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City of Virginia Beach Comprehensive Sea Level Rise and Recurrent Flooding Response Plan

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City of Virginia Beach Comprehensive Sea Level Rise and Recurrent Flooding Response Plan

October 13, 2017

Study Goal and Outcomes

Goal:

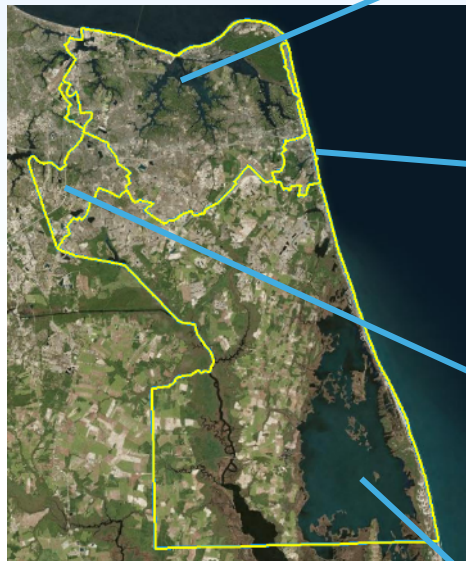
Produce information and strategies that will enable Virginia Beach to establish long-term resilience to sea level rise and associated recurrent flooding





Outcomes:

- A full understanding of flood risk and anticipated changes over planning and infrastructure time horizons
- Actionable flood resilience plans that combine engineered protection measures, accommodation, and/or land use management strategies
- A fine-tuned public outreach process to advance resilience initiatives

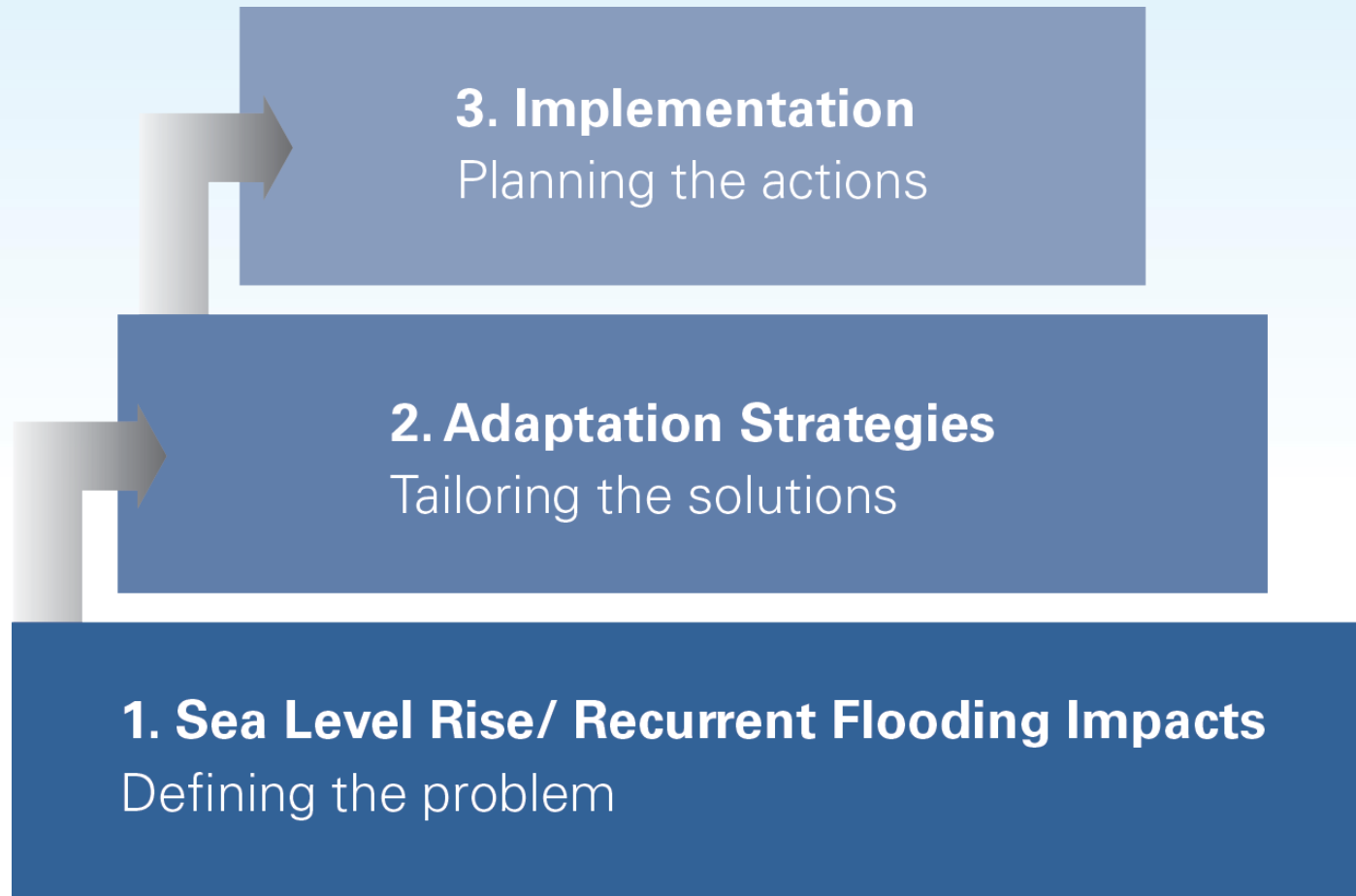
Watershed Level Plans

- Economic and environmental diversity require 4 distinct plans



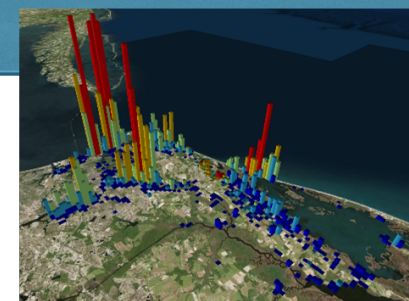
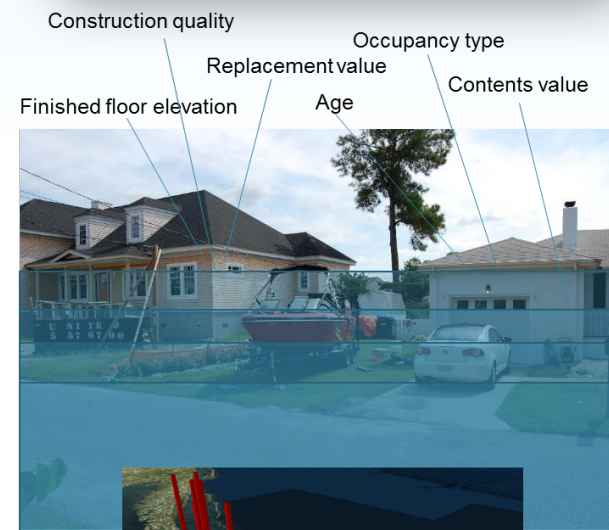
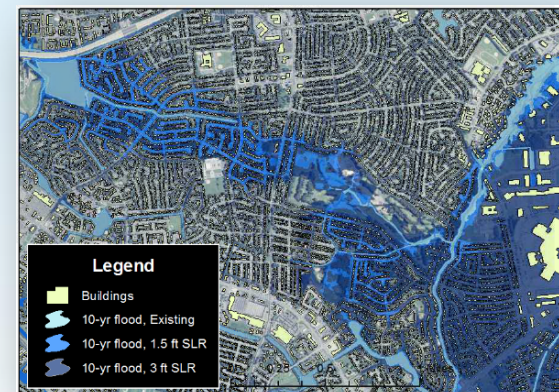
Planning Area/ Natural Resources	Defining Characteristics	Challenges
Lynnhaven / Tidal sheltered bay, estuarine, fringing marsh 	Mixed residential, military, commercial, lower elevation properties with high tax base. High quality natural resources. Assets at vulnerable elevations.	Addressing repetitive losses from recurrent flooding and preservation of low-lying natural resources.
Oceanfront / Ocean, headland beaches, tidal inlet, bay 	Dense commercial and residential development. Tourism as primary economic driver. Redevelopment opportunities. USACE Civil Works flood risk reduction project.	Protecting existing development and economic base while instilling resilience as a keystone in redevelopment.
Elizabeth River / Estuarine, fringing marshes 	Dense residential, commercial, industrial development. Aging infrastructure.	Upgrading infrastructure and maintaining water-based industrial economy with higher sea levels.
Southern / Ocean, barrier beaches, back bays and extensive marshes 	Light residential, military, rural, recreational, waterfowl and land preserves. Agriculture important economic concern. Low elevation gradients.	Establishing land use strategies that preserve resources and limit new development and infrastructure in areas susceptible to future flooding.

Comprehensive SLR Study Approach



Phase 1: Sea Level Rise/Recurrent Flooding Impacts

- Objective: Identify the location, frequency and potential cost of existing and future flood risk to the City
- How will vulnerability change with increasing flood levels due to SLR?
 - Where will we see the flood footprint expand?
 - How much more frequent will flooding occur?
 - What assets are vulnerable?
 - What are the losses, how will they change?
 - What assets are at the highest risk?

