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INDUSTRY CORNER

COLLABORATIVE STRATEGIES FOR SEA LEVEL RISE ADAPTATION IN HAMPTON ROADS, VIRGINIA

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INTRODUCTION

The Hampton Roads region is located in southeastern Virginia where the Chesapeake Bay meets the Atlantic Ocean. The region includes seventeen municipal governments and has a large federal government presence with 26 federal agencies represented (See Figure 1). The region has a population that exceeds 1.7 million and is home to the deepest water harbor on the U.S. East Coast. Hampton Roads' economy is dependent on the local waterways and houses the world's largest naval facility, the sixth largest containerized cargo complex and supports a thriving shipbuilding and repair industry as well as a tourism industry. However, the region's vast coastline also contributes to its vulnerability from climate change.

Hampton Roads is experiencing sea level rise at twice the global rate with regional projections in the January 2017 National Oceanic and Atmospheric Administration (NOAA) report, *Global and Regional Sea Level Rise Scenarios for the United States*, of 1.9 feet of sea level rise at the low end and 11.5 feet of sea level rise under the most extreme case between 2000 and 2100 (NOAA, 2017). Planning for adaptation to sea level rise requires regional partnerships and strategies, especially for watersheds that cross municipal boundaries.

While many of the municipalities in the region are forward thinking in their approaches to sea level rise, there is not a regional plan for adaptation and current federal funding models do not support analysis of and planning for sea level rise impacts on a regional scale. For coastal communities to be successful in sea level rise adaptation, there has to be a national understanding that water knows no borders and only collaborative problem-solving approaches that cross municipal boundaries will move regions toward adaptation. Functional boundaries of ecosystems or watersheds need to be the focus of adaptation rather than political boundaries of local, state, and federal entities. Coordination and collaboration between entities is the only way to achieve optimal outcomes.

KEYWORDS

sea level rise, coastal flooding, flood resilience, coastal community planning, regional planning, adaptation strategies, regional planning

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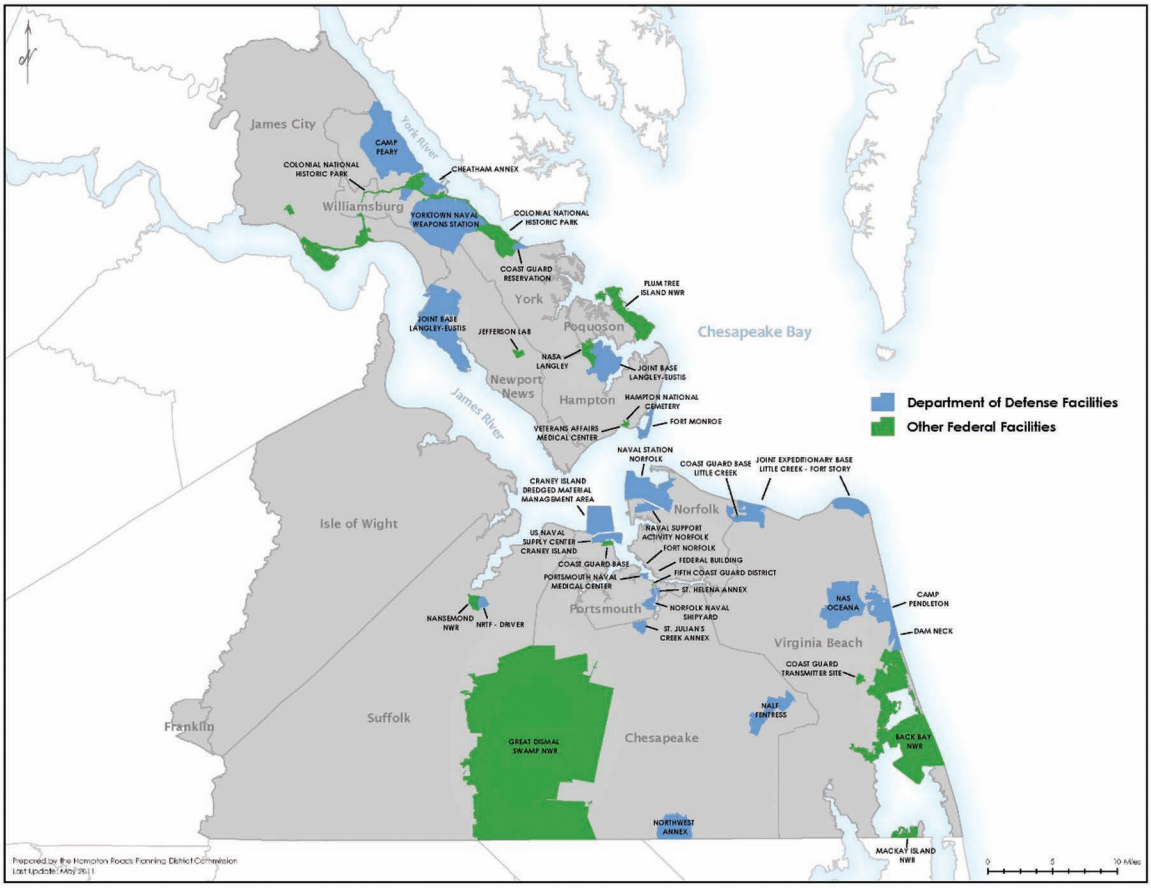
FIGURE 1. Hampton Roads Region Municipalities and Federal Facilities (Image Courtesy of the Hampton Roads Military and Federal Facilities Alliance).



FRAMING THE PROBLEM

Relative Sea Level Rise in Hampton Roads

Global contributors to sea level rise (SLR) are the thermal expansion of seawater and melting of ice sheets and glaciers. Local geomorphology also plays a significant role in local SLR. The Hampton Roads region is experiencing sea level rise at approximately twice the global rate (Boon 2012; Ezer and Corlett 2012a, 2012b; Sallenger et al. 2012). This increased rate of SLR for Hampton Roads is attributed to land subsidence related to glacial isostatic adjustment, or changes to the earth's crust due to glacial formation and melting, land subsidence from natural processes and groundwater withdrawals, and regional ocean currents. The Gulf Stream, which follows the eastern coastline of the United States, is slowing in velocity due to climate change, which in turn is contributing to an increased SLR in the Hampton Roads region (Boon et al. 2010; Ezer et al. 2013). The Gulf Stream current actually lowers sea levels along the Mid-Atlantic by drawing water away from the coast and moving it towards the middle of the ocean. As the velocity of the Gulf Stream decreases it draws less water away from the coast, essentially increasing sea level (Strain).

