VIRGINIA
COASTAL RESILIENCE
MASTER PLAN

PHASE 1

DECEMBER 2021

Office of Governor Ralph S. Northam
Commonwealth of Virginia

DCR

Letter from the Governor

December 7, 2021

My Fellow Virginians,

Nearly four years ago when the Commonwealth began the process of developing this document, we knew Virginia had a long way to go to adapt to our coastal flooding problems — both present and future. I was raised on the Eastern Shore — this is personal to me — and I know our coastal communities are already struggling with the consequences of climate change, and that the best science predicts that conditions will worsen in the coming years. After completing the exercise of crafting the Commonwealth's first ever Coastal Resilience Master Plan, we now have a clearer picture of the scope and scale of the challenges facing the Commonwealth.

The Virginia Coastal Resilience Master Plan describes and identifies many projects proposed by local governments and other sponsors that will make some areas and assets more resilient in the near term. However, there are many areas of identified risk for which neither short nor long term solutions currently exist. For that reason, perhaps the most important information provided by this initial Master Plan is the identification of the broad gaps in flood protection and adaptation capacity and coverage all along our coastline, as well as the need for additional data and analysis to further refine our understanding of the impacts of climate change.

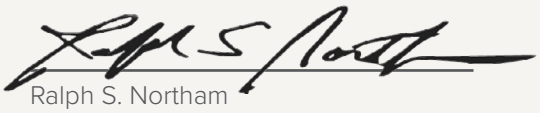
Getting to this point is essential and significant progress.

The Commonwealth has now developed a baseline level of knowledge about where and to what degree sea level rise and storm surge will increase flooding, and what communities and built and natural infrastructure will be impacted. We have integrated that knowledge into the Master Plan and related state resilience and adaptation initiatives, which will help us support responsible coastal planning and direct financial assistance and technical support where it is most needed. We will continue to refine our understanding of coastal climate change impacts by adding in predictive rainfall models and other new data, broaden our outreach efforts to impacted communities, and turn our focus to coastal areas with the most risk and need.

The science behind this Plan also shows definitively that some communities and facilities in Virginia will cease to be habitable or accessible over the next 60 years because of more frequent flooding, impacts from catastrophic events, or permanent inundation. And while the Plan identifies critical components of the built environment that we should protect where they are, even at great cost, it is clear that we must also focus on the most important and effective flood protection measure of all: moving people and structures out of harm's way. It is our duty as public servants to have honest, frank conversations with residents about these facts, and to back up those conversations with action that supports and incentivizes adaptation and protection measures while also pursuing the difficult but strategic and orderly relocation of individuals, communities, and economic assets.

Future versions of the Virginia Coastal Resilience Master Plan will continue to identify and prioritize adaptation strategies that are realistic, not wishful. Climate change will permanently alter the physical limits of our coastal lands, but with thoughtful planning and a willingness to make tough decisions, we can adapt and maintain the thriving communities, economies, and ecosystems that make coastal Virginia such a special place.

Sincerely,



Ralph S. Northam

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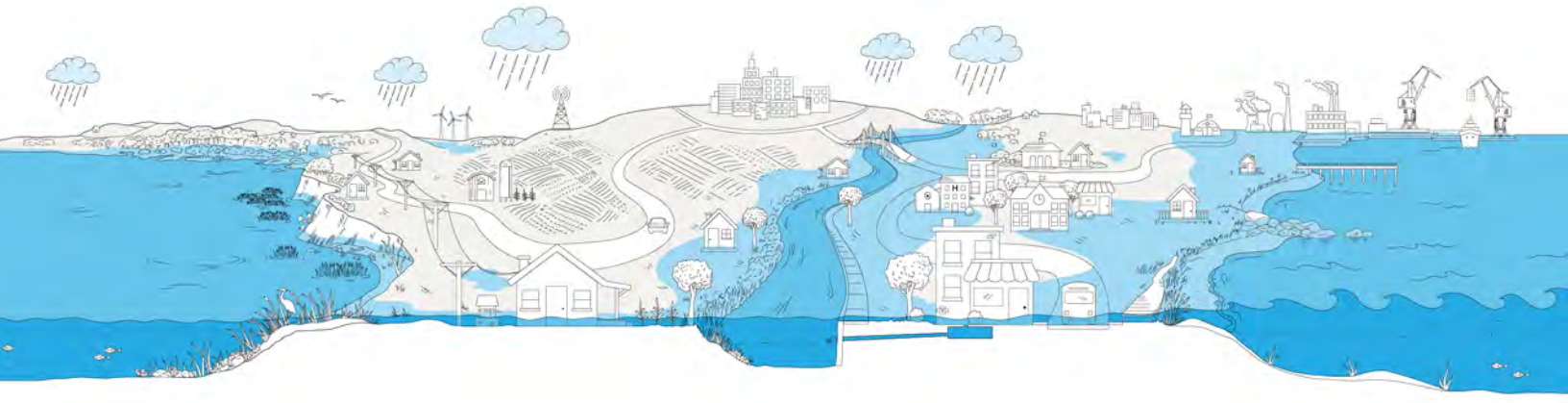
Executive Summary

Photo courtesy of the Port of Virginia

The Executive Summary summarizes the purpose, process, and key findings from the first phase of the Master Plan, and provides an overview of the current and planned steps the Commonwealth will take to achieve a resilient coastal Virginia.

Why This Plan

The Virginia Coastal Resilience Master Plan is a call to action for the Commonwealth. From growing cities to migrating coastal wetlands, Virginia's coast faces a new reality. As sea levels rise and severe weather intensifies, climate change is threatening our cherished coastal regions' economic, cultural, and environmental resources.



The impacts of sea level rise and climate change will be felt across the Commonwealth and beyond. Phase One of the Master Plan establishes where we are and sets the course for what we must do to adapt and protect our coast by identifying viable strategies for resilience that are practical and equitable.

Nearly six million people, or 70% of the state's population, call coastal Virginia home.[1] Our coastal regions are thriving economic hubs, hold unique cultural resources, and offer unparalleled natural beauty, which collectively shape diverse landscapes and communities. However, coastal Virginia faces growing threats. Between rising sea levels and changing precipitation patterns, Virginia has already recorded changes to the frequency and intensity of floods that pose increasingly greater risks to our communities.

Flooding affects many Virginians but does not do so equally. Each community faces varying levels of flood exposure, vulnerability to harm or damage, and associated risks, tied to its individual socioeconomic, historical, and physical context. While some communities are well-resourced and focused on the challenges ahead, others lack capacity or allocated funds to address growing and changing flood risks. To achieve functional resilience, we must create equitable opportunities to build capacity and center social and economic equity as a fundamental factor in all our efforts.

With so much at stake, we cannot afford a hands-off approach.

The reality of rising sea levels and changing precipitation patterns brings with it both a challenge and an opportunity: charting a comprehensive path toward long-term coastal resilience to protect people, homes, businesses, infrastructure, and ecosystems.

Stakeholder Engagement

1,300+ people participated in a public survey focused on understanding how flooding has affected them, their preferred resilience strategies, and how much of a risk they feel flooding poses to their community now and in the future.

300+ local and regional practitioners participated in webinars, meetings, and workshops.

500+ resilience projects and capacity-building initiatives related to flooding or resilience identified by regional and local practitioners.

What We've Done

The Master Plan builds on the 2020 Virginia Coastal Resilience Master Planning Framework, which outlined the goals and principles of the Commonwealth's statewide coastal resilience strategy. Recognizing the urgent challenge flooding already poses, the Commonwealth developed Phase One of the Master Plan on an accelerated timeline and focused this first assessment on the impacts of tidal and storm surge flooding on coastal Virginia.

The Master Plan leveraged the combined efforts of more than two thousand stakeholders, subject matter experts, and government personnel. We centered the development of this plan around three core components:

- A **Technical Study** compiled essential data, research, processes, products, and resilience efforts in the Coastal Resilience Database, which forms much of basis of this plan and the Coastal Resilience Web Explorer;
- A **Technical Advisory Committee** supported coordination across key stakeholders and ensured the incorporation of the best available subject matter knowledge, data, and methods into this plan; and
- **Stakeholder Engagement** captured diverse resilience perspectives from residents, local and regional officials, and other stakeholders across Virginia's coastal communities to drive regionally specific resilience priorities.

Key accomplishments of this first phase of the Master Planning effort include:

- Determined current and future land **exposure to coastal flooding hazards**, and identified anticipated changes in future coastal flood frequency across the Commonwealth.
- Used the modeled the coastal flood hazard information to estimate **impacts** to Community Resources, Critical Sectors, and Natural Infrastructure.
- Identified areas with both high **social vulnerability** and coastal flood hazard exposure to determine areas with the greatest potential needs and risks.
- Conducted **workshops** with Planning District and Regional Commissions, localities, and communities to refine the assessment of impacts due to coastal flooding with local knowledge and understanding.
- Established an inventory of locally-driven coastal **resilience projects** that address regional and statewide needs, and a process for understanding, tracking, and collecting data on ongoing and future proposed resilience projects
- Developed an initial data-driven approach to **evaluate and prioritize projects** based on how well efforts align with the guiding principles of the Commonwealth's coastal resilience strategy outlined in the Framework, and developed an initial mechanism to align identified coastal resilience projects with potential funding sources.
- Leveraged and augmented previous work supported by the Virginia Coastal Zone Management Program to establish an **inventory of grant and loan programs** relevant to resilience efforts to assist regions and localities with securing financial resources.
- Created the **Coastal Resilience Database and Web Explorer** which makes data on coastal flood hazards, impacts, ongoing and proposed projects and initiatives, funding programs, and other relevant information publicly available to support resilience efforts at the state, regional, and local levels.
- Collected information on proposed and ongoing **capacity-building and planning initiatives** related to resilience, and identified the needs of localities and regions across coastal Virginia to advance their resilience efforts.
- Initiated a **public planning process** and established a baseline understanding of public perspectives and on-the-ground knowledge of coastal flood hazards and preferred strategies to adapt and protect coastal Virginia through workshops with regions, localities, and members of the public.

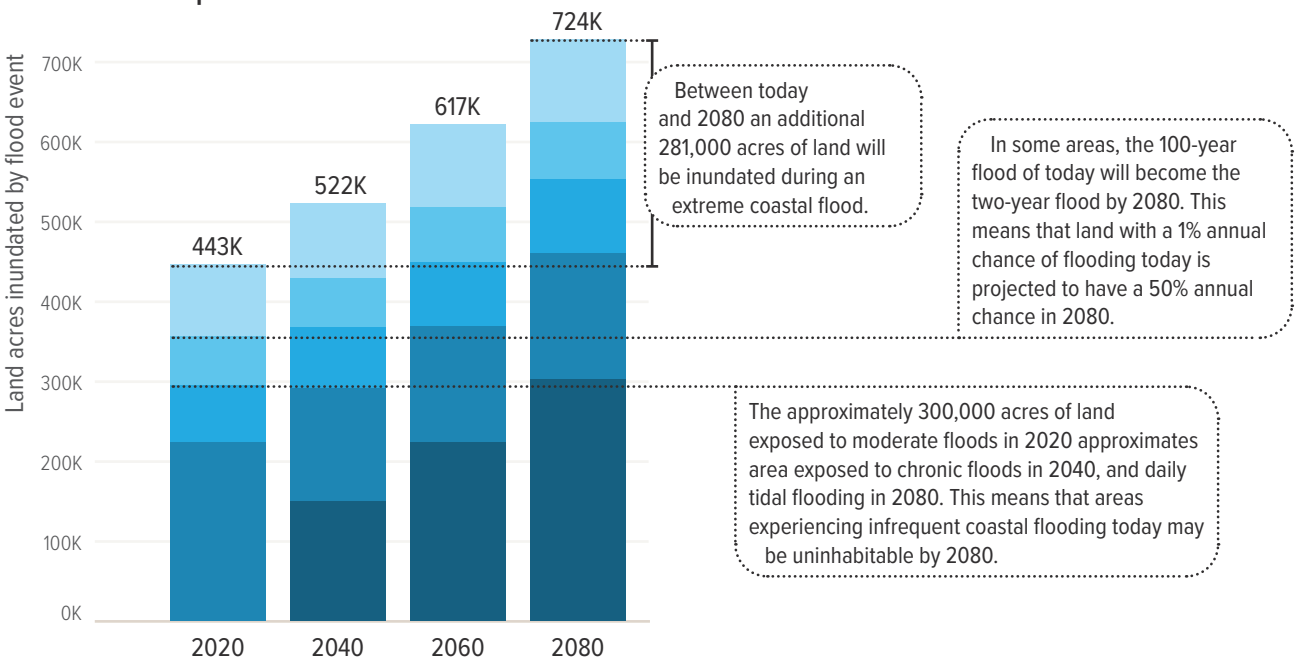
What We've Learned

The Master Plan's Technical Study focuses on how sea level rise will affect tidal and coastal storm surge flooding to assess how coastal flood hazards and impacts will change over time. Due to the time available to complete Phase One, the Technical Study does not examine existing or future flood hazards for riverine, stormwater, and compound flooding as affected by sea level rise, nor does it consider how climate change may affect precipitation trends and flooding hazards.

The Technical Study examines nine coastal flood events representing varying magnitudes that can be compared over time horizons: 2020, 2040, 2060, and 2080. The 2020 time horizon represents existing baseline conditions to compare future changes in sea level rise and coastal flood hazard events. The Master Plan simplifies these nine flood events into five reference events, outlined below, but data for all nine events can be found on the Coastal Resilience Web Explorer.

As sea levels rise, flood hazards grow worse in two important ways: floodplains will expand, and floodwaters will deepen. The area of land exposed to coastal flooding will gradually grow in response to sea level rise, and the types of coastal flood impacts that are considered "rare" and "extreme" today will become more frequent and even commonplace in the future.

Growth in Floodplain Extents



Reference Flood Event	Annual Exceedance Probability (AEP)	Average Return Interval (Frequency)	Example Storm/Event Type
Tidal	Mean High Water	Inundated Daily	Daily High Tide
Chronic	20% AEP	5 years	Gale, Smaller Coastal Storm
Moderate	4% AEP	25 years	Tropical Storm, Nor'easter
Major	1% AEP	100 years	Strong Nor'easter, Category 2 hurricane
Extreme	0.2% AEP	500 years	Category 3+ hurricane

Over the course of the past year, we have learned how essential this work is and how much more there is to do.

Moving forward, we must go beyond determining how flood hazards will change. We must use this information to start honest and productive conversations on how to reduce impacts to communities, critical infrastructure, and natural systems through adaptation, protection, and relocation measures at community, locality, and regional scales.

A key objective of the Technical Study was to identify what social, economic, and natural assets are at risk due to coastal flooding. Understanding these potential impacts is critical to selecting resilience projects which will minimize damage or disruption to a region's way of life. The Technical Study combined hazard information with information on Virginia's social, natural, and built resources to understand where our greatest vulnerabilities and needs lie. The Technical Study then measured and mapped projected impacts due to coastal flooding to identify geographic hotspots that face acute flood risks. Identifying these hotspots allows the Commonwealth to highlight areas that may require additional support to plan for resilience and prioritize or implement resilience projects.

Notable Findings from the Technical Study's Impact Assessment

Between 2020 and 2080...

the number of **residents** living in homes exposed to major coastal flooding is projected to grow from approximately 360,000 to 943,000, an increase of **160%**.

the number of residential, public, and commercial **buildings** exposed to an extreme coastal flood is projected to increase by almost **150%**, from 140,000 to 340,000, while annualized flood damages increase by over **930%** from $550 million to $5.7 billion.

the number of miles of **roadways** exposed to chronic coastal flooding is projected to increase from approximately 500 to nearly 2,800 miles, an increase of **460%**.

an estimated 170,000 acres, or **89%**, **of existing tidal wetlands** and 3,800 acres, or **38%**, **of existing dunes and beaches** may be permanently inundated, effectively lost to open water.

Virginia Coastal Resilience Web Explorer

The Coastal Resilience Web Explorer is a publicly available tool that provides access to maps, data, and other relevant technical information developed through the Master Plan's Technical Study and housed in the Coastal Resilience Database. The Master Plan summarizes the nine flood events into five reference events. To view the floodplains, related data for these nine events, and associated impacts, go to https://www.dcr.virginia.gov/crmp/ResilienceExplorer.

What We're Doing About It

We need actionable, practical solutions to protect coastal communities and assets from potential harm due to flooding. The Commonwealth, in cooperation with the regional and local entities, compiled an inventory of many of the most pressing existing resilience projects and capacity-building initiatives in coastal Virginia for this first phase of the Master Plan. This effort identified over 500 projects and initiatives employing a range of strategies to increase resilience. Of these, 140 resilience projects related specifically to coastal flood hazards, but these projects are just a small portion of the overall needs for the Commonwealth.

Capacity-building and planning initiatives include activities that give regions and localities the knowledge, skills, and tools they need to understand their risks and take concrete actions, such as developing resilience projects, to protect their residents and assets from the threats posed by coastal hazards. The Commonwealth classified initiatives into three categories.

- **Studies and data tools** include efforts that improve the jurisdiction's understanding and knowledge of relevant current and future coastal flood hazards, vulnerabilities, and risks, and options to adapt to future risks to improve outcomes for community, economic, and ecosystem resilience.
- **Programs, plans, and policies** include efforts that improve the jurisdiction's ability to implement and engage in coastal resilience planning.
- **Technical assistance** includes efforts to improve the jurisdiction's ability to execute and fund coastal resilience efforts.

Resilience projects refer to activities that lead to on-the-ground projects to reduce the risk of potential flood damage. The Commonwealth identified three primary classes of resilience projects that use different strategies to adapt to sea level rise and changing flood hazards.

- **Natural and nature-based** strategies aim to preserve, restore, or mimic risk-mitigating features that occur naturally in the landscape through the engineering and construction of features that replicate or enhance natural conditions and ecosystem services.
- **Structural** interventions prevent coastal or riverine floodwaters from passing into inland areas through the protection of individual assets or the blocking of flood pathways.
- **Hybrid** projects incorporate both natural and nature-based features and structural methods. Implementing both strategies can maximize the potential benefits of each intervention for the benefiting area.

Achieving a resilient coastal Virginia will require more resources than currently exist.

While we do not yet know the total cost for making coastal Virginia resilient to sea level rise and other coastal hazards, we do know it is well into the billions of dollars. Even the hundreds of resilience projects that have already been identified likely only represent a small sample of the much greater need to protect our coastal assets across the Commonwealth. Yet the cost of doing nothing is increasingly expensive and not an option to protect and adapt coastal Virginia's social, economic, and natural assets.

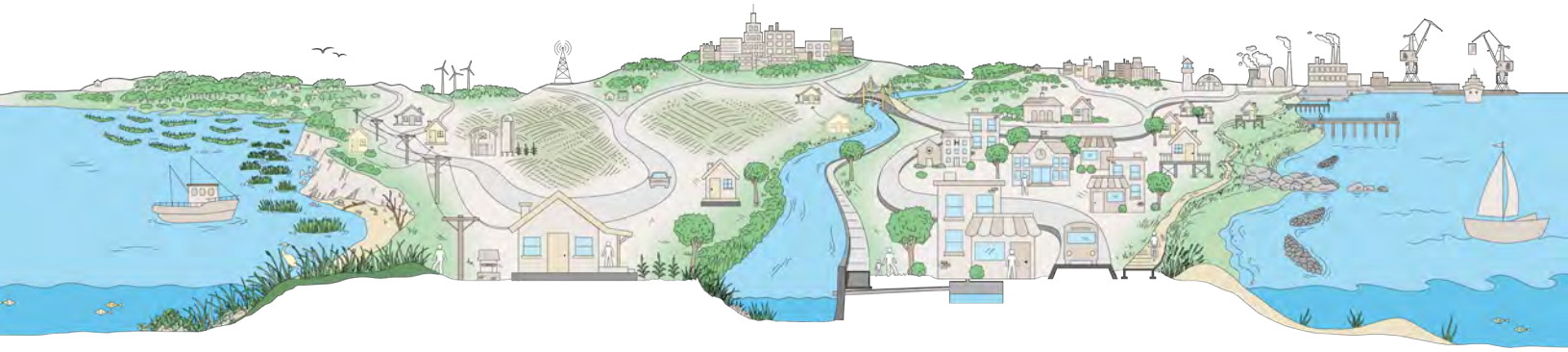
To maximize finite resources, the Commonwealth researched and initially analyzed grant and loan programs and financing mechanisms to identify potential sources for resilience strategies. The primary state-level funding mechanism for coastal resilience project development and capacity building will be the Virginia Community Flood Preparedness Fund, launched in 2021. Managed by the Department of Conservation and Recreation, this statewide program fills pressing needs by prioritizing low-income communities and provides a permanent and dedicated funding stream to finance flood resilience project development, related studies, and capacity building initiatives.

With so much at stake and finite resources, we must work to prioritize resilience projects that advance pragmatic coastal resilience in alignment with the Commonwealth's vision.

The Commonwealth developed a preliminary evaluation approach to assess projects against standardized criteria that aligns with the goals and principles of the statewide coastal resilience strategy identified in the Framework. This process will allow the Commonwealth to establish a transparent, repeatable process, so jurisdictions can plan or revise projects that align with criteria. Future phases of the Master Plan will aim to refine and implement the evaluation approach to prioritize resilience projects and identify potential funding or technical needs to support implementation.

What's Next

The first phase of the Master Plan is a call to action for the Commonwealth, its regions, localities, communities, and many other stakeholders, to continue this work.



Phase One of this Coastal Resilience Master Plan is a foundational first step towards a resilient coastal Virginia. In considering the 6 million people who live in coastal Virginia and the region's economic impact on the Commonwealth, we have learned over the past year how essential this work is and how much more there is to do. This process must be sustained, evolve and grow as priorities, needs, and data change over time.

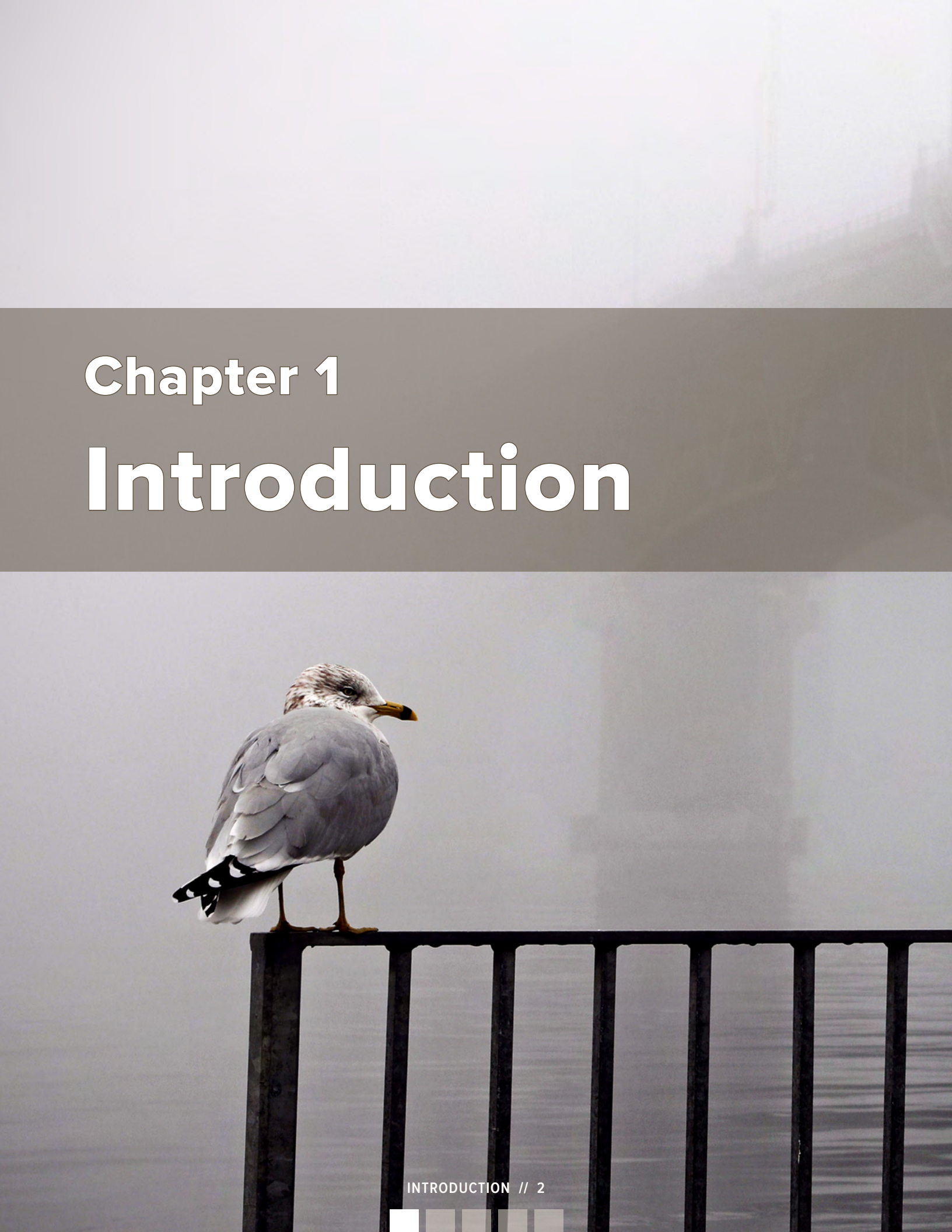
This first phase will catalyze additional analyses, data collection, risk and impact assessments, and most importantly, an expanded and sustained public engagement process. We are planning for successive updates of the Master Plan on a five-year cycle, managed by the Department of Conservation and Recreation in consultation with the Technical Advisory Committee. What we have learned during Phase One drives the need to continue this work and complete Phase Two in a shorter cycle to fully develop a Coastal Resilience Master Plan for Virginia. We anticipate the completion of Phase Two of the Master Plan by the end of calendar year 2024.

Continuous maintenance and enhancements will be essential to incorporate new data, analysis, projects, and funding opportunities between iterations of the Master Plan for the Commonwealth. In recognition of these needs, key recommendations for Phase Two include the following:

- Broaden the analysis and characterization of hazards by including rainfall-driven, riverine, and compound flooding in the Technical Study's coastal hazard and impact assessments.
- Expand and improve the inventory of resilience projects by continuing to add proposed and planned projects and refining the data requested from project owners to better understand the scope and benefits of projects.
- Develop and implement sustainable public planning, outreach, and engagement processes.
- Revise and expand the project evaluation and prioritization approach, based on the risks and impacts identified in the Technical Study's updated impact assessment and gap analyses.
- Determine options and opportunities to develop adaptation and protection solutions for identified gaps in high risk and vulnerable areas.
- Expand the Coastal Resilience Web Explorer and Database beyond the coastal region to encompass statewide resilience planning needs.

The Commonwealth has already moved to expand this work to help us to better understand the full risk to our coastal region as soon as possible. We learned through this process that coastal flooding is not the only flood hazard facing our coastal communities. In recognition of this, in early 2022, the future condition rainfall and riverine flooding analysis will begin with anticipated completion by 2023. **As we press forward,** the Commonwealth will work with coastal localities and solicit advice from the Technical Advisory Committee to expand the project inventory and to better understand the capacity-building needs of coastal communities. Additionally, the Commonwealth will sustain activities beyond the Technical Study that require long-term oversight and maintenance to ensure the continued progress and success of the Master Planning effort.

Chapter 1
Introduction



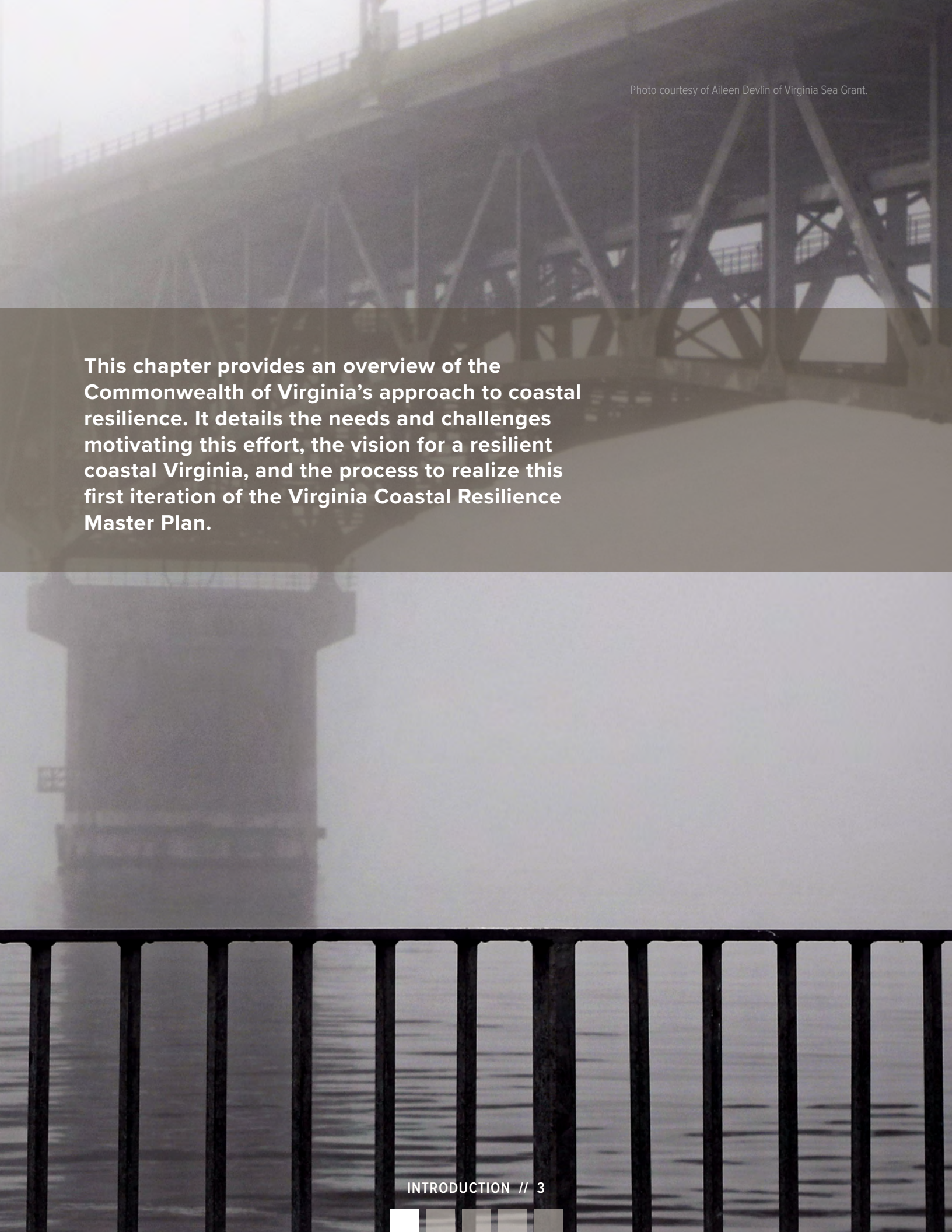


Photo courtesy of Aileen Devlin of Virginia Sea Grant.

This chapter provides an overview of the Commonwealth of Virginia's approach to coastal resilience. It details the needs and challenges motivating this effort, the vision for a resilient coastal Virginia, and the process to realize this first iteration of the Virginia Coastal Resilience Master Plan.

Our Driving Motivation

From growing cities to migrating coastal wetlands, coastal Virginia faces a new reality.

As sea levels rise and severe weather intensifies, climate change threatens our cherished coastal regions' economic, cultural, and environmental resources. All Virginians, either directly or indirectly, will be affected by sea level rise, stormwater flooding, elevated water tables, and worsening storm surge impacts. We must act now to protect the Commonwealth and prepare for this rapidly approaching reality.

Water plays a defining role in coastal Virginia and poses a flood threat requiring careful management and planning. Historically, water was a critical advantage to early settlements and economies. Over time, these historic settlements have grown into vibrant coastal communities. Today, nearly six million people, or 70% of our population, call coastal Virginia home.[2] Our coastal regions contain nearly 1,500 miles of roads and properties valued at a cumulative $17.4 billion lying less than five feet above the high tide line.[3]

With so much at stake, we cannot afford hands-off or uninformed approaches.

From 2019 to 2020 alone, Virginia experienced nine weather and climate disasters which incurred over $1 billion in costs.[4] In recent decades, changes in precipitation patterns are responsible for about one-third of flood damages.[5] Climate change will further intensify these events, and their costs will likewise grow. Given this, we must move beyond relying on historical conditions and outdated data and standards so we can pivot to a forward-facing approach that is resilient to such changes.

This inevitable reality, while challenging, brings great opportunity to chart a comprehensive, statewide path toward long-term coastal resilience to protect homes, businesses, infrastructure, and ecosystems. The Virginia Coastal Resilience Master Plan will prepare the Commonwealth for more intense, severe flooding by identifying viable, effective, and equitable solutions and strategies.

Working across localities, regions, and state agencies will ensure we maximize limited resources through coordinated efforts. We will learn from each other and identify opportunities to improve collective outcomes. As resilience efforts move forward, it is essential to acknowledge that climate change challenges each region, locality, neighborhood, and individual in different ways. We must consider each one's unique needs as we identify gaps and target opportunities for the most cost-effective and long-term solutions.

Flooding affects most Virginians but does not do so equally.

Each community faces varying levels of flood exposure, vulnerability to harm or damage, and associated risks due to its unique economic, social, and historical context. Further, some localities and counties lack the financial resources, staff capacity, and the political support to push resilience efforts forward. Climate change will further exacerbate these disparities. We must center social and economic equity in all our efforts to achieve an equitably resilient coast for all Virginians.

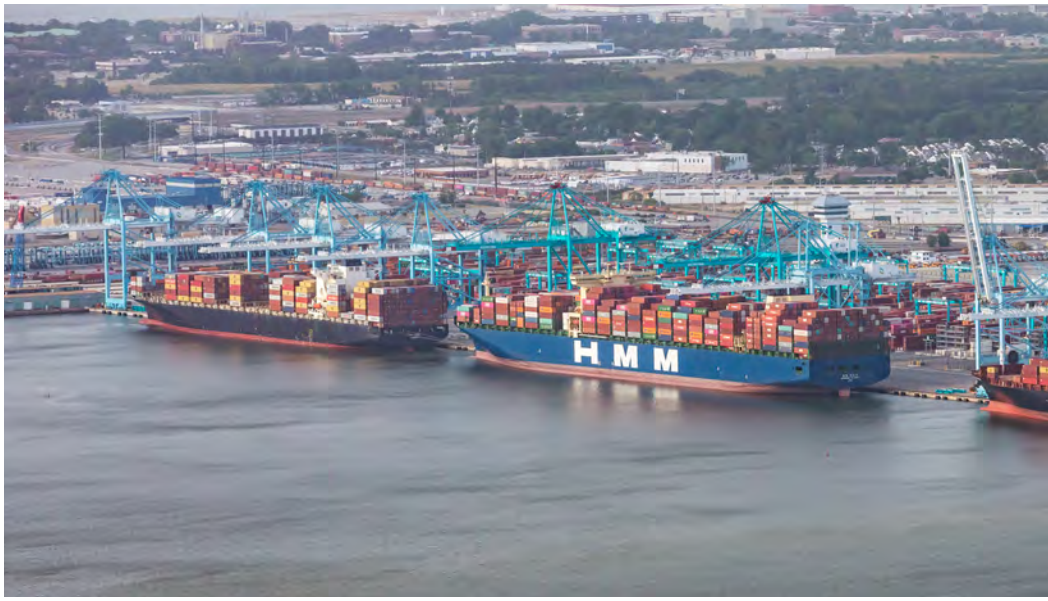
Climate Change and the Chesapeake Bay

The Chesapeake Bay is a vital natural treasure, the nation's largest estuary and an economic engine for the Commonwealth of Virginia. The Bay's health is harmed by climate change, sea level rise, and extreme weather events. These phenomena will continue to impact its water quality, habitats and living resources and threaten progress towards the regional partnership's commitment to a restored Chesapeake Bay.

In October 2021, Governor Ralph Northam, the Chair of the Chesapeake Executive Council, adopted Executive Council Directive No. 21-1 Collective Action for Climate Change. The Directive was signed by Bay watershed leaders, including Virginia, four other states, the District of Columbia, the Chesapeake Bay Commission and the U.S. Environmental Protection Agency. The Directive calls for addressing the threats of climate change in all aspects of the partnership's work, prioritizing communities and habitats most vulnerable to ever-increasing risks posed by climate change, applying the best scientific, modeling, monitoring and planning capabilities of the Chesapeake Bay Program, and connecting Chesapeake Bay restoration goals with emerging opportunities in climate mitigation, and resilience.

Defining Resilience

Resilience refers to the capability to anticipate, prepare for, respond to, and recover from hazards to minimize damage to social well-being, health, the economy, and the environment.[12]



Virginia's Changing Climate

Climate change is affecting Virginia in multiple ways. Virginia recorded increasing seasonal temperatures, rising sea levels, and changing precipitation patterns[7] as global average temperatures have risen 1.8° F (1° C) over the past century.[8] These changes are accelerating, with the most significant rates of change observed since the late 1990s.

Virginia is already witnessing the adverse effects of climate change. Sewell's Point tide gage on Naval Station Norfolk has measured over 18 inches of sea level rise in the past century.[9] The intensity, duration, and frequency of rainfall events have been increasing across coastal Virginia, and these increases are expected to continue. Flood risks along coastlines are intensifying, demonstrated by more frequent, enduring, and severe nuisance flood events caused by rain, wind, lunar high tides, storms, or any combination of events.

Scientists project that these trends will continue and, in many cases, worsen.[10, 11] Areas accustomed to nuisance flooding will become permanently inundated in the next fifty years. Solutions designed to solve today's problems will not apply to the increased resilience challenges Virginia will face as climate trends continue.

Historic Sea Level Rise Trend in Sewell's Point, Virginia

Source: National Oceanic and Atmospheric Administration, 2021[6]

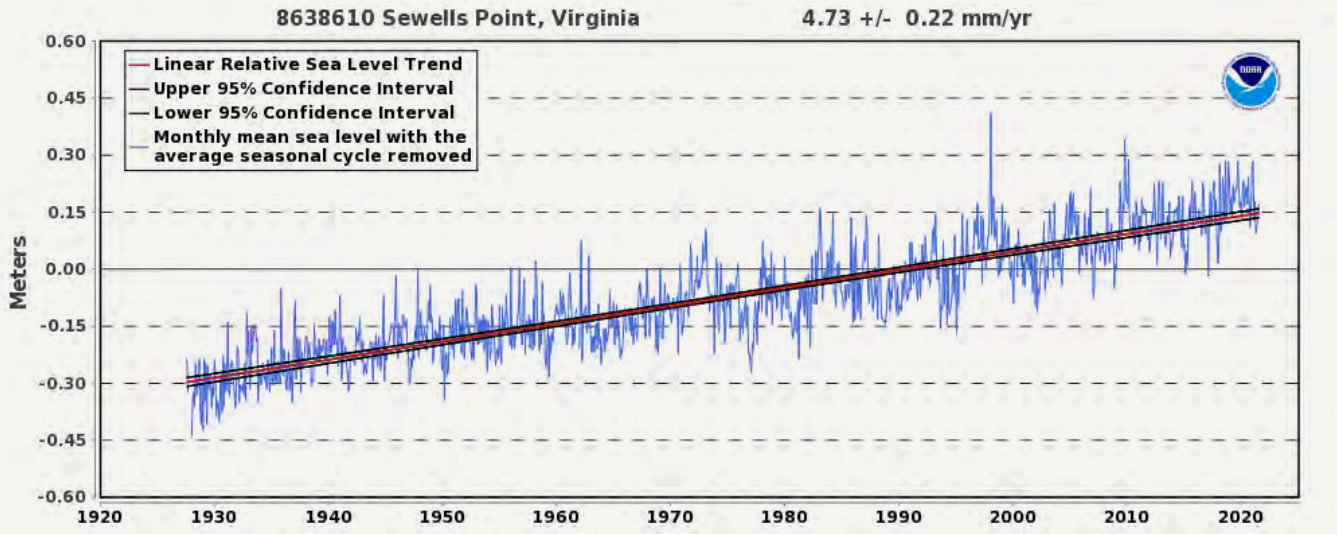


Photo courtesy of the Port of Virginia.

The Call for a State-Led Effort

The scale, complexity, and need to coordinate efforts between communities and regions on these coastal challenges necessitates state-level leadership. For thousands of years, people have pioneered new ways to live and thrive alongside Virginia's waters. As flood risks accelerate, current individual resilience efforts are increasingly insufficient to protect coastal communities from potential damage and loss caused by coastal storms and floods.

The need to invest in resilience is urgent, but resources are limited. Too often, investments are disjointed and far less than what communities require to address their most critical needs, or are insufficiently allocated to prioritize resilience efforts. Further, existing efforts vary widely in scale and effectiveness due to inequities in capacity and financial resources. Consequently, partners, programs, and policies are spread too thin to make meaningful progress.

