



Stormwater Resiliency in the Nation's Oldest City

FSA 2021 Fall Conference
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What are the effects of climate change ?

- Increased damage from coastal storms
- Storm water/municipal drainage no longer work during high tide
- Increasing frequency of flood events
- Inundated roads (nuisance flooding)
- Salt-water intrusion
 - Rivers and aquifers becoming more saline
 - Re-location of municipal drinking wells
- Plant and tree mortality
- Lowland fields no longer suitable for agriculture



Global Climate Change



Storm Surge/Waves



Hurricanes/Tropical Storms



Sea-Level Rise



Rainfall (changes in intensity and distribution)



Growth in coastal population



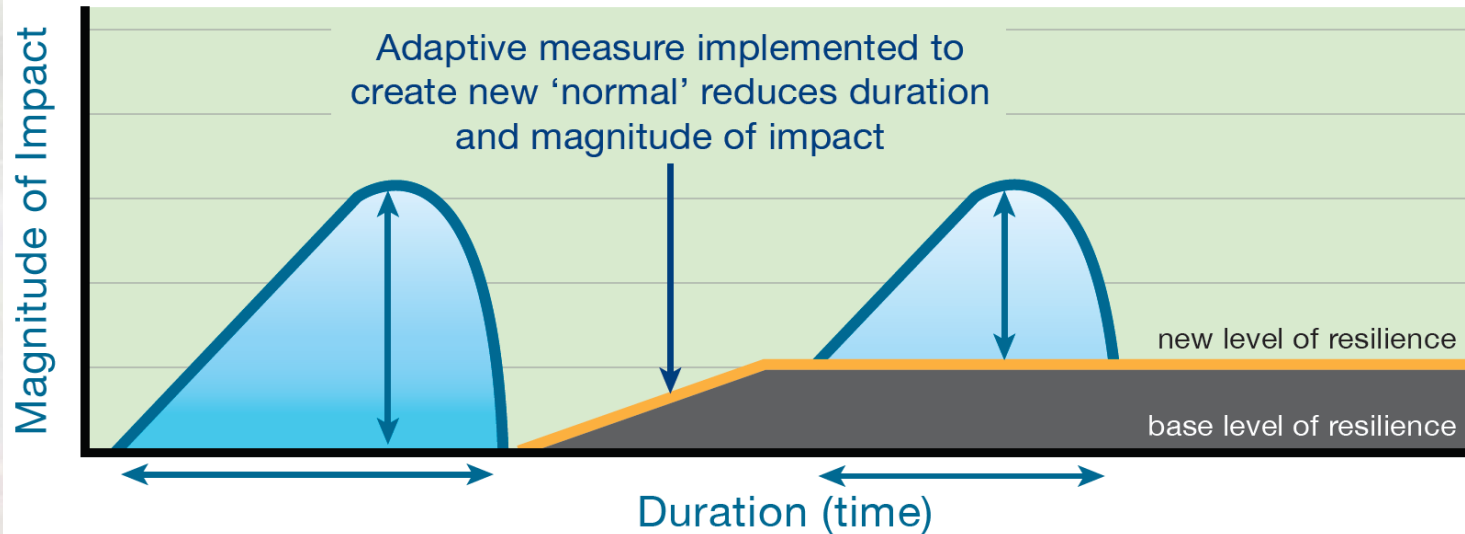
Need for resilient and adaptive planning and design



Resiliency - the ability of a natural or built system to recover from an extreme load or event.

Adaption - adjustment in response to changes in the factors that impact the functionality of a natural or built system.

Resilience Improvement Cycle

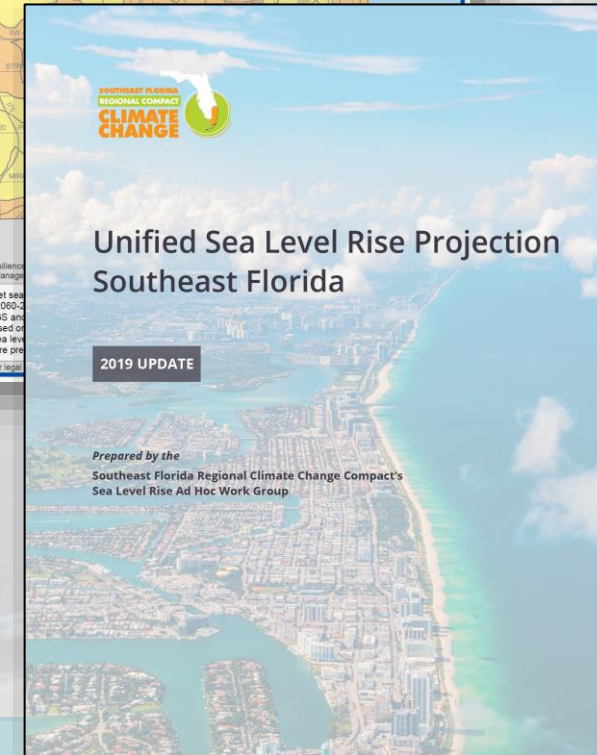
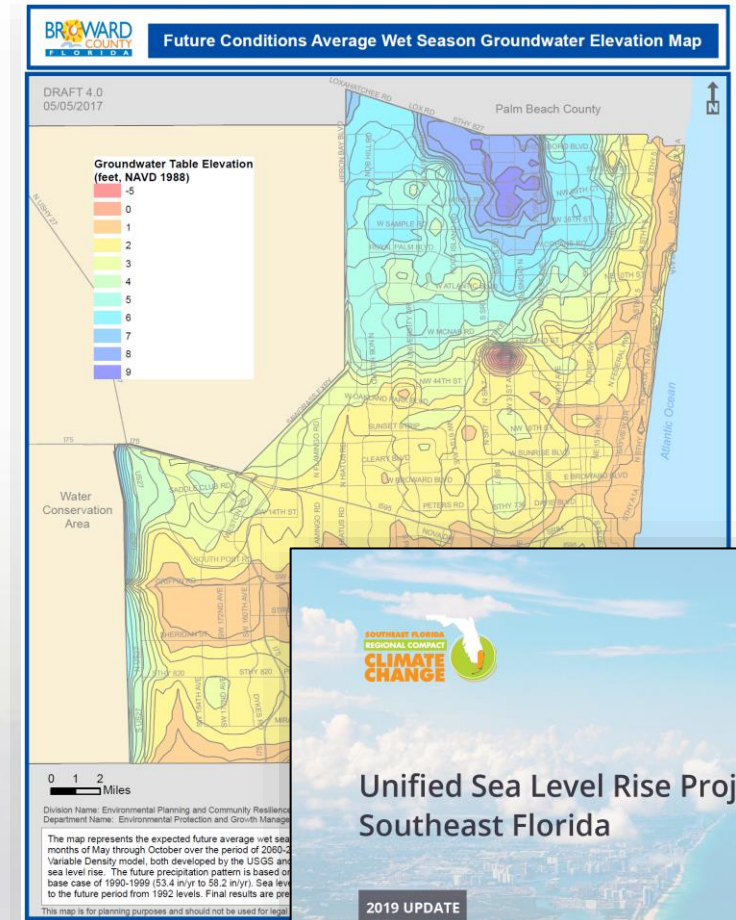
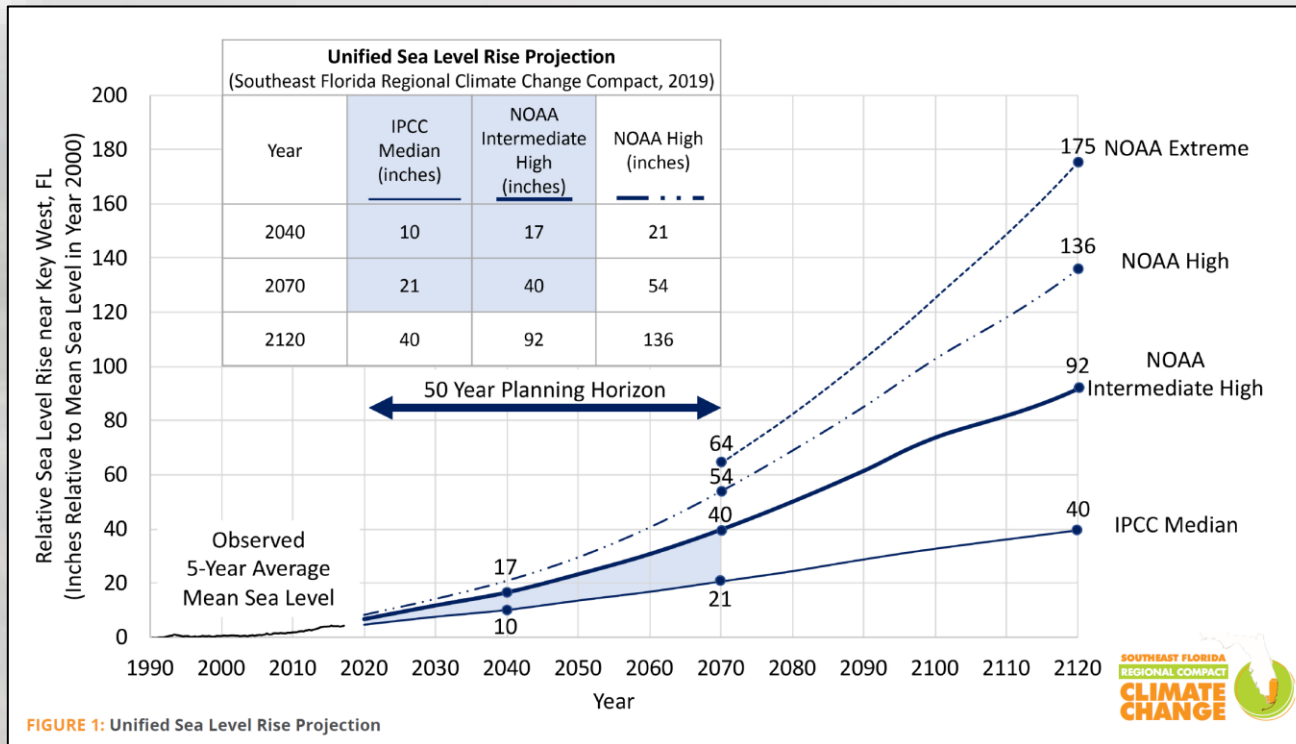




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Impacts of Future Climate Change

- Sea Level Rise
- Groundwater Table Rise
- Changes in Hydrology –
 - More Intense Storms







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Broward County Future Conditions 100-Year Flood Map Project

