Quantifying Vulnerability and Risk: Case Studies in Resilience

AMONTario Climate Change & Asset Management Conference

March 23, 2021

Welcome

- Introductions
- Drivers and the “ESG Tsunami”
- Project Examples
  - Melbourne Water
  - JEA - community owned electric, water, sewer utility (Jacksonville)
  - Washington DC Department of Transport
- Common processes in risk & vulnerability assessments

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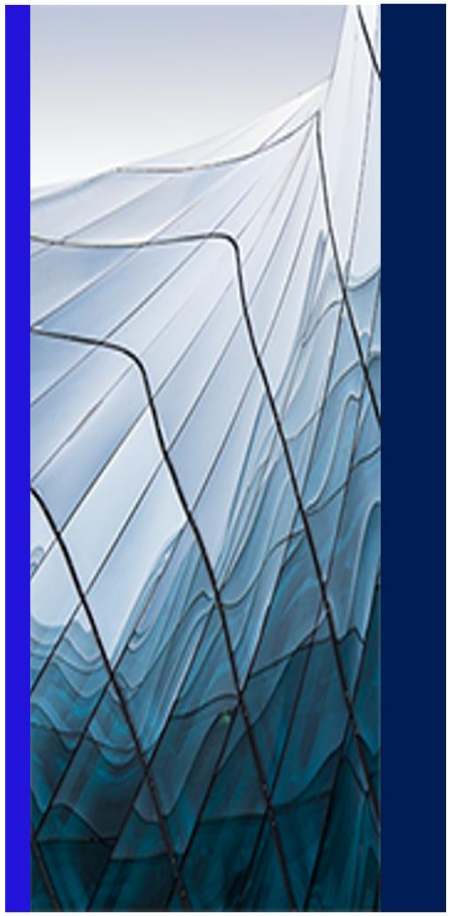
Workshop Strategy

Three modes

- Presentations
- Polls and Discussion of Results
- Questions & Answers



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Drivers and the “ESG Tsunami”

Financial Sector has determined so called long-term non-financial risks, are financial risks.

- Investors
- Creditors
- Insurers

Managing threats and vulnerabilities, is top of mind in financial decisions.

- Investors diversify risk
- Creditors set interest rates
- Insurers evaluate premiums

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Poll #1

- What is your organization's primary driver for considering climate vulnerability risk and resilience?

__Legislative or Funding Requirements
__Maintaining Levels of Service
__Financial Costs
__Disclosure Expectations
__Legal Risks or Liabilities

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We have investors, creditors, and insurers too…

Lately we have become our own client.

Walk our talk!

- Integrated Annual Report for Stakeholders
- Climate Commitments
- Climate Risk Health Check

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Resiliency in action

Dive into three projects

- Melbourne Water
- JEA - community owned electric, water, sewer utility (Jacksonville, FL)
- Washington DC Department of Transport

Themes

- View into assets outside of Canada
- Similarities in approach underlying each project
- Scalable: from single asset > larger infrastructure > to a portfolio of assets.

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Case Study 1

Craig Clifton
Global Technology Leader, Resilience and Climate Change

A case study in building resilience in municipal infrastructure - Melbourne, Australia

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Melbourne Water
Enhancing Life and Liveability

Jacobs
Challenging today.
Reinventing tomorrow.

Poll #2

- What types of “resilience risk” keep you awake at night?

__ Natural Hazards
__ Malevolent Acts
__ Climate change (projected future climate hazards)
__ All of the above

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Overview

- An overview of Melbourne's wastewater system: an overview
- Imperatives for resilience
- Resilience concepts and their application in water and wastewater systems
- Benefits of adding resilience to risk
- Case study: Melbourne's Western Treatment Plant
- Imperatives for resilience revisited

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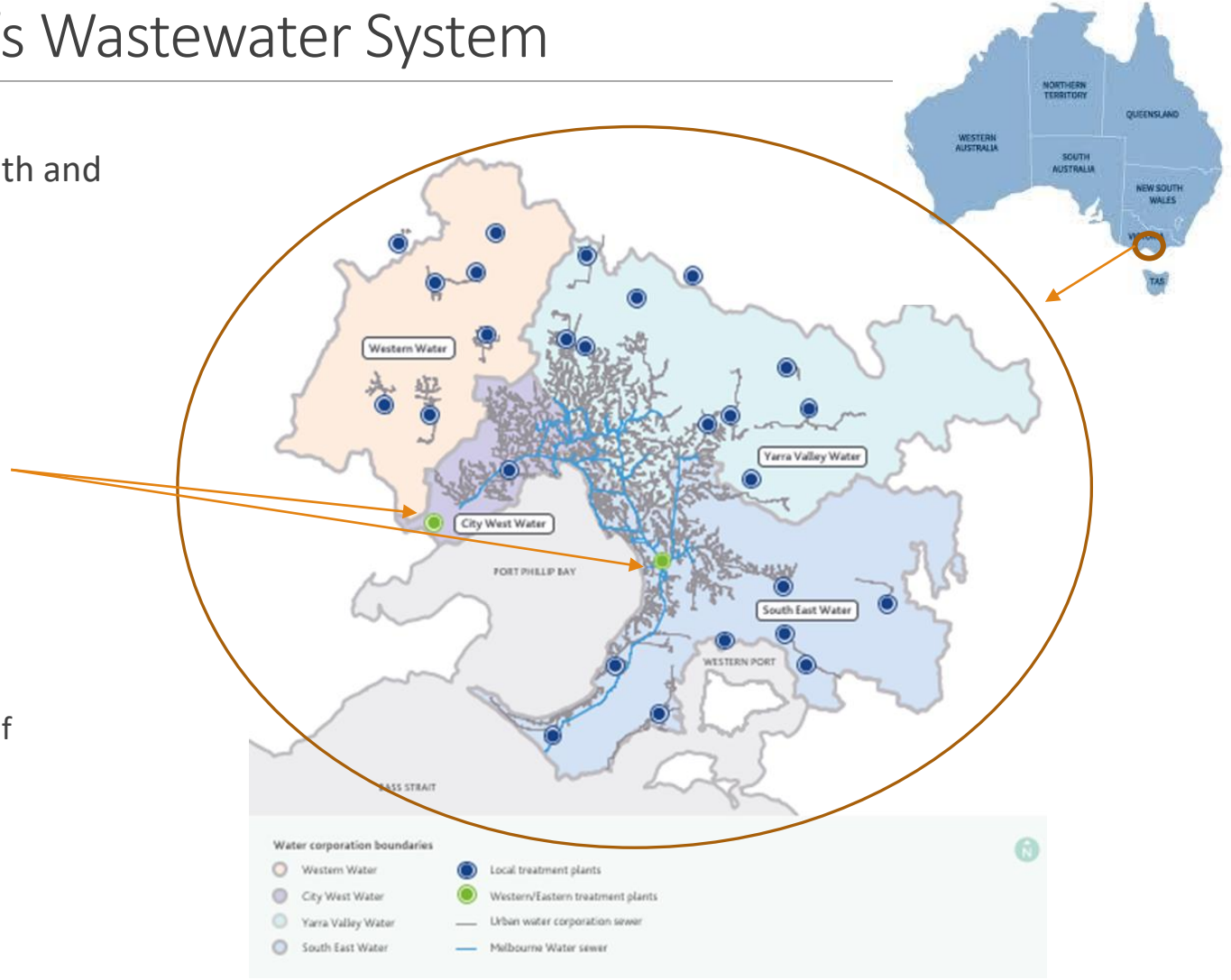
Melbourne's Wastewater System

- System established in 1890s to protect public health and the environment for the people of Melbourne
- Melbourne Water (MW):
  - Provides "bulk" wastewater services to retail water businesses
  - Operates two large wastewater treatment facilities - Western and Eastern Treatment Plants (WTP, ETP)
  - Maintains trunk sewer network
- Retail water businesses
  - Operate smaller treatment plants
  - Mainly independent of MW although some dispose of effluent to MW's ETP outfall
- Sewerage system services
  - Population of ~5 million
  - Urban area of ~10,000 km^2



Imperatives for resilience

- Melbourne is changing rapidly:
  - Population changes, urbanisation, climate change
  - Increasing likelihood of disruptive events
  - Decisions are required to renew/build sewerage and water supply infrastructure
- Affordability of water and wastewater services (and other utilities) is critical to government and pricing regulator
- Going beyond just 'least cost' solutions and *just enough, just in time* decisions:
  - Removes the 'shock absorbing' capacity of the system
  - Reduces future options
  - Increases long-term cost
- Continuing with BAU will erode system resilience and create risks that are *not fully understood, explicitly disclosed or adequately considered*
- Incremental change will not meet the scale of future challenges or capture opportunities

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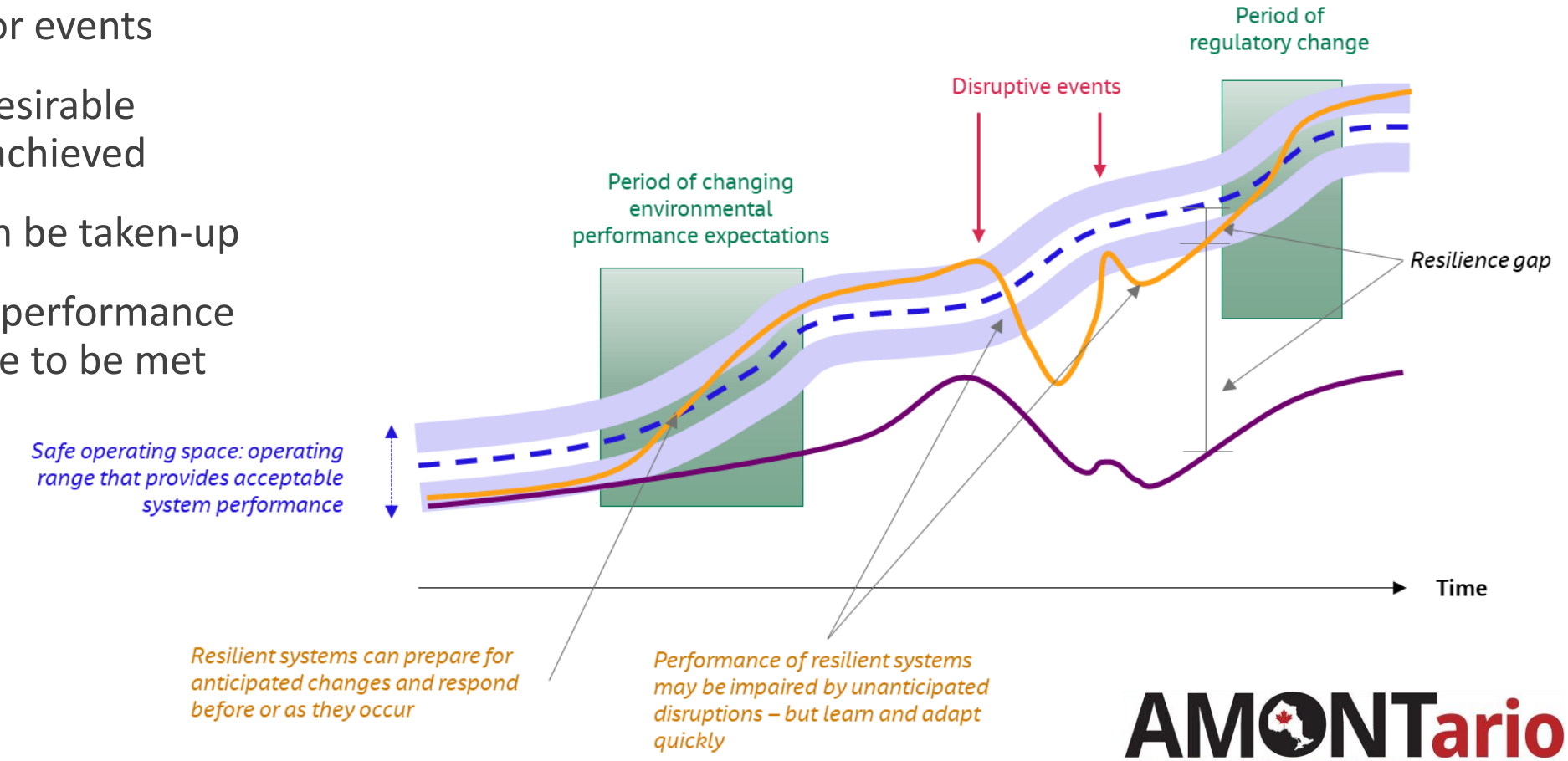
What would a resilient system look like?