State-level leadership is filling these gaps by expanding and coordinating available resources to create a comprehensive array of solutions addressing social and physical flood vulnerabilities. In recent years, the Commonwealth has expanded staff support of resilience efforts. The Master Plan will be managed by the Department of Conservation and Recreation with guidance and support from the Chief Resilience Officer and Special Assistant to the Governor for Coastal Adaptation and Protection. This effort creates a unified and efficient strategy to identify critical resources and priority areas and prioritize strategies to protect them. State leadership can best consolidate resilience priorities and needs across the coastal regions. We intend to deliver this through inclusive and coordinated actions, objectively evaluating projects to support priorities and assisting in securing or directly allocating funding.

To date, a fundamental gap remains in the allocation of resources for resilience efforts. All communities need access to resources and funding that support resilience, especially historically under-resourced communities. Even as we expand our efforts there will there never be enough funding to protect all homes, businesses, infrastructure, and other coastal assets where they currently exist. Difficult decisions must be made to ultimately move people and structures out of harm's way and incentivize resilient development processes. These decisions can be made easier with effective state leadership and policies backed by information needed to understand communities' most vulnerable assets. In turn, such information can help identify and prioritize mitigation projects with the greatest collective impact.

Through this first Master Planning effort, the Commonwealth aims to facilitate collaboration, coordination, and communication across the state's coastal regions, while helping to close the funding gap between higher- and lower-resourced communities.

Photo courtesy of Aileen Devlin of Virginia Sea Grant.

Integrating Coastal Resilience into Local and Regional Planning Processes

The Master Plan assesses the potential consequences of climate-change-driven increases to future coastal flood hazards. The coordination of the Master Plan with local and regional planning processes, such as hazard mitigation and comprehensive plans, is critical to protecting and preparing coastal communities for changing flood risks.

Hazard mitigation refers to the proactive, preventative planning process of identifying and performing sustained actions to reduce or eliminate the long-term risks to human life and property from hazards and their effects.[13] Mitigation is a crucial part of the disaster management cycle. The Federal Emergency Management Agency requires local, tribal, and state governments to develop hazard mitigation plans to examine the risks and consequences of relevant hazards and identify mitigation strategies to reduce the risk of potential impacts on people and property.

In Virginia, local governments develop **comprehensive plans** to guide the jurisdiction's future physical development and growth in a way that promotes the health, safety, morals, order, convenience, prosperity, and general welfare of residents. These plans identify long-range recommendations for the jurisdiction's general development, including developing a capital improvement plan.

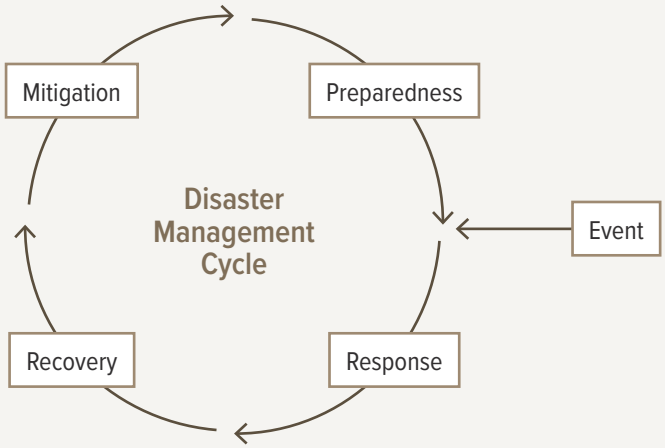


Photo courtesy of Aileen Devlin of Virginia Sea Grant.

The Need for Regionally Tailored Solutions

Although state leadership is vital, a one-size-fits-all approach will not achieve comprehensive resilience. Coastal Virginia contains diverse landscapes and communities, from the urban centers in Hampton Roads to the undeveloped barrier islands along the Eastern Shore. Such variances among localities result in differences in flood vulnerability stemming from a combination of physical, social, and economic factors.

Across the Commonwealth, local stakeholders hold different preferences on how to address such challenges. These variations require solutions adapted to each region's unique needs, values and priorities, while aligning with goals and guiding principles of the Commonwealth's broader coastal resilience strategy.

In developing this Master Plan, the Commonwealth coordinated with key stakeholders who know their communities best. Collaborative exercises included local and county governments; planning and regional commissions; non-governmental organizations; and coastal residents. These efforts captured regional objectives, projects, and community needs to create the cohesive statewide strategy presented in this Master Plan.

The Virginia Coastal Resilience Master Planning Framework introduced the four Master Planning Regions to streamline the Commonwealth's efforts while acknowledging varying needs and priorities.

What Is a Planning District or Regional Commission?

A **Planning District Commission** (PDC) or **Regional Commission** (RC) is a political subdivision of the Commonwealth chartered through the Regional Cooperation Act and created through agreements between local governments.[14] These districts aim to encourage and facilitate cooperation among local governments and between state and local government to address regional problems. The PDCs and RCs serve as liaisons between localities and state agencies and conduct strategic planning for the region. Their roles may include studying problems of regional significance, identifying cost-saving opportunities through coordinated governmental efforts, and providing technical assistance and implementing services upon request of member localities, among other duties.

Virginia consists of 21 PDCs and RCs, eight of which contain tidally influenced shorelines or waters. As participants in the Virginia Coastal Zone Management Program, Virginia's eight coastal PDCs and RCs meet quarterly to discuss matters of shared interest in Virginia's designated Coastal Zone, including coastal adaptation and protection efforts that cross local boundaries. The Master Plan focuses on all the territory within these eight PDCs and RCs, which extends beyond Virginia's Coastal Zone in some regions.

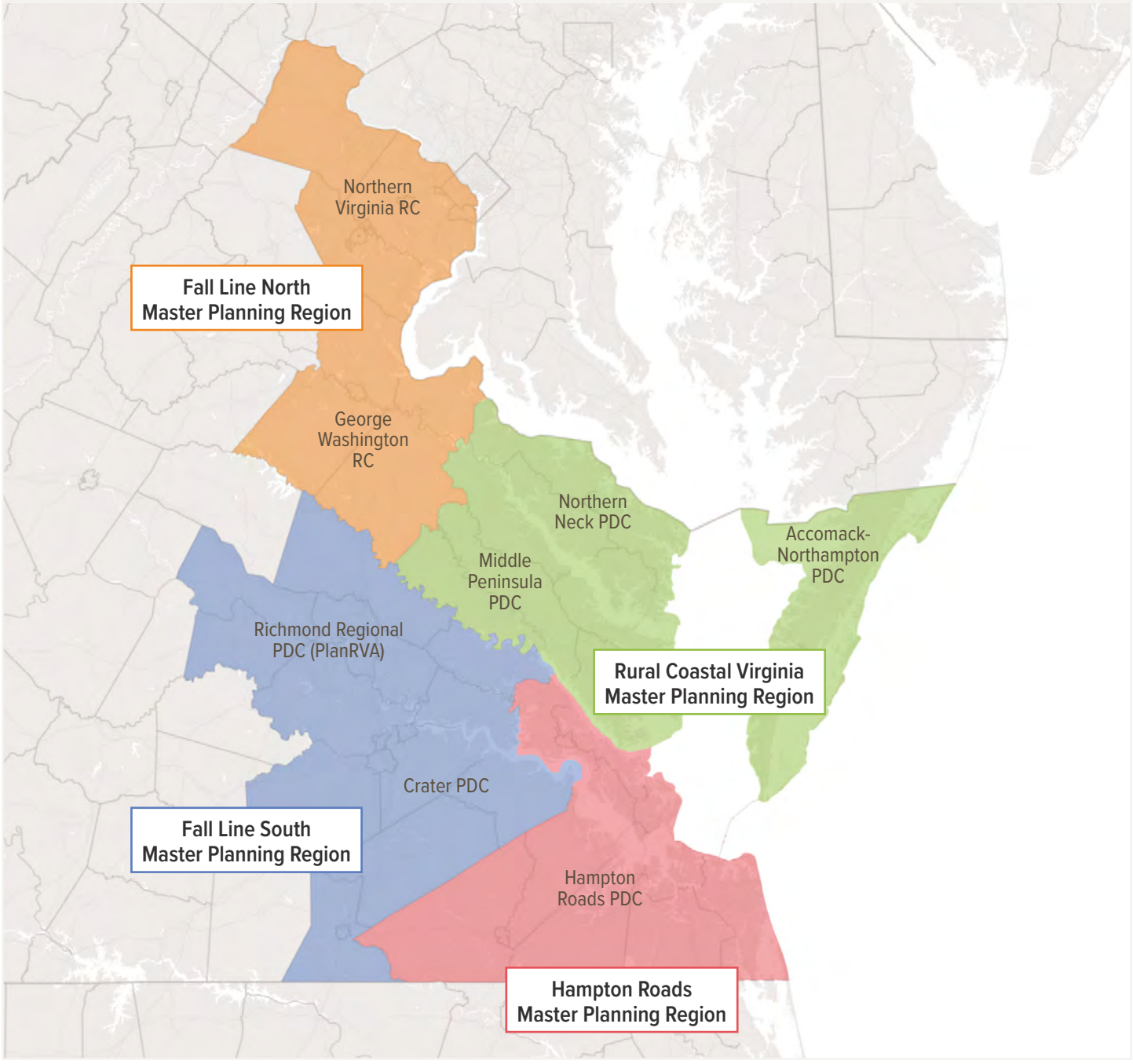
Several PDCs and RCs include member localities of an adjoining commission for planning continuity purposes. This structure exists for PlanRVA and the Crater PDC for Chesterfield County and Charles City County; the Middle Peninsula PDC; and the Hampton Roads PDC related to Gloucester County; and for the Crater PDC and the Hampton Roads PDC related to Surry County. To avoid confusion, member localities are listed only under the legislatively enabled PDC or RC, and not for other districts with which the locality shares membership.

Photo courtesy of Aileen Devlin of Virginia Sea Grant.

Introduction to the Master Planning Regions

The four Master Planning Regions consist of eight PDCs and RCs that already work together to address shared and regional planning needs. These regions include coastal areas or those containing tidally influenced waters and encompass localities and counties with similar development patterns, economies, flood exposures and risks, and resilience priorities.

The Master Planning Regions are geographic regions with shared characteristics but are not political subdivisions defined in code, with the exception of the Rural Coastal Virginia Master Planning Region which is coincident with the Rural Coastal Virginia Community Enhancement Authority (§ 15.2-7600 through 15.2-7607). The Master Plan's Technical Study utilizes these Master Planning Regions in addition to smaller regional and locality based political subdivisions to summarize coastal hazard exposure, impacts, community context, and projects. While the Commonwealth engaged with local and regional public staff within the Master Planning Regions, the outcome of the Master Plan should not be taken as an official position of these political subdivisions.



A Continuation of Efforts

Since 2008, the Commonwealth has attempted to lead a coordinated planning process to fill unmet and emerging resilience needs. While the state has made headway, building upon the previous work of multiple administrations, commissions, and studies has proved challenging. These cumulative efforts underscore the need for a unified coastal resilience strategy in Virginia. This prior work leveraged the creativity and ingenuity of the many coastal communities involved and should be considered as we chart a path forward that is both holistic and inclusive.

2008

Governor Kaine releases Climate Change Action Plan

2013

Recurrent Flooding Study for Tidewater Virginia is released by the Virginia Institute of Marine Science

2014

General Assembly establishes Legislative Joint Subcommittee on Coastal Flooding to review flood preparedness options

The Secure Commonwealth Panel is amended to the Secure and Resilient Commonwealth Panel and the Panel creates a Recurrent Flooding Subcommittee

Governor McAuliffe appoints Virginia's first Chief Resilience Officer

2015

General Assembly passes legislation requiring all Hampton Roads Planning District Commission localities to address projected sea level rise and recurrent flooding in comprehensive plans

The Evolution of the Shoreline Resiliency Fund

In 2016, the Virginia General Assembly created the Shoreline Resiliency Fund to provide revolving loans to local governments to help residents and businesses subject to recurrent flooding. However, the Fund suffered from a lack of initial funding.

In 2020, the tides finally turned. The Commonwealth joined the Regional Greenhouse Gas Initiative, a market-based initiative to reduce carbon dioxide emissions from the power sector. The Regional Greenhouse Gas Initiative establishes annual caps, or allowances, for cumulative carbon dioxide emissions from all participating states' electric power sectors. Each state auctions off these allowances to power producers.

The Virginia General Assembly recast the Shoreline Resiliency Fund as the Virginia Community Flood Preparedness Fund and dedicated 45% of Regional Greenhouse Gas Initiative auction funds to the new program. Grants and loans from the new fund will be used solely for "enhancing flood prevention or protection and coastal resilience," with at least 25% of funding going to projects in low-income areas, as defined in the legislation.

2016

The Commonwealth Center for Recurrent Flooding Resiliency is established

2018

General Assembly creates the position of Special Assistant to the Governor for Coastal Adaptation and Protection via § 2.2-435.11 to ensure a permanent focus on addressing coastal hazards

Governor Northam signs a transmittal letter to the National Oceanic and Atmospheric Administration that continues the Virginia Coastal Zone Management Program in perpetuity and directs all state agencies to carry out duties consistent with the Program

ConserveVirginia initiative brought a new, data-driven approach to land conservation that identified nearly 545,500 acres of high priority natural wetlands and floodplains

2018/2019

Executive Orders 24 and 45 are signed to foster consistent and sustainable long-term action on climate change mitigation, including coastal resilience, setting state planning and elevation standards for state-owned buildings

2020

Virginia Community Flood Preparedness Fund replaces the Shoreline Resiliency Fund and is funded by Regional Greenhouse Gas Initiative (RGGI) auction sales

Virginia Coastal Resilience Master Planning Framework is released, and state agencies begin initiating the implementation of resilience measures

Executive Order 71 is signed to establish the Virginia Coastal Resilience Technical Advisory Committee to advise the Commonwealth on the Virginia Coastal Resilience Master Plan

General Assembly codifies the Chief Resilience Officer position via § 2.2-222.4

2021

Virginia Coastal Resilience Master Plan: Phase One is released

Virginia Community Flood Preparedness Fund offers $35 million through its two first grant cycles

Next Steps

See Chapter 5 for future efforts and next steps.

Our Vision of Resilience

The threats to Virginia's coast are severe, and it is not possible to eliminate the risk.

The Commonwealth needs actionable, viable solutions that are as bold and innovative as they are equitable and compassionate. We can realize a future where the burden of acceptable risk is equitably distributed among the communities and residents of coastal Virginia.

Short- and long-term efforts must be balanced as we seek to reduce risk.

Short-term strategies allow for the protection and accommodation of areas facing acute threats. In some cases, where long-term protection is not feasible, short-term measures may buy time to develop more innovative and long-term solutions. In such cases, moving forward will require acknowledging that some areas face risks beyond available capabilities or resources to protect. A shift towards long-term resilience requires difficult but necessary choices.

The reality is that there will be a need to strategically relocate and reconsider growth in some areas to avoid or reduce the potential for chronic and crippling flood loss. The balance between short- and long-term solutions will be vital to ensure the Commonwealth has time to prepare and support communities that need it most.

The shift to long-term resilience requires reevaluating how we adapt to living with more frequent and intense floods.

We cannot rely exclusively on structural projects that block and divert water. Still, in some places, these projects will remain vital to protecting critical physical infrastructure. Where feasible, we can implement natural or nature-based interventions to enhance or replicate the functions of native habitats that abate and absorb floodwaters. The use of both structural and nature-based measures will allow us to adapt more quickly to worsening flood risks by maximizing the protection and benefits of each.

Photo courtesy of Aileen Devlin of Virginia Sea Grant.

Goals and Principles of the Statewide Effort

The Master Plan strives to guide the Commonwealth toward a resilient and thriving coast while representing just one component of a broader statewide resilience strategy.

The Virginia Coastal Resilience Master Planning Framework identified the following four goals of these statewide efforts:

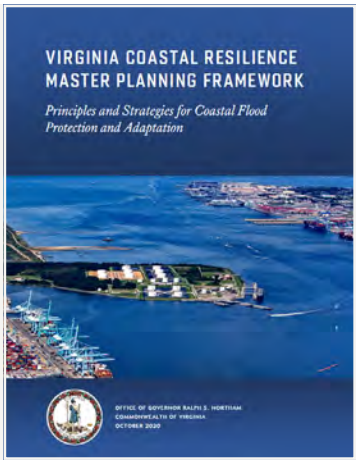
1. Identify priority projects to increase the resilience of coastal communities, including both built and natural assets at risk due to sea level rise and flooding.
2. Establish a financing strategy, informed by regional differences and equity considerations, to support the execution of the plan.
3. Effectively incorporate climate change projections into all the Commonwealth's programs addressing built and natural infrastructure in the coastal zone at risk due to sea level rise and flooding.
4. Coordinate all state, federal, regional, and local coastal adaptation and protection efforts in accordance with the guiding principles of the Framework.

Building on a Framework

In October 2020, the Commonwealth released the Virginia Coastal Resilience Master Planning Framework, a precursor to the Master Plan.

It was created to increase coastal resilience with a whole of government approach by laying out the guiding principles, goals, objectives, and desired outcomes for the Master Plan and related state resilience initiatives.

Visit the Department of Conservation and Recreation's website to learn more about the Framework and read the document.



The Framework also outlines guiding principles to inform the plan's analysis, prioritization, strategy, and ongoing implementation efforts. These guiding principles value long-term effectiveness and equity in actions while prioritizing strategies that adapt to new realities and risks.

Based on these principles, the Commonwealth's planning and prioritization processes use clear objectives to evaluate success against these principles.

The Framework's guiding principles include the following:

1. Acknowledging climate change and its consequences, and basing decision-making on the best available science.
2. Identifying and addressing socioeconomic inequities and working to enhance equity through coastal adaptation and protection efforts.
3. Recognizing the importance of protecting and enhancing natural infrastructure like natural coastal barriers and fish and wildlife habitat by prioritizing nature-based solutions.
4. Utilizing community- and regional-sale planning to the maximum extent possible, seeking region-specific approaches tailored to the needs of individual communities.
5. Understanding fiscal realities and focus on the most cost-effective solutions for the protection and adaptation of our communities, businesses, and critical infrastructure.

Phase One: 2021 Master Plan

The Master Plan represents a pivotal milestone to advance Virginia's broader resilience strategy. The Master Planning process aimed to achieve the following objectives, in line with the Commonwealth's previously identified goals and principles:

- **Determine the consequences of inaction.** Establish a baseline to understand the changing nature of coastal hazards and potential impacts if we do not take mitigating actions.
- **Identify where the Commonwealth can support.** Capture local and regional stakeholders' existing resilience efforts. Assess needs, gaps, and opportunities to build capacity and directly support project development, implementation, and funding.
- **Establish a project database.** Develop a living database of resilience projects and related capacity-building initiatives to understand existing and planned efforts and encourage regional coordination.
- **Build a foundation for continued planning and partnership.** Through the planning process, partner with many stakeholders to leverage localized knowledge and subject matter expertise to the maximum extent possible. Establish engagement processes and relationships for future work.

This initial Master Plan is a substantial achievement. Despite this, we acknowledge that this plan is a foundational effort with known limitations and opportunities for development. The Master Plan provides the needed starting point for resilience planning and will evolve. The processes and products behind this plan will be refined, modified, and improved to remain up to date with the latest science, policy, and knowledge.

We must sustain and evolve the Master Plan through proposed updates of every five years. The Department of Conservation and Recreation will manage the plan update, with guidance from the Chief Resilience Officer and Special Assistant to the Governor for Coastal Adaptation and Protection.

This document represents the combined efforts of more than two thousand stakeholders, subject matter experts, and state and local government officials. We centered the development of this plan around three core components:

- A **Technical Study** compiled essential data, research, processes, products, and resilience efforts in the Coastal Resilience Database, which forms much of basis of this plan and the Coastal Resilience Web Explorer;
- A **Technical Advisory Committee** supported coordination across key stakeholders and ensured the incorporation of the best available subject matter knowledge, data, and methods into this plan; and
- **Stakeholder Engagement** captured diverse resilience perspectives from residents, local and regional officials, and other stakeholders across Virginia's coastal communities to drive regionally specific resilience priorities.

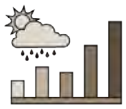
Photo courtesy of Aileen Devlin of Virginia Sea Grant.

Technical Study

The Technical Study consists of multiple analyses assessing future coastal flooding hazards, identifying affected assets and areas, prioritizing resilience strategies, and identifying pathways for implementing and funding these initiatives. The Technical Study leverages multiple datasets, including both publicly and commercially available sources. Unless noted, the Technical Study analyses is the source for all information and depictions of flood hazards, impacts, projects, and capacity-building needs in the Master Plan. For detailed documentation on methodologies and data sources, refer to Appendices C, E, G, H, and I. Future efforts will more thoroughly address the gaps in knowledge, resources, and resilience strategies identified through these analyses.

The Technical Study process can be summarized in six key steps:

1. Characterize Communities – This step developed data-driven profiles for each Master Planning Region to understand the unique social, cultural, and economic compositions of coastal communities.



2. Understand Hazards – This assessment analyzed Virginia's coastal environment to understand changes to flood hazards threatening the built and natural resources now and in the future.

3. Assess Impacts – This analysis overlaid flood extents and depths on asset datasets to assess and summarize the potential risk to communities, infrastructure, and the natural environment.

4. Identify Resilience Strategies – Stakeholder input helped identify projects that reduce the risk for flood damage by protecting communities and assets, accommodating certain levels of flooding, and enhancing natural and nature-based systems.

5. Align Funding Sources – This assessment of potential funding sources compiled relevant grant and loan programs for resilience strategies and aligned identified projects with potential funding sources and strategies.

6. Determine Gaps in Capacities, Projects, and Funding – An analysis of communities and assets that lack projects or the ability to implement them helped identify unmet needs and inform short-term actions.

Photo courtesy of the Norfolk and Portsmouth Belt Line Railroad.

Technical Advisory Committee

Governor Northam established the Virginia Coastal Resilience Technical Advisory Committee under Executive Order 71. The Technical Advisory Committee played a central role in advising the Commonwealth and ensuring the best available subject matter knowledge, data, and methods were incorporated into this plan, wherever possible. The Commonwealth's Chief Resilience Officer chairs the Technical Advisory Committee.

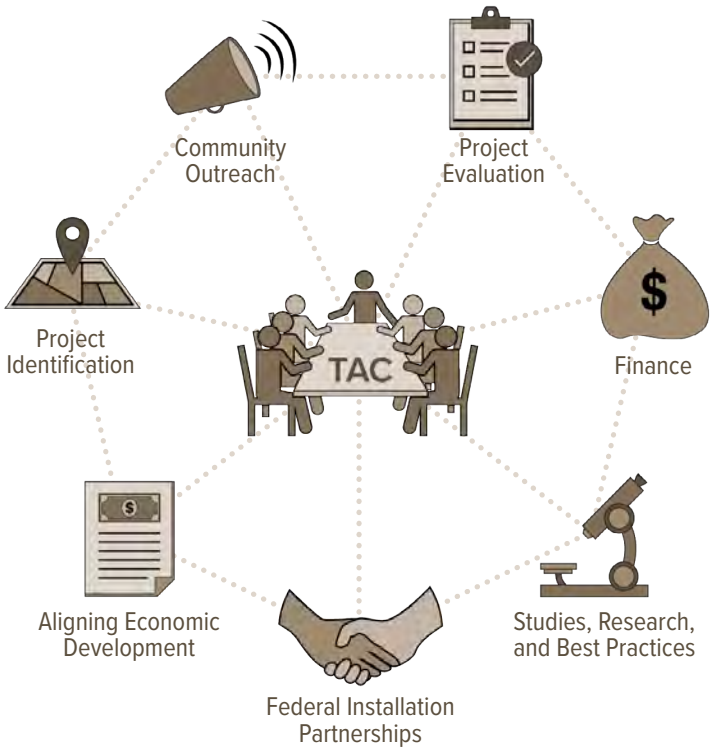
This committee consists of representatives from state agencies, coastal planning districts and regional commissions, academic advisors, and other key stakeholder organizations. The Technical Advisory Committee included the following seven subcommittees:

- Aligning Economic Development Subcommittee
- Community Outreach Subcommittee
- Federal Installation Partnerships Subcommittee
- Finance Subcommittee
- Project Evaluation Subcommittee
- Project Identification Subcommittee
- Studies, Research, and Best Practices Subcommittee

Each Subcommittee serves a focused role. The Project Identification, Project Evaluation, Finance, Community Outreach, and Studies and Best Practices Subcommittees provided advice and feedback on the study approach. In contrast, the Federal Installation Partnerships and Aligning Economic Development Subcommittees helped the Commonwealth address their respective topics in a more independent process. The Commonwealth thanks all members for the time generously donated to this effort.

The work of the Technical Advisory Committee does not end with this first version of the Master Plan. It will continue to facilitate implementation, evaluate progress, and develop updates to support the ongoing commitment of the Commonwealth to adapt to the new and changing reality.

Visit the Department of Conservation and Recreation's website for more information on the Technical Advisory Committee and Subcommittee membership and upcoming meetings.



Stakeholder Engagement

Understanding how communities live with water is critical to ensuring the Master Plan equitably addresses flooding issues for all Virginians. Residents who live and work in coastal Virginia had the opportunity to provide input to the Master Plan through multiple in-person and virtual workshops, webinars, public meetings, and surveys. The Commonwealth is leveraging the information gained through these processes to conceptualize, implement, and support successful and lasting resilience strategies.

Building a dynamic and long-term participatory stakeholder engagement strategy is essential to capture and reflect the continual changes that coastal Virginia's communities and environments experience. The Commonwealth developed a short-term plan to build relationships and conduct outreach in affected areas by working across localities and Planning District and Region Commissions.

The following sections summarize outreach activities during this first iteration of the Master Plan. Information gathered through these activities is integrated throughout this document.

Voices of Coastal Virginia

Through surveys, webinars, workshops, public meetings, this plan reflects input and knowledge from residents, community organizations, representatives from local, county, and regional government, military installations, and other stakeholders invested in the resilience of coastal Virginia.

2,000+ people provided input into the Master Planning process via participation in surveys, webinars, virtual and in-person workshops, and public meetings.

80% of residents who responded to surveys believe flooding poses a serious or extreme challenge over the next 20-40 years.

11% of residents who responded to surveys said they were very familiar with the Commonwealth's existing resilience efforts before their engagement.

68% of residents who responded to surveys said they believe the Master Plan will benefit their community.

Photo courtesy of Aileen Devlin of Virginia Sea Grant.

Engagement with Local Practitioners

In July and August 2021, the Commonwealth conducted webinars and practitioner workshops with the eight coastal Planning District Commissions and Regional Commissions. These sessions aimed to inform practitioners about the Commonwealth's coastal resilience efforts while also gathering input and insight on the unique resilience issues facing each region.

More than 150 people representing multiple regional and local units of government and invited partners in resilience-related fields participated in these meetings. Each session presented on the planning process and Technical Study and gathered feedback on preliminary findings. Participants engaged in brainstorming, mapping, and visioning activities to collect information related to valued local assets, planning concerns and challenges, and priority resilience strategies. Refer to Appendix J for a summary of the workshops.

In addition to the planning meetings, the Commonwealth developed a survey to capture ongoing resilience planning efforts and organizational challenges. The survey engaged practitioners and representatives from regional and planning district commissions, localities, tribes, state agencies, federal partners, nonprofit organizations, and relevant stakeholder groups. Nearly 100 people responded and completed self-assessments regarding their risk awareness and capacity to engage and fund resilience strategies. Refer to Appendix L for the complete list of questions and summarized responses.

Finally, the Commonwealth also engaged practitioners in the identification of resilience projects and capacity building and planning initiatives. Refer to Chapters 3 and 4 for more details on these efforts.

Engagement with the General Public

From July to October 2021, the Commonwealth hosted public meetings in each of the eight Planning District and Regional Commissions across coastal Virginia. Similar to the practitioner workshops, these meetings socialized the goals and objectives of the Master Plan. Participants engaged in map and survey activities to gather information to support the Technical Study process and preliminary findings. The Commonwealth advertised public meetings through state agency websites and with the support of local partners and media channels. Refer to Appendix K for a summary of the meetings.

The Commonwealth also developed and distributed a public survey to capture Virginians' lived experiences related to flooding. As of October 2021, over 1,300 participants answered questions about how flooding has affected them and their awareness of existing resilience efforts, among others. The survey requested input on preferred resilience strategies and was widely distributed on social media channels and amplified by local and regional partners. Refer to Appendix M for the complete list of questions and summarized responses.

Engagement with Federal Partners

Recognizing the value of federal installations to Virginia's economy, the Commonwealth established the Federal Installation Partnerships Subcommittee at the onset of the Master Plan. The Subcommittee's purpose statement centered on understanding federal installation coastal resilience needs, information sharing, and collaboration to advance shared goals.

The Commonwealth convened an outreach meeting in partnership with the Subcommittee and Federal Installation stakeholders on August 18, 2021. The meeting informed federal installation stakeholders

Photos courtesy of Dewberry and Aileen Devlin of Virginia Sea Grant (VASG).

on the Master Plan, gathered information, and sought to identify coordination opportunities for advancing resilience initiatives.

Over 30 participants engaged in the meeting, including representatives from NASA, the National Park Service, the U.S. Navy, Coast Guard, Office of Local Defense Community Cooperation, Department of Defense Chesapeake Bay Program, and congressional staffers. The Commonwealth shared information on coastal flood hazards that should benefit ongoing studies at the installations. Information on federal installation resilience projects was requested but was not evaluated for whether it aligned with the Commonwealth's principles and goals relating to its broader coastal resilience strategy. Such data will help the Commonwealth better understand holistic needs across the state. Many participants noted that resilience planning was challenging, took a sustained commitment, and was tedious but also highly needed and essential. Participants shared ongoing responses to federal climate resilience planning directives, which require all federal facilities to complete a climate-resilience assessment by 2022.

Many facilities had completed, ongoing, or planned studies through various programs, such as Joint Land Use Studies and Military Installation Resilience Review efforts. The Department of Defense has provided some supporting tools and guidance, including the agency's Climate Adaptation Plan released in fall 2021. Some participants noted that federal facilities will face challenges by coastal flood hazards that will also affect surrounding communities, underscoring the need for continued long-term coordination. Participants also pointed out that coordination and information sharing were essential and improving over time. See Appendix K for more information on the meetings with federal partners.

Engagement with Under-Resourced Communities

The Commonwealth conducted meetings that specifically engaged socially vulnerable or under-resourced communities. These meetings, held in a hybrid in-person and virtual format, sought to understand better how flooding and coastal hazards impact citizens' day-to-day activities. The Commonwealth identified target communities by leveraging outputs of the Technical Study to determine locations exhibiting combined moderate to high social and flood vulnerability. The Commonwealth hosted 12 meetings between September 2 and October 28, 2021 in Portsmouth, Norfolk, Newport News, Hampton, Chesapeake, Virginia Beach, Gloucester, Cape Charles, Aquia Harbour, and Dahlgren. These meetings attracted 132 in-person and 135 virtual participants. The Commonwealth has tentatively planned additional meetings for 2022.

The meetings were structured to gather critical insight into community issues. These insights included how communities "live with water" and input to inform resilience strategies and future projects. Meetings also provided an overview of coastal resilience and preparedness, including "Know Your Zone" and safe evacuation information. Questions to the public were developed with support from the Community Outreach Subcommittee to better understand individuals' experiences with flood issues in these communities. For example, the Commonwealth asked participants if they had to change their route to work, school, or the grocery store due to flooding. Answers helped ground-truth existing data. Participants offered some feedback on these questions, but most comments focused on local municipal issues, such as drainage problems and narrow culverts. Eastern Shore residents expressed concern about coastal flooding, but many comments related more to rainfall issues.

Connecting with these communities proved challenging between the ongoing COVID-19 pandemic and the Master Plan's time frame. Some meeting locations were adjusted to provide additional room and internet connectivity requirements, which, at times, moved meetings away from the target communities and participants. Despite accommodations, virtual participants were unable to engage with mapping exercises to show where and what kind of flooding was occurring in their communities, a valuable part of the meetings. Future efforts may benefit from additional engagement with community organizes, NGOs, and other stakeholders to bolster locality contributions and gain an increased understanding of local issues.

Photo courtesy of Aileen Devlin of Virginia Sea Grant.

Dewberry

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Photos courtesy of Dewberry and Aileen Devlin of Virginia Sea Grant (VASG).

How to Use the Plan

The Master Plan advances the Framework into an actionable strategy identifying specific problem areas, necessary projects, critical gaps, and unmet needs. Local, state, and regional stakeholders can use this document to better understand their relevant coastal risks and opportunities and access resources to support resilience decision-making.

In addition to the Master Plan, this process has put forward the publicly available Coastal Resilience Web Explorer. The Web explorer presents hazard and impact data developed for the Technical Study, an inventory of ongoing and planned resilience projects and capacity-building initiatives, and potential funding opportunities for resilience efforts. This data is housed in the Coastal Resilience Database, which will be actively maintained as a living repository of study results and locally-identified resilience needs.

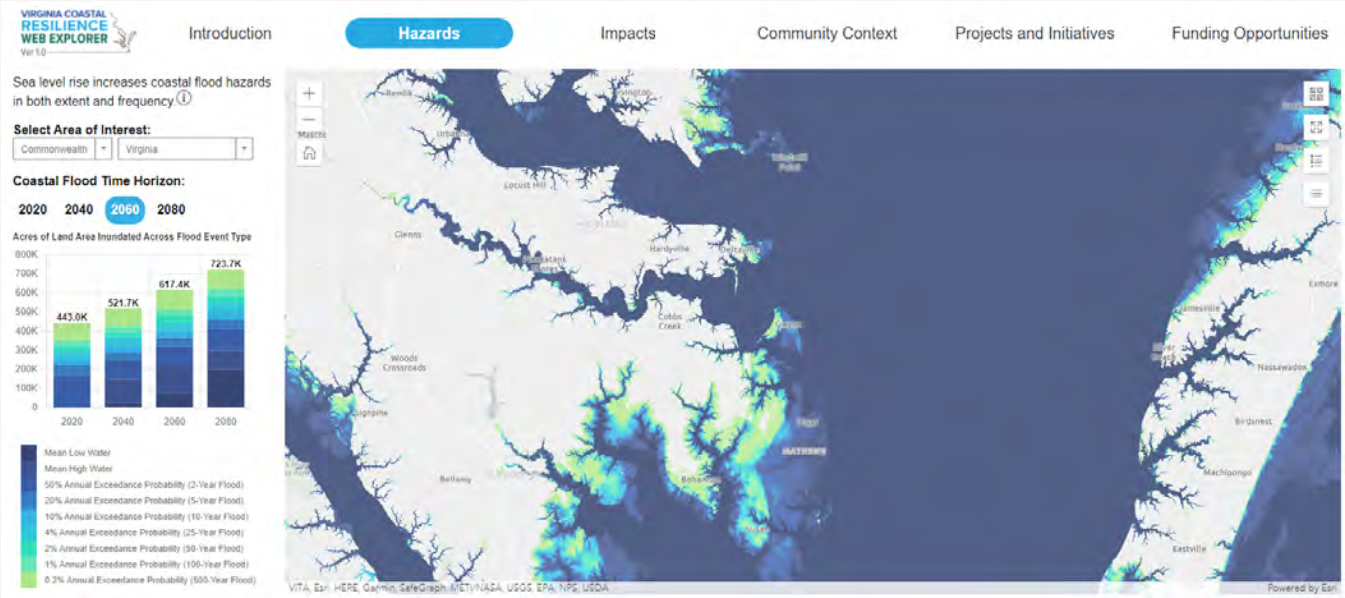
Still, the Master Plan has limitations that will be addressed in future iterations as available resources allow. The Technical Study compiled a database representing the baseline for coastal flood hazards, assets at risk, and resilience strategies. Although the analytical process leveraged the best publicly available data and methods suitable for the purposes and goals of this initial effort, there are known limitations to the outputs, discussed in Chapter 3 and Appendix E.

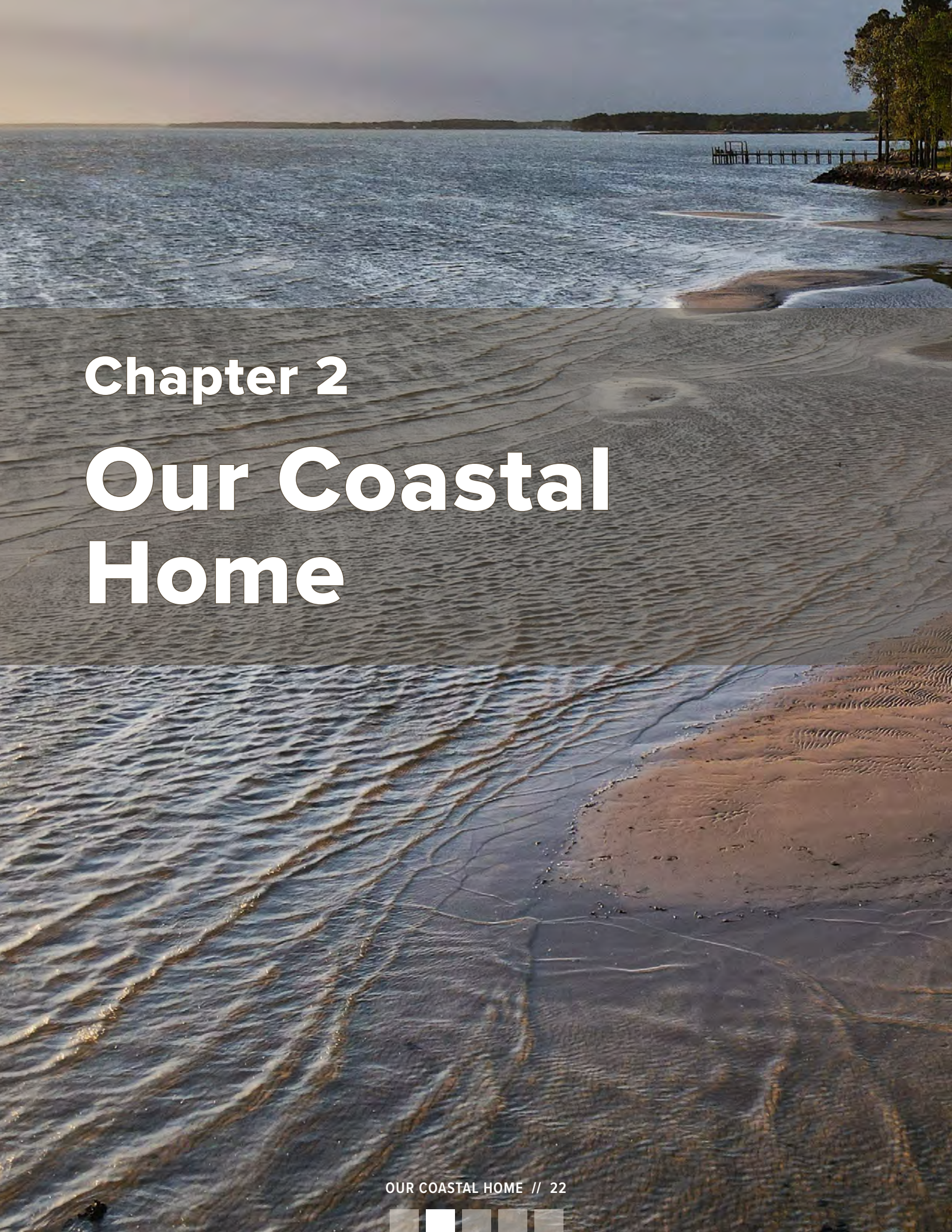
The Master Plan provides future coastal flood scenarios that residents and public officials can use to prepare for and mitigate coastal flood hazards. These datasets should be used strictly as a planning reference and not for navigation, permitting, or other legal purposes. Chapter 3 and the technical appendices discuss these limitations and the appropriate applications of the data in more detail. The following chapters highlight key findings and recommendations from the Technical Study process.

Learn More through the Coastal Resilience Web Explorer

The Coastal Resilience Web Explorer is a publicly available tool that provides access to maps, data, and other relevant technical information developed through the Master Plan's Technical Study and housed in the Coastal Resilience Database. This online resource features a map-based data viewer for flood exposure and impacts, an inventory of resilience project and capacity-building initiatives that highlights potential funding sources identified by the Master Planning process, and a database of identified funding and financing programs that support coastal resilience efforts.

Visit the Coastal Resilience Web Explorer at https://www.dcr.virginia.gov/crmp/ResilienceExplorer.





