Resiliency Planning!

What's it Going to Take?

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Land & Water Engineering Science

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So, what do we mean by resiliency?

The capacity for an infrastructure asset to absorb climate stressors (i.e. exposure) and return to pre-disturbed state without any lasting functional change to the asset.

Are the floating houses built on water in the neighborhood of Ijburg in Amsterdam Resilient?

We are going through a paradigm shift in planning and designing, to account for changing conditions.

If a RESILIENT asset is to be built today, added capital investment is of concern; therefore, life cycle cost analysis is to be conducted to evaluate its reduced maintenance cost and extended service life benefits.

In addition, adaptative design can ensure its performance under added stressors during its service life.

PLANNING APPROACH FOR RESILIENCY

Future Climate Projections → Infrastructure Inventory → Vulnerability Assessment → Vulnerability Prioritization → Adaptive Strategy → Adaptive Plan Selection

- Extreme heat
- Extreme drought
- Precipitation intensity
- Sea level rise
- Storm surge

Even though the planning process is the same, opportunities and constraints for rural and urban communities differ.

STRESSOR – EXTREME HEAT

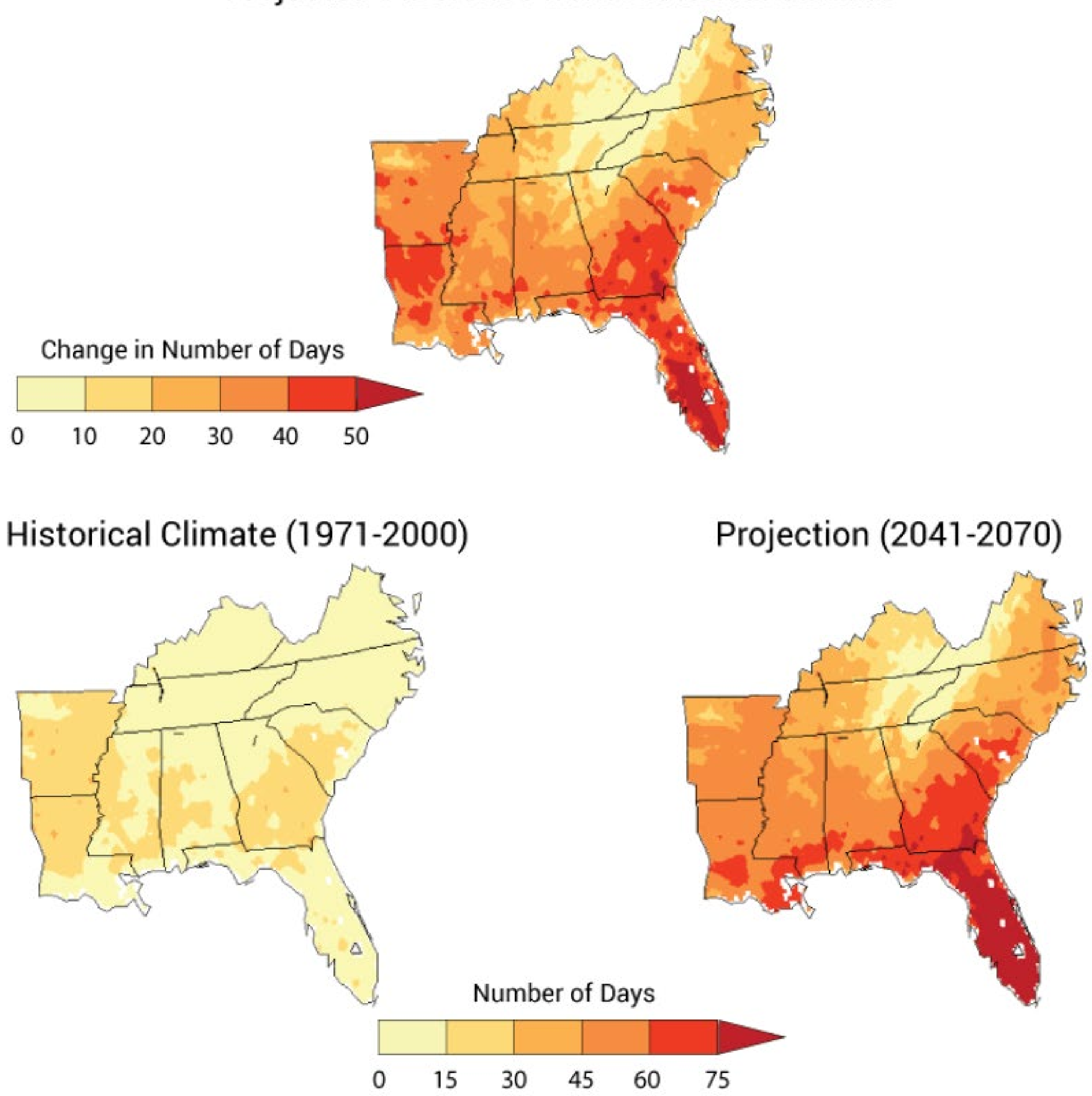
Inland areas are projected to warm more than the coasts

Future predictions for 2041-2070 under high greenhouse emissions.

Temperatures are projected to increase by 4°F to 8°F by the end of the century

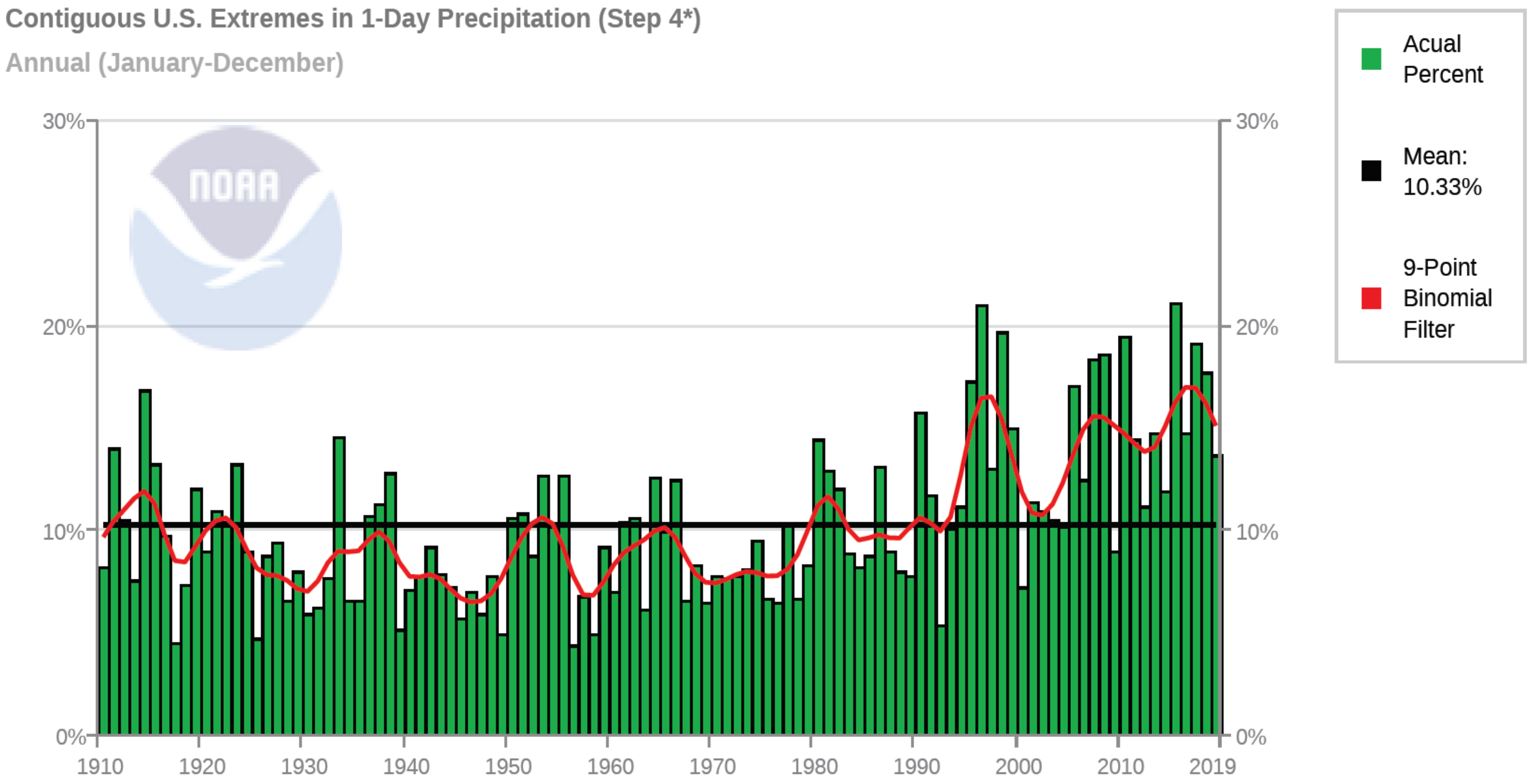
Source: U.S. Global Change Research Program, National Climate Assessment, Southeast Region, Accessed from,

http://nca2014.globalchange.gov/report/regions/southeast)