- Prepared for, able to withstand and then recover and learn from disruptive trends or events
- Change toward desirable outcomes can be achieved
- Opportunities can be taken-up
- Changing system performance objectives continue to be met



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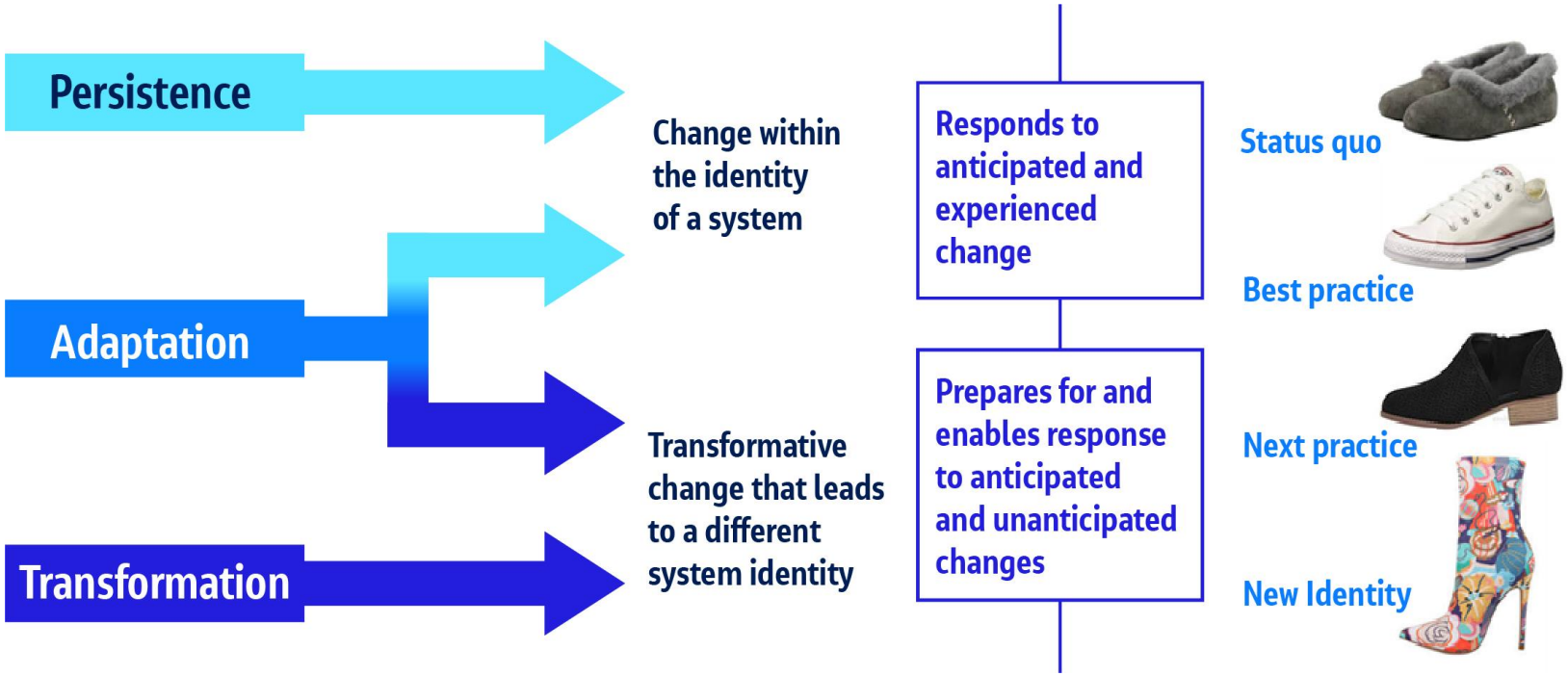
What would a resilient system look like?

- Ability to **persist, adapt or transform** at any given point in time
- Build on the strong culture of risk management and extend this to resilience
- Including resilience will increase the safe operating space
- Focusing on risk alone will narrow the safe operating space as we focus on maintaining the status quo



e.g. Expansion of process unit within an existing WWTP – with the current linear sewerage system

e.g. Developing a resource recovery system for biosolids with 100% beneficial use – as part of implementation of a circular wastewater management system

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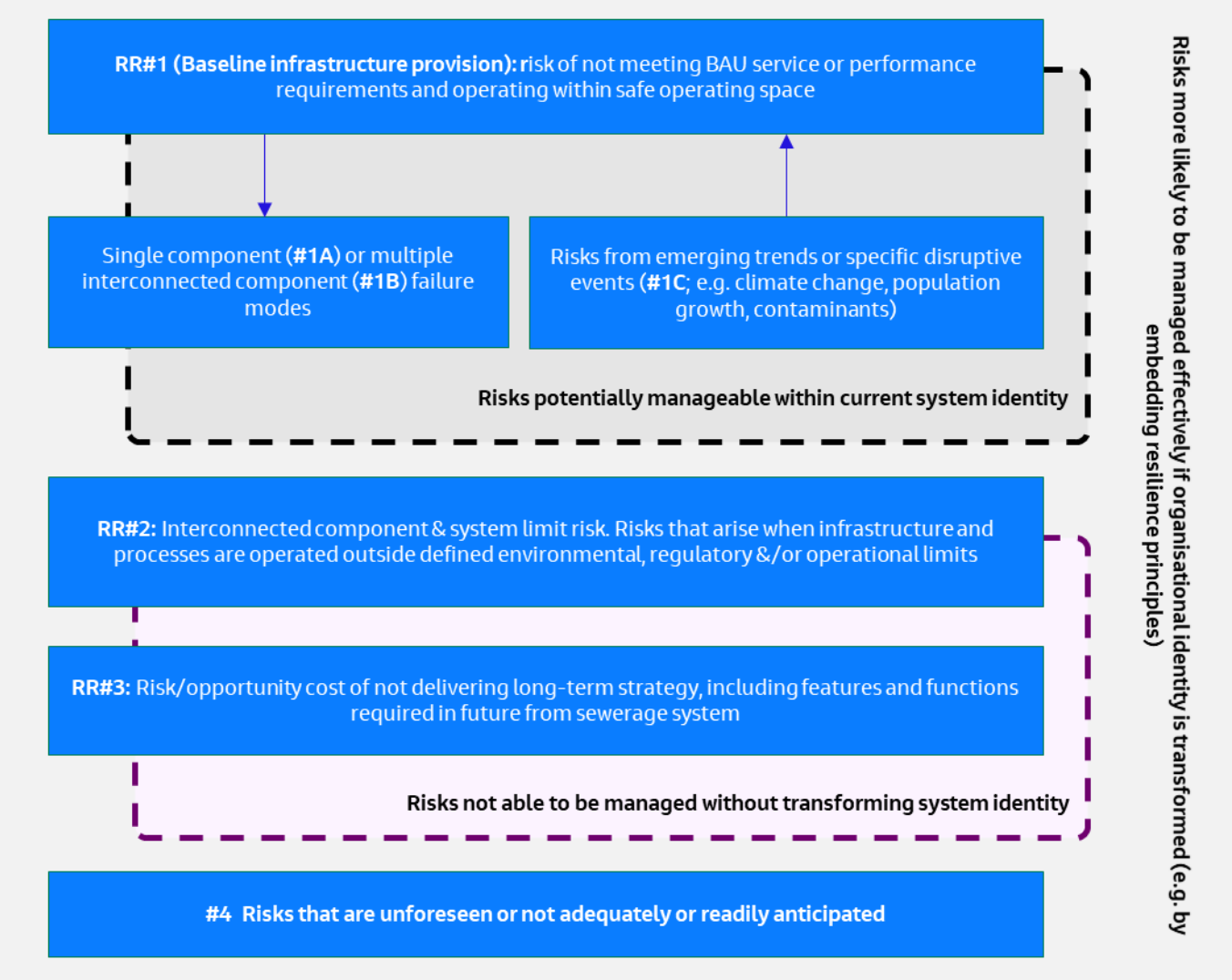
Resilience risks



- **RR#1:** BAU risk management – providing infrastructure to meet current and anticipated regulatory obligations and customer service requirements.
  - *A) baseline growth*
  - *B) Compounding concurrent failures*
  - *C) Emerging slow moving foreseeable factors, e.g. climate change*
- **RR#2:** Arise when interconnected system limits are approached or exceeded without being recognised or planned for
- **RR#3:** Opportunity cost from not delivering on long-term strategy
- **RR#4:** Risks that are difficult to foresee or anticipate and rely on organisational resilience

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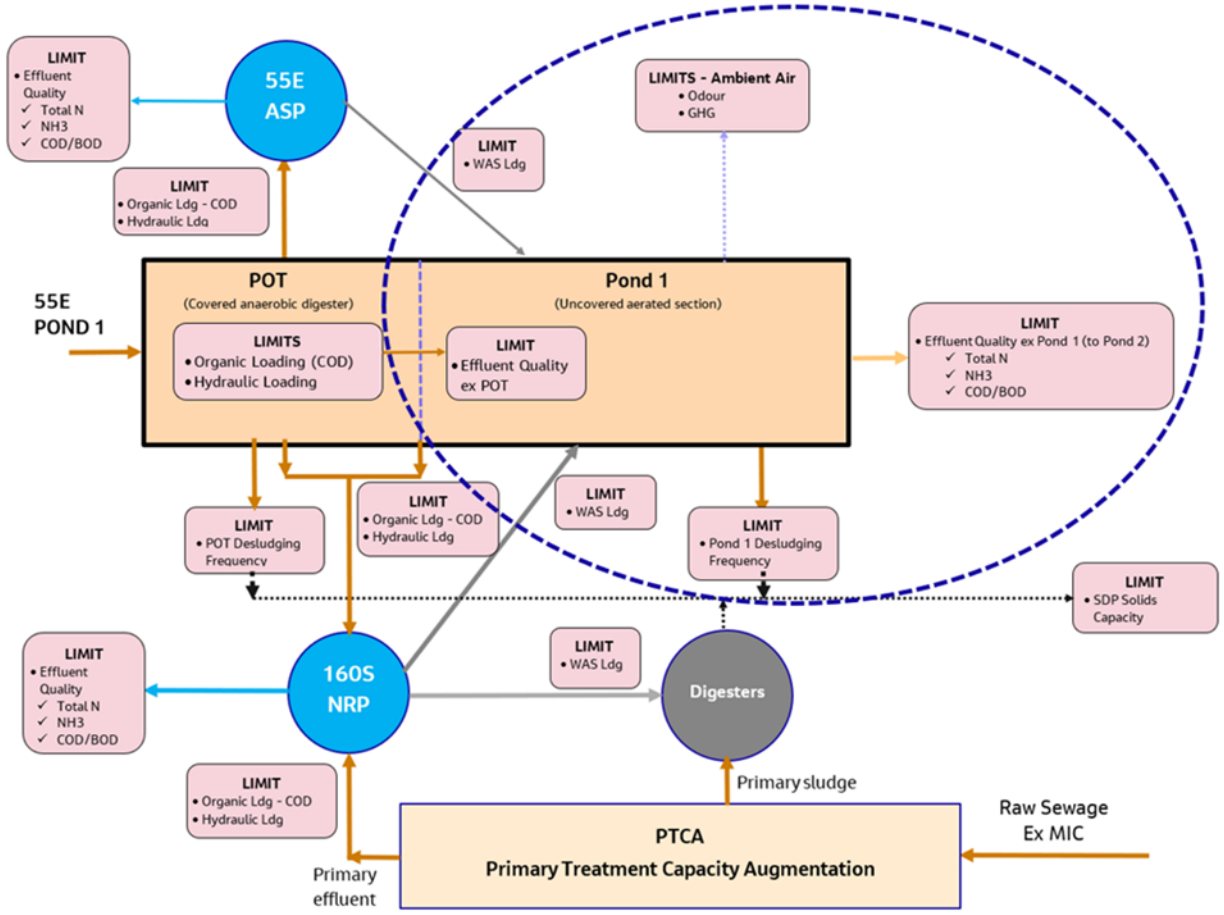
The benefits of adding resilience to risk

- Creates a broader systematic view
- Allows us to acknowledge the inherent complexity and inter-dependencies in the sewerage system
- Supports the shift from just enough, just in time to systemic longer term decision making
- Enables an alternative and broader view of risk and opportunities
- Brings previously undisclosed or inadequately disclosed risks to attention of decision-makers