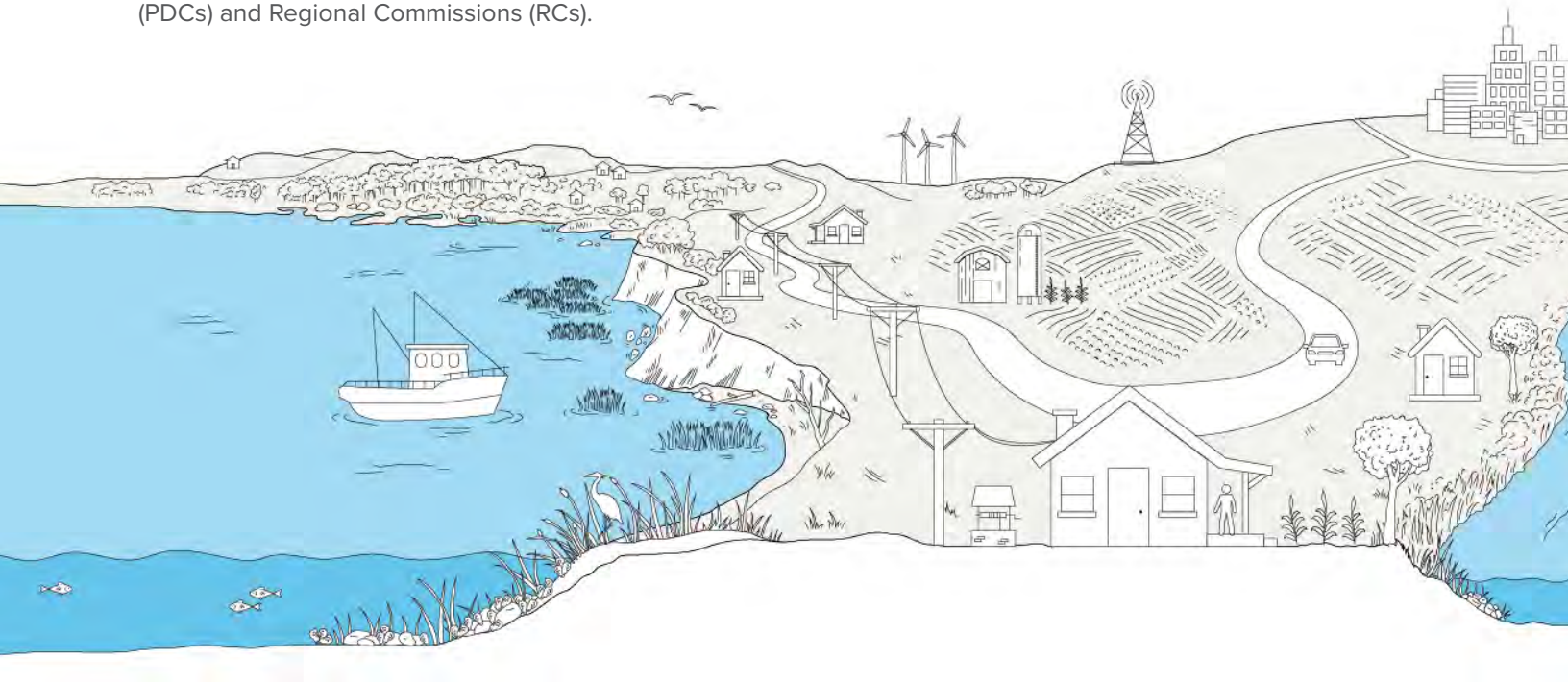
Chapter 2
Our Coastal Home

Photo courtesy of Aileen Devlin of Virginia Sea Grant

This chapter characterizes the geographic areas within the four Master Planning Regions, the flood hazards they face, and the projected amplification of those hazards in the future.

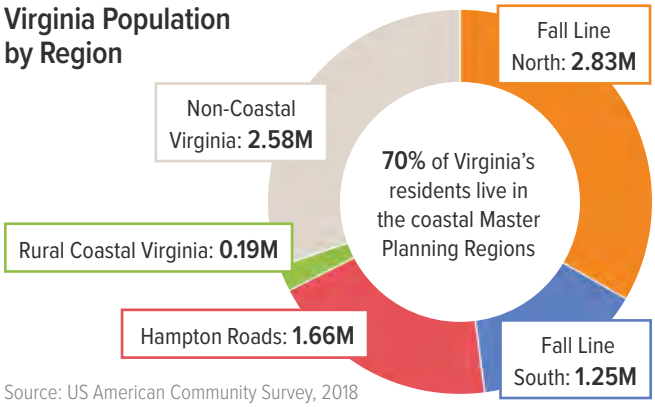
Who We Are

The communities of Coastal Virginia face shared and unique challenges defined by distinct populations, economies, and landscapes. As introduced in Chapter 1, the Master Planning Region framework divides coastal communities into four geographically defined areas to present their distinct hazards, risks, priorities, and existing resilience efforts. The Master Planning Regions are defined by the boundaries of Planning District Commissions (PDCs) and Regional Commissions (RCs).



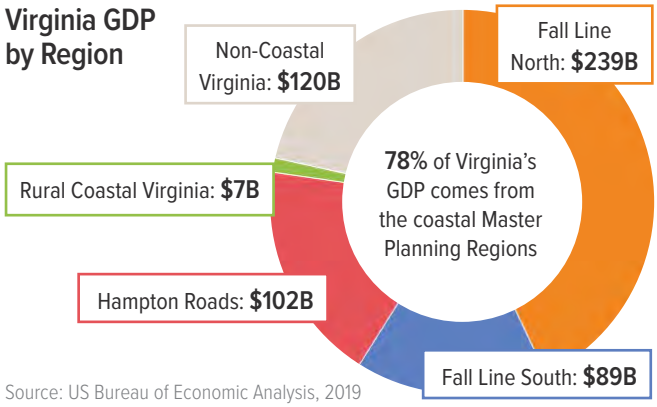
Within each region are multiple towns, cities, and counties with unique neighborhoods, businesses, critical infrastructure, natural resources, and institutions that shape each community's economy and culture. Characterizing these assets is essential to understand what is at risk due to coastal flooding and ultimately identify resilience strategies that benefit entire communities and minimize potential disruption of a region's way of life.

Virginia Population by Region



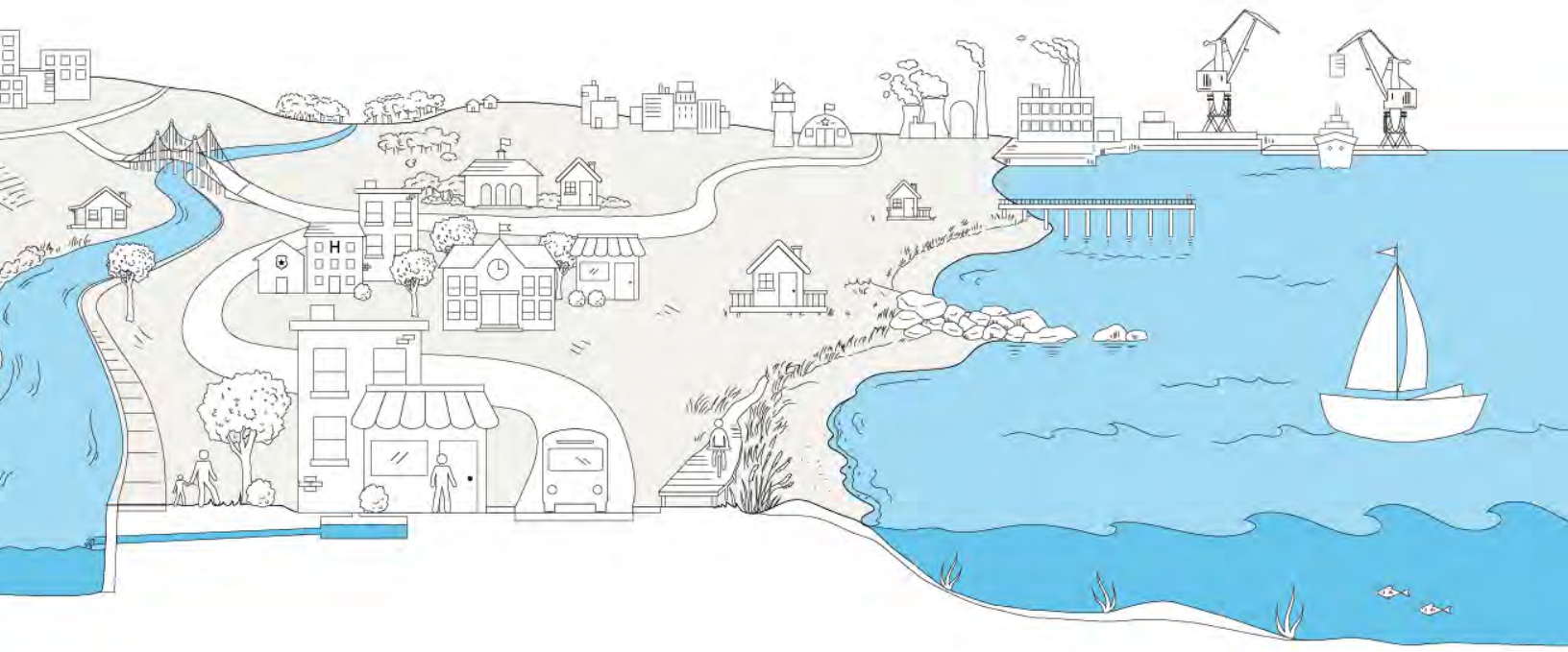
Source: US American Community Survey, 2018

Virginia GDP by Region



Source: US Bureau of Economic Analysis, 2019

In the following pages, gross domestic product (GDP) is used a measure of economic activity, capturing the dollar value of goods and services produced in each area. It provides insights into what industries are particularly relevant in each region that may be affected by changing climate and coastal flood hazards.



Characterizing the Master Planning Regions and Assets

Assets refer to the physical structures that provide social, economic, and ecological value to coastal Virginia. Each Master Planning Region has a unique combination of assets influencing their priorities regarding coastal resilience. The Commonwealth simplified assets into three categories for the Master Plan:

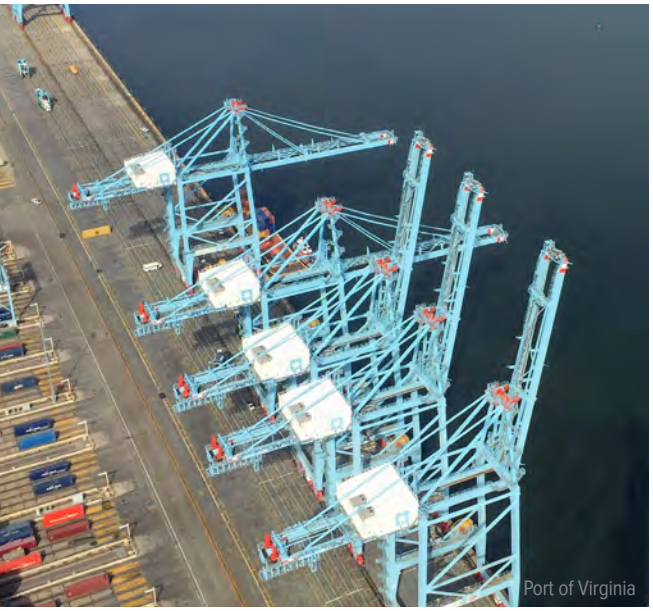
Community Resources are physical assets contributing to coastal Virginia's unique economic and social environment, including residential neighborhoods, lands owned and used by tribes, agricultural lands, and businesses and employers.

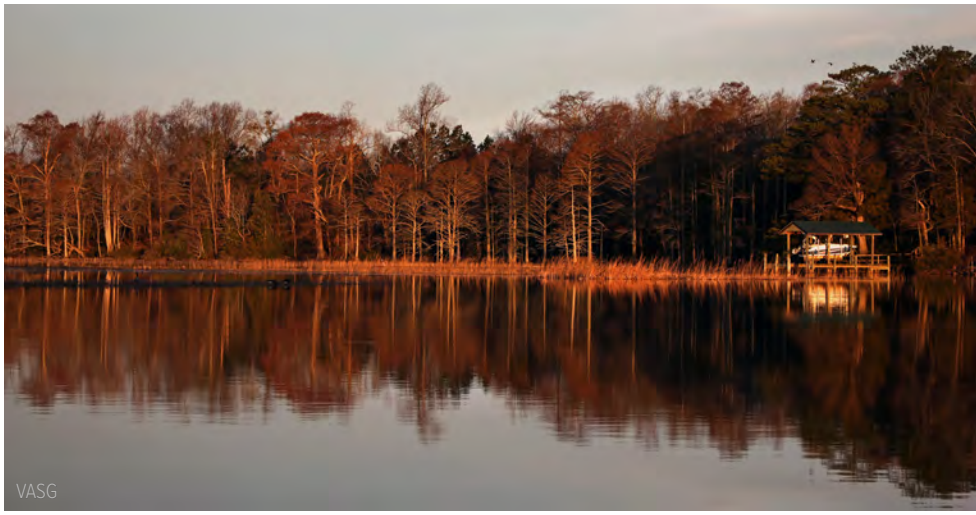
Critical Sectors are the facilities and networks vital to everyday functions, including transportation, communications, commercial and critical manufacturing, defense, energy, health and emergency services, government services, education, water, waste, and wastewater.

Natural Infrastructure refers to the aquatic and coastal lands that provide fish and wildlife habitat, recreation opportunities, natural flood protection, and other ecosystem services to the surrounding region.

Hampton Roads Master Planning Region

Hampton Roads is the most heavily developed of the Master Planning Regions and home to more than 1.6 million people. The region's economy is driven by its significant military presence and the Port of Virginia, as well as its natural beauty that draws in tourists. Hampton Roads has documented some of the highest rates of relative sea level rise along the eastern seaboard.[15]


Port of Virginia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Photos courtesy of Aileen Devlin of Virginia Sea Grant (VASG), Port of Virginia, and Virginia Department of Transportation (VDOT).

Regional Localities

Localities within Hampton Roads PDC: Cities of Williamsburg, Hampton, Newport News, Poquoson, Norfolk, Portsmouth, Suffolk, Chesapeake, Virginia Beach, and Franklin; Towns of Boykins, Branchville, Capron, Courtland, Drewryville, Ivor, Newsoms, Smithfield, and Windsor; and Counties of James City, York, Isle of Wight, and Southampton.

Primary Flood Hazards

Hampton Roads contains more than 1,560 miles of tidally influenced shoreline.[16] In a targeted survey, resilience practitioners in Hampton Roads ranked coastal flood hazards in order of priority to their jurisdiction or organization as follows:

1. Rainfall-Driven Flooding
2. Storm Surge Flooding
3. Tidal Flooding
4. Riverine Flooding
5. Coastal Erosion
6. Groundwater Impacts

Community Resources

Hampton Roads holds some of Virginia's oldest communities, including historical attractions, like Jamestown and Williamsburg. The region is also home to one federally recognized tribe (Nansemond Indian Nation), and two state-recognized tribes (Cheroenhaka Nottoway Indian Tribe and Nottoway Indian Tribe of Virginia). The waterfront access of some coastal cities has enabled military- and port-related economies to thrive. The military is a key employer in the region, with nearly 140,000 defense personnel and contractors working in the region, primarily at Naval Station Norfolk, the nation's largest naval base.[17] Other Department of Defense-related spending, including shipbuilding and ship repair, is a key driver of the regional economy.

Critical Sectors

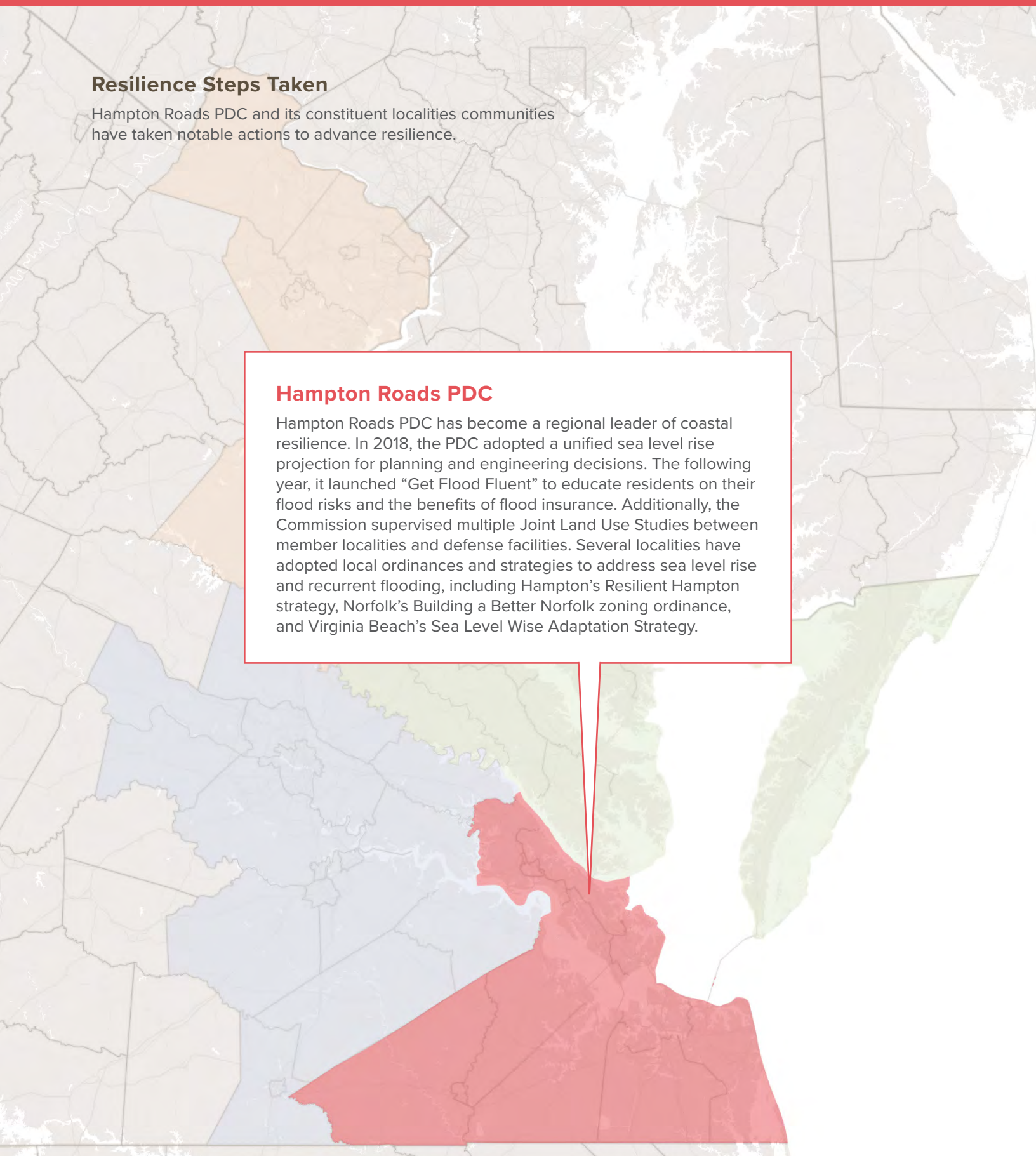
Hampton Roads is among the Commonwealth's most intensely developed regions and has numerous assets of state and national significance. The region's military and economic activity require robust supporting infrastructure, including one of the East Coast's largest ports, the Port of Virginia. Hampton Roads contains multiple bridges and tunnels to connect localities across water bodies, including the Chesapeake Bay, Hampton Roads, and Monitor-Merrimac Memorial Bridge Tunnels. The region contains many government facilities, including over 30 universities, colleges, trade schools, and multiple military installations, including Naval Station Norfolk and Joint Base Langley-Eustis, among others.

Natural Infrastructure

Despite areas of intense development, Hampton Roads contains many ecologically significant wetlands and marshes, including the Back Bay, Great Dismal Swamp, and Plum Tree Island National Wildlife Refuges. Many tidal waterways and rivers bisect the region's low-lying and flat terrain. Industrial activity and vessel traffic are common along the Elizabeth River, its three branches, and their extensive shorelines but can accelerate erosion or risk environmental contamination. The proximity of ecologically valuable lands to urbanized areas will challenge some habitats' ability to adapt to rising sea and salinity levels. Sparsely developed bayfront areas will allow some habitats, like tidal marshes, to migrate upland and hold their own.

Resilience Steps Taken

Hampton Roads PDC and its constituent localities communities have taken notable actions to advance resilience.



Hampton Roads PDC

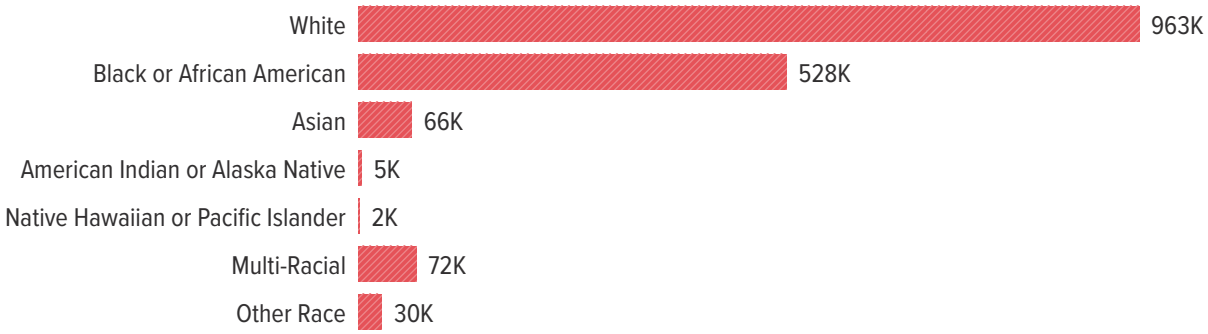
Hampton Roads PDC has become a regional leader of coastal resilience. In 2018, the PDC adopted a unified sea level rise projection for planning and engineering decisions. The following year, it launched “Get Flood Fluent” to educate residents on their flood risks and the benefits of flood insurance. Additionally, the Commission supervised multiple Joint Land Use Studies between member localities and defense facilities. Several localities have adopted local ordinances and strategies to address sea level rise and recurrent flooding, including Hampton’s Resilient Hampton strategy, Norfolk’s Building a Better Norfolk zoning ordinance, and Virginia Beach’s Sea Level Wise Adaptation Strategy.

Demographic and Economic Context

Hampton Roads is a large populous region, comprised of both rural and urban communities. With more than 1.6 million residents, it is the second largest Master Planning region and one of the most racially and economically diverse. While some neighborhoods or localities are highly affluent and economically prosperous, others have very high rates of vulnerable and historically under-resourced communities, which increases the need for resilience solutions that serve to advance equity.

Hampton Roads Population by Race*

Source: US American Community Survey, 2018

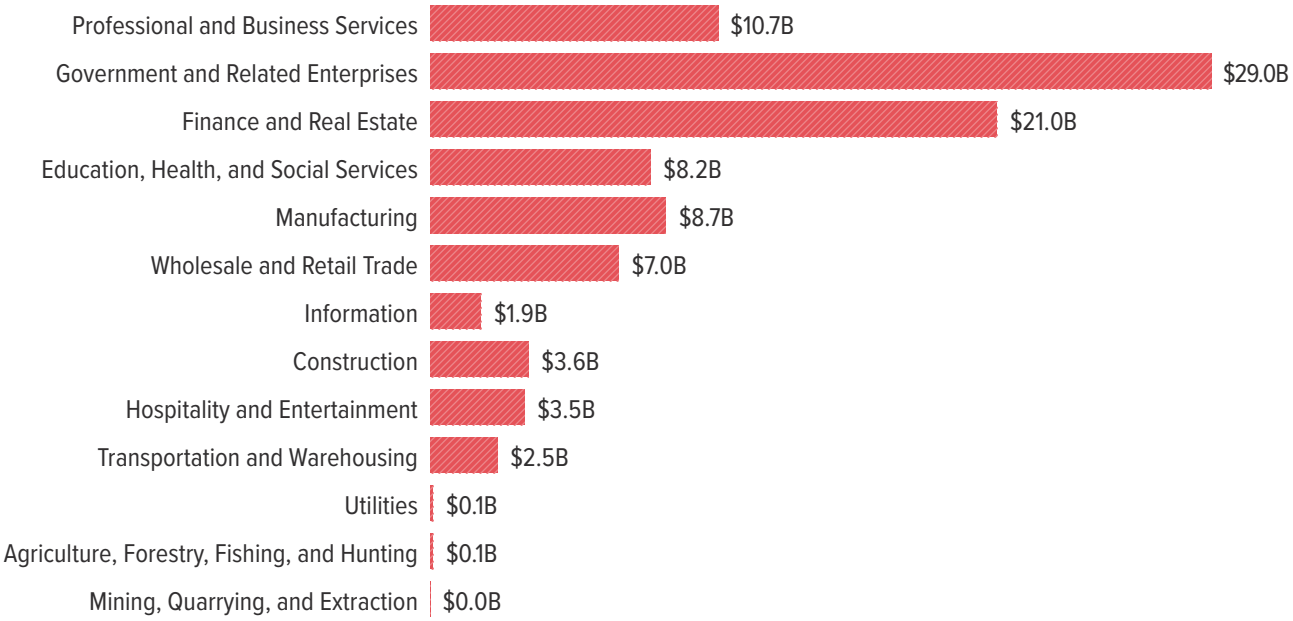


* Note the Census Bureau collects data on race separately from ethnicity, including Hispanic and Latino populations that can report any of the listed races.

The region has a large and diverse economy. Government and government related services comprise the region's top grossing economic sector, largely driven by the high concentration of military installations, a major employer in the region. Numerous business districts, hospitals, universities, and other anchor institutions also play a role in driving local economic and social activity. These institutions have often played a stabilizing role in the Hampton Roads economy, and if they are threatened by increasing coastal flood hazards, that could place their continued presence in jeopardy, potentially risking devastating downstream effects on the economic vitality of the region as a whole.

Hampton Roads Gross Domestic Product (GDP) by Industry Segment

Source: US Bureau of Economic Analysis, 2019



Rural Coastal Virginia Master Planning Region

Rural Coastal Virginia[18] is known for its lush natural landscapes that support water-dependent economies and attract visitors from throughout the Commonwealth and beyond. Home to over 185,000 residents, the region contains smaller, dispersed communities, tied together by agriculture, aquaculture, fishing, and service industries. Rural Coastal Virginia includes thousands of shoreline miles with many low-lying communities along the Chesapeake Bay and its tributaries, including Eastern Shore, made up of Accomack and Northampton Counties.

Photos courtesy of Aileen Devlin and Mallory Huxford of Virginia Sea Grant (VASG), Virginia Commercial Space Flight Authority (VCSFA), and Virginia Department of Transportation (VDOT).

Regional Localities

Localities within Accomack-Northampton PDC: Towns of Accomac, Belle Haven, Bloxom, Cape Charles, Cheriton, Chincoteague, Eastville, Exmore, Hallwood, Keller, Melfa, Nassawadox, Onancock, Onley, Painter, Parksley, Saxis, Tangier, and Wachapreague; and Counties of Accomack and Northampton.

Localities within Middle Peninsula PDC: Towns of Urbanna, Tappahannock, and West Point; and Counties of Essex, Gloucester, King and Queen, King William, Mathews, and Middlesex.

Localities within Northern Neck PDC: Towns of Colonial Beach, Irvington, Kilmarnock, Montross, Warsaw, and White Stone; and Counties of Lancaster, Northumberland, Richmond, and Westmoreland.

Primary Flood Hazards

Rural Coastal Virginia contains more than 4,050 miles of tidally influenced shoreline, the most of any Region.[19] In a targeted survey, resilience practitioners in Rural Coastal Virginia ranked coastal flood hazards in order of priority to their jurisdiction or organization as follows:

1. Rainfall-Driven Flooding
2. Storm Surge Flooding
3. Coastal Erosion
4. Tidal Flooding
5. Groundwater Impacts
6. Riverine Flooding

Community Resources

Rural Coastal Virginia is home to many historic communities that were settled due to water-dependent economic activity. Access to water and natural resources supports agricultural, aquaculture, fishing, and tourist economies. Increasingly, the region has a growing number of waterfront or water-accessible residential developments as more people from urban centers move or purchase second homes. The region is also home three federally recognized tribes (Pamunkey, Upper Mattaponi, and Rappahannock) and one state-recognized tribe (Mattaponi). The Pamunkey Indian Tribe and the Mattaponi Tribe both possess reservation lands which border tidal waters and are exposed to rising seas and erosion.

Critical Sectors

Compared to other regions, Rural Coastal Virginia has fewer major roads and limited rail infrastructure, but its transportation network is crucial to move goods and people. The region hosts several federal facilities, including a large concentration on Wallops Island, a barrier island in northeast Accomack County. These facilities include the National Aeronautics and Space Administration (NASA) Wallops Flight Facility and other sites that are cumulatively valued at almost $1 billion.[20, 21] Rural property owners tend to rely on septic systems for wastewater disposal, and some rely on wells for drinking water. As flood risks intensify, impacts to roads, wastewater, and water assets may significantly constrain and adversely affect communities.

Natural Infrastructure

Ecologically significant tidal marshes, barrier islands, and coastal forest ecosystems span throughout the region, providing natural resources for economic use and natural beauty for the enjoyment of residents and visitors. Rural Coastal Virginia contains the country's longest stretch of undeveloped barrier islands, including Volgenau Virginia Coast Reserve, managed by The Nature Conservancy.[22] Natural resources, such as fish, crabs, and oysters, drive local economies, supporting tourism and local food production. Roughly 6% of the region's GDP originates from the agriculture, forestry, fishing, and hunting sector, the highest share of any Master Planning Region.[23]

Resilience Steps Taken

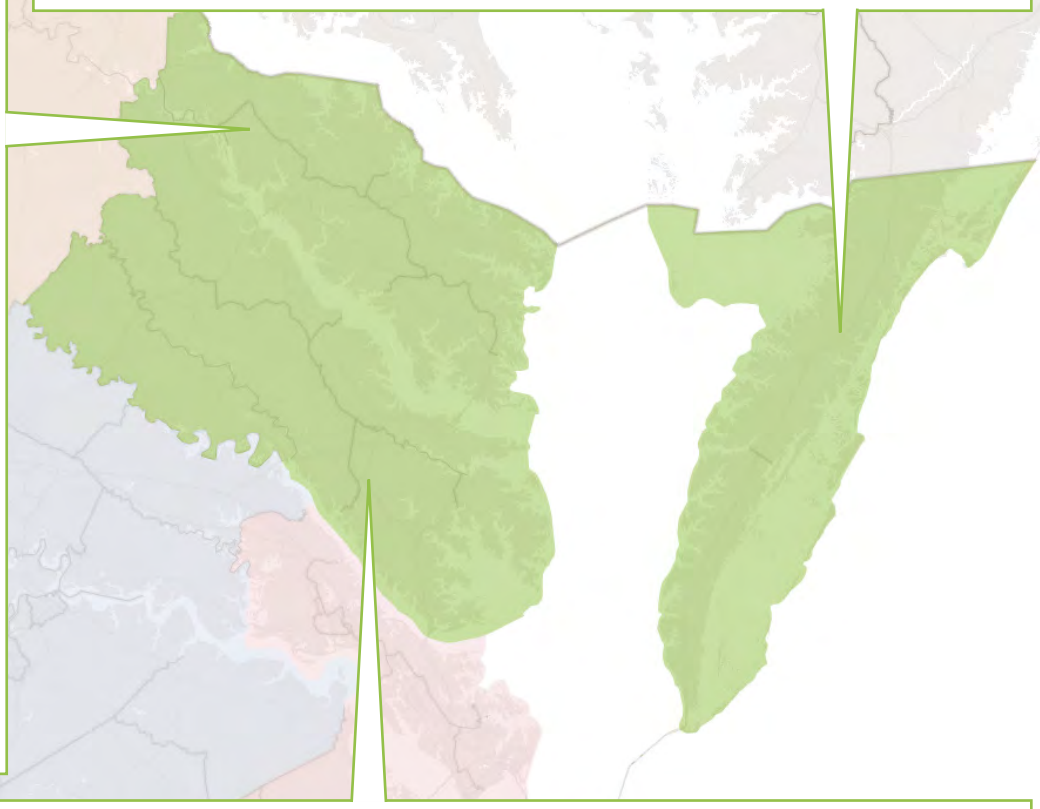
Each PDC in Rural Coastal Virginia has worked to advance resilience in distinct ways. Many localities have taken steps to bolster resilience, including through hazard mitigation planning and participation in the Resilience Adaptation Feasibility Tool (RAFT) process. RAFT provides communities with external assessments of their existing efforts and opportunities to develop actionable checklists and take action to improve their community's resilience.

Northern Neck PDC

Northern Neck Planning District Commission has been a leader in implementing and educating others on living shorelines and nature-based solutions. The Commission manages the Northern Neck Living Shorelines Initiative,[26] educating engineers, designers, and property owners on shoreline management best practices, including living shorelines, and administers a home elevation program using FEMA funds. Several member localities have adopted growth policies and zoning practices to limit development in risky areas and incorporated resilience into comprehensive and hazard mitigation plans. In 2019, ten of Northern Neck's member localities participated in RAFT.

Accomack-Northampton PDC

The Accomack-Northampton PDC has led several initiatives to further resilience, including managing the Climate Adaptation Working Group with The Nature Conservancy, coordinating relevant research, like the Transportation Infrastructure Inundation Vulnerability Assessment, and developing the Eastern Shore Resiliency Project Database with input from stakeholders and localities. The Commission has also leveraged funding from the Federal Emergency Management Agency to elevate more than 50 homes since 1999. In 2018, seven of the Commission's member localities participated in RAFT.



Middle Peninsula PDC

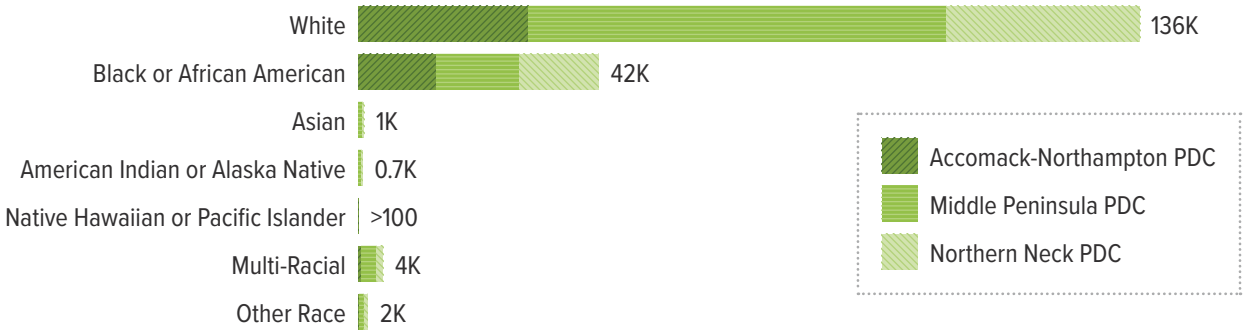
The Middle Peninsula PDC manages multiple programs to bolster its member localities' resilience to flooding. Currently, the Commission is revising its hazard mitigation plan and is working to integrate resilience into the updated plan. The Living Shoreline Incentive Program provides low-interest loans and grants to install living shorelines. Another example is the Fight the Flood program, which directs financial support to local property owners to implement flood resilience measures. The Middle Peninsula Chesapeake Bay Public Access Authority, supported by the Virginia Coastal Zone Management Program, provides coastal residents with information on public access issues in coastal areas, including resources on the acquisition or transfer of access rights and conservation easements. Between 2021 and 2022, six of Middle Peninsula's member localities will participate in RAFT.

Demographic and Economic Context

With a population of approximately 185,000 residents, Rural Coastal Virginia has the lowest and most spread-out population compared to other Master Planning Regions. As the name suggests, the rural nature of this region influences the demographics, lifestyles, and livelihoods of its residents. Rural Coastal Virginia is home to varied residential communities that attract residents for many different reasons, from agrarian families who have lived on the land for generations, to retirees and vacation homeowners who are newer to the area and drawn to the proximity of water and abundance of natural resources. The region is economically varied and has the highest portion of elderly residents of any Master Planning Region.

Rural Coastal Virginia Population by Race* and PDC

Source: US American Community Survey, 2018

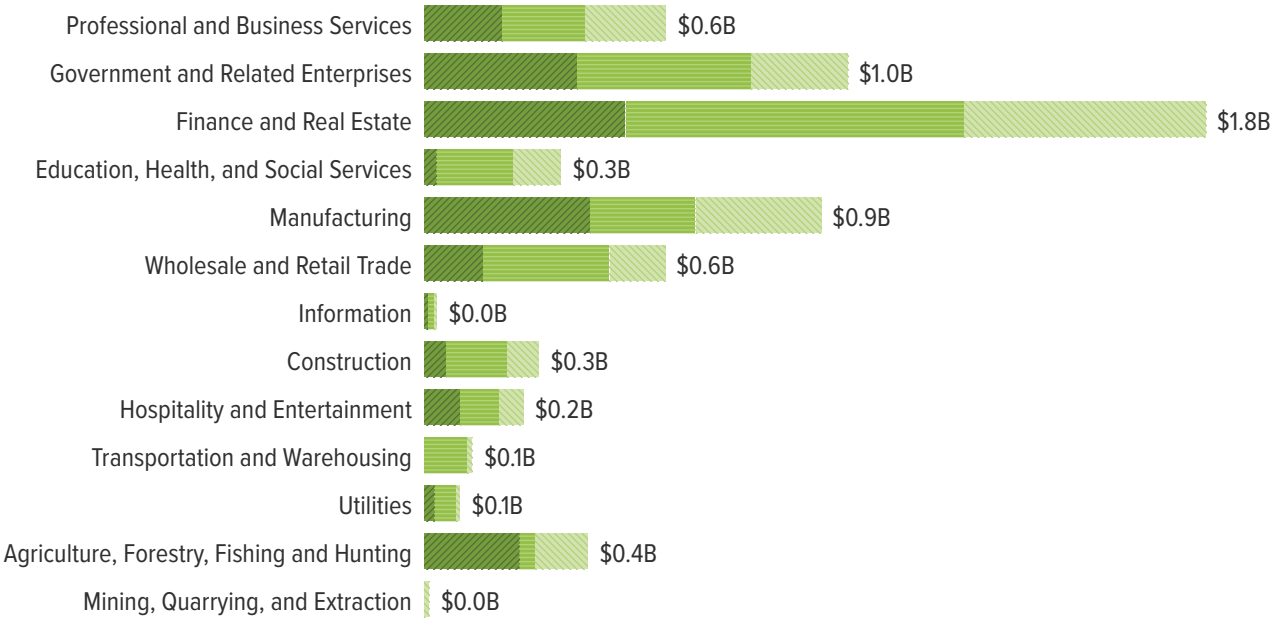


* Note the Census Bureau collects data on race separately from ethnicity, including Hispanic and Latino populations that can report any of the listed races.

Rural Coastal Virginia has the smallest economy compared to other Master Planning Regions and it faces significant economic risks related to coastal flood hazards. Finance and real estate industries comprise the largest economic sector. Property taxes are critical to supporting local government revenues and the regional economy, meaning increased coastal hazards may threaten the viability of water-adjacent neighborhoods. The region also has the highest GDP derived from agriculture, forestry, fishing, and hunting — all industries that may be particularly susceptible to changing temperatures, precipitation patterns, and sea levels.[24, 25] Rural Coastal Virginia is home to the NASA Wallops Flight Facility, which contributes significantly to Accomack-Northampton PDC's GDP. The relative scale of the Wallops Facility, however, may overshadow other critical economic sectors, like mining and quarrying.

Rural Coastal Virginia Gross Domestic Product (GDP) by Industry Segment and PDC

Source: US Bureau of Economic Analysis, 2019



Fall Line North Master Planning Region

Fall Line North is partially within the coastal plain, marked by the falls of the Potomac and Rappahannock Rivers. The region is home to more than 2.8 million Virginians, including predominately urban and suburban communities in the Washington, D.C. metropolitan area. The region does not directly touch the Atlantic Ocean or the Chesapeake Bay, but it contains tidally influenced waters of the Potomac and Rappahannock Rivers that make low-lying waterfront cities, like Alexandria and Arlington, especially vulnerable to storm surge and sea level rise.

Photos courtesy of Dewberry and Northern Virginia RC (NVRC).

Regional Localities

Localities within George Washington RC: Towns of Bowling Green and Port Royal; City of Fredericksburg; and Counties of Caroline, King George, Spotsylvania, and Stafford.

Localities within Northern Virginia RC: Towns of Clifton, Middleburg, Hamilton, Haymarket, Hillsboro, Lovettsville, Purcellville, Occoquan, Quantico, and Round Hill, Cities of Alexandria, Fairfax, Falls Church, Manassas, and Manassas Park; Towns of Dumfries, Herndon, Leesburg, and Vienna; and Counties of Arlington, Fairfax, Loudoun, and Prince William.

