Incorporating Climate Resilience Into Public Infrastructure Planning From Florida To Boston (Translating Actionable Climate Science into Resilient Infrastructure)

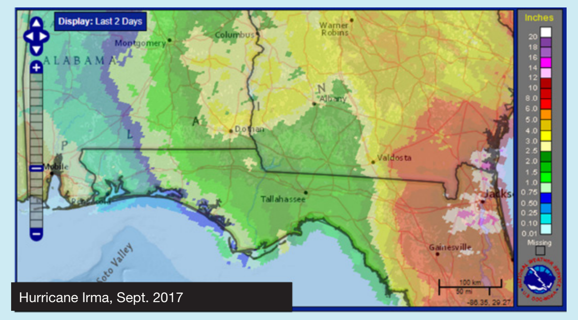
Laurens van der Tak, PE, D.WRE, Jacobs
Sea Level Hotspots from Florida to Maine, Drivers, Impacts, and Adaptation Workshop Sponsored by NOAA, US CLIVAR, and NASA

JACOBS

Context

A variety of climate resilience planning and design case studies are summarized to illustrate how climate science is being translated to protect public infrastructure and coastal shorelines from Miami to Boston using data and tools from both public and private sources. Lessons learned address how to integrate general circulation model and emissions scenario results with client-driven planning horizons, risk tolerance and projected impacts, to plan resilient water sector investments.

Actionable climate science needs to be readily available for key climate variables such rainfall intensity-duration-frequency, sea level rise and storm surge in a form that can be readily used by engineers and planners to make informed decisions on coastal infrastructure investments with useful life of between 20 and 100 years, recognizing uncertainty.



JEA in Jacksonville FL is facing new reality – most extreme flooding in 2016-2017 since 1853 – increasing focus on resiliency

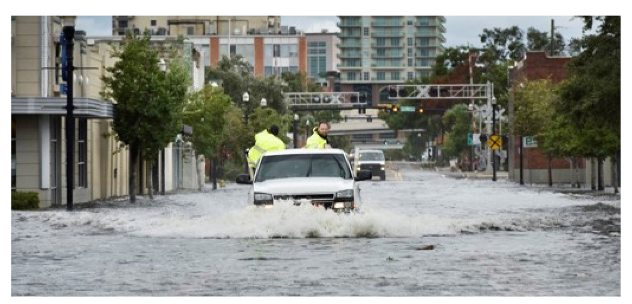
Many coastal communities are engaged in climate resilience planning, largely since Hurricane Sandy in 2011

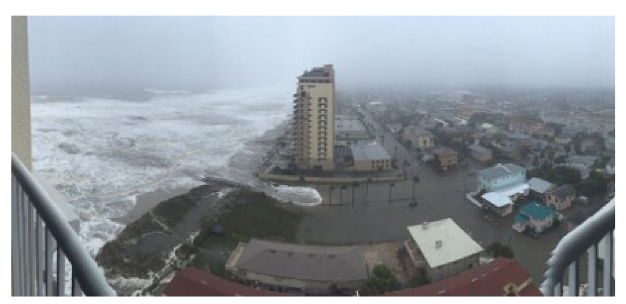
- Boston (BWSC), Stormwater/Wastewater Asset Management and Climate Plan, MA
- New York (NYCDEP): Wastewater Resiliency Plan and East Side Coastal Resiliency "Rebuild by Design", NY
- NJ Shoreline Protection (USFWS)
- NJ Transit
- Maryland (WSSC): Climate Change Vulnerability Assessment, Adaptation and Mitigation Plan, MD
- WMATA (DC) Metro Station Flood Analysis
- Alexandria: Stormwater Master Plan and Climate Analysis, VA
- EPA Community Resilience Pilot Project, Wilmington NC
- St. Petersburg, Wet Weather Overflow Mitigation Program, FL
- Jacksonville (JEA), Climate Resiliency Program
- Miami-Dade (WASD), Ocean Outfall Legislation Program, FL
- Miami Beach, SLR Integrated Water Mgt Plan