STRESSOR – PRECIPITATION INTENSITY

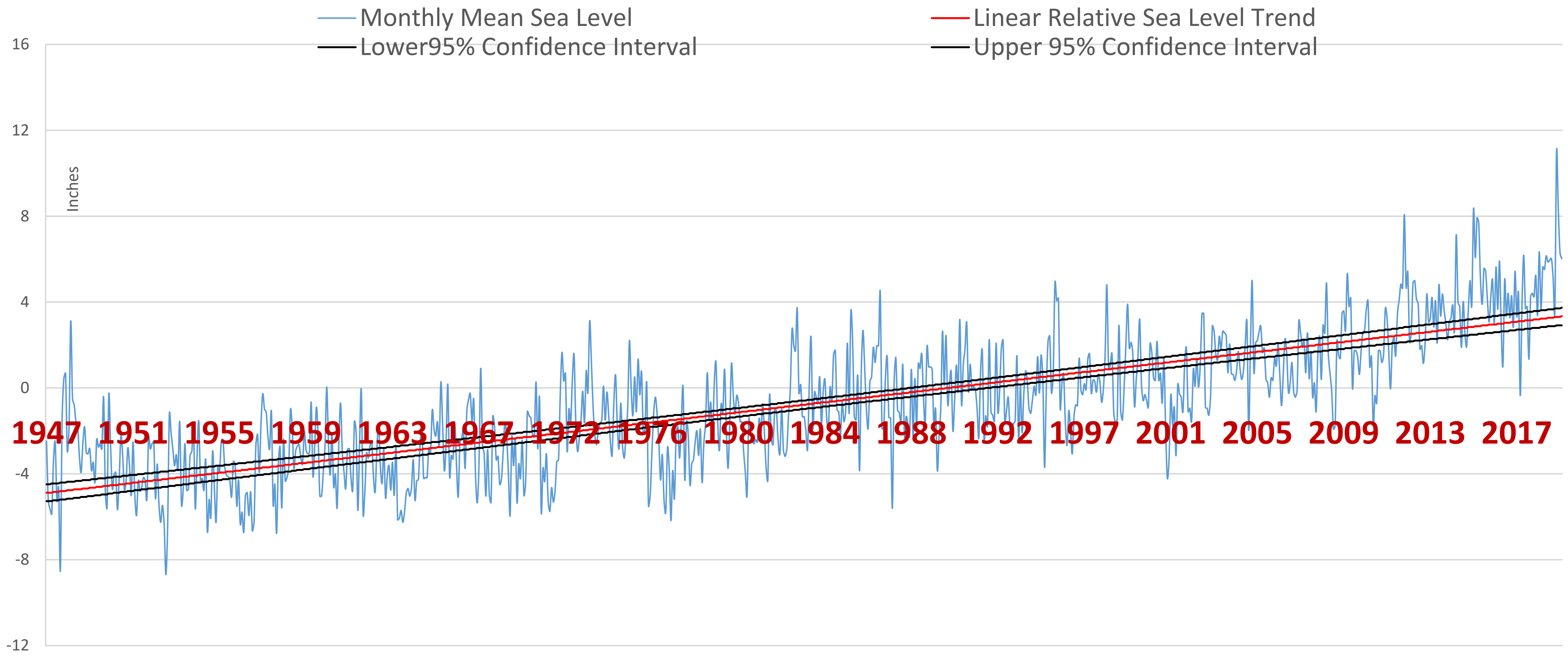
Increasing trend of the extreme precipitation during the last century



Percentage of Extreme 24-Hour Annual Precipitation Events in the US

From 1895 to 2019 average of 0.19-inch increase has been observed

STRESSOR – SEA LEVEL RISE– LOOKING BACK



Relative Sea Level Trend in St. Petersburg, FL (NOAA)

This station is located at 27° 45.6' N and 82° 37.6' W in the vicinity of Albert Whitted Airport

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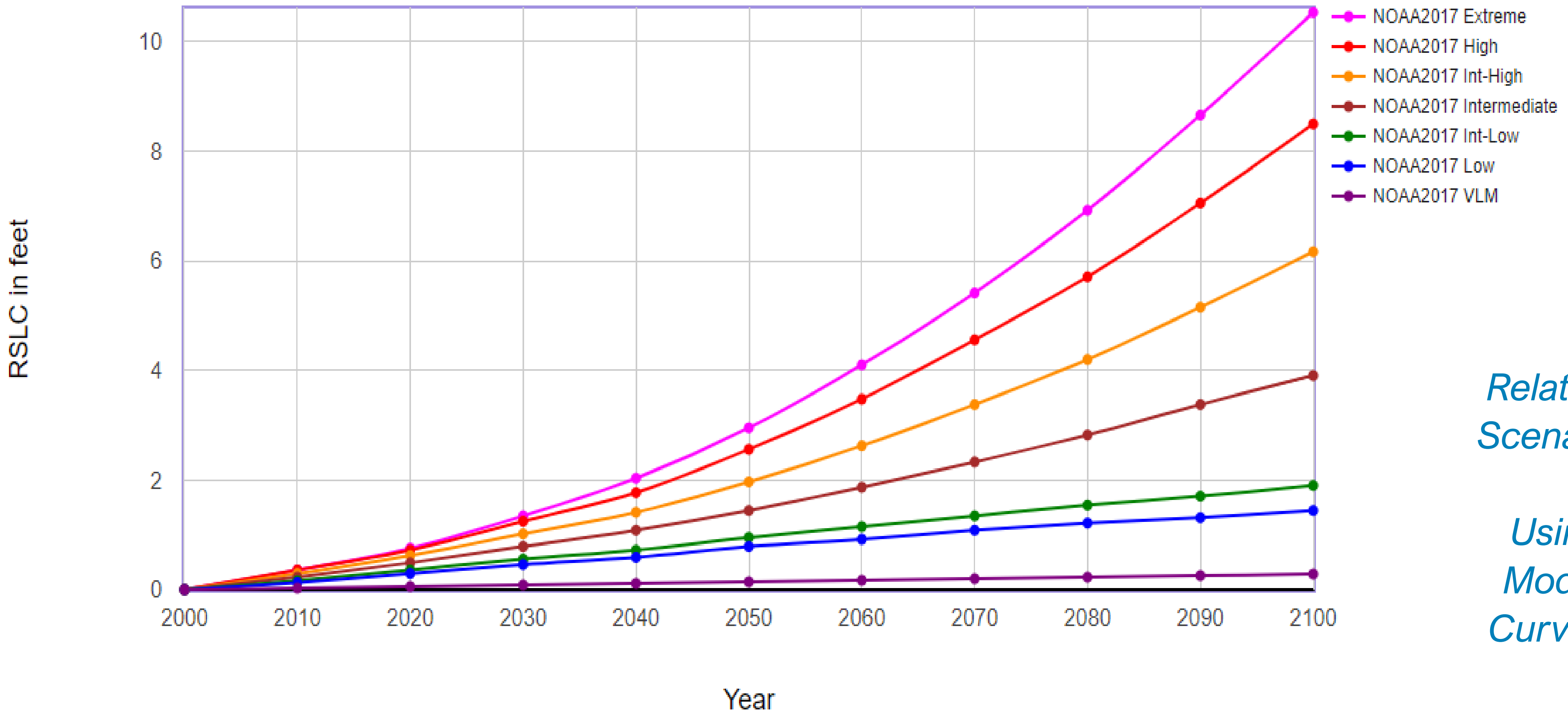
STRESSOR – SEA LEVEL RISE – LOOKING FORWARD



Relative Sea Level Rise Scenarios in Tampa Bay, Florida Using the Regionally Modified NOAA 2017 Curves (USACE, 2019)