Primary Flood Hazards

Fall Line North contains nearly 375 miles of tidally influenced shoreline.[27] In a targeted survey, resilience practitioners in Fall Line North ranked coastal flood hazards in order of priority to their jurisdiction or organization as follows:

1. Rainfall-Driven Flooding
2. Riverine Flooding
3. Coastal Erosion and Tidal Flooding (Tie)
4. Storm Surge Flooding
5. Groundwater Impacts

Community Resources

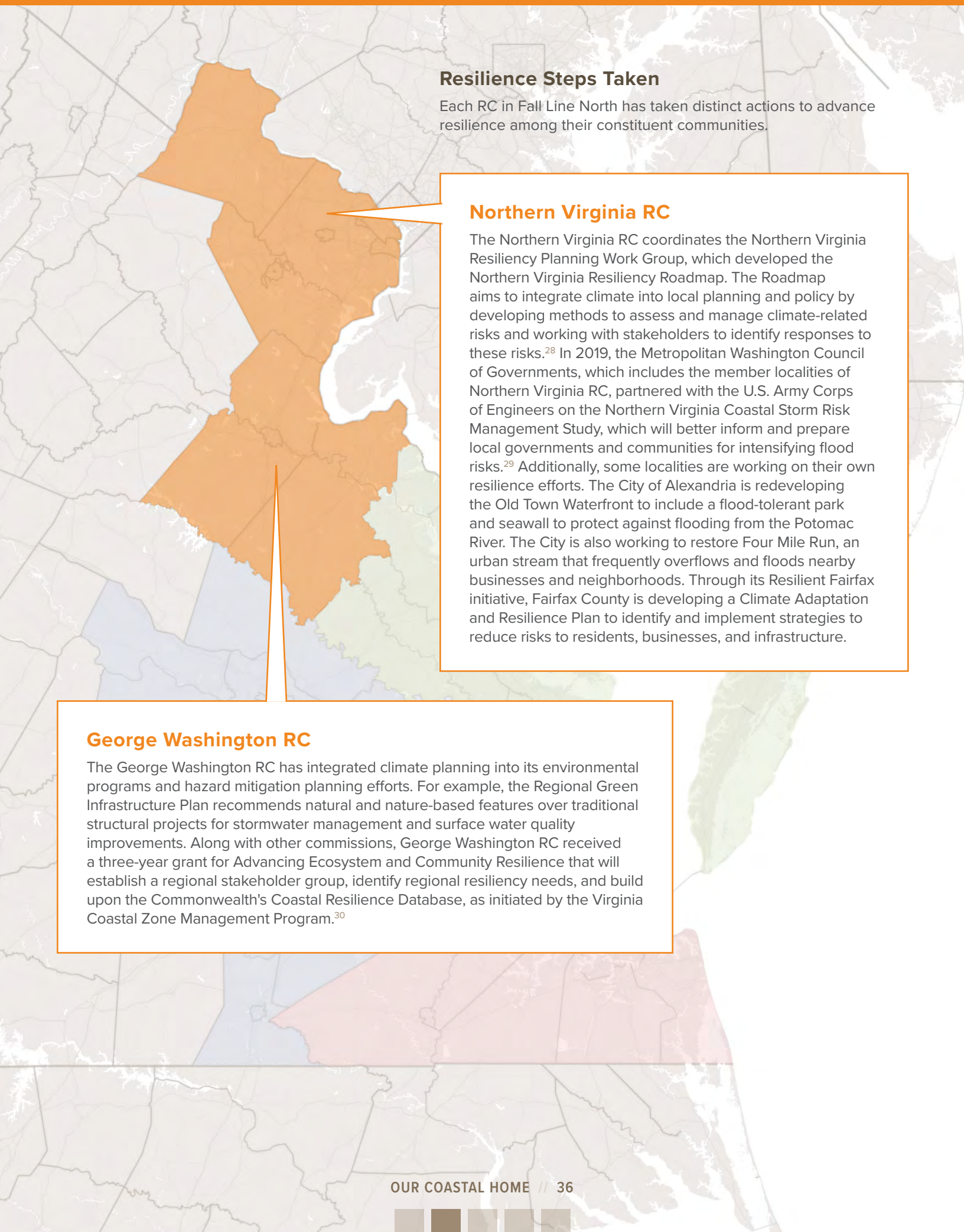
Most of Fall Line North's residential and commercial development is concentrated around Washington, D.C. and along the Potomac River. Some of the region's historic neighborhoods, like Old Town Alexandria, lie adjacent to major rivers, such as the Potomac and Rappahannock, which can overflow and flood vulnerable neighborhoods and nearby businesses. Fall Line North's primary economic driver is its proximity to the nation's capital, which draws commuters and visitors from all over the country. The region is also home to one state-recognized tribe: the Patawomeck Indian Tribe of Virginia.

Critical Sectors

Fall Line North's dense residential and commercial development necessitates a robust network of transportation systems, communication facilities, energy infrastructure, and many more critical assets. Among these assets are air, road, and rail transportation infrastructure, including Ronald Reagan Washington National Airport, which provides critical support to the Commonwealth's economy. Fall Line North also contains several low-lying military bases which are already experiencing rainfall driven flooding, including Marine Corps Base Quantico, Fort Belvoir, and Naval Support Facility Dahlgren.

Natural Infrastructure

Despite its intense development, the region still contains a number of ecologically valuable tidal freshwater marsh and woodlands. The Potomac and Rappahannock Rivers provide essential ecosystem services to the region but already experience shoreline erosion due to natural processes. As sea levels rise and storm surge flooding intensifies, shoreline habitats may increasingly be at risk as erosion accelerates and upstream salinity levels rise. Additionally, large portions of the Northern Virginia shoreline were hardened in the past, resulting in habitat loss.



Resilience Steps Taken

Each RC in Fall Line North has taken distinct actions to advance resilience among their constituent communities.

Northern Virginia RC

The Northern Virginia RC coordinates the Northern Virginia Resiliency Planning Work Group, which developed the Northern Virginia Resiliency Roadmap. The Roadmap aims to integrate climate into local planning and policy by developing methods to assess and manage climate-related risks and working with stakeholders to identify responses to these risks.[28] In 2019, the Metropolitan Washington Council of Governments, which includes the member localities of Northern Virginia RC, partnered with the U.S. Army Corps of Engineers on the Northern Virginia Coastal Storm Risk Management Study, which will better inform and prepare local governments and communities for intensifying flood risks.[29] Additionally, some localities are working on their own resilience efforts. The City of Alexandria is redeveloping the Old Town Waterfront to include a flood-tolerant park and seawall to protect against flooding from the Potomac River. The City is also working to restore Four Mile Run, an urban stream that frequently overflows and floods nearby businesses and neighborhoods. Through its Resilient Fairfax initiative, Fairfax County is developing a Climate Adaptation and Resilience Plan to identify and implement strategies to reduce risks to residents, businesses, and infrastructure.

George Washington RC

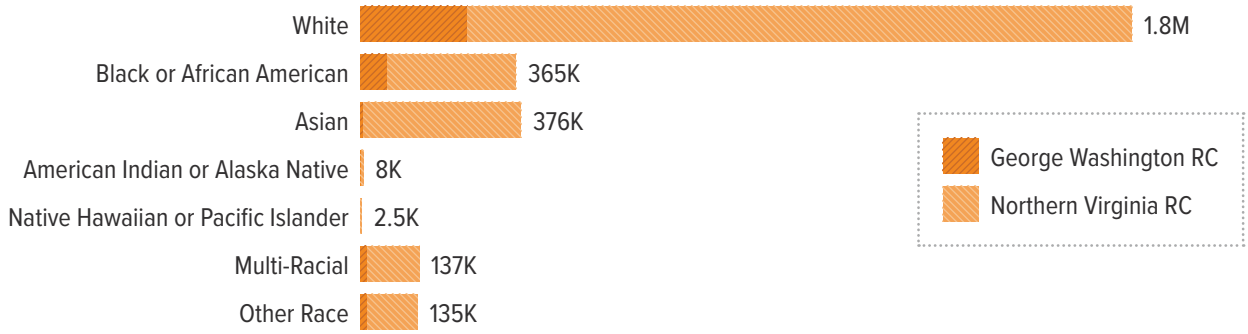
The George Washington RC has integrated climate planning into its environmental programs and hazard mitigation planning efforts. For example, the Regional Green Infrastructure Plan recommends natural and nature-based features over traditional structural projects for stormwater management and surface water quality improvements. Along with other commissions, George Washington RC received a three-year grant for Advancing Ecosystem and Community Resilience that will establish a regional stakeholder group, identify regional resiliency needs, and build upon the Commonwealth's Coastal Resilience Database, as initiated by the Virginia Coastal Zone Management Program.[30]

Demographic and Economic Context

Fall Line North is the most populous and economically productive Master Planning Region. The region is home to approximately 2.8 million people — 87% of whom reside in Northern Virginia RC. The Northern Virginia RC is primarily an urban and highly developed area. In contrast, the George Washington RC consists of one city, Fredericksburg, with a variety of smaller towns and cities, historic neighborhoods, and rural communities. The region is racially and economically diverse and has a high concentration of families with children.

Fall Line North Population by Race* and RC

Source: US American Community Survey, 2018

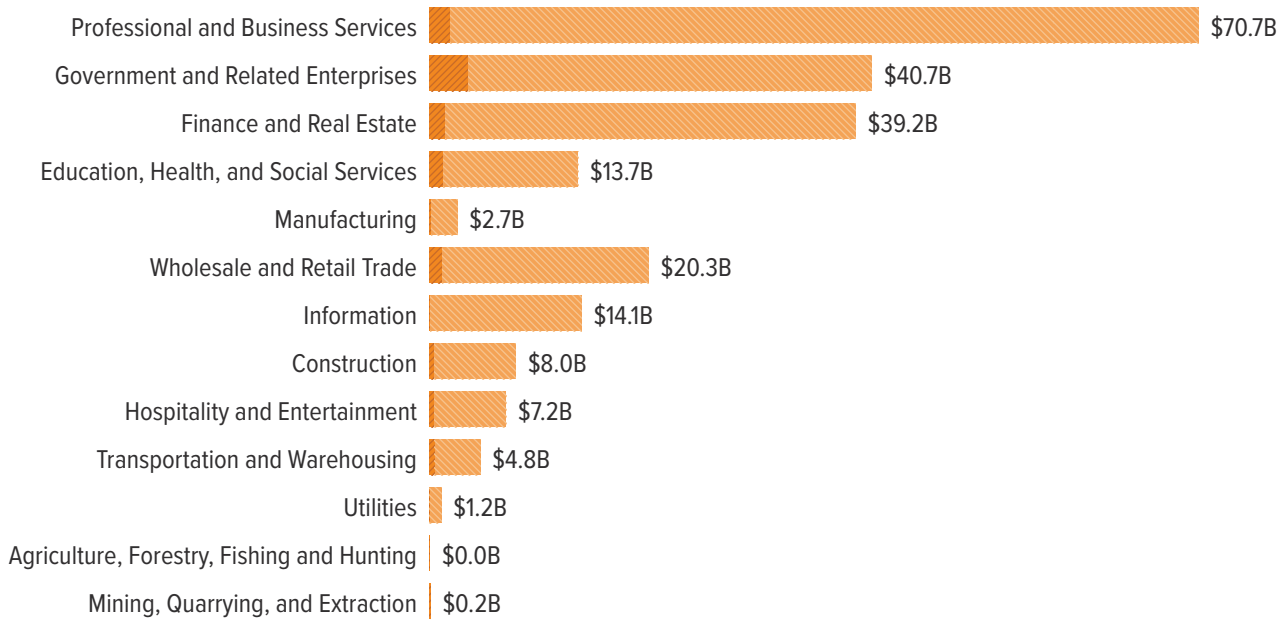


* Note the Census Bureau collects data on race separately from ethnicity, including Hispanic and Latino populations that can report any of the listed races.

As part of the Washington, DC metropolitan area, the region benefits from its proximity to the nation's capital and the high level of economic activity in the area. Professional and business services, government and government-related services, finance, and real estate are major economic sectors, particularly in Northern Virginia. Some sectors may experience increasingly severe flood impacts to structures, supporting infrastructure, and supply chains.

Fall Line North Gross Domestic Product (GDP) by Industry Segment and RC

Source: US Bureau of Economic Analysis, 2019



Fall Line South Master Planning Region

Virginia's coastal zone extends into Fall Line South up to the falls of the James River in Richmond and Appomattox River in Petersburg. The falls historically played a vital role in the region's development by stopping boat traffic and facilitating the growth of port and commercial centers that moved goods along the rivers. More than 1.2 million Virginians live in a mix of urban, suburban, and rural communities, including the state's capital city, Richmond. Several localities have tidally influenced waters that can overflow during intense precipitation and storms.

Dewberry


VDOT


VASG


VASG


KN

Photos courtesy of the Dewberry Team, Ken Newman (KN), Aileen Devlin of Virginia Sea Grant (VASG), and the Virginia Department of Transportation (VDOT).

Regional Localities

Localities within Crater PDC: Towns of Claremont, Dendron, Jarratt, McKenney, Surry, Stony Creek, Wakefield, and Waverly; Cities of Colonial Heights, Petersburg, Hopewell, and Emporia; and Counties of Dinwiddie, Greensville, Prince George, Surry, and Sussex.

Localities within Richmond Regional PDC (PlanRVA): City of Richmond; Town of Ashland; Counties of Charles City, Chesterfield, Goochland, Hanover, Henrico, New Kent, and Powhatan.

Primary Flood Hazards

Fall Line South contains roughly 860 miles of tidally influenced shoreline.[31] In a targeted survey, resilience practitioners in Fall Line South ranked coastal flood hazards in order of priority to their jurisdiction or organization as follows:

1. Rainfall-Driven Flooding
2. Riverine Flooding
3. Tidal Flooding
4. Storm Surge Flooding
5. Coastal Erosion
6. Groundwater Impacts

Community Resources

Fall Line South has extensive agricultural lands interspersed with residential and commercial development along the James River. The region is home to several treasured historic sites, including Pocahontas Island, one of the Commonwealth's earliest free African American settlements. In PlanRVA, the Commonwealth's capital Richmond drives the local economy. Crater PDC's access to major roadways, rail lines, and port facilities fuel its industrial and manufacturing economy, but the region also has a significant agricultural sector. Fall Line South has two federally recognized tribes: the Chickahominy and the Chickahominy Tribe Eastern Division.

Critical Sectors

The Richmond metropolitan region, which includes both the Cities of Richmond and Petersburg, is a transportation hub containing freight and passenger rail lines, multiple airports, and major interstates and roads. Several thoroughfares, including State Route 10 and U.S. Routes 58 and 460, serve as evacuation routes for Fall Line South and Hampton Roads communities.[32] Further, access to the James River allows the Richmond Marine Terminal, part of the Port of Virginia, to receive and distribute goods throughout the state and beyond. The region's access to multiple transportation modes is a crucial driver of its economy. Richmond also contains many government facilities, including the Virginia State Capitol and multiple universities and colleges.

Natural Infrastructure

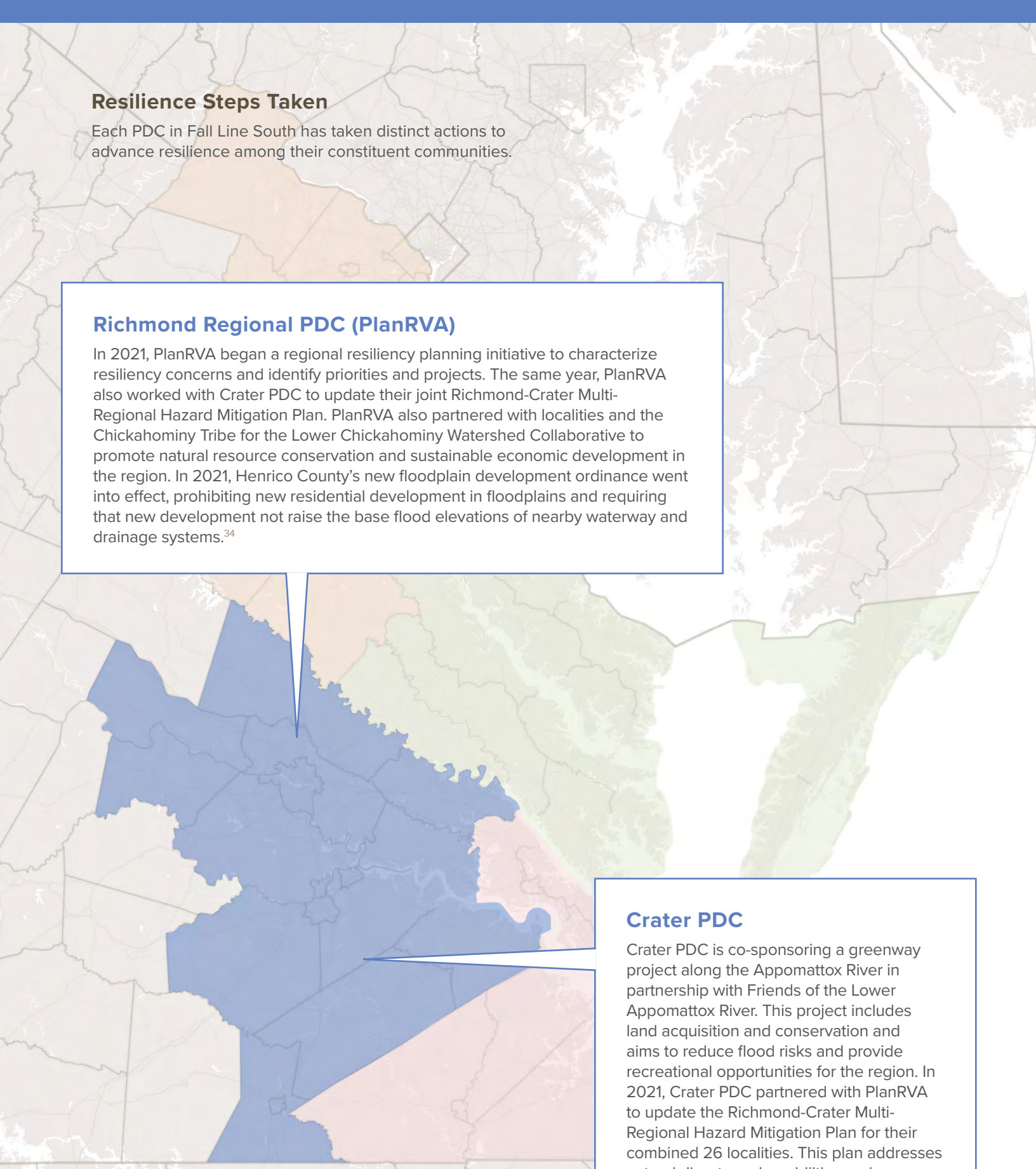
Ecologically important freshwater wetlands and other ecosystems line the James and Chickahominy Rivers. Fall Line South also contains state-designated scenic rivers which drive local economies by attracting visitors. The Appomattox and Meherrin River trails and their surrounding natural landscapes provide critical habitat for native species and ample recreational opportunities for residents and visitors. As sea levels rise and saltwater moves upstream, the region's freshwater wetlands, like those along the James River, are increasingly at risk of habitat degradation or other irreparable harm.

Resilience Steps Taken

Each PDC in Fall Line South has taken distinct actions to advance resilience among their constituent communities.

Richmond Regional PDC (PlanRVA)

In 2021, PlanRVA began a regional resiliency planning initiative to characterize resiliency concerns and identify priorities and projects. The same year, PlanRVA also worked with Crater PDC to update their joint Richmond-Crater Multi-Regional Hazard Mitigation Plan. PlanRVA also partnered with localities and the Chickahominy Tribe for the Lower Chickahominy Watershed Collaborative to promote natural resource conservation and sustainable economic development in the region. In 2021, Henrico County's new floodplain development ordinance went into effect, prohibiting new residential development in floodplains and requiring that new development not raise the base flood elevations of nearby waterway and drainage systems.[34]



Crater PDC

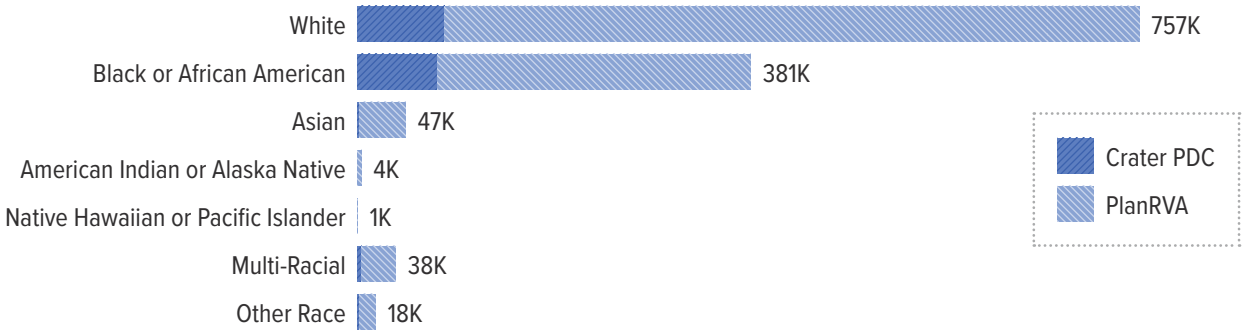
Crater PDC is co-sponsoring a greenway project along the Appomattox River in partnership with Friends of the Lower Appomattox River. This project includes land acquisition and conservation and aims to reduce flood risks and provide recreational opportunities for the region. In 2021, Crater PDC partnered with PlanRVA to update the Richmond-Crater Multi-Regional Hazard Mitigation Plan for their combined 26 localities. This plan addresses natural disaster vulnerabilities and strategies to mitigate or eliminate the long-term risk associated with these disasters.[33]

Demographic and Economic Context

Fall Line South is a large populous region, with approximately 1.2 million residents — 86% of whom live in PlanRVA. It is home to the Commonwealth's own capital city of Richmond and a range of large and small urban and rural communities. The region is racially and economically diverse, with high numbers of historically under-resourced and economically stressed communities, emphasizing the need for centering equity considerations in resilience measures and investments.

Fall Line South Population by Race* and PDC

Source: US American Community Survey, 2018

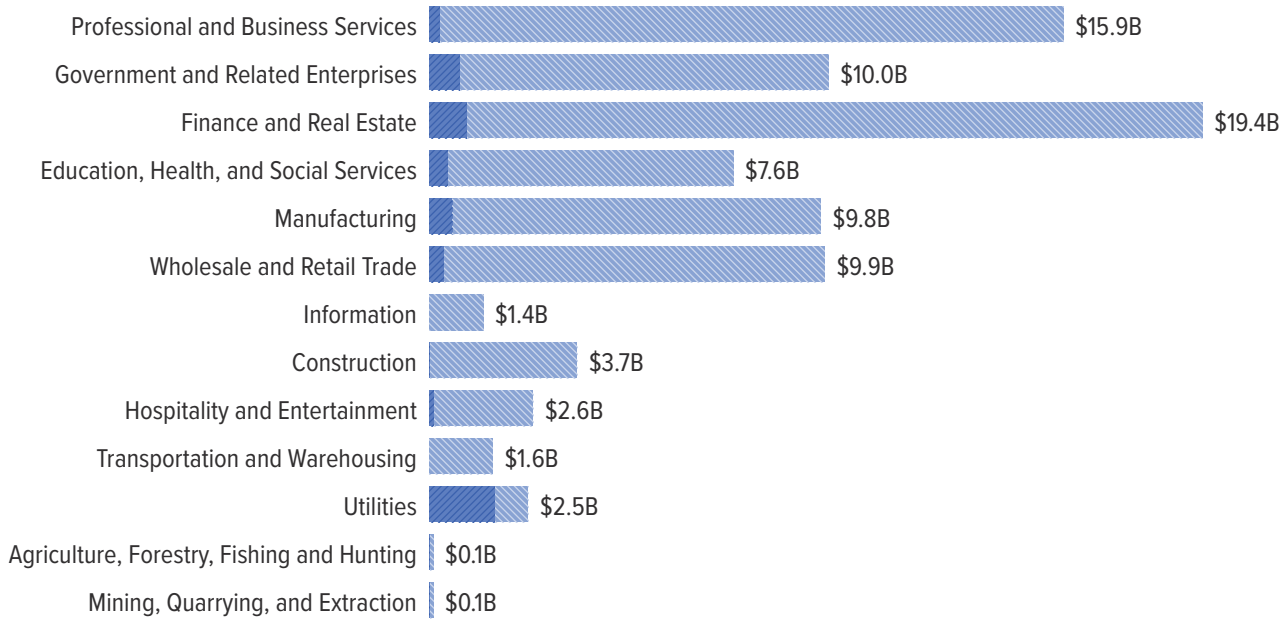


* Note the Census Bureau collects data on race separately from ethnicity, including Hispanic and Latino populations that can report any of the listed races.

A diverse array of industries supports the regional economic base. The region is a transportation hub and home to the Commonwealth's capital city of Richmond and a range of large and small urban and rural communities. Finance and real estate, professional and business services comprise of the two largest economic sectors. The region also has the largest manufacturing and utility-related sectors of any Master Planning Region.

Fall Line South Gross Domestic Product (GDP) by Industry Segment and PDC

Source: US Bureau of Economic Analysis, 2019



Our Changing Coastal Environment

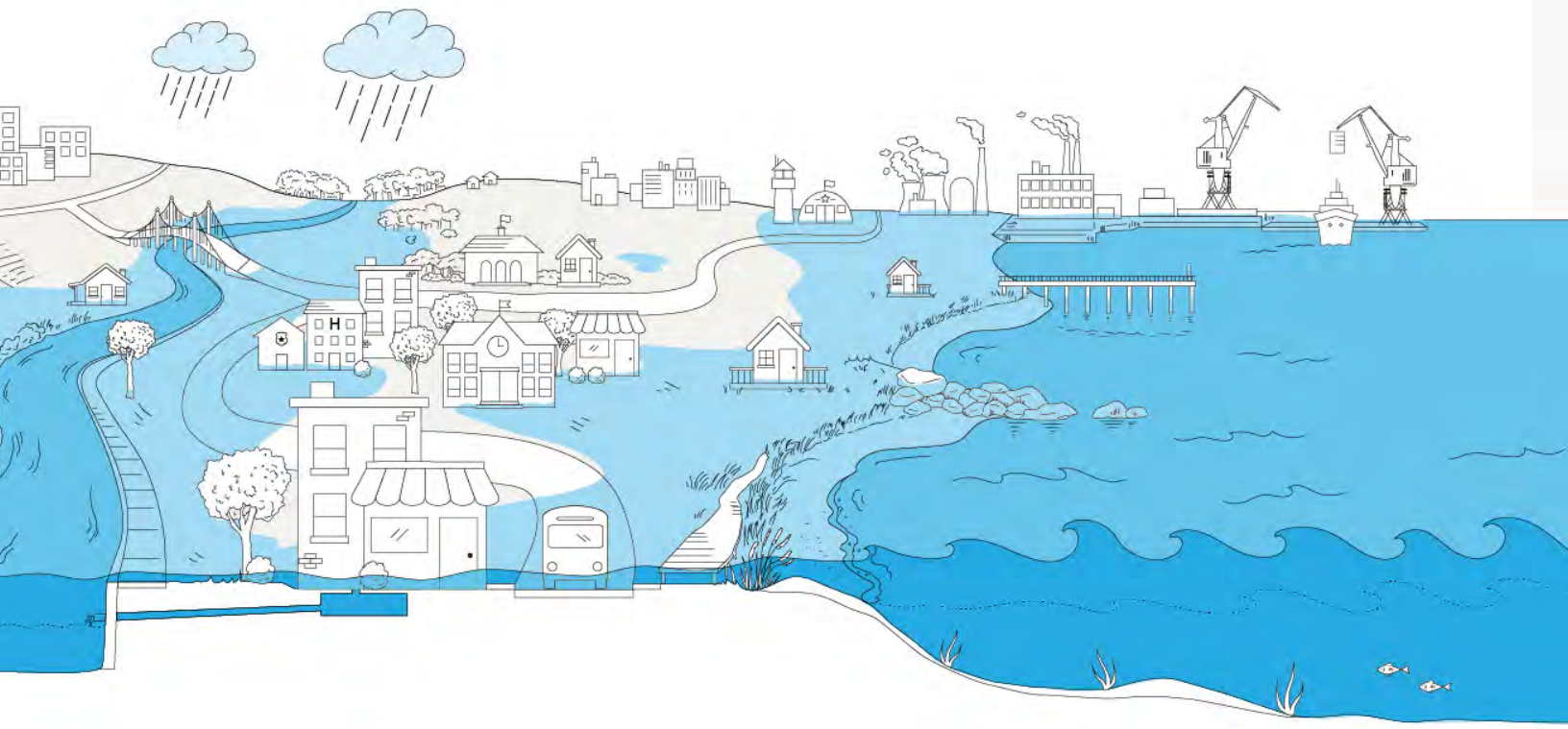
Flooding is a natural and necessary process. It helps recharge groundwater, renew wetlands, and replenish agricultural lands. However, more frequent and severe floods can overwhelm the current capacity of natural and built infrastructure. Future projected flood hazards could bring about worsening and new consequences that put people, infrastructure, and ecosystems in harm's way.

These issues are not new to the Commonwealth, but flood hazards are measurably changing due to climate change. Between rising sea levels and changing precipitation patterns, coastal Virginia has already witnessed changes to the frequency and intensity of floods and adverse impacts on water quality. The Commonwealth recognizes that climate change will further accelerate these changes, making flood resilience a statewide priority. Identifying risks and crafting strategies is a crucial first step.

Historical Flood Damage

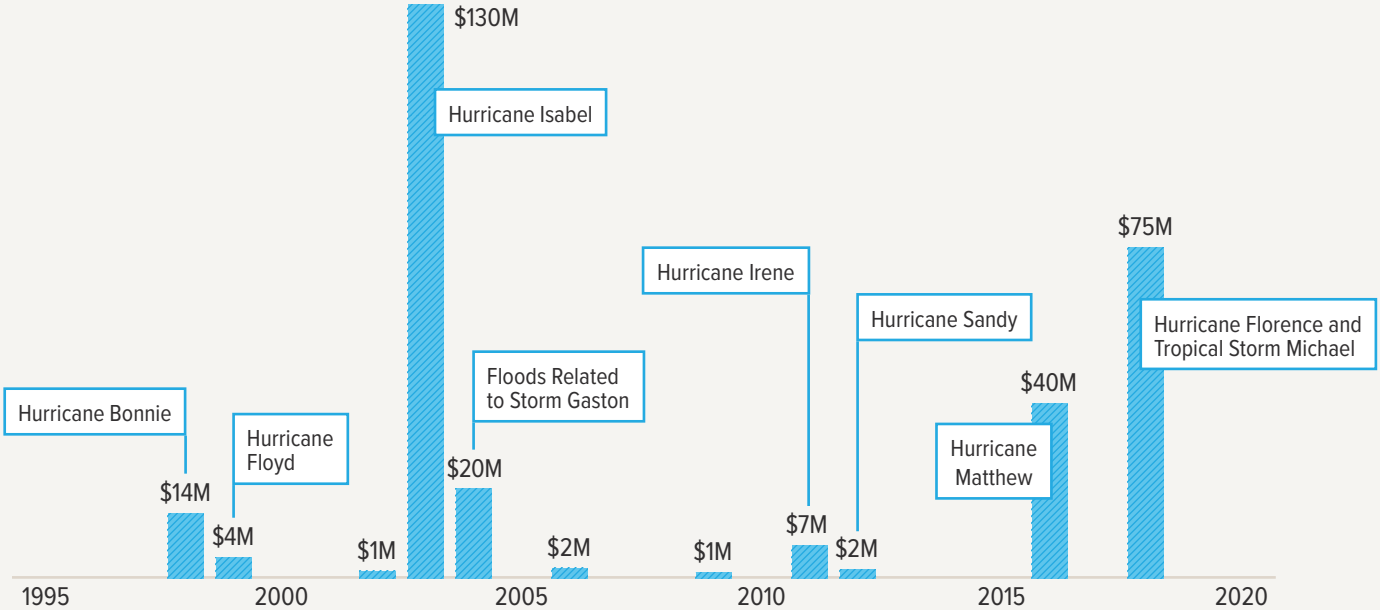
A presidentially declared disaster event refers to a major disaster or emergency event, such as a flood or hurricane, that can receive federal assistance for response and recovery efforts. The amount of federal financial assistance distributed for a declared disaster event can illustrate the relative severity of historical floods.

However, the process of securing federal assistance after a disaster requires significant staff time and capacity from local governments. Some communities may not have necessary staff or resources allocated to secure these funds. Further, other communities may experience more storms that are smaller, unnamed, and not eligible for federal assistance. Historical flood damages illuminate the scale of previous disasters, but also underscore the need for capacity at a local level to support coastal resilience to reduce potential future damage.



Total Federal Financial Assistance Dollars for Declared Flood Events in Virginia

Includes individual, public assistance, and hazard mitigation grant amounts. Source: Federal Emergency Management Agency, 2020[35]



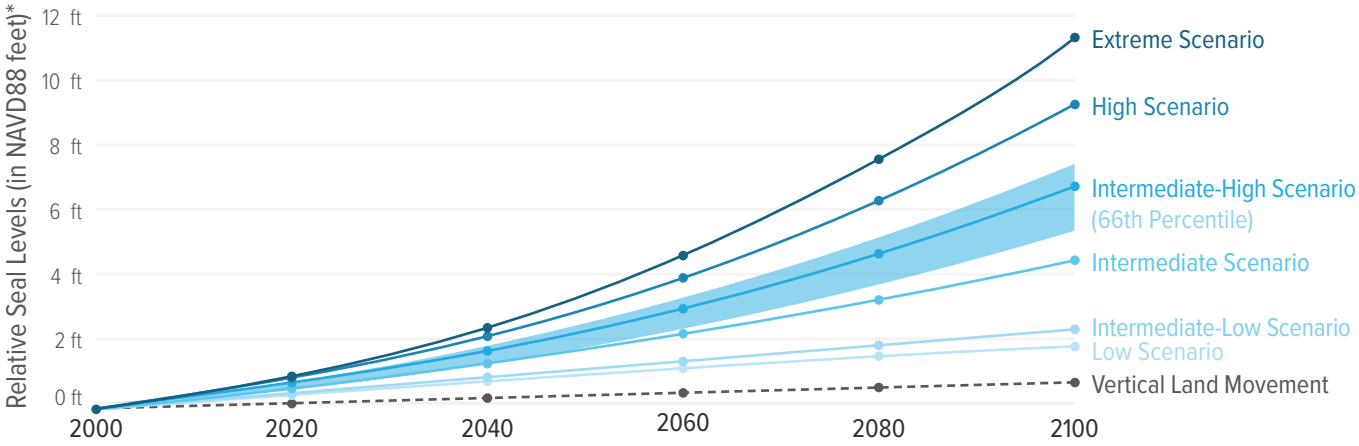
The Science of Rising Sea Levels

Climate change drives sea level rise in two significant ways: thermal expansion and ice melt. Thermal expansion occurs when the ocean absorbs the heat that greenhouse gases trap in Earth's atmosphere, causing the volume of seawater to expand. As the atmosphere heats up, land-bound ice glaciers and ice sheets melt. This melting now accounts for roughly twice as much sea level rise as thermal expansion.[36] According to the Fourth National Climate Assessment, the Southeast United States has already experienced increased rates of sea level rise. These rates are projected to intensify further in the future as temperatures continue to rise and ice melt accelerates.[37] Preparing for future conditions is more critical than ever before.

With over 6,700 miles of tidally influenced shorelines, planning for sea level rise is a critical first step to protect the Commonwealth's communities, natural and cultural resources, and built infrastructure.[38] Based on the Virginia Institute for Marine Science and the Commonwealth Center for Recurrent Flooding Resilience recommendations, Virginia adopted the National Atmospheric and Oceanic Administration's (NOAA) Intermediate-High Sea Level Rise Curve as the state standard for resilient planning and design for state-owned structures, as outlined in Executive Order 45.[39] Further, the Virginia Department of Transportation's has integrated both sea level rise and increased precipitation considerations into their structure and bridge design manual.[40]

NOAA et al. 2017 Relative Sea Level Change Scenarios for Sewell's Point in Norfolk, Virginia

Source: U.S. Army Corps of Engineers (2021)[45]

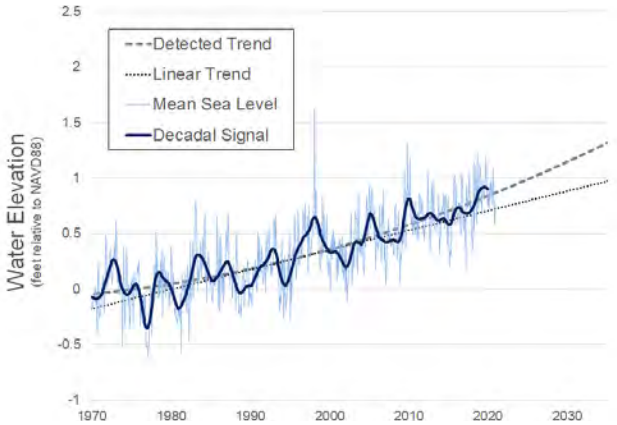


* Note the North American Vertical Datum of 1988 (NAVD88) is a land-based elevation and is relevant to first-floor elevations and other land-based engineering criteria.

In alignment with Executive Order 45, the Commonwealth used the Intermediate-High curve as the most likely scenario for future coastal flood hazards and related impacts in the Master Plan Technical Study.[41, 42] Observed changes in Virginia supported this selection. The Virginia Institute of Marine Science has detected trends of acceleration over the long-term linear trend. Future flooding analyses within the Master Plan reflect this acceleration in the rate of sea level rise. Known water level variations above the observed acceleration trend are consistent with the Intermediate-High projection.[43] As global temperatures continue to rise, the processes that drive sea level change, like ice melt, will similarly intensify, accelerating the rate of sea level rise.

Observed Trends of Accelerating Sea Level Rise at Sewell's Point in Norfolk, Virginia

Adapted from Virginia Institute of Marine Science, 2019. Sea Level Rise Report Cards: Norfolk, Virginia.[44]

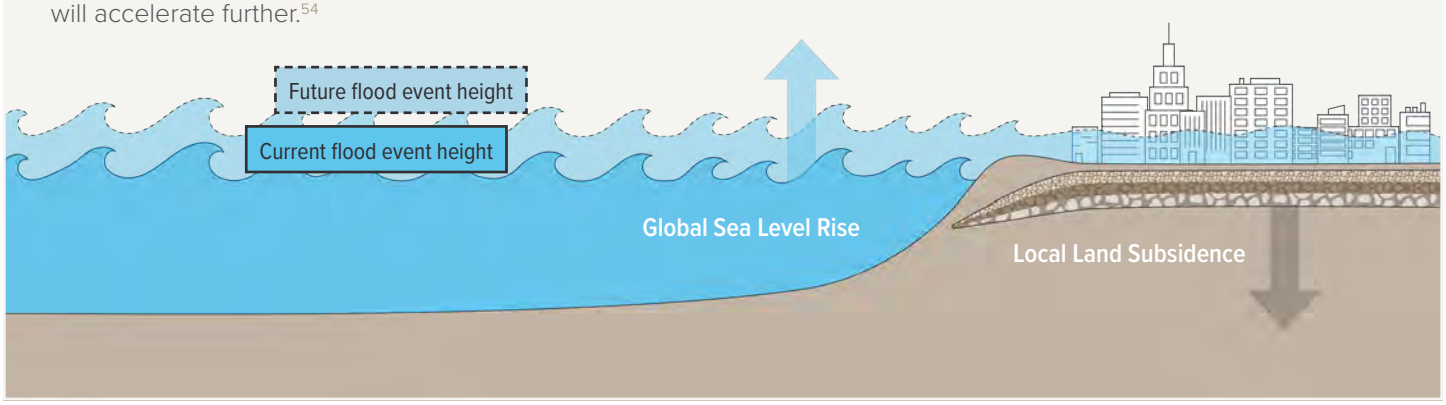


Why Virginia's Sea Levels Are Rising So Fast

Global and local factors contribute to how fast and severe sea levels rise and affect Virginia. Historically, land subsidence accounted for nearly half of Virginia's relative sea level rise.[48] Land subsidence refers to the sinking of the ground, also called local vertical land movement. Subsidence occurs due to groundwater withdrawal and large-scale regional vertical movement of the continental plate (glacial isostatic rebound) due to ongoing shifts associated with the Chesapeake Bay meteor impact crater.