Typical drivers for climate resilience work in US East reflect climate hazards specific to each jurisdiction

Temporary – acute shock
- Riverine flooding (extreme rainfall events)
- Coastal flooding (extreme tides, surge events)
- Coastal erosion
- Extreme temperatures
- Drought

Permanent – chronic stress
- Coastal flooding (SLR)





Common tasks in these projects assume climate projections are available for key climate variables, to quantify risk

- Goals/Objectives
- Establish Future
- Extreme Weather Scenarios
- Tools

- Asset Inventory/ Criticality Assessment
- Flood Modeling
- Vulnerability
- Operations and Safety

- Cost/Benefit Analysis
- Strategy Prioritization
- Design and Construction Standards
- Integrate with planning/design cycles

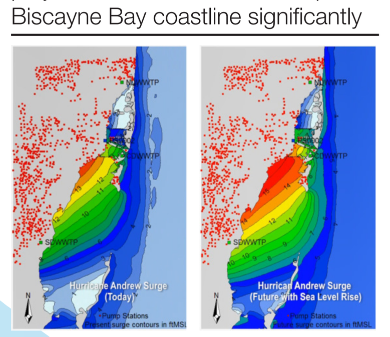
- JEA Resiliency Plan
- CIP for Resilience

- Project Definition
- Design/Construction
- Funding

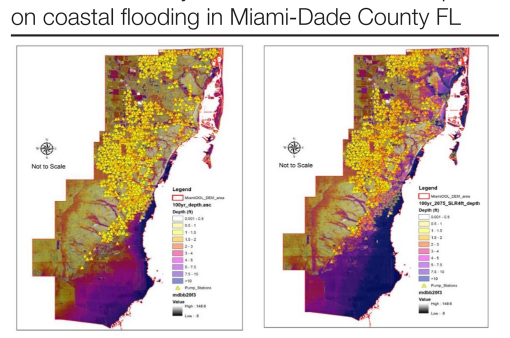
- Status Reporting
- Periodically Compare New Climate Projections to Triggers
- Update Resilience Plan, as Needed

Miami-Dade FL's $6 Billion Wastewater Infrastructure Program

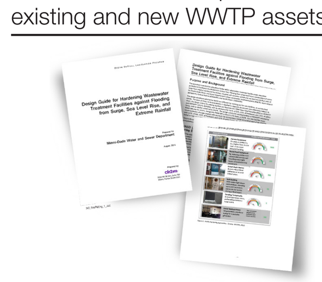
Hurricane Andrew storm surge with projected 4 ft of SLR would impact Biscayne Bay coastline significantly



Storm surge with 4 ft projected SLR and extreme rainfall by 2075 will have severe impacts on coastal flooding in Miami-Dade County FL



Risk assessment and benefit-cost analysis led to preparation of wastewater facility flood hardening design guidelines for Miami-Dade Water and Sewer Department's existing and new WWTP assets



Main References

CH2M HILL (CH2M, a wholly owned subsidiary of Jacobs Engineering Group Inc.). Climate Projections and Scenarios for Washington Suburban Sanitary Commission Climate Vulnerability Assessment. Technical memorandum prepared for WSSC. October 2015 (draft), April 2018 (final).
CH2M HILL (CH2M, a wholly owned subsidiary of Jacobs Engineering Group Inc.). Adaptation Strategies for Pilot Facilities at Risk from Coastal Flooding. Technical memorandum prepared for WSSC. June 2017.
CLIMsystems. https://www.climsystems.com/simclim
Jacobs Engineering Group Inc. Activity 3: Sea Level Rise and Precipitation Projections, and Recommended Climate Scenarios. Technical memorandum prepared for JEA. December 2018.
Jacobs Engineering Group Inc. Activity 3: Surge and Inland Flood Modeling. Technical memorandum prepared for JEA. March 2019.
NOAA. Global and Regional Sea Level Rise Scenarios for the United States. NOAA Technical Report NOS CO-OPS 083. January 2017.
US Army Corps of Engineers. Sea-Level Change Curve Calculator (Version 2017.55)