The NOAA report, *Global and Regional Sea Level Rise Scenarios for the United States* (NOAA Technical Report NOS CO-OPS 083), provided updated SLR scenarios for the United States. Using values from the intermediate curves, intermediate low, intermediate, and intermediate high, the estimated relative SLR projections are 1.21, 2.3, and 3.12 feet respectively by 2050 and 2.4, 4.56, and 6.86 feet respectively by 2100 (NOAA, 2017). Figure 2 below summarizes this data:

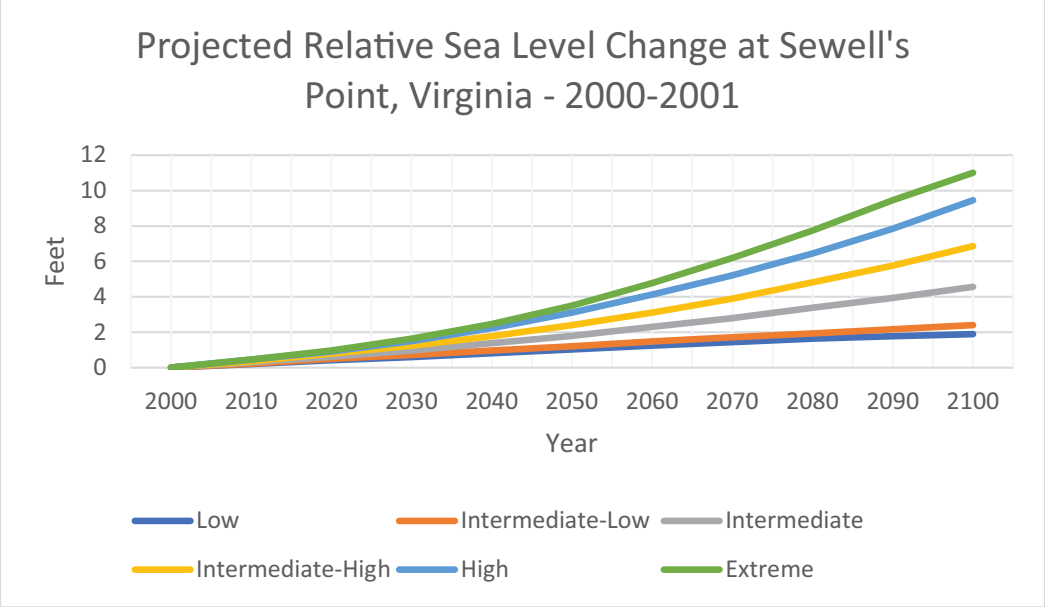
The Hampton Roads region, also often called the Tidewater for its low lying coastal areas, is relatively flat and the water table lurks just below the surface in many areas. The two largest cites, Virginia Beach and Norfolk, are susceptible to the impacts of sea level rise based on elevation alone, with the City of Virginia Beach having an average elevation of 12 feet (Virginia Beach Geofacts) and the City of Norfolk having an average elevation of 10 feet (Norfolk, Virginia). Mitigation strategies and adaptation solutions are already being adopted throughout the region in an effort to minimize the short term and long term impacts of SLR. However, these efforts are not coordinated between the municipalities, and each municipality is developing independent approaches to SLR scenarios and adaptation responses.

Leadership at the Virginia Commonwealth Level

Leaders and environmental advocates across Virginia concerned about SLR were able to build bipartisan support at the state level to study the impacts of SLR in 2012. That year the Senate passed Senate Joint Resolution 76 (2012), which directed the Virginia Institute of Marine Science to study strategies for adaptation to prevent recurrent flooding in the localities of the Tidewater and Eastern Shore. The report, *Recurrent Flooding Study for Tidewater Virginia*, released in January 2013, detailed to a wide audience the near-term risks associated with increased coastal flooding.

The report highlighted the Hampton Roads cities of Virginia Beach, Portsmouth, Norfolk, Chesapeake, Hampton, and Poquoson as confronting significant challenges related to sea level

FIGURE 2. Projected Relative Sea Level Change at Sewell's Point, Virginia—2000–2100.



rise. Using the best available science at the time and assuming a 1.5 foot rise in sea level and a 3 foot storm surge, the study found that in these localities the percentage of the total land area vulnerable to flooding ranged from 11% to 69% (Mitchell, 2013).

In the year following the release of the VIMS report, 2014, the Commonwealth of Virginia took several steps to investigate the problems associated with and solutions to SLR including:

- The Secure Commonwealth Panel (SCP) of the Commonwealth formed a Recurrent Flooding Sub-Panel to further investigate a Commonwealth response to increased recurrent flooding. The sub-panel submitted a report to the Secretary of Public Safety and Homeland Security, Brian Moran, with a list of recommendations (Recurrent Flooding Sub-Panel, 2014).
- The General Assembly established a Joint Subcommittee to formulate recommendations to address recurrent flooding (Va. Sen. JR 3 (2014). The Subcommittee, now called the Joint Subcommittee on Coastal Flooding, has been renewed twice and its members annually put forward legislation aimed at facilitating flooding adaptation and resilience in the Commonwealth of Virginia (Va. HJ 26 (2018).
- Governor McAuliffe convened a Climate Change and Resiliency Update Commission tasked with presenting actionable agenda items for the governor with regards to climate change resiliency (Va. EO 19 (2014). The then-Governor also heeded initial recommendations to establish a designated state point of contact on the issue and appointed Secretary Moran as Chief Resilience Officer of Virginia.

