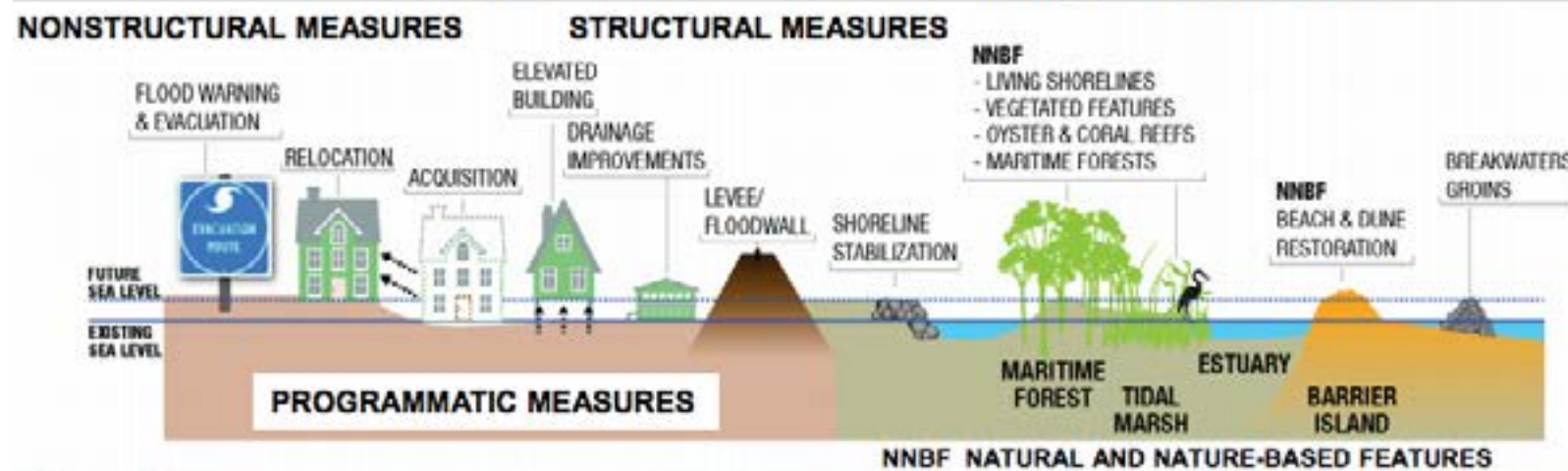


Three categories of adaptation strategies:

Natural Non-structural Structural

We should consider them as a suite of adaption strategies that can work together

Full Array of Coastal Storm Risk Management Measures



Coastal Virginia is experiencing one of the highest rates of sea level rise and flooding on the East Coast. The Hampton Roads region ranks 19th in the world in the value of assets (\$84.6 billion in current assets and \$581.7 billion in future assets) exposed to increased flooding associated with both storm surges and tidal flooding. To protect lives, property and the future of the region, we need resilient cities that have planned for and are adapted to higher water levels. Residents should understand their risk and take action on individual properties and in their community.

Why are we experiencing flooding?

Sea Level Rise - warmer oceans are causing higher average coastal water levels relative to land. As water rises, areas are inundated, shore-lines retreat and flooding increases.

Subsidence - the land surface in this region is sinking due to geologic forces and the extraction of groundwater, which increased sea level rise.

Storm Surge- an abnormal rise of water can be generated by a storm, above what is expected by a tide. Low-pressure weather systems and wind often cause storm surge.

Total water level = sea level rise + storm surge + tide + waves + rainfall

Key Terminology

Resilience- the ability to adapt to changing conditions and rapidly recover from disruptions. It is the capacity to survive and thrive in the face of shocks and stresses, which may require transformation under certain conditions.

Adaptation- actions to address sea level rise through making changes in the way that we plan and build cities, protect shorelines and natural areas, build houses, and prepare for future storms.

Mitigation of sea level rise risk- actions that reduce the impact that sea level rise can have on the natural or build environment.

***Mitigation of climate change** refers to the reduction or prevention of the emission of gasses associated with climate change. *

Non- Structural Solutions



Floodplain Policy & Management	Flood-proofing and Impact Reduction	Flood Warning and Preparedness	Relocation
Benefits: Improved and controlled flood-plain development Reduced opportunity for damages Improved natural coast environment	Benefits: Reduced opportunity for damages Increased community resilience No increase in flood potential elsewhere	Benefits: Reduced opportunity for damages Increased community resilience Improved public awareness and responsibility	Benefits: Reduced opportunity for damages No increase in flood potential elsewhere Improved natural coast environment
Drawbacks: Susceptible based on high water, wave height, and storm duration Requires agency collaboration	Drawbacks: Susceptible based on high water, wave height, and storm duration	Drawbacks: Susceptible based on high water, wave height, and storm duration	Drawbacks: Costs may be prohibitive Disruptive to residents
Initial Construction: N/A O & M: N/A	Initial Construction: \$ O & M: \$	Initial Construction: N/A O & M: N/A	Initial Construction: \$\$\$ O & M: \$

1. Floodplain policy and Management examples

- Preserve open space and/or increase open space in the floodplain
Do not allow additional development in the floodplain.
Buyout properties in floodplains
- Enforce higher building standards for safer development

2. Relocation

- Buy-out houses at risk of flooding

3. Flood proofing and impact reduction

- Elevate service equipment
- Install flood vents
- Elevate house

4. Flood warning & preparedness

- Monitor flood conditions and warnings
- Learn about flood hazards, and how to reduce flood damage and flood insurance premiums.