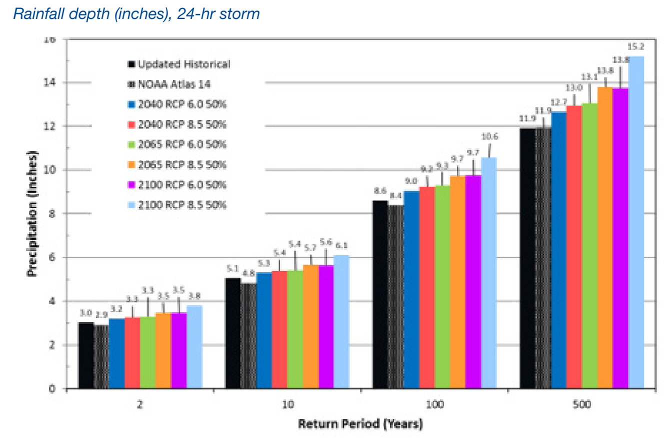
Acknowledgments

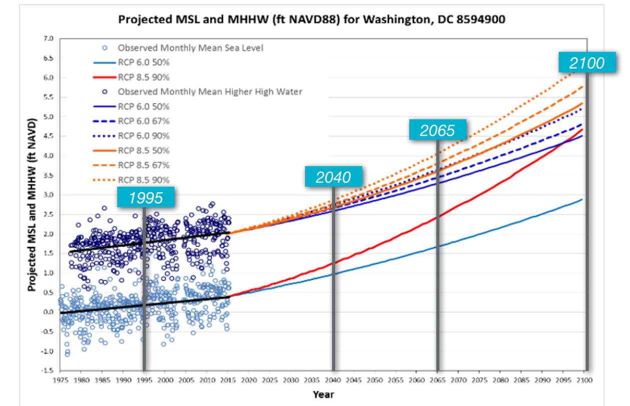
Jason Bird, Patrick Gervais, Adam Hosking, Mark Jaworski, Say-Chong Lee, Bill McMillin, Phil Pasteris, Swamy Pati, Paula Sanjines, Miranda Santucci, Peter Urich (CLIMsystems)

Climate Change Vulnerability Assessment, Adaptation and Mitigation Plan

Climate Projections are derived from tools like SimCLIM for rainfall, and USACE Sea Level CalculatorRainfall and Sea Level Rise for Washington Suburban Sanitary Commission, Maryland