Some of these factors are naturally occurring, while others are man-made. The U.S. Geological Survey attributes about half of the subsidence rate to groundwater withdrawals.[49] Because groundwater extraction is human-caused, reducing extraction rates could mitigate related subsidence. As water is withdrawn, the aquifer system compacts, causing the land above to subside. More than 100 million gallons of water are extracted daily from the Potomac aquifer, the Southern Chesapeake Bay region's deepest and thickest aquifer.[50] A study of land subsidence in the Southern Chesapeake Bay region found that, on average, groundwater withdrawls contribute 3 millimeters in sea level rise annually in the region, with rates ranging from 1.1 to 4.8 millimeters annually.[51, 52]

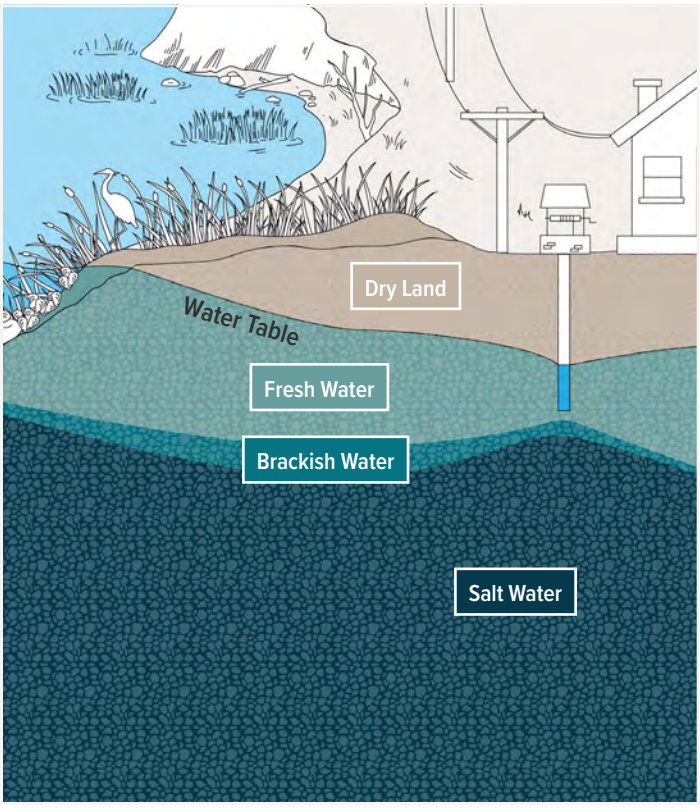
In the future, other factors — such as changes to regional ocean currents, upstream flood control, thermal expansion, and glacial ice melt — will play more significant roles in how fast Virginia's sea levels rise.[53] Virginia's sea levels are already rising much quicker than most of the country due to these issues, and scientists projected that future rates will accelerate further.[54]



Implications for Water Quality

Climate change affects the quality and quantity of water available to people and ecosystems. Combating these changes can be costly if not adequately and proactively mitigated. Dependable and safe groundwater supplies help maintain communities, but rising sea levels threaten this critical resource. As sea levels rise, saltwater can enter groundwater and aquifers, making these water resources unsafe to drink and unusable for irrigation.

There are locations where freshwater and saltwater naturally meet. These transition zones are usually kept in balance because freshwater moves towards the sea, keeping saltwater at bay and fresh groundwater supplies safe. As extraction rates and sea levels rise, roles can reverse, and saltwater can move inward and infiltrate freshwater aquifers. If this happens often and to a severe enough extent, freshwater supplies can become unsustainable.[46] Areas relying on sole-source aquifers, like the Eastern Shore and its Yorktown-Eastover system, may increasingly face challenges with saltwater intrusion of drinking water supplies.[47]



The Science of Changing Precipitation Patterns

As temperatures warm due to climate change, surface water evaporation increases, leading to more moisture in the air. The more moisture held in the air, the higher the chance for heavy precipitation. Heavy rainfall can lead to flooding by overflowing rivers and streams or falling faster than the ground can absorb it. In developed areas, intense rainfall can overwhelm drainage systems, leading to stormwater or flash flooding and the overflow of combined sewer systems into waterways.

The Fourth National Climate Assessment noted that Virginia is experiencing rainfall events that are more intense (two or more inches of precipitation) and frequent compared to historical averages, which are projected to continue in the future.[55] After experiencing the impacts of three extreme precipitation events in 2016, the City of Virginia Beach completed an analysis and found a statistically significant trend of heavy rainfall increasing by 7% every decade since the 1950s.[56] Based on these findings, the report recommended a 20% increase to the City's design guidance to account for growing rainfall intensities. The Commonwealth independently verified these trends, and the findings spurred further work across the state.

Research conducted by the Virginia Transportation Research Council shows that rainfall volume and frequency has consistently increased at rainfall stations across the Commonwealth.[57] There was a large variability in increases across these stations, and no apparent spatial trend was determined in the records. Based on these results, the Virginia Department of Transportation updated its bridge design guidelines to accommodate a 20% increase in rainfall intensity and a 25% increase in discharge.

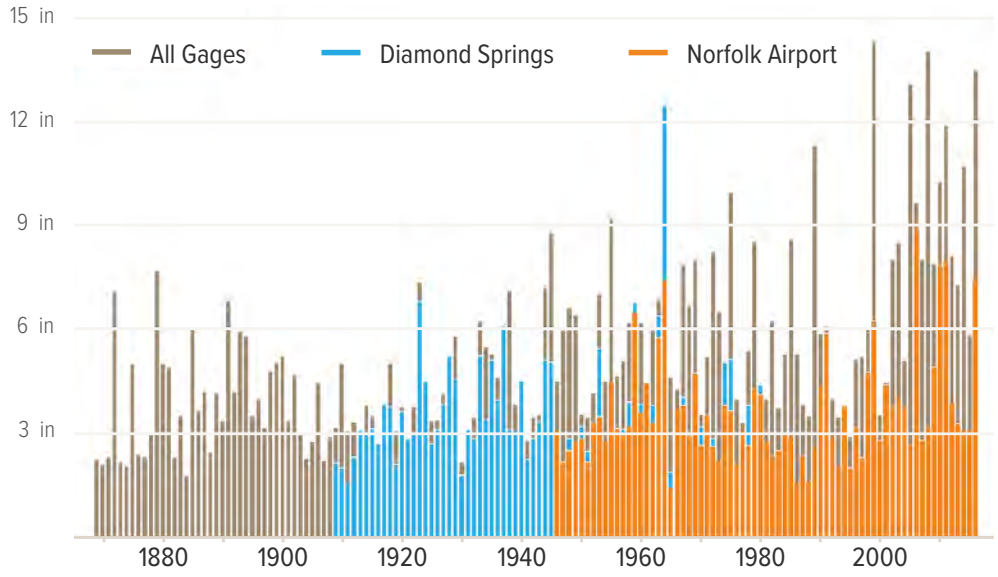
Additionally, the Commonwealth progressed two key efforts to address the identified trends in increasing heavy rainfall. First, an ongoing effort for the Chesapeake Watershed by the Mid-Atlantic Regional Integrated Sciences and Assessments (MARISA) program was augmented to provide future heavy rainfall projections across the entire Commonwealth, which are now publicly available.[58] [59] The Commonwealth also recognizes that NOAA Atlas 14, the federal standard reference source for civil engineering drainage design, is outdated, and has partnered with Delaware, Maryland, and North Carolina to fund a future update, which should be updated by fall 2023.[60]

This iteration of the Master Plan does not include a detailed analysis of changes to rainfall-driven flooding due to changing precipitation patterns in Virginia. The Commonwealth is evaluating plans for modeling these hazards, and updates will be captured in future versions of this Master Plan.

Annual Maximum 24-hour Rainfall in Virginia Beach, Virginia

Source: City of Virginia Beach, 2018[61]

Analysis of heavy rainfall events within a 60-mile radius of Virginia Beach showed clear trends in increasing annual maximum 24-hour rainfall. Trend line fit to this historical record shows a positive slope with a three-inch increase per century, statistically significant at the 99% confidence level.



Public and Professional Perspectives: Experiences with Rainfall and Flooding

Over 1,300 Virginians responded to a public online survey with questions relating to their lived flooding experiences and preferences on resilience strategies. Of those respondents:

- **80%** have witnessed rainfall-driven flooding in their communities, more than any other flooding type.
- **81%** believe that stormwater drainage improvement projects would provide benefits to their community.

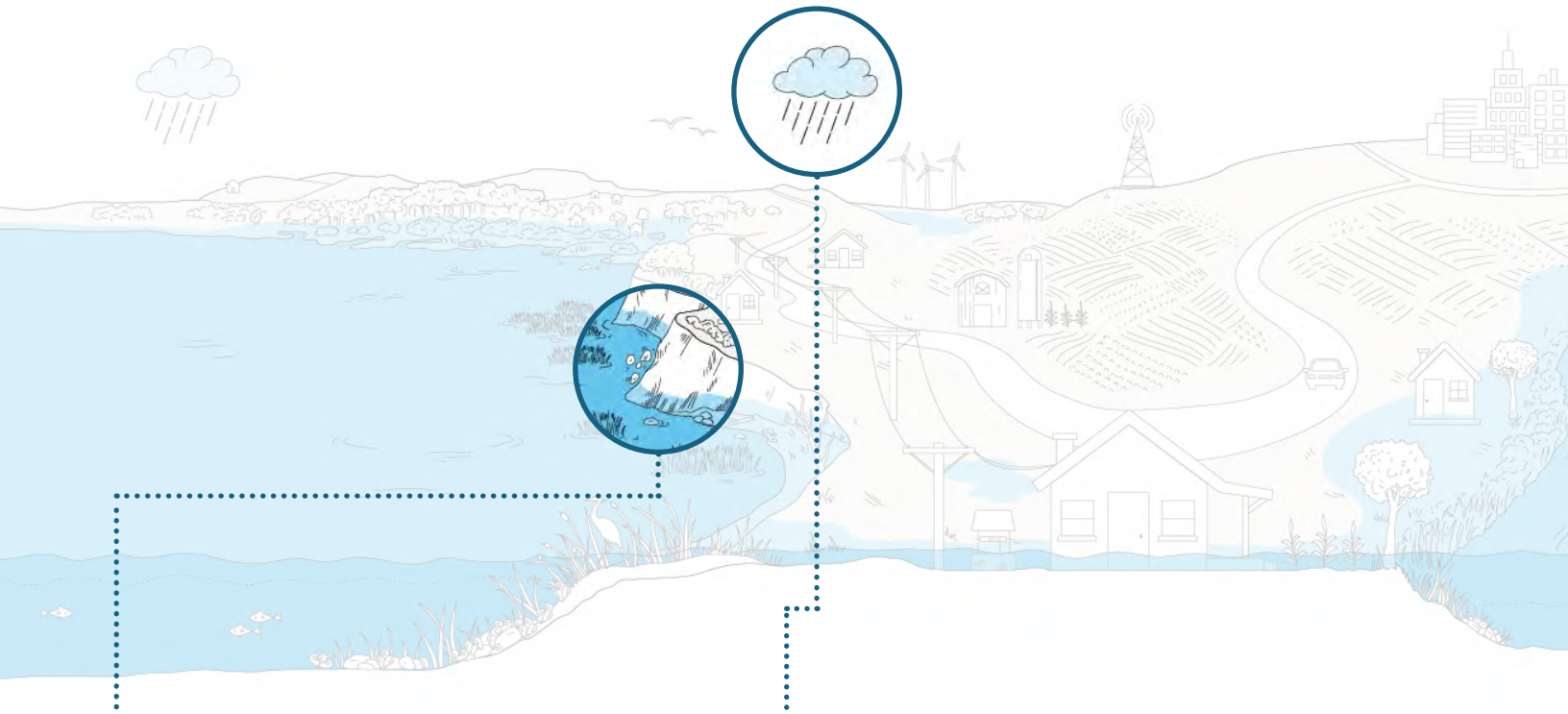
Nearly 100 representatives from government and partner organizations responded to a survey with questions related to their professional flooding experiences and preferences on resilience strategies. Of those respondents:

- **64%** cited rainfall-driven flooding among the top two coastal hazards of concern facing their jurisdiction.
- **70%** identified stormwater drainage improvements as among their top five priority resilience project types.

Photo courtesy of Aileen Devlin of Virginia Sea Grant.

Current and Future Coastal Hazards

Coastal Virginia faces threats from multiple flood-related hazards, many of which will worsen with climate change. Not all these hazards are assessed quantitatively in this iteration of the Master Plan. Tidal and coastal storm surge flooding are the focus of this phase of the master planning process. Planning is underway to improve the representation of additional threats in future studies, which is discussed more in Chapters 3 and 5.



Coastal Erosion Future Efforts

Regular tides, strong waves, and high winds cause coastal erosion that wears away sediment and land. Sea level rise will accelerate erosion, displacing sand and sediment faster than natural accretion can replace it. Extensive impervious surfaces in coastal areas can further intensify erosion by facilitating more forceful stormwater runoff. Erosion threatens both built structures, like private property and public infrastructure, and natural landscapes, like beaches and wetlands.

Rainfall-Driven Flooding Future Efforts

Prolonged or intense rainfall can inundate inland areas when runoff overwhelms natural or built drainage systems, leading to stormwater flooding and ponding. Some rural areas lack stormwater systems. Many other drainage systems were built decades ago and did not anticipate current development and climate patterns. Consequently, they are increasingly under-capacity and ill-prepared for future conditions. As sea levels rise, elevated water levels can impair drainage infrastructure, leading to increased flooding challenges.

External Factors

In addition to changes in sea levels and precipitation patterns, environmental factors — such as urban development, aging infrastructure, and higher groundwater levels — can all play a factor in exacerbating flood hazards. The first phase of the Master Plan does not include these factors in its assessment of future coastal hazards.

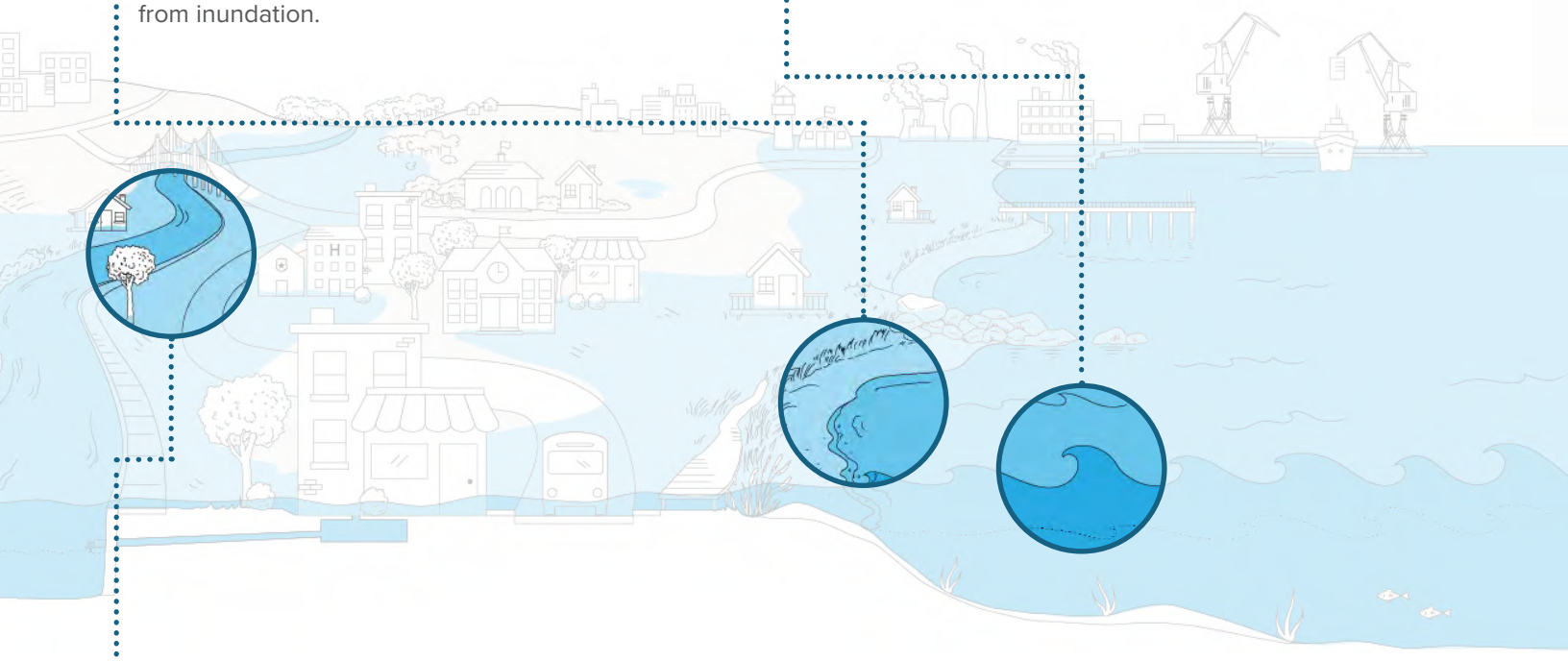
Urban Development – The population of Virginia has nearly doubled in the past 50 years.[62] Projections indicate that our population will continue to grow.[63] The growing population has brought changes in the use of land and resources. Residential and commercial development now exist on lands that were once open naturalized spaces. Developed areas have higher impervious surface coverage making the ground less absorptive of water and more susceptible to flood hazards.

Tidal Flooding Phase One

Tidal flooding occurs when ordinarily dry land is temporarily inundated during daily high tides. Tidal flood elevations vary each month and throughout the year, but as sea levels rise, high tide waters will extend farther inland. Similarly, the likelihood of sunny-day and nuisance flooding will increase as extreme high tides, such as those occurring during full or new moon cycles, will extend further into areas historically out of reach from inundation.

Coastal Storm Surge Flooding Phase One

Minor to severe storm events can drive tidal waters onto land, inundating upland areas. Sea level rise increases storm surge depths, allowing greater wave heights to reach further inland and even overtop existing coastal defenses. These higher waves elevate the risk of frequent and severe damage in low-lying regions while causing flood waters to penetrate deeper into to inland communities.



Riverine Flooding Future Efforts

Prolonged or intense rainfall can also cause rivers and streams to overflow their banks or shorelines, leading to riverine, or fluvial, flooding. Virginia's rivers and streams stretch more than 100,000 miles throughout the Commonwealth.[64] These riverine networks and estuarial areas provide essential ecosystem services like supporting fisheries, agriculture, and tourism and protecting local water quality. Some rivers are also tidally influenced, meaning that sea level rise can lead to higher water levels and amplified flood risks.

Compounding Flooding Future Efforts

Coastal flood hazards each pose challenges on their own, but when they occur at the same time, their potential to cause damage increases. When extreme high tides or coastal storm surges happen at the same time as intense rainfall, tidal waters can block stormwater drainage outfalls and even cause water to flow upstream into drainage ditches and pipes, resulting with more widespread flooding in inland areas.

Aging Infrastructure – Much of Virginia's infrastructure is decades old and built before changes in population and climate were widely known and understood. Rising demand for services combined with increased flood hazard conditions places increased burden on already aging infrastructure systems and can lead to higher risk of service disruption and utility failure. This drives the need to use new future climate projections when performing needed infrastructure upgrades and replacements.

Higher Groundwater Levels – As sea levels rise, the composition of groundwater systems changes. The water table rises, saturating more of the soil beneath the ground's surface. As subsurface soil becomes more saturated, its capacity to absorb additional waters from rainfall or flooding declines, raising the risk for surface inundation by interrupting flow directions. Further, high groundwater levels can overwhelm treatment plants and sewage lines, contaminating the nearby environment and drinking water supplies.

Chapter 3
Our Current Situation

This chapter captures a snapshot of coastal flooding to determine what is at stake within the Commonwealth and presents a brief overview of the Technical Study process. State-wide and regional breakouts summarize current and projected future coastal flood hazards, and the associated potential impacts to Virginia's essential and cherished assets.

Understanding the Effects of Coastal Flooding

Key Terminology

The following list defines key terms frequently referenced in the following sections.

- **Hazard** – The potential occurrence of a physical event or trend that may threaten people, systems, or assets.
- **Asset** – Physical components or resources of value that may be directly affected by hazards.
- **Exposure** – The likelihood and degree to which an asset, population, or system will be physically affected by flooding. Flood exposure for a given asset is a factor of the magnitude of the hazard present at its location.
- **Vulnerability** – The degree to which an asset, population, or system associated with the asset is likely to be adversely affected by the hazard. Vulnerability can be physical or social and encompasses a variety of concepts, including exposure, sensitivity, and adaptive capacity.
    - **Sensitivity** – Innate susceptibility to harm from interaction with the hazard.
    - **Adaptive capacity** – The ability to adjust to a new situation or cope with the consequences of a hazard event.
- **Risk** – The expected value of direct and indirect consequences associated with the potential functional disruption of the asset or system. Quantifying risk to an asset generally requires considering the probability a hazard event will occur, and the associated consequences of that event to the asset. Such consequences include the direct structural and functional losses, as well as indirect social, environmental, and economic losses.
- **Impact** – Consequences on physical and social environments due to the interaction of assets with the hazard (such as tidal and coastal floods). Projected impacts may be described using a variety of metrics including exposure, vulnerability, and risk.

Understanding where, when, why, and to what extent coastal flooding impacts occur will inform which areas and assets may require resources or support to implement resilience strategies. Persisting social and economic inequities may lead certain communities to experience the detrimental effects of coastal flooding worse than others.

The Technical Study assessed hazards and impacts to characterize how coastal flood hazards may affect Virginia's people and landscapes today and in the future. Direct physical consequences, like damage to structures and the loss of some ecological habitats, are presented using quantitative metrics. Indirect socio-economic consequences, such as a reduction in recreational tourism due to diminished natural resources, and other ecological changes, such as oyster habitat loss, are discussed qualitatively. In the following section, direct physical consequences are presented quantitatively, while indirect socio-economic consequences are primarily presented qualitatively.

The Technical Study also examined metrics for characterizing community vulnerabilities and capacities. These metrics provide relevant context for identifying where and how physical flood impacts may compound social and economic challenges, potentially worsening existing inequalities. Together, these factors are used to gain a more expansive understanding of the potential effects of coastal flood hazards and identify high-priority areas for resilience interventions.

Limitations of the Assessment

The objective of this analysis is to provide context on what is at stake for Virginia's coast as sea levels increase, as well as informing state, regional, and local planning efforts. The analyses provide a reasonable approximation of changes to both coastal flood hazards and risk, but do have data and analytical constraints. Such limitations are highlighted throughout the chapter and expanded upon in Appendix E.

Process for Assessing Impacts and Priority Areas

The impact assessment portion of the Technical Study is summarized in the steps illustrated below and presented in more details throughout this chapter.

Define the Coastal Flood Hazard Landscape

Modeling coastal flood conditions determines the frequency with which a flood event may occur, how severe flooding may be at a location, and how the hazard will grow and change over time.

Characterize Community Vulnerabilities & Capacities

Virginia's coastal communities have unique demographic, economic, social, and political characteristics that drive regionally distinct resilience and equity-related challenges that may be exacerbated by coastal hazards.

Measure Impacts to Community Resources

Measure Impacts to Critical Sectors

Measure Impacts to Natural Infrastructure

The Master Plan categorizes assets into three themes: Community Resources, Critical Sectors, and Natural Infrastructure. The function, location, characteristics, and value of a given asset inform our understanding of the consequences that may occur due to coastal flooding hazards. Projected physical impacts to these assets are evaluated using a variety of methods and metrics, including exposure, vulnerability, and risk.

Identify Impact Hotspots and Priority Areas

Metrics capturing both the physical impacts of coastal flood hazards and the relevant community context helps drive an understanding of which areas are most in need of resilience actions and support.

Coastal Flood Hazards

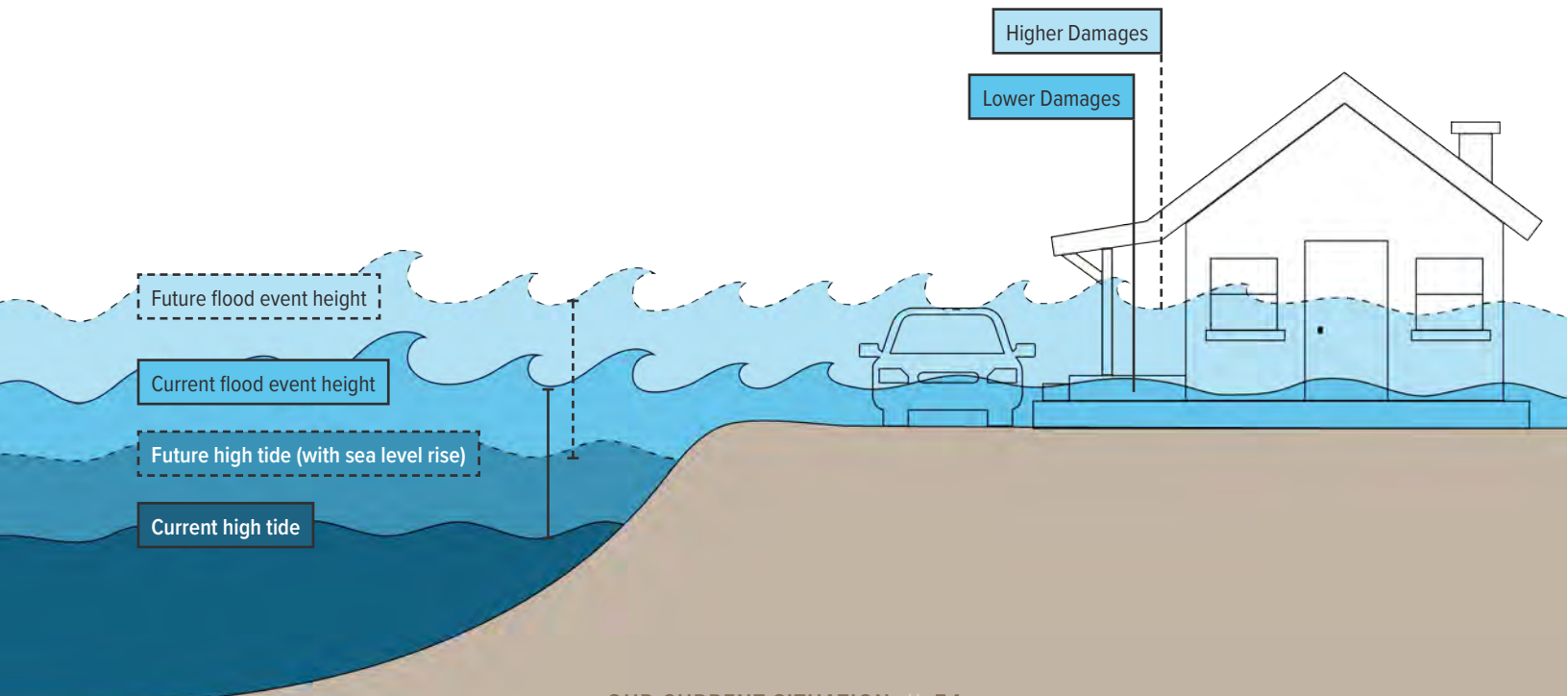
Coastal flood hazards are already increasing. They will continue to worsen as sea level rise accelerates and climate change intensifies. Understanding how and when these flood risks will change is critical to ultimately identifying and prioritizing effective resilience strategies that protect coastal Virginians and their communities.

To understand these changes, the Technical Study modeled coastal flood hazard scenarios based on two dimensions: time and magnitude. The analysis considers nine flood events that vary in likelihood of occurrence and severity (magnitude) and examined how these events will change from today to 60 years in the future. Examining an array of flood events and time horizons allows for planning across a range of timescales and risk tolerances. This analysis relied on the publicly available science and datasets for sea level rise projections, topography, and present-day tidal and storm surge flooding extents.

Limitations of the Flood Hazard Modeling Approach

Flood Types – The assessment does not examine existing or future coastal hazards for riverine, stormwater, and compound flooding, coastal erosion, or marsh migration as affected by sea level rise. This analysis also does not include data on the intensity, duration, and frequency of precipitation events or how those factors may change due to climate change. The Commonwealth will work to incorporate additional flood hazard data models in future versions of the Master Plan.

Landscape and Demographic Changes – Future hazard and impact projections are based on today's built, natural, and social conditions. The analysis does not consider future population growth, increasing development patterns, or other changes in the physical landscape across time horizons. By assuming these variables as constant, the hazard modeling and impact assessment are effectively the results of a no-action scenario in which no mitigating or exacerbating actions have occurred. This no-action analytical approach provides a baseline for decision-making and understanding of how project investments and policy actions may reduce future risk.



Sea Level Rise Over Time

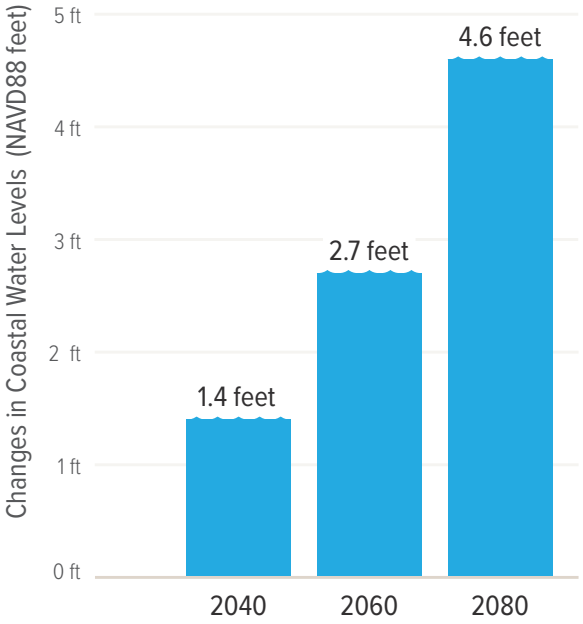
This first phase of the Master Planning process focuses on how coastal flood hazards and impacts will change over time. Rising sea levels will elevate water levels along the coast and in tidally influenced water bodies, resulting in more frequent and severe tidal and coastal storm surge flooding, depending on local elevation and topography.

The Commonwealth selected the NOAA Intermediate-High sea level rise curve to model future flood hazards across three future time horizons: 2040, 2060, and 2080. The 2020 time horizon represents existing baseline conditions to compare future changes in sea level rise and flood hazard events.

NOAA's sea level rise projections are not uniform across the Commonwealth of Virginia due to differences in subsidence rates and oceanographic processes. A spatially varying coverage of sea level rise projections from NOAA was used rather than a single value, which varied across the state from 0.2 feet in 2040 and up to 0.4 feet in 2080. These sea level scenarios were then combined with today's tidal and storm surge conditions to estimate flood extents, depths, and wave conditions for the future scenarios. This approach allows the assessment to more precisely determine how areas will be affected differently by future coastal flooding. Refer to Appendix C for more information.

Sea Level Rise Projections for Sewell's Point in Norfolk, Virginia

Relative to 2020 sea levels



Public and Professional Perspectives: Experiences with Coastal Flooding

Over 1,300 Virginians responded to a public online survey with questions relating to their lived flooding experiences. Of those respondents:

- **50%** have witnessed tidal flooding in their communities.
- **75%** have witnessed storm surge flooding in their communities.

Nearly 100 representatives from government and partner organizations responded to a survey with questions related to their professional experiences. Of those respondents:

- **36%** cited tidal flooding among the top two coastal hazards of concern facing their jurisdiction.
- **37%** cited storm surge flooding among the top two coastal hazards of concern facing their jurisdiction.

Flood Events and Scenarios

The Technical Study examines nine types of flood events representing the spectrum of flood magnitudes that can be compared over time. For each time horizon, flood extents and depths were produced for two tidal flood conditions and seven coastal storm surge events.

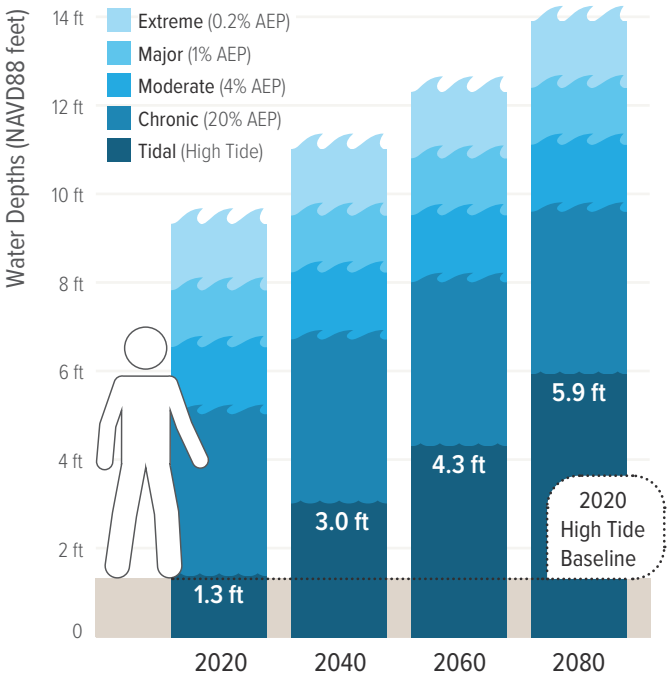
The two tidal flooding conditions include the average low tide (mean low water, or MLW) and the average high tide (mean high water, or MHW).[65] The seven coastal storm surge events represent flood conditions from small coastal storms to severe hurricanes, with this associated likelihood of occurring. This likelihood is expressed in terms of annual exceedance probability (AEP), the probability that a flood event will occur in any given year. The Technical Study considers the 50%, 20%, 10%, 4%, 2%, 1%, and 0.2% AEP storm surge events. A 1% AEP event is the equivalent of a 100-year-flood, which defines the FEMA Special Flood Hazard Area. Both terms describe a flood event that has a one-in-one-hundred chance of occurring or being exceeded by an event of greater magnitude in any given year.

The Master Plan aggregates these nine events into five reference flood events to simplify presentation across the document. The five reference events represent flood events that are commonly used for planning purposes, such as the 1% AEP (major coastal flood, or 100-year-flood) and 0.2% AEP (extreme coastal flood, or 500-year-flood). The full nine events are shown on the Web Explorer.

The Technical Study mapped flood extents, depths, and wave conditions for each flood event across the four time horizons, incorporating regional sea rise projections. Together, these represent probabilistic scenarios that can be used to assess the changes to asset exposure and impacts over time and inform planning processes.

While these scenarios are simplified for presentation throughout this document, the full array of modeled flood scenarios and associated impacts for all nine flood events and four time horizons can be accessed through the Web Application.

Floodwater Depths Across Events for Sewell's Point in Norfolk, Virginia



Coastal Flood Events Modeled and Referenced throughout the Master Plan

Reference Flood Event	Event Description (Likelihood)	Average Return Interval (Frequency)	Chance of occurring in...* 5 years	10 years	30 years	Example Storm Type
Tidal	Mean Low Water	Always Inundated	100%	100%	100%	None, Daily High Tide
	Mean High Water	Inundated Daily	100%	100%	100%	
Chronic	50% AEP	2 years	97%	100%	100%	Gale, Smaller Coastal Storm
	20% AEP	5 years	70%	90%	100%	
Moderate	10% AEP	10 years	41%	65%	96%	Tropical Storm, Nor'easter
	4% AEP	25 years	19%	30%	71%	
Major	2% AEP	50 years	10%	18%	46%	Strong Nor'easter, Category 2 hurricane
	1% AEP	100 years	5%	10%	26%	
Extreme	0.2% AEP	500 years	1%	2%	6%	Category 3+ hurricane

* Note chance of occurring is calculated for any given time period and does not take into account how hazard exposure may increase over time with sea level rise.

The Significance of Growing Floodplains

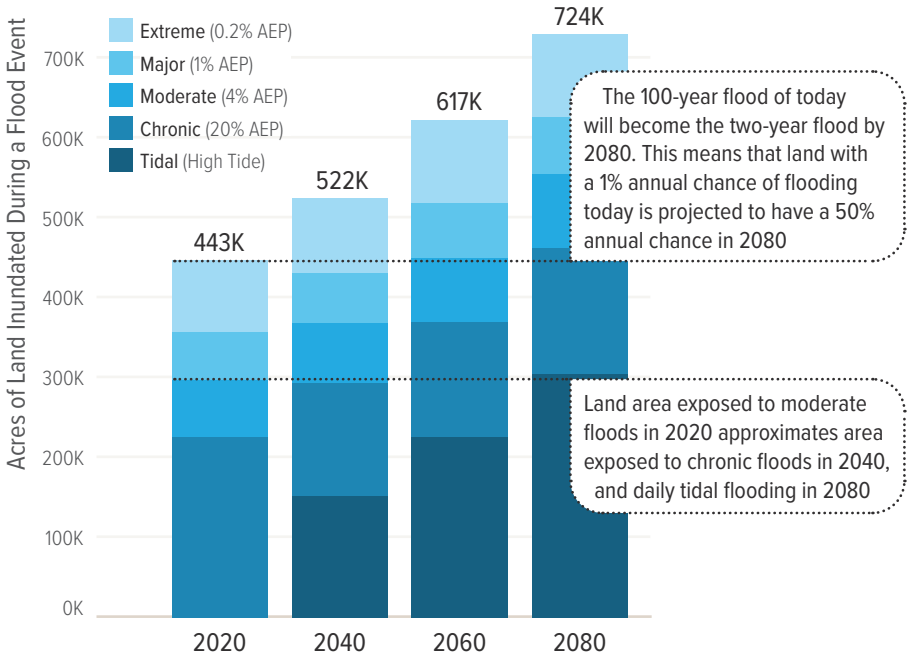
As sea levels rise, flood hazards will worsen in two important ways: floodplains will expand while floodwaters deepen. As a result, the types of coastal flood impacts that may be considered “rare” and “extreme” today will become more frequent in the future. Similarly, normally dry land will be inundated permanently and effectively “lost” if no mitigating actions are taken and ecosystems, like marshes and wetlands, are unable to migrate.

Expanding Floodplains

As floodplains extend inland, the likelihood that areas will experience flooding in a given year will increase. In 2020, a chronic flood (20% AEP) would inundate approximately 223,000 acres. But as sea levels rise, by 2080, that floodplain will more than double in size to 460,000 acres, expanding to cover approximately the same area currently flooded by an extreme coastal flood (0.2% AEP). Meanwhile, land exposed to an extreme flood will grow from 443,000 to 724,000 acres, an increase of over 60%. Tidal floodplains are also projected to grow dramatically: most of the 223,000 acres of land currently exposed to chronic floods (20% AEP) will be inundated permanently or on a daily basis by 2080.

Land Exposure Across Event Types

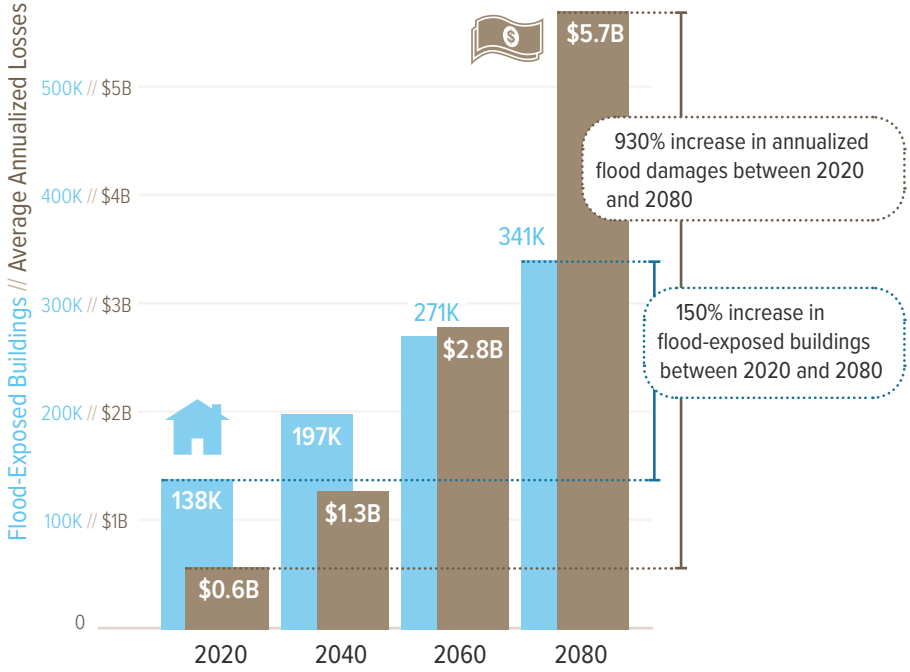
Relative to high tide 2020



Deepening Floodwaters

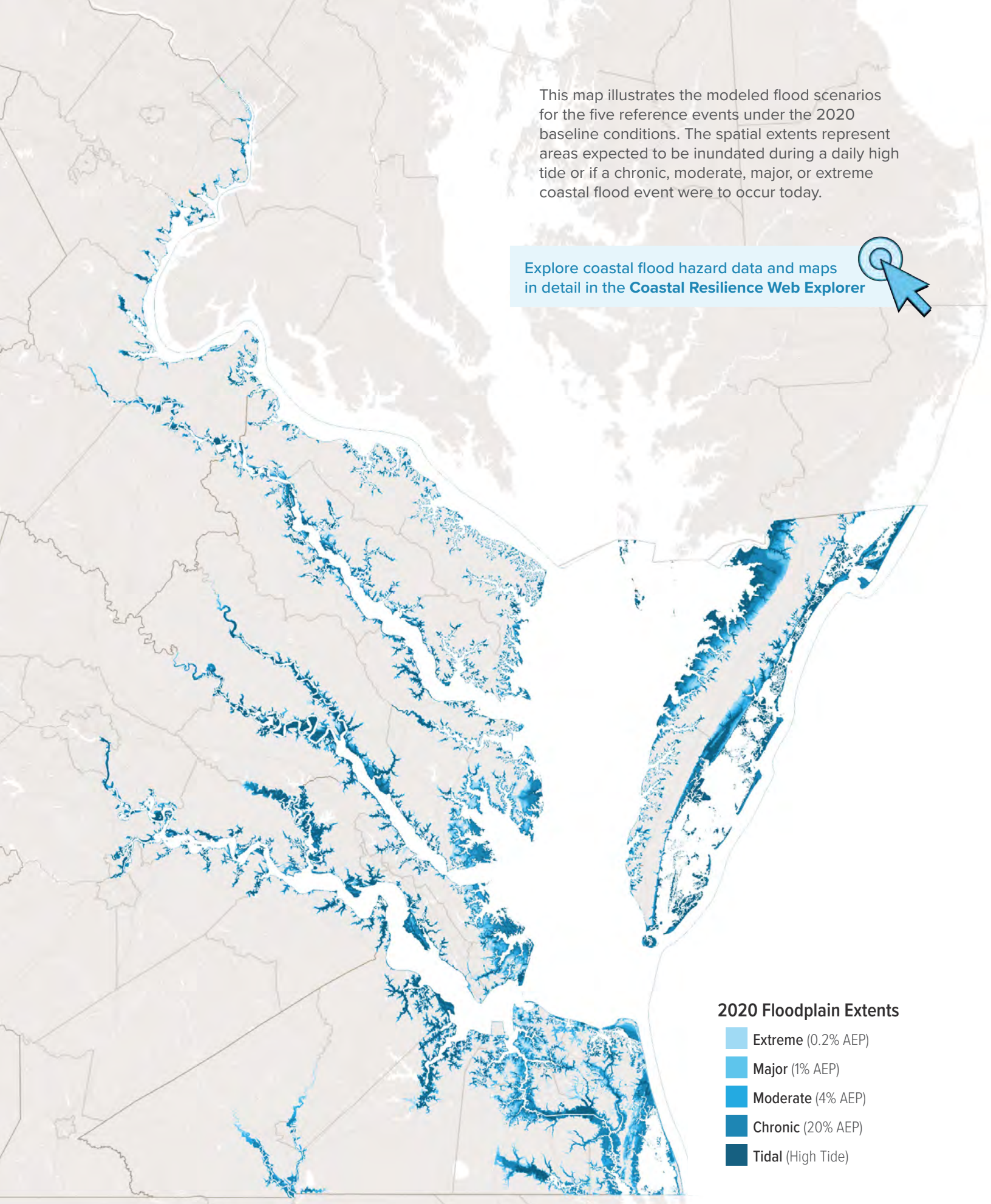
Deeper floodwaters are more dangerous, damaging, and costly. This means that as sea levels rise the damages we can expect to see every year will increase if no mitigating actions are taken. Between 2020 and 2060, the number of buildings exposed to an extreme coastal flood (0.2% AEP) is projected to nearly double from 138,000 to 271,000 while annualized flood damages increase by 400% from $0.6 to $2.8 billion. Even more dramatically, by 2080, the number of buildings exposed to an extreme coastal flood is projected to increase by nearly 150% to 341,000, while annualized flood damages increase by over 930% to $5.7 billion.