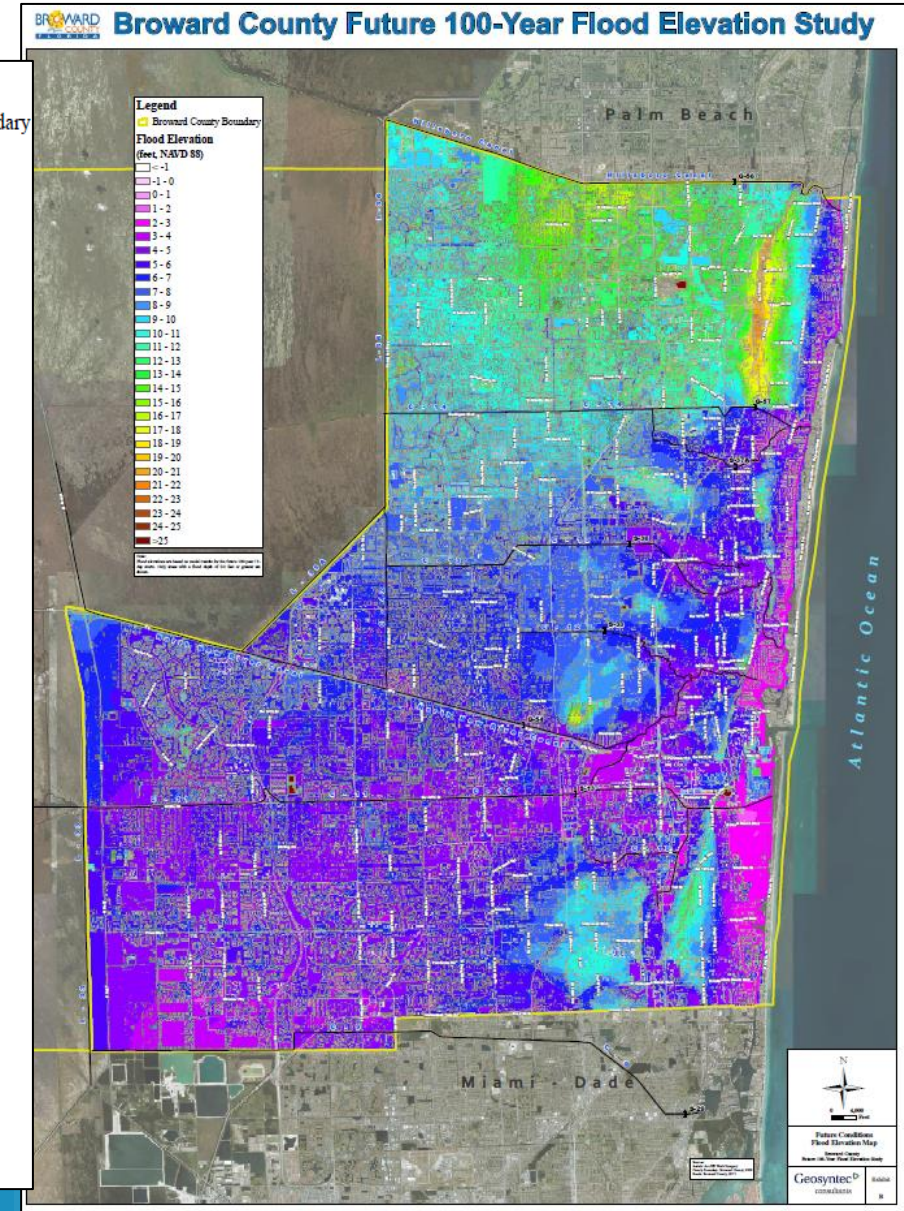
❖ Goals:

- Future Resiliency for Buildings and Infrastructure in Face of Projected Sea Level Rise and Climate Change
- Reducing flood risk for development and re-development
- Increasing sustainability of structures over lifespan
- Incorporate future map into County code

❖ Approach and Advantages:

- Integrated surface water – groundwater hydrological model
- Integrate future sea level rise, groundwater table rise, rainfall, and land use changes
- Support updates for water management operations
- Coordinate with 30 municipalities and 21 water control districts, SFWMD and USGS
- Develop Future Conditions Rainfall Intensity- Duration data
- Consider ongoing FEMA coastal flood surge modeling efforts

❖ Develop regulatory future conditions 100-year flood elevation maps to establish finished floor elevations





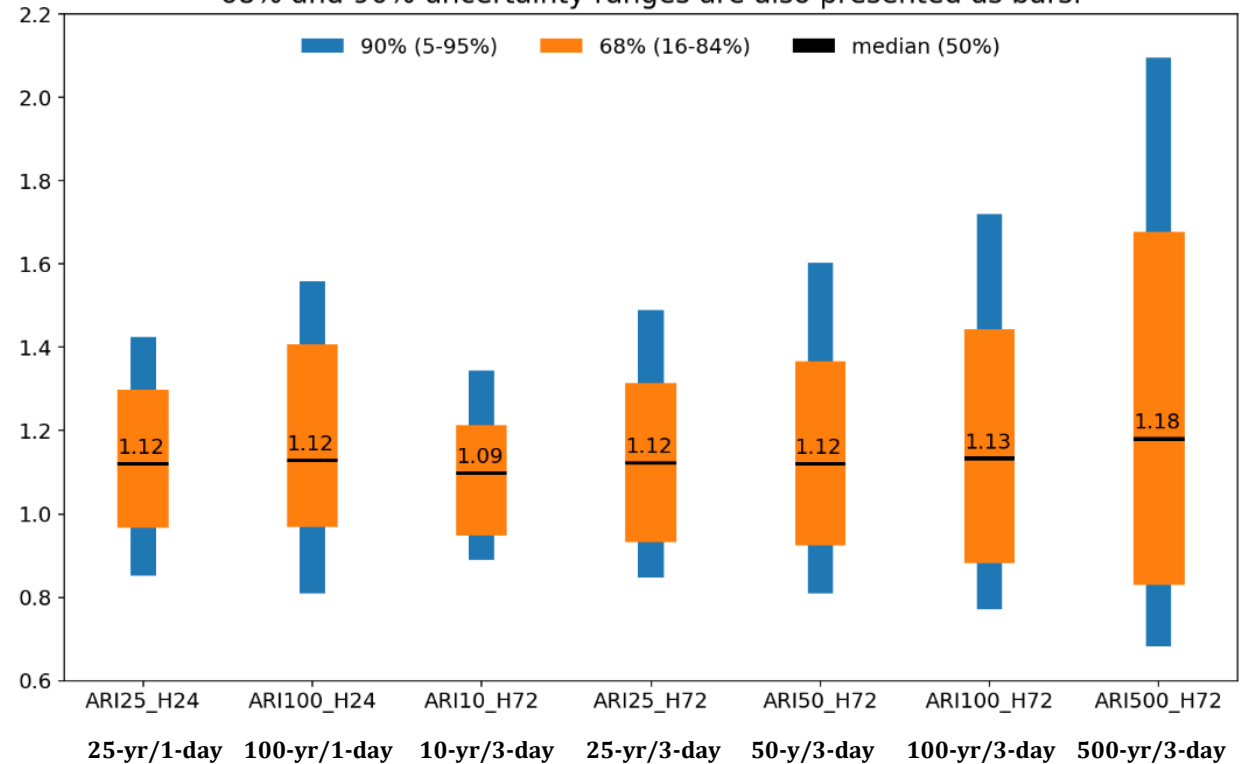
Future Change Factor Results for Design Storms

Broward County - Single model domain-wide scaling values for design storm events

- 25 year/1 day = 12% increase*
- 100 year/1 day = 12% increase*
- 10 year/3 day = 9% increase*
- 25 year/3 day = 12% increase*
- 50 year/3 day = 12% increase*
- 100 year/3 day = 13% increase*
- 500 year/3 day = 18% increase*

*% Change Factor to be applied over NOAA Atlas 14 precipitation frequency estimates

Super Ensemble Medians of Spatially Aggregated DDF Change Factors under RCP8.5 (2041-2090 vs. 1956-2005) across Broward County. 68% and 90% uncertainty ranges are also presented as bars.



Whisker diagram of SUPER ensemble medians of spatially aggregated DDF change factors with uncertainty ranges.



Existing and Forecasted Estimated Nuisance Flooding Conditions at St. Augustine's Maria Sanchez Lake based on FDEO's 2016 Coastal Vulnerability Assessment



Existing



12" SLR (2030s)

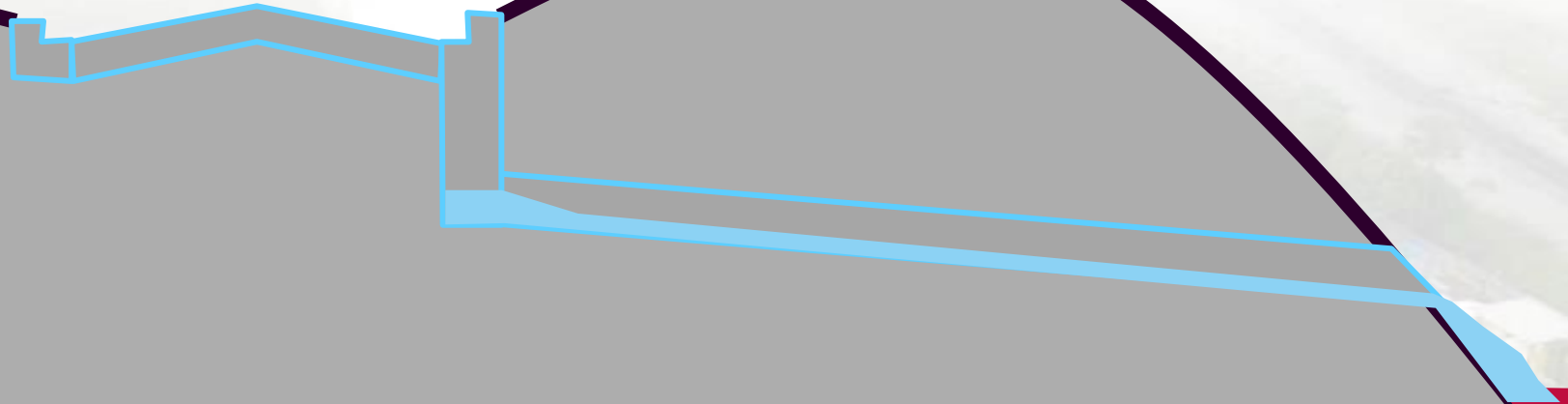


24" SLR (2040s)



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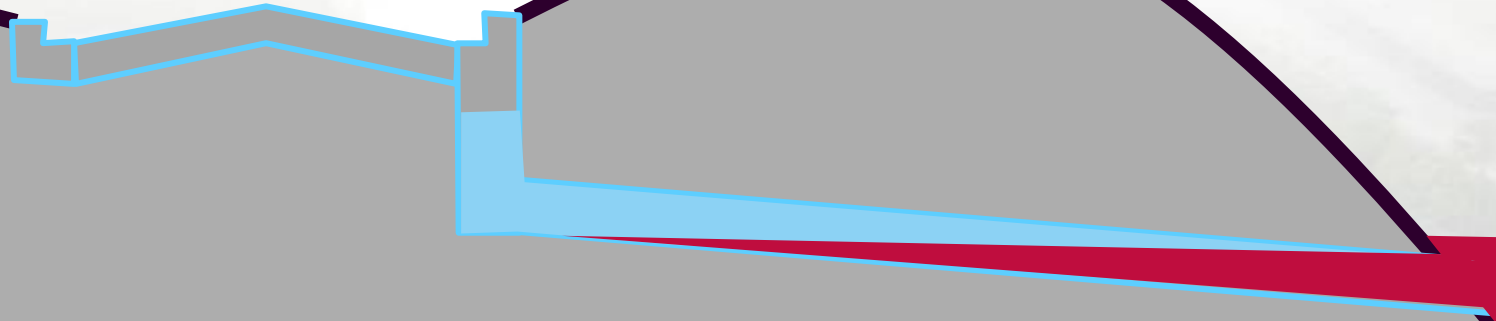
Current Free Outfall Conditions