Rainfall depth (inches), 24-hr storm





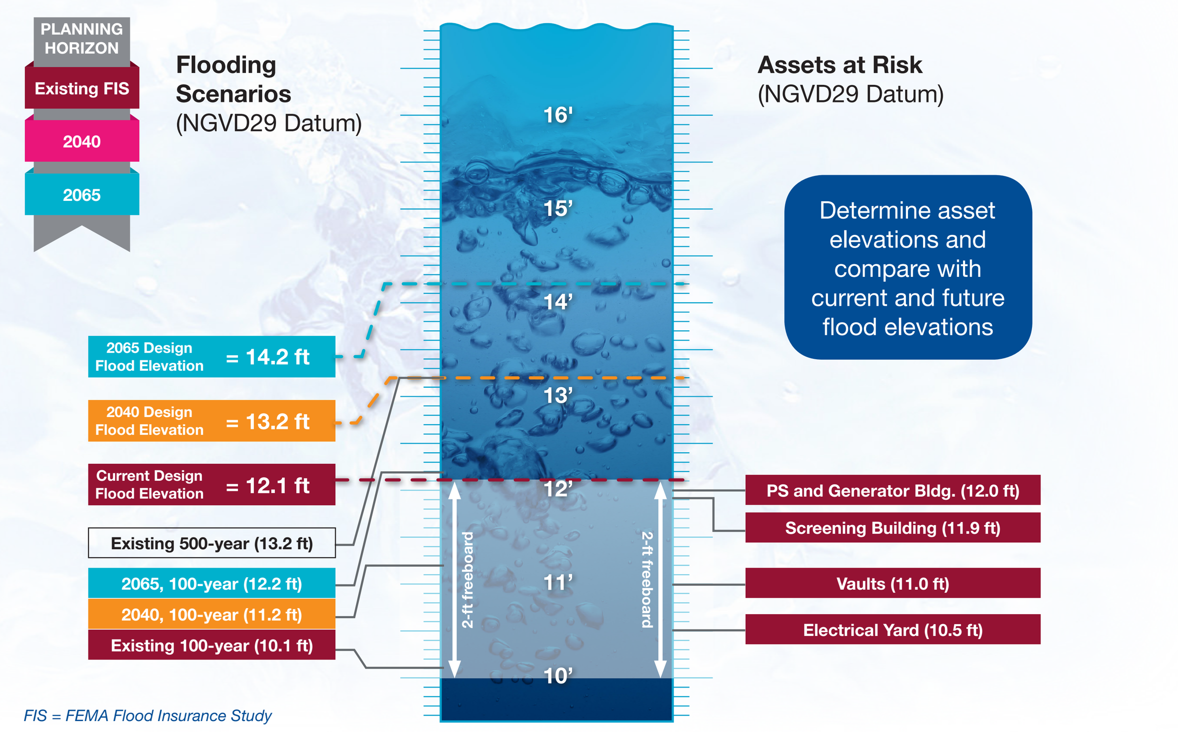
Range of climate scenarios used to bracket levels of risk. Factors in scenario planning include: levels of service (storm % chance today), planning horizon tied to service life of infrastructure, and emission scenarios and ensemble statistics

Precipitation Projection Climate Scenarios used for Riverine Modeling

Scenario Description	1	2	3	4	5	6	7	8	9	10	11	12
a) Emissions Scenario												
RCP6.0 50% non-exceedance	•	•	•	•	•	•						
RCP8.5 50% non-exceedance							•	•	•	•	•	•
b) Planning Horizon												
2040	•			•			•			•		
2065		•			•			•			•	
2100			•			•			•			•
c) Storm Return Period (year)												
100	•	•	•				•	•	•			
500				•	•	•				•	•	•