In 2016, the General Assembly recognized the need to assist localities in their efforts to mitigate the impacts of SLR and created the Commonwealth Center for Recurrent Flooding Resiliency (CCRFR) jointly at Old Dominion University, the Virginia Institute of Marine Sciences, and the Virginia Coastal Policy Center at William & Mary's Law School (Va. HB 903 (2016). This Center has enabled the universities to leverage their assistance to localities and state agencies providing essential continuity and technical assistance or applied research on a wide variety of flooding related subjects. This partnership has enabled the quick deployment of a water-sensor network as well as localized subsidence monitoring and economic impacts analysis.

While these early efforts by the Commonwealth to understand the impacts of SLR and move toward adaptive solutions were helpful, none had provided for a single entity or agency to be responsible for the planning, coordination and implementation of adaptive solutions to SLR at the local, state and federal level. In 2018, following three years of efforts, the General Assembly passed a bill creating and funding a new Special Assistant to the Governor for Coastal Adaptation and Protection (Va. HB 345 (2018). This position became effective on July 1, 2018, and an appointment is pending. The Special Assistant will report directly to Governor Northam and will be the lead in developing and in providing direction and ensuring accountability for a statewide coastal flooding adaptation strategy. It will provide for coordination of efforts related to SLR at the local, state and federal levels.

Leadership at the Local Level

HRPDC Coastal Resiliency Committee

Virginia is divided into 21 Planning District Commissions (PDCs), or voluntary associations of local governments designed to foster cooperative intergovernmental planning for issues of

greater than local significance. The activity of the various PDCs reflects the nature of their home region, however, all PDCs lack any implementing authority (Va. § 15.2-42 et. seq.).

The Hampton Roads Planning District Commission (HRPDC) is comprised of 17 member localities and provides a regular home to collaborative meetings between officials across the region and initiatives on issues related to flooding, such as stormwater, emergency management, and water resources. As such, the Commission was a natural convener for sea level rise and resilience planning efforts.

Recognizing the importance of flooding in regional planning, the HRPDC and their sister organization, the Hampton Roads Transportation Planning Organization (HRTPO), conducted a series of studies between 2010 and 2014 investigating the potential impacts to the region from recurrent flooding. HRPDC staff published a series of reports analyzing assets at risk in the region and determined that sea level rise was a grave concern for the region and estimated that 877 miles of roadways could be exposed to floodwaters with 1 meter of sea level rise (McFarlane, 2012).

In a three-part series, the HRTPO focused on accessibility onto military facilities in the event of flooding and determined that sea level rise projections should be included in planning for future projects and that roadways serving the military were vulnerable to flooding (Belfield, 2013).

On March 6, 2014, former Mayor of Virginia Beach, William Sessoms, addressed a letter to the Director of the HRPDC, copying the Mayor of the City of Norfolk, Paul Fraim, an outspoken advocate for flooding resilience, requesting they take a leadership role regionally in sea level rise and resilience planning (Sessoms, 2014).

In quick response, at the March 20, 2014, meeting of the HRPDC Executive Committee the staff proposed establishment of a Regional Committee to Address Recurrent Flooding (HRPDC Executive Committee; Mar. 20, 2014). However, the PDC in its current form could only plan, recommend, or convene; it could never direct a locality to make ordinance changes and thus the tasking of the new committee was unclear. Further, most actions of the PDC are voted on by the full Commission in a one-locality one-vote manner so only matters of priority to the entire region rise to the level of the full commission. The issue of flooding and resilience has been gaining ground within the HRPDC membership localities in recent years, however, localities are impacted disproportionally when it comes to flooding, and so it is less of a concern to certain, more elevated, localities. As such, while the committee moves forward, regional collaboration at the PDC level remains a coalition of the willing.

Since its initial formation in 2014, the HRPDC's committee has taken several forms. Now called the Coastal Resiliency Committee, the group is comprised of deputy manager level decision-makers, and meets quarterly, while workgroups comprised of staff and other subject matter experts, including those from academia, meets monthly to dive deeper into various issues. The Committee's current initiatives include a region-wide advertising campaign to encourage residents to purchase flood insurance as well as data gathering initiatives.

Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Planning Pilot Project

Recognizing the impact of SLR on national security and the need for regional planning across levels of government, leaders from the United States Navy and the White House under former President Barack Obama proposed a pilot project in the Hampton Roads area.

Officially launched in June 2014, the "Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Planning Pilot Project" or Intergovernmental Pilot Project (IPP)

was an effort to combine the skills and expertise of regional stakeholders to develop a Whole of Government and Whole of Community template for intergovernmental strategic planning. In Hampton Roads, this template would then be used to implement an integrated strategic plan to address sea level rise and flooding, however, the Navy hoped that such a template could be applied outside the region to other challenges.

For over two years, the IPP, facilitated by Old Dominion University in Norfolk, Virginia, brought together hundreds of stakeholders from across all levels of government, academia, industry and the community.

Participation in the IPP was voluntary for members of each committee and working group, including the Steering Committee. While some organizations, agencies, and localities tasked staff members with participation, many more volunteered their time and expertise because of a dual understanding of the magnitude of flood related issues facing the region and because of a belief that a collaborative approach to building resilience was essential.

The project advanced regional adaptation through the evaluation and recommendation of potential governance structures, the development of clear sector-based recommendations, the increased public awareness, the awareness of barriers to full federal participation in local resilience building, and the relationship building between numerous organizations involved in the Pilot Project. As an unfunded, volunteer-based project, the IPP organizers lacked any implementation authority, and so all work was done in concert with other resilience related activity in the region and aimed to leverage and enhance any other constructive process.

Although the project founders initially imagined a clearer path forward for local, state, and federal cooperation with regards to sea level rise planning, the initiative resulted in significant relationship and awareness building within the region. Furthermore, many workable recommendations have been followed by various stakeholders, and many more remain relevant. The IPP focused on the concept that water knew no jurisdictional boundaries and that increased collaboration at every stage is essential for effective resilience building.