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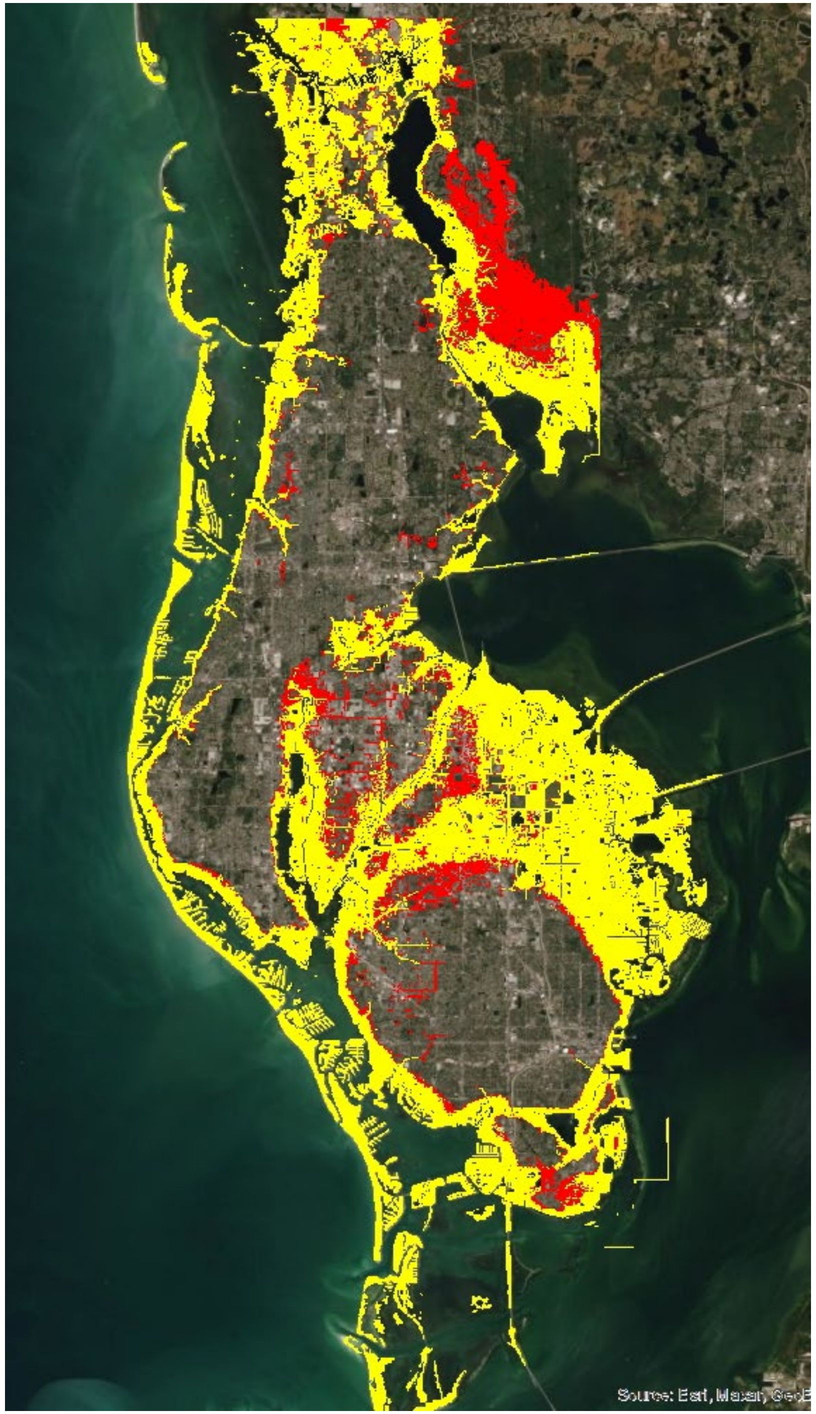
STRESSOR – STORM SURGE