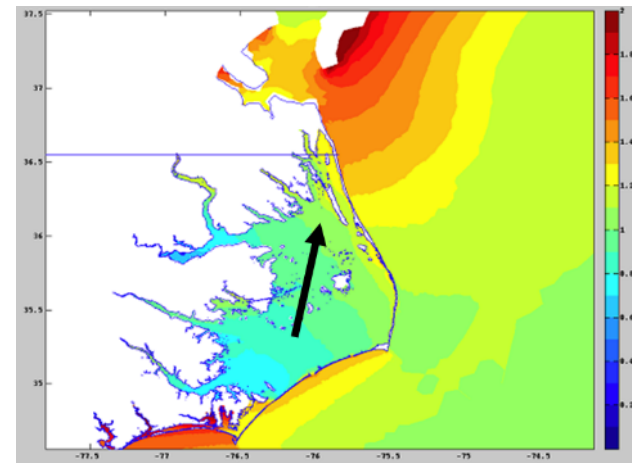
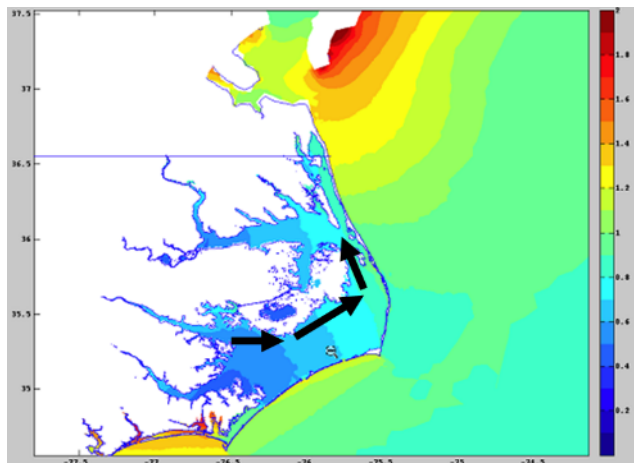


VB SLR Planning Scenarios

Life Cycle Alignment	Time Horizon/ Time Period	SLR Value	Relevance	Use
Municipal Planning	20-40 years 2035-2055	1.5 ft	Comprehensive Plan & Outcomes Short end of Commercial and Utility life-cycles	Vulnerability assessment Key planning value Basis for evaluation of all adaptation strategies
Critical Infrastructure Long-term awareness Adaptive Capacity	50-70 years 2065-2085	3.0 ft	Utility Infrastructure life-cycle Transportation infrastructure lifecycles Residential structure lifecycles	Secondary vulnerability assessment to provide insight into long-term risk Basis for long-term infrastructure decisions Evaluate cost-effectiveness of additional protection for adaptable resilience strategies

Flood elevations - Not a static increase!

- SLR Integration:
 - 1.5 ft SLR scenario
 - Added as a static increase to surge elevations
 - Non-linear aspects captured through re-evaluation of dune erosion and wave modeling over increased water levels.
 - 3 ft SLR scenario
 - Detailed modeling from USACE and North Carolina used to integrate non-linear response in surge elevations
 - Wave modeling and dune erosion also re-evaluated.



Flood Assessment Conditions



- Tidal
 - Daily tidal flooding
 - Future permanent inundation
 - Defined by NOAA, Mean Higher High Water



- Nuisance
 - Wind-driven surge, extreme tide events
 - Repetitive losses/
loss of function or service
 - Defined by water level analysis



- Storm Surge
 - Nor'easters, tropical storms, hurricanes
 - 10-, 25-, 50-, 100-, 500-yr recurrence intervals
 - Defined by probabilistic analysis

Hazard Assessment Process

Flood Stillwater Surfaces

Integrate best source data into seamless 3D surface

SLR Non-linearity

Apply non-linear factors to surfaces

Floodplain Delineation

Map new floodplains at each flood frequency

Wave Hazard Modeling

Model changes to wave heights/dune erosion

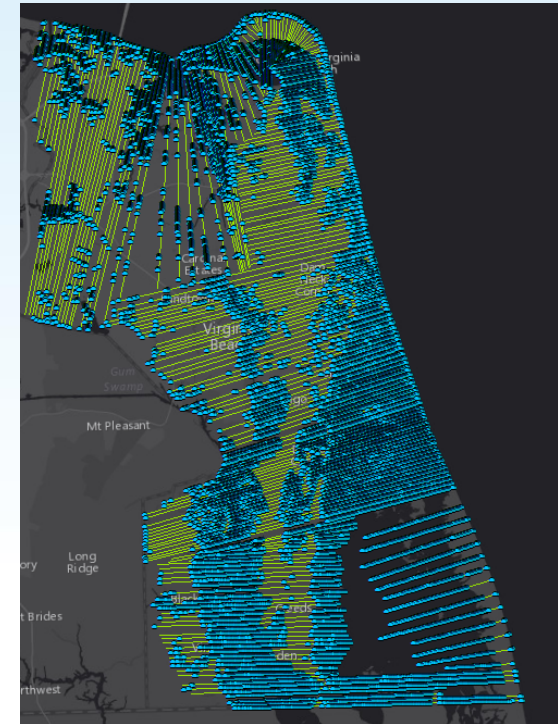
Total Flood Elevation Surface

Build new 3D surface including wave effects

Depth Grids

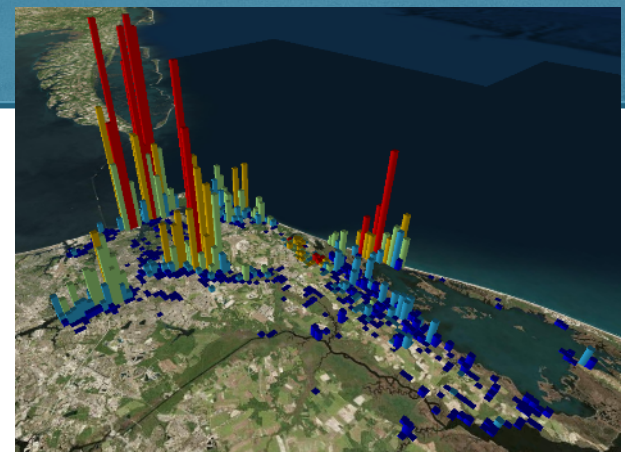
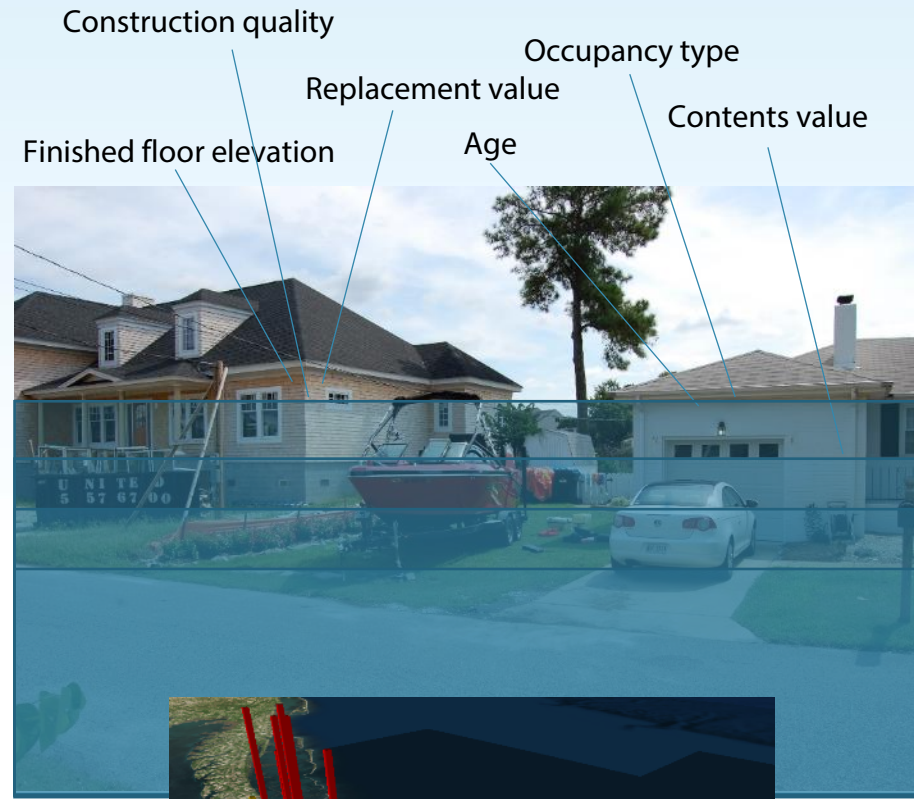
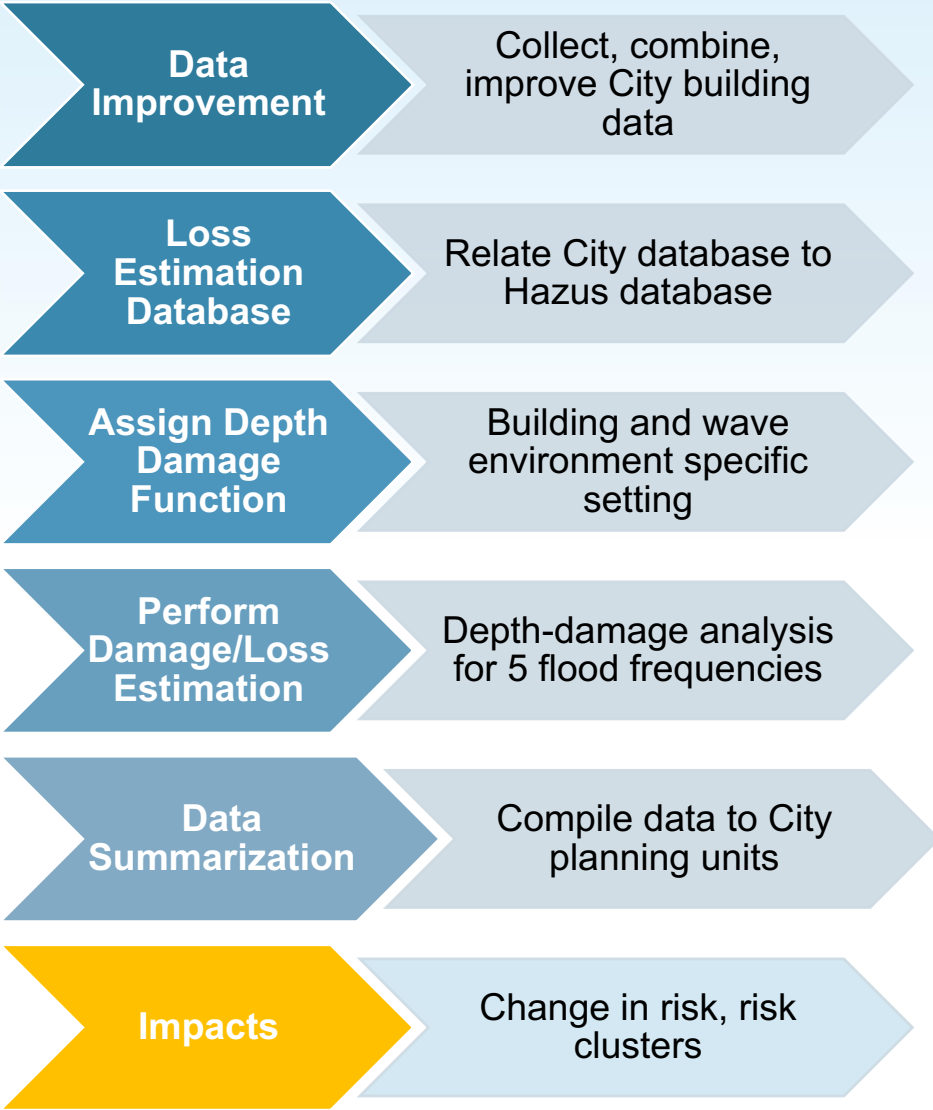
Calculate depth of flood for each condition