DUTCH DIALOGUES VIRGINIA

Drawing on the Dutch adaptation experience post deadly floods in the 1950's, the Dutch Dialogues were an integral part of developing a water plan for the New Orleans area in the years following Hurricane Katrina (Nemes). Following the lead of New Orleans Dutch Dialogues, the Virginia Dutch Dialogs took place in Norfolk, Virginia in June 2015 and focused on two areas: Newmarket Creek, a shared watershed between Hampton and Newport News, facing flooding challenges from tides, precipitation, and storm surge with a variety of land uses and a critical transportation artery; and Tidewater District of Norfolk, an area including a baseball stadium, low income housing in the St. Paul's District, and the historical neighborhood of Chesterfield Heights, which includes industrial facilities, and facing flooding challenges from poor drainage and environmental degradation of shorelines. The design charrettes were facilitated by David Waggoner of Waggoner and Ball, the same firm responsible for the Greater New Orleans Urban Water Plan (HRPDC, Dutch Dialogue Virginia).

Although Norfolk and Hampton were the two municipalities leading the charge for this event, city staff members and other subject matter experts from across the region came together to join experts in 'living with the water' from the Netherlands and New Orleans over the course of the 5-day event.

FIGURE 3. Hampton University & Old Dominion University student design project for Chesterfield Heights in Norfolk, Virginia, showing base map and extent of living shoreline designed by students.

The Tidewater District or Ohio Creek Watershed had been the focal point of a leading-edge student project, which brought architecture students from Hampton University together with engineering students from Old Dominion University to work with the Chesterfield Heights neighborhood to adapt it to flooding. Partners from the project, including some of the undergraduate students and their professors, Virginia Sea Grant, and Wetlands Watch also took part in the design charrettes sharing their ideas with the visiting experts.

The evolution of these ideas would be folded into Virginia's application to the Housing and Urban Development National Disaster Resilience Competition, and ultimately form the foundation for the concepts behind the $120.5 million-dollar award to the Commonwealth (HUD NDRC Grantee Profiles, 2016). The other site, Newmarket Creek, is now the focus

FIGURE 4. Hampton University & Old Dominion University student design project for Chesterfield Heights. Extent of Chesterfield Heights living shoreline.

area of the first pilot initiatives to come out of the City of Hampton's resilience plan discussed in the following section.

In addition to focusing on two distinct geographical area, a team of local stakeholders worked with Dutch experts to discuss flooding adaptation from a regional perspective as well. Regional recommendations included a sea level rise compact with willing localities and business leaders and strong leadership by the PDC where statutory authority was allowed (HRPDC Meeting; July 16, 2016). To date, in Hampton Roads, while regional leaders collaborate, there is no clear sea level rise compact. Thus, while the Dutch Dialogues Virginia were a clear impetus for action at the local level, regional cooperation still lagged.

Coalition of the Willing: Adaptation Plans and Strategies of Municipalities

Five of the seventeen municipalities in the Hampton Roads region recognize the threat of sea level rise, the need to evaluate the impacts of sea level rise, and have identified resources that have allowed them to be proactive in the planning for adaptation. Each have identified unique SLR scenarios, managed the process differently, and are moving forward with different approaches. Below is a summary of the approaches taken by the five municipalities active in SLR adaptation:

Virginia Beach

After initially investing in the first phase of a Comprehensive Sea Level Rise and Recurrent Flooding Plan, as well as a Comprehensive Stormwater Analysis, the City of Virginia Beach applied for and received a NOAA Resiliency grant in 2016. The grant has further enabled the city to analyze the impacts of sea level rise citywide and is in the process of developing strategies

to protect homes, businesses and military bases from SLR. These efforts have been led by the stormwater engineering division of the city of Virginia Beach. The city of Virginia Beach has a history of protecting the city from coastal storms using natural solutions, like the widening of beaches along the Atlantic Ocean and the Chesapeake Bay, built solutions, like a protective seawall at the Oceanfront (which doubles as a Boardwalk), raising of at-risk homes, and planning solutions, requiring finish floor elevations to be at least two feet above the 100-year flood plain (Virginia Beach, 2016).

Hampton

The City of Hampton has taken a city-wide initiative to improve resilience, Resilient Hampton. Their approach will address both extreme events like hurricanes and nor'easters and chronic stresses like recurrent flooding. Their approach to rising seas is "Living with the Water" and is an outgrowth of their participation in the Dutch Dialogues Virginia. They are developing innovative solutions based on strategies used in the Netherlands, which has a long history of fighting and living with water. This holistic approach looks for synergies and multiple benefits by integrating flood risk mitigation, engineering, and urban design with environmental goals, and community and economic development. This City of Hampton has completed Phase 1

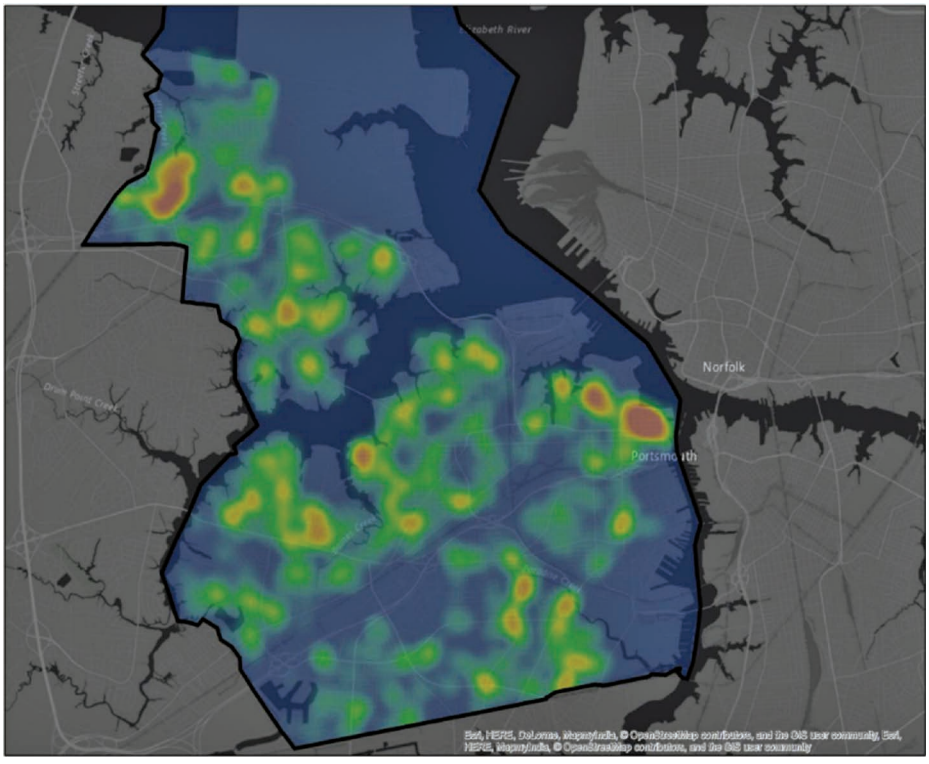
FIGURE 5. The seawall in Virginia Beach, Virginia, built by the Army Corps of Engineers in 2001 also serves as a boardwalk and retains stormwater.

