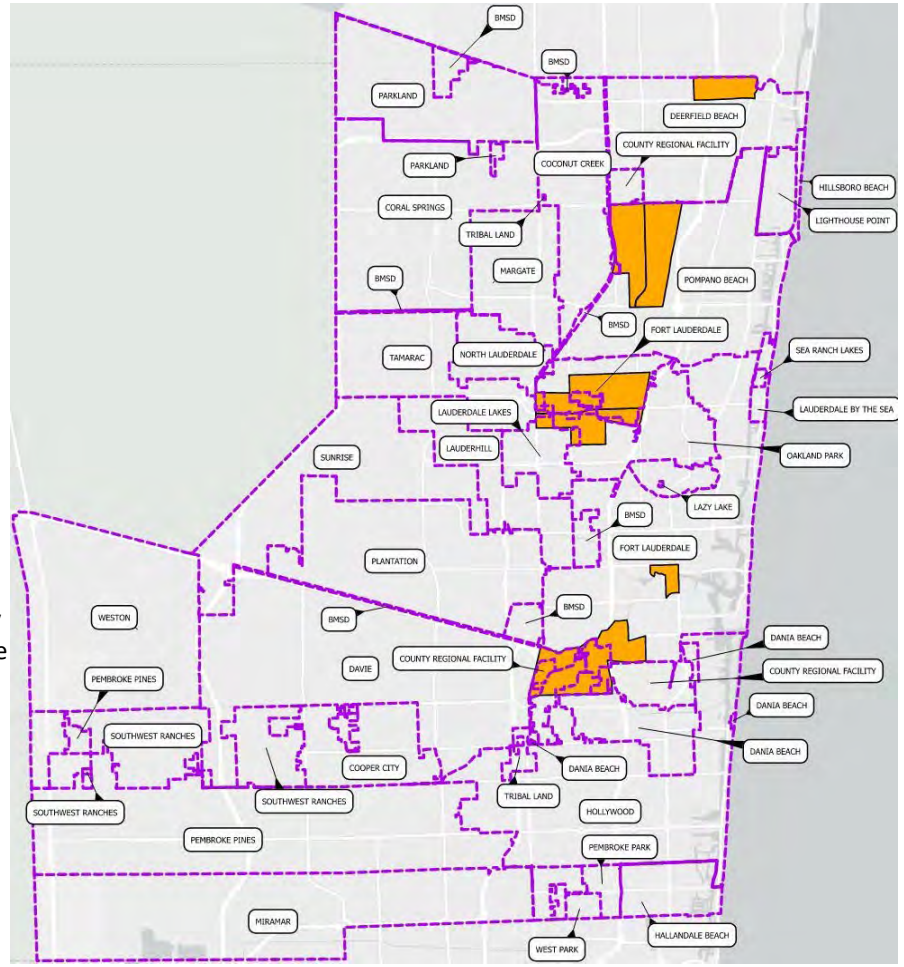
We are currently evaluating localized adaptation strategies in areas of Low and Moderate Income (LMI) and FEMA Disaster Resilience zones