To Loss Estimation



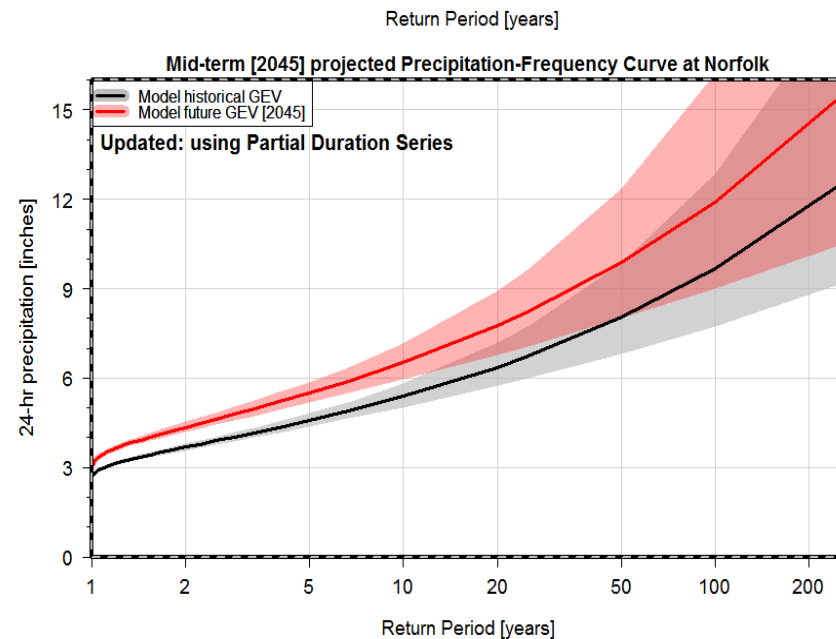
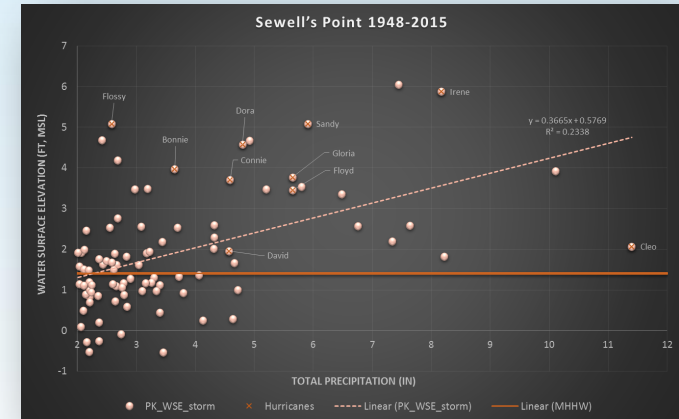


Loss Estimation Process



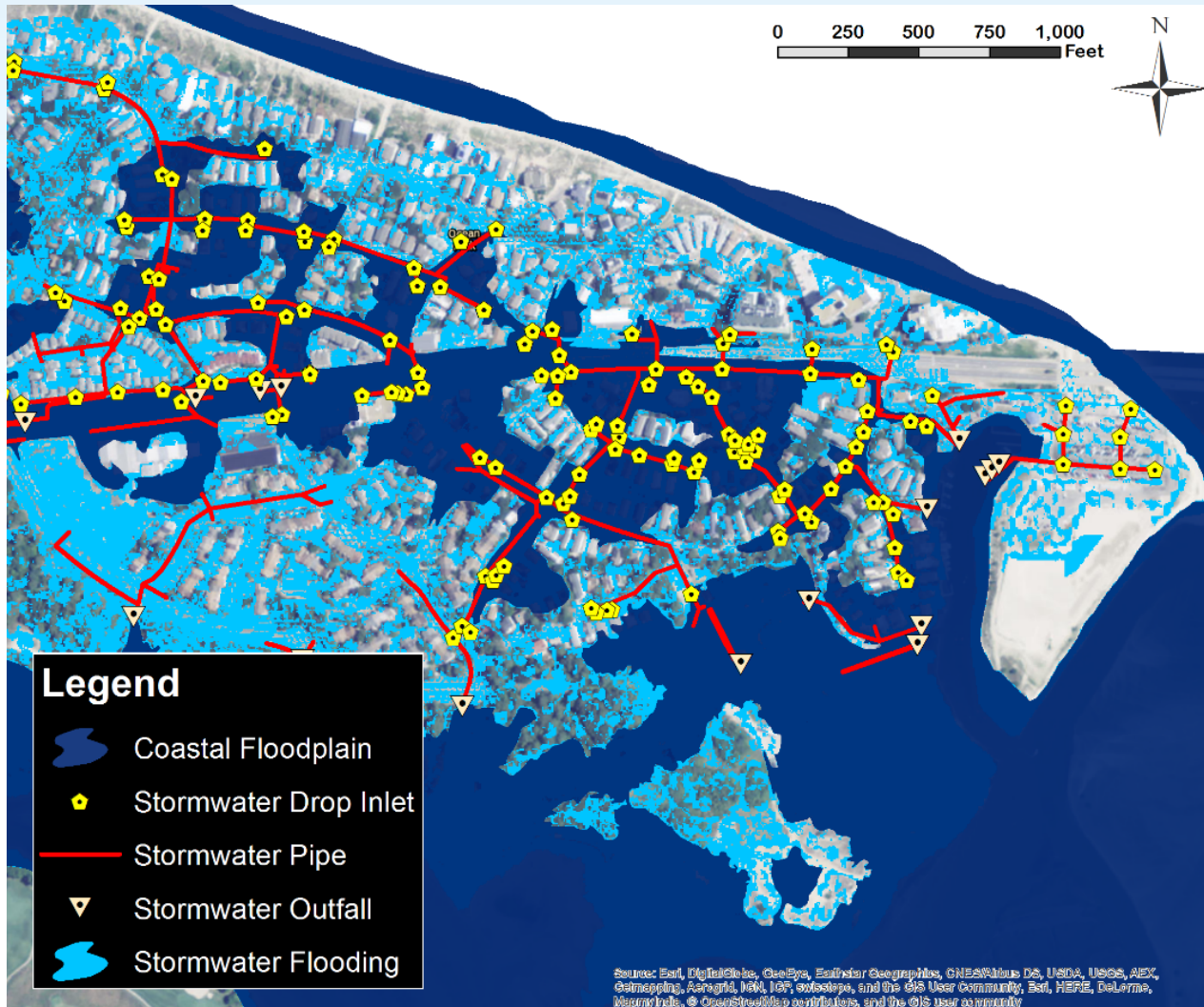
“Whole Picture” Analyses

- Rainfall/surge correlation
 - >50% of rainfall events occur during elevated water levels
- Joint-probability of rainfall/storm surge
 - Rainfall/surge design probabilities
- Regional Precipitation Trends
 - Heavy rainfall increasing
- Future precipitation conditions
 - Up to 20% increase in design rain
- Probable maximum event precipitation
 - Design “check storm”