of the project which included a city wide assessment of the problem and potential solutions, gathering of best available data on SLR and climate change, establishment of guiding principles, values and goals based on community outreach, review of legal implications of resilience project and policy implementation, drafting of a preliminary evaluation tool to help leaders in decision making, and developed a plan for next steps which included the selection of a geographic area and their first resiliency project (Living with Water).

Portsmouth

In 2015 the City of Portsmouth embarked on a data gathering initiative with the Virginia Modeling and Simulation Center (VMASC) and determined that recurrent flooding was a larger and more immediate problem than SLR and disproportionately impacted lower income residents. The City then partnered with VIMS to develop several flooding models to help them understand the impacts of future SLR so that they could develop a comprehensive plan that will take into account climate change and sea level rise. The comprehensive plan focus will be to mitigate the impacts of climate change, provide economic resiliency, and protect critical infrastructure. The City of Portsmouth is adopting a city-wide approach to their comprehensive planning and will incorporate resiliency strategies across every city department. The city is a recognized leader in Virginia and in the National Flood Insurance Program Community Rating System providing a 15% reduction on flood insurance premiums for eligible policies. Adaptation strategies under consideration include seawall replacement, tide gate replacement

FIGURE 6. A sample heat map from the *Portsmouth Comprehensive Planning Support Report 1* prepared by VMASC. This image illustrates the clustering of respondents with similar intensity of response to whether or not they suffered home or property damage due to flooding (Behr, 2015).



and improvements, and a stormwater management plan that includes both gray and green infrastructure solutions (Resiliency in Portsmouth, 2018).

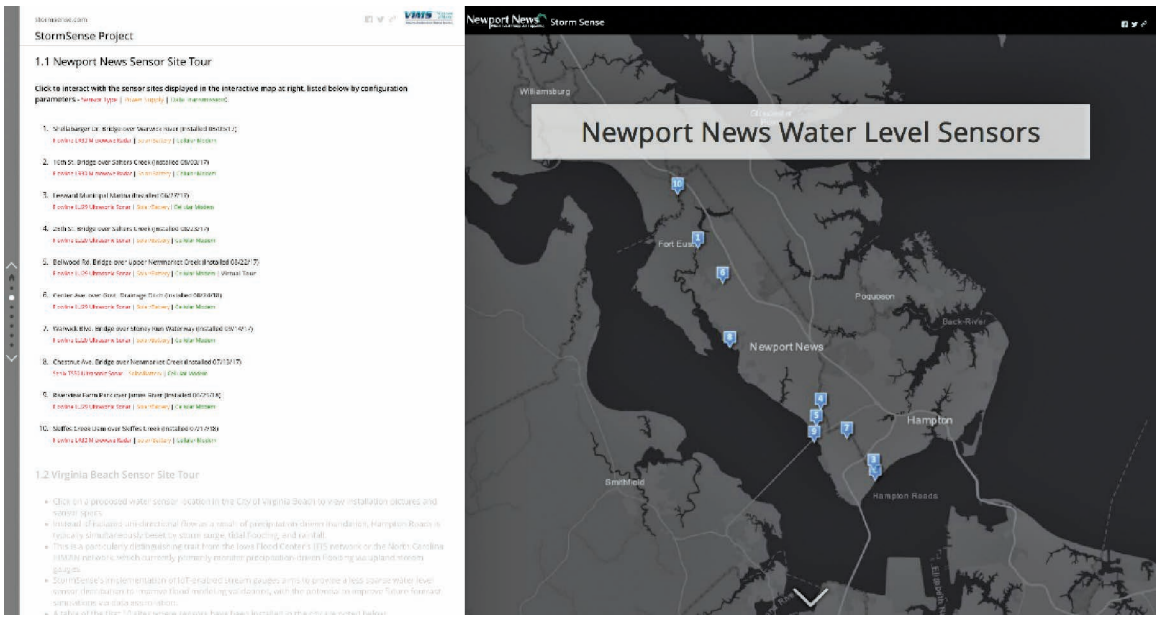
Newport News

The City of Newport News has focused their resilience strategies in the area of Emergency Management. They have invested in StormSense software through a partnership with the Virginia Institute of Marine Science that helps predict localized flooding based on rising sea levels. The software uses sensors, historical data, and big data analytics to determine most impacted areas. They are using this information to pre-plan for evacuation techniques, relocation needs, and staging requirements; additionally, they are using it to develop all hazard response planning (Newport News). The City of Newport News is not as vulnerable to SLR as neighboring cities because it is more elevated than other areas. They are addressing the immediate risks of flooding with stormwater improvements and increasing freeboard requirements, but they do not have a plan to address the longer-term problem of sea level rise because they believe that the issue is regional and should be managed at the regional level (Amin, 2016).