Current 100-year Storm Surge

2040 Storm Surge with High SLR

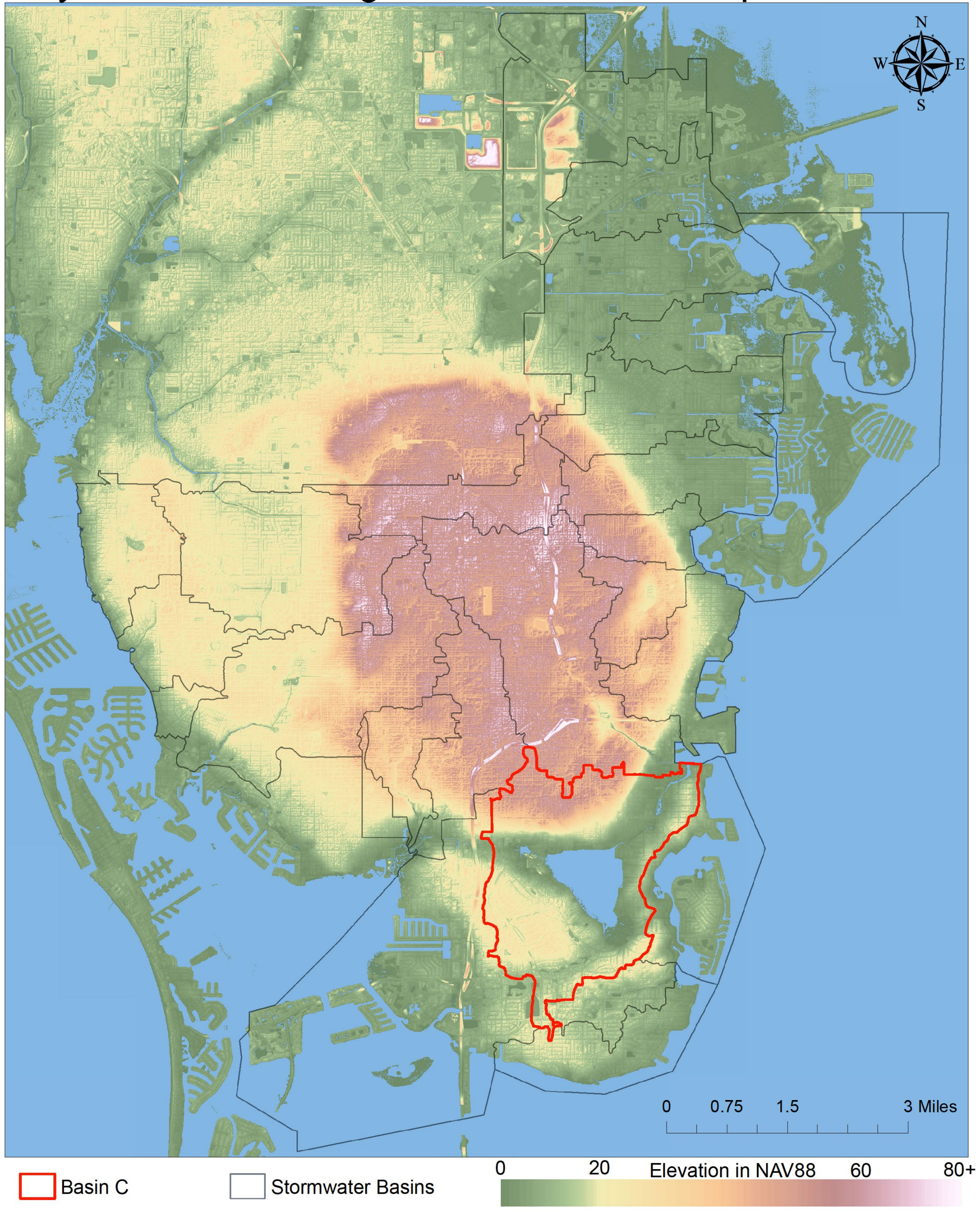


Source: FIEMA

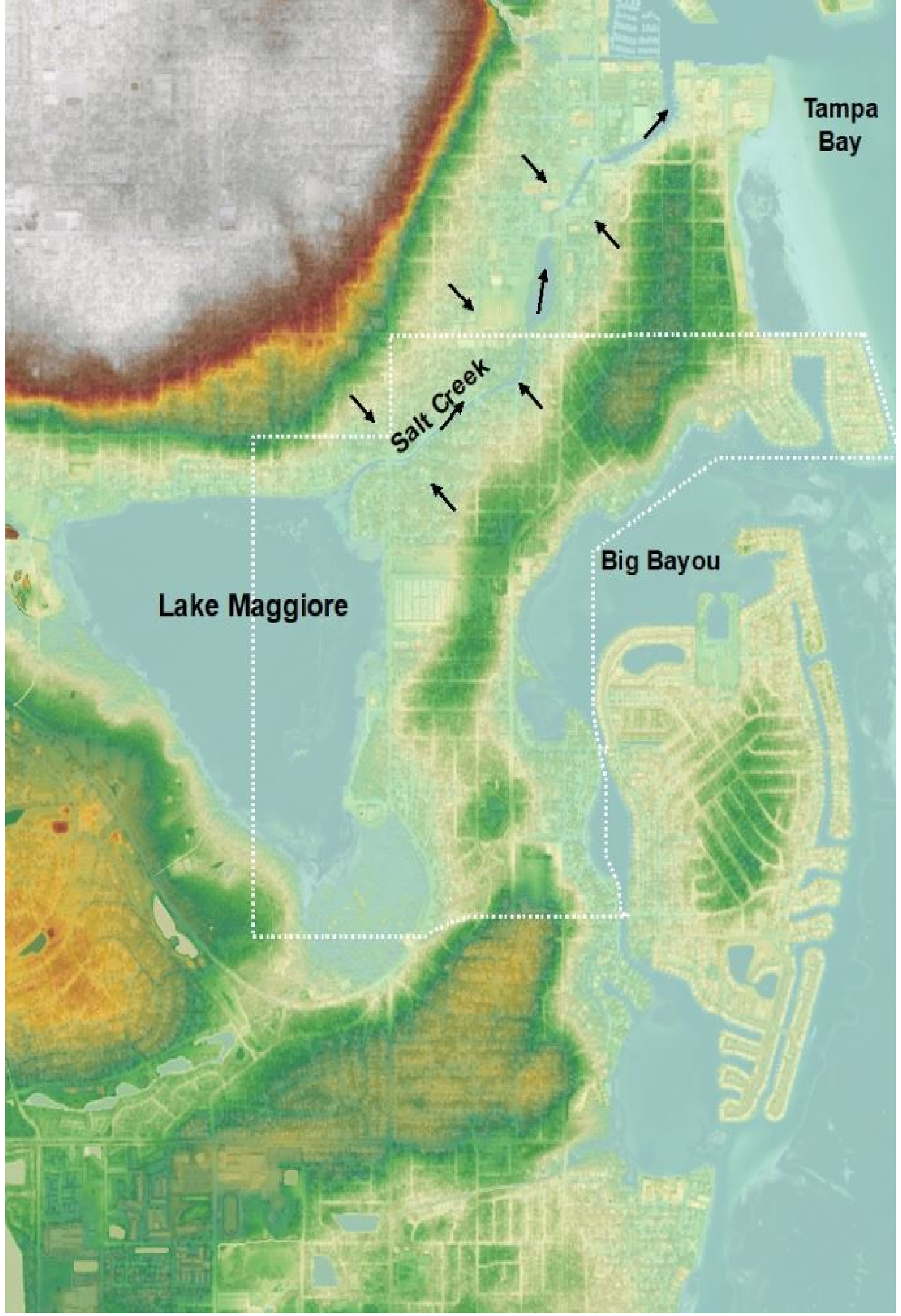
St. Petersburg, FL

+/- 250 miles of coastline

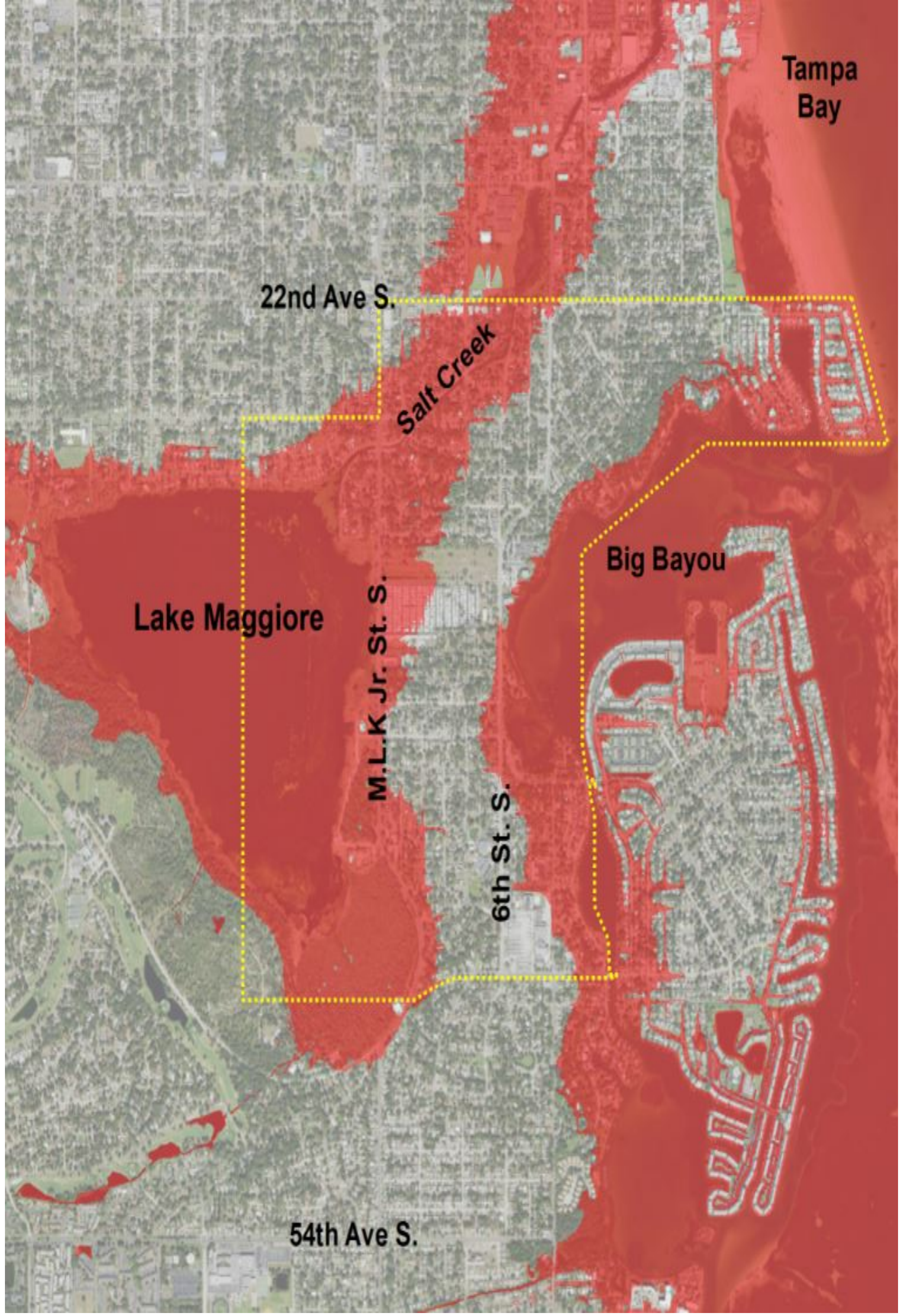
City of St. Petersburg LiDAR Elevation Map and Basins