Stormwater incorporation

- Higher coastal water levels diminish stormwater system performance

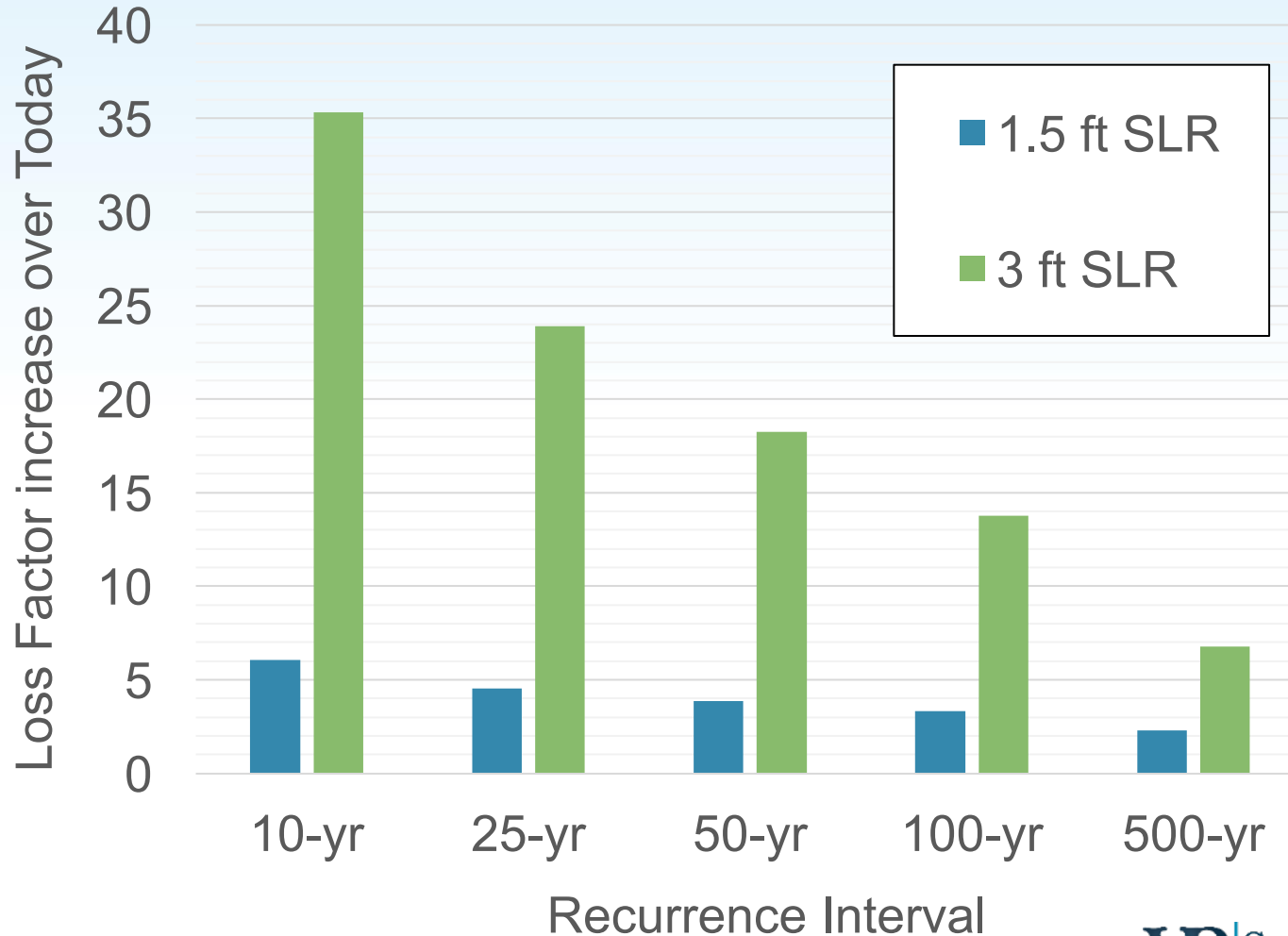


- Coastal Flooding
- Stormwater Conveyance
- Combined Flooding

Loss Information - Context

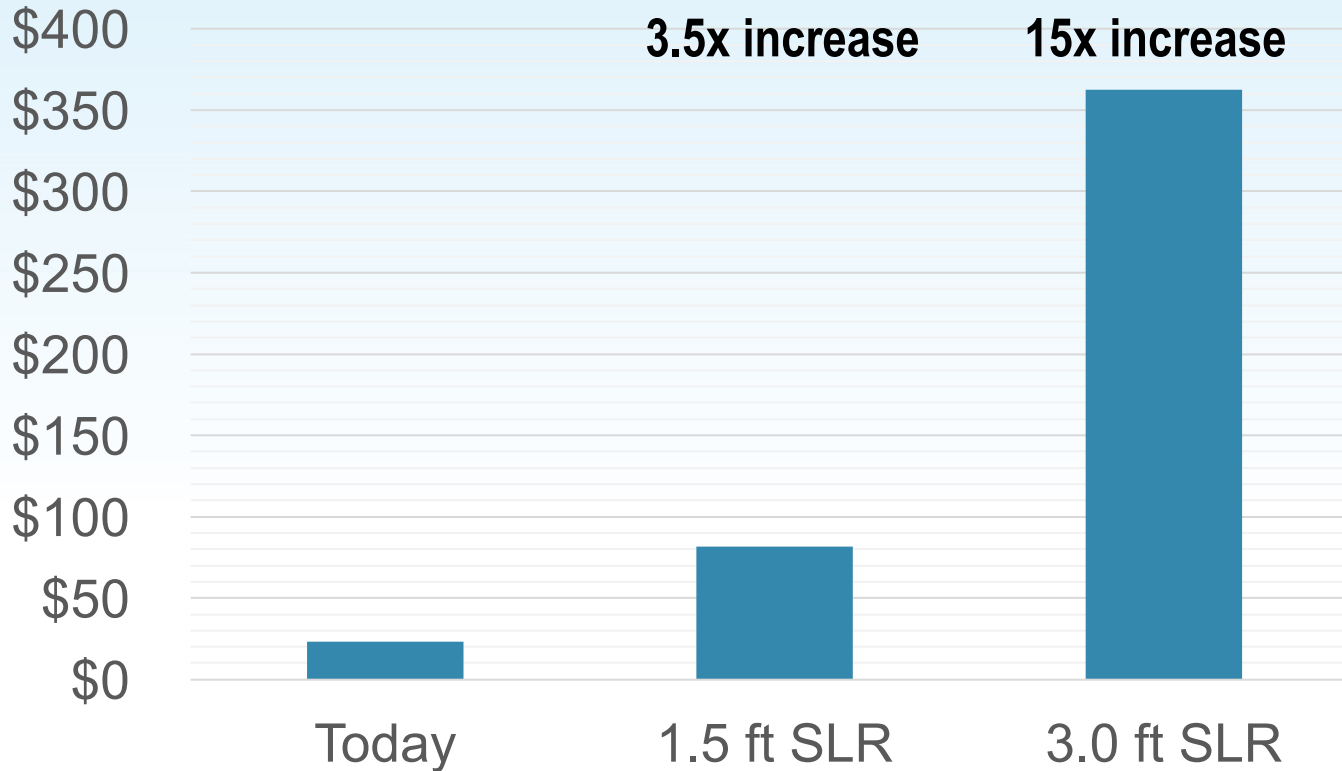
- Losses represent today's built environment and flood control infrastructure
- In today's dollar - future losses do not include inflation
- Potential reduction of loss by flood risk management strategies NOT represented
- Starting point for identification of needed policy and engineering measures

City-Wide Loss Factor Increases Over Today



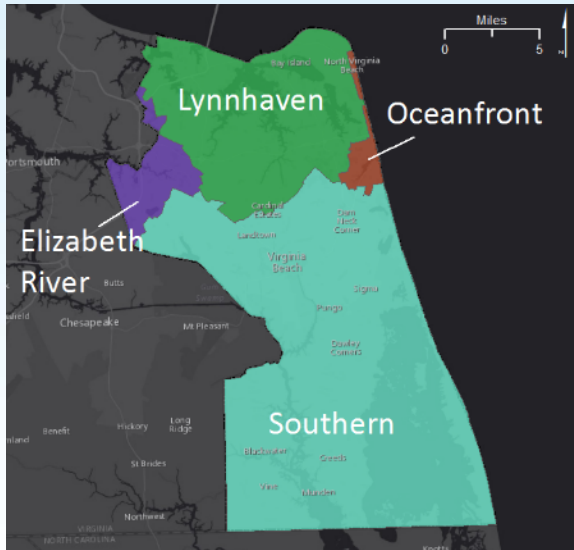
Projected Changes in Flood Loss

Annualized Losses (Millions)