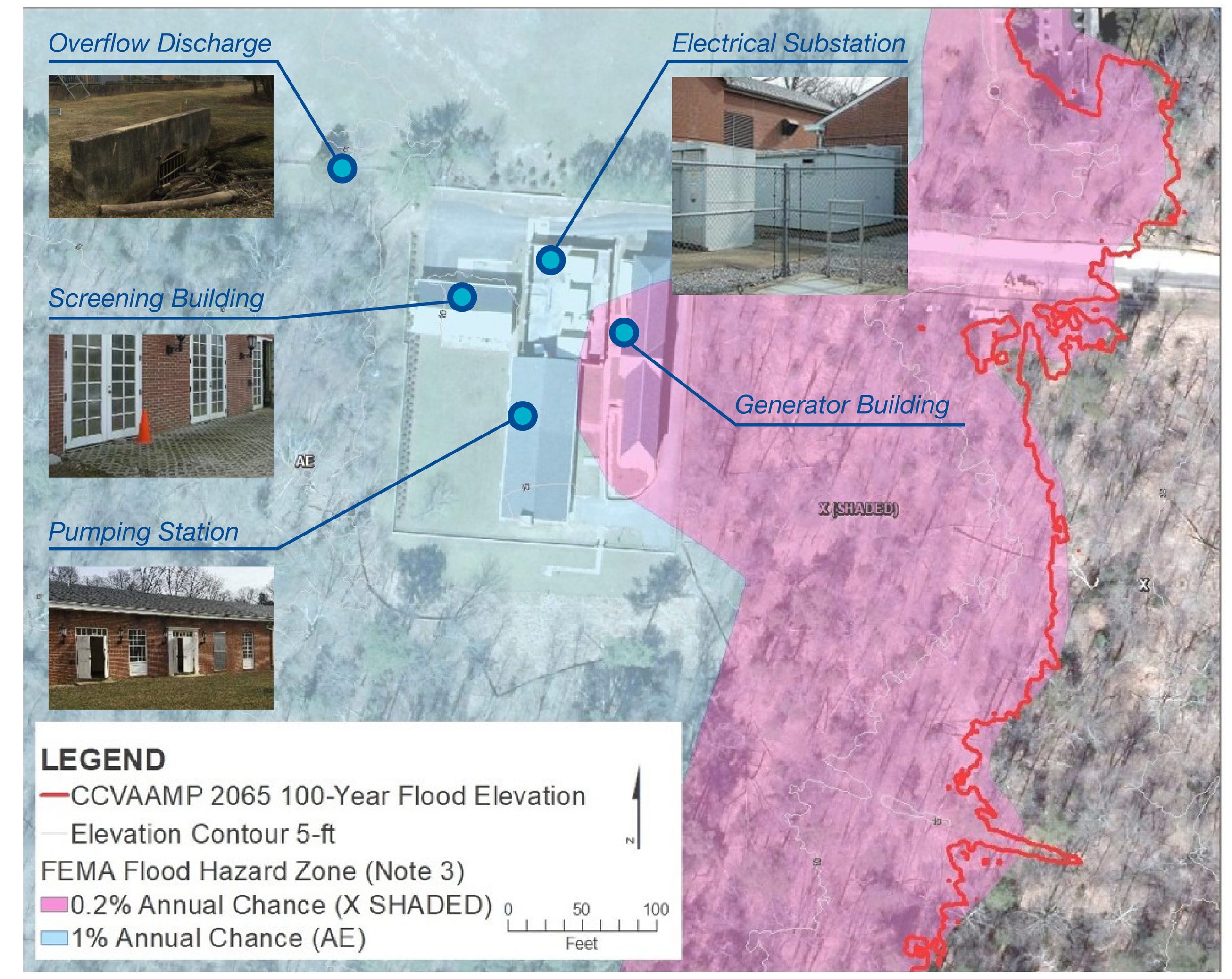
Risk Assessment / Alternatives Development Process

1. Identify all assets at risk below recommended design flood elevation (DFE).
2. Determine Level of Service (LOS) of all assets at risk.
3. For high LOS assets under the DFE, develop asset-level strategy.
4. For all buildings at risk, develop building-level strategies.
5. Calculate benefit of adaptation.
6. Compare benefits to cost of floodproofing alternatives.

