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

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City of Virginia Beach

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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

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

1. **Sea Level Rise/ Recurrent Flooding Impacts**
   Defining the problem

2. **Adaptation Strategies**
   Tailoring the solutions

3. **Implementation**
   Planning the actions
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?
<table>
<thead>
<tr>
<th>Life Cycle Alignment</th>
<th>Time Horizon/Time Period</th>
<th>SLR Value</th>
<th>Relevance</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal Planning</td>
<td>20-40 years 2035-2055</td>
<td>1.5 ft</td>
<td>Comprehensive Plan &amp; Outcomes Short end of Commercial and Utility life-cycles</td>
<td>Vulnerability assessment Key planning value Basis for evaluation of all adaptation strategies</td>
</tr>
<tr>
<td>Critical Infrastructure</td>
<td>50-70 years 2065-2085</td>
<td>3.0 ft</td>
<td>Utility Infrastructure life-cycle Transportation infrastructure lifecycles</td>
<td>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</td>
</tr>
</tbody>
</table>
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

**Data Improvement**
- Collect, combine, improve City building data

**Loss Estimation Database**
- Relate City database to Hazus database

**Assign Depth Damage Function**
- Building and wave environment specific setting

**Perform Damage/Loss Estimation**
- Depth-damage analysis for 5 flood frequencies

**Data Summarization**
- Compile data to City planning units

**Impacts**
- Change in risk, risk clusters

![Image of building with risk indicators and data attributes]
“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

Loss Factor increase over Today

Recurrence Interval

10-yr 25-yr 50-yr 100-yr 500-yr

1.5 ft SLR

3 ft SLR

Sea Level Wise
A vibrant future for Virginia Beach
Projected Changes in Flood Loss

Annualized Losses ( Millions)

<table>
<thead>
<tr>
<th></th>
<th>Today</th>
<th>1.5 ft SLR</th>
<th>3.0 ft SLR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annualized</td>
<td>$0</td>
<td>$50</td>
<td>$400</td>
</tr>
<tr>
<td>Losses (Millions)</td>
<td>3.5x increase</td>
<td>15x increase</td>
<td>4.4x increase over 1.5 ft</td>
</tr>
</tbody>
</table>
Watershed Loss Changes with SLR

Watershed Today 1.5 SLR 3 ft SLR

<table>
<thead>
<tr>
<th>Watershed</th>
<th>Today</th>
<th>1.5 SLR</th>
<th>3 ft SLR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elizabeth River</td>
<td>2.48</td>
<td>8.18</td>
<td>23.60</td>
</tr>
<tr>
<td>Lynnhaven</td>
<td>15.97</td>
<td>53.27</td>
<td>158.14</td>
</tr>
<tr>
<td>Southern</td>
<td>4.62</td>
<td>17.94</td>
<td>165.31</td>
</tr>
<tr>
<td>Oceanfront</td>
<td>0.49</td>
<td>2.37</td>
<td>15.72</td>
</tr>
<tr>
<td>Total</td>
<td>23.56</td>
<td>81.76</td>
<td>362.77</td>
</tr>
</tbody>
</table>

Annualized Losses, Millions

Today

- Southern: 20%
- Oceanfront: 2%
- Elizabeth River: 10%
- Lynnhaven: 68%

1.5 ft SLR

- Southern: 3%
- Oceanfront: 4%
- Elizabeth River: 10%
- Lynnhaven: 65%

3 ft SLR

- Southern: 46%
- Oceanfront: 6%
- Elizabeth River: 6%
- Lynnhaven: 44%
Strategic Growth Areas

50-yr recurrence interval flood, 3 ft SLR Scenario

Legend
- Today
- 1.5 ft SLR
- 3 ft SLR

SGAs Risk
- Low
- Medium
- High

Loss by SGA

Total Losses, Millions of $

<table>
<thead>
<tr>
<th>SGA Area ID</th>
<th>Today</th>
<th>1.5 ft Scenario</th>
<th>3 ft Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
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<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Legend
- Today
- 1.5 ft SLR
- 3 ft SLR
Annualized Loss Concentration

- Intensification and Growth

Legend

Total Loss
Low
Mild
Moderate
High
Severe

Today 1.5 ft SLR 3 ft SLR

Dewberry

Sea Level Wise
A vibrant future for Virginia Beach
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?
**Example Policy/Regulatory Strategies**

<table>
<thead>
<tr>
<th>Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incorporate resilience measures into design and siting standards</td>
</tr>
<tr>
<td>Increase freeboard and/or require in future floodplain</td>
</tr>
<tr>
<td>Downzone flood prone areas through regulation or voluntary agreement</td>
</tr>
<tr>
<td>Restrict rebuilding of severe repetitive loss structures</td>
</tr>
<tr>
<td>Require site plan review and SLR checklists for development (large or small)</td>
</tr>
<tr>
<td>Develop special services districts to finance local flood control measures</td>
</tr>
<tr>
<td>Provide property tax discounts or rebates for flood resilience or open space conservation</td>
</tr>
<tr>
<td>Extend and improving public education and outreach about flood risks and climate change</td>
</tr>
<tr>
<td>Participate in Community Rating System</td>
</tr>
</tbody>
</table>
Evaluation and Prioritization

- Qualitative:
  - Feasibility Scoring

<table>
<thead>
<tr>
<th>Technical</th>
<th>Administrative</th>
<th>Political</th>
<th>Legal</th>
<th>Fiscal</th>
<th>Environmental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access to Needed Tools</td>
<td>Complexity</td>
<td>Staffing</td>
<td>Maintenance</td>
<td>Political Support</td>
<td>Public Support</td>
</tr>
<tr>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

- 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
Adaptation Plan Development

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

High Risk Areas:
- Flood pathway(s)
- Alternative strategies
- Loss avoided by strategy
- Benefit cost ratio
- Project cost/feasibility
- Project priority
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 improved 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
Project Contacts

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