4.4x increase over 1.5 ft

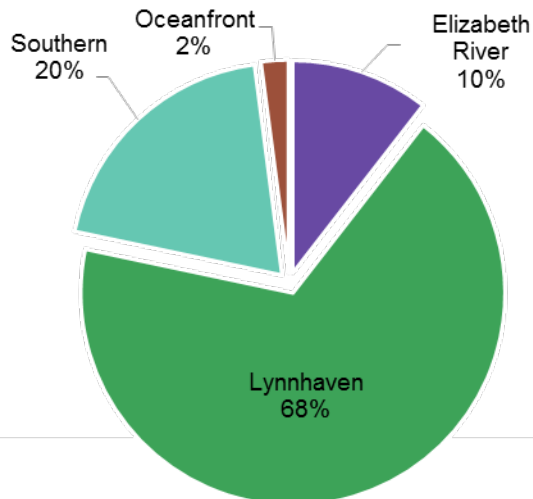
Watershed Loss Changes with SLR



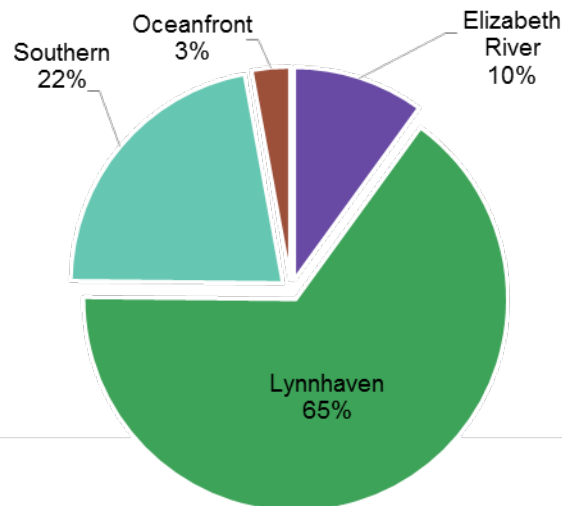
Annualized Losses, Millions

Watershed	Today	1.5 SLR	3 ft SLR
Elizabeth River	2.48	8.18	23.60
Lynnhaven	15.97	53.27	158.14
Southern	4.62	17.94	165.31
Oceanfront	0.49	2.37	15.72
Total:	23.56	81.76	362.77

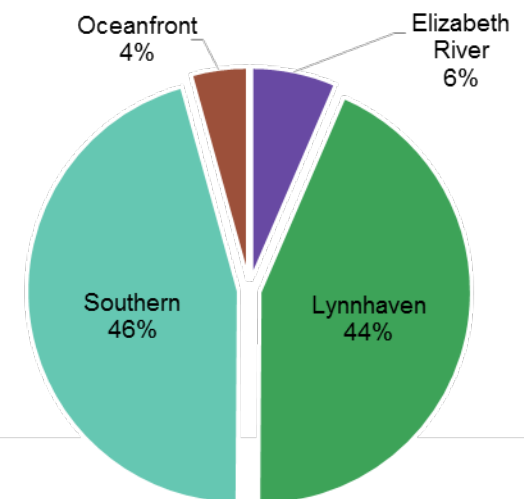
Today



1.5 ft SLR

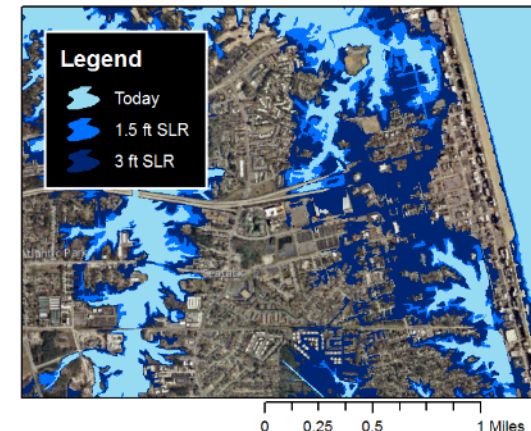
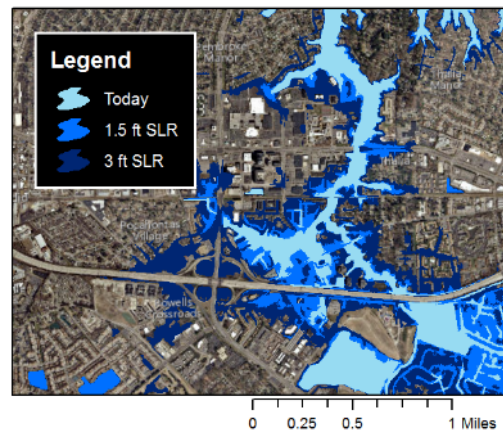
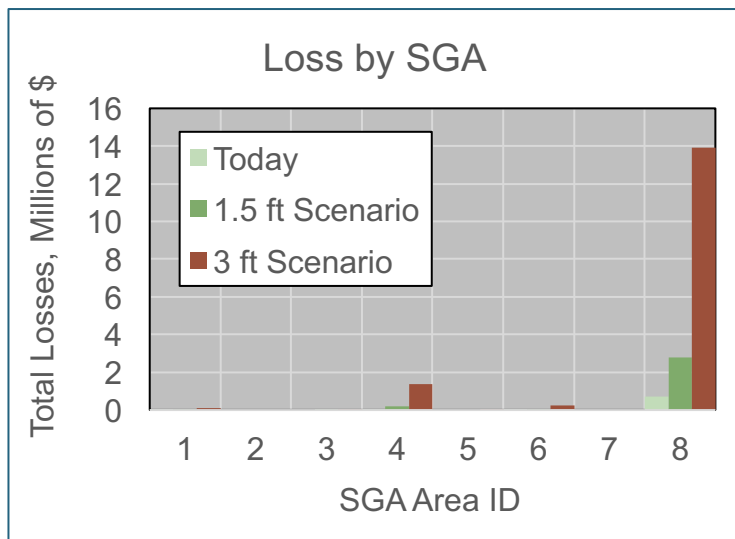
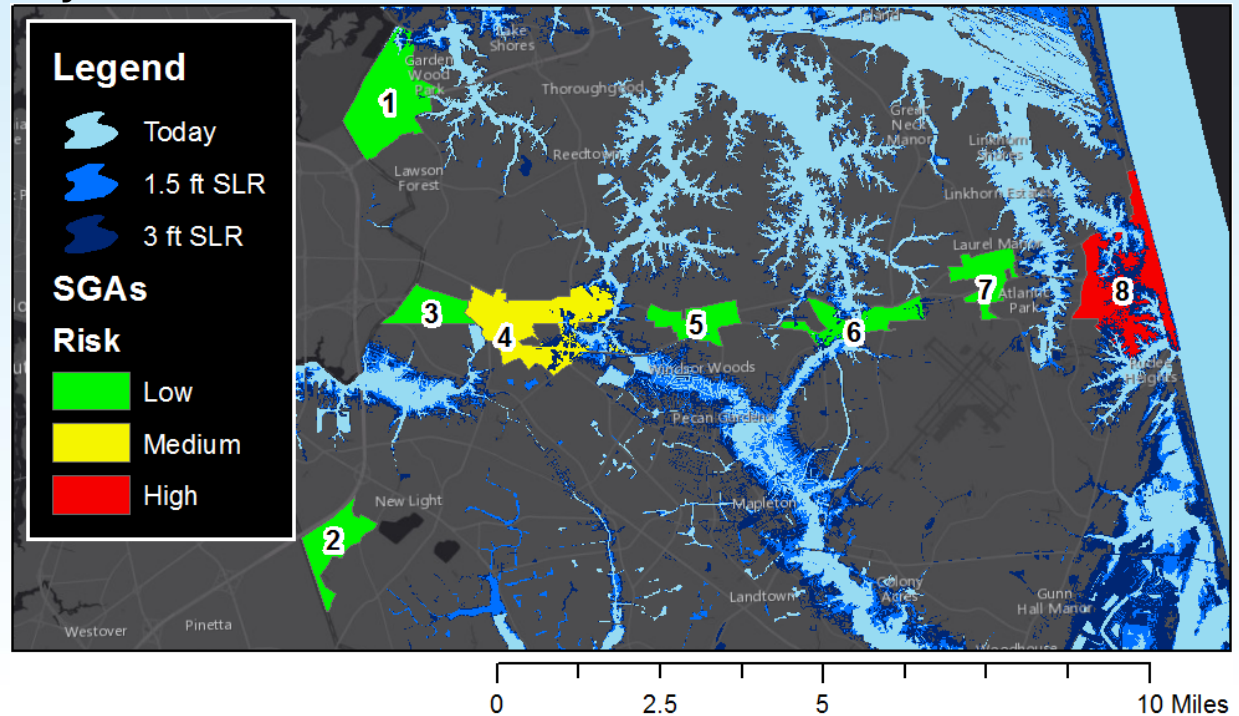