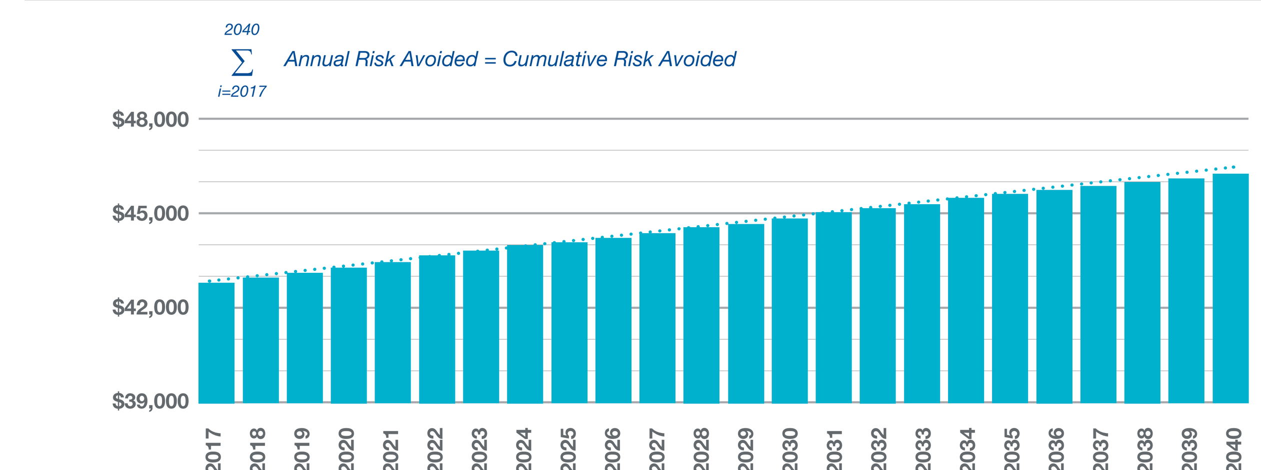


FIS = FEMA Flood Insurance Study

Broad Creek Wastewater Pump Station



Cumulative Risk Avoided



Includes:
- Increasing probability of floods from now to 2040
- Potential of strategy failure
- Annual risk discounted to present dollars

*RR = (Probability of flood event) * (1 -- Strategy Failure Potential) * (Asset Replacement Cost)*

Compare Strategy Costs to Cumulative Risk Avoided

Assets at Risk and Area Level Strategies

Building/Area	All Assets At Risk			
	Quantity	Cost of Replacement	Strategy Costs	Cumulative Risk Avoided
Electrical Yard	7	$5,510,000	$452,000	$1,070,000
Generator Building	5	$20,520,000	$300,000	$390,000
Pump Station Building	2.3	$22,300,000	$300,000	$2,160,000
Screening Building	5	$1,340,000	$160,000	$130,000
Valve Vaults	8	$260,000	$90,000	$50,000
Surge Tank Area	1	$20,000	-	-

Recommended Strategies Based on Benefit-Cost Analysis
• Elevate Electrical Yard
• Install temporary door covers around Generator Building and Pump Station Building

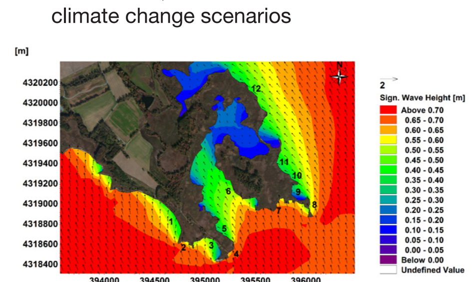
Temporary door and louver covers

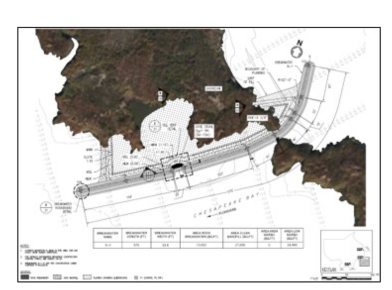
Elevate equipment

Coastal Protection with Nature-Based Solutions to Restore and Protect Habitat

USFWS Eastern Neck Wildlife Refuge, Maryland, Living Shoreline

- Assess historic and projected shoreline loss
- Using USACE's Sea Level Change Curve Calculator, model future wave, water current and storms under a multitude of climate change scenarios
- Prioritize shorelines for immediate protection
- Design and construct resilient nature based solutions to restore and protect habitat

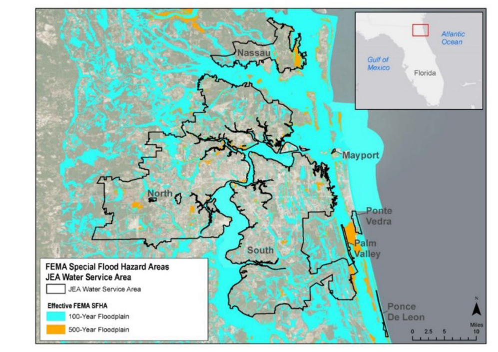


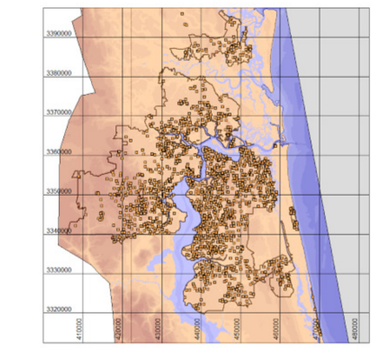


Monmouth Beach, New Jersey, NFWF Funded 1-Mile Dune and Habitat Restoration Project