FEMA Community Disaster Resilience Zones

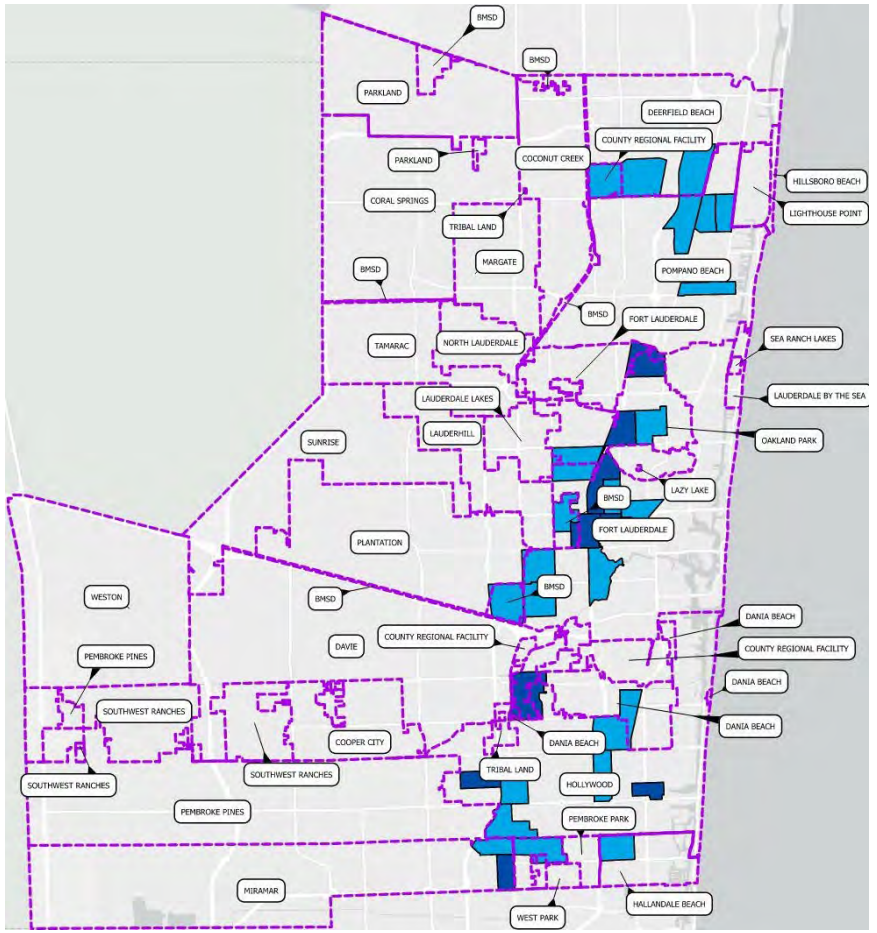
Municipality



High-risk areas under **current** SLR

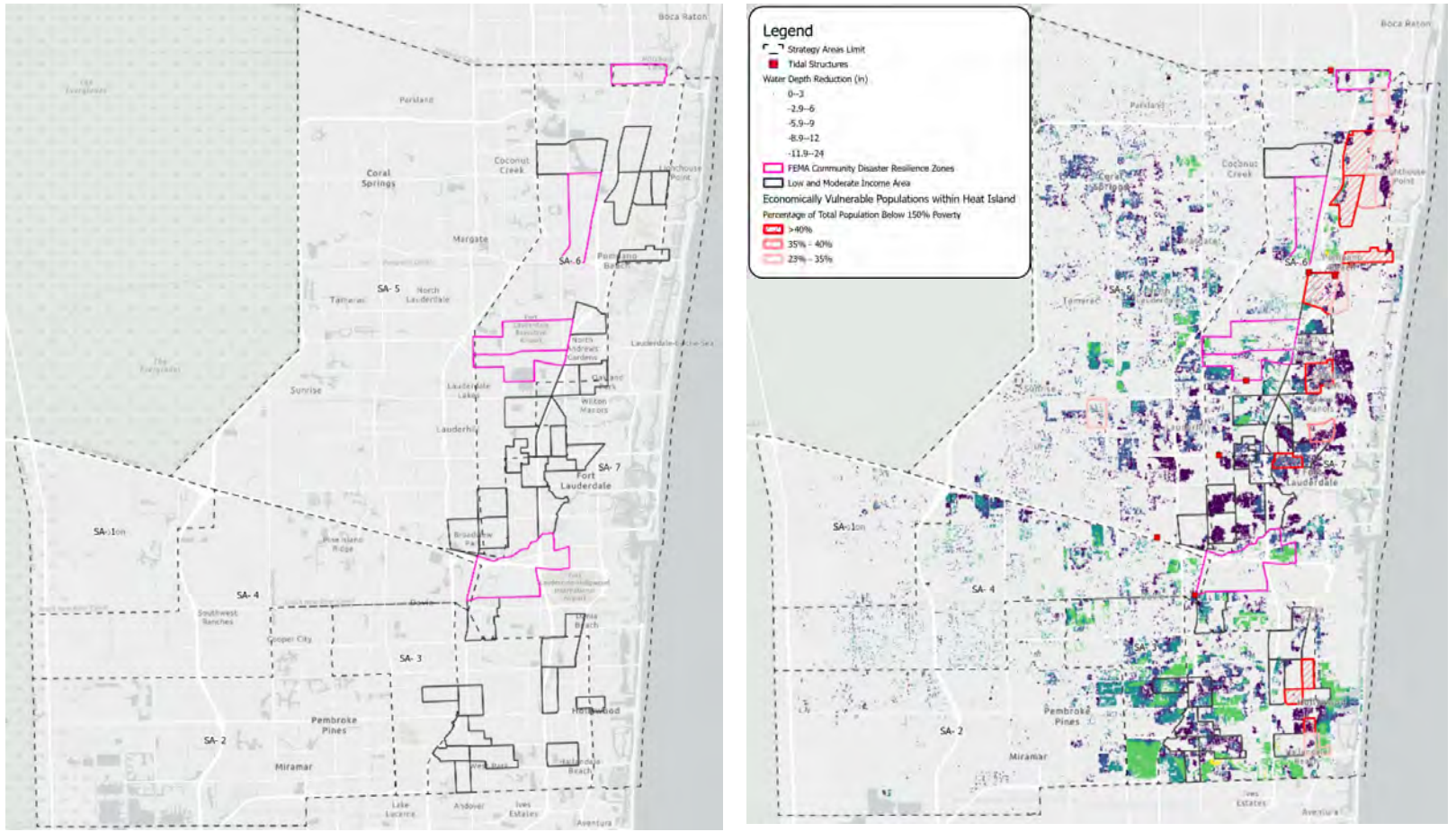
Additional high-risk areas under **2.0ft** SLR

Municipality



Zooming in areas within LMI and FEMA Disaster Resilience.
Will define strategies specific for this areas.