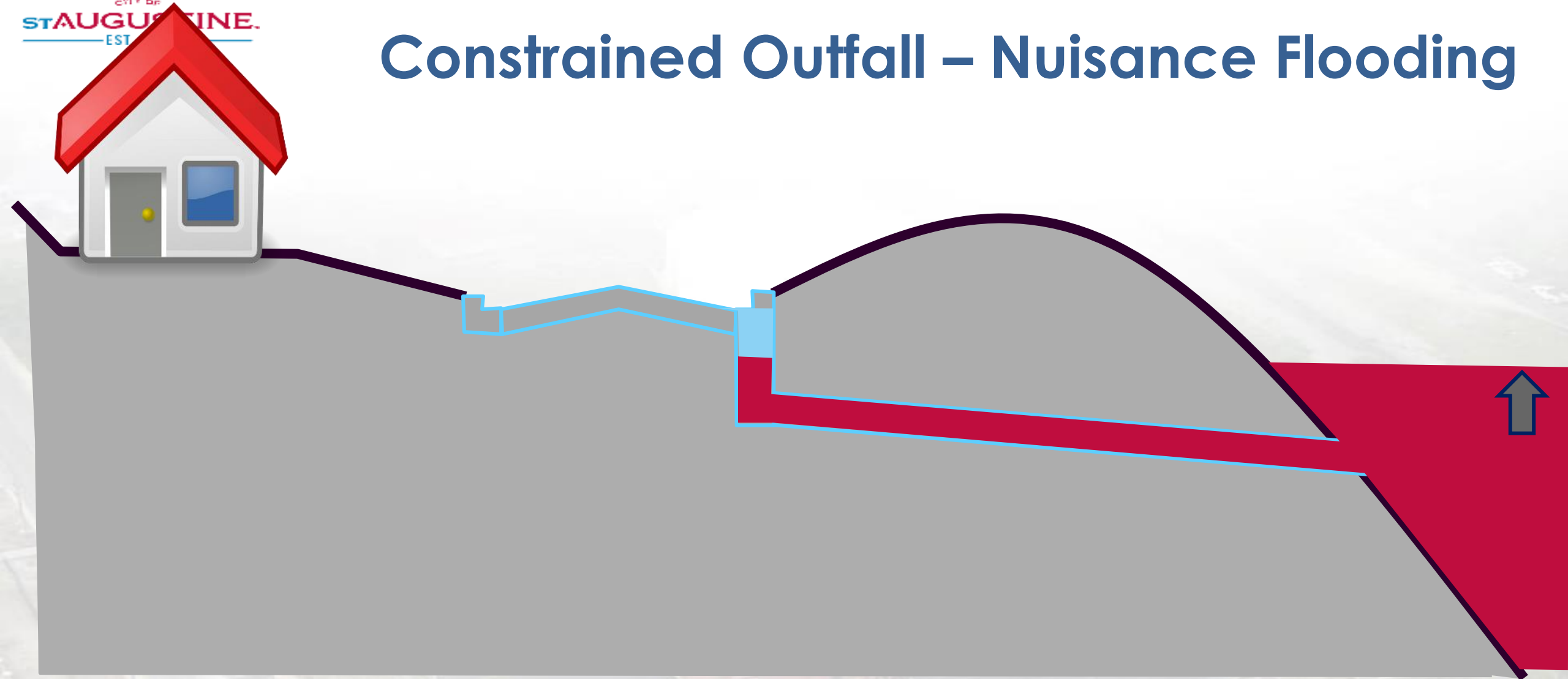
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Increasing Tailwater (Tidal) Conditions





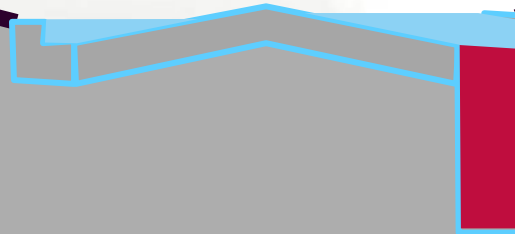
Constrained Outfall – Nuisance Flooding





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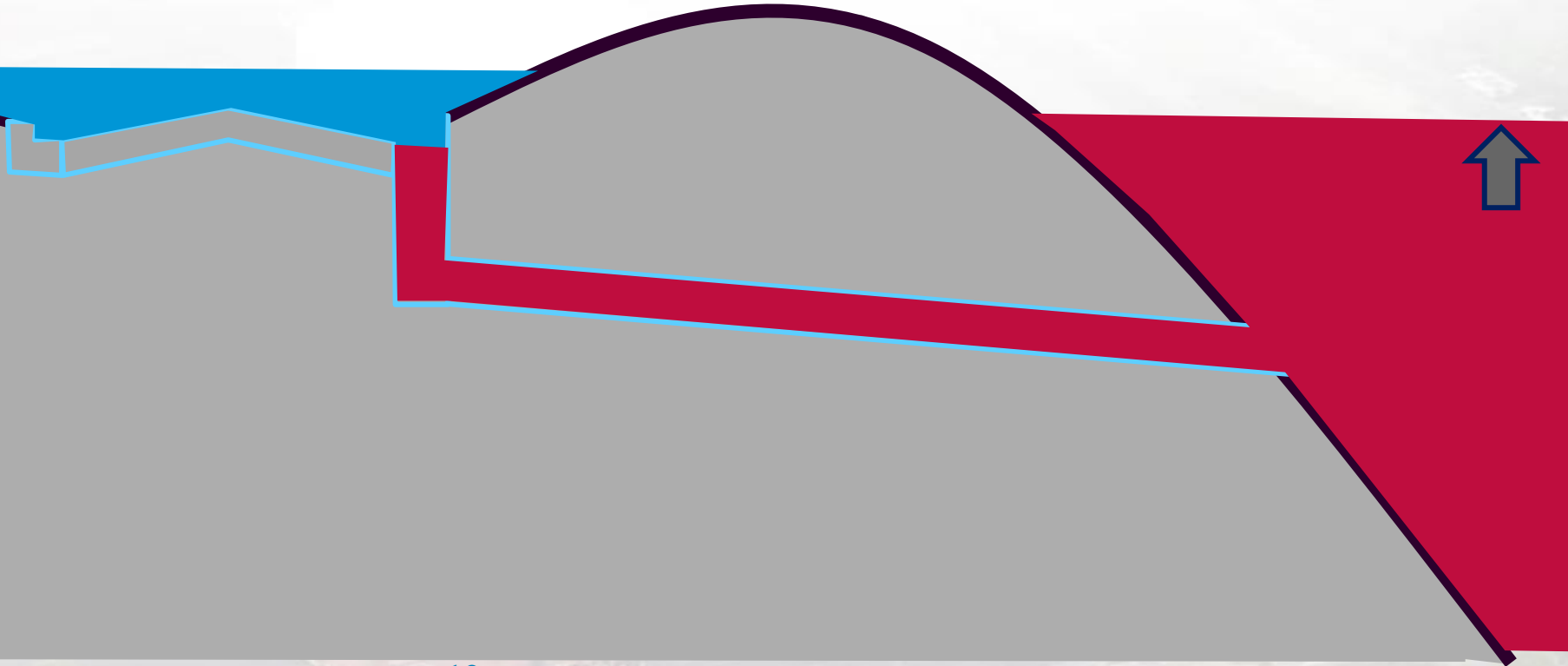
Constrained Outfall – Chronic Flooding





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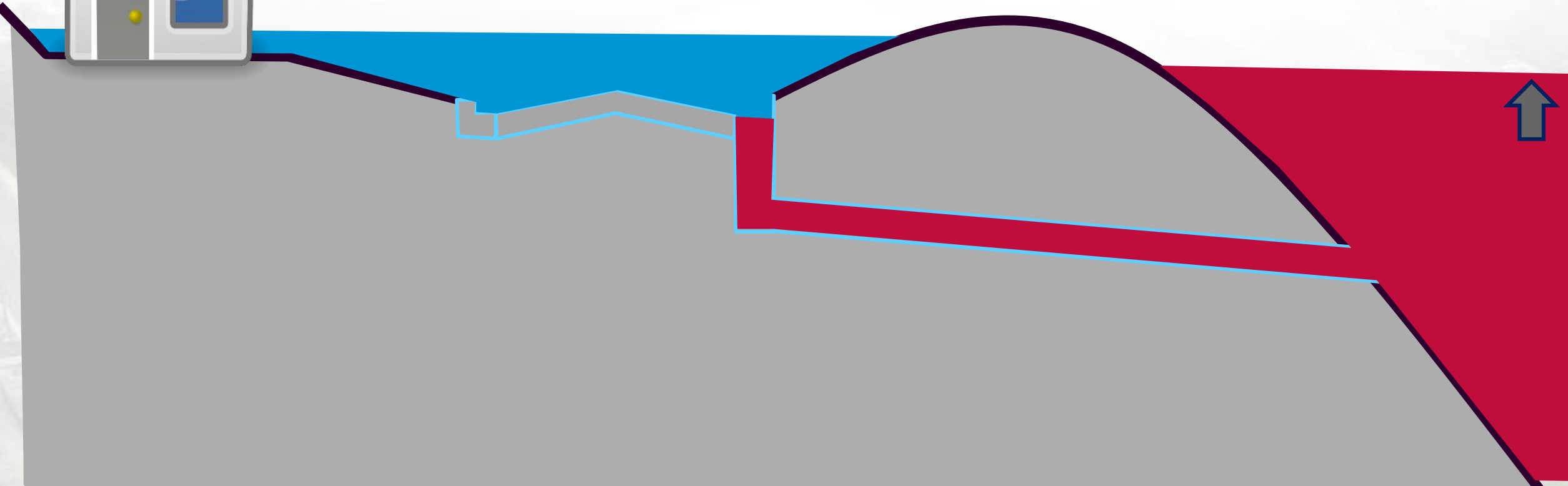
Future Infrastructure / Roadway Impacts





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Future Habitable Structure Impacts





Ground Surface



Sea Level

Groundwater Table

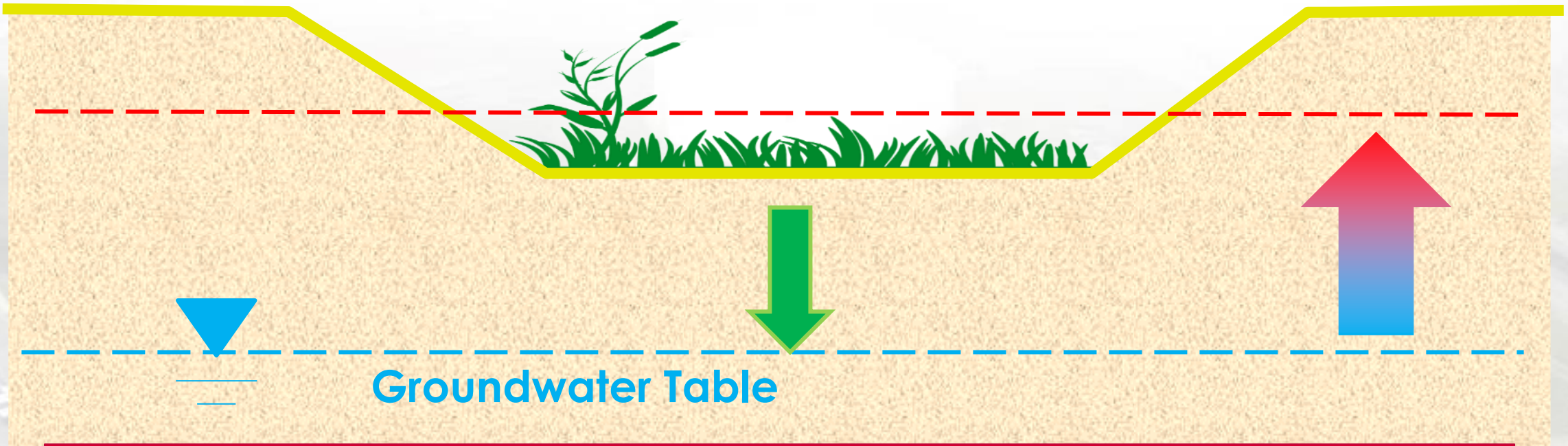
Average Groundwater Table Rise May Inhibit Performance of BMPs Relying on Infiltration



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Retention Pond / Bioretention / Rain Garden / Swale