Norfolk

The City of Norfolk was selected as one of the Rockefeller Foundation's 100 Resilient Cities in 2013. They appointed a Resilience Officer and have had access to the resources of the Rockefeller Foundation in developing a resilience strategy for the city with goals of designing a coastal community of the future, creating economic opportunity and advancing initiatives to connect communities, deconcentrate poverty and strengthen neighborhoods. The city is also the main sub-recipient of the Commonwealth's award as part of the National Disaster Resilience Competition of $115 million for the Ohio Creek Watershed, which will reduce flooding, and improve public spaces for the Chesterfield Heights and Grandy Village neighborhoods. The

FIGURE 7. The image above is from the StormSense website. Data allows users to view water levels in Newport News, Virginia.



City provided the cost match for a Norfolk Coastal Storm Risk Management Study, conducted in partnership with United States Army Corp of Engineers, which proposes $1.8 billion in improvements that include a combination of solutions to reduce flooding risk in the city, although there is no guarantee those projects will be funded. Further, the study can only consider solutions specific to Norfolk despite shared watersheds. These solutions include both structural, nonstructural, and natural and nature-based solutions (Norfolk Resilient City). Norfolk has also adopted a first of its kind "resilient" zoning code, which requires various resilience measures be implemented on every project.

Various Approaches to Leadership, Funding and Strategies

Table 1 represents various funding sources, management methods, and strategies for flooding adaptation in five localities of Hampton Roads based on publicly available information.

SHARED ADAPTATION STRATEGIES

Data Gathering and Research

Despite adapting in different ways, all localities adapting to sea level rise in Hampton Roads recognize the importance of quality data and the severe challenges that lack of data can cause. The CCRFR partners and the HRPDC both aim to work with localities to fill these data and analysis needs. The CCRFR partners utilize regular events such as the Hampton Roads Adaptation Forum, a quarterly forum in its 6th year hosted by ODU, Virginia Sea Grant, and the HRPDC; the HRPDC Coastal Resiliency meetings; and other outreach initiatives to determine data and research needs.

Key data and research needs include current and near time flooding predictions and water levels, relative sea level rise scenarios, and all data that would inform damage assessments and adaptation strategies including a complete data set of the first-floor elevations of all structures.

Water Sensor Network and Real Time Flood Data

Regional partners are working together to expand a water sensor network to better predict street level flooding in coastal Virginia. StormSense, a multi-partner project, which has grown out of a

FIGURE 8. A view of Downtown Norfolk, Virginia.

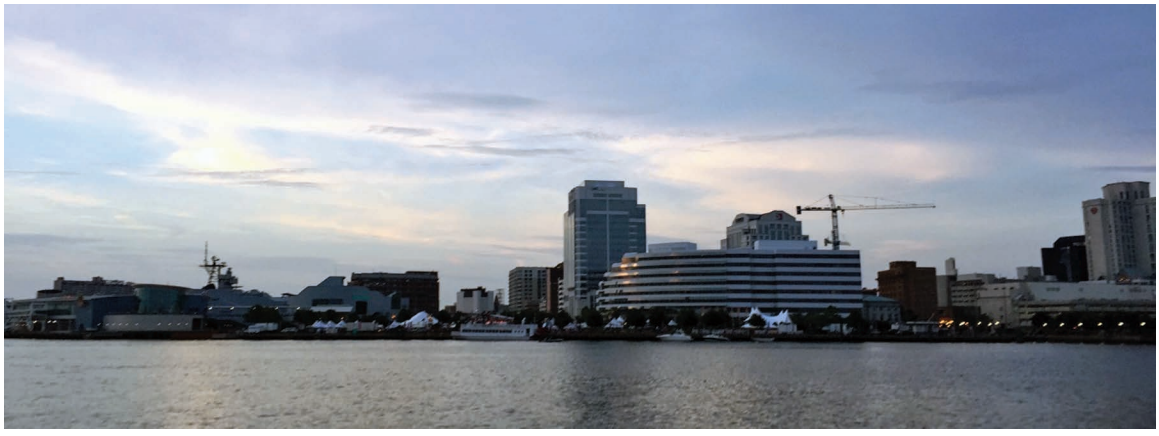


TABLE 1. Municipal Approaches to seal level rise leadership, funding, and strategies.

	Municipalities				
	Virginia Beach	*Norfolk*	*Portsmouth*	*Hampton*	*Newport News*
External Funding Sources	NOAA, Amazon	HUD NDRC, USACE, Rockefeller Foundation			NIST
Managing Department	Stormwater Engineering	Chief Resiliency Officer	Planning	Community Development	Engineering and Emergency Management
Community Education, Outreach and Engagement	X	X	X	X	
Strategies					
Built Infrastructure					
Stormwater Improvements	X	X	X	X	X
Levees or Floodwalls	X +	X +	X +	+	
Storm Surge Barriers	+	+		+	
Elevating Roads and Buildings	X +	X	X	+	
Natural Solutions					
Wetlands	+	+		+	
Green Infrastructure (Rain gardens, buffers)		X	X	X	
Dunes & Beaches	X	X		X	
Oyster Reefs	X	X			
Policy and ordinance Changes					
Preserve Open Space	X			X	
Freeboard Requirements	2 ft.	3 ft.	3 ft.	3 ft.	2 ft.
Higher Building Codes and Standards		X			
Buy-out of at risk structures		X	X		X
Flood Warning Systems	+	+	+	+	+