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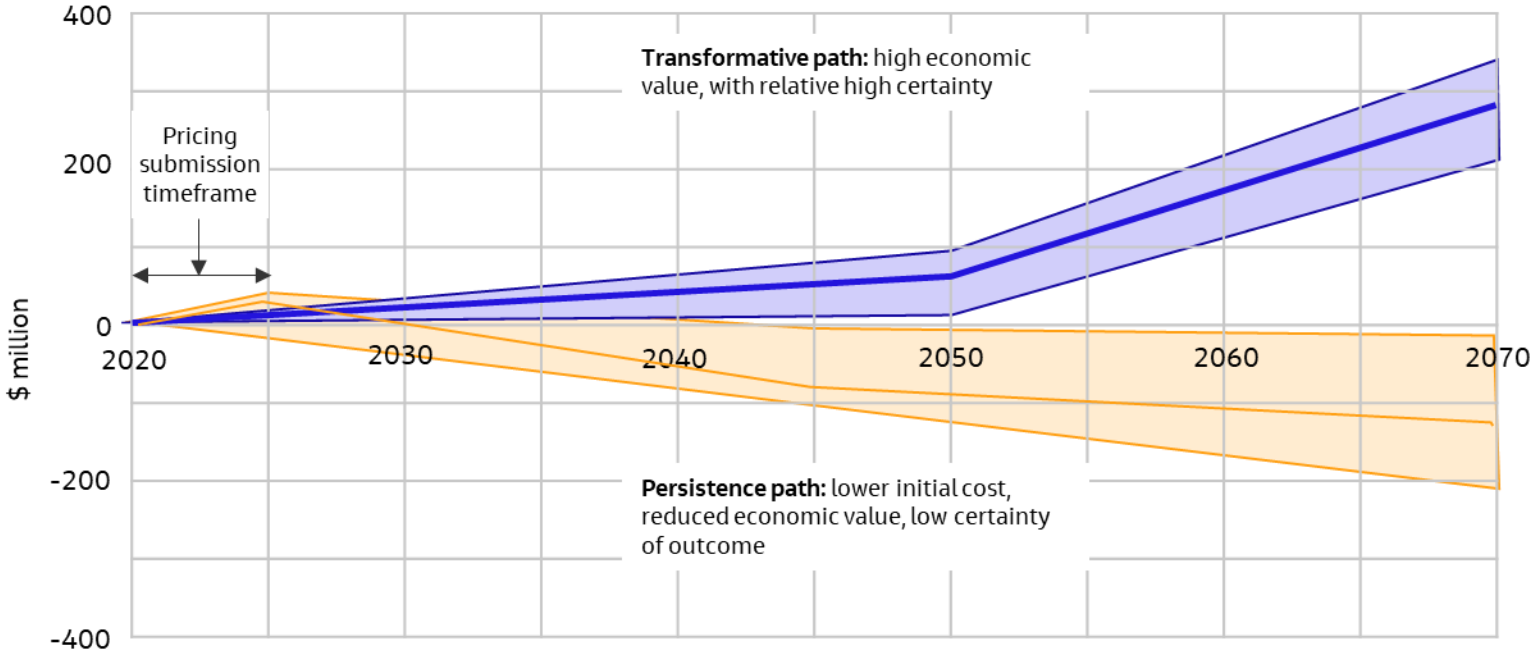
An economic case for resilience

- Persistence pathway – least cost, just enough-just in time:
  - Risk response deferred - lower initial cost
  - Reduced long-term economic value as risk & risk costs realised
  - Higher uncertainty of outcomes
- Transformation path:
  - May lead to higher initial costs as investments are made to address risk
  - Building resilience provides better long-term value
  - Improves certainty of outcome
- Five-year regulatory pricing reviews may not capture the bigger picture until its too late



Expected value ~ Best case value × Probability of best outcome + Worst case value × Probability of worst outcome

*Conceptually: l*ow resilience/persistence pathway compared with high resilience/transformation pathway

- Bigger difference between best and worst case outcome
- Best case outcome poorer
- Higher likelihood of worst case outcome

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Conclusion: why invest for resilience?

- **Change and uncertainty are the only certainties**:
  - Population, urbanisation, climate change, environmental regulation, pandemic etc.
  - Increasing likelihood of disruptive events and chronic stresses
  - Legacy infrastructure is aging and resilience is being eroded
- **Affordability of utility services is critical to governments – adds to pressure for underinvestment**
- **Least cost/persistence solutions and *just enough, just in time* decisions:**
  - Removes the 'shock absorbing' capacity of the system – flexibility, redundancy
  - Systems operate close to or outside their safe operating space
  - No pathway from tactical/operational planning to achievement of long-term vision/opportunities
  - Increases long-term cost
- **Continuing with BAU creates risks that conventional risk management frameworks are not necessarily set up to consider – and so are *not fully understood, explicitly disclosed or adequately considered***
- **Transformative investment often required to meet the scale of future challenges and to connect long-term vision with tactical and operational planning**

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Acknowledgements

Melbourne Water
Enhancing Life and Liveability

Clare McAuliffe

Jacobs
Challenging today.
Reinventing tomorrow.

David Lynch, Lucas van Raalte

AUSTRALIAN RESILIENCE CENTRE

Paul Ryan

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Questions & Answers

A case study in building resilience in municipal infrastructure - Melbourne, Australia

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Discussion Questions

- What types of “resilience risk” keep you awake at night?
- To what extent does “least cost – just enough – just in time” define how your organisation invests in its assets?
- If your organisation has been able to invest for resilience in its assets, what has driven this?

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Discussion Questions

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Case Study 2

Enrique Lopezcalva
Global Practitioner Water Resources & Resilience

JEA System Resilience Plan: Climate Adaptation for a Coastal Florida Water/Wastewater Utility

March 23, 2021

Jacobs Challenging today. Reinventing tomorrow.

The project assessed climate change vulnerability & risk and developed specific capital improvement recommendations for the water & wastewater systems

Hurricane Matthew (2016)

Hurricane Irma (2017)

Acknowledgements to JEA staff and main Jacobs project leads:

Laurens van der Tak, PE
- Americas Water Resilience Director

Laurens.vandertak@jacobs.com

Jason M. Bird, CFM
- Florida Resilience Practice Leader &
- US South Water Resources Solutions Leader
- United Nations ARISE US Network Chair

Jason.Bird@jacobs.com

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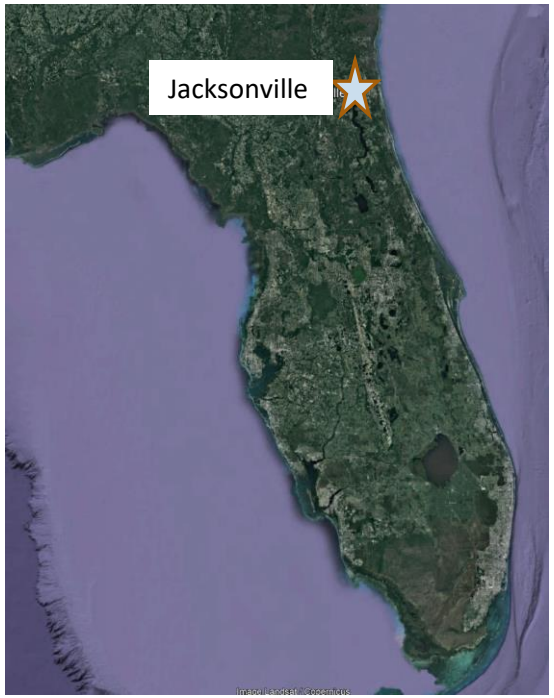
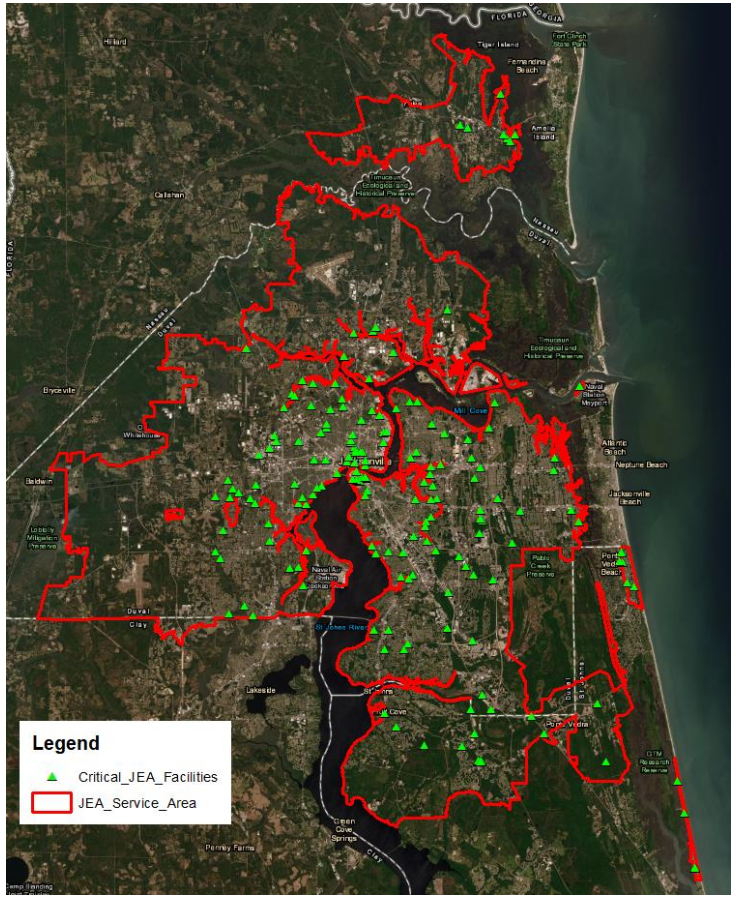
JEA operates over 1,700 Facilities across a 4-County Region with nearly 500,000 Customers in Northeast Florida

- Water Reclamation Facilities: 11
- Wastewater Pump Stations: 1,400
- Water Treatment Plants: 38
- Potable Wells: 150
- Chilled Water Plants: 4





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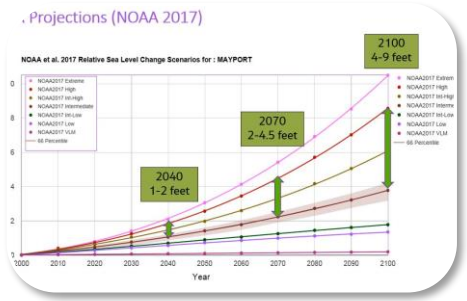
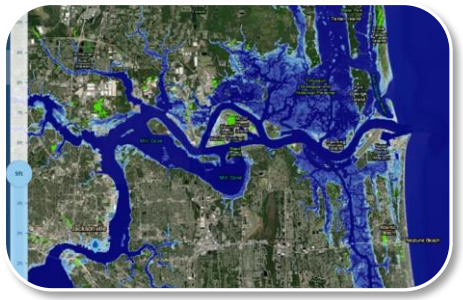
JEA's Resiliency Program Activities

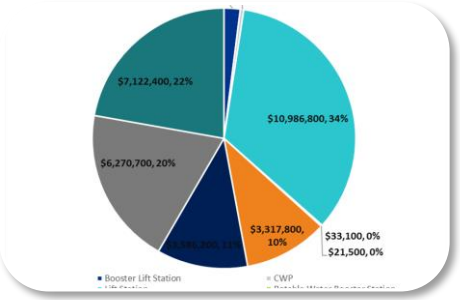


Establish Future Extreme Weather Scenarios

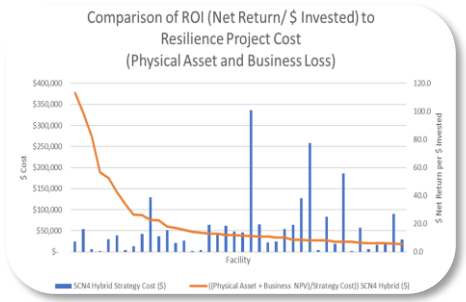


Vulnerability Assessment & Risk Analysis

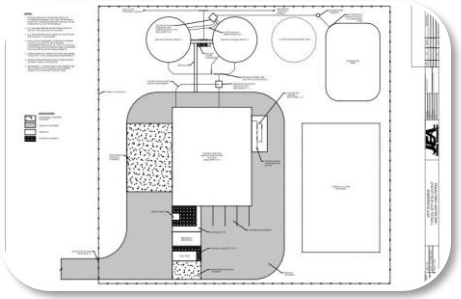
Develop Mitigation & Adaptation Strategies