Ground Surface



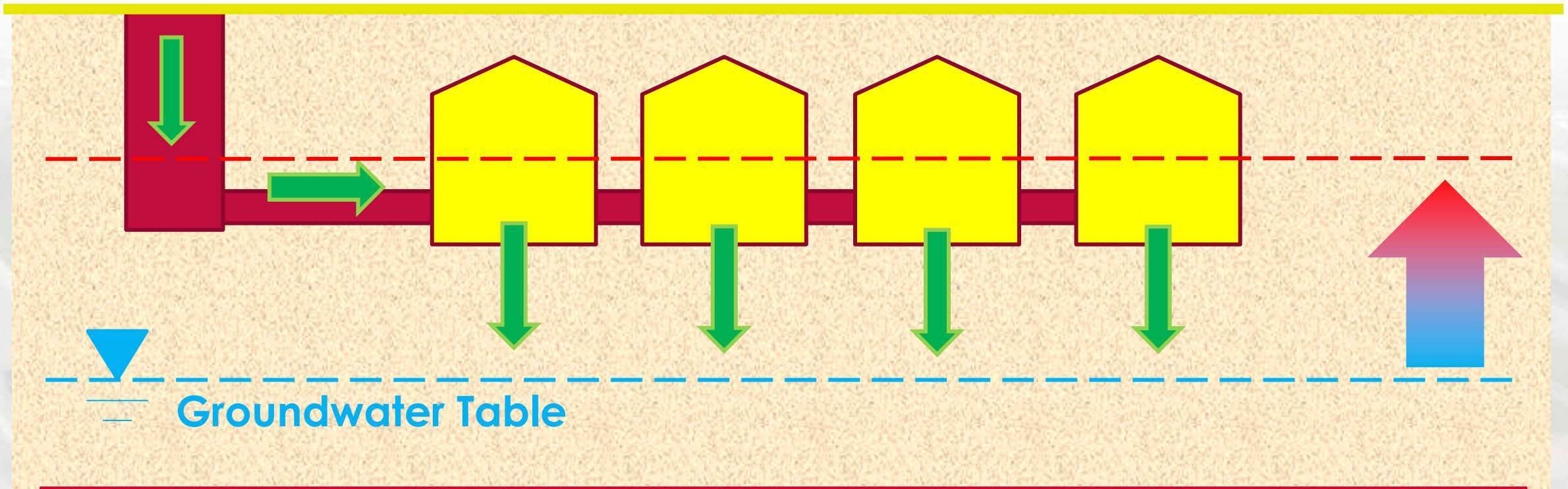
Groundwater Table

Average Groundwater Table Rise May Inhibit Performance of BMPs Relying on Infiltration



Exfiltration System / French Drains

Ground Surface

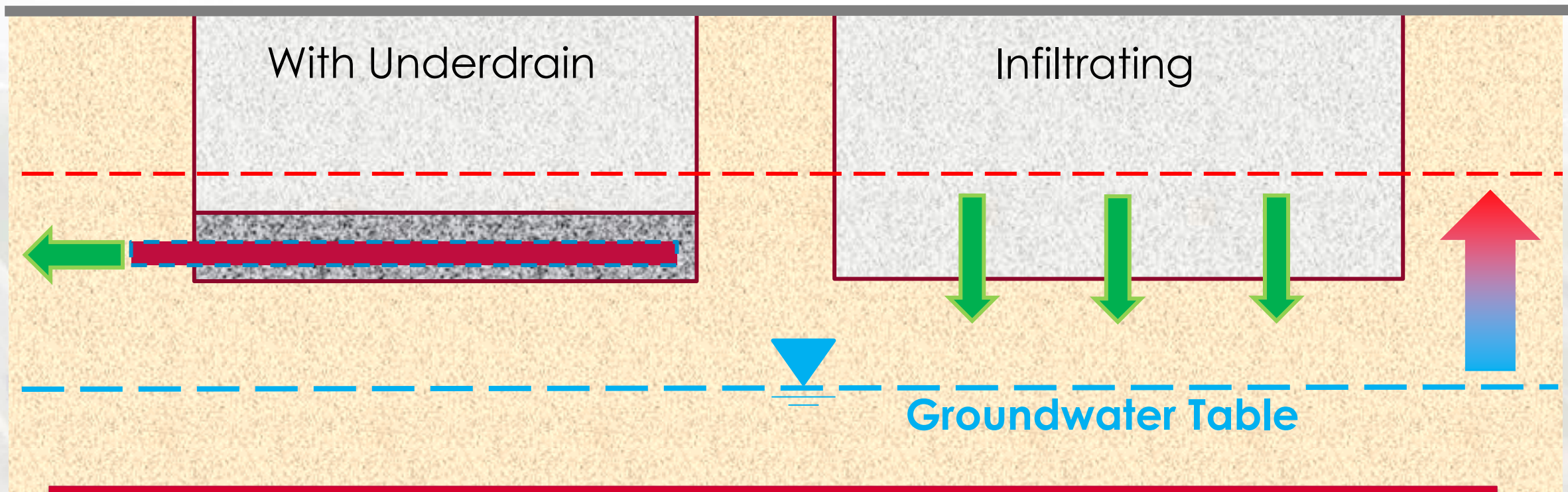


Average Groundwater Table Rise May Inhibit Performance of BMPs Relying on Infiltration



Pervious Pavement Systems

Pavement Surface



Average Groundwater Table Rise May Inhibit Performance of BMPs Relying on Infiltration



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❖ Future GSI/LID BMP Strategies

- Design for Future Conditions
- Adapt Design Criteria to Changing Hydrologic Conditions
- Evaluate Current BMP Performance Conditions
- Retrofit Existing BMPs
- Consider Active Control
- Adaptive Management





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- ❖ Local governments need to plan effectively for future sustainability through resilient strategies and adaptation
- ❖ Understand the multi-faceted risk fronts
- ❖ Engage in multi-disciplinary and sustainable solution approaches
- ❖ Expand technical toolbox for assessing impacts through integrated modeling
- ❖ Learn and Adapt



Source: https://www.flickr.com/photos/go_greener_oz/3046225225/in/photostream/



Source: <https://thebulletin.org/2018/05/how-much-and-how-fast-will-global-sea-level-rise/>



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Local Planning Efforts

- Stormwater Master Plan Update (2013)¹
- ✓ Planning for Sea Level Rise in the Matanzas Basin (2015)²
- ✓ Community Resilience Initiative – Pilot Project (2016 – 2017)
 - ❑ Coastal Vulnerability Assessment³
 - ❑ Strategic Adaptation Plan⁴

STORMWATER UTILITY FEE UPDATE

NEW STORMWATER RATES ON 2014 UTILITY BILLS
Stormwater rates will be changing. Some rates will be lower, some higher, depending on the size of your home or developed property.
Residential customers will pay a flat rate, while non residential properties are computed based on developed, impervious area.

Small home (Impervious area less than 1,444 sq ft)	\$ 1.64/month
Average home (Impervious area between 1,444 and 4,400 sq ft)	\$ 7.00/month
Large home (Impervious area greater than 4,400 sq ft)	\$11.20/month
Multi-family unit (condos, apartments, duplex, and other)	\$ 2.66/month
Mobile home	\$ 5.95/month
Non-residential customers	\$ 7.00/sq ft/yr/acre

Why does the city need a stormwater fee? The fee goes to cover the cost of maintaining and improving the City's stormwater collection and treatment system.

What is an impervious area? An impervious area is any surface that does not allow soil infiltration of rainwater to occur, and includes roofs, driveways, patios, sidewalks, and other paved areas.

Where can I get more information? [Fluxholders for City Stormwater and FAQ webpage.](#)

I think my fee is incorrect: what should I do? Remember that you need to consider driveways, patios, paved parking areas, and other impervious areas to estimate your fee. If you still feel that your fee needs an adjustment, please contact City Public Works at 904.225.1060, or visit our website at <http://www.ci.st.augustine.fl.us>

For more information on stormwater and other water resource services, please visit www.ci.st.augustine.fl.us or contact us at 904.225.1060.

January 2014

PLANNING FOR SEA LEVEL RISE IN THE MATANZAS BASIN
Opportunities for Adaptation 2015

Stormwater Master Plan Update Phase I

City of St. Augustine, Florida

February 2013

CDM Smith



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Local Planning Efforts

Coastal Vulnerability Assessment

- Evaluated total area flooded, roads, bridges, buildings, 2,550 historic and archeological resources, water and wastewater plants, groundwater supply
- **3 Scenarios:**
 - Mean Higher High Water – daily inundation about 2' NAVD88
 - Nuisance Flooding – 12-17 times per year, 3.75' NAVD88
 - 1% annual chance flood event – 26% chance in 30 years, 6-10' NAVD88





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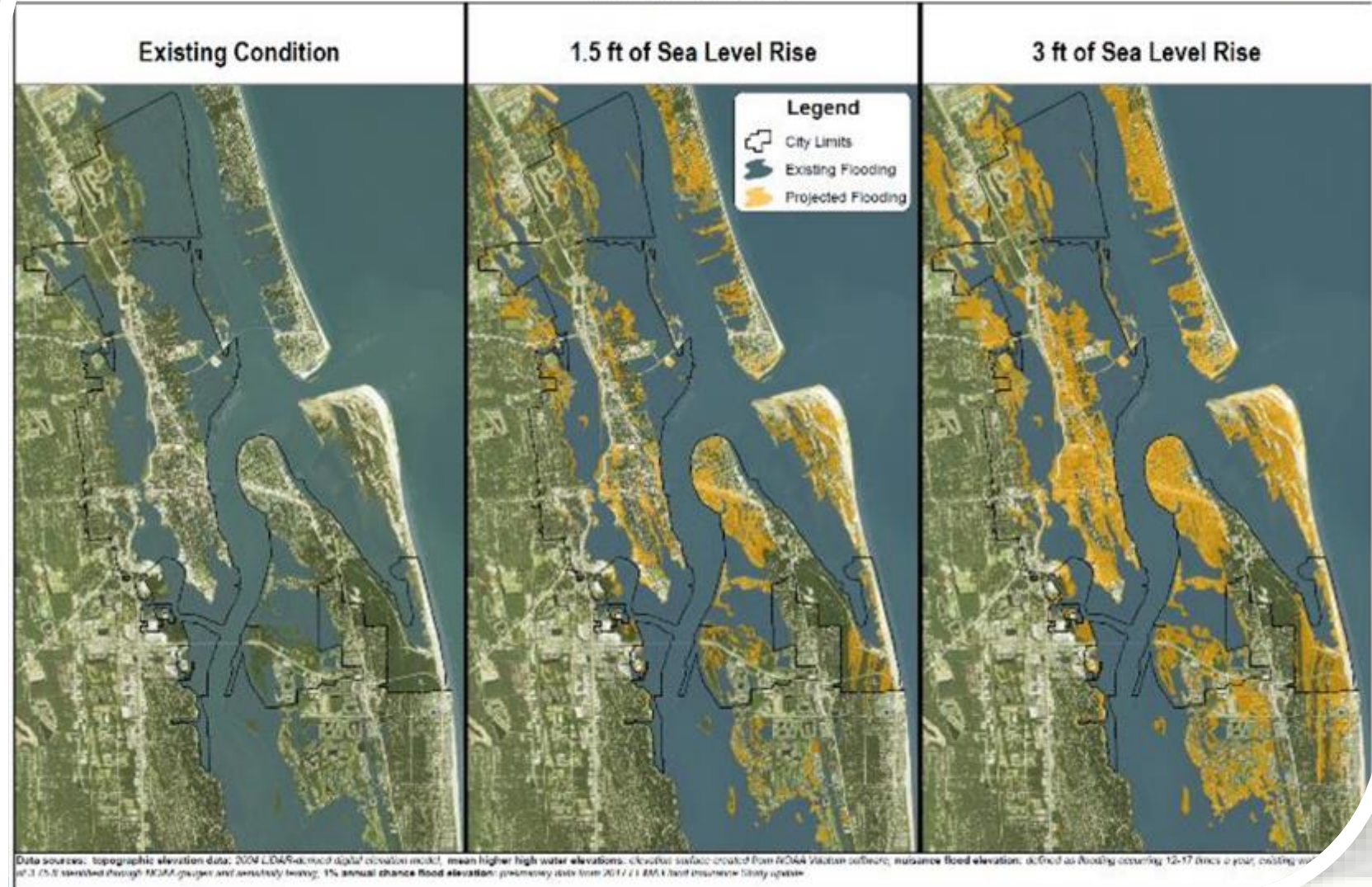
Local Planning Efforts