Key:
X Implemented Solutions
+ Solutions Under Consideration

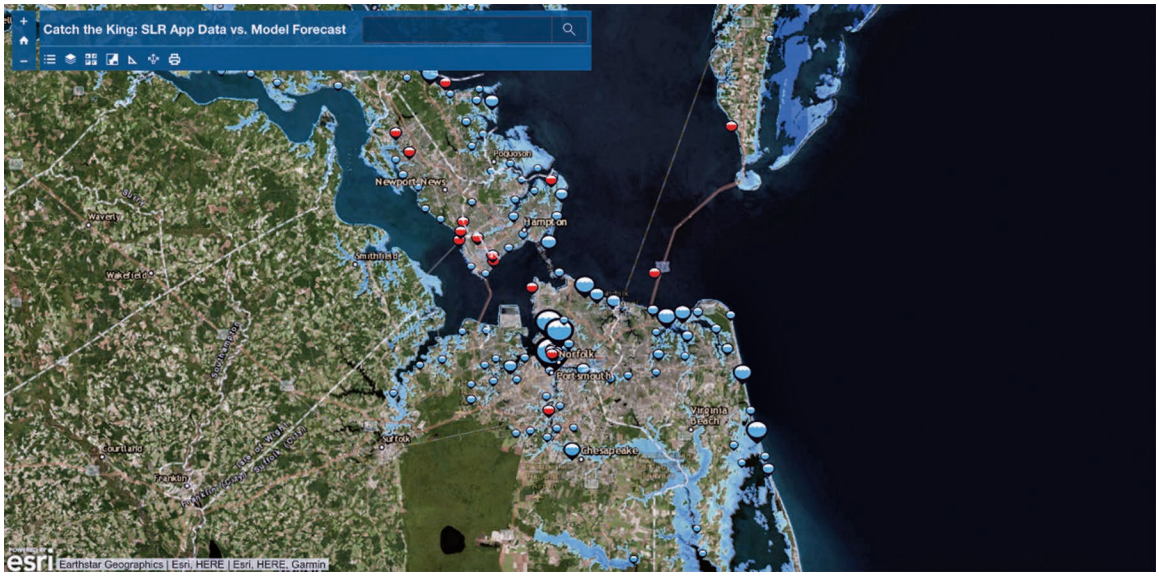
small grant to the City of Newport News, aims to predict flooding resulting from storm surge, rain and tides through the use of 'Internet of Things' enabled water level sensors coupled with hydrodynamic modeling at VIMS and supported by the CCRFR (Loftis, StormSense). RISE, a 501(c)(3) non-profit founded with funds from the National Disaster Resilience Competition Award is working to test and deploy this low-cost water sensor test bed across the region (Rise Resilience). Residents are even involved in gathering real-time flood data; in November 2017, the Virginian-Pilot and other media partners sponsored a Catch the King Tide event which encouraged citizens to map a higher-than usual high-tide to spread awareness of rising seas (Mayfield, 2017). Though this was a one-time event, residents can use the app anytime to map high water. GPS data that citizens generate by 'pinning' floodwaters in the 'Sea Level Rise' iphone or Android application is used to validate flooding models. Prediction of water levels 36 hours in advance is now available via TideWatch and can be accessed by localities or citizens alike (Loftis, TideWatch).

Relative Sea Level Rise—Narrowing the Uncertainties

While uncertainties always remain, best available data of anticipated relative sea level rise is always needed. As noted earlier, one of the reasons Hampton Roads suffers from a high rate of sea level rise is its high rate of subsidence. Scientists with Old Dominion University and NASA's Jet Propulsion Laboratory in cooperation with USGS and the Hampton Roads Sanitation District (HRSD) are working together to monitor subsidence in coastal Virginia. While historic maps show even rates of subsidence, satellite data now shows great variability across the region (Bekeart, 2017).

The Sustainable Water Initiative for Tomorrow (SWIFT) project of the HRSD began injecting treated water back into the Potomac Aquifer in May 2018. While this project is

FIGURE 8. The map, generated by Dr. Derek Loftis of the Virginia Institute of Marine Science who led the project, shows citizen science Sea Level Rise App Observations versus the VIMS model-predicted maximum flooding extents. The citizen scientist inputs are used to validate the model which predicts water levels 36 hours in advance.



primarily driven by concerns with groundwater availability and regulatory costs relating to Chesapeake Bay TMDL requirements, this project may also result in the slowing of local subsidence rates. Project managers are working closely with researchers to collect and share data. Further, HRPDC has coordinated regional installation of GPS stations, which will be used to validate the localized subsidence data gathered from satellite data.

Concurrently, researchers at VIMS have published sea level rise report cards that contain a wealth of data and projects a range of sea level rise in 2050 (Boon, 2018). Localities have used local data and worked with consultants to determine various planning scenarios for sea level rise. While there is general agreement that the sea is rising, and at an accelerated rate, there is still uncertainty as to when specific scenarios may be met. This uncertainty plays heavily into planning decisions at the municipal level. Regardless of the chosen planning scenario, localities recognize that critical facilities must be hardened to a higher standard. However, selection of realistic planning scenarios is essential for a cohesive and resilient adaptation strategy.

Filling Gaps in Data and Analysis

In lieu of state data collection, localities are working closely with academic researchers at ODU and VIMS and consultants to fill data needs. The HRPDC Coastal Resiliency Committee and the Hampton Roads Adaptation Forums serves as a venue for sharing results.

Virginia Beach, which has heavily invested in analysis, recently shared with Forum attendees and the Coastal Resiliency Committee the results of a precipitation analysis of Coastal Virginia. Following Hurricane Matthew, which was referred to as a 1,000-year storm event, residents and experts alike had assumed that precipitation patterns had changed in recent years. The City of Virginia Beach commissioned a study to analyze these changing patterns. As a result of the study, the city is considering up to a 20% increase in design-storm standards (Johnson, 2017). While Virginia Beach staff has met individually with many localities to share the detailed results of this study, which are applicable throughout the region, the HRPDC Coastal Resiliency Committee has hosted conversations designed at facilitating regional adaptation of these proposed standards.

Additionally, localities support investment in green infrastructure for its co-benefits as well as cost-savings when compared with gray infrastructure. However, data is still needed with regards to the long-term efficacy of green infrastructure, such as living shorelines or oyster reefs.

Involvement in the Community Ratings System

Localities participating in the National Flood Insurance Program (NFIP) may participate in the Community Ratings System (CRS), a voluntary program, which aims to encourage responsible floodplain management activities by localities. Residents of participating localities are eligible to receive a percentage savings off of their flood insurance premiums based on the CRS class of their locality.

Currently, there are 25 Virginia communities participating in the program, 7 of which are located in Hampton Roads. Other localities are currently considering applying to the program or are under review for participation. This process can be arduous and time consuming, which often acts as a barrier to participation. In an effort to assist localities, Wetlands Watch, convenes a Coastal Virginia CRS User Group and offers hands-on support to localities. In an effort to encourage locality participation, Wetlands Watch has even undertaken a cost-benefit analysis based on the anticipated administrative burden on the locality and the overall cost savings to residents determining that the average benefit to cost ratio was 15:1 (Stiff, 2017).