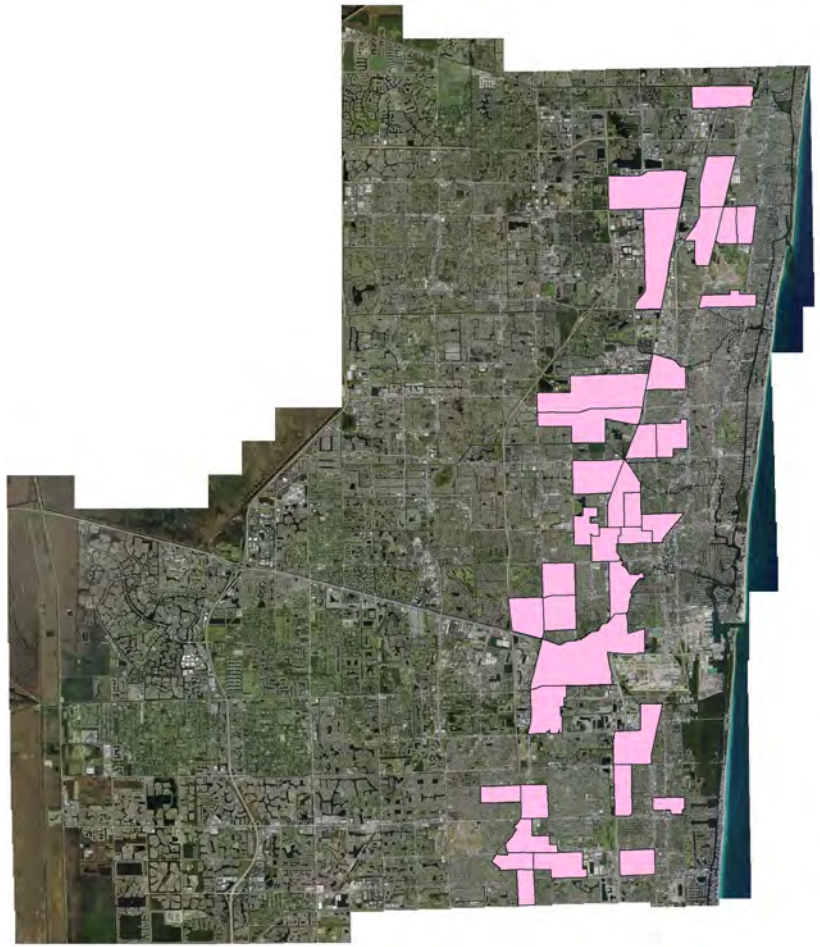
Modeling of Adaptation Strategies shows improvements in flooding conditions in LMIs. Evaluations will continue to explore more localized solutions.



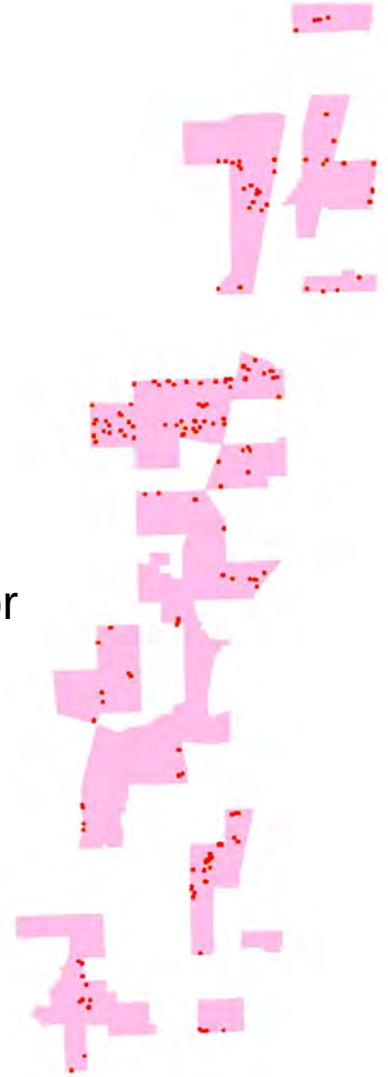
Flood Reduction Provided by Adaptations

Highest risk heat areas are dashed; green infrastructure improvements are also intended to reduce the heat in these areas