Strategic Adaptation Plan:

- ✓ Educate the public about SLR & policy responses
- ✓ Develop baseline budgets
- ✓ Adopt policies that limit spending in areas where retreat or re-design are more effective
- ✓ Base decisions on FEMA's updated FIRMs
- ✓ Install LID/Green infrastructure
- ✓ **Targeted upgrades to City's stormwater system**
- ✓ WWTP options
- ✓ FDOT roadway improvements for resiliency
- ✓ Historic Preservation Comprehensive Plan

Existing and Future Coastal Floodplains

Nuisance Flooding
St. Augustine, Florida



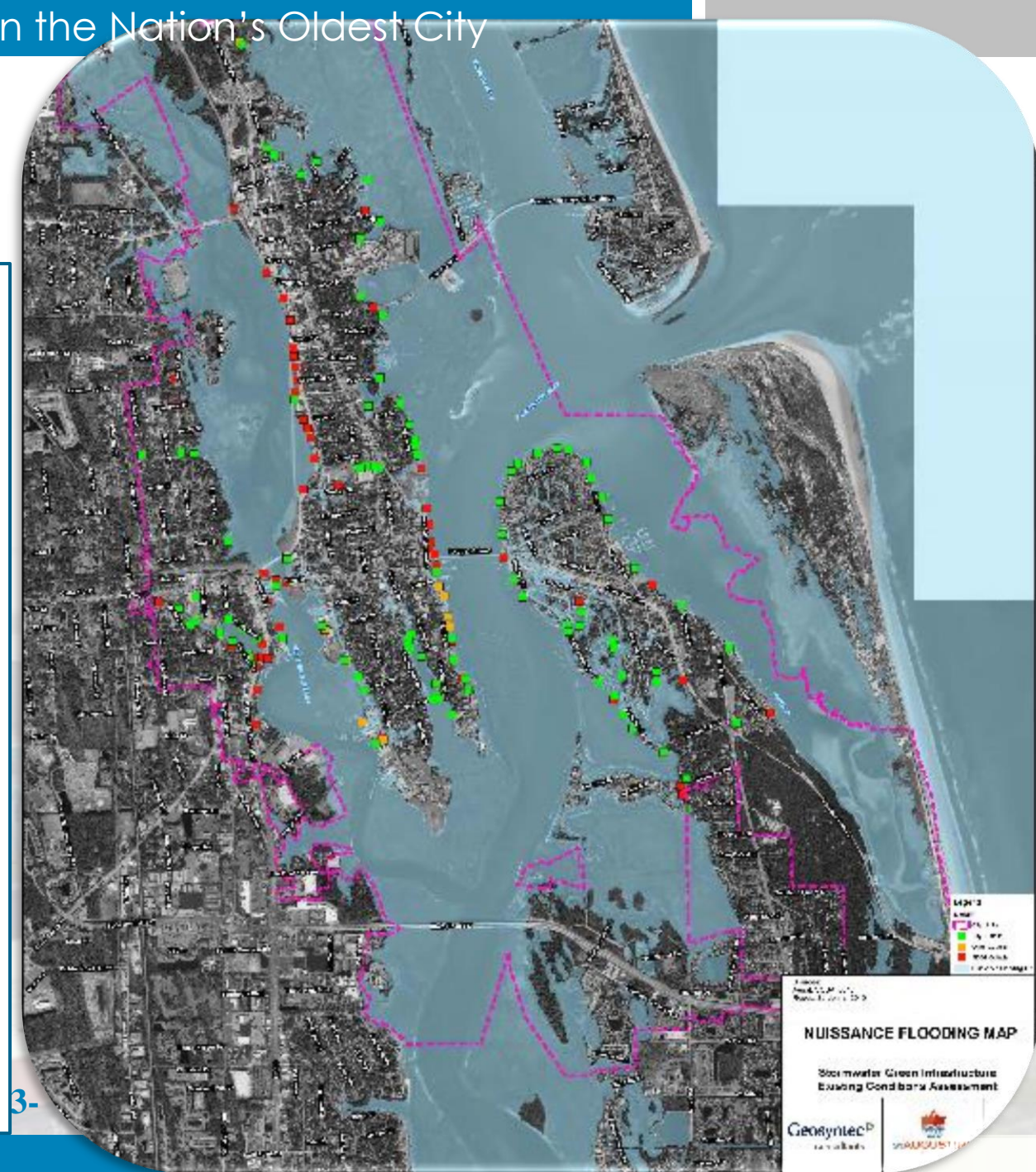


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Local Planning Efforts

Stormwater Resiliency Master Outfall Plan

1. Data collection
2. Coordination with FDOT
3. Comprehensive Outfall Atlas
4. *Field Confirmation of Outfall Data*
5. Future Resiliency & Adaptation Criteria Evaluation
6. Outfall Improvement Assessment & Prioritization
7. Master Plan

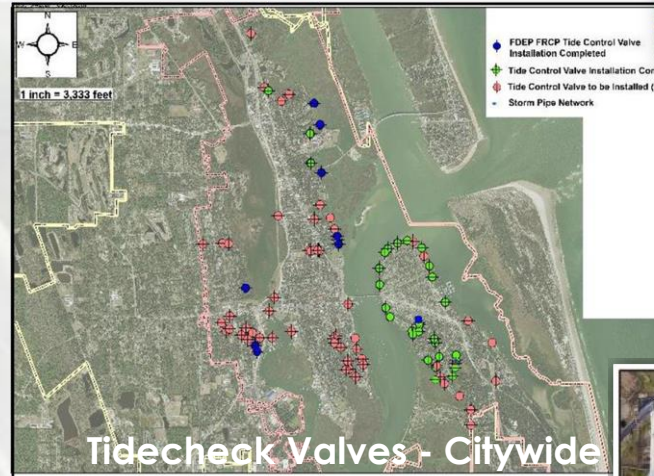
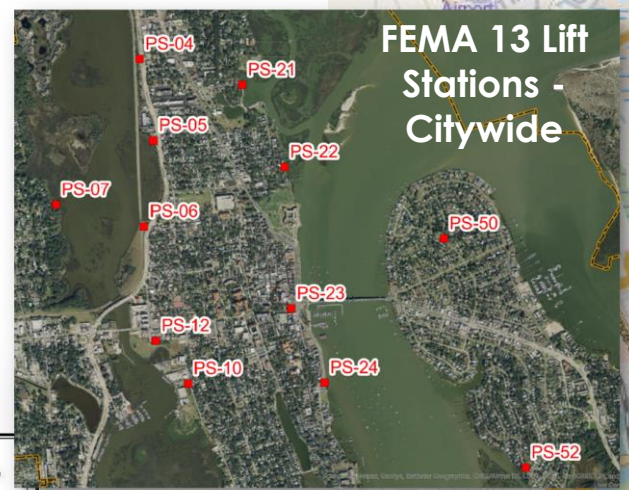


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Project Implementation

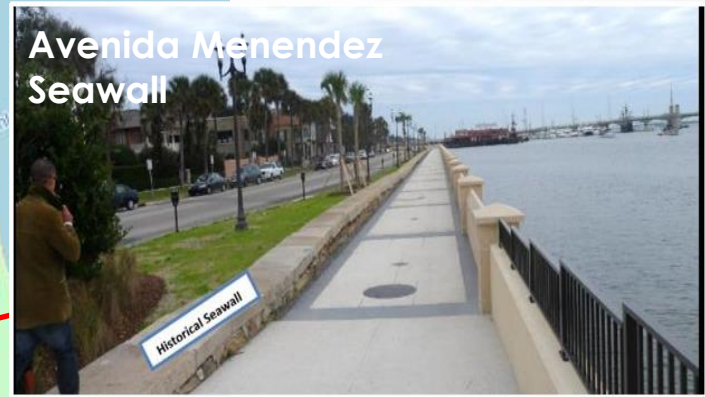
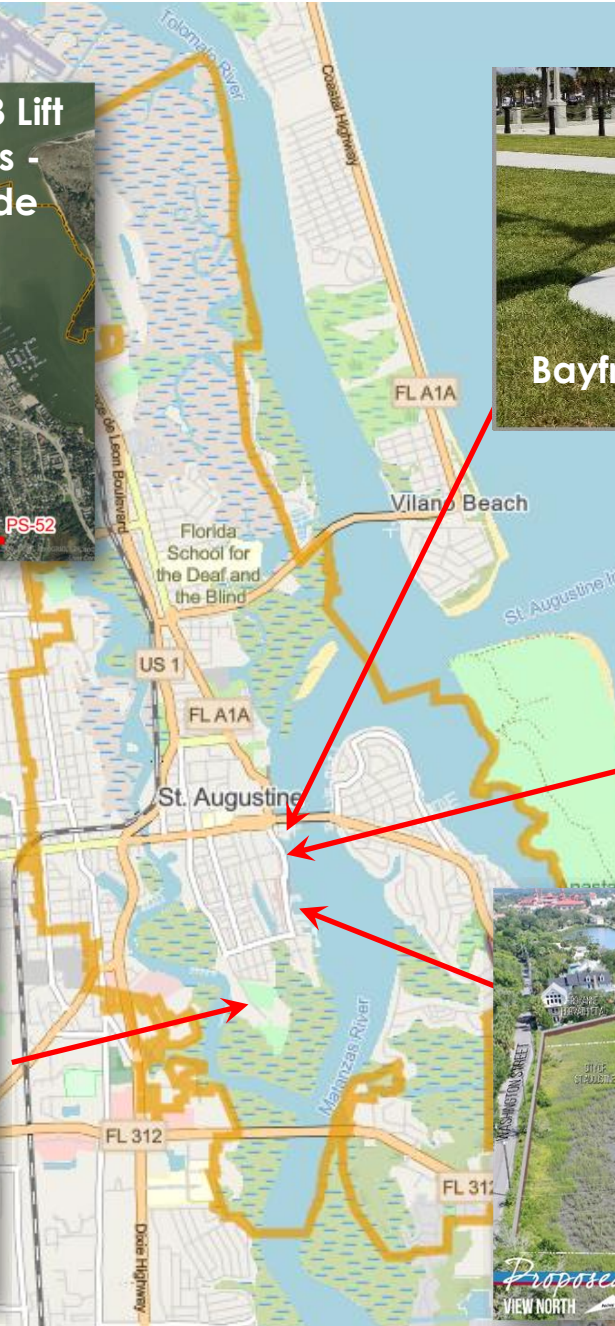


City of St. Augustine
PUBLIC WORKS DEPARTMENT
P.O. Box 210, St. Augustine, FL 32084 Phone: 352.432.1040

Stormwater Outfall Retrofit with Tide Control Valves
Existing City Stormwater Outfall Map



Figure 10: Perimeter Flood Wall and Pump Station



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St. Augustine
MRS. D. C. C. Kimley-Horn



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Tide Check Valves – Davis Shores

Completed (2017-2019)