FIGURE 9. Traditional stormwater management using gray infrastructure versus stormwater management using green infrastructure.

NEED FOR REGIONAL SOLUTIONS

Enduring Relevance of IPP Recommendations

As coastal communities throughout the United States move forward in planning and adapting to SLR the recommendations from the Hampton Roads Intergovernmental Pilot Project can provide guidance in terms of changes that can and should be considered for resilience and adaptation.

Key recommendations from the Private Infrastructure Committee

The following are highlights of recommendations from the Private Infrastructure Committee:

- Regional planning is necessary and state and federal agencies should play an important role in the development and implementation of strategies. Adaptation will be costly and

local governments will need state and federal investment in adaption strategy implementation. Along these lines, regional SLR scenarios should be developed on a regular basis (4 years) that utilize information from the United States National Climate Assessment which is updated to include the rapidly changing body of scientific literature. This is necessary for all communities throughout the United States, not just coastal communities impacted by SLR. Rising temperatures, changing precipitation patterns, drought and heat waves are climate change impacts that should be anticipated throughout the United States.

- Building codes strategies should be implemented for construction and substantial improvements that are forward looking. Most building codes rely on historical data in terms of requirements related to flooding and severe wind. The National Climate Assessment states that storms will increase in severity and frequency across the United States and building codes should be changed to anticipate these future conditions. For coastal communities, increasing freeboard standards, the required elevation of the first floors of structures, to account for future SLR or changing from a 100-year flood plain management strategy to a 500-year flood plain management strategy would enable communities to start thinking in terms of future impacts rather than historical record. Additionally, transitioning to green building codes that encourage on-site management of stormwater, on-site renewable energy, and water use strategies of reduction and reuse are necessary to build community resilience.
- Communities should develop land use practices that consider adaptation, restoration, and growth. Structure buy-out strategies and transitions to open/green space in low lying areas will improve resilience. Transitioning growth to land at higher elevations, which will be protected longer, can provide economic sustainability in regions that will need to transition to accommodate SLR.
- Water management planning that considers fresh water supply (surface and aquifer), stormwater, waste water, water reuse, flooding and sea level rise and reflects the interconnectivity of these systems is necessary.
- The built environment has both public and private fund investment. Bringing private investment entities (cable, electric, gas, etc.) into the discussion is critical. Providing regional guidance to private companies in regards to future climate change impacts can help them understand how to change their investments in operations and maintenance planning and spending to make their companies and services more resilient. For example, Dominion Power has upgraded their substations in the Hampton Roads region to prepare for flooding related to hurricanes. This preparation also makes them resilient to SLR. If they are provided planning scenarios for SLR, as they make future investment in operations and maintenance, they can consider these scenarios in their upgrades.
- Widespread adoption of green and blue infrastructure practices should be encouraged to help mitigate nuisance flooding and urban heat island effect. Residents and commercial businesses can be incentivized to adopt these practices through the implementation of stormwater fee reductions.

Analysis of Regional Planning Structures and Resolution of the Intergovernmental Pilot Project

Led by Roy Hoagland, the former Director of the Virginia Coastal Policy Center at the College of William & Mary's Law School, the Legal Working Group of the IPP analyzed potential

collaborative structures for regional adaptation to sea level rise, the existing authorities inherent in those structures, or what sort of action would be required to gain certain authorities (for example, the ability of certain stakeholders like federal agencies, NGOs or others to meaningfully participate) (Steinhilber, 2016).

At the direction of the Steering Committee of the IPP, the analysis began with HRPDC leadership and analyzed limitations within the Code of Virginia. Other strategies for collaboration were also considered. Other collaborative models considered included public-private partnerships, the Chesapeake Bay Watershed Agreement (a federal-state collaboration), and special service districts created to oversee financing, management, and implementation. However, at the time, there was no movement to create such an independent organization, and leadership was left to individual localities.

One model discussed was a joint exercise of powers by political subdivisions per agreement, similar to the Southeast Florida Climate Compact. Virginia code authorized two or more political subdivisions, by agreement, to join together to carry out powers or duties they were otherwise authorized or required to perform (Va. Code § 15.2-1300). In Florida, four counties have come together to form the Compact and have jointly adopted sea level rise planning scenarios and adhere to a regional climate adaptation plan (SE Florida Regional Climate Change Compact). Although this was often discussed during the IPP, the participating localities in Hampton Roads were already acting on their own and did not see a benefit to formally signing a new compact, especially if no shared funds were attached or to be made available as a result of signing a new agreement.

The IPP was initially scoped as a two-year project, and due to funding constraints and the changing landscape of flooding adaptation in the Commonwealth, the project is set to conclude on time with the adoption of a Resolution. Nine conclusions were set forth and agreed to in principal by the majority of the Steering Committee including that an entity be established and charged with facilitating and planning actions to be implemented by designated implementers (understood to be either localities or a new authority created by the state such as a special service district).

HRPDC was designated, at their behest, with being the regional lead for collaborative sea level rise planning (Appendix C-1, Steinhilber, 2016). HRPDC acknowledged their role as leaders and among other initiatives, noted that they had recently taken actions to appoint decision makers to the Coastal Resiliency Committee (as opposed to staff-level positions initially appointed), to allocate funds to support a new Coastal Resiliency Planner Position, and serve as project coordinator for two regional Joint Land Use Studies that considered flooding as the main encroachment on to military facilities (HRPDC Memorandum #2016-104).

CONCLUSION

Localities across the Hampton Roads region recognize the risks they face from sea level rise and flooding and are actively adapting to a future with the water. However, despite multiple efforts, the region still suffers from the lack of a coordinated regional approach to financing and implementing resilient solutions, especially in watersheds which include multiple localities. New leadership initiatives at the state and regional level are steps in the right direction but will not adequately address the regional flooding issues.

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