Natural Solutions



Dunes & Beaches	Vegetated Features (Wetlands)	Oyster Reefs	Maritime Forests/Shrub Communities
Benefits: Breaking of offshore waves Attenuation of wave energy Slow inland water transfer	Benefits: Dissipates wave energy Slows inland water transfer Provides habitat and ecosystem services Increased natural storm water infiltration	Benefits: Breaking of offshore waves (low waves) Attenuation of wave energy Slow inland water transfer	Benefits: Wave attenuation and/or dissipation Shoreline erosion stabilization Soil retention Provides habitat and ecosystem services
Drawbacks: Requires renourishment No high water protection Appropriate for limited situations Possible impacts to sediment transport	Drawbacks: No high water protection Uncertain of successful vegetation growth and competition with invasive species	Drawbacks: No high water protection Uncertain of successful vegetation growth and competition with invasive species Can reduce water circulation and create navigational hazard	Drawbacks: No high water protection Requires land area Vegetation height and density important
Initial Construction: \$\$\$ O & M: \$\$	Initial Construction: \$\$ O & M: \$	Initial Construction: \$\$\$\$ O & M: \$\$\$	Initial Construction: \$\$\$ O & M: \$\$

Structural Solutions



Levees	Storm Surge Barriers	Groins	Detached Breakwaters
Benefits: Surge and wave attenuation and/or dissipation Reduce flooding Reduced risk for vulnerable areas	Benefits: Surge and wave attenuation and/or dissipation Reduced salinity intrusion	Benefits: Shoreline stabilization Protection from wave forces Can be combined with beach nourishment projects to extend their life	Benefits: Shoreline stabilization behind structure Wave attenuation
Drawbacks: Divert floodwater to other locations Overtopping threat Susceptible to erosion Access to structure restricted	Drawbacks: Landward flooding possible with extended closure May change chemical, physical and biological processes of estuary Not suitable for all locations Visually obstructive	Drawbacks: Erosion of adjacent sites Can be detrimental to shoreline ecosystem No high water protection	Drawbacks: May change physical and biological processes No high water protection Visually obstructive
Initial Construction: \$\$\$\$ O & M: \$\$\$	Initial Construction: \$\$\$\$ O & M: \$\$\$	Initial Construction: \$\$\$ O & M: \$\$	Initial Construction: \$\$\$\$ O & M: \$\$\$

Key: low cost=\$, highest cost= \$\$\$\$ for Operation and maintenance (O & M)

Sources

US Army Corps of Engineers (2013) Coastal Risk Reduction and Resilience. CWTS 2013-3. Washington, DC: Directorate of Civil Works, US Army Corps of Engineers.

US Army Corps of Engineers (2015) North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk. Washington, DC: Directorate of Civil Works, US Army Corps of Engineers.

Sage. February 2015. Natural and Structural Measures for Living Shorelines. Retrieved February 2016 from: https://coast.noaa.gov/digitalcoast/_/pdf/living-shoreline-brochure.pdf

Federal Emergency Management Agency (2014). Homeowner’s Guide to Retrofitting, Six Ways to Protect Your Home From Flooding. FEMA P-312, 3rd Edition. Washington, DC: Federal Emergency Management Agency.

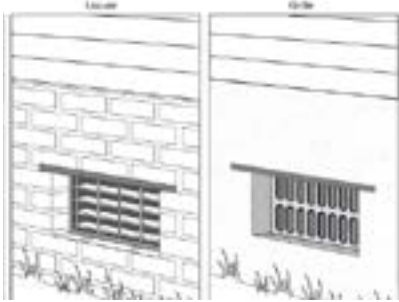
National Hazard Mitigation Association. Fact Sheet 2012-01: Resilient Neighbors Profiles. Retrieved February 2016 from: <http://charmeck.org/stormwater/Storm-WaterAgencies/Documents/Peers%20PDF/FloodResilienceCommunityProfile.pdf>

Federal Emergency Management Agency (2008). Openings in Foundation Walls & Walls of Enclosures. Technical Bulletin 1/August 2008. Washington, DC: Federal Emergency Management Agency.

Van Rijn, L.C. (March 2013). Design of Hard Coastal Structures Against Erosion. Retrieved from <http://www.leovanrijn-sediment.com/papers/Coastalstructures2013.pdf>

Elgershuizen, J.H.B.W. (1981) Some environmental impacts of a storm surge barrier. Marine Pollution Bulletin, 12 (8), 265-271.

Options for Property Owners



Flood vents prevent water pressure that can destroy foundations by allowing flood waters to freely flow through a crawlspace or garage.

This brochure was developed by Carol Considine, Wie Yusuf and Michelle Covi at Old Dominion University. Contact mcovi@odu.edu for more information

Options for Property Owners



Cisterns and rainbarrels store storm water which can be used for irrigation or even to wash your car. An inch of rainfall on a 300 sq. ft section of roof can fill a 110 gallon barrel.



Landscaping can be designed to capture stormwater and allow it to slowly be absorbed by the plants and soil.



Air conditioning/ heat pump compressors can be elevated on a platform to prevent damage in case of flood.