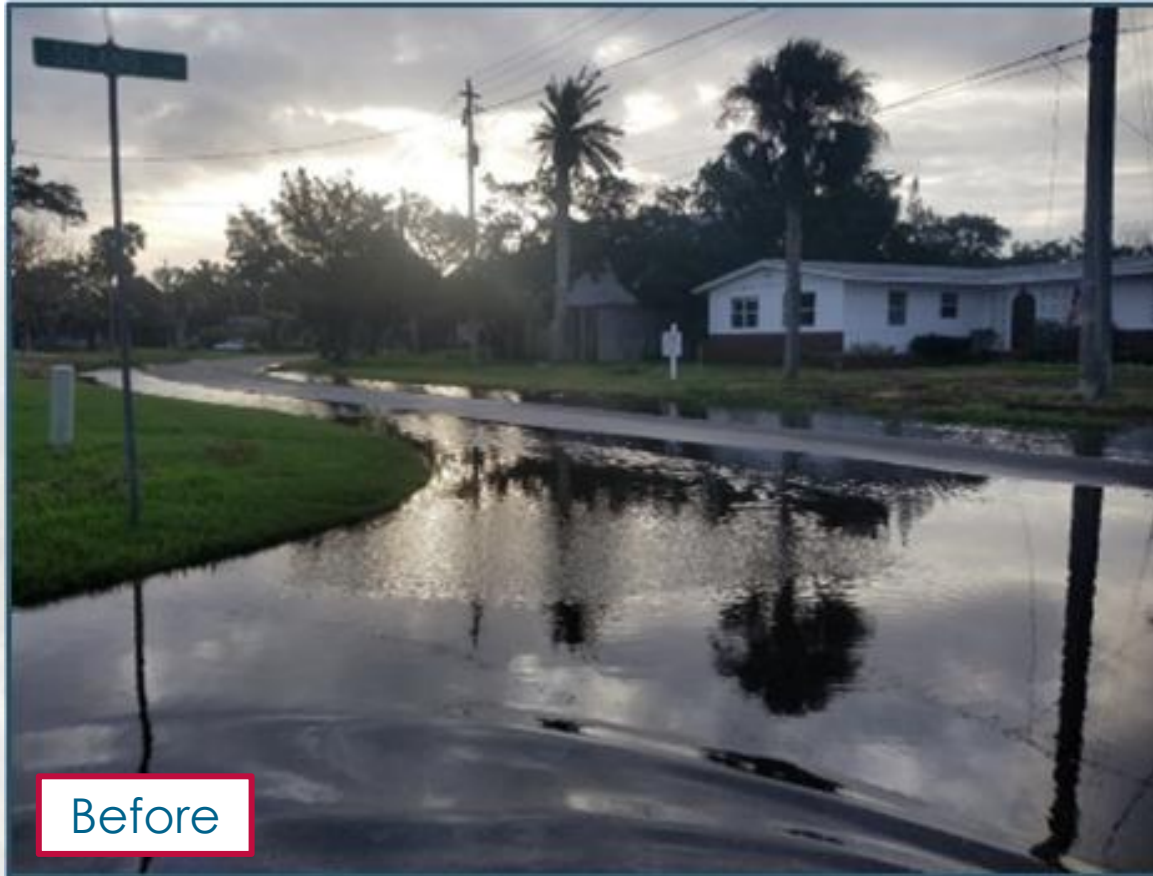
- 27 Outfalls
- Retrofitted with Tideflex Checkmate⁵ and WaPro WaStop⁶ Inline Check Valves
- Cost Share Funding through SJRWMD





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Tide Check Valves – Davis Shores



Before



After

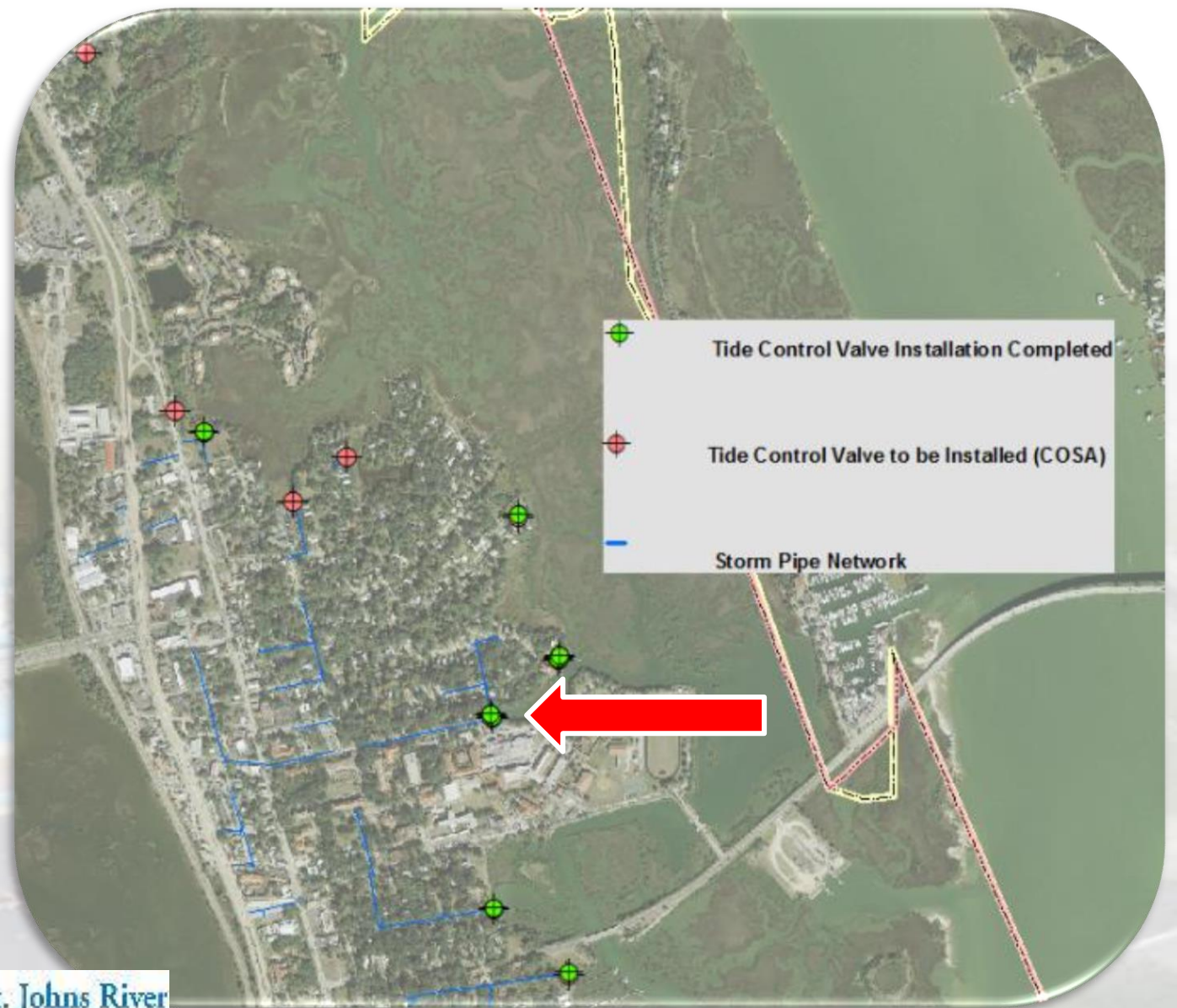
Davis Shores – 27 Outfalls Retrofitted with Tideflex Checkmate³ and WaPro WaStop⁴ Inline Check Valves



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Tide Check Valves – Macaris

- Completed (2019)**
- 2 Outfalls
 - Retrofitted with WaPro WaStop⁴ Inline Check Valves
 - Cost share funding through SJRWMD



Geosyntec
consultants





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Tide Check Valves – Macaris



Before - 66-inch Stormwater Outfall



Before – 30-inch Stormwater Outfall

Macaris – 2 Outfalls Retrofitted with WaPro WaStop⁴ Inline Check Valves



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Tide Check Valves – Macaris



❖ Macaris Outfall –

- Pre-cleaned and flushed the pipe
- Installed partial plug in pipe
- Desilted outfall area
- Valve installation



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Tide Check Valves – Macaris



After: 30-inch
Stormwater Outfall

After: 66-inch
Stormwater Outfall

**Macaris Outfall –
After Install**



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Tide Check Valves – Macaris

**Macaris
Outfall –
Nuisance
Flooding
Comparison**

Before



Before



After



After



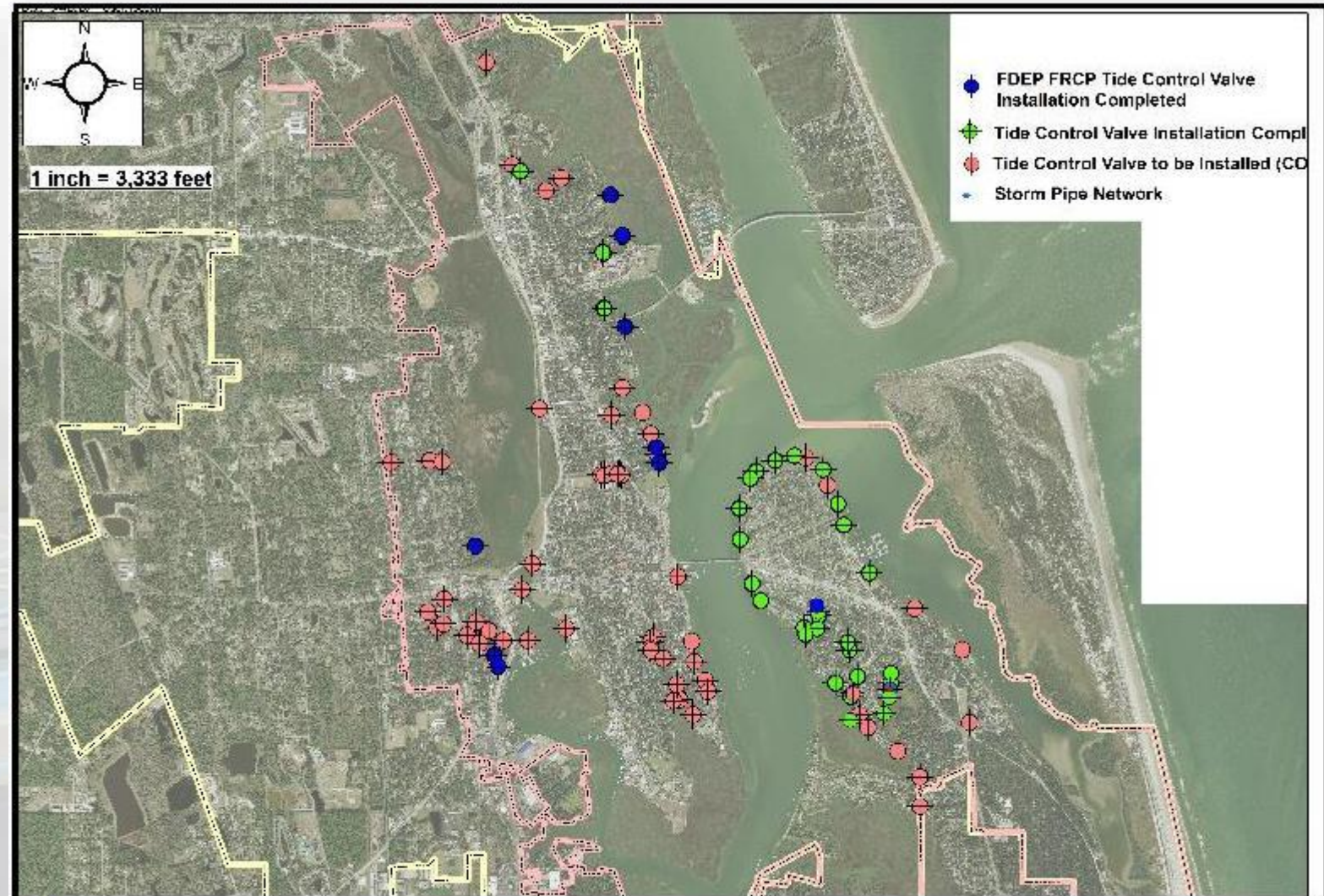


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Tide Check Valves – Other

FDEP Florida Resilient Coastlines Program (FRCP) Grant for 10 more outfalls (Completed 2020)

- ✓ City selected 10 additional outfalls for retrofitting with tide check valves
- ✓ Blue dots are the valves as part of the grant
- ✓ Green dots are completed retrofits
- ✓ Red dots are outfalls that remain for retrofitting