Identifying Storage Opportunities in Priority Areas

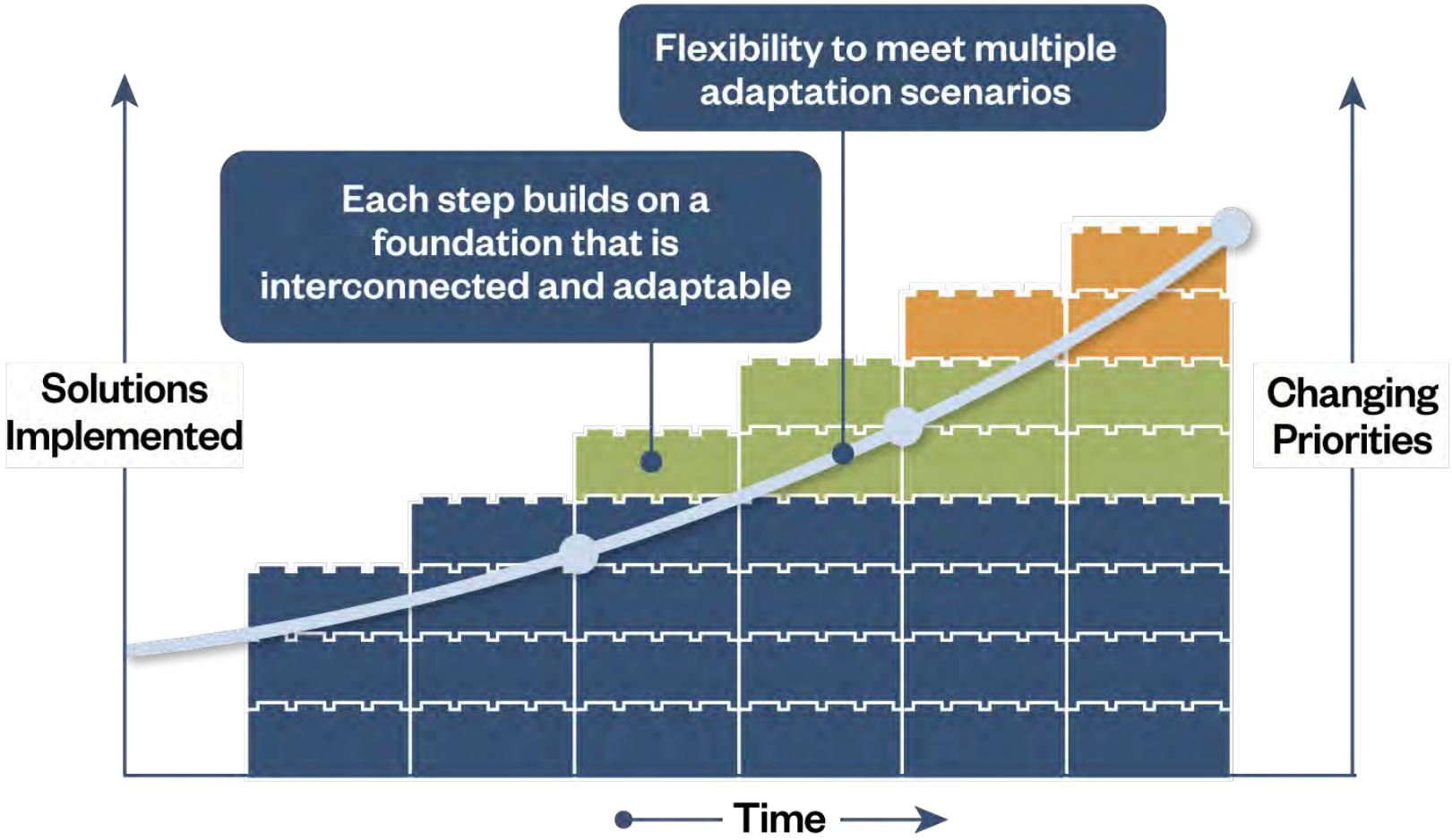


- Large expanses of impervious surfaces were identified using Deep Learning algorithm.
- Polygons obtained with this algorithm were aggregated when located with 10 feet of each other
- The lowest point within each area was identified using the DEM raster.
- Storage Areas were added around each lowest point, with a size of **10%** of the impervious area or **5,000 sq.ft.**
- This procedure identified **154 storage areas** with a total of 48 acres located within larger areas of impervious surfaces that could potentially be converted to storage.
- Next steps include performing the same analysis for the rest of the County.