VULNERABILITY ASSESSMENT



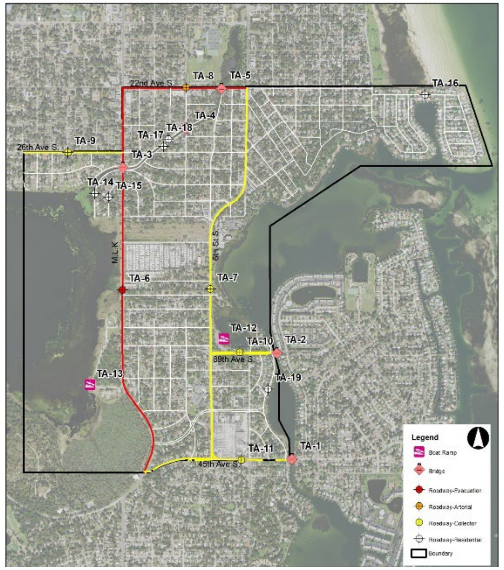
Topography of the Region



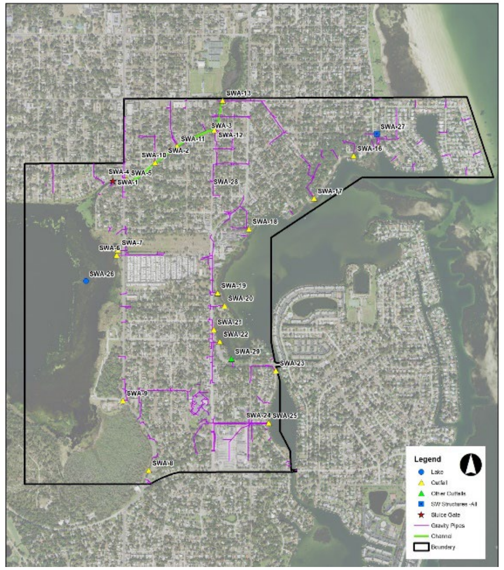
Vulnerable Areas

INFRASTRUCTURE INVENTORY

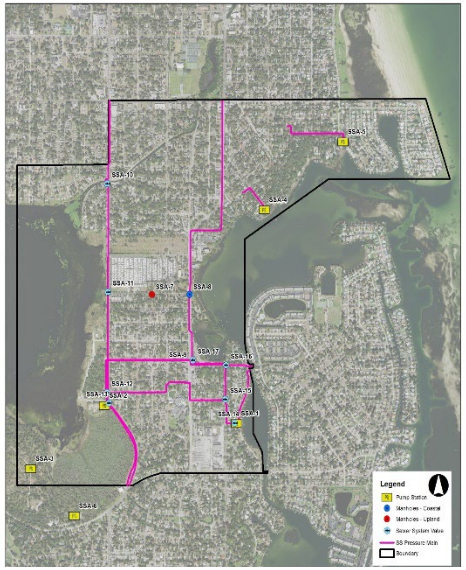
Asset Categories



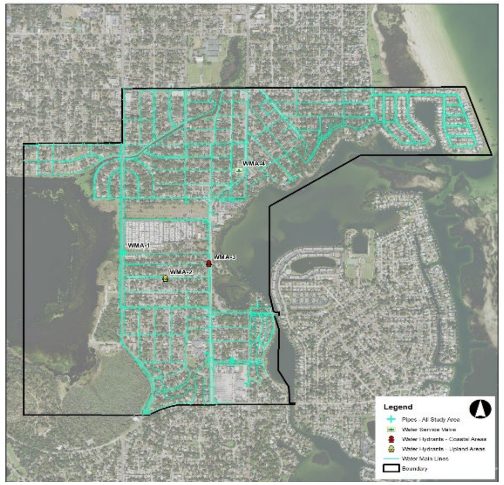
Transportation Assets



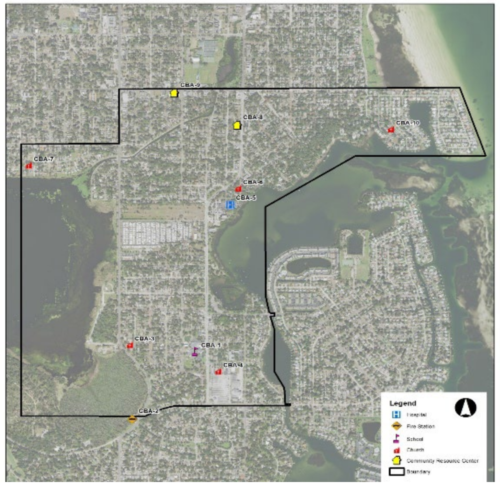
Stormwater Assets



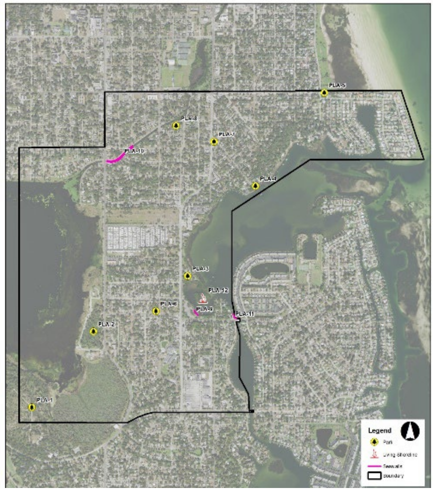
Wastewater Assets



Water Supply Assets



Critical Buildings Assets



Public Lands & Structures Assets

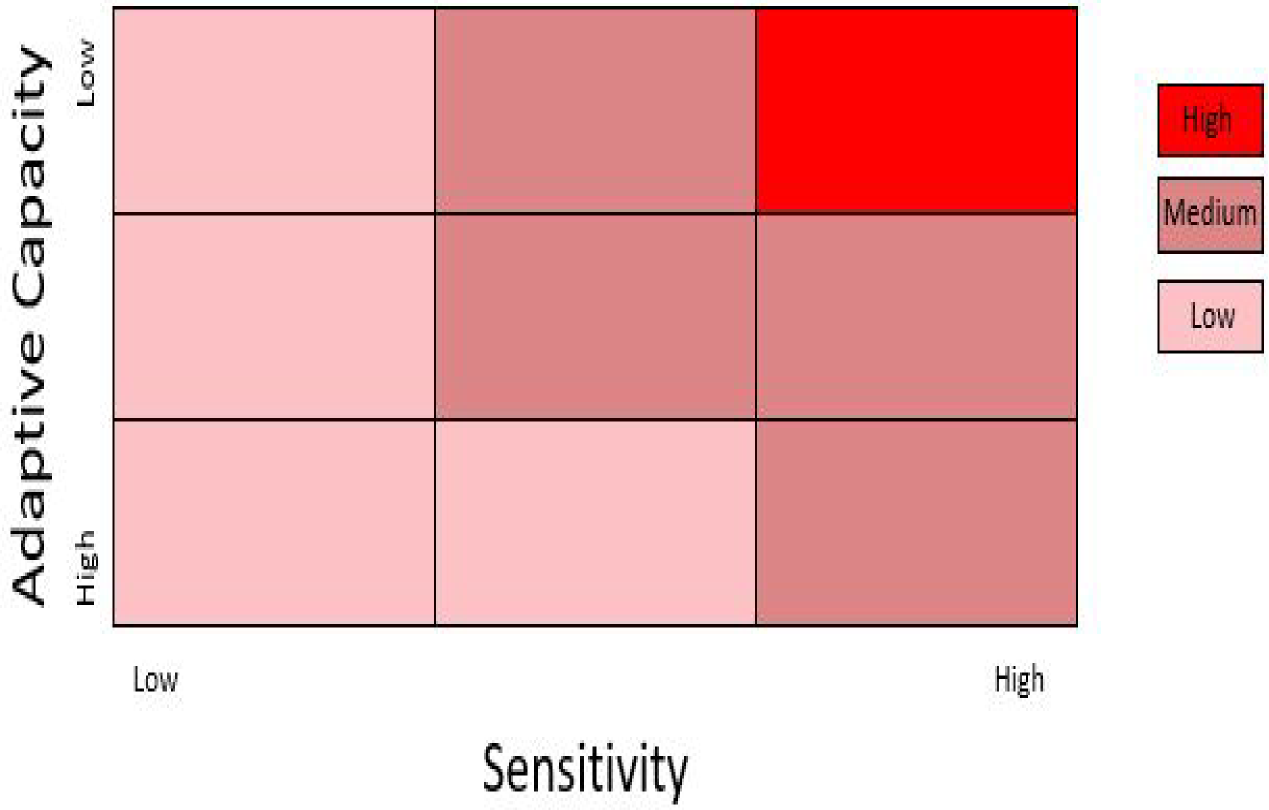
$$Vulnerability = Sensitivity \times Adaptive\ Capacity$$

SENSITIVITY

The degree to which an asset may be affected by exposure to the climate factor

ADAPTIVE CAPACITY

An asset's capability to accommodate impacts of a stressor caused by exposure to the climate factors is called adaptive capacity.



The relationship between "Adaptive Capacity" and "Sensitivity"

Sensitivity Classifications

Score	Definition	Rank
1	Slightly Susceptible in 2070	Low
2	Somewhat Susceptible in 2070	Medium-Low
3	Moderately Susceptible in 2070	Medium
4	Very Susceptible in 2070	Medium-High
5	Extremely Susceptible in 2070	High

Adaptive Capacity Classifications

Score	Definition	Rank
1	Infrastructure can adjust to climate threat with no modification or cost	
2	Infrastructure can adjust to climate threat with slight modification and minimal cost	
3	Infrastructure can adjust to climate threat with some modification and cost	
4	Infrastructure cannot adjust to climate threat without modification and cost	
5	Infrastructure cannot adjust to climate threat without substantial modification or cost	

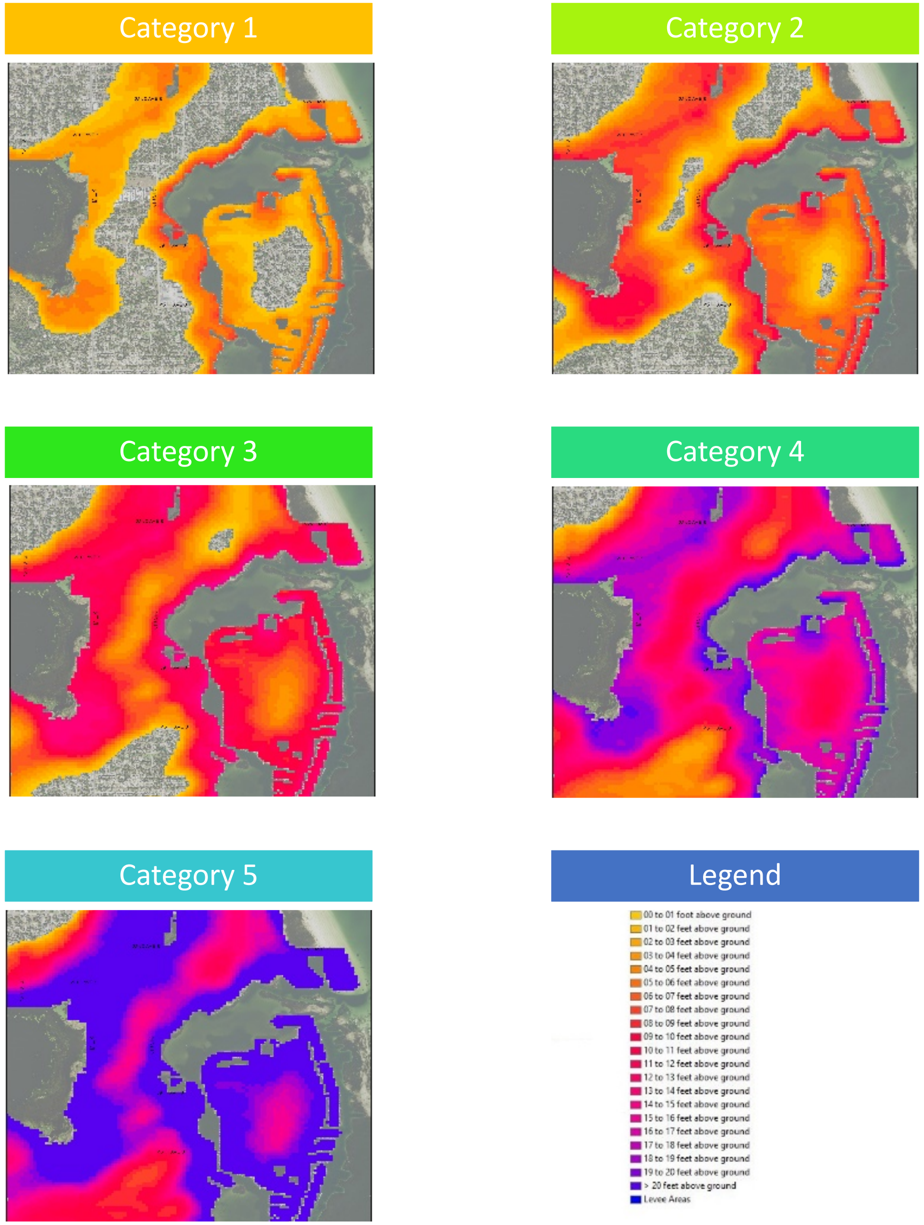
PRIORITIZE VULNERABILITIES

Infrastructure vulnerabilities are prioritized by measuring the risk associated with each asset

$$\boldsymbol{Risk = Likelihood \times Consequence}$$

LIKELIHOOD ANALYSIS

The anticipated changes associated with SLR, storm surge, and extreme precipitation were projected on maps for the year 2070 and assessed according to the likelihood that they would impact infrastructure.