City of St. Augustine

PUBLIC WORKS DEPARTMENT

P.O. Box 210, St. Augustine, FL 32085 Phone: (904) 625 1040

Stormwater Outfall Retrofit with Tide Control Valves

Existing City Stormwater Outfall Map

SHEET

1 of 1

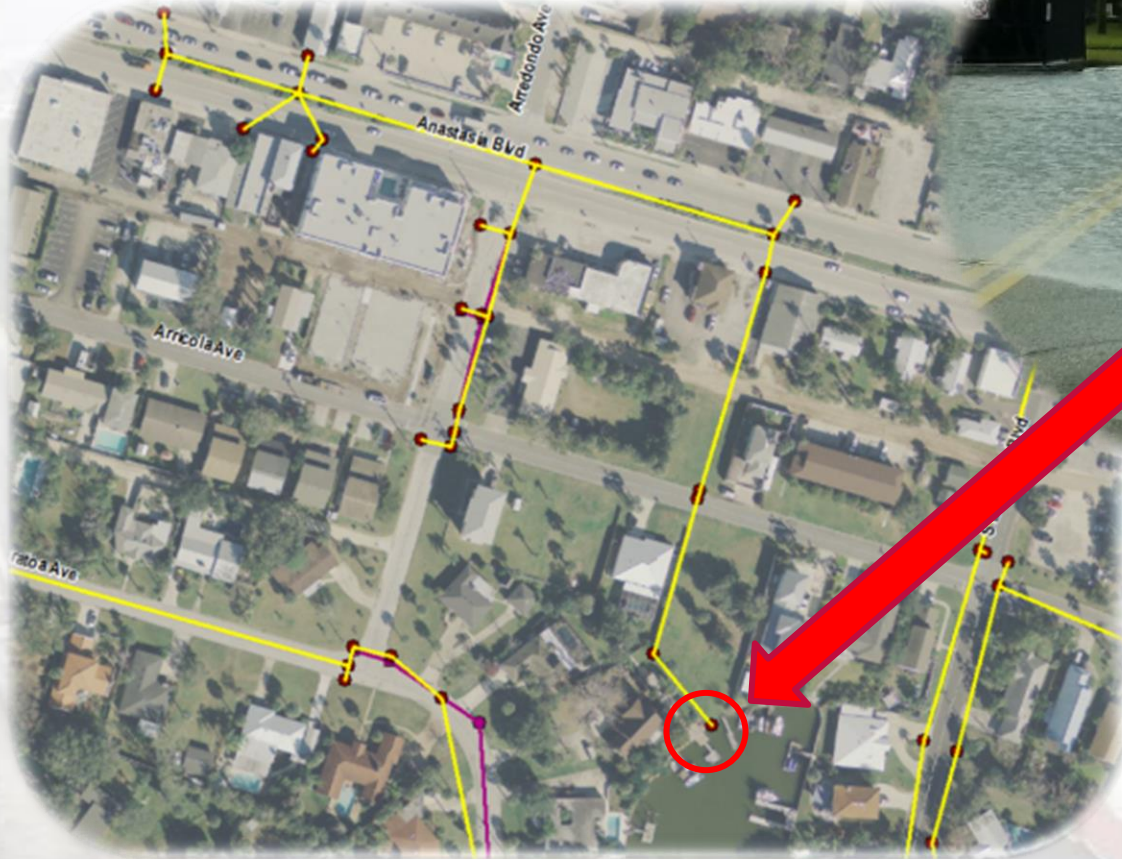


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Tide Check Valves – Other

FDEP FRCP

Nuisance Flooding
Before Valve
Installation





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Tide Check Valves – Other

FDEP
FRCP

Valve
Installation





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Tide Check Valves – Other



FDEP FRCP

Nuisance Flooding
Eliminated After Valve
Installation



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Avenida Menendez Seawall

Completed (2013)

- Suffered storm damages
- Required consensus building
- Encapsulated the original seawall
- Walking promenade
- Stormwater treatment
- Environmental mitigation
- Elevated to 7 feet NAVD
- FEMA/HMGP funding



FEMA TAYLOR ENGINEERING, INC.





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Avenida Menendez Seawall - Connectivity

Current Project

- Reinforce existing seawall to support new wall
- Replace failing section of seawall
- Elevate a section of seawall to tie into north and south elevations to “close the gap”
- Awarded HMGP funding – Phase 1 design (2021)



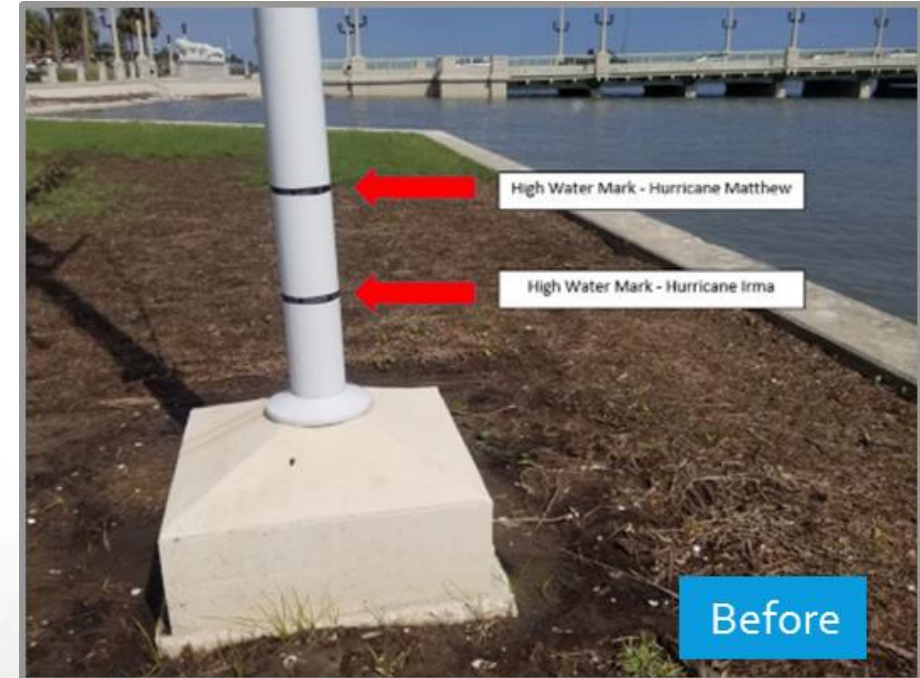


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Bayfront Park

Completed (2018)

- Elevated behind the existing seawall to 7 feet NAVD
- Installed drainage system
- Pedestrian walkway to connect historical seawall to the Bridge of Lions
- Florida Inland Navigation District (FIND) funded



MATTHEWS
DESIGN GROUP



Wastewater Treatment Plant Resiliency Retrofit



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Completed (2020)

- Initially identified in the coastal vulnerability assessment as critical infrastructure at risk now
- Evaluated existing infrastructure to assess vulnerability of flooding from storm surge and projected Sea Level Rise



Perimeter Wall and Pump Station Estimated Costs at Multiple Heights for Year 2030 (2018 dollars)

Type of Wall	Top Elevation (feet NAVD)	Average Height of Wall (feet)	Protection Cost	Category of Hurricane Protection Level (2030)	Preventable Damage Cost	Benefit/Cost Ratio
Sheet Pile	18	11	\$ 3,700,000	3	\$16,000,000	4.3
	20	13	\$ 4,200,000	4	\$21,000,000	5.0
	25	18	\$ 5,300,000	5	\$21,000,000	4.0



Figure 10: Perimeter Flood Wall and Pump Station



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Wastewater Treatment Plant Resiliency Retrofit

- Alternative lower cost solution
- Protection to 12 feet (plant is at \approx 7 feet NAVD 88)
- Most critical infrastructure protected
- Total cost \approx \$148,000





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Current Project

- ❖ Funded through FEMA's Public Assistance (PA) Program
- ❖ Guaranteed maximum price for entire project \$13.8 M
- ❖ Notice to Proceed issued January 4, 2021
- ❖ Construction duration ≈ 2 years
- ❖ List of 13 Lift Stations to be Rehabilitated or Replaced:
 - ❖ LS-4, 5, 6, 7, 10, 11, 12, 21, 22, 23, 24, 50, and 52
- ❖ Arricola Ave. Force Main
- ❖ www.citystaug.com/FEMA13

FEMA 13 Lift Stations

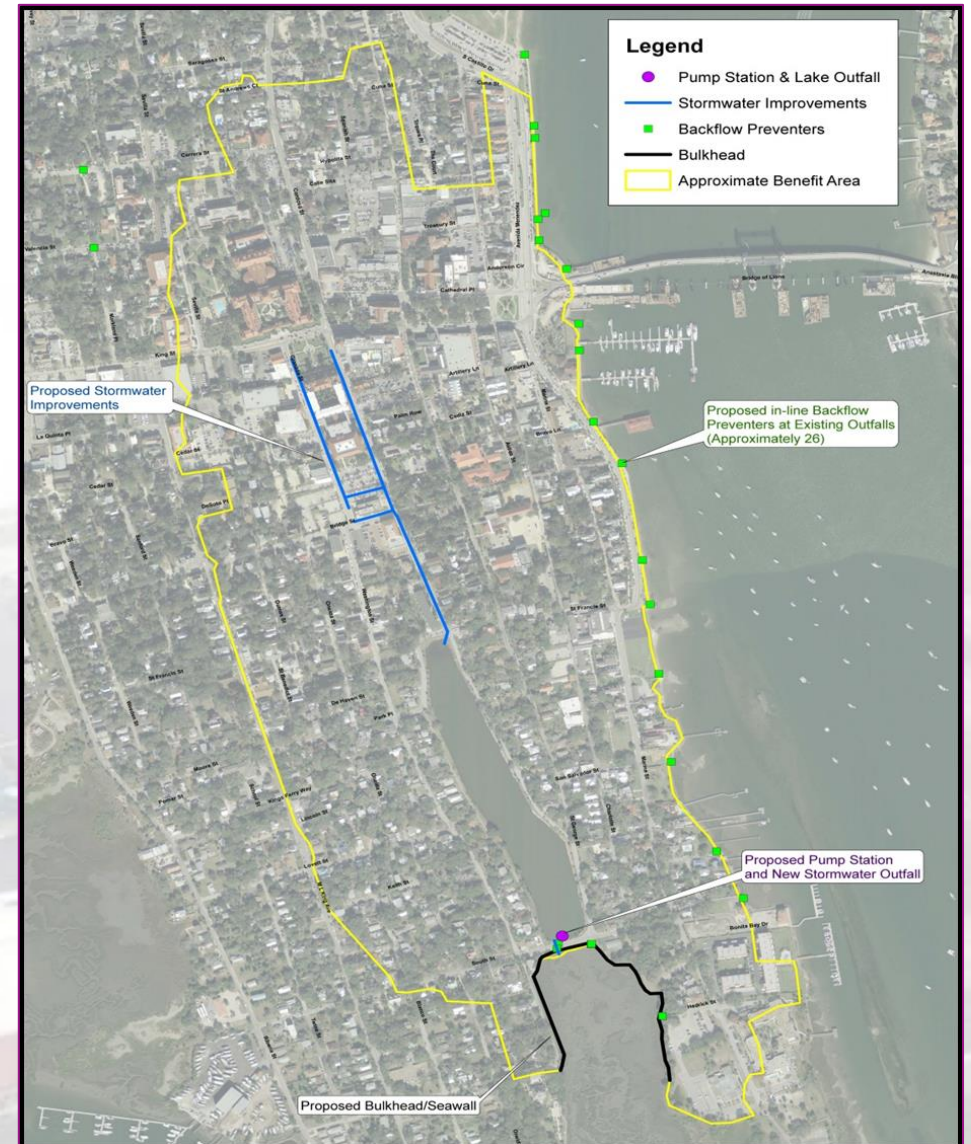




Lake Maria Sanchez Flood Mitigation Project

Current Project

- ❖ Hurricane Matthew – Federal Funding Available through the Hazard Mitigation Grant Program (HMGP) –
 - ✓ Proposed stormwater pump station
 - ✓ Proposed flood wall (or seawall)
 - ✓ Proposed major stormwater infrastructure upgrades
 - ✓ Replace utilities in conflict with the proposed stormwater system
 - ✓ Proposed tide check valves in stormwater outfalls