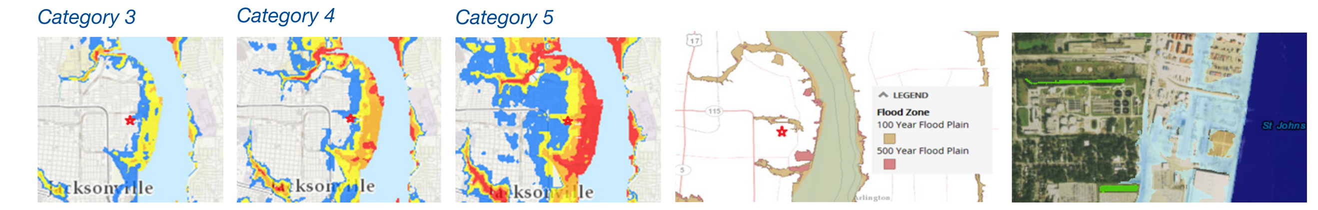
JEA System Resiliency Plan, Jacksonville FL

JEA Operates over 1,700 Water/Wastewater Facilities across a 4-County Region with nearly 500,000 Customer Accounts

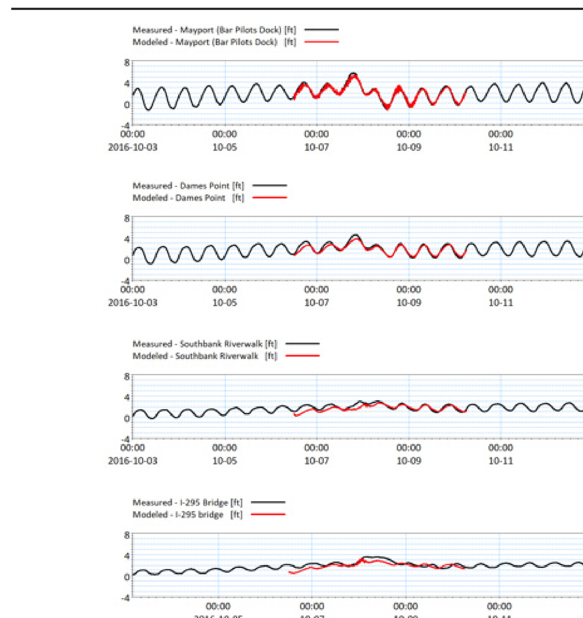


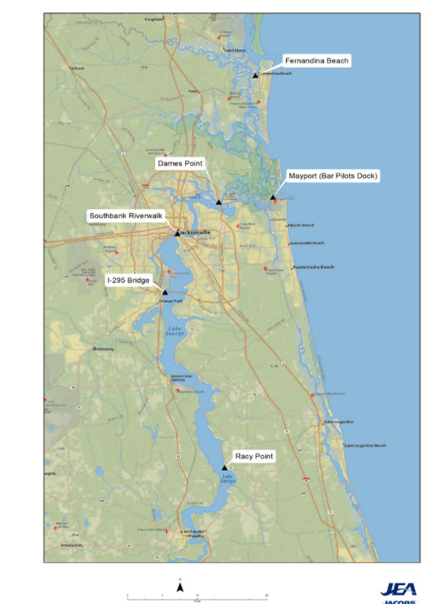


Ongoing efforts will be leveraged to identify near-term, intermediate, and long-term adaptation measures