Building Exposure and Averaged Annualized Loss

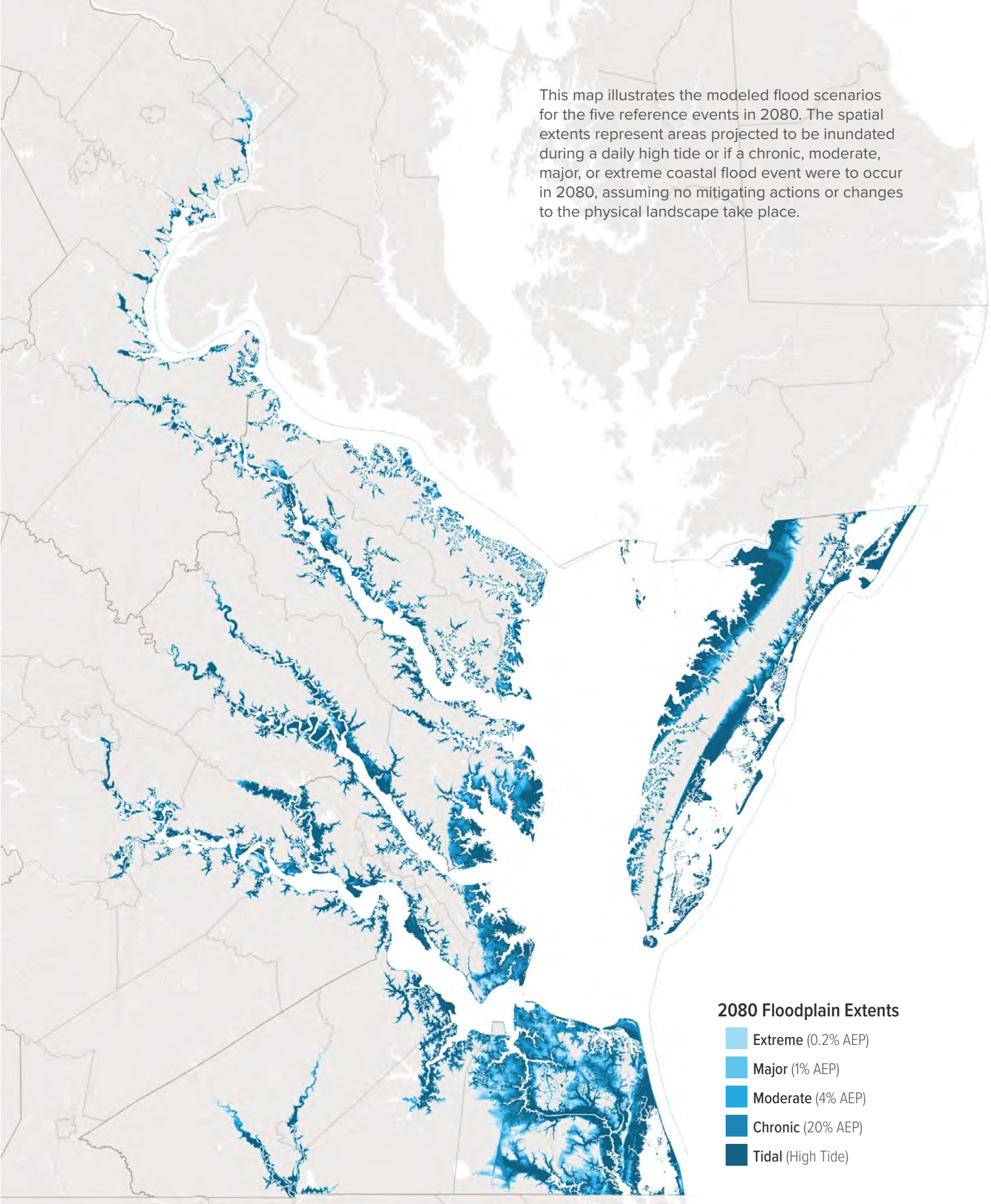


This map illustrates the modeled flood scenarios for the five reference events under the 2020 baseline conditions. The spatial extents represent areas expected to be inundated during a daily high tide or if a chronic, moderate, major, or extreme coastal flood event were to occur today.

Explore coastal flood hazard data and maps in detail in the **Coastal Resilience Web Explorer**



This map illustrates the modeled flood scenarios for the five reference events in 2080. The spatial extents represent areas projected to be inundated during a daily high tide or if a chronic, moderate, major, or extreme coastal flood event were to occur in 2080, assuming no mitigating actions or changes to the physical landscape take place.



Hazard Profile:

Hampton Roads

Areas of new coastal flood exposure

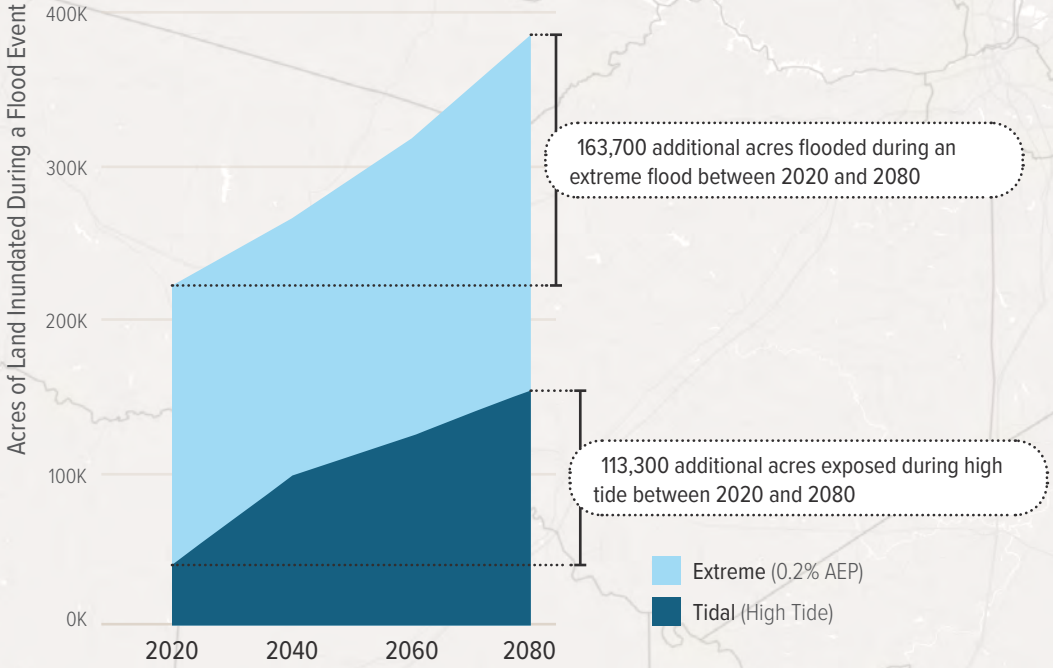
Between today and 2080, approximately 163,700 additional acres of land in Hampton Roads will be exposed to flooding during an extreme coastal flood (0.2% annual exceedance probability). Within those areas of new coastal hazard exposure lie 188,400 buildings and 550,200 residents.

Areas of effective land loss

Between today and 2080, approximately 113,300 additional acres of land in Hampton Roads will be inundated daily during high tide. Within those areas of new effective land loss lie approximately 23,900 buildings and 63,800 residents.

Land Exposure in Hampton Roads Across Event Types

Baseline land area considers all areas not inundated during low tide in 2020



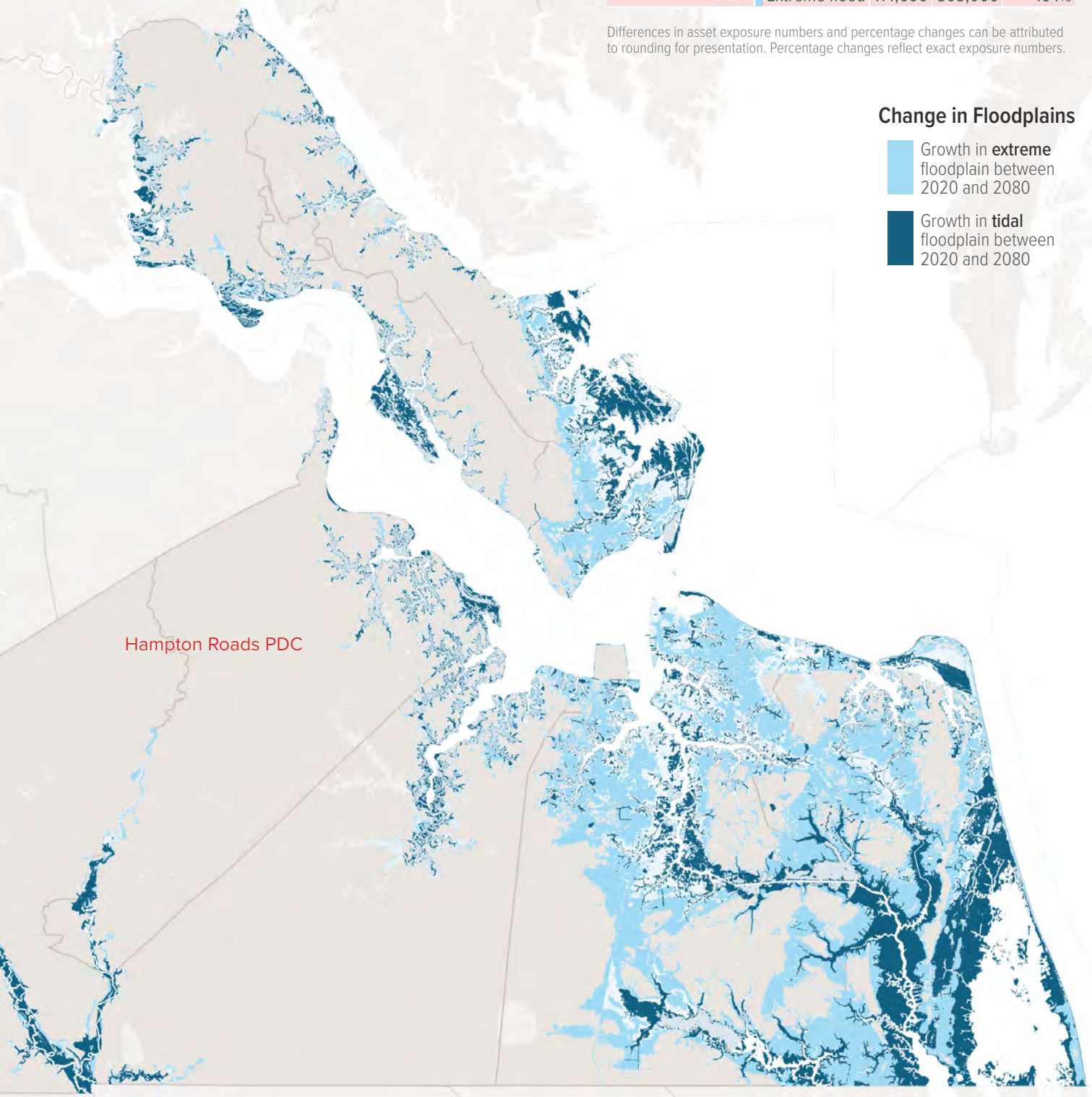
Land Acres Exposed

		2020	2080	Change
Hampton Roads PDC	High tide	37,800	151,000	+ 300%
	Extreme flood	220,100	383,800	+ 74%

Buildings Exposed

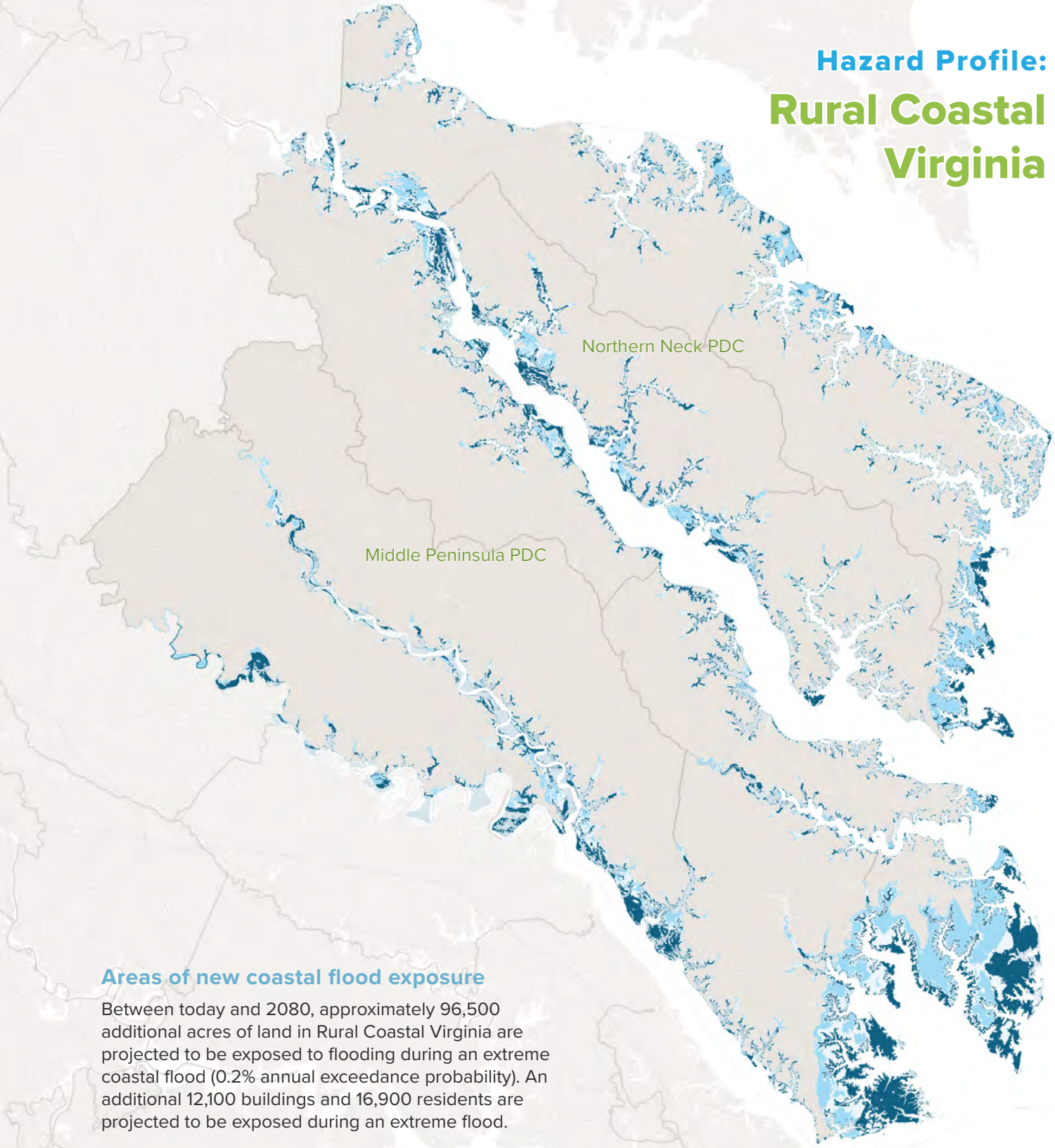
		2020	2080	Change
Hampton Roads PDC	High tide	450	24,300	+ 5337%
	Extreme flood	114,600	303,000	+ 164%

Differences in asset exposure numbers and percentage changes can be attributed to rounding for presentation. Percentage changes reflect exact exposure numbers.



Hazard Profile:

Rural Coastal Virginia



Areas of new coastal flood exposure

Between today and 2080, approximately 96,500 additional acres of land in Rural Coastal Virginia are projected to be exposed to flooding during an extreme coastal flood (0.2% annual exceedance probability). An additional 12,100 buildings and 16,900 residents are projected to be exposed during an extreme flood.

Areas of effective land loss

Between today and 2080, approximately 157,200 additional acres of land in Rural Coastal Virginia are projected be inundated daily during high tide. Approximately 14,100 buildings and 17,200 residents are projected to be displaced from these areas.

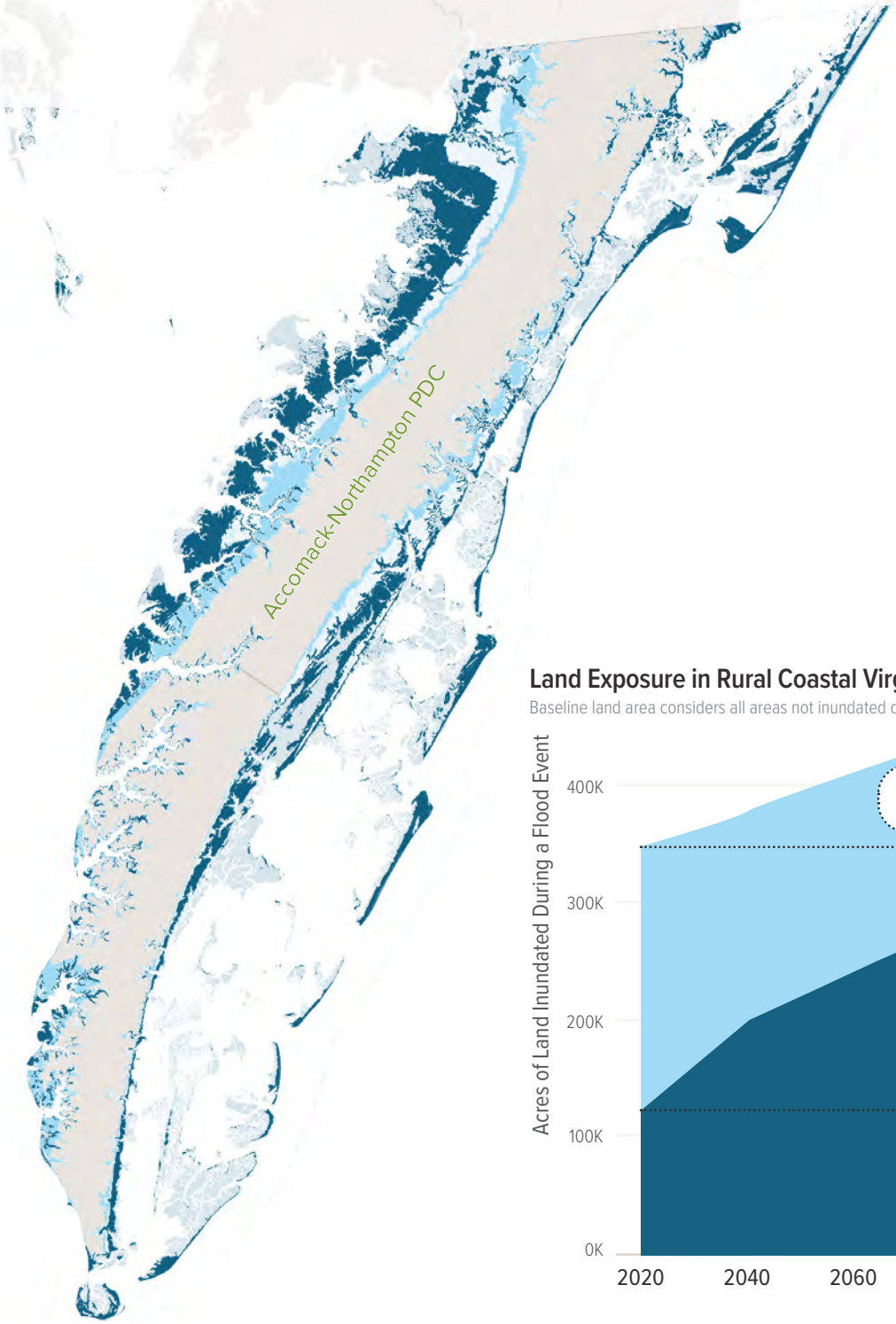
Land Acres Exposed

		2020	2080	Change
Accomack-Northampton PDC	High tide	90,300	176,200	+ 95%
	Extreme flood	206,600	238,700	+ 16%
Northern Neck PDC	High tide	9,400	30,000	+ 219%
	Extreme flood	37,200	63,700	+ 71%
Middle Peninsula PDC	High tide	25,500	76,200	+ 199%
	Extreme flood	102,600	140,500	+ 37%

Buildings Exposed

		2020	2080	Change
Accomack-Northampton PDC	High tide	100	6,700	+ 6173%
	Extreme flood	8,500	10,600	+ 25%
Northern Neck PDC	High tide	130	1,900	+ 1444%
	Extreme flood	3,000	7,700	+ 155%
Middle Peninsula PDC	High tide	120	5,900	+ 4796%
	Extreme flood	10,100	15,400	+ 52%

Differences in asset exposure numbers and percentage changes can be attributed to rounding for presentation. Percentage changes reflect exact exposure numbers.



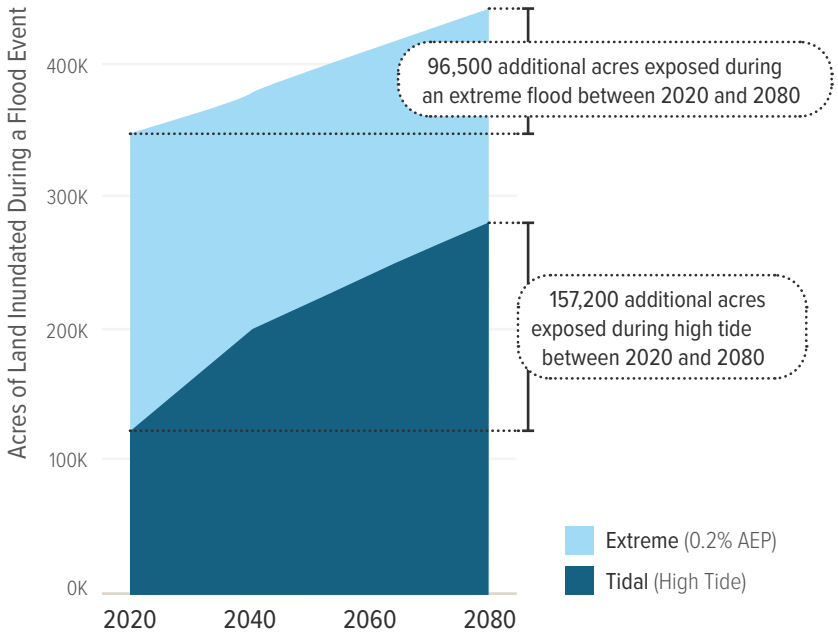
Change in Floodplains

Growth in **extreme** floodplain between 2020 and 2080

Growth in **tidal** floodplain between 2020 and 2080

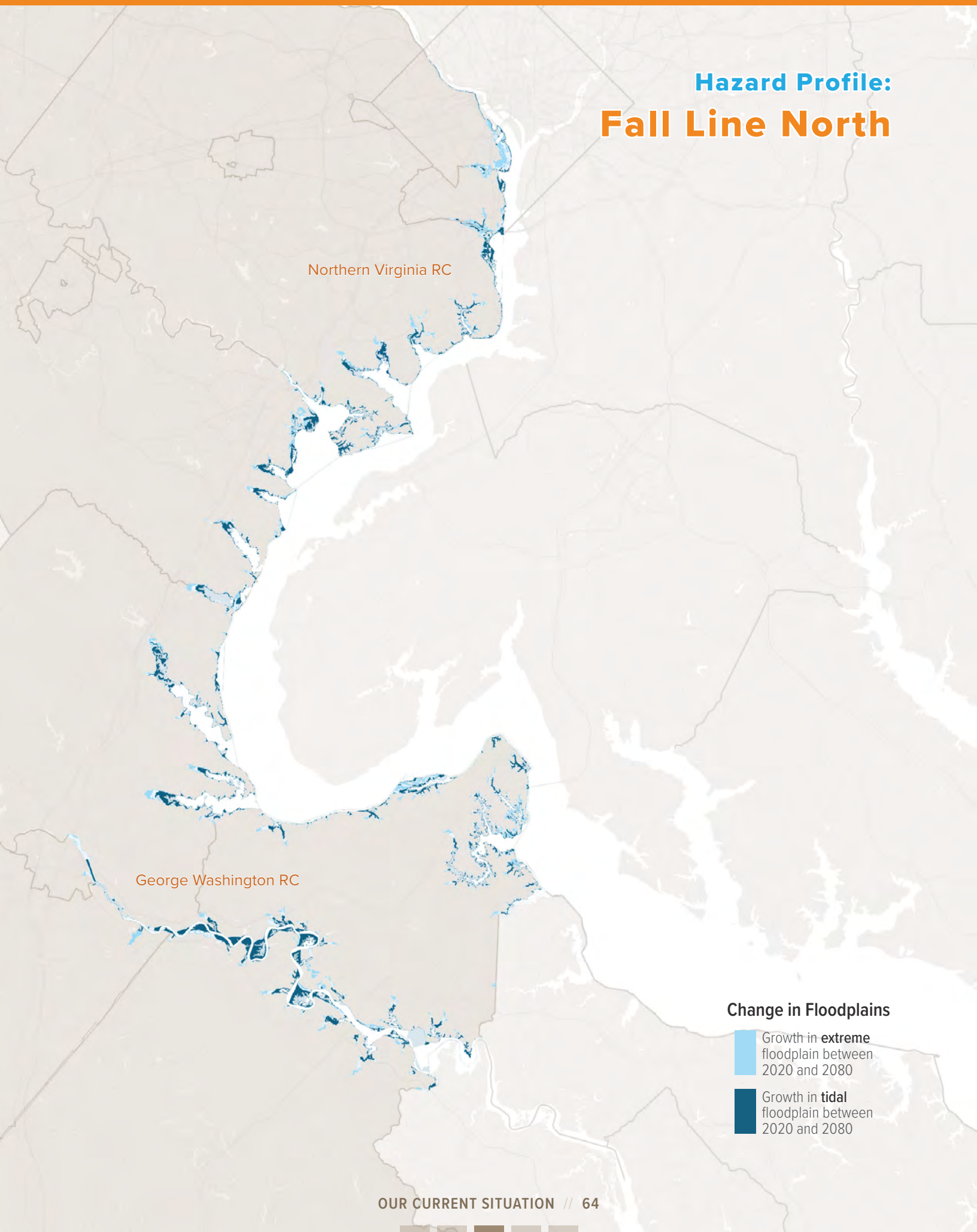
Land Exposure in Rural Coastal Virginia Across Event Types

Baseline land area considers all areas not inundated during low tide in 2020



Hazard Profile:

Fall Line North



Areas of new coastal flood exposure

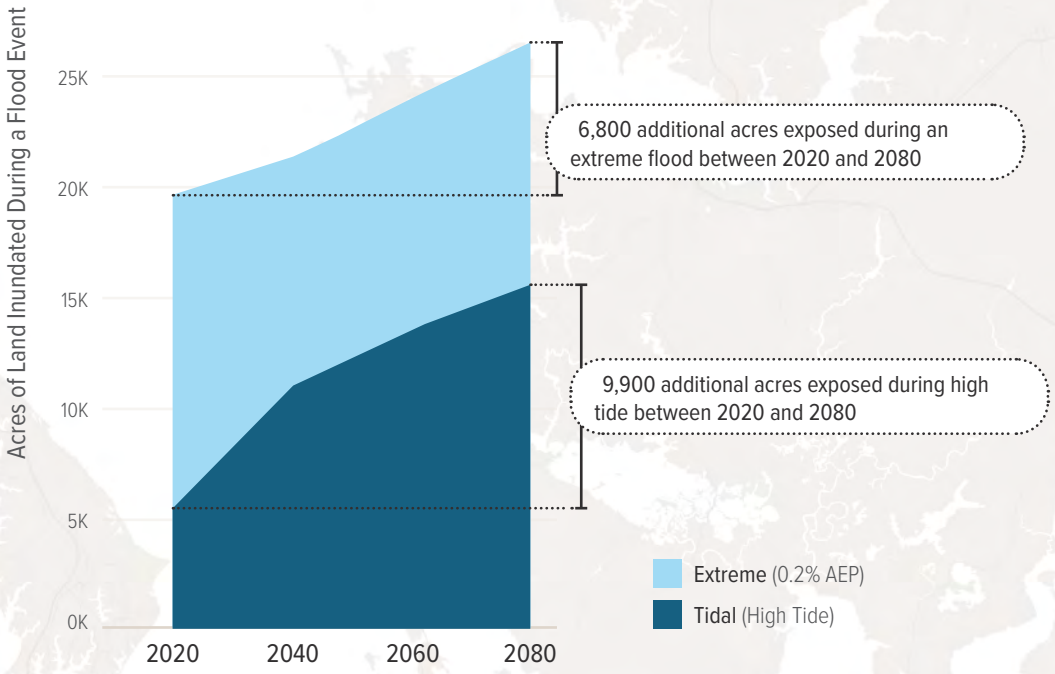
Between today and 2080, approximately 6,800 additional acres of land in Fall Line North will be exposed to flooding during an extreme coastal flood (0.2% annual exceedance probability). Within those areas of new coastal hazard exposure lie approximately 1,800 buildings and 14,600 residents.

Areas of effective land loss

Between today and 2080, approximately 9,900 additional acres of land in Fall Line North will be exposed daily during high tide. Within those areas of new effective land loss lie approximately 300 buildings and 1,800 residents.

Land Exposure in Fall Line North Across Event Types

Baseline land area considers all areas not inundated during low tide in 2020



Land Acres Exposed

		2020	2080	Change
George Washington RC	High tide	4,000	10,900	+ 170%
	Extreme flood	13,400	17,300	+ 29%
Northern Virginia RC	High tide	1,600	4,700	+ 191%
	Extreme flood	6,200	9,000	+ 46%

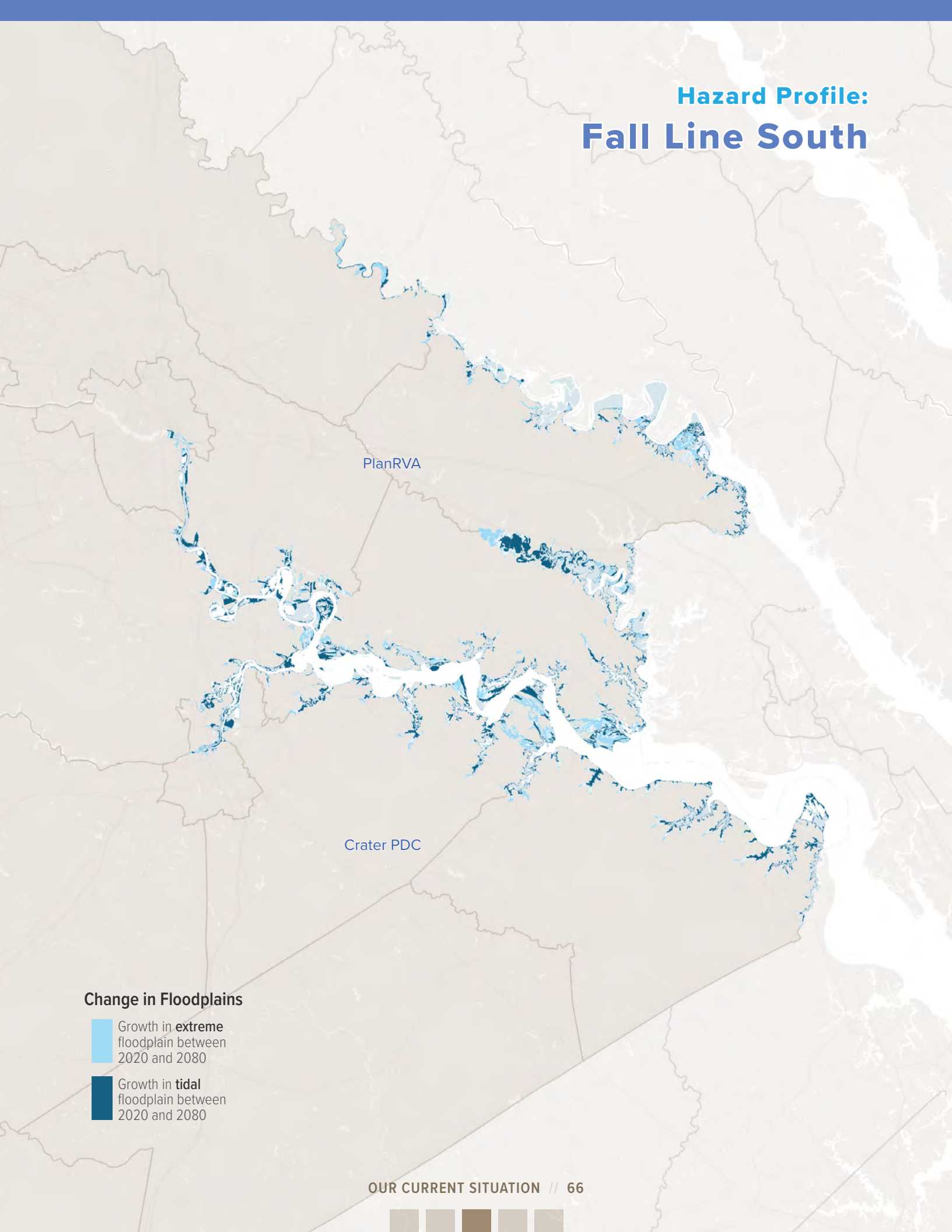
Buildings Exposed

		2020	2080	Change
George Washington RC	High tide	10	100	+ 930%
	Extreme flood	220	550	+ 151%
Northern Virginia RC	High tide	< 10	210	+ 4180%
	Extreme flood	920	2,400	+ 162%

Differences in asset exposure numbers and percentage changes can be attributed to rounding for presentation. Percentage changes reflect exact exposure numbers.

Hazard Profile:

Fall Line South



Areas of new coastal flood exposure

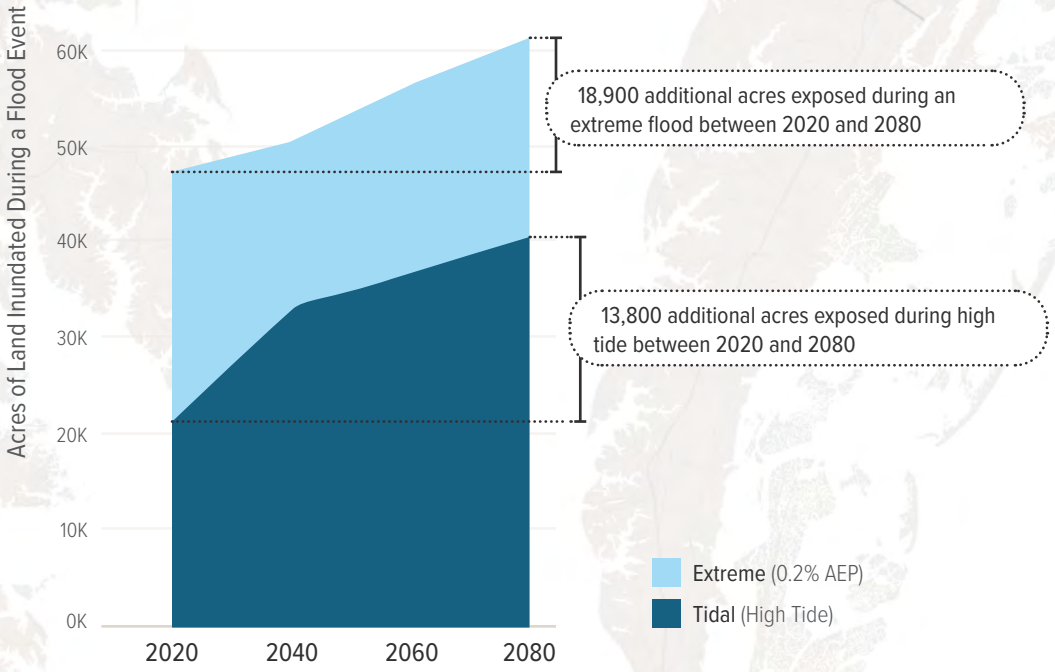
Between today and 2080, approximately 13,800 additional acres of land in Fall Line South will be exposed to flooding during an extreme coastal flood (0.2% annual exceedance probability). Within those areas of new coastal hazard exposure lie approximately 960 buildings and 1,500 residents.

Areas of effective land loss

Between today and 2080, approximately 18,900 additional acres of land in Fall Line South will be exposed daily during high tide. Within those areas of new effective land loss lie approximately 270 buildings and 560 residents.

Land Exposure in Fall Line South Across Event Types

Baseline land area considers all areas not inundated during low tide in 2020



Land Acres Exposed		2020	2080	Change
Crater PDC	High tide	4,600	10,500	+ 130%
	Extreme flood	12,300	16,200	+ 31%
PlanRVA	High tide	16,800	29,700	+ 77%
	Extreme flood	34,600	44,600	+ 29%

Buildings Exposed		2020	2080	Change
Crater PDC	High tide	< 10	110	+ 1275%
	Extreme flood	150	280	+ 85%
PlanRVA	High tide	30	190	+ 593%
	Extreme flood	620	1,450	+ 133%

Differences in asset exposure numbers and percentage changes can be attributed to rounding for presentation. Percentage changes reflect exact exposure numbers.

Community Vulnerabilities & Capacities

A truly resilient coastal Virginia must be one where all residents can live safely and thrive for generations to come. But we know not all communities and individuals have access to the same resources, nor will they be affected by flooding in the same way. Recognizing these disparities allows the Commonwealth to identify communities for additional support and select effective resilience strategies that aim to narrow existing inequities, while bolstering resilience.

The Master Plan characterizes equity considerations from two levels: community social vulnerability and jurisdictional capacity. The resilience of a community of individuals with shared characteristics differs from that of a local or county government, but both are essential to realizing a resilient coastal Virginia. Understanding the inequities among communities and between jurisdictions is a critical first step to advancing coastal adaptation efforts that also advance equity and justice.

Communities where many residents share economic and social characteristics that limit their ability to prepare for and recover from disasters are more likely to experience damage and harm from a flood. Disadvantaged populations and those with lower incomes already experience the physical and economic harms of disasters more often and acutely, making it even harder for them to recover afterward.[66] But centuries of injustices, from discriminatory land use policies to targeted disinvestment of community services, have pushed marginalized populations into more flood-prone areas.[67] Today, coastal Virginia contains communities with predominately African American populations and tribal communities with reservations and ancestral lands that face rising seas. Other communities have linguistic barriers preventing residents from obtaining critical resources to prepare for future flood risks. These types of inequities, both big and small, will only intensify with climate change.[68, 69]

Jurisdictions vary in their ability to secure funds through grant applications, taxes, and fees, or even dedicated staff time. Local and county governments with more robust tax bases, often driven by high property values, may have more financial resources and capacities to implement resilience projects and

What Is Equity?