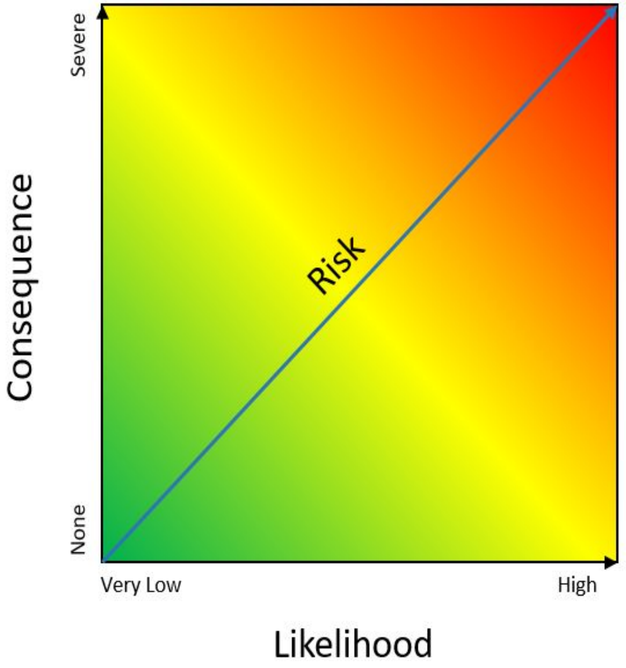


Project Area Storm Surge Conditions

PRIORITIZE VULNERABILITIES

CONSEQUENCE ANALYSIS

Consequence analysis is the second factor used to determine risk. The assessment is conducted to understand the significance of climate change and is qualitative :

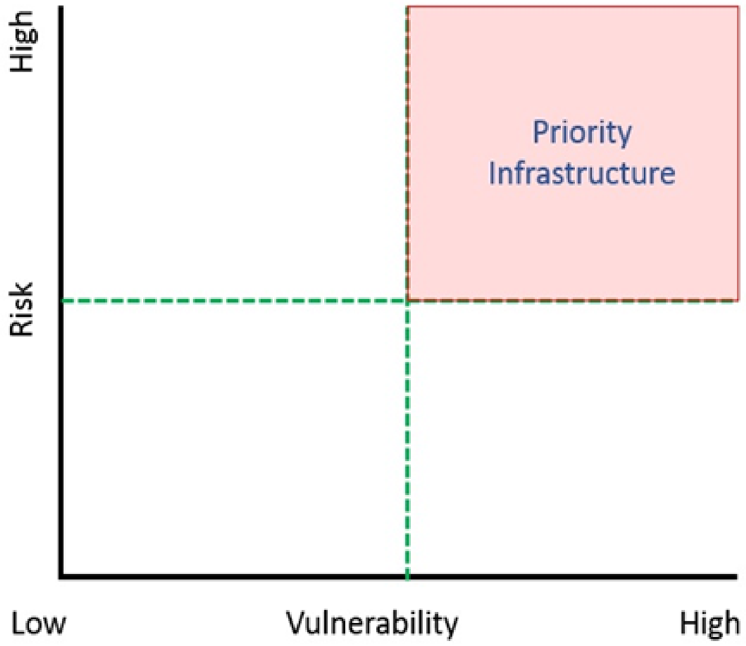


- *Public health*: The impacts of factors such as water quality, disease, heat stress, air quality and discomfort on residents, work force and tourists
- *Public safety:* The impacts regarding the safe evacuation during the storms or other physical threats of residents, work force and tourists
- *Economic loss:* The impacts of government infrastructure or public services including damage to public assets on the economy of the local businesses, tourism, and loss of public services.
- *Environmental damage:* The impacts that changes the natural resources, damages the native habitats, contaminate water or wildlife.
- *Cultural and historical significance:* The impacts to the historical communities or cultural assets such as bridges, government buildings, parks, water features, or natural areas.

PRIORITIZE VULNERABILITIES

Score	Definition	Rank
1	Resilient	Insignificant Impact
2	Temporary or inconvenient delay, loss, or setback	Minor Impact
3	Widespread delay, loss, or setback	Moderate Impact
4	Significant and long-lasting delay, loss, or setback	Major Impact
5	Extensive loss; likely irreversible/not cost feasible to restore	Catastrophic

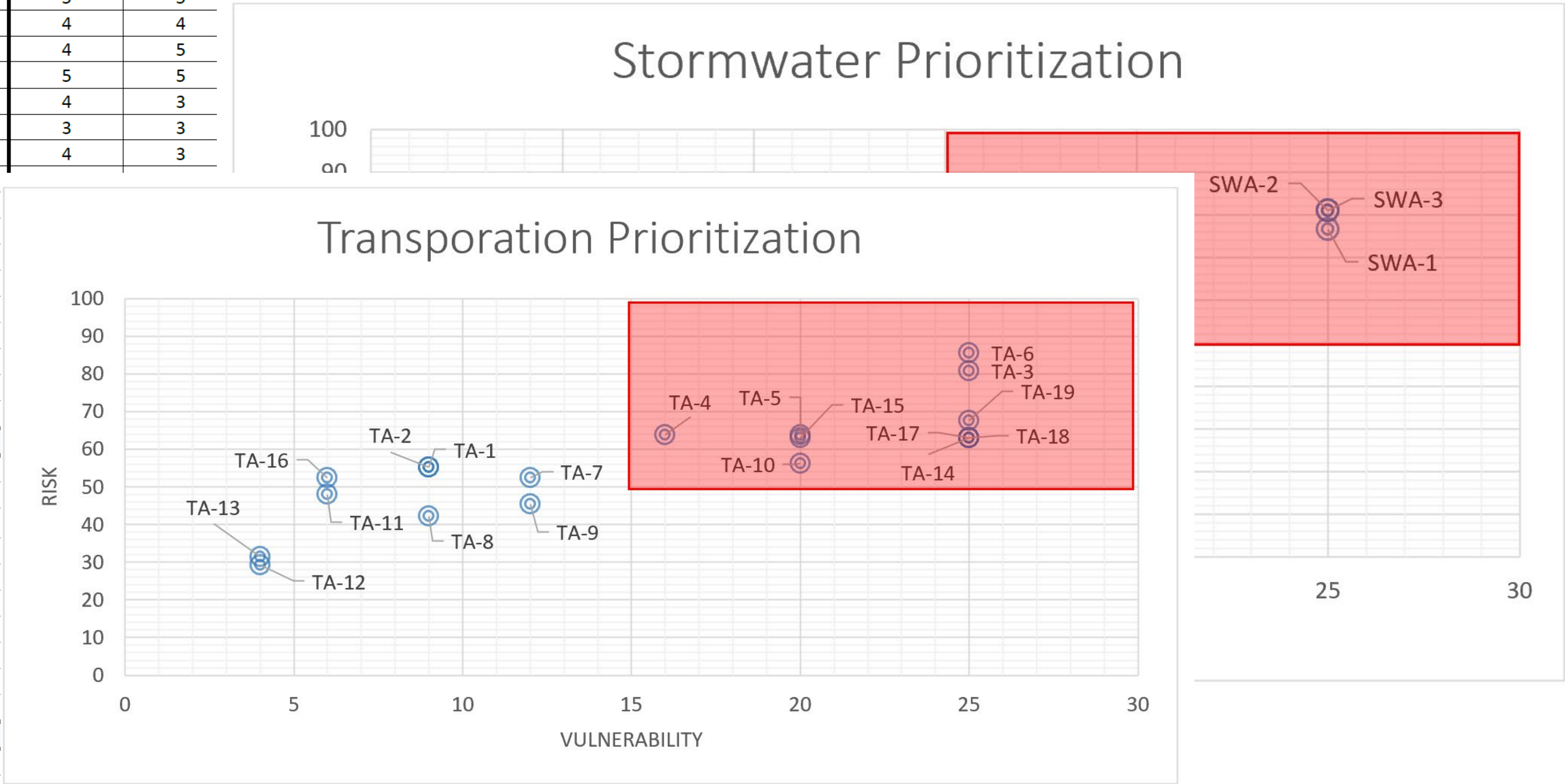
Scoring structure for consequence analysis categories for City assets