3 ft SLR



50-yr recurrence interval flood, 3 ft SLR Scenario

Strategic Growth Areas



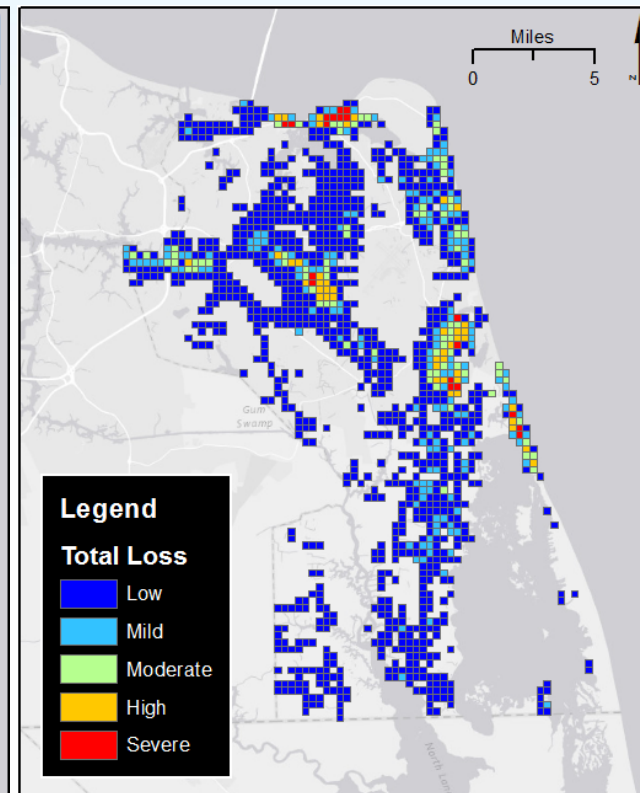
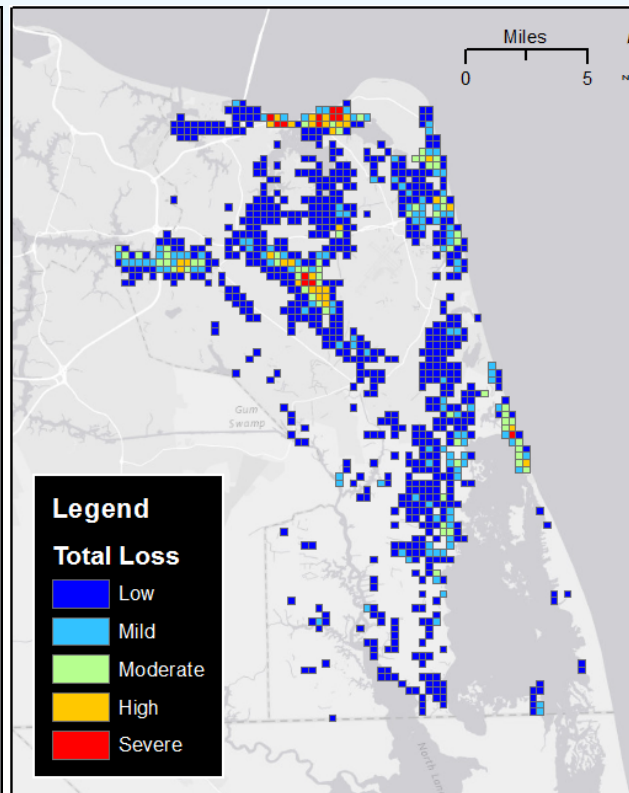
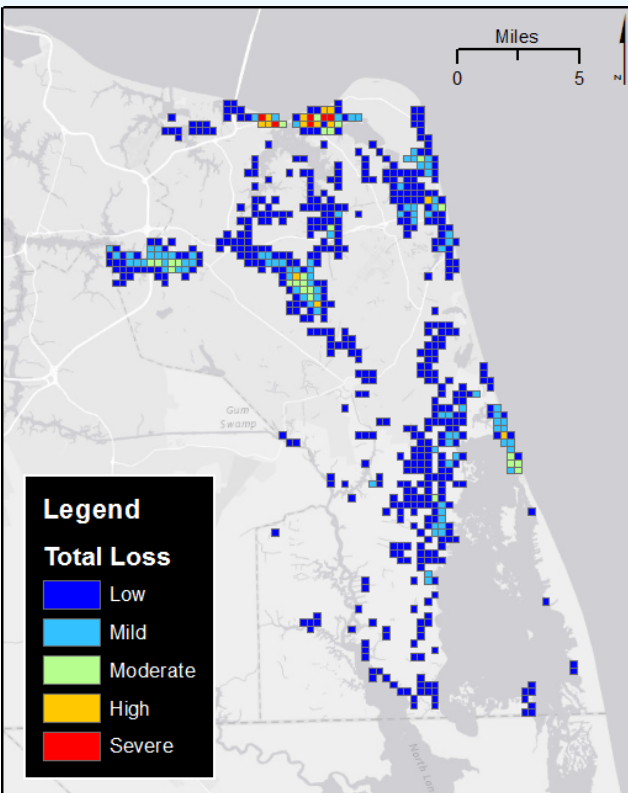
Annualized Loss Concentration

- Intensification and Growth

Today

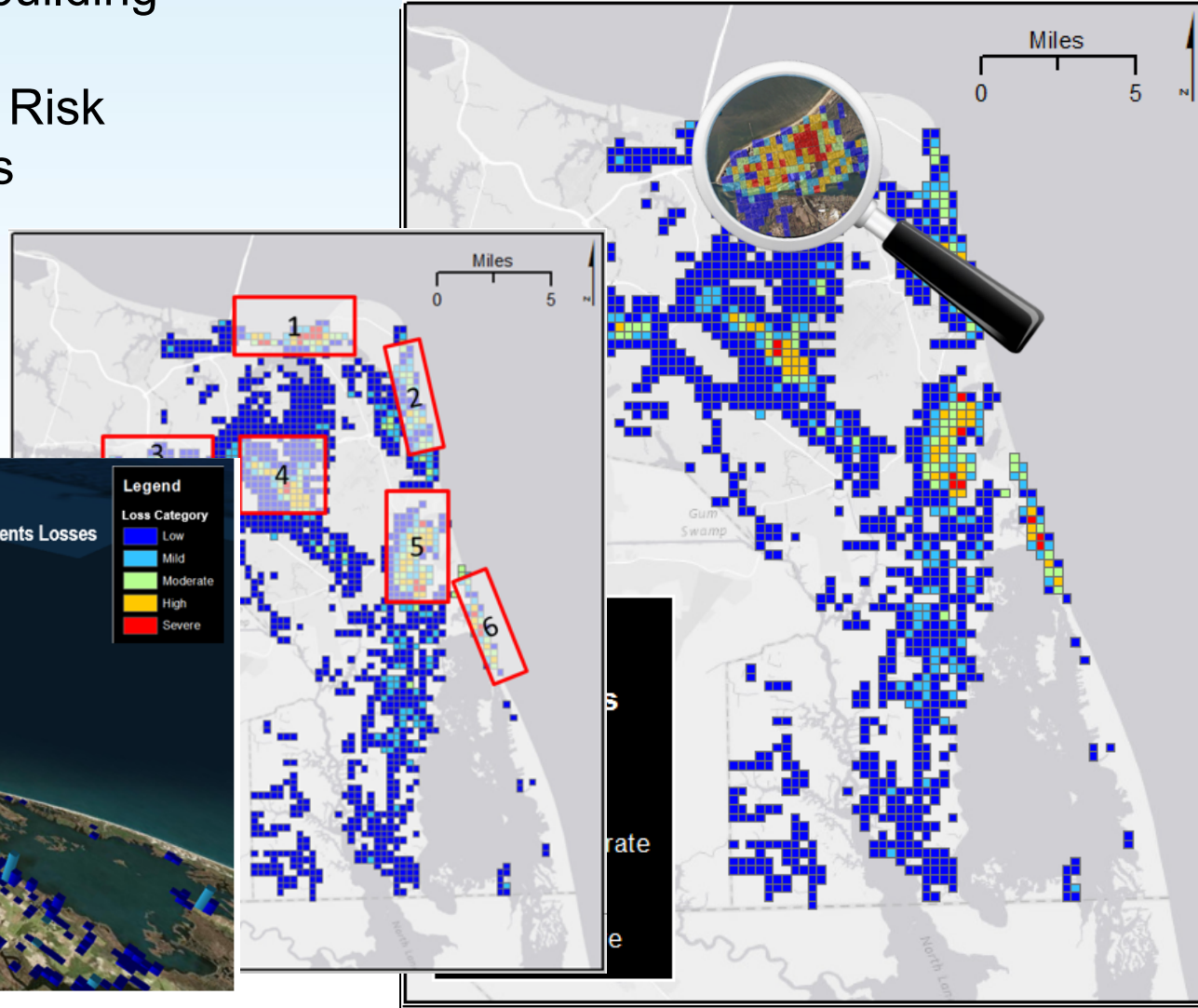
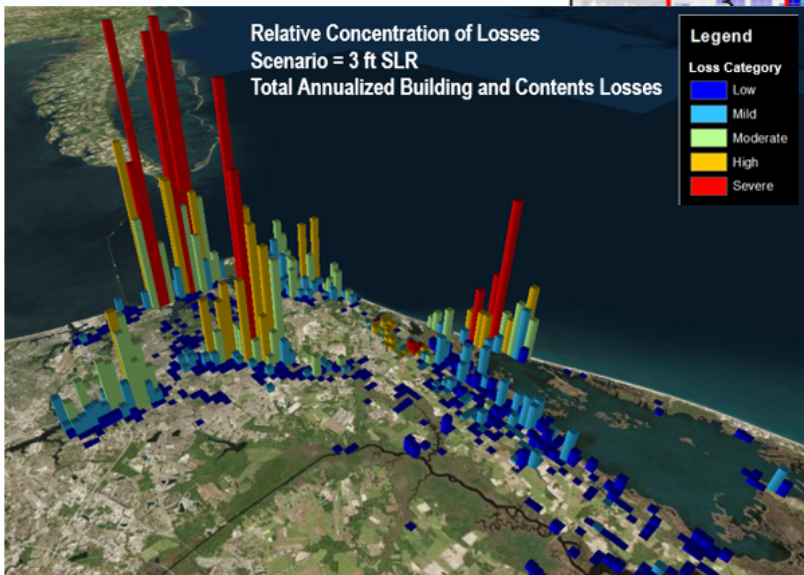
1.5 ft SLR