Lake Maria Sanchez Flood Mitigation Project

❖ Flood Protection (Structures)

- ✓ Estimated 200 Acre Benefit Area
- ✓ 25-Year Storm Event + 2050 Sea Level Rise (6.4 Feet Storm Surge)
- ✓ Protect 186 Structures (Currently at Risk)

❖ Flood Protection (Roadways)

- ✓ 10-Year, 24-Hour Rainfall Event Level of Service (7.6 inches)
- ✓ Protected from Coastal Flooding
- ✓ Reduces both Depth and Duration of flooding





Lake Maria Sanchez Flood Mitigation Project

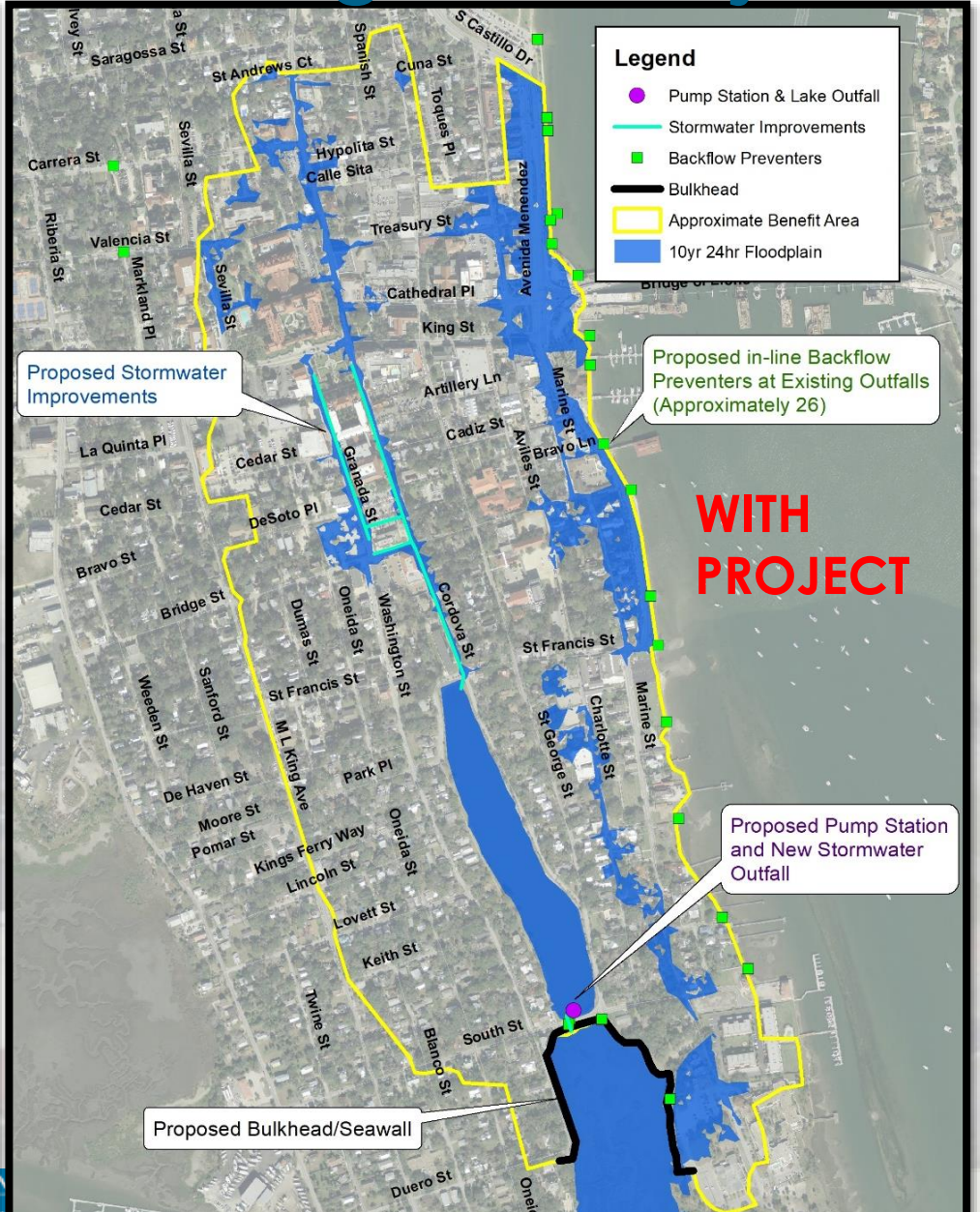


*25-year + 2050 SLR Coastal Storm Surge Event (Not Rainfall)

Lake Maria Sanchez Flood Mitigation Project



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*10-year 24-hour
Rainfall event with
MHW + 2050 SLR
Tidal Condition



Lake Maria Sanchez Flood Mitigation Project





Lake Maria Sanchez Flood Mitigation Project



LAKE MARIA SANCHEZ
PUMP STATION BLDG

Proposed
FENCE + LANDSCAPE





Lake Maria Sanchez Flood Mitigation Project



RAYMOND O.
MARGARET M CONNOR

GARY L STEHLI

ROXANNE HORVATH
ET AL

Proposed
VIEW EAST

LAKE MARIA SANCHEZ
FLOOD WALL REINFORCEMENT

*PROPERTY LINES ARE APPROXIMATE AND
SHOWN FOR GRAPHICAL PURPOSES ONLY





Moving Forward

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❖ Current Flood Mitigation Investments ≈ \$36,133,000 (\$27,611,932 grant funded):

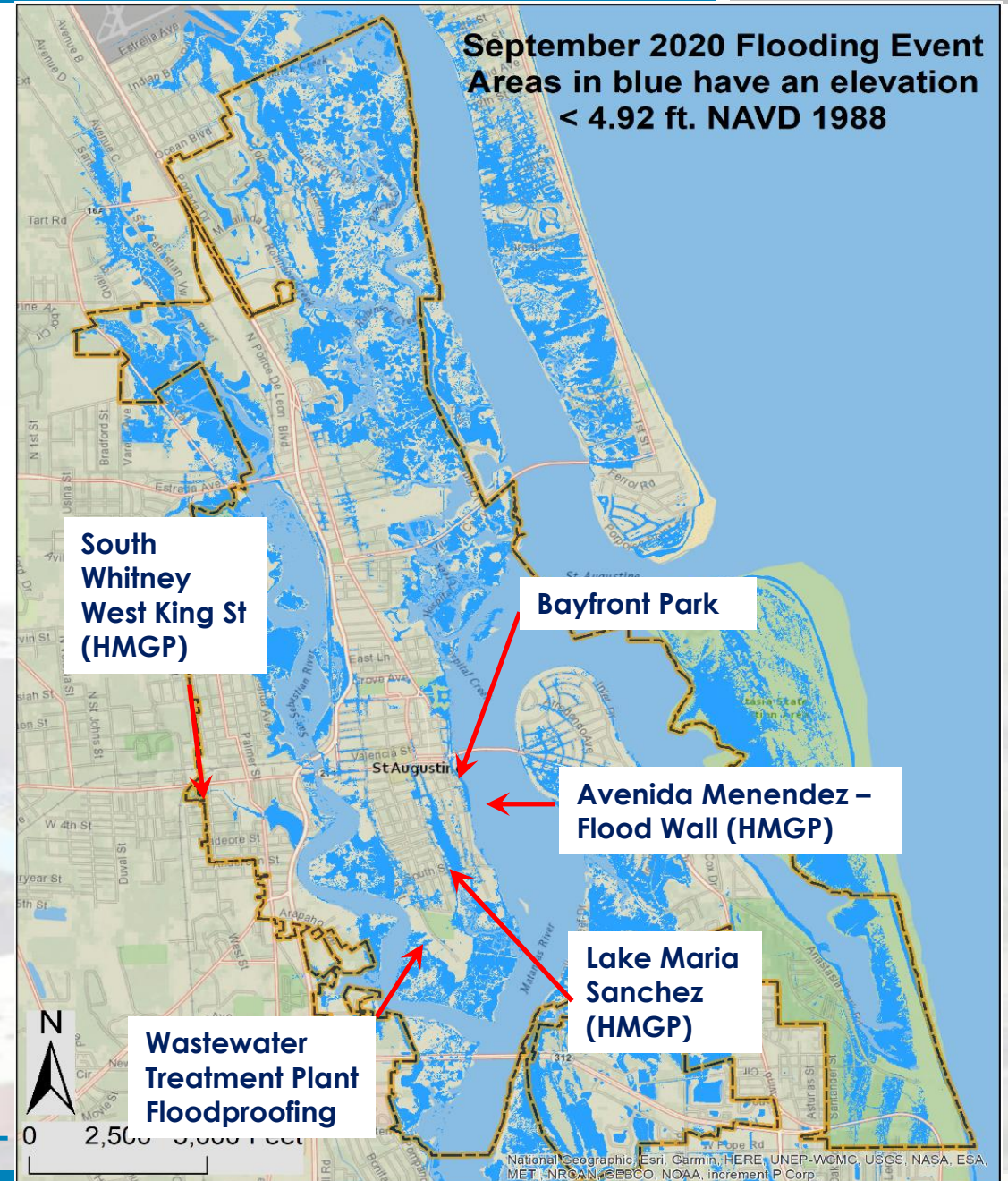
- ❑ Lake Maria Sanchez*
- ❑ Avenida Menendez Flood Wall*
- ❑ Installed tide check valves (43 Citywide)**
- ❑ Coquina Park
- ❑ South Whitney/West King (SWWK) Flood Mitigation*
- ❑ South Dixie Highway Culvert Replacement**
- ❑ Lincolnville Utility and Drainage Improvements*, **
- ❑ FEMA 13 Lift Station Hardening and Flood Proofing*

❖ Additional Flood Mitigation Projects planned &/or in progress:

- ❑ Stormwater Outfall Resiliency Master Plan
- ❑ South Davis Shores Resiliency Master Plan
- ❑ Septic Tank Vulnerability Assessment to Sea Level Rise
- ❑ Stormwater Master Plan Update Phase 2
- ❑ Other Resiliency projects

*Denotes Federally Funded Project (FEMA –PA, HMGP; HUD/DEO-CDBG-NR)

**Denotes State Funded Project (SJRWMD, FDEP)



References and Recognition

1. Stormwater Master Plan Update - Phase 1: City of St. Augustine. February 2013. CDM Smith.
2. Planning in the Matanzas Basin: Opportunities for Adaptation. Kathryn Frank, Ph.D.; Michael Volk, MLA; Dawn Jourdan, Ph.D., Esq.; August 2015.
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4. Florida Community Resiliency Initiative Pilot Project: Adaptation Plan for St. Augustine, FL. May 2017.
<https://www.citystaug.com/570/Coastal-Vulnerability>
5. Tideflex Technologies - Tideflex Checkmate Ultraflex Slip-in Inline Check Valves.
<http://www.redvalve.com/tideflex/tideflex-products/checkmate-inline-check-valve/>
6. Wapro - Wastop Inline Check Valve.
<http://www.wapro.com/en-us/content/wastop-inline-check-valve>
7. Photo credits: Alamy Stock Photo – Sean Pavone (bridge at sea), Rob Clement (Castillo de San Marcos), AP Photo – John Bazemore (flooding at bayfront/fort),
8. St Johns River Water Management District Cost Share Programs -
<https://www.sjrwm.com/localgovernments/funding/>
9. Florida Department of Environmental Protection Florida Resilient Grant Program
<https://floridadep.gov/rcp/florida-resilient-coastlines-program>



Presentation Questions & Answers

Contact Information

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