The Governor's Office of Diversity, Equity, and Inclusion defines **equity** as the creation of opportunities for historically underrepresented populations to have equal access and equitable opportunity. Equity is also the process of allocating resources, programs, and opportunities to employees, customers, and residents, to address historical discrimination and existing imbalances. Therefore, achieving equity requires an organizational commitment that all employees, customers, and residents have equitable access to opportunities, resources, and the ability to fully contribute to the agency's mission and goals.[70]

initiatives. The process of securing financial support can be demanding for jurisdictions with limited funds, staff, and institutional knowledge. Jurisdictions with limited resources but high flood exposure may struggle to find the financial resources to implement resilience projects, let alone pay for repairs or reconstruction after a disaster. Further, several key federal funding sources require demonstration of cost-effectiveness through methodologies highly dependent on property values. These requirements can pose significant hurdles to securing needed mitigation or resilience dollars for low-income and under-resourced localities. With climate change, some localities will face increasingly frequent and severe flooding and storm events, further stressing already-limited budgets, and potentially widening these disparities.

Identifying these areas with high community social vulnerability and low local government capacity will allow the Commonwealth to direct more resources and support to areas that may be more adversely affected by flooding due to underlying social and economic factors.

Resilience Adaptation and Feasibility Tool (RAFT)

The Resilience Adaptation and Feasibility Tool (RAFT) process helps Virginia's coastal localities to improve their resilience to flooding and other coastal hazards while remaining economically and socially viable. This process helps localities to proactively build capacity to address resilience and coastal hazards by undergoing an external assessment of resilience and developing a Resilience Action Checklist with actions that can be taken within a year.

Since 2018, many localities in coastal Virginia have participated in RAFT. Goal 4 of the Commonwealth's broader coastal resilience strategy aims to have all coastal localities engaged in the RAFT process.

Social Vulnerability

Social vulnerability captures how well a community can prepare, withstand, and recover from a disaster, based on the degree to which its residents exhibit certain demographic conditions. Higher social vulnerability indicates a community is more susceptible to human suffering and financial loss during and after a flood.

The Technical Study identified communities with high concentrations of vulnerable individuals using the U.S. Centers for Disease Control and Prevention's (CDC) Social Vulnerability Index framework.[71] The Index aims to help public health officials and emergency response planners identify and map the communities that will most likely need support before, during, and after a hazardous event.[72] This framework uses Census variables to compare demographic factors across tracts, localities, and counties. The Master Plan adapts this research-backed method to a more geographically granular level to identify inequities within neighborhoods and localities.

The Social Vulnerability Index framework examines four types of demographic factors contributing to a community's social vulnerability: socioeconomic status; household composition and disability; language, race and ethnicity; and housing type and transportation.

Factors and Variables Contributing to the CDC's Social Vulnerability Index

Factor	Variables
Socioeconomic Status	Persons Living Below Poverty Line
	Workforce Unemployment
	Adults with No High School Diploma
	Per Capita Income
Household Composition and Disability	Elderly Persons Aged 65 or Older
	Youth Aged 17 or Younger
	Persons with Disabilities
	Single Parent Households
Language, Race, and Ethnicity	Population by Race and Ethnicity
	Persons Speaking English "Less than Well"
Housing Type and Transportation	Multi-Unit Structures
	Mobile Homes
	Crowded Living Quarters
	Households with No Vehicle
	Persons Living in Group Quarters

What We Heard about Social Vulnerability

Through meetings and surveys, both residents and practitioners across the Master Planning Regions contributed their perspectives about equity-related resilience challenges.

"Those with money or resources are able to get resources to protect their property and pay for shoreline protection or navigate the grant process to get their homes raised. Those without financial resources or knowledge of the grants aren't able to protect their property as well and the county doesn't have resources to assist." – *Practitioner, Middle Peninsula PDC*

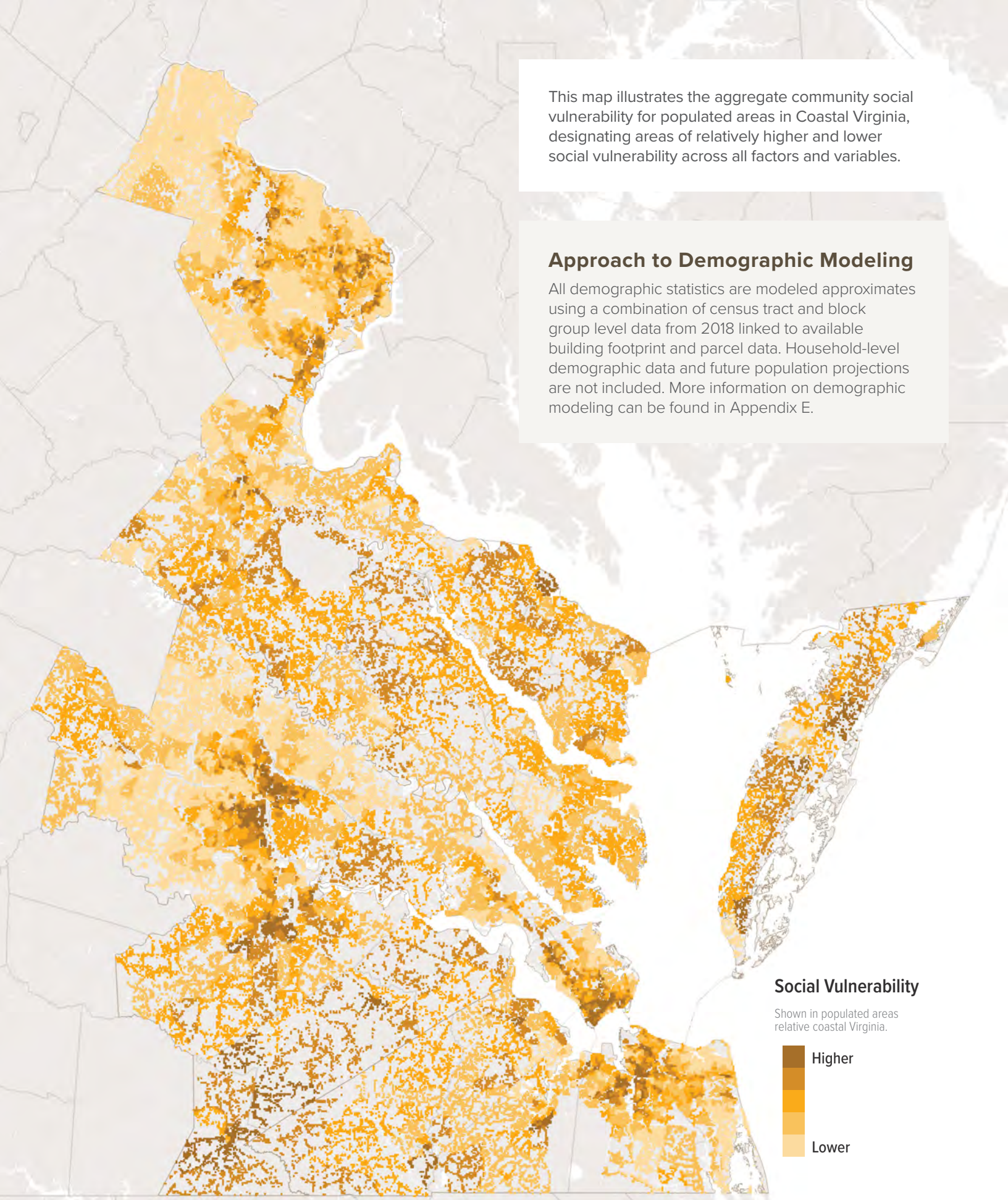
"We have a few affordable housing and mobile home communities in floodplains that could be disproportionately affected." – *Practitioner, Northern Virginia RC*

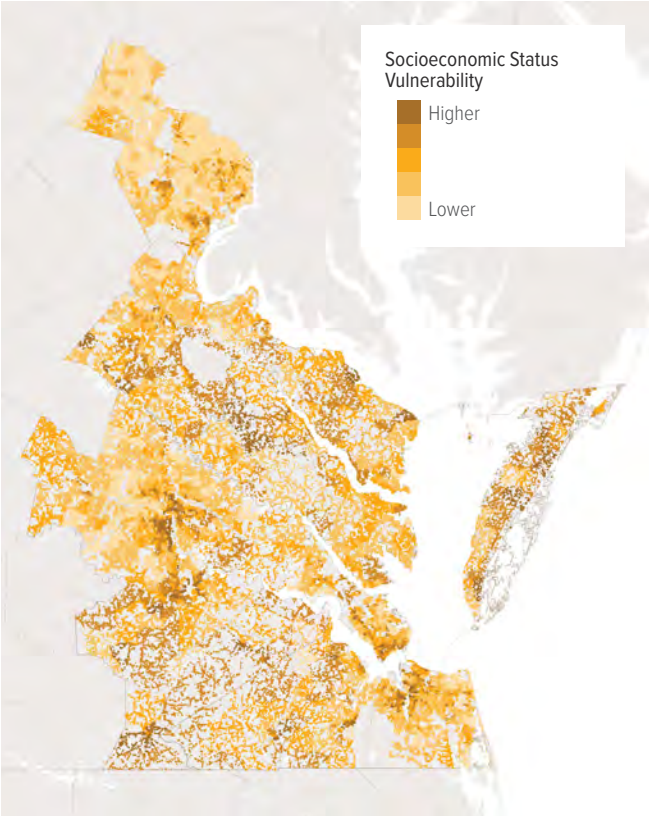
"The U.S. Army Corps of Engineers [benefit-cost ratio] models all prioritize the homes of wealthy individuals over those of lesser means - even the Corps recognizes this. However, we are forced to accept and use their methodology in order to secure federal funding." – *Practitioner, Hampton Roads PDC*

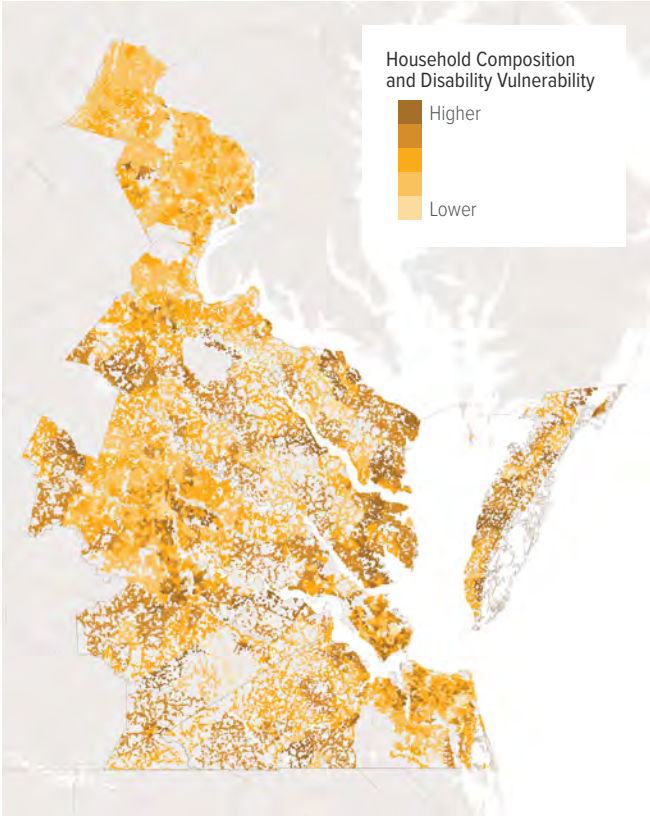
This map illustrates the aggregate community social vulnerability for populated areas in Coastal Virginia, designating areas of relatively higher and lower social vulnerability across all factors and variables.

Approach to Demographic Modeling

All demographic statistics are modeled approximates using a combination of census tract and block group level data from 2018 linked to available building footprint and parcel data. Household-level demographic data and future population projections are not included. More information on demographic modeling can be found in Appendix E.







Socioeconomic Status

People with lower incomes or savings tend to have less available capital to pay for projects that protect their property or possessions from potential flood damage. Similarly, individuals with limited incomes are less likely to have homeowners, renters, or flood insurance. After a flood or storm event, low-income populations may struggle to afford necessary repairs or, in extreme cases, to relocate.

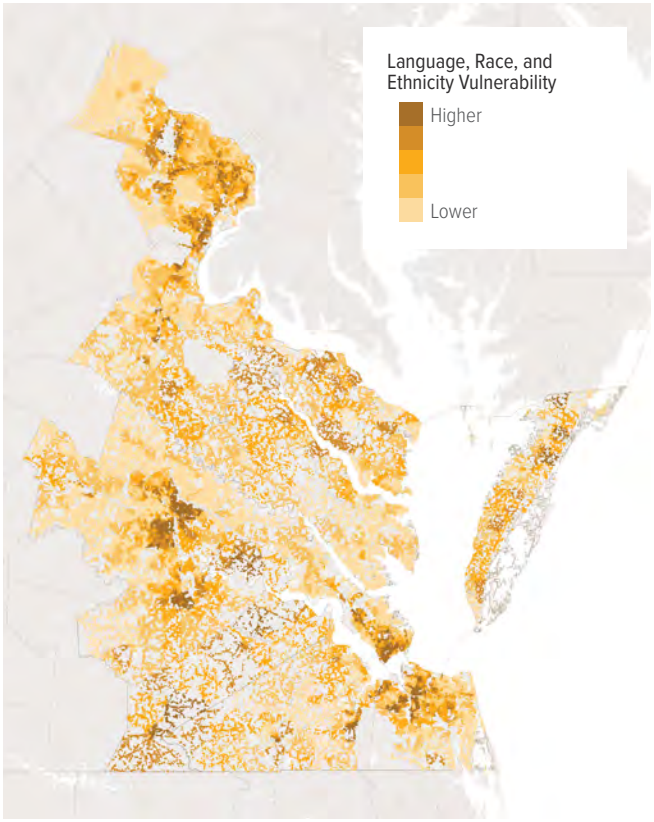
Household Composition and Disability

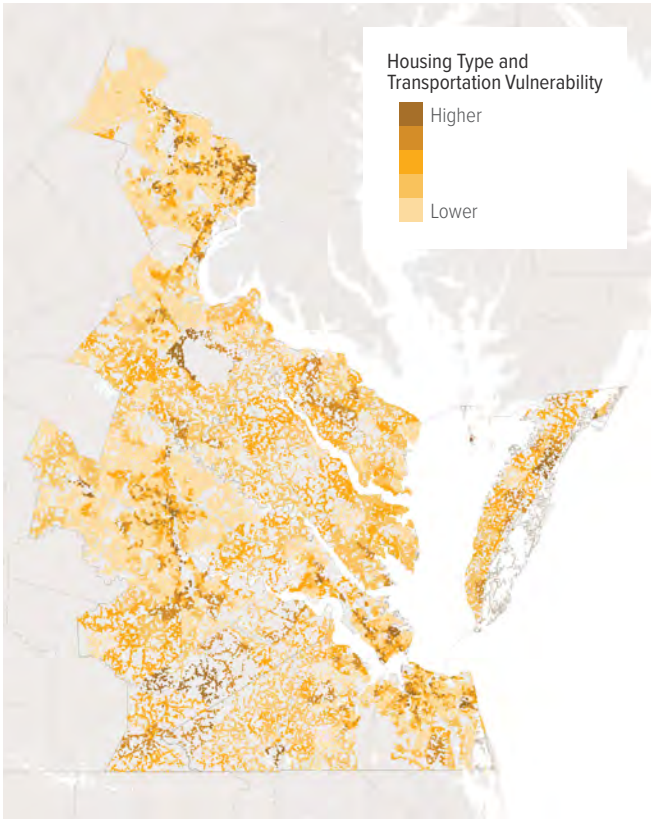
Households with older adults and single parents may live on fixed or limited incomes with few savings to afford projects that reduce their potential harm due to flooding. People of any age with physical, sensory, or cognitive challenges may require the assistance of others to prepare or even evacuate for flooding or storm events.

Variables	In Coastal Virginia	In 2020 Floodplain*
Persons Living Below Poverty Line	9.3%	13.2%
Workforce Unemployment	4.8%	5.6%
Adults with No High School Diploma	9.1%	8.9%
Per Capita Income	$34,800	$34,500

Variables	In Coastal Virginia	In 2020 Floodplain
Elderly Persons Aged 65 or Older	12.9%	14.7%
Youth Aged 17 or Younger	23.1%	20.8%
Persons with Disabilities	4.6%	5.6%
Single Parent Households	14.8%	16.6%

* Note any resident or housing unit modeled to be within the extreme (0.2% AEP) floodplain for 2020 is considered exposed to coastal flooding. Demographic modeling utilizes 2018 American Community Survey data from the US Census and approximates flood-exposed population based on building footprints. Estimates are likely to be more accurate in higher density urban areas where more geographically precise population estimates are available. More detail is available in Appendix E.





Language, Race, and Ethnicity

Centuries of discriminatory and racist policies have forced many communities of color to live in areas that are more vulnerable to flood damage and less likely to have the necessary resources to adapt to changing flood risks. Communities of color refer to African American, Native American, Asian and Pacific Islander, and Hispanic and Latino populations. Similarly, people who do not speak English well may struggle to access resources and information to reduce their risk of flood damage.

Variables	In Coastal Virginia	In 2020 Floodplain
People of Color (Non-White)	38.2%	37.3%
Persons Speaking English "Less than Well"	3.3%	1.0%

Housing Type and Transportation

A person's housing type and vehicle access can indicate how well a person can prepare for and respond to flooding or coastal storms. Occupants of apartment buildings, mobile homes, and group quarters, including nursing homes, will have limited control on whether resilience measures are implemented for their residences. Access to a personal vehicle can indicate how flexible a person's transportation options are.

Variables	In Coastal Virginia	In 2020 Floodplain
Multi-Unit Structures	16.4%	11.7%
Mobile Homes	2.0%	2.3%
Crowded Living Quarters	2.2%	1.7%
Households with No Vehicle	6.0%	7.0%
Persons Living in Group Quarters	2.3%	4.1%

Explore social vulnerability factor maps in detail in the **Coastal Resilience Web Explorer**

Local Government Resources and Capacity

Local, county, and regional governments vary in their ability to implement adaptation projects due to differences in financial resources and technical capacities. These cross-jurisdictional inequities arise for various reasons, including legislative authorities, historical economic disadvantages, and even institutional knowledge.

The available resources and capacity at a jurisdiction's disposal remain challenging to measure.

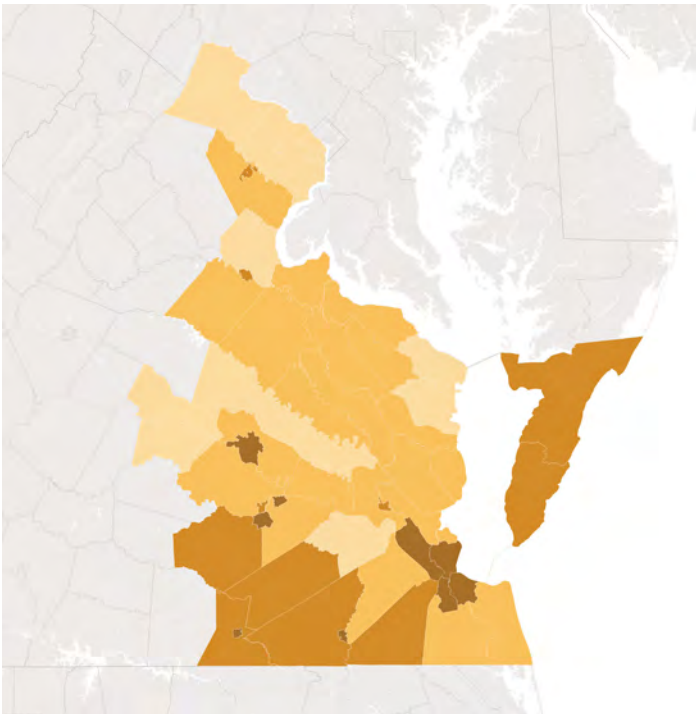
Still, understanding these differences among localities is essential to directing potential support in the future. The Technical Study identified localities experiencing these limitations using two metrics: the Fiscal Stress Index framework, developed by the Virginia Department of Housing and Community Development's Commission on Local Government; and the results from an online survey distributed to local and regional practitioners as part of the Commonwealth's Stakeholder Engagement strategy.

What We Heard about Jurisdictional Capacity

Through meetings and surveys, both residents and practitioners across the Master Planning Regions contributed their perspectives about equity-related resilience challenges

"The scope and scale of inequity in our region across multiple disciplines is staggering. And the lack of capacity at the local level to even compete for funding - not to mention the capacity to accomplish the planning/ projects is real." – *Practitioner, Crater PDC*

"A major hurdle is fully understanding the benefits and need to address equity. Several projects and policies speak to equity, but there is not a strong holistic understanding at a City-wide level of the importance of addressing equity." – *Practitioner, Hampton Roads PDC*



Fiscal Stress

Building resilience requires additional funding at the local, state, and federal level. The Fiscal Stress Index is intended to represent a locality's ability to raise additional funds from the current tax base, relative to the Commonwealth, based on revenue capacity, realization of the capacity, and median household income.[73] Localities with low fiscal stress may have more fiscal options to raise additional funding for coastal resilience efforts. Without additional funding to advance resilience, government across all levels will need to reallocate existing funding sources.

Fiscal Stress Index Classes

Source: Virginia Department of Housing and Community Development, 2019

- High Fiscal Stress
- Above Average Fiscal Stress
- Below Average Fiscal Stress
- Low Fiscal Stress

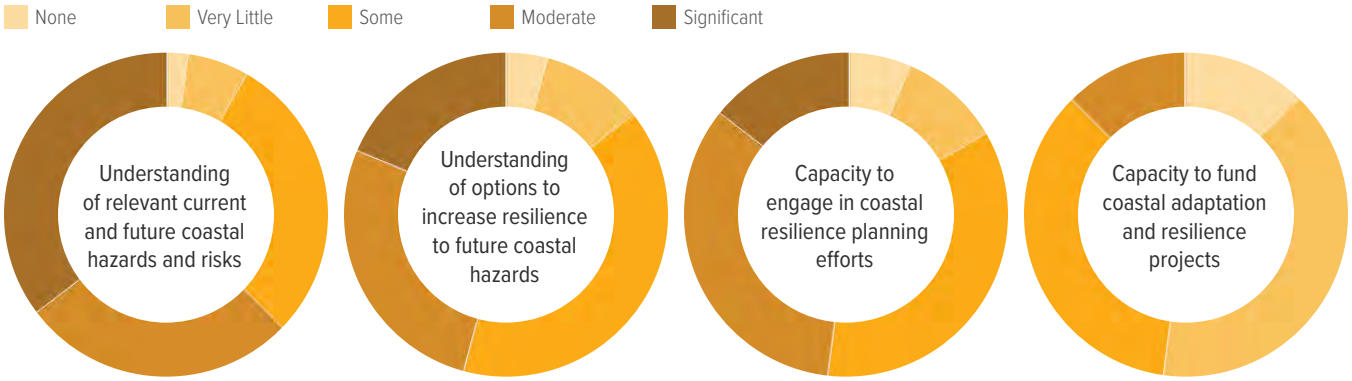
Experience and Capacity

Nearly 100 local and regional practitioners involved in resilience efforts in coastal Virginia participated in the Commonwealth's targeted online survey. More than half (58%) of respondents represented local or county governments in 48 distinct localities throughout coastal Virginia. Respondents also represented military and federal partners (5%), Planning District and Regional Commissions (6%), tribal members or representatives (2%), and community or non-profit organizations (12%).

Participants also conducted a qualitative self-assessment of their jurisdiction's competencies and capacities. More than 90% of surveyed regional and local governments reported having at least some understanding of relevant coastal hazards, and 88% said they have at least some understanding of their adaptation options to address such hazards. Yet, nearly half (49%) reported their jurisdiction had little to no capacity to fund coastal resilience projects.

Regional, local or tribal governments' resilience planning experience

Count by responding jurisdictions

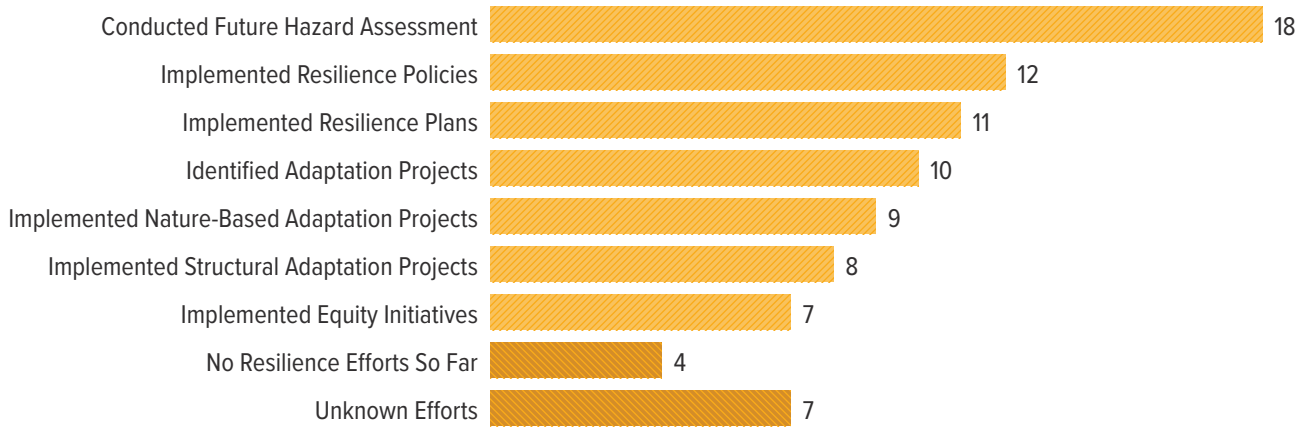


Dedicated resources for coastal resilience will be vital to implementing resilience projects. Still, money alone cannot achieve a resilient coastal Virginia. Some communities lack the staff and technical expertise to compete for funding, even if more dollars become available. More specifically, communities of color and with lower household incomes historically have faced barriers to obtaining these types of resources.

The survey asked representatives to self-report their organization's experience in planning, implementing, and securing funding for coastal resilience efforts. Of those who responded, more than half reported that their local or regional government had at least assessed future hazards. At the same time, more than 10% said they had not yet engaged in any efforts to increase coastal resilience.

Regional, local or tribal governments' resilience planning experience

Count by responding jurisdictions. Jurisdictions include tribes, towns, cities, counties, PDCs, and RCs.



Capacity and Vulnerability: Hampton Roads

Community Resources and Capacity

Fiscal Stress: The fiscal stress of cities and counties across Hampton Roads ranges from high fiscal stress (in the cities of Franklin, Hampton, Newport News, Norfolk, and Portsmouth) to above average fiscal stress (in Southampton County and the cities of Suffolk, and Williamsburg), to below average fiscal stress in other areas. This means that even if political support exists, many communities in Hampton roads will likely struggle to generate additional local revenues from their current tax base to fund resilience efforts.

Experience & Capacity: With a notable history of confronting coastal flood challenges, it is unsurprising that many communities in Hampton Roads have already invested significantly in building capacity to increase resilience. When local and regional representatives were surveyed about experience and ability to engage in resilience-related efforts, Hampton Roads rated higher than any other region in most capacity metrics. Practitioners working in Hampton Roads are generally well-educated about coastal resilience — notably over three-quarters of practitioners reported they had either moderate or significant awareness of their coastal flood risks, and over 90% reported at least some understanding of adaptation options. However, capacity to plan and fund resilience efforts still varies significantly across the region. While most jurisdictions have demonstrated at least some capacity to plan for coastal resilience — and a few have begun implementing robust coastal adaptation plans, such as Hampton, Norfolk, and Virginia Beach — some have very little capacity to conduct resilience planning efforts given limited resources. Most Hampton Roads jurisdictions also consider capacity to fund adaptation projects a significant challenge, especially due to the high costs of some of the large-scale projects already identified.

Social Vulnerability

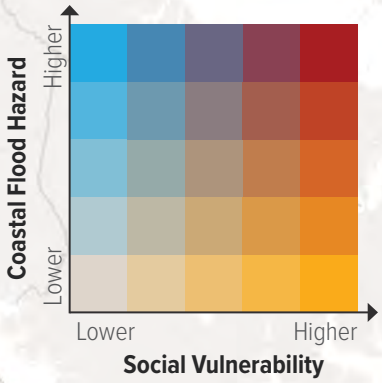
Compared to other regions, flood-exposed residents in Hampton Roads are more likely to be urban residents, economically stressed families, and people of color.

Socioeconomic Status: Hampton Roads is home to flood-exposed communities and individuals who experience poverty and other forms of economic stress — these communities may experience the economic burdens of flood hazards more significantly than others. Out of the region's flood-exposed residents, approximately 13% live below the poverty line, 6% are unemployed, and 9% of adults lack a high school diploma. These rates are moderate compared to other PDCs/RCs but many of these economically stressed communities are particularly concentrated in cities like Newport News, Hampton, Portsmouth and Norfolk.

Language, Race & Ethnicity: Hampton Roads has the highest portion of residents of color exposed to flooding. Out of the region's flood-exposed residents, approximately 39% are non-white (the highest portion of any region) and 6% are Hispanic. The region also has pockets of flood-exposed communities with low English proficiency in places like Virginia Beach and Chesapeake who may experience additional challenges accessing critical information and resources.

Household Composition & Disability: The region has a high number of families living in flood-exposed areas. Approximately 21% of exposed of residents living in areas with coastal flood exposure are aged 17 or younger and a significant of number of exposed households are single parent households (approximately 18%).

Housing Type & Transportation: A significant portion of the region's flood-exposed residents live in housing situations considered challenging for emergency management and adaptation. Approximately 4% of flood-exposed residents live in group quarters, likely related to the high presence of education and military-related campuses in the region. Due to the more urbanized nature of many Hampton Roads communities approximately 11% of flood-exposed housing units are multi-unit structures and 7% of flood-exposed households report no access to a vehicle.



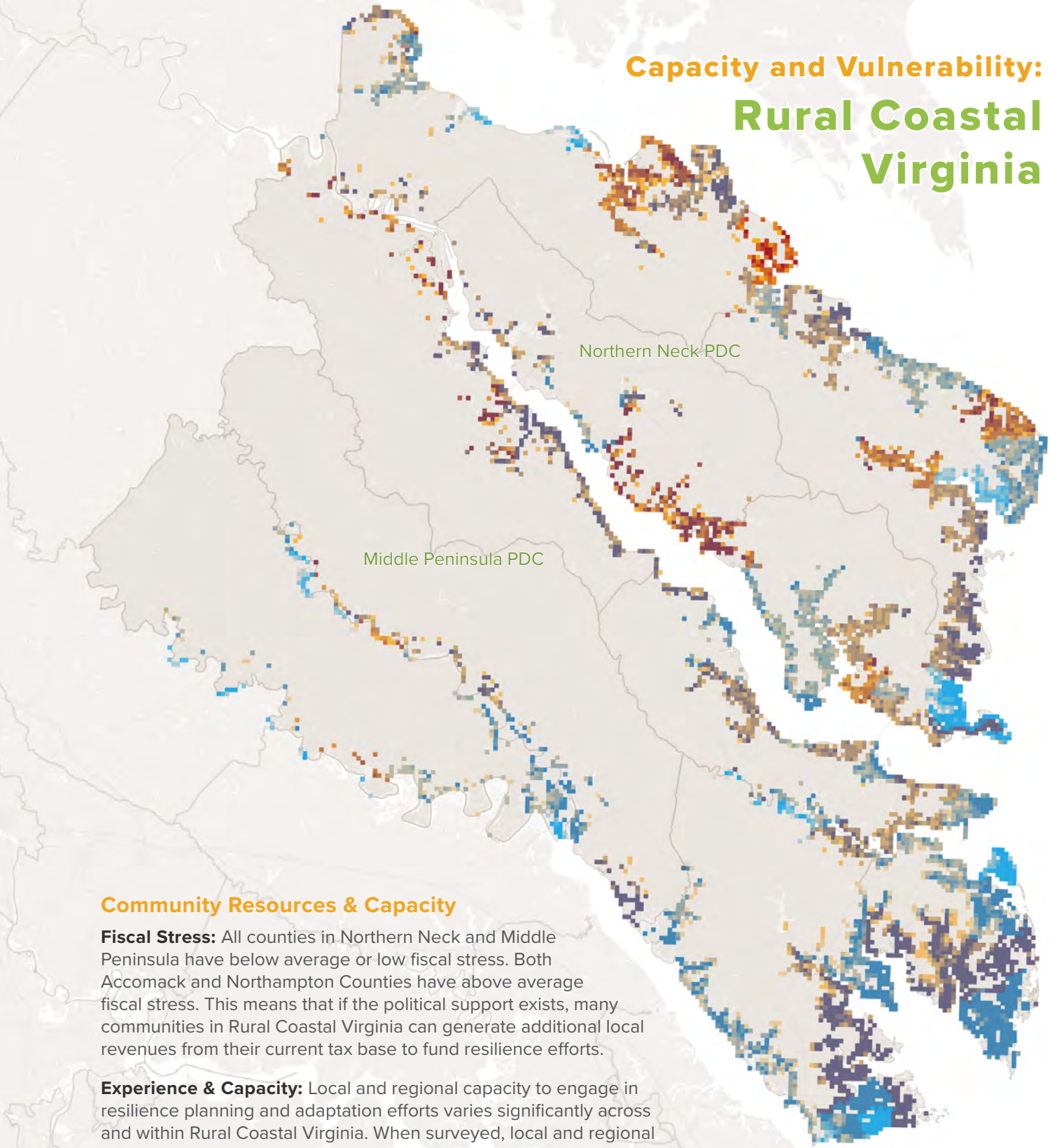
This map depicts the intersection of community social vulnerability with coastal flood hazard exposure. Red areas identify neighborhoods with both high social vulnerability (based on 2020 demographics) and high exposure to coastal flood hazards (based on all modeled 2080 flood scenarios).

Explore social vulnerability and hazard maps in detail in the **Coastal Resilience Web Explorer**

Hampton Roads PDC

Capacity and Vulnerability:

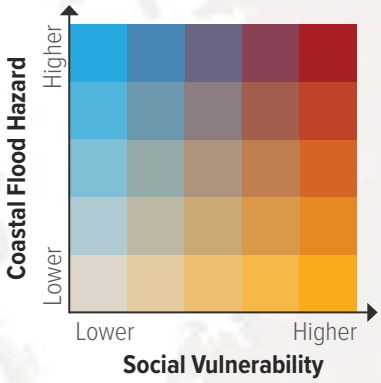
Rural Coastal Virginia



Community Resources & Capacity

Fiscal Stress: All counties in Northern Neck and Middle Peninsula have below average or low fiscal stress. Both Accomack and Northampton Counties have above average fiscal stress. This means that if the political support exists, many communities in Rural Coastal Virginia can generate additional local revenues from their current tax base to fund resilience efforts.

Experience & Capacity: Local and regional capacity to engage in resilience planning and adaptation efforts varies significantly across and within Rural Coastal Virginia. When surveyed, local and regional representatives self-reported being at both ends of the capacity spectrum. Middle Peninsula PDC has notable experience obtaining grant funding to implement resilience projects, while others reported practically no experience. When asked to self-assess their understanding of current and future coastal hazards and risks, practitioners in Rural Coastal Virginia rated themselves comparatively lower than most other regions. Similarly, practitioners in Rural Coastal Virginia reported having lower capacity to fund resilience efforts.



This map depicts the intersection of community social vulnerability with coastal flood hazard exposure. Red areas identify neighborhoods with both high social vulnerability (based on 2020 demographics) and high exposure to coastal flood hazards (based on all modeled 2080 flood scenarios).

Accomack-Northampton PDC

Social Vulnerability

Flood-exposed residents in Rural Coastal Virginia are more likely to be elderly, disabled, and experience certain types of socioeconomic, housing, and transportation-related challenges that may limit coastal adaptation and resilience.

Socioeconomic Status: Rural Coastal Virginia has pockets of economically stressed communities and communities of color. Out of the region's flood-exposed residents, approximately 15% live below the poverty line (18% in Accomack-Northampton), and 14% of adults lack a high school diploma (18% in Accomack-Northampton). Limited education and financial resources can make both accessing critical information and resources harder.

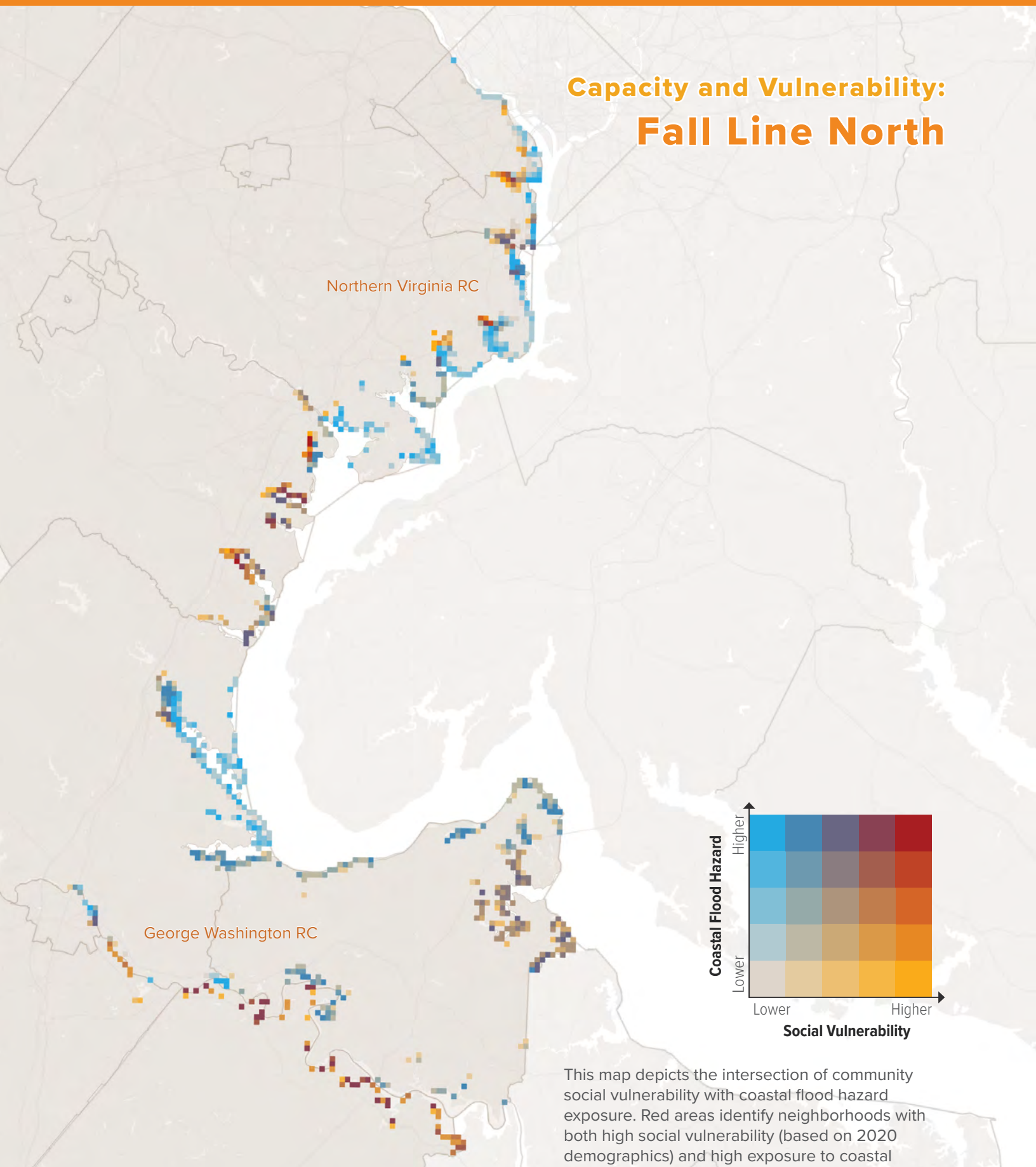
Language, Race & Ethnicity: The region has the lowest portion of non-white residents, but each PDC has communities of color that face historic and persisting disadvantages. In Northern Neck, 30% of flood exposed residents identify as non-white (primarily African American), compared to 21% in Accomack-Northampton and 13% in Middle Peninsula. In Accomack-Northampton, 7% of flood-exposed residents are Hispanic/Latino, and 2% have limited English proficiency.

Household Composition & Disability: Rural Coastal Virginia has notably higher shares of seniors and persons with disabilities who live in flood-exposed areas. In Northern Neck, approximately one-third of residents living in areas with coastal flood exposure are aged 65 and older (compared to 12% state average). Elderly people are more likely to require financial support, transportation, medical care, or assistance from others with ordinary daily activities during disasters.