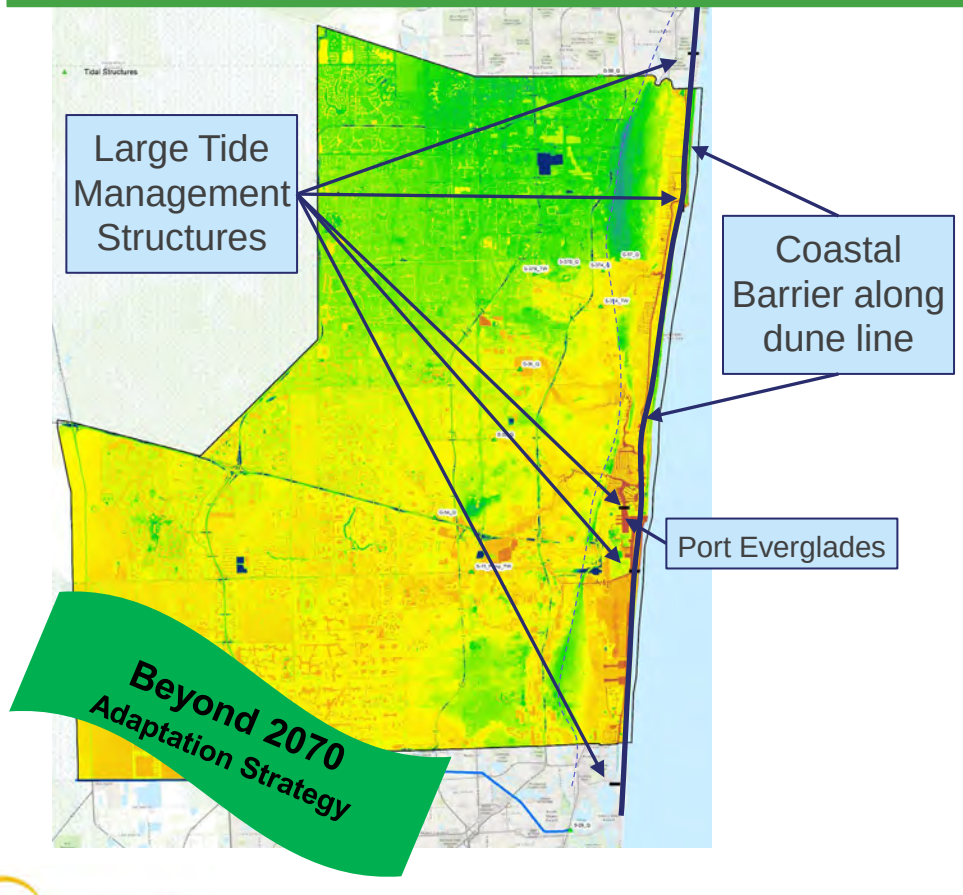
Identifying Storage Opportunities in Priority Areas

Adaptations will be recommended on a sequential basis, and adjusted in the future to adjust to updated data and to meet evolving priorities



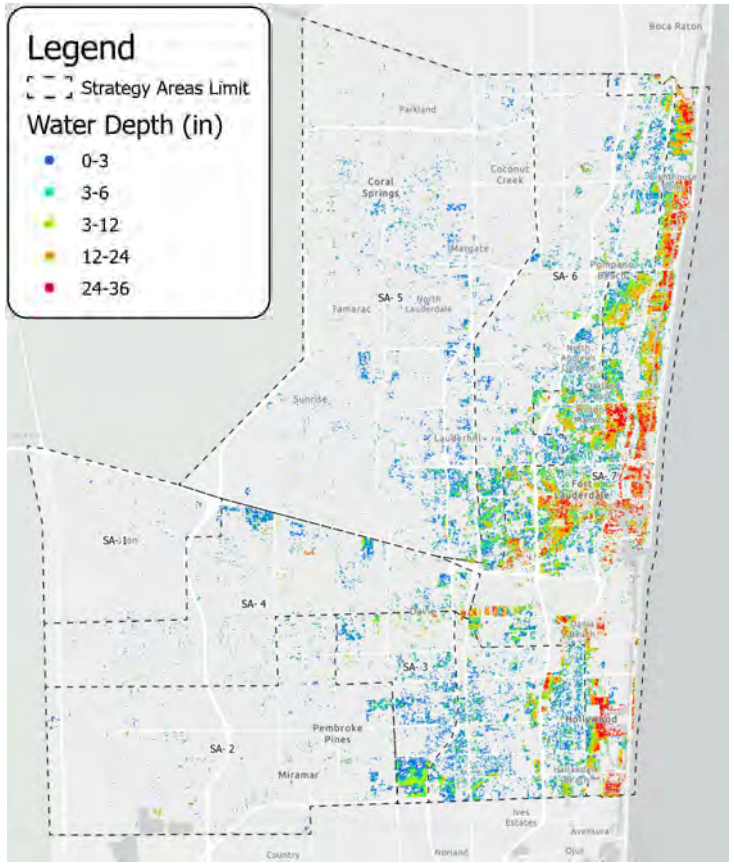
Longer Term Solutions Include a Combination of Surge Barriers and Large Tide Management Structures