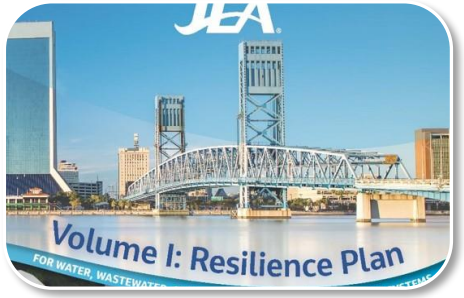
Economic Cost-Benefit Analysis



Prioritize Strategies



Update Design and Construction Standards



Develop Resilience Plan & Implementation Roadmap

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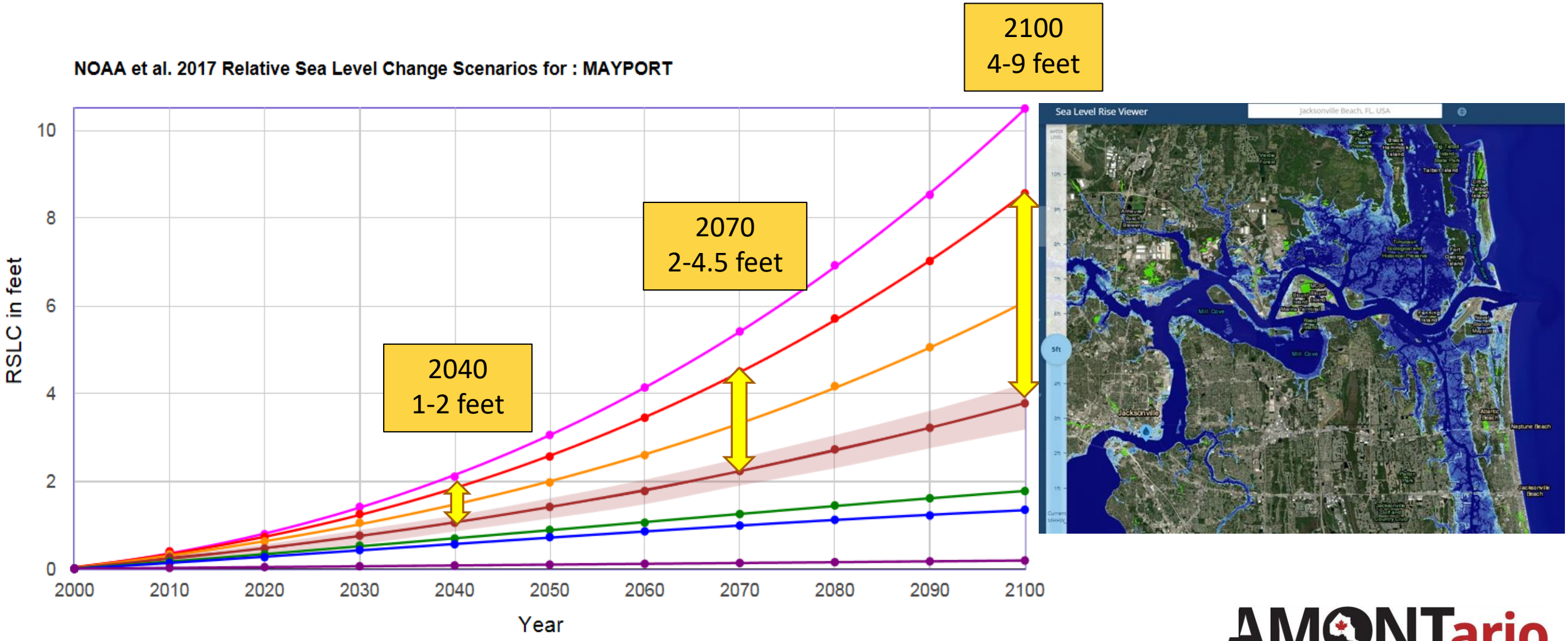
Sea Level Rise (SLR) Projections (NOAA 2017)



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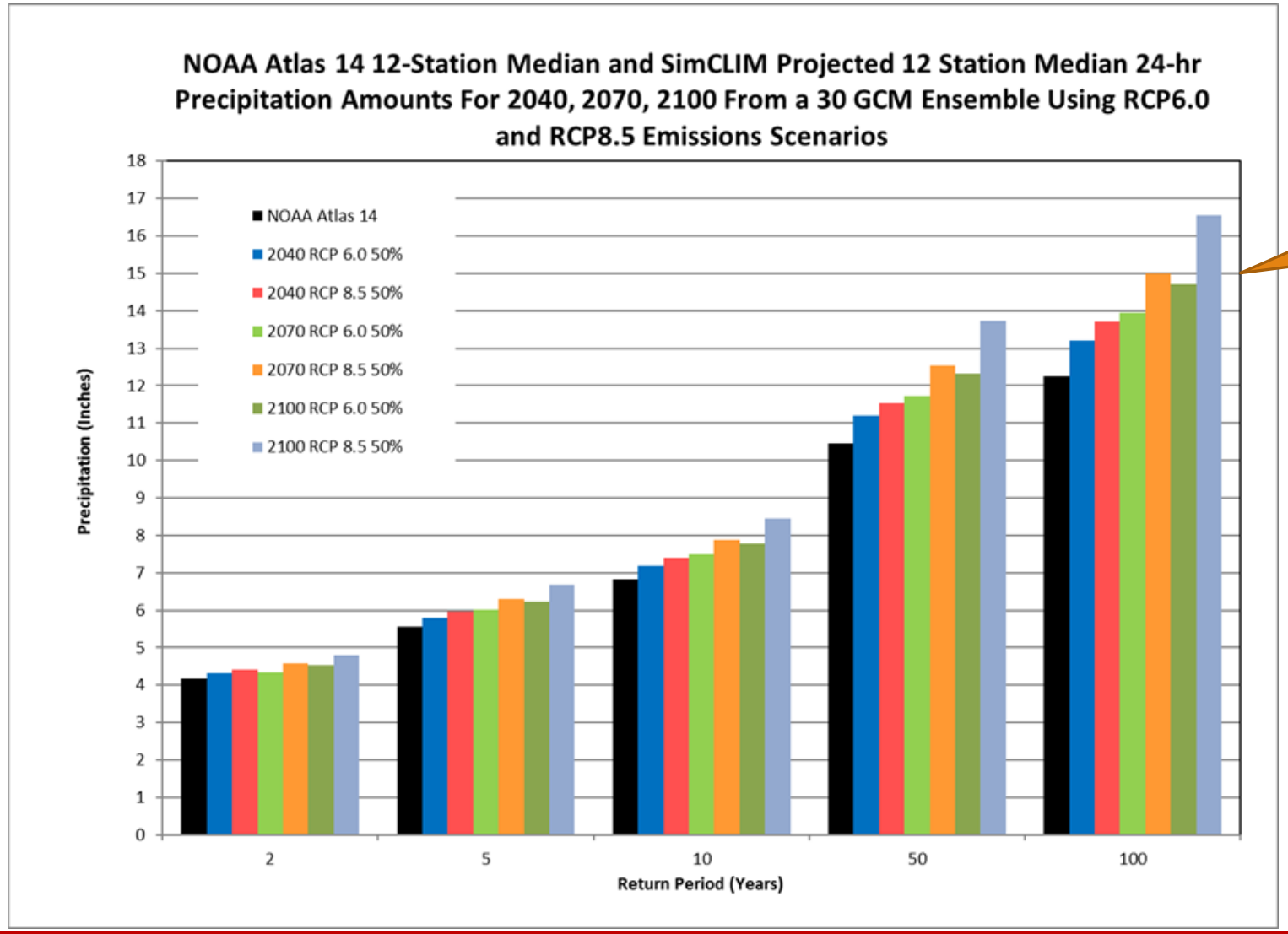
Rainfall Intensity Duration Frequency Projections

Median of Global Climate Model Projection Ensemble



100-yr 24-hr rainfall expected to increase by 8% to 35% from 2040 to 2100

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100-year Storm: Base Scenario versus Scenario 4

2070, Rain (higher emissions – RCP8.5), SLR (NOAA High) and Storm Surge

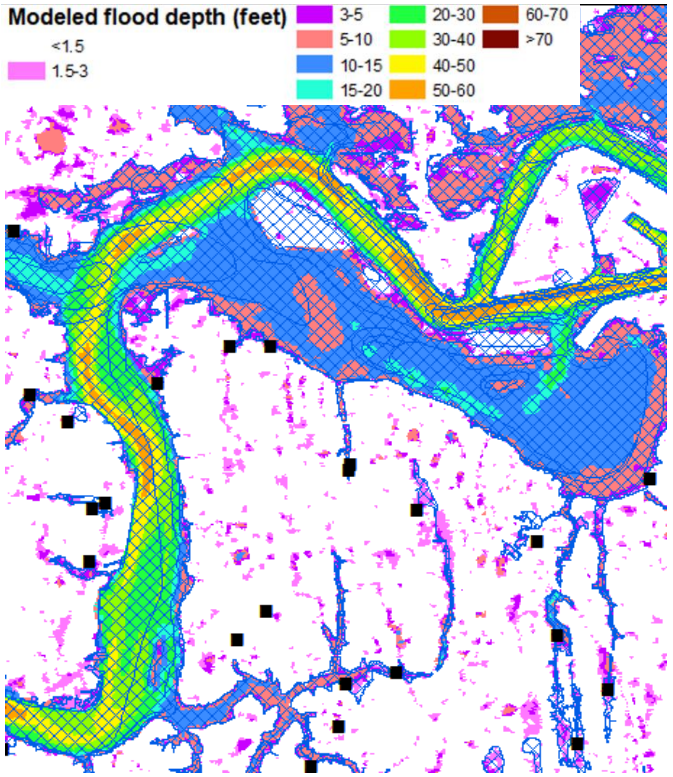
Facilities in Floodplain

All JEA Facilities:

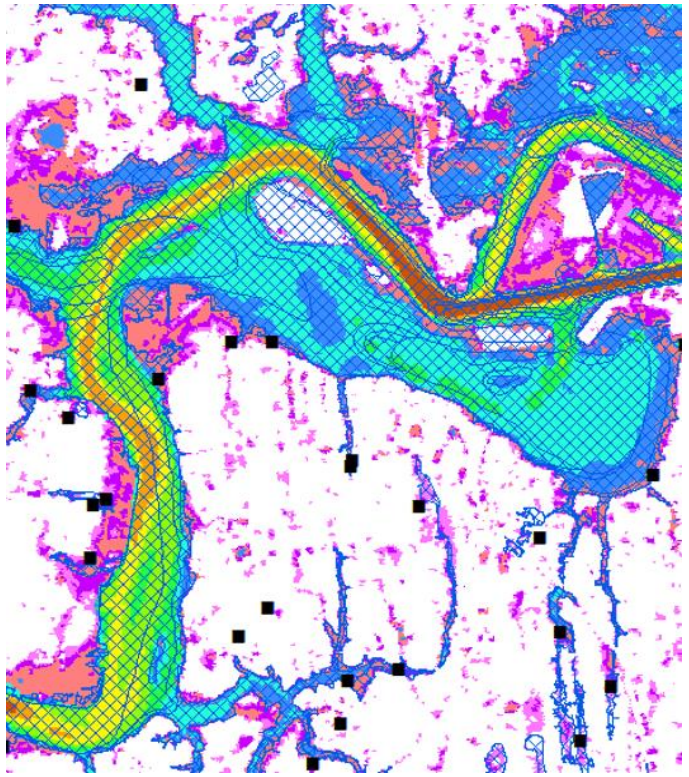
- Current: 210 (12.6%)
- Scenario 4: 390 (22.9%)

Priority JEA Facilities:

- Current: 90 (50%)
- Scenario 4: 118 (65%)



Baseline: 100 year



Scenario 4, 2070: 100 year (RCP8.5, NOAA High)