Approach to Prioritizing Assets

Basin C & Lake Maggiore Outfall Resiliency Assessment Plan

Asset ID	Asset Name	Vulnerability (Sensitivity x Adaptivity)			Likelihood of Impact 2070					Consequence (n=25)						Risk
		Sensitivity (n=5)	Adaptive Capacity (n=5)	Overall Vulnerability (n=25)	SLR	Storm Surge	Ext Precip	Ext Heat	Ave (n=5)	Health	Safety	ECO	ENV	C&H	SUM	Risk (n=125)
Transportation																
TA-1	Bridge at 45th Avenue South	3	3	9	2	5	3	3	3.25	2	5	4	3	3	17	55.25
TA-2	Bridge at 39th Avenue South	3	3	9	2	5	3	3	3.25	2	5	4	3	3	17	55.25
TA-3	Bridge at MLK	5	5													
TA-4	Bridge at 7th St S	4	4													
TA-5	Bridge at 22nd Ave S	4	5													
TA-6	Dr. MLK St S [E]	5	5													
TA-7	6th St S [C]	4	3													
TA-8	22nd Ave S [A]	3	3													
TA-9	26th Ave S [C]	4	3													
TA-10	39th Ave S [C]															
TA-11	45th Ave S [C]															
TA-12	Grandview Park Boat Ramp															
TA-13	Lake Maggiore Park Boat Ramp															
TA-14	Pallanza Dr S [R]															
TA-15	Ivanhoe Way S [R]															
TA-16	22nd Ave SE [R]															
TA-17	E Harbor Dr S [R]															
TA-18	W Harbor Dr S [R]															
TA-19	Sunrise Dr S [R]															
Critical Buildings																
CBA-1	Lakewood Elementary School															
CBA-2	Fire Station 8															
CBA-3	New Life Missionary Baptist Church															
CBA-4	Calvary Chapel Southside															
CBA-5	Kindred Hospital Bay Area															
CBA-6	Downtown Open Bible Church															
CBA-7	New Beginnings Comm Church															
CBA-8	Harbordale YMCA															
CBA-9	Bartlett Park Comm Rec Cntr															
CBA-10	St. Paul Missionary Baptist Church															
Stormwater																
SWA-1	Sluice Gate at 27th Avenue South															
SWA-2	Channel Salt Creek - South															



ADAPTATION STRATEGIES

General Recommendations

AquaDams are used as temporary protection measures against storm surge.

- Short Term Considerations
  - Install pumps to alleviate flooding
  - Install Backflow preventors
  - temporary design features for pavement washouts
  - Extend surge area inland for pavement design
  - Native species and Large canopy tree Landscaping to combat heat Island effect
  - Use cooler pavements where reflectance can be enhanced by using reflective aggregate, a reflective or clear binder, or a reflective surface coating
  - Develop design guidelines and specifications for pavements, cements, and bridge joints shall provide added consideration for material expansion and contraction, as higher temperature affects rutting, asphalt movement, slab buckling, frequent maintenance, joint failure
  - Adding safe bike lanes will encourage green transportation and reduce carbon emission
  - Buffer sidewalks and parking lots with infiltration strips, grid pavements, and vegetation to reduce flooding as SLR reduces basin drainage
  - Incorporate sustainable design standards such as Green Roads and Envision

ADAPTATION STRATEGIES

General Recommendations

Sample recommendation strategy for each asset at Risk

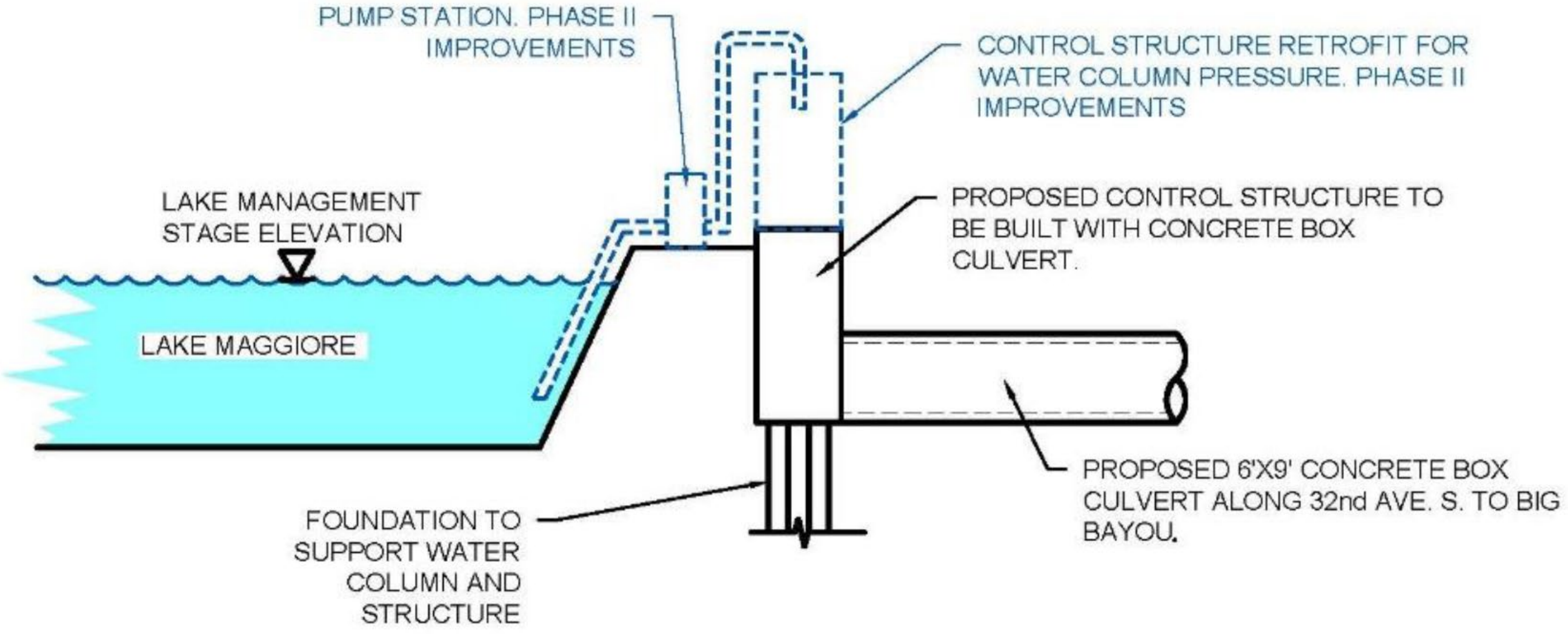
Transportation	
Asset ID	Project Strategies
TA-6	Short Term Consideration ▪ Evaluate alternative evacuation routes, pumping without backflow prevention may not provide the temporary relief when lake levels are high. Long Term Considerations ▪ Elevate the road profile from 45th Avenue South to 26 Avenue South to a minimum of 6.00 FT NAVD (2070 SLR projected Mean High Tide is 3.0 Feet Integrate MLK road profile adjustment with MLK bridge improvement at intersection with 28th Avenue South and Pallanza Drive South (TA-3). Bridge replacement shall address the hydraulic need for discharge from Lake Maggiore. ▪ Consider improving the drainage capacity from the road to Lake Maggiore ▪ Consider construction of the secondary outfall see concept plan ▪ Alternate project may be considered to dam and pump

ADAPTIVE DESIGN STRATEGIES TO SPREAD CAPITAL INVESTMENT AND ENSURE PERFORMANCE FOR SERVICE LIFE

Example of an Adaptive design approach

Proposed BC outfall with a capacity of 230 cfs is reduced with SLR. Modifying structure to add hydraulic head will increase discharge capacity.

Current design to account for future Hydraulic capacity.