Structural and Nature-based barriers plus large tide management structures including locks, gates and pump stations. This strategy will require active participation/leadership of federal and state agencies, as well as coordination with neighboring counties.



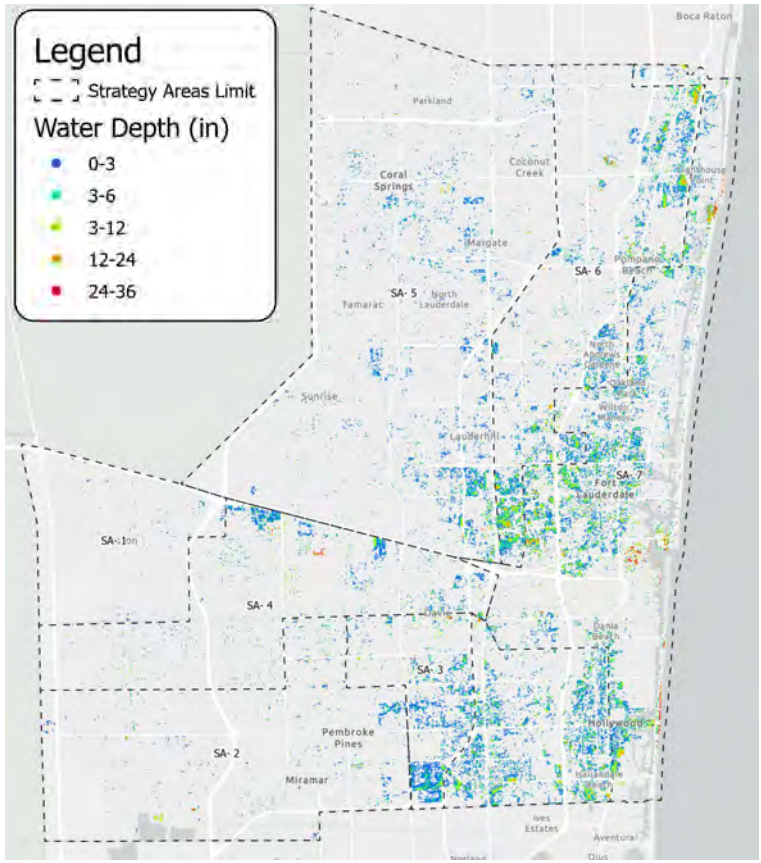
Sample of similar structures in The Netherlands. South Florida will add groundwater management to the challenges faced in the Netherlands

Combination of Surge Barriers and Large Tide Management Structures (preliminary results)