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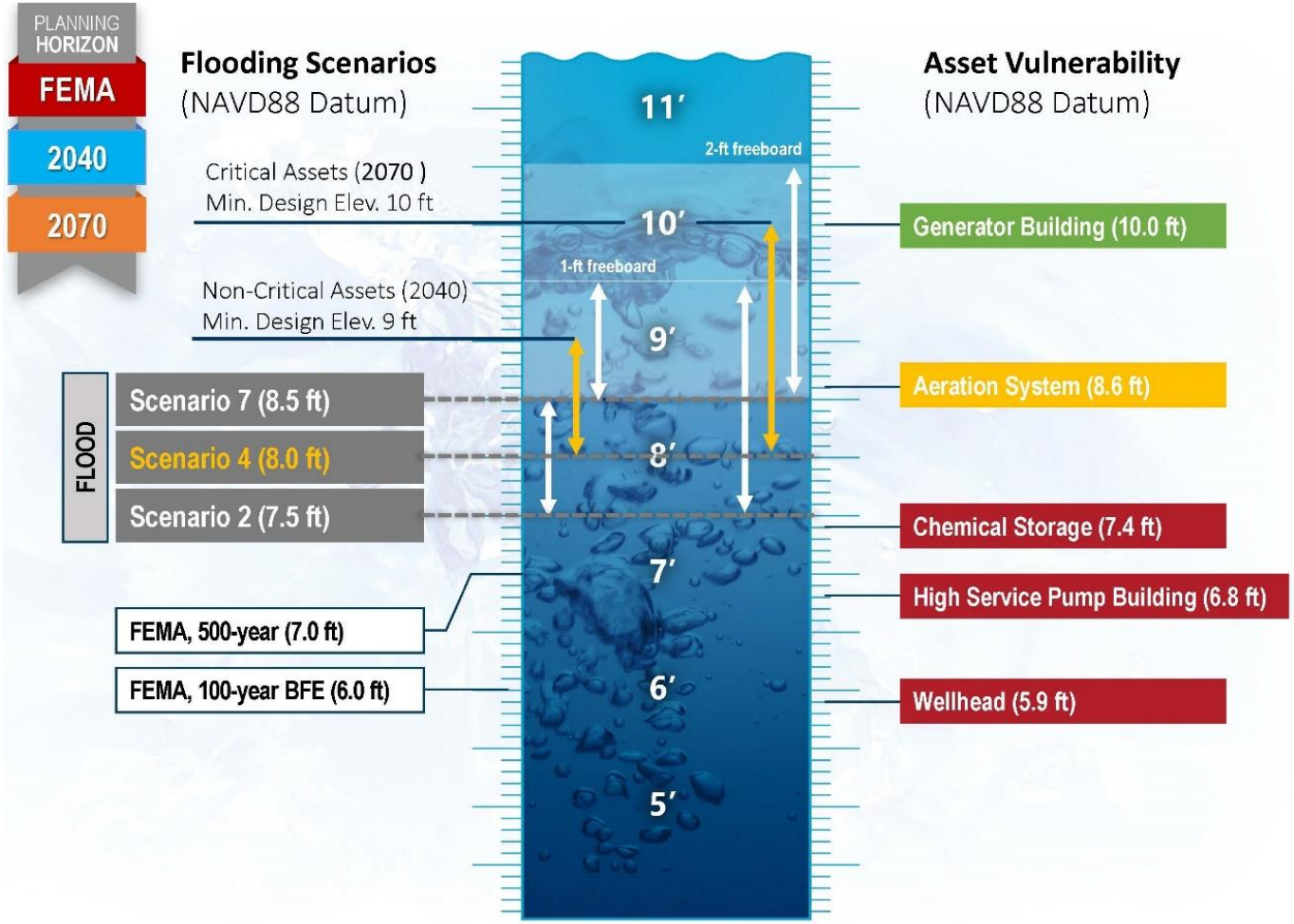
Key Insight: Asset Level Flood Vulnerability is more valuable than a facility-wide application of DFE[1]

- Determine flood pathways and lowest point of impact.
- Identify all assets at risk below selected DFE.
- Quantified vulnerability of assets and facilities for comparison.
- Evaluate Level of Service (LOS) of all exposed assets based on criticality.
- Compare to Design Flood Elevations (DFE) from flood modeling.



[1]Design Flood Elevation

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Adaptation Strategies: all on the table, including temporary deployable solutions

- For high LOS assets at risk of flooding today, focused on three categories:
- Elevating,
- Hardening and
- Perimeter Barriers
- For individual assets and asset groups, i.e. buildings.
- Building-level strategy for at risk buildings preferred over asset level strategies

Temporary Movable Barriers

Source: www.floodstopbarrier.com

Source: http://usfloodcontrol.com/tiger-dam-products/

Manual Flood Panels/Gates

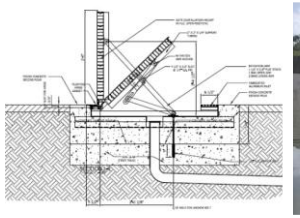
Source: www.floodbarriers.com

Source: www.floodpanel.com

Source: www.floodcontrolinternational.com

Automated Flood Gates

Source: www.floodcontrolinternational.com



Source: www.floodbreak.com

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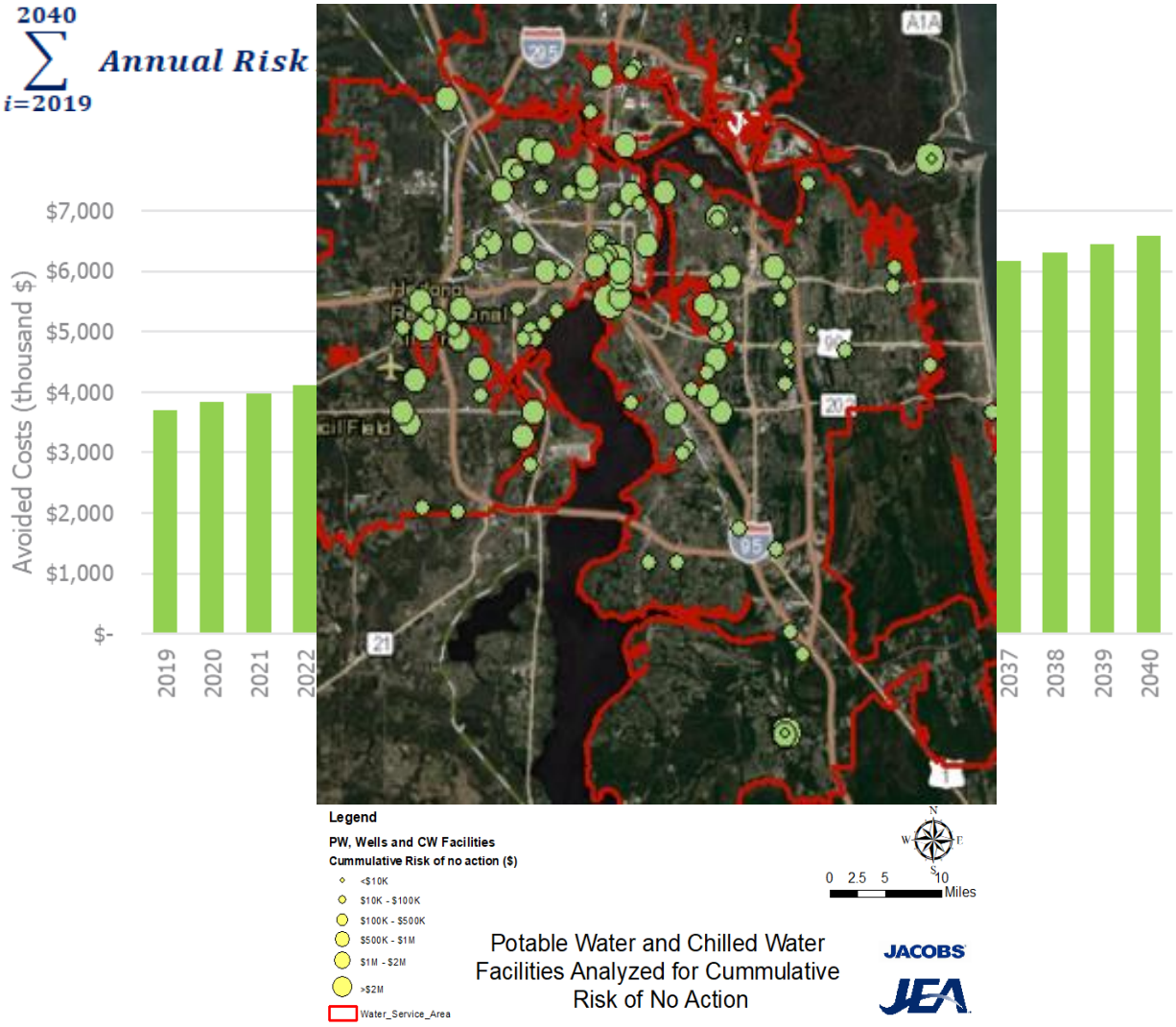
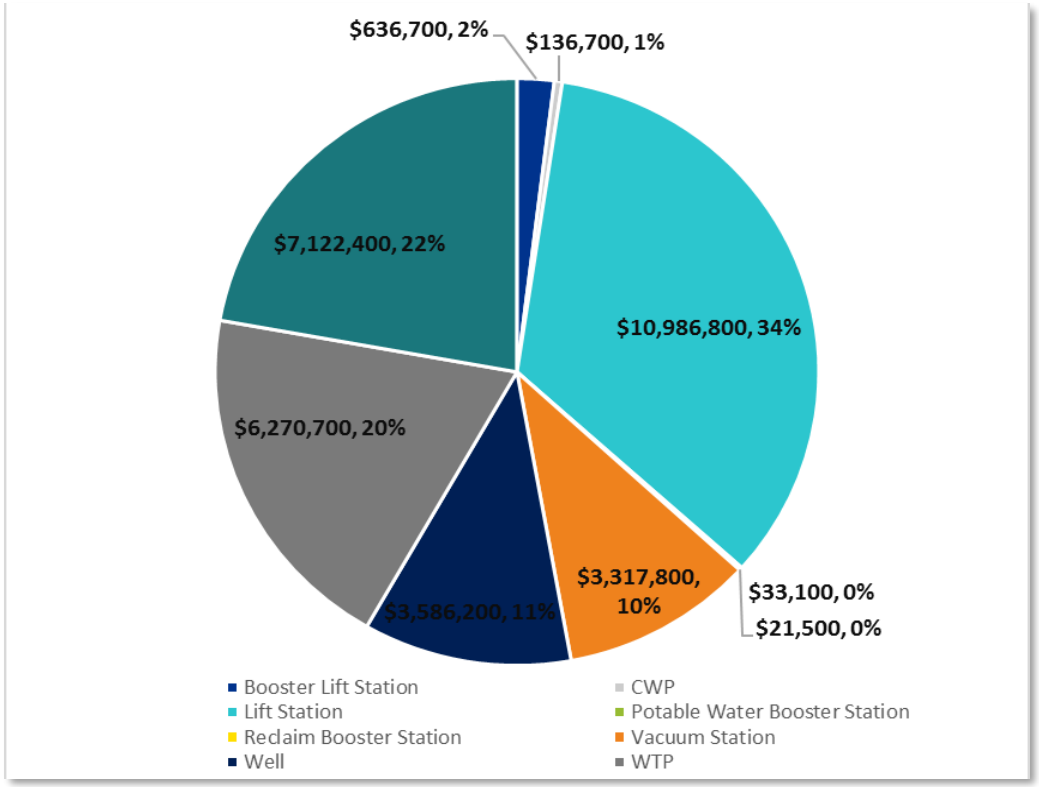
Key Insight: Explicitly account for the evolution of monetized risk: it increases over time because exposure increases over time