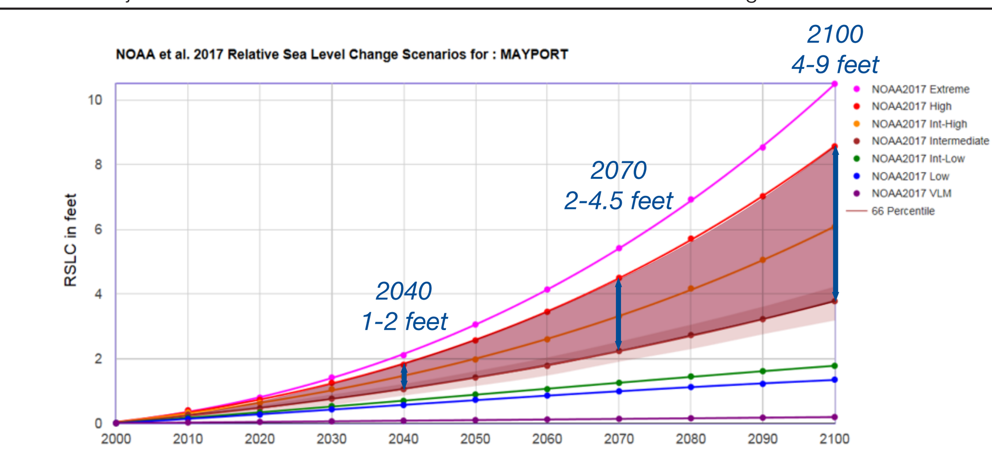


St. John's River Flood Model Calibration: Hurricane Matthew



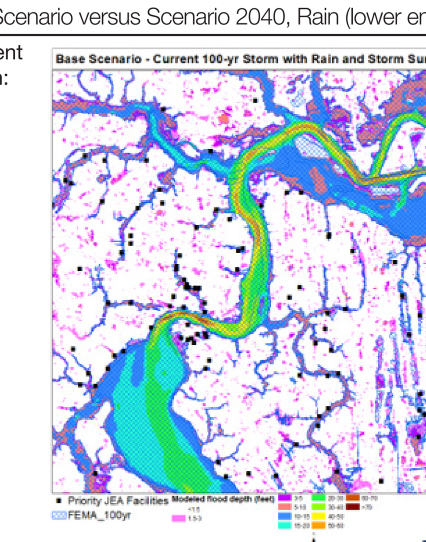


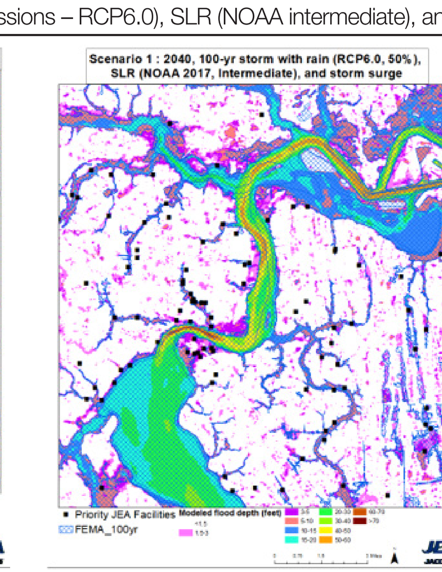
2017 Updated SLR Projections for Mouth of St. Johns River Used in Scenario Planning



100-year Storm: Base Scenario versus Scenario 2040, Rain (lower emissions – RCP6.0), SLR (NOAA intermediate), and Storm Surge

All JEA Facilities in current and projected floodplain:
Current: 210 (12.6%)
Scenario 1: 288 (16.9%)





Site vulnerabilities provides basis for mitigation strategies

Near-term (0-5 years)
- Map out critical operational components, equipment, and supply chain elements
- Floodproof low-lying electrical equipment
- Enhance redundant power supply
- Incorporate higher performing and adaptive designs into guidelines
- Develop business case for a larger investment to protect the WRF

Mid-to-long-term (5-20 years)
- Identify and implement new technology and higher design standards for new components
- Elevate low-lying portion of the site and possibly the entire site above the BFE

Summary
- Actionable climate science drives decision making in infrastructure planning
- Tools are needed for readily summarize projections for SLR and rainfall IDF
- Ensemble approach is generally preferred to assess the range of risks and uncertainty. No preference for a given GCM/RCM
- If possible, confidence intervals or likelihood of projections would help explain uncertainty in projections to local stakeholders, to facilitate dynamic adaptive planning