Base Scenario Water Depth

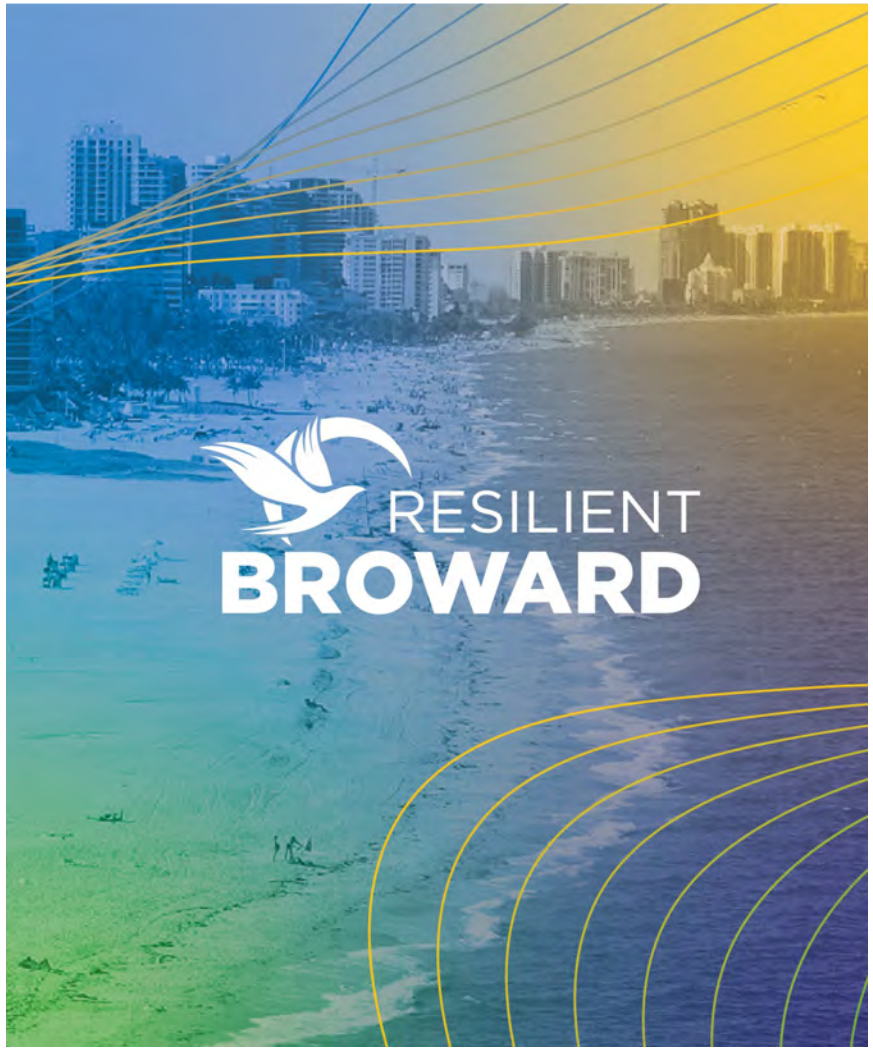
Rain	SLR	Tidal
50-yr. 3d	3.3 ft	100-yr. Storm Surge



Adaptation Strategy Water Depth

Water Depth Reduction
(124,076 Properties)

Delta Flood Depth (inches)		%
> = 24		15.0
from 12	to 24	14.2
from 6	to 12	15.7
from 3	to 6	15.6
from 0	to 3	39.5