$$\sum_{i=2019}^{2040} \textit{Annual Risk}$$

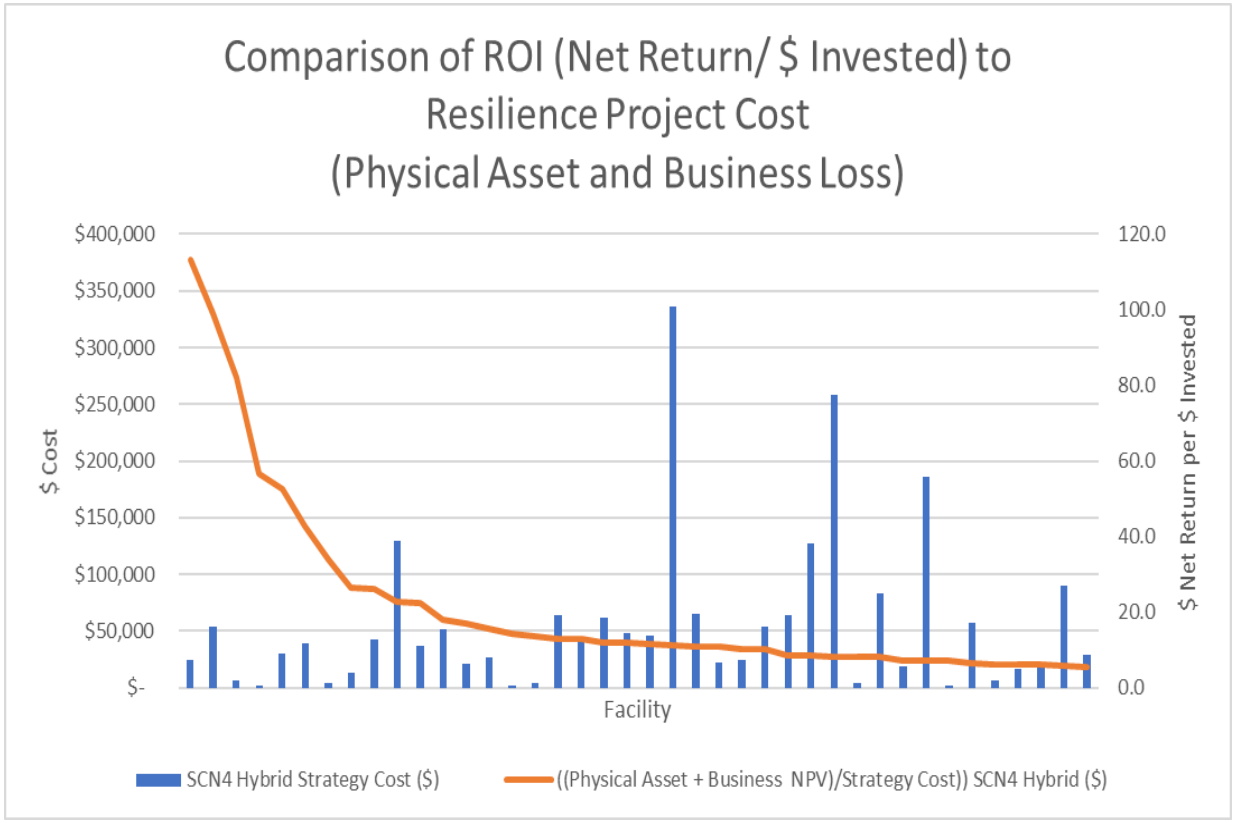


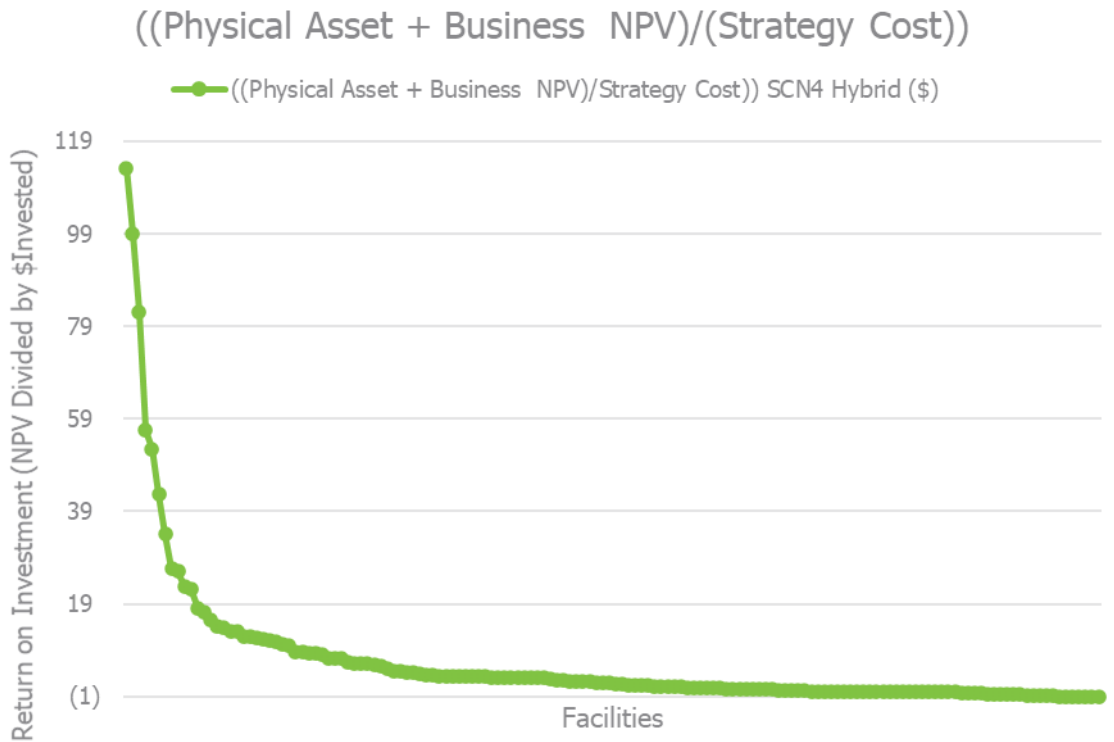
Potable Water and Chilled Water Facilities Analyzed for Cummulative Risk of No Action



Total Monetized Risk by Facility Type

Key Insight: Facility Resilience Investments Prioritized Based on Both Monetized Risk and Cost/Benefit (Return on Investment)





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Additional Insights & Lessons Learned

- Climate-based scenario planning including coastal and riverine flood modeling is essential to bracket risk.
- Inclusion of both direct and indirect (avoided risk costs) to capture full strategy benefits.
- Return on investment (ROI) justifies proactive resilience investment.
- Building operational resilience requires strong leadership, forward looking policy, design guides, staff training and communication plan.

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Questions & Answers

JEA System Resilience Plan: Climate Adaptation for a Coastal Florida Water/Wastewater Utility

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Case Study 3

Enrique Lopezcalva
Global Practitioner Water Resources & Resilience

Riverine Flood Resilience in an Urban Environment – Buzzard Point Floodplain Feasibility Study Washington DC District Department of Transportation

March 23, 2021

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Riverine flood exposure from the Potomac and Anacostia rivers in Washington DC is projected to increase in the future, impacting vibrant new development areas

District Department of Transportation Objectives:

- Determine appropriate base flood elevation to protect public infrastructure in the study area
- Develop conceptual mitigation strategies for study area
- Lay the groundwork for future environmental approvals and permitting requirements
- Develop feasibility study geotechnical, roadway, and landscaping criteria
- Define environmental compliance requirements and perform assessment of potential impacts

Preliminary Results from
Existing Conditions Hydraulic Model

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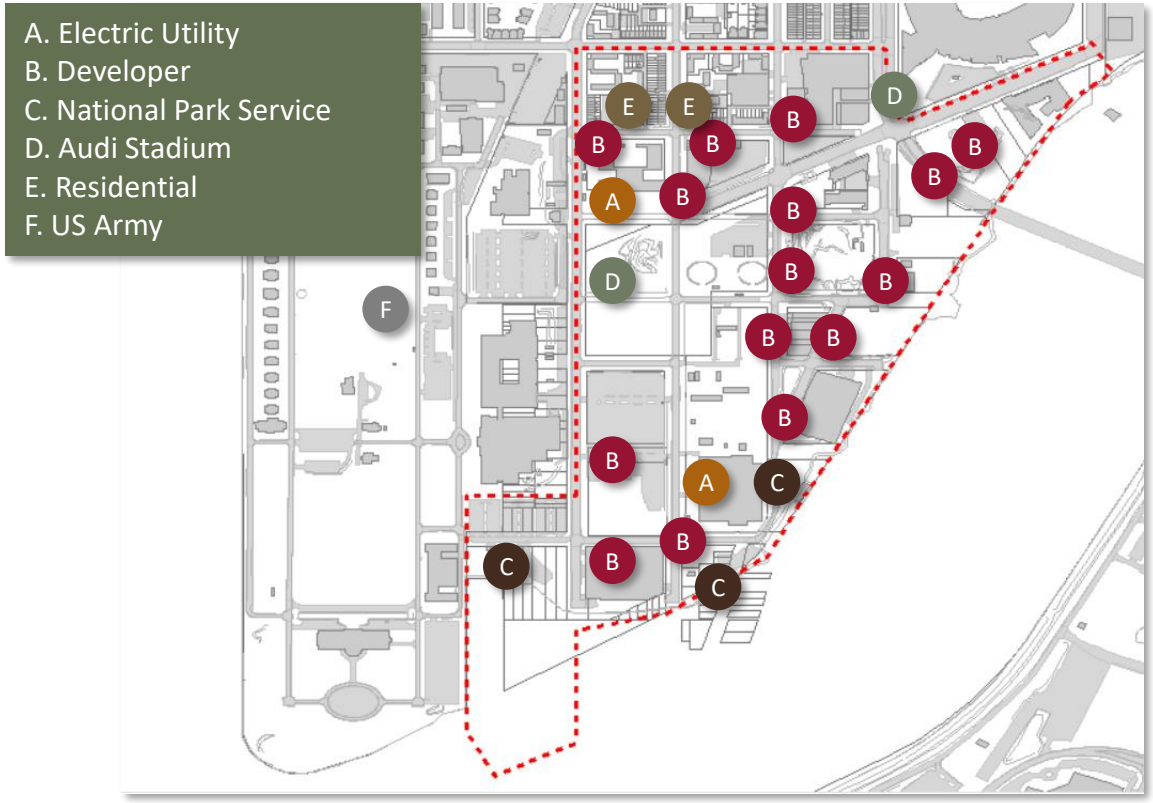
Multiple land ownership and land function in addition to transportation infrastructure and assets

- Multiple institutional stakeholders engaged
- Private parties will be engaged in further planning efforts
- Solutions to explore need to account for land ownership, right of way, required easements
- Flood exposure is multi-sector, multi-stakholder



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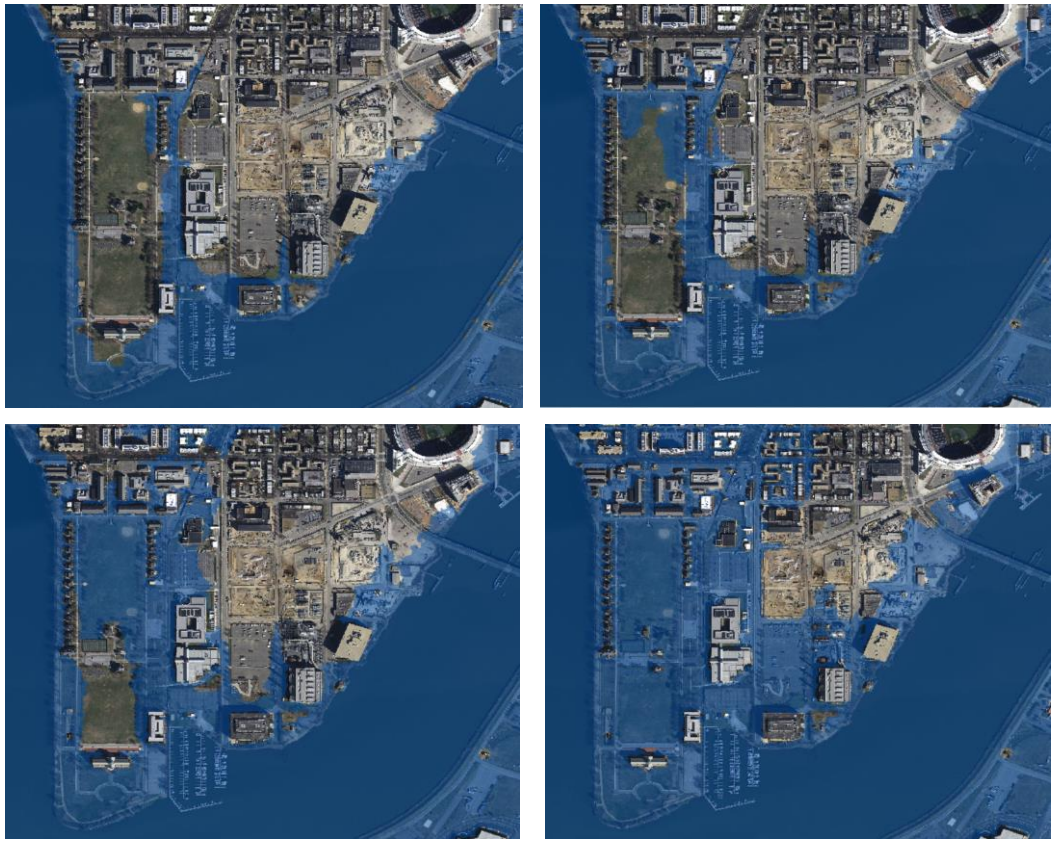
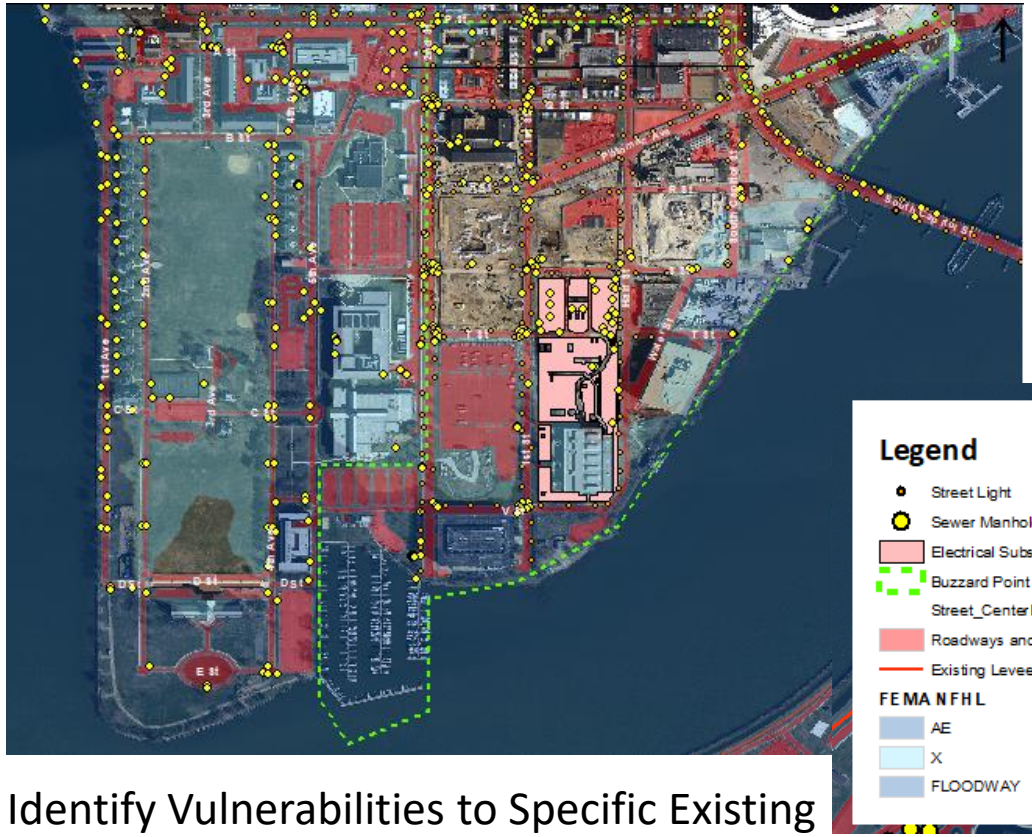
Conducted hydrodynamic modeling, combining coastal model (Potomac and Anacostia rivers are tidal) and riverine models

Multiple Scenarios Modeled – Agreement on Scenarios is Key!