3 ft SLR



Concentration of Risk

- Aggregated from building level risk
- Efficiently ID High Risk Areas for solutions



Citywide Context

Most of the City has limited coastal flood exposure, in clustered areas

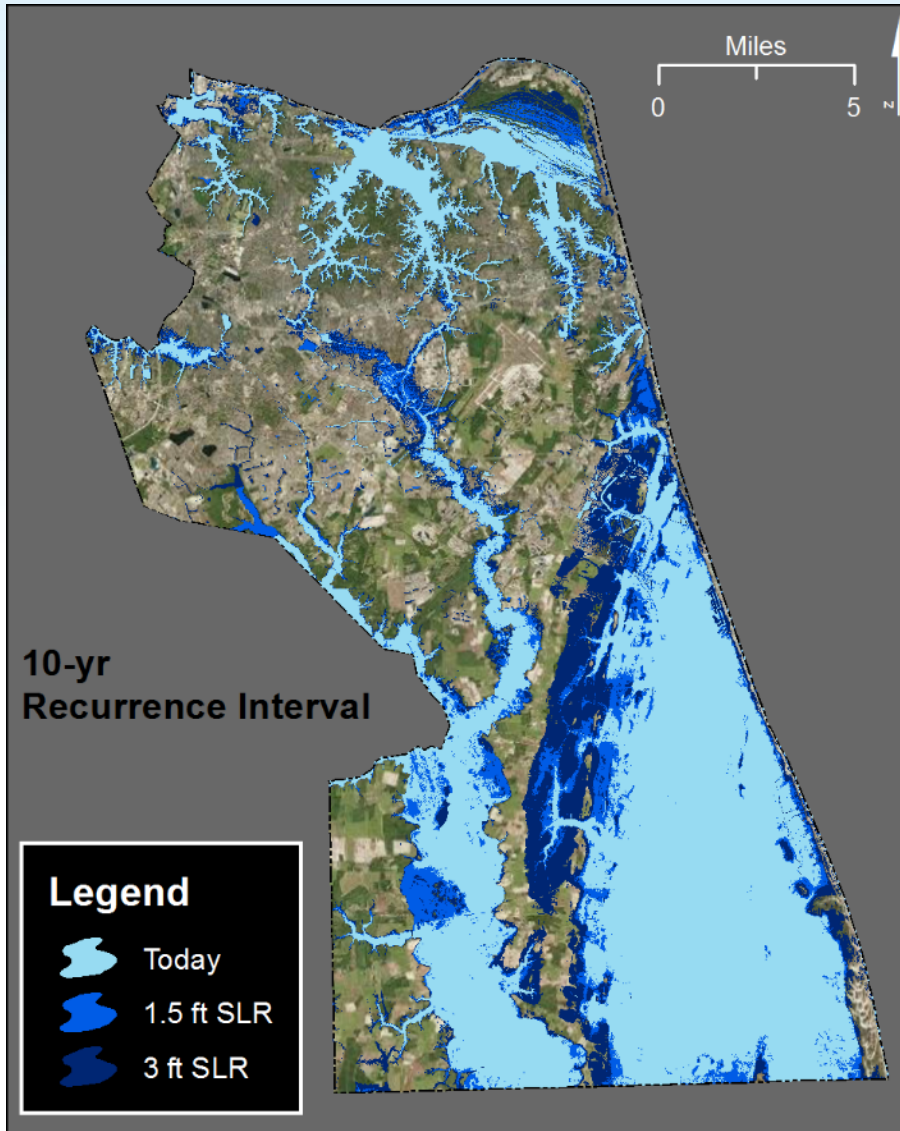
- Today: <1% of buildings
- In 30 years: 2% of buildings
- In 60 years: 7% of buildings

Bottom line:

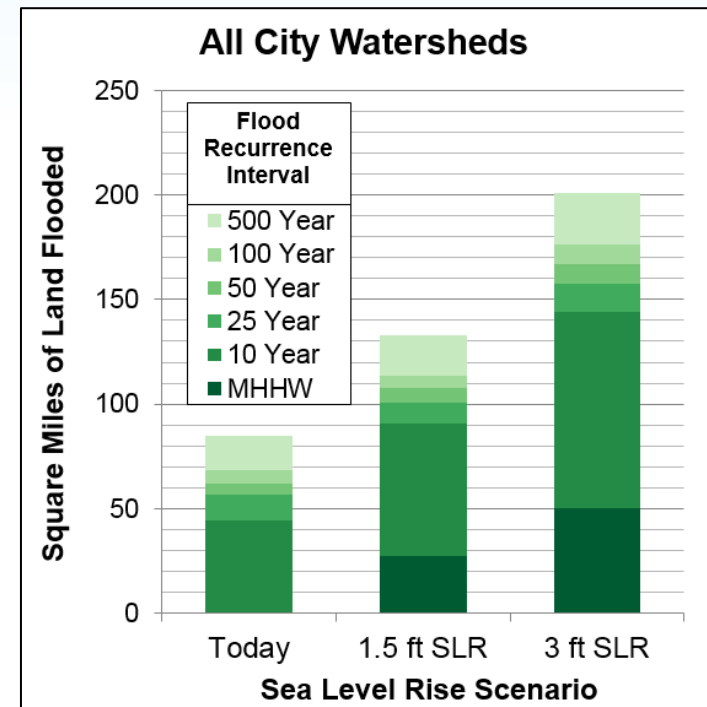
Proactive solutions *can* help the City avoid future losses



Projected Changes in Coastal Flooding



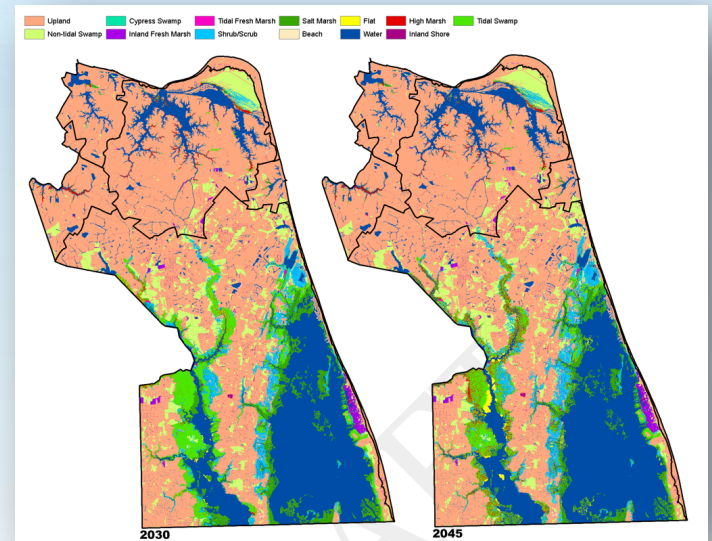
- Areas subject to flooding will increase:
 - In 30-40 years: 1.5 times
 - In 60-70 years: 2 times



Flood Impacts

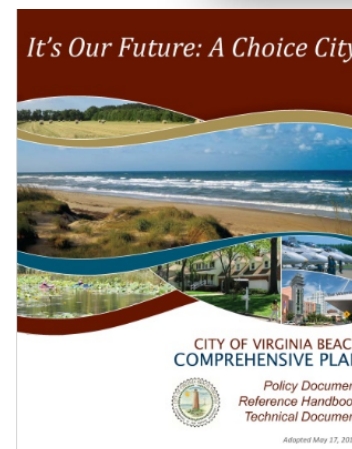
- Marsh Evolution Analysis

- Back Bay and North Landing River areas have the largest projected losses.
- Largest losses projected for Back Bay and North Landing River
- Lynnhaven – salt marsh expected to be resilient
- Initial discussion of implications and results to inform strategies



Phase 2: Adaptation Strategies

- **Objective:**
Develop, assess and prioritize a range of strategies through feasibility and cost-performance metrics to minimize short- and long-term flood risk
- What planning, policy, and engineering strategies are needed to address the risk portfolio?
 - What policy has to be created or changed?
 - How can land use be managed?
 - Where do structural solutions make sense?
 - What's the return on investment?
 - What strategies work best?
 - When should implementation occur?



APPENDIX K - FLOODPLAIN ORDINANCE ARTICLE I. - GENERAL PROVISIONS

Sec. 1.1. - Statutory authorization and purpose.