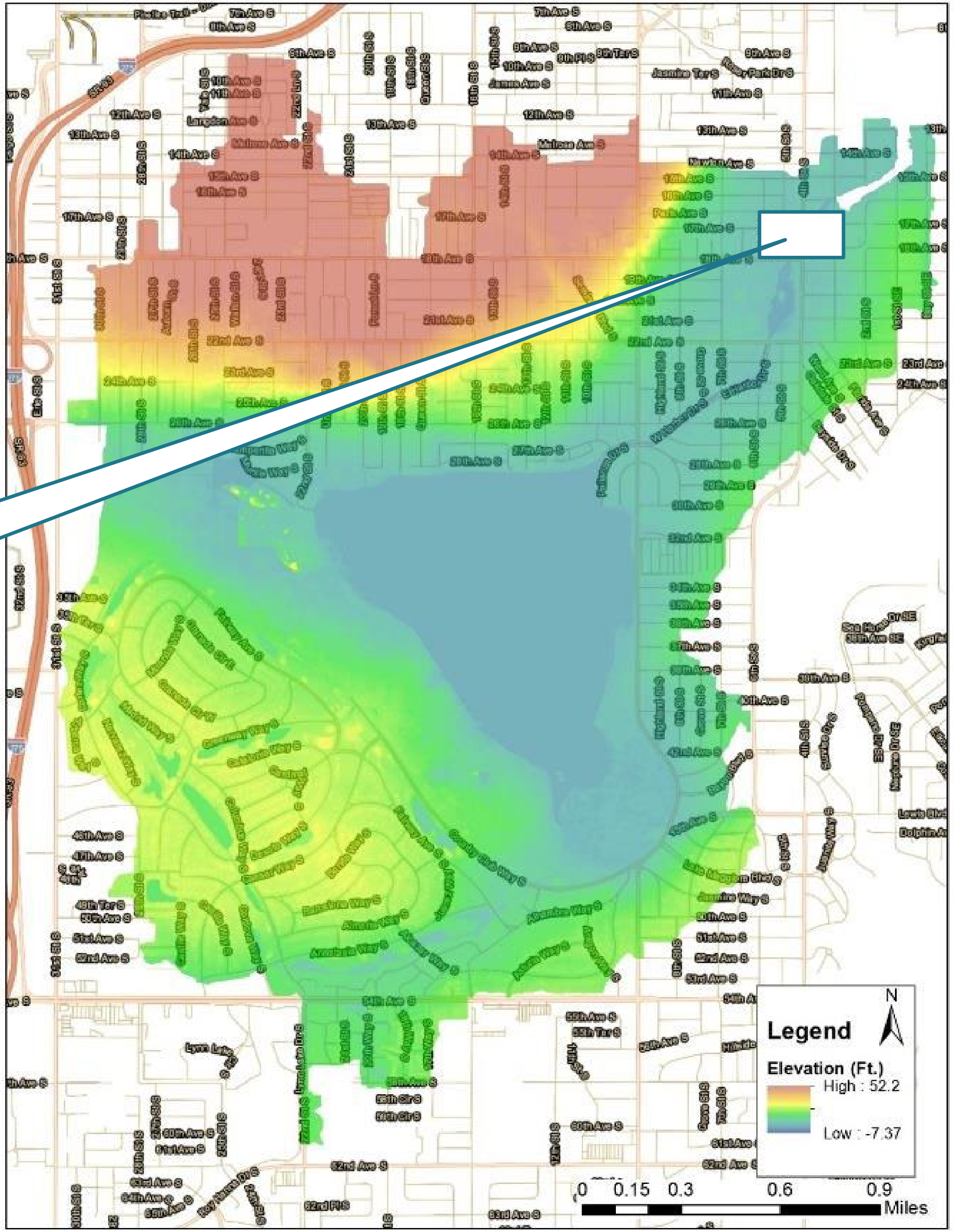


ADAPTIVE DESIGN STRATEGIES TO SPREAD CAPITAL INVESTMENT AND ENSURE PERFORMANCE FOR SERVICE LIFE

Example of adaptive design approach

Sluice Gates/Dam to stop saltwater intrusion and SLR impact

Pumping capacity to be increased gradually over the decades



ADAPTIVE DESIGN STRATEGY CATEGORIES

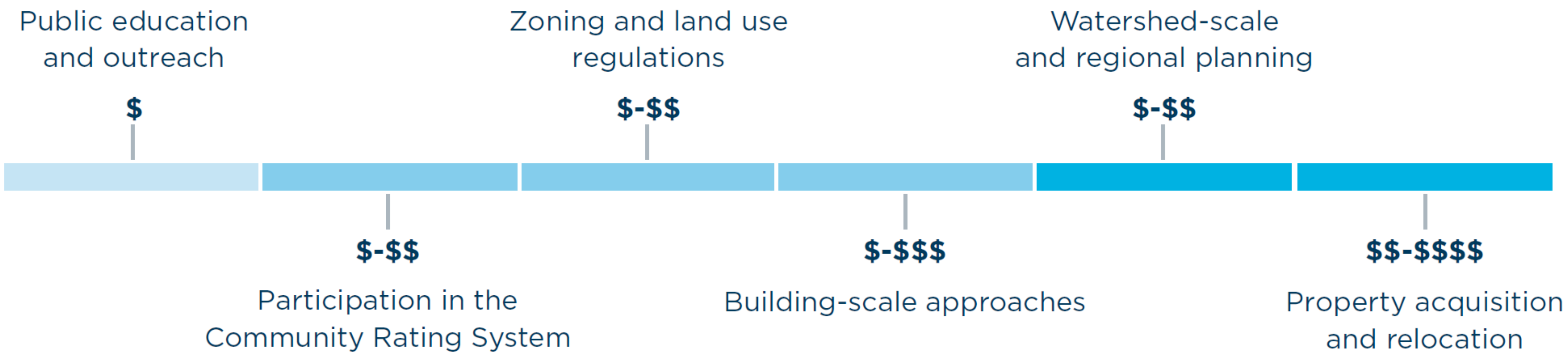
Coastal & Shoreline

Stormwater & Drainage

Land Use & Policy

COST & COMPLEXITY COMPARISON

Land use and policy

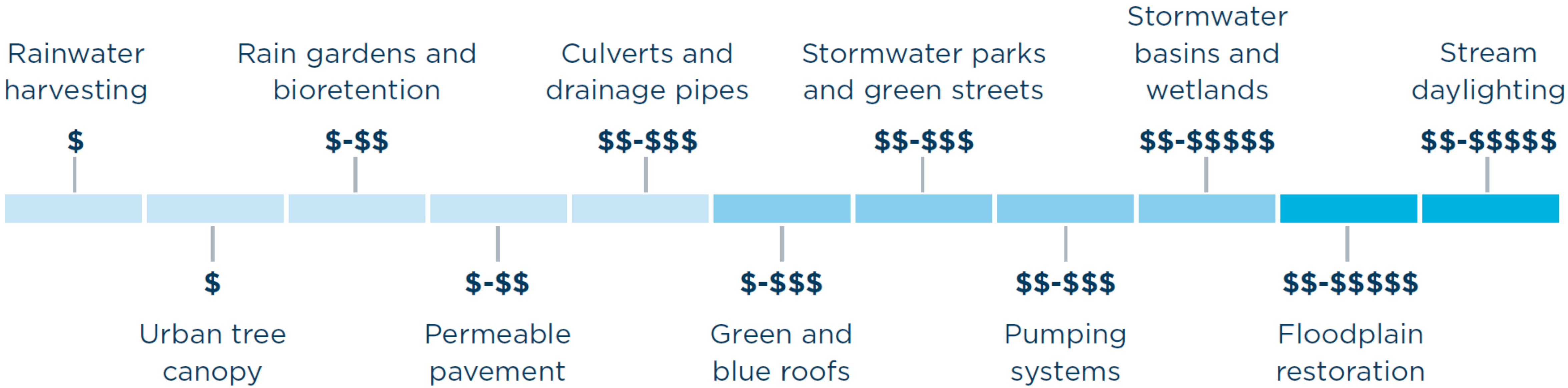


Cost*			Complexity level	
	$	Less than $100,000		Low
	$$	$100,000 – $500,000		Medium
	$$$	$500,000 – $1 Million		High
	$$$$	$1 Million – $5 Million		
	$$$$$	$5 Million+		

Source: Flood Coalition.org

COST & COMPLEXITY COMPARISON

Stormwater and drainage



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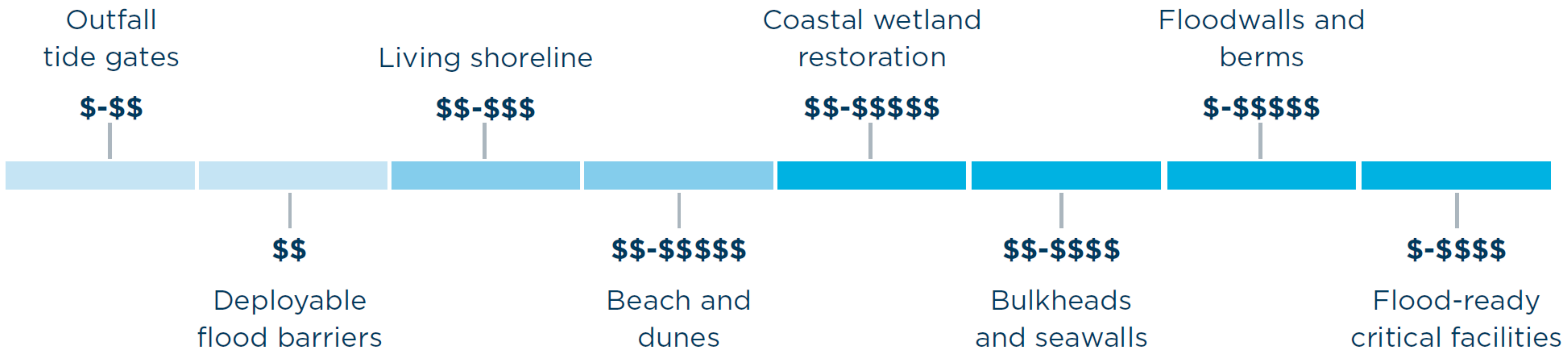
COST & COMPLEXITY COMPARISON

Coastal and shoreline



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Questions?