Identify Vulnerabilities to Specific Existing & Future Assets – Agreement on which assets is key!

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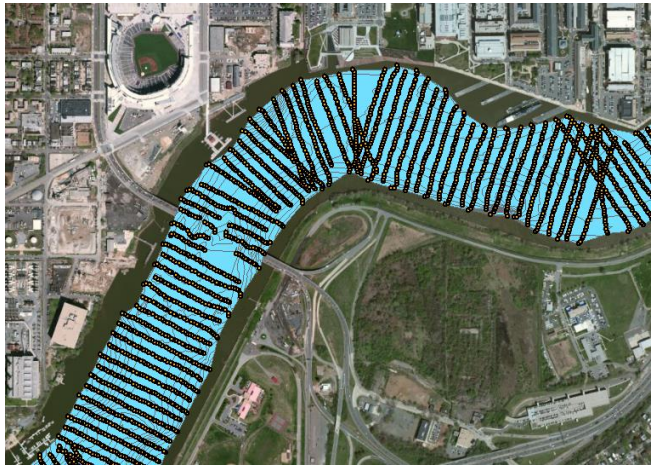
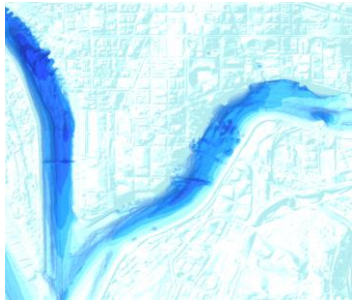
Key Insight: Technical details matter in different degrees to different stakeholders – need to engage agencies with the information that they care about

2018 LiDAR (Ground Points)

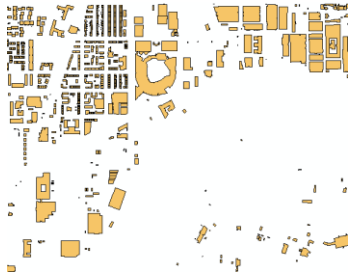


USACE Bathymetry Survey 2012

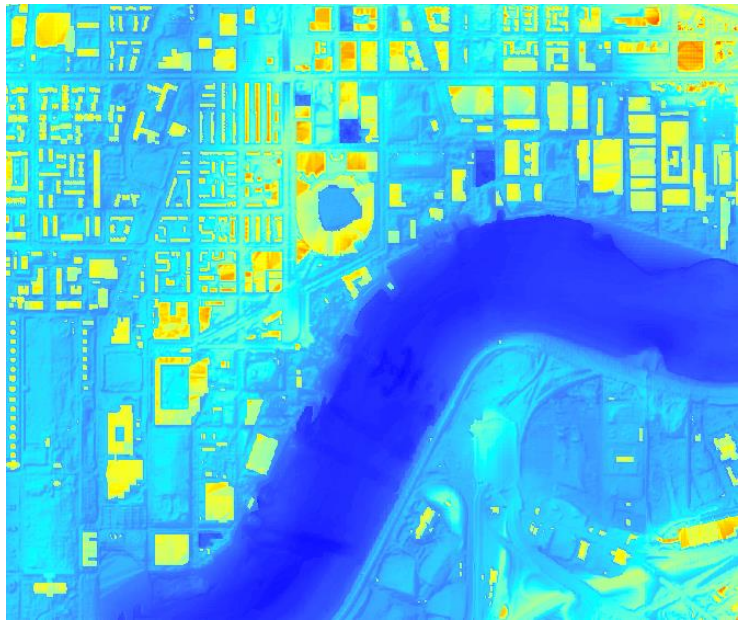
Digital Elevation Model (DEM) development multi-step transparent process



Combined LiDAR and Bathymetry DEM



Building Footprints



Combined DEM
[Buildings at 50 ft above ground surface]

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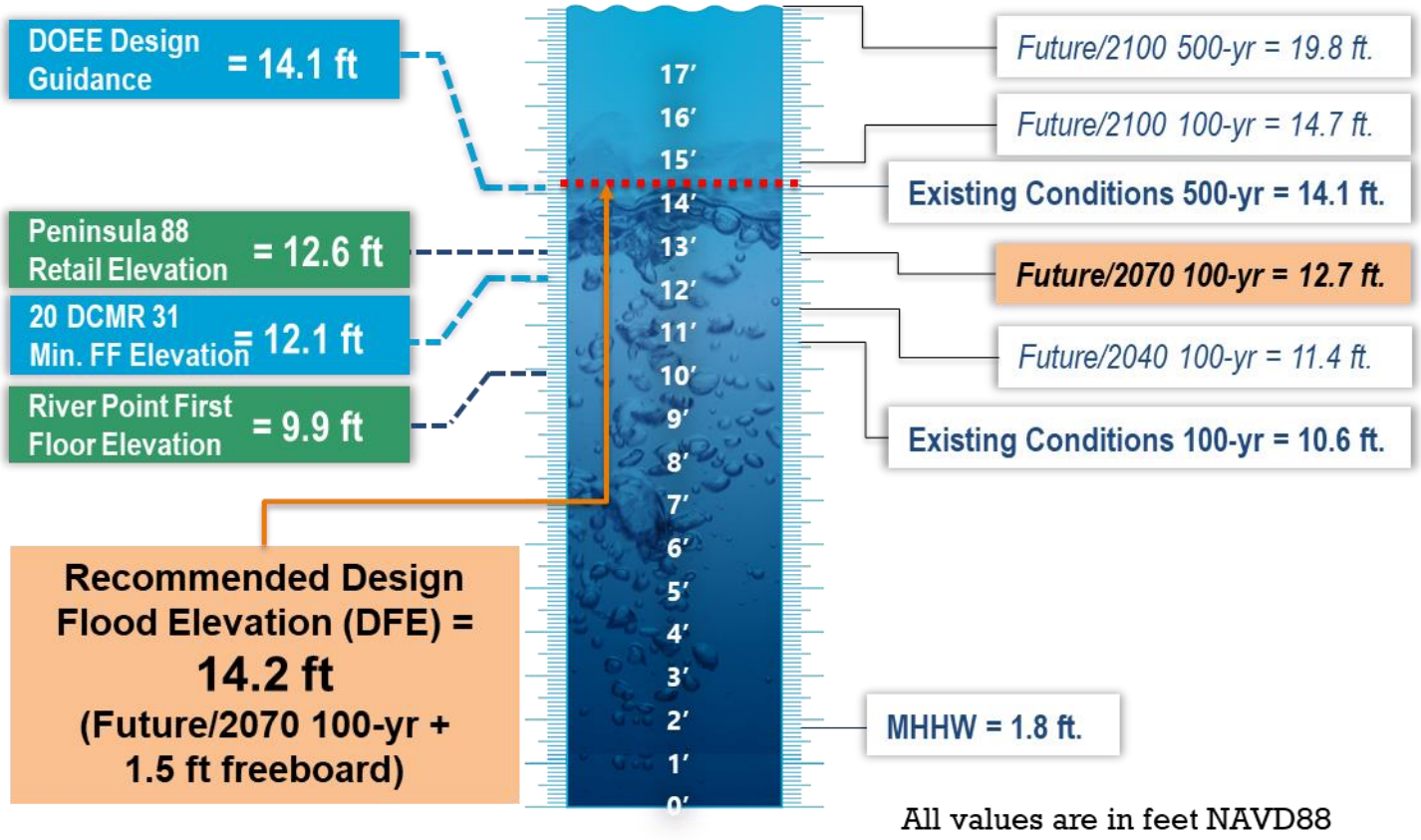
Definition of Design Flood Elevation critical in the process: level of protection and level of investment are correlated

- Based on multiple scenarios and level of exposure
- Informed by vulnerability
- Informed by existing codes and standards
- Informed by overall future conditions under climate change



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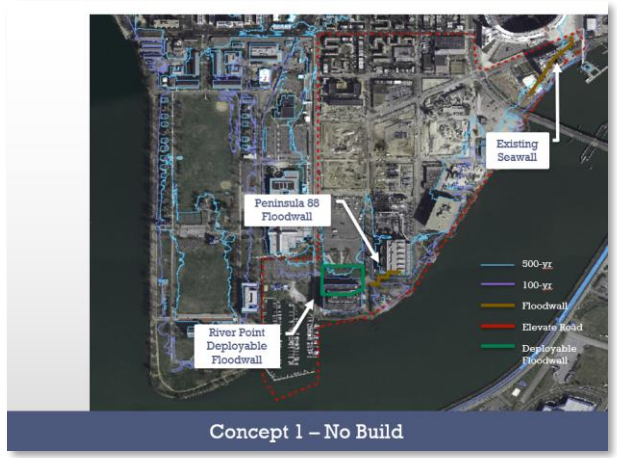
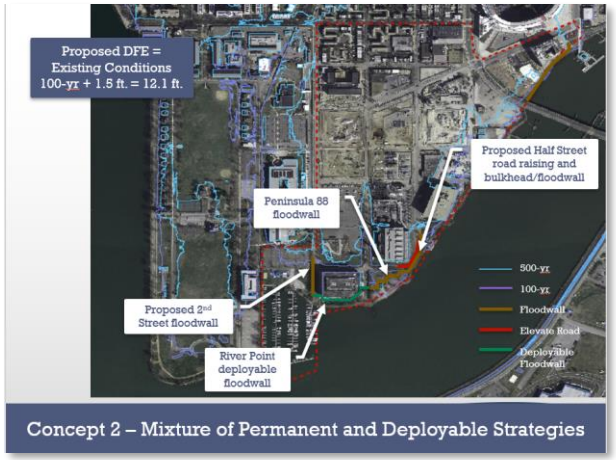
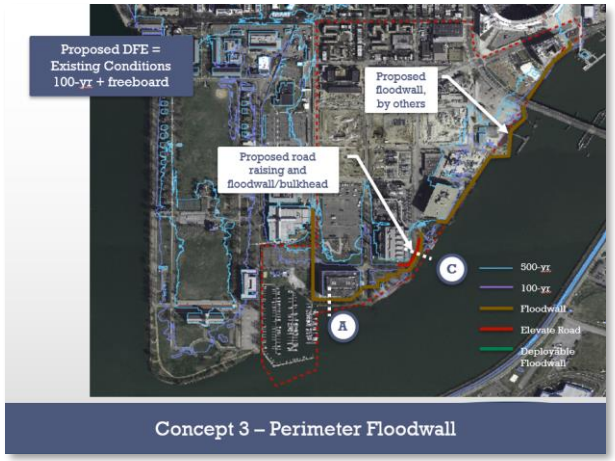
Multiple concepts characterized in terms of multiple criteria