- A. This ordinance is adopted pursuant to the authority granted to local governments by the Virginia Flood Damage Prevention Act, Chapter 13.1 of the Code of Virginia, to prevent and minimize flood hazards, the disruption of commerce and governmental services, the loss of life and property, and the impairment of the tax base by:
 1. Regulating uses, activities, and development that, alone or in combination with other uses, activities, and development, will cause unacceptable increases in flood height or damage;
 2. Restricting or prohibiting certain uses, activities, and developments that are likely to cause unacceptable increases in flood height or damage;
 3. Requiring all uses, activities, and developments that do occur in floodplains to be designed, constructed, and maintained to prevent flooding and flood damage;
 4. Protecting individuals from buying land and structures that are likely to be damaged by flooding;
 5. Acknowledging that the tide data over the last one hundred (100) years is not representative of the tide data over the last one hundred (100) years of flooding caused by both sea level rise and subsidence.

(Ord. No. 3309, 11-26-13)

Example Policy/Regulatory Strategies

Incorporate resilience measures into design and siting standards

Increase freeboard and/or require in future floodplain

Downzone flood prone areas through regulation or voluntary agreement

Restrict rebuilding of severe repetitive loss structures

Require site plan review and SLR checklists for development (large or small)

Develop special services districts to finance local flood control measures

Provide property tax discounts or rebates for flood resilience or open space conservation

Extend and improving public education and outreach about flood risks and climate change

Participate in Community Rating System

Evaluation and Prioritization

- Qualitative:
 - Feasibility Scoring

Feasibility												
Technical		Administrative		Political		Legal		Fiscal		Environmental		
Access to Needed Tools	Complexity	Staffing	Maintenance	Political Support	Public Support	Federal Laws	Consistent with State and	Potential Legal Challenges	Cost	Funding Availability	Limited Environmental Consequences	Consistent with State Environmental Goals

- Quantitative:
 - Cost Benefit Analysis –
 - Return on investment – are strategies cost-effective?



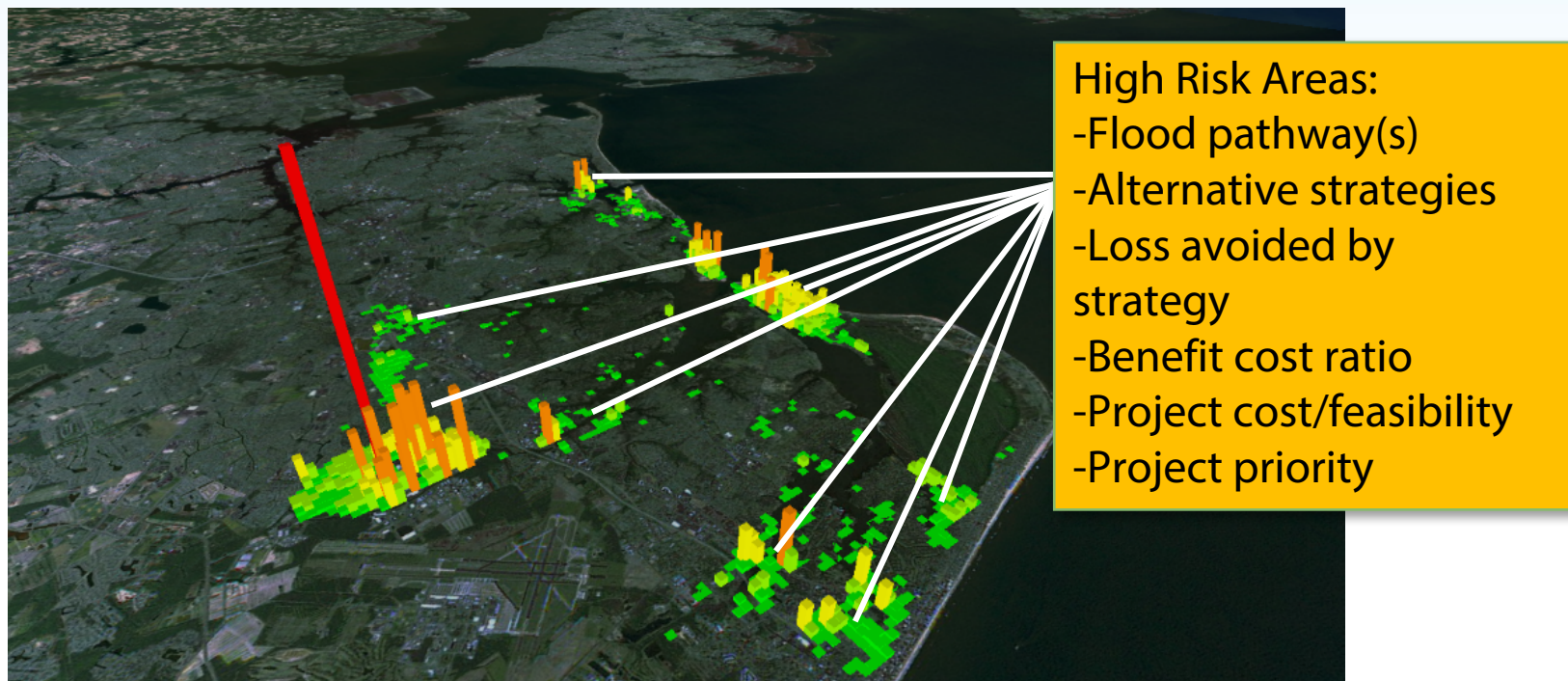
Flood Risk Management Strategies

- **Lynnhaven Evaluation**
 - Division of strategies into:
 - Structural projects with quantifiable economic benefits
 - Quantifiable admin. and policy measures
 - Non-quantifiable admin. and policy measures
 - Expanded, revised, and initial scoring in framework
 - Evaluating economic loss information to prepare benefit cost analysis

Flood Impact Management Strategy (FIMS)	Flood Mitigation Measure(s) Associated with FIMS					Total Feasibility Score	Total Feasibility Numerical Ranking	Total Feasibility Rating
	(Check all that apply)							
	Measure Type (VB Plan ID)	Short Description of Proposed Measure, Project or Action	City-Wide	Specific Details for Lynnhaven Critical Loss Focus Area(s)	Project Est. Cost			
Lynnhaven Neighborhood Projects	Acquisition (SPE-2)	Voluntary acquisition of the most flood-prone residential buildings in various subdivisions	TBD	Major Critical Loss Focus Areas (L1, L2, L8)	\$275,000/structure	159.0	2	High
	Mitigation Reconstruction	Mitigation-reconstruction (demo-rebuild) of flood-prone residential buildings in poor structural condition	TBD	Major Critical Loss Focus Areas (L1, L2, L8)	\$150,000/structure	150.0	7	High
	Elevation	Structural elevation of flood-prone residential buildings in good structural condition	TBD	Major Critical Loss Focus Areas (L1, L2, L8)	\$176,000/structure	138.5	16	Med-High
	Dry Floodproofing	Dry Floodproofing of flood-prone non-residential concrete/masonry buildings subject to shallow, short-duration flooding	TBD		\$75,000/structure	128.0	20	Med-High
	Floodwalls	Short floodwalls where permitted to protect existing flood-prone buildings from short-duration flooding	TBD		\$100,000/structure	124.5	22	Medium
	Wet Floodproofing	Wet floodproofing where permitted to protect existing flood-prone buildings to reduce flood damage and service losses	TBD		\$50,000/structure	143.5	15	Med-High
Lynnhaven Watershed Administration & Policy	Coordinate SVM with Parks (PLA-B)	Develop process to ID & coordinate green SVM needs/activities w/ Parks and Recreation projects, facilities and open space acquisition plans.	Yes	Applied across entire Lynnhaven Watershed	\$TBD	151.0	6	High
	Add Freeboard	Change freeboard requirement to 3 feet for all new new	Yes	Applied across entire Lynnhaven	\$TBD	181.0	1	High

Adaptation Plan Development

- City-wide policy recommendations
- Watershed specific measures to address high risk areas
- Sequenced to complexity, short and long-term risks



Phase 3: Implementation

Objective: Integrate the best-performing adaptation strategies in actionable plans that mechanisms to ensure implementation.



- How do we move forward with the preferred solutions?
 - What are the costs and design features?
 - How to we sequence the short- and long-term measures?
 - How do we fund?
 - What is our action plan for each watershed?
 - How do we get public buy-in, sponsors, and/or regional support?

Public Outreach

Goal:

Educate about the study and empower target audiences with accurate and timely information, and what they can do to reduce flood impacts

Why is Community Outreach Important?

- Most residents are unaware of the City's resiliency efforts
- There is high awareness of Norfolk's resiliency program and improvements.
- The City is assessing the 4 Watersheds for improve resiliency
- City Council committed approximately \$300 million over 15 years for stormwater improvements
- The City has made some infrastructure improvements already over the past few years
- ***Keeping residents informed and engaged is paramount!***

Why Is Public Engagement Important?

- Citizens must be informed with accurate and timely data
- Multiple communication options must be provided to engage the public
- Regular communication and updates keep the issue top of mind that the City cares about its residents and employers
- Citizens can share information with others when equipped with the right communication tools
- Citizen input and buy-in to future improvements and construction projects

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