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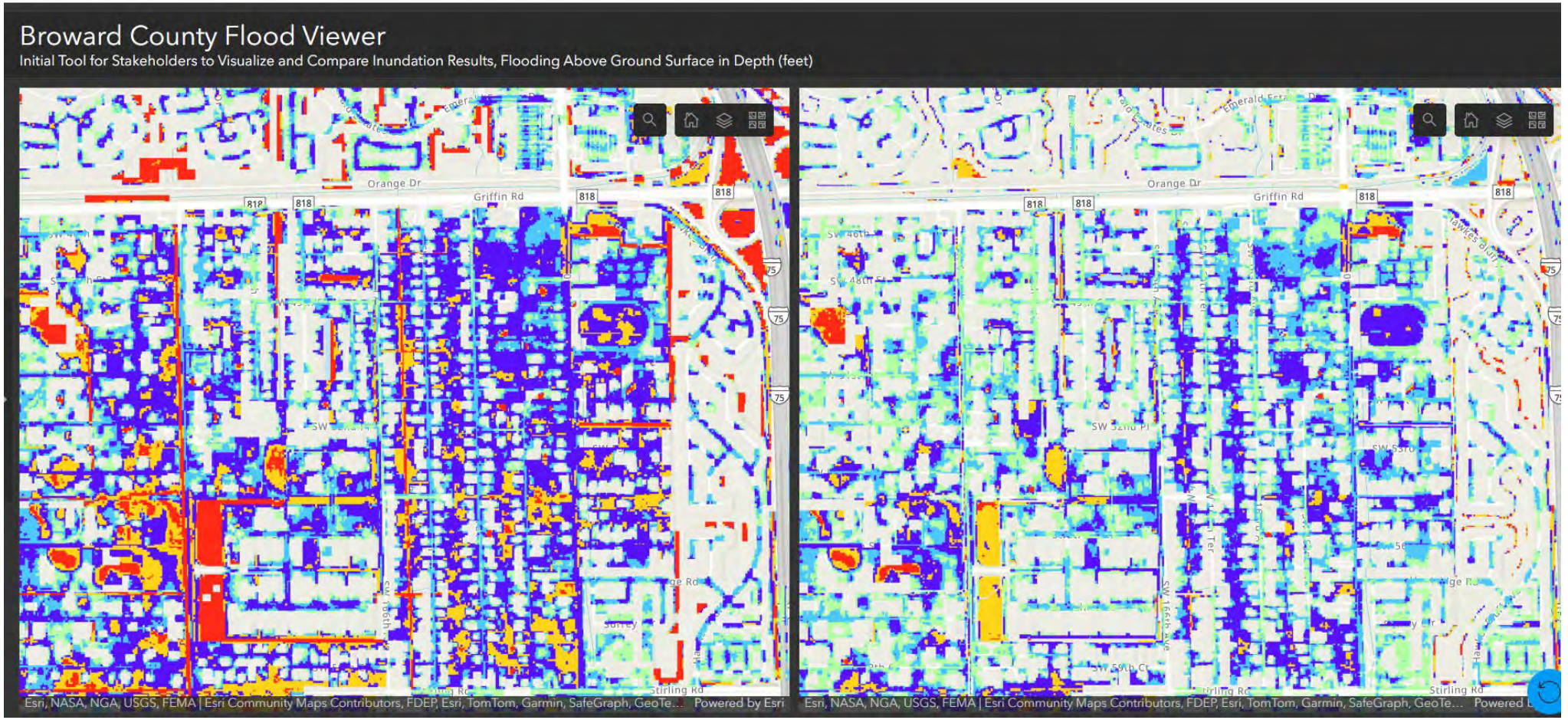
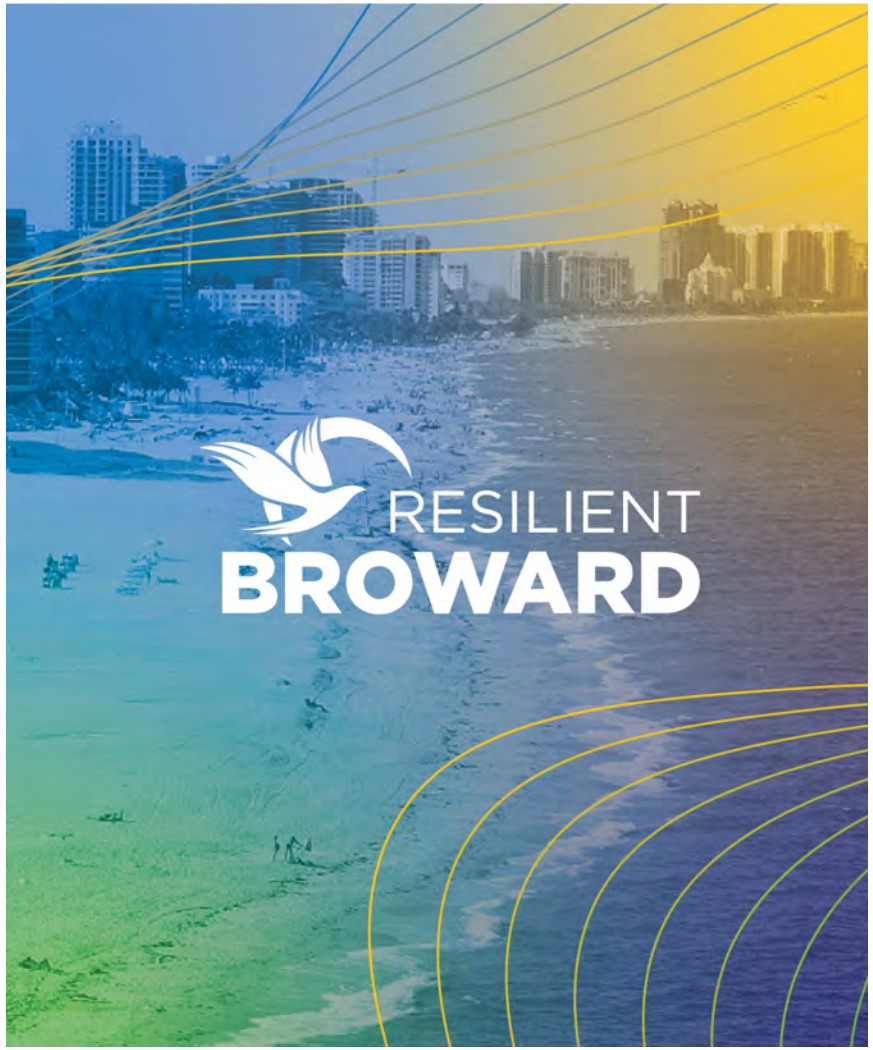
Discussion

Hazen

Example Use of the Flood Viewer

https://hazensawyergis.maps.arcgis.com/apps/dashboards/3f2e1effc1d44d8997091e466b037eec





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Concluding Thoughts/Next Steps

Hazen

We've evaluated adaptation strategies, identified where these strategies are effective and identified where additional adaptation is necessary

Next Steps

- **Continue development of targeted adaptations with an emphasis on heat reduction**
  - LMI and FEMA Disaster Resilience Zones
  - Areas not adequately improved by initial strategies
- **Review adaptation results with North Stakeholders (one meeting remains)**
- **Process the results from all 52 scenarios**
- **Complete Economic Analysis (compare to baseline)**