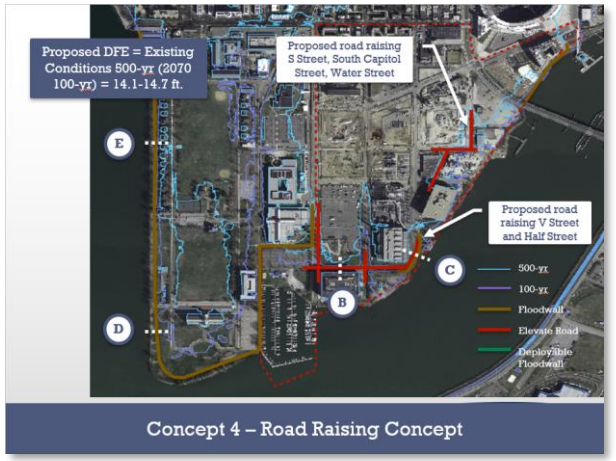
Concept 1 – No Build



Concept 2 – Mixture of Permanent and Deployable Strategies



Concept 3 – Perimeter Floodwall



Concept 4 – Road Raising Concept

Category and Criteria	Weight	Max Points
Performance		
1. Effectiveness based on selected flood event	25%	25
2. Ease of operation and maintenance	10%	10
3. Inspection needs	5%	5
Constructability		
4. Complexity of construction	10%	10
5. Schedule duration	5%	5
6. Conflicts with existing drainage and utility infrastructure	5%	5
Implementation		
7. Complexity of Agency Approvals	5%	5
Community Compatibility		
8. Compatibility with Buzzard Point Vision Framework	20%	20
9. Compatibility with Anacostia Waterfront Framework	5%	5
10. Impacts to existing or approved land use	10%	10

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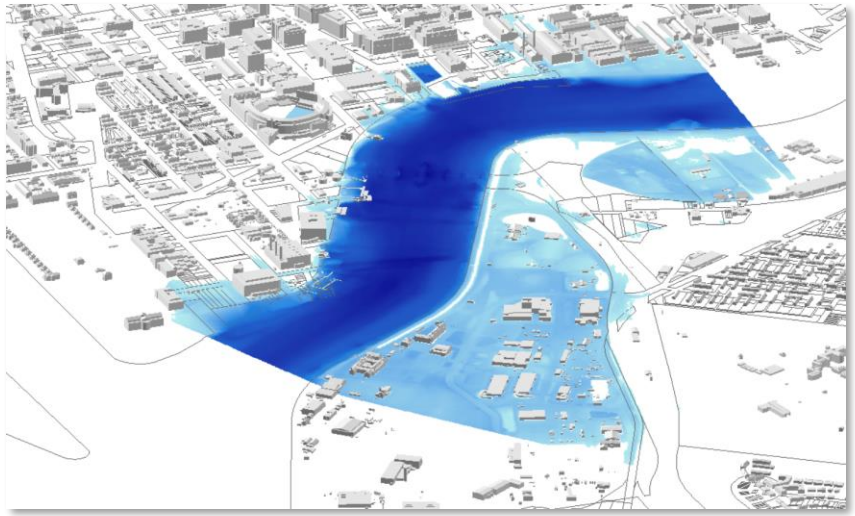
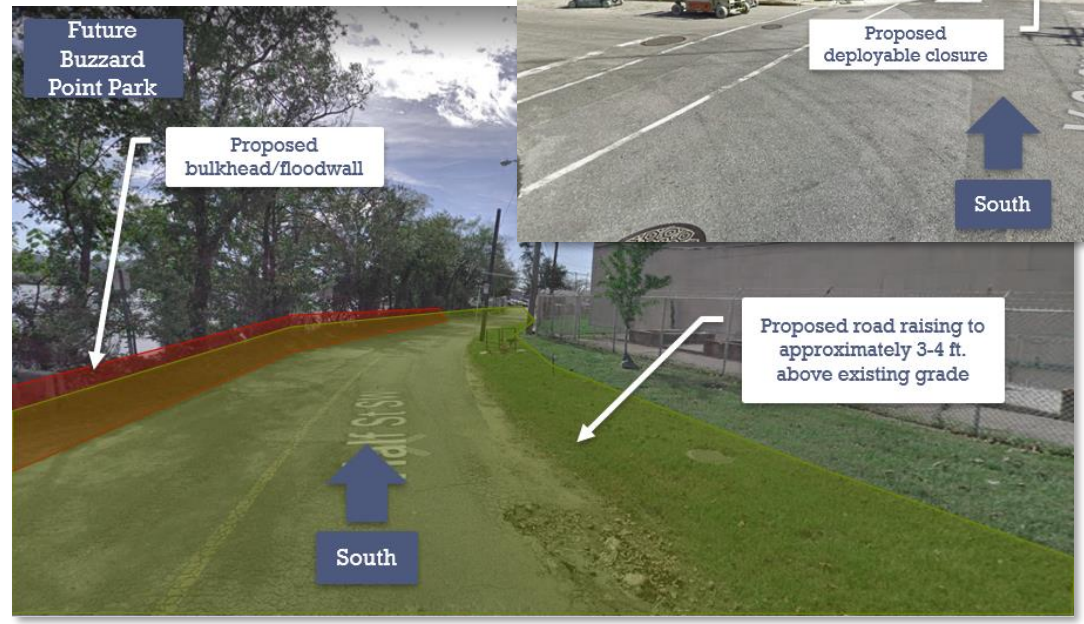
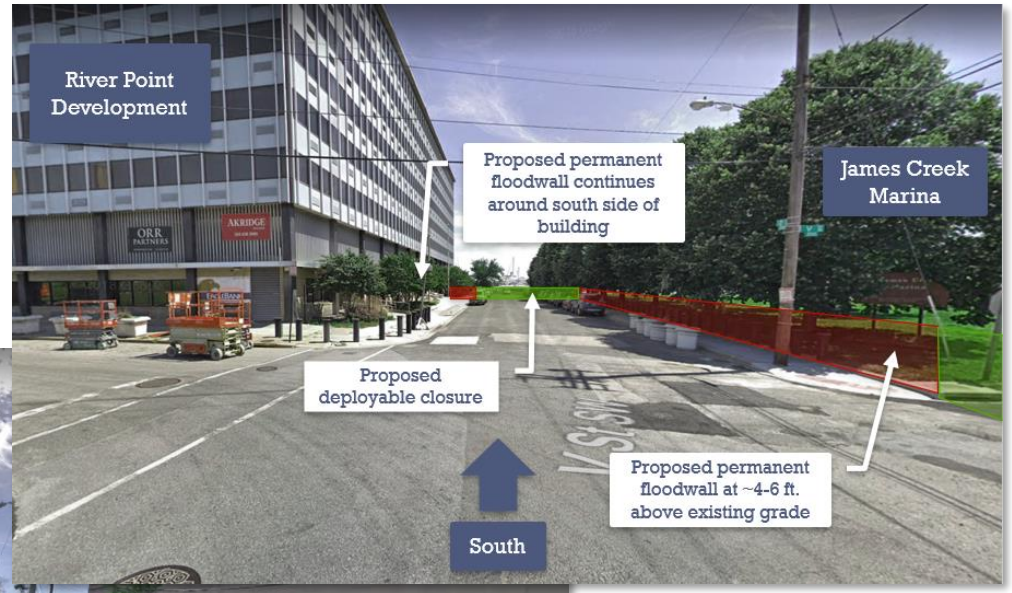
Key Insight: Renderings of flood conditions and proposed concepts are critical in urban environments with multiple stakehodlers







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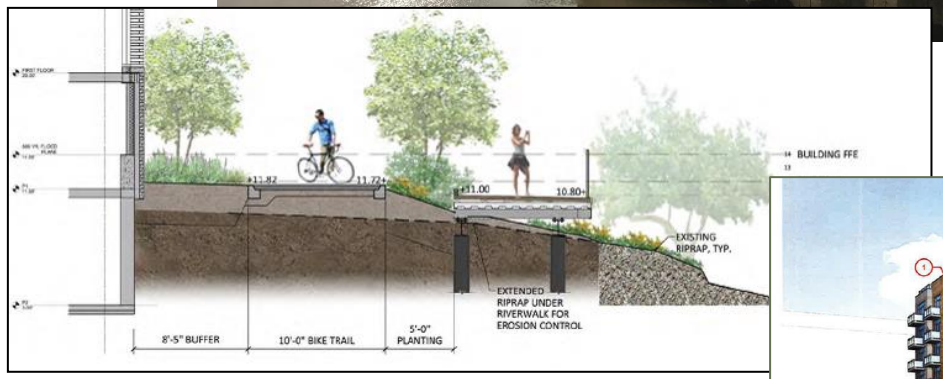
Key Insight: existing and planned mitigation measures are critical to build upon and some of them will fall beyond your jurisdiction

- Can we count on plans from other agencies and parties?
- Can we align with their schedules?
- Can we rely on structures designed, built, maintained and operated by others, including private parties?
- Can they rely on solutions?



August 9, 2018 Revisions to 1900 Half Street Zoning Submittal

2018 Revisions to Peninsula 88 Zoning Submittal

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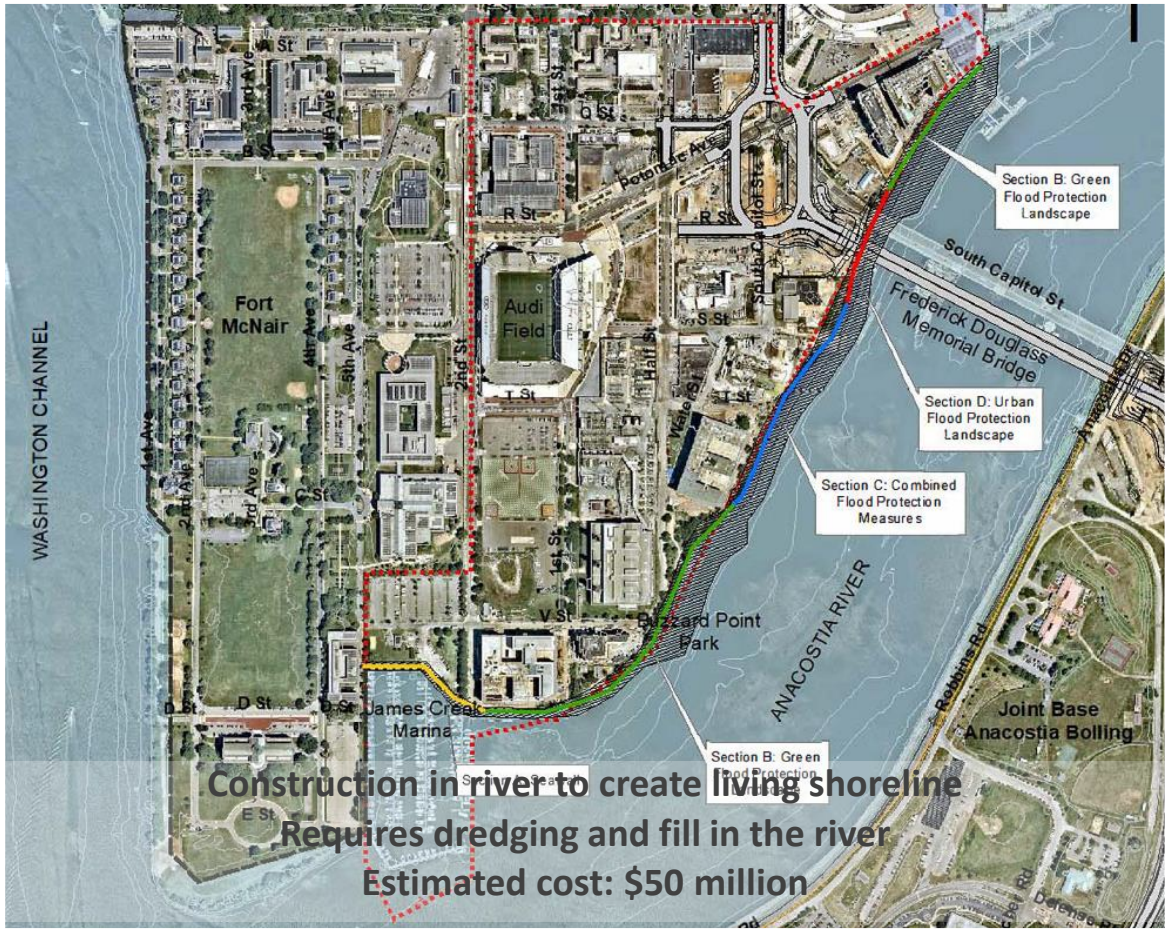
Nature-Based concept selected will include a living shoreline in combination with other typologies as necessary

- Further definition of technical details
- Feasibility of specific typologies for different reaches in the shoreline
- Environmental documentation
- Funding
- Additional agency engagement



Questions & Answers

Riverine Flood Resilience in an Urban Environment – Buzzard Point Floodplain Feasibility Study Washington DC District Department of Transportation

March 23, 2021

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Common Process in Risk and Vulnerability Assessments

- Step 1 is not trivial and it sets the path for the rest of the project
- The framework responds to the drivers
- Buy in from project team (from staff up to “C-suite”) and elected officials is critical
- Forecasts and state of science continuously evolve

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Poll

- Status of your own organization risk and resilience assessments

Quantifying Vulnerability and Risk: Case studies in Resilience

Open Discussion

AMONTario Climate Change & Asset Management Conference

March 23, 2021

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