Housing Type & Transportation: Rural Coastal Virginia has the highest numbers of flood-exposed mobile homes, which are typically not designed to withstand severe weather. In Accomack-Northampton, mobile homes make up 15% of housing units in flood-exposed areas. Many residents experience transportation-related challenges, including lack of vehicle access or limited transportation route options and alternatives. Many communities are only accessible by single roads or bridges, making them highly vulnerable to isolation if critical pathways and supply chains are flooded.

Capacity and Vulnerability:

Fall Line North



This map depicts the intersection of community social vulnerability with coastal flood hazard exposure. Red areas identify neighborhoods with both high social vulnerability (based on 2020 demographics) and high exposure to coastal flood hazards (based on all modeled 2080 flood scenarios).

Community Resources and Capacity

Fiscal Stress: Localities in both Northern Virginia and George Washington Regional Commissions have overall moderate-lower fiscal stress compared to other coastal regions. No locality is rated as having high fiscal stress, while the cities of Manassas, Manassas Park, and Fredericksburg have above average fiscal stress. All other counties have either below average or low fiscal stress. This means that if the political support exists, many communities in Fall Line North can generate additional local revenues from their current tax base to fund resilience efforts.

Experience & Capacity: Numerous localities in Fall Line North have made significant strides in understanding and managing a variety of flood challenges — demonstrating that significant capacity to improve resilience exists within the region. However, this capacity is not evenly distributed. When surveyed about experience and ability to engage in resilience-related efforts, local and regional practitioners from Northern Virginia RC (such as the Counties of Arlington and Fairfax) reported significant past participation in resilience efforts while practitioners from George Washington RC reported relatively little (with the exception of the City of Fredericksburg). All jurisdictional representatives who responded to the survey reported at least some awareness of their flood risks and over three-quarters reported at least some understanding of their adaptation options. However, capacity to engage in resilience planning efforts ranged significantly and over half of responding jurisdictions reported no or very little capacity to fund resilience.

Social Vulnerability

Compared to other regions, flood-exposed residents in Fall Line North are less likely to be socioeconomically vulnerable, but more likely to be young, non-white, and live in urban areas.

Socioeconomic Status: Flood-exposed residents in Fall Line North have the highest median income and lowest rates of poverty, low-education, and unemployment compared to other regions. Out of all flood-exposed residents in the region, only approximately 7% in Northern Virginia RC and 3% George Washington RC are living below the poverty line.

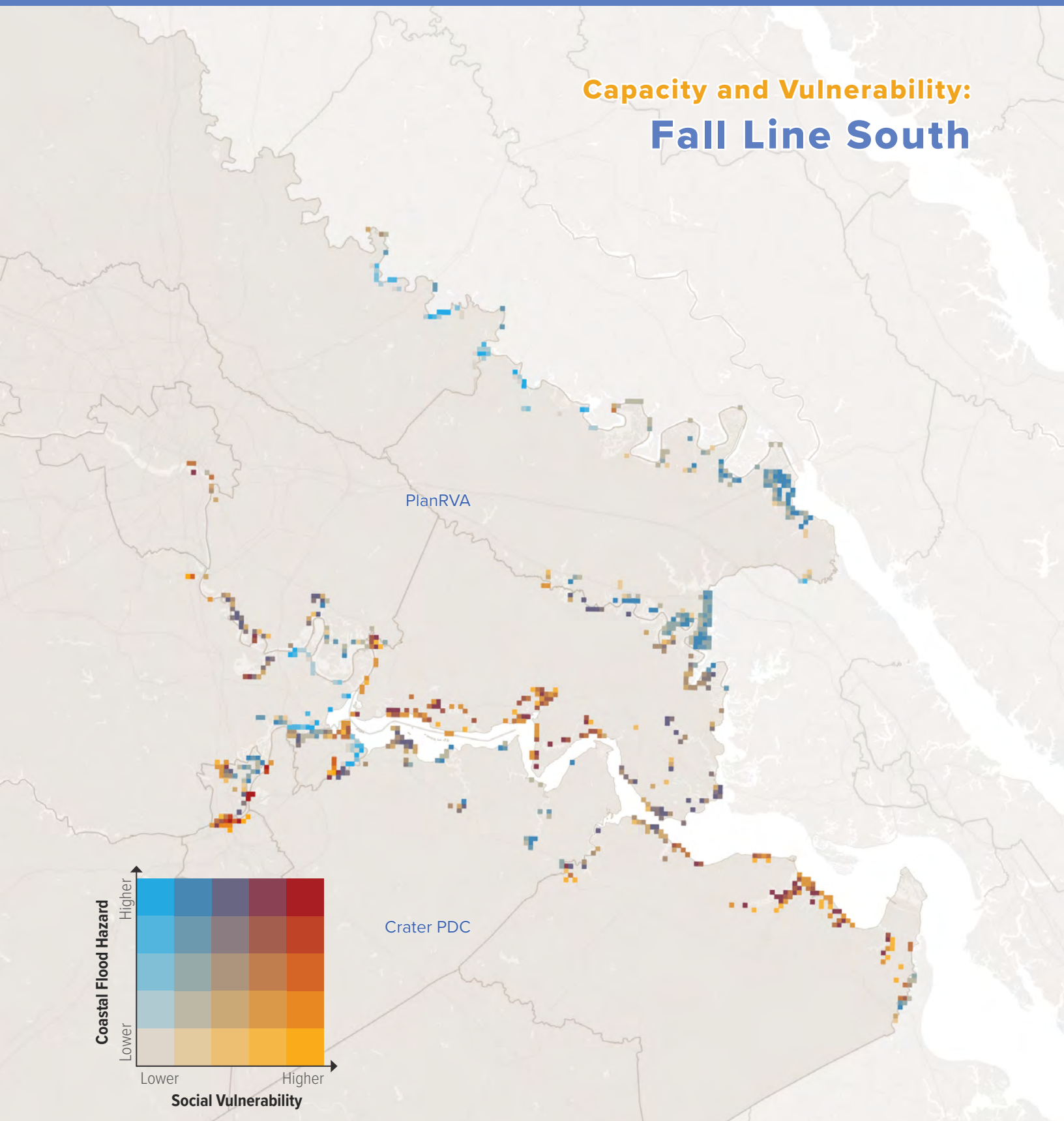
Language, Race & Ethnicity: Fall Line North has an ethnically diverse populous and the highest rates of Hispanic and non-English speaking residents in the floodplain of any region. Of residents living in flood-exposed areas, 11% are Hispanic and 3% in Northern Virginia RC have limited English proficiency. Out of the region's flood-exposed residents, 32% in Northern Virginia RC and 28% in George Washington RC are people of color.

Household Composition & Disability: The region has a high number of families living in flood-exposed areas. Of all residents living in areas with coastal flood exposure, approximately 21% in Northern Virginia RC and 23% in George Washington RC are aged 17 or younger. With fewer coastal-residing retirees, the region has the lowest rates of elderly residents living in the coastal floodplain.

Housing Type & Transportation: Out of all Master Planning Regions, Fall Line North has the highest portion of exposed multi-unit structures, particularly in Northern Virginia RC. Out of all housing units in the floodplain, 39% in Northern Virginia are multi-unit buildings (compared to 5% in George Washington RC). Northern Virginia RC also has the highest portion of flood-exposed residents who live in crowded housing units: 4% of all housing units in the coastal floodplain. The region also has a significant number of flood-exposed residents who lack access to a vehicle: 8% of flood-exposed residents in Northern Virginia RC and 5% in George Washington RC.

Capacity and Vulnerability:

Fall Line South



This map depicts the intersection of community social vulnerability with coastal flood hazard exposure. Red areas identify neighborhoods with both high social vulnerability (based on 2020 demographics) and high exposure to coastal flood hazards (based on all modeled 2080 flood scenarios).

Community Resources and Capacity

Fiscal Stress: The fiscal stress of cities and counties across Fall Line South ranges from high to low fiscal stress. The cities of Richmond, Hopewell, and Petersburg, and Emporia have high fiscal stress while Colonial Heights and counties of Dinwiddie, Greensville, and Sussex have above average fiscal stress, while all other counties have either below average or low fiscal stress. Higher fiscal stress is more prevalent among the localities that make up Crater PDC than PlanRVA. If the political support exists, communities in Fall Line North with lower fiscal stress are more likely to be able to generate additional local revenues from their current tax base to fund resilience efforts.

Experience & Capacity: Compared to the other Master Planning Regions Fall Line South jurisdictions have relatively less experience managing coastal flood hazards and planning for resilience. When surveyed about experience and ability to engage in resilience-related efforts, local and regional representatives self-reported lower planning and funding capacity. Most jurisdictions reported having at least some capacity to plan for resilience, but none reported having high planning capacity and many reported having very little understanding of their relevant resilience options. Similarly, over half of responding jurisdictions reported no or very little capacity to fund resilience efforts, and overall, the region reported less resilience funding and financing experience than other regions, particularly outside federal and state grant options. PlanRVA and the City of Richmond reported higher past engagement in coastal resilience planning, but overall, the region still has a significant need for resilience planning and funding capacity development.

Social Vulnerability

Compared to other regions, flood-exposed residents in Fall Line South are likely to be economically disadvantaged and members of socially vulnerable demographic groups.

Socioeconomic Status: Fall Line South is home to communities with a mix of economic circumstances and has the highest rate of coastal flood exposure for residents suffering from severe economic stress. Of all residents living in the coastal floodplain, approximately 16% are living below the poverty line in both PlanRVA and Crater PDC. The region also has high rates of flood-exposed residents who are unemployed and have limited education.

Language, Race & Ethnicity: Both PDCs in Fall Line South have significant rates of non-white populations exposed to coastal flooding hazards. Of residents living in flood-exposed areas, an estimated 35% in Crater PDC and 26% in PlanRVA are people of color. These rates may change over time as, in Crater PDC in particular, many areas projected to experience floodplain growth in the region are areas dominated by historically underserved communities and people of color.

Household Composition & Disability: Fall Line South has pockets of senior populations with high coastal flood exposure. Of all residents living in areas with coastal flood exposure, approximately 26% in Crater PDC and 14% in PlanRVA are aged 65 or older. The region also has relatively high rates of flood exposed persons with disabilities: approximately 9% of residents in the floodplain in Crater PDC and 6% in PlanRVA are living with a disability.

Housing Type & Transportation: With a mix of both rural and urban areas, the region has relatively high portions of flood-exposed of residents living with forms of urban housing challenges (including crowding and multi-unit structures) as well as rural housing challenges (including mobile homes). The region, particularly Crater PDC, also has a significant number of coastal flood-exposed residents living in group quarters, likely due to prevalence of both universities and prisons near tidally influenced waterways.

Impacts on Community Resources

Community Resources are vital to the health and well-being of the community. These assets include the structures and lands that make up coastal Virginia's rich economy and culture, such as residential neighborhoods, lands owned and used by tribes, agricultural lands, public parks, green spaces, public buildings, community gathering spaces, and businesses.

Damage to Community Resources may hinder or disrupt important social functions in an affected area, such as economic activity and cultural traditions. If these assets are badly or repeatedly damaged due to flooding, some businesses and residents may eventually decide to relocate to areas where the perceived flood risks are lower. Characterizing impacts to Community Resources is critical to protecting coastal Virginia's unique way of life for future generations to enjoy.

The following sections summarize impacts on Community Resources by asset type and by Master Planning Region. For each Master Planning Region, impact hotspots are presented to illustrate areas projected to experience higher impacts relative to the rest of the region. See Appendix E for details on how impact metrics and hotspots are calculated.

What Is a Community Resource Hotspot?

An impact hotspot refers to an area that contains a concentration of identified assets projected to be affected by coastal flooding.

Each asset within Community Resources is affected differently by coastal flood hazards. These potential impacts are measured using unique metrics. To illustrate hotspots, these metrics are standardized to aggregate and compare impacts across different assets, both statewide and within the Master Planning Regions.

Limitations to Modeling Community Resource Impacts

The Technical Study's impact assessment relies on existing building footprint and parcel datasets to approximate population and structure impacts. Impact projections do not consider population growth, intensifying development, or other changes to the physical landscape that may affect Community Resource assets. Assuming these variables as constant allows the Commonwealth to model "no-action" future scenarios where flood hazards increase while the physical landscape remains unchanged.

Public Perspectives: Lived Experiences with Community Resource Impacts

Over 1,300 Virginians responded to a public online survey with questions relating to their lived flooding experiences. Of those respondents:

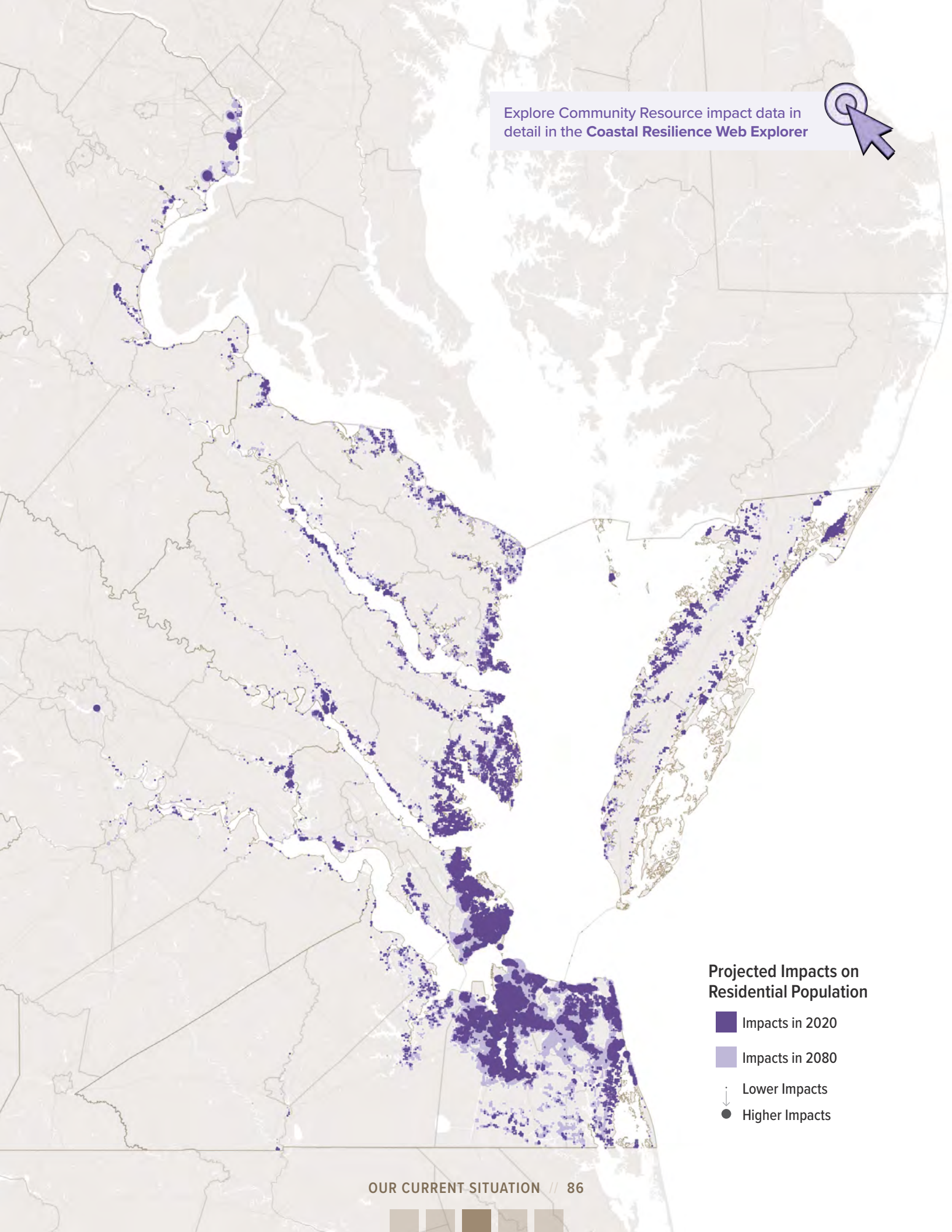
- **36%** have had their home or business flooded during a major storm or heavy precipitation in the past decade.
- **22%** have experienced damage to personal possessions, including vehicles, due to flooding.
- **26%** have experienced limited access to services, such as closure of hospitals, schools, or government offices.

What Virginians Are Saying about Impacts on Community Resources

Through meetings and surveys, both residents and practitioners across the Master Planning Regions contributed their perspectives about Community Resource assets.

> "Once sea levels rise, you'll lose whole portions of history." – *Resident, Northern Neck PDC*

> "Our biggest challenge is that our flood zones are located in mostly developed residential areas. Existing homes were mostly built without known flood elevations." – *Practitioner, Hampton Roads PDC*


Explore Community Resource impact data in detail in the **Coastal Resilience Web Explorer**
Projected Impacts on Residential Population
Impacts in 2020
Impacts in 2080
Lower Impacts
Higher Impacts

Population

Communities are built around the people who inhabit them, and coastal Virginians serve as the foundation of their communities. Although damages to structure and assets are more observable, coastal hazards can affect the health, safety, and wellbeing of residents in many ways.

Exposure – Around 70% of Virginia's population lives in coastal Virginia.[74] With this comes the inherent risks of being affected by coastal flooding and sea level rise. If a major coastal flood occurred today, approximately 200,000 residents live in homes that are projected to experience flooding. Assuming no mitigation actions are taken, the number of residents would grow to over 320,000 by 2040 and nearly 720,000 by 2080, an increase of about 260% from 2020.

Some residents will experience frequent, chronic and even daily tidal flooding in and around their homes much more often. Today, 47,000 residents live in homes exposed to chronic flooding, but by 2080, approximately 360,000 residents will be exposed, an increase of nearly 680%.

Vulnerability & Risk – Residents of flood-prone areas are more likely to experience the direct adverse effects of coastal flooding, such as jeopardized health and safety, flooded roadways, and disruption of schools and businesses. Likewise, this risk will affect community functions, like infrastructure, education, public facilities, and local businesses.

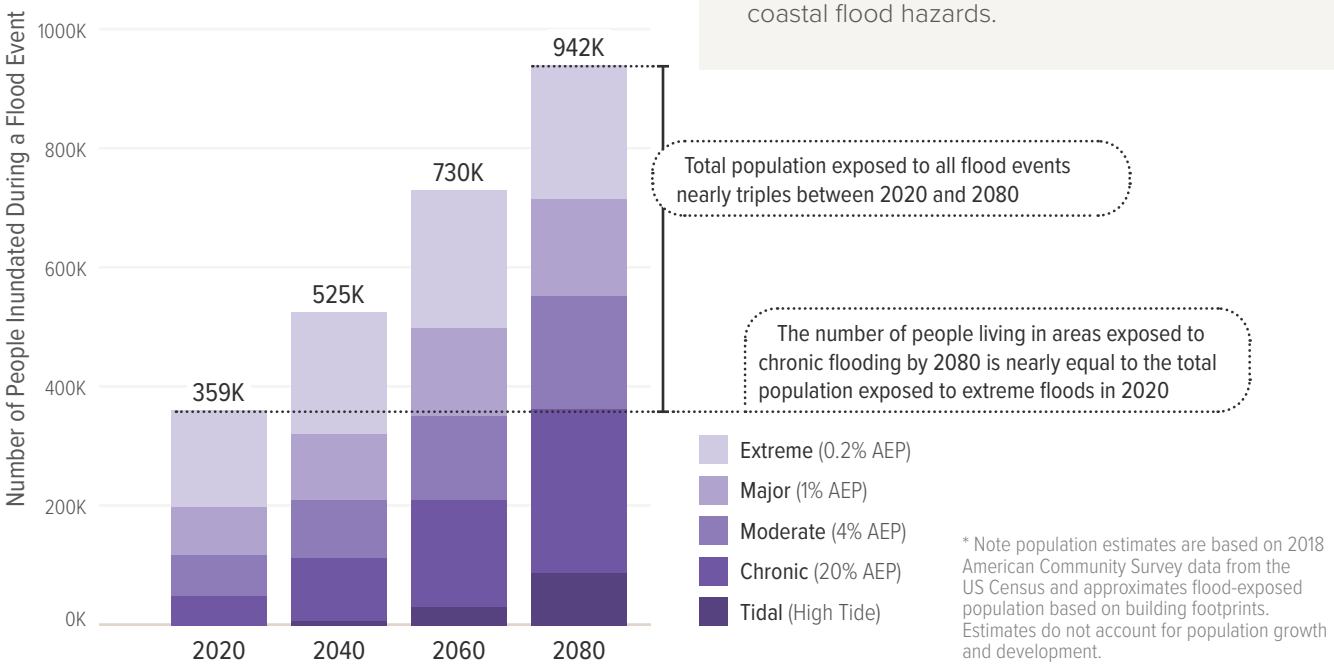
Properties damaged by flooding may become unsafe or impractical for residents to continue living in them. Severe or frequent flooding may even lead to the displacement of residents and businesses. The impacts of potential displacement are devastating for community resilience, relationships, and the overall well-being of the coastal Virginians. If many people are displaced and seek to relocate at the same time, the surrounding communities may experience stress if they lack the housing or services to accommodate many new residents in a short amount of time.

Community Vulnerability & Capacity

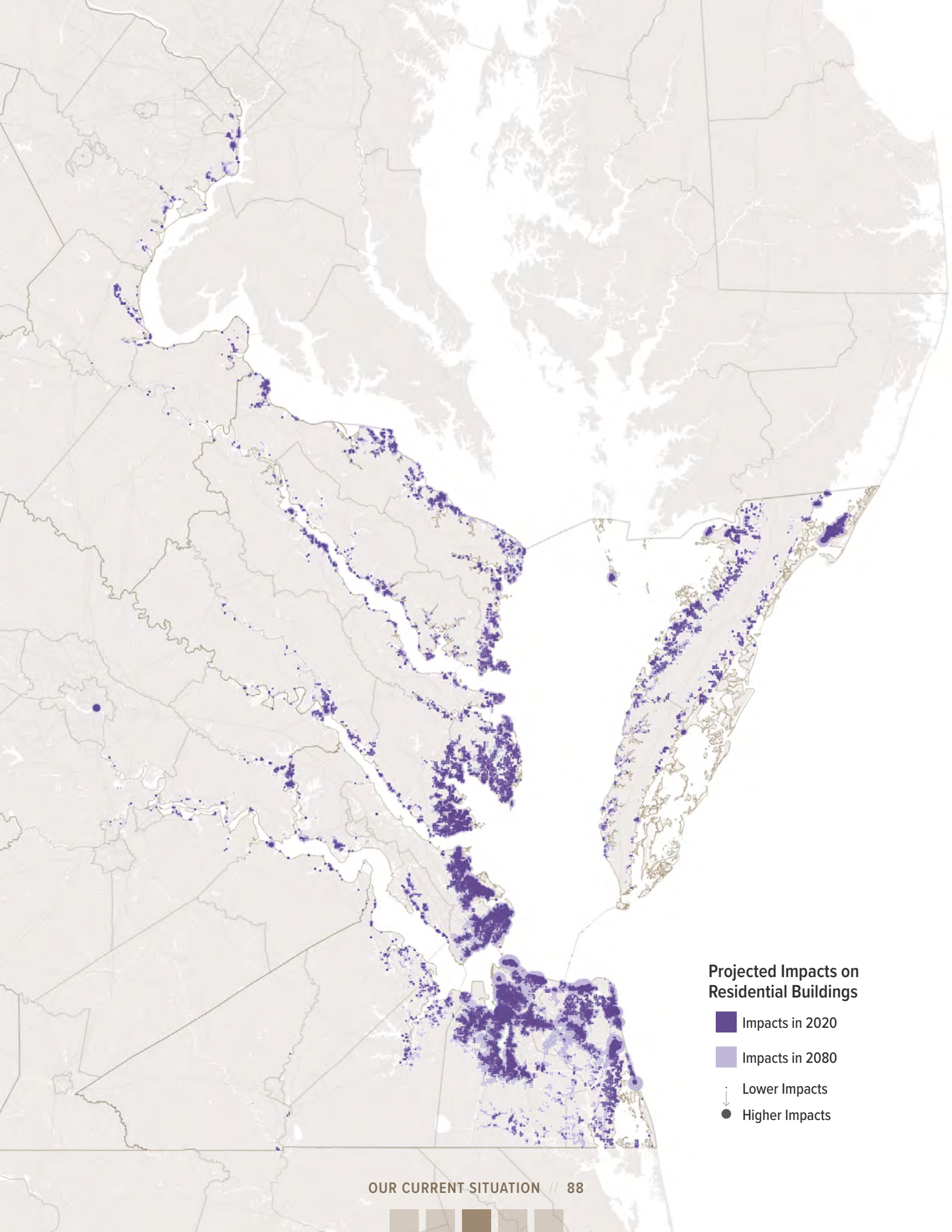
Numerous demographic factors, such as income, race, and education, influence a person's ability to prepare for and respond to flooding events effectively.

For example, lower-income households or those with limited savings may be unable to buy and maintain flood insurance, a much-needed safety net following a flood. Communities with higher shares of socially vulnerable populations may experience more severe impacts from flooding due to underlying factors that limit their ability to adapt to coastal flood hazards.

Population Exposure Across Event Types*



* Note population estimates are based on 2018 American Community Survey data from the US Census and approximates flood-exposed population based on building footprints. Estimates do not account for population growth and development.


Projected Impacts on Residential Buildings
Impacts in 2020
Impacts in 2080
Lower Impacts
Higher Impacts

Residential Buildings

Many residential structures were built without adequate knowledge of coastal flood hazards or how these hazards will change in the future due to sea level rise, or climate change. As the threat of coastal flooding intensifies, flood-exposed residents may need to decide whether to adapt their homes or seek to relocate elsewhere.

Exposure – Today, more than 73,000 residential structures with a combined value of over $43.6 billion would be exposed during a major coastal flood. By 2080, assuming development and population trends stay the same, the number of exposed residential structures will grow to 246,000, an increase of more than 235%. For already-exposed residential structures, the likelihood of severe damages will increase as potential floodwaters deepen. These estimates do not account for the potential exposure of future buildings in coastal floodplains.

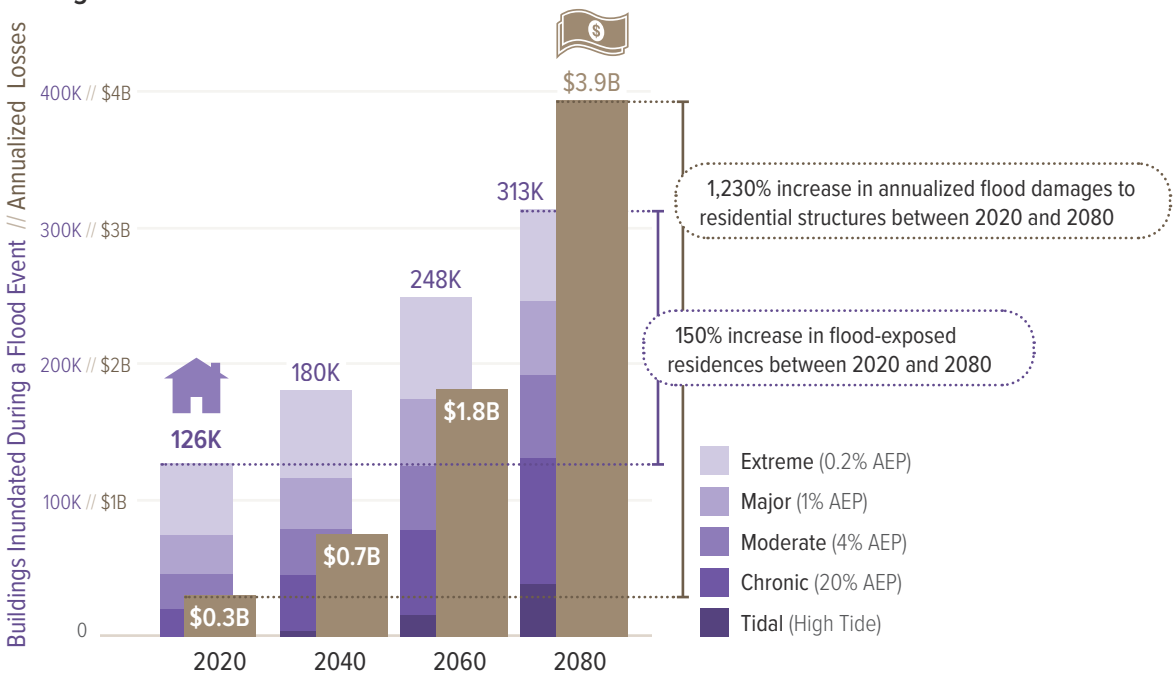
Vulnerability & Risk – Flood damages to residential homes and their contents vary based on the structure's elevation and specific design elements, such as foundation type, number of stories, and first-floor height. If a major coastal flood occurred today, coastal Virginia is projected to incur approximately $4.9 billion in direct residential damages to structures and their contents. By 2080, however, a major coastal flood would cause more than $35.9 billion in damages, an increase of nearly 640%.

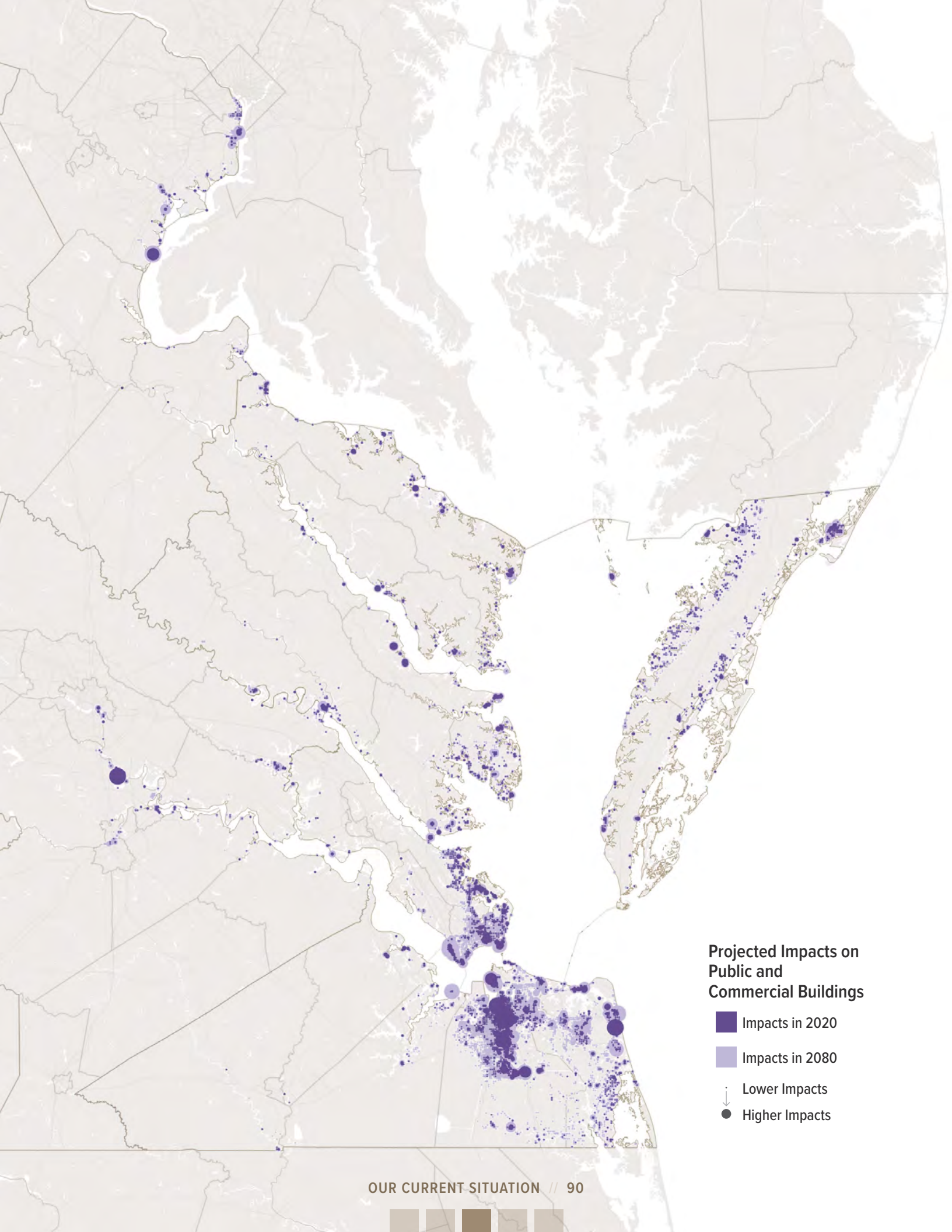
Across all events, the average annualized loss — which refers to the average amount of damages to homes expected every year — is projected to rise from $0.3 billion to $3.9 billion, between now and 2080, an increase of over 1,230%.

Community Vulnerability & Capacity

If community members lack safe housing in the face of increased sea level rise and recurrent flooding, the entire community suffers. For socially vulnerable communities, residents may lack the resources to adapt, respond, and recover adequately.

Residential Building Exposure Across Event Types and Averaged Annualized Loss




Projected Impacts on Public and Commercial Buildings
Impacts in 2020
Impacts in 2080
Lower Impacts
Higher Impacts

Public and Commercial Buildings

Public and commercial structures include non-residential buildings used for private business, educational, religious, and civic uses. These structures play a vital role in providing public services and maintaining the health of the economy.

Exposure – Today, nearly 7,500 public and commercial structures would be exposed during a major coastal flood event. Cumulatively these structures are valued at more than $24.2 billion. Between 2020 and 2080 the number of structures exposed to major coastal floods will grow by 180% to nearly 21,000, exposing buildings with an estimated value of more than $75.1 billion. Between 2020 and 2060, the number of public and commercial structures in low-lying areas projected to be exposed to chronic flooding will grow from under 2,500 to nearly 7,900, an increase of 220%. In the same time frame, the number of structures inundated during high tide is projected to rise from 400 to more than 2,200, an increase of 450%.

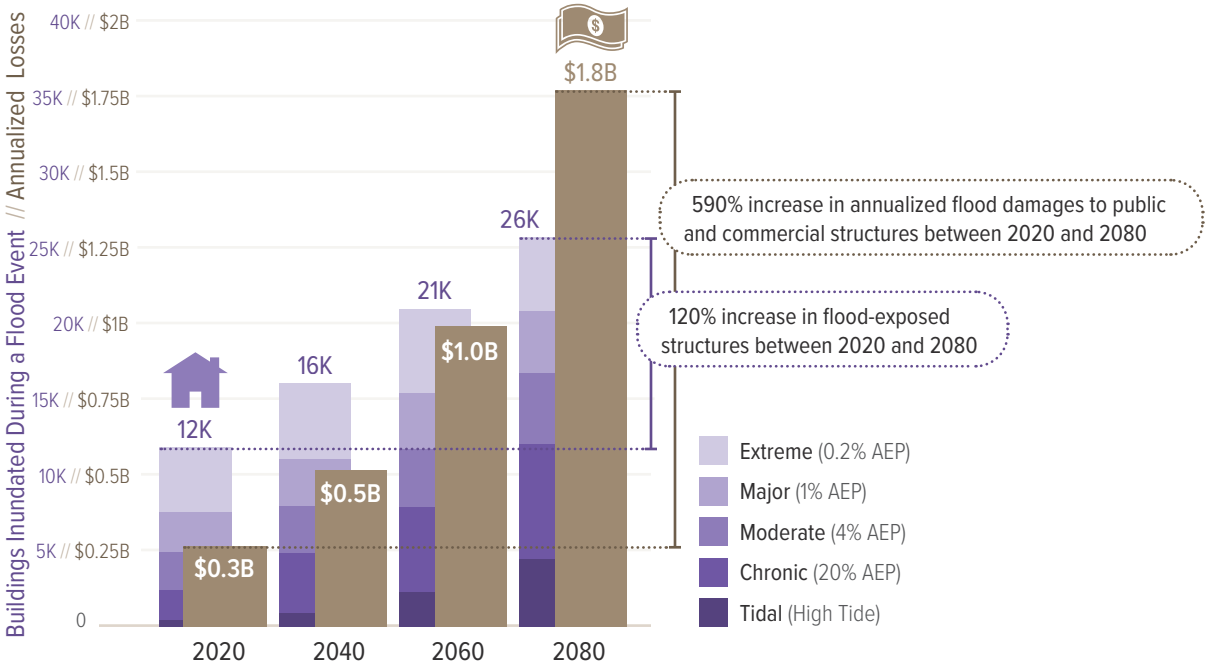
Vulnerability & Risk – Today, a major flood is projected to result in approximately $4.7 billion in direct damages to public and commercial structures and their contents. By 2080, an event of the same probability is projected to cause over $22 billion in damages, an increase of nearly 370%. Even minor events would come at a high cost: chronic flooding in 2080 is projected to cause more than $9.4 billion in building damages. Across all events, the average annualized loss — which refers to the average cost of damages to buildings expected any given year — is projected to increase from $0.25 billion to $1.75 billion, an increase of approximately 590%, between now and 2080. In addition to the direct damages, flooding of these buildings can disrupt economic activity by interrupting public services and forcing businesses to close, either temporarily or permanently.

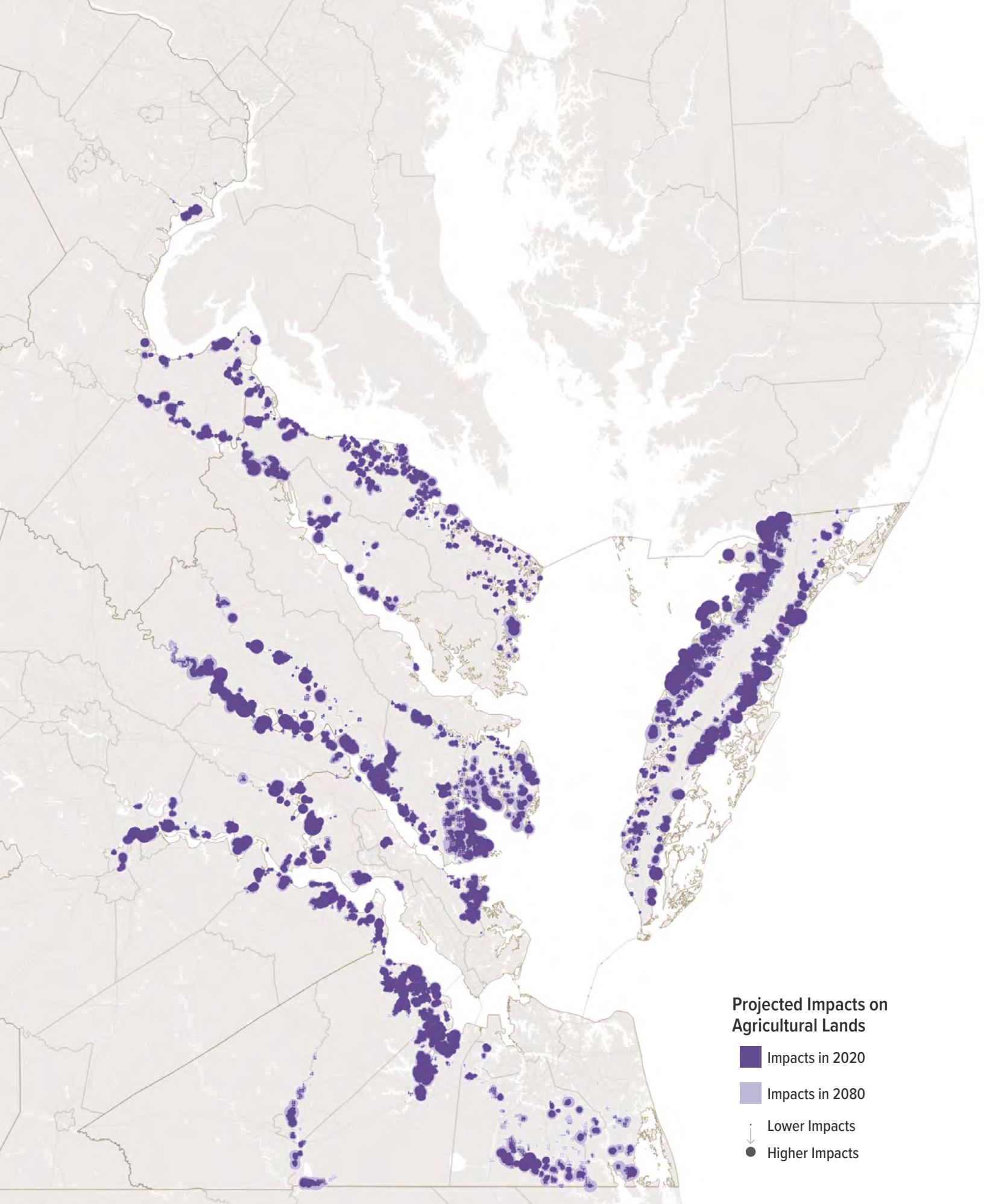
Some industries and businesses are more susceptible to coastal hazards because they are less capable of adapting to changing environmental conditions than others. Industries relying on natural resources may be more acutely affected by changing coastal environments, such as leisure, hospitality, and retail firms that rely on tourism.[75]

Community Vulnerability & Capacity

Business closures may lead to lost hours or wages, which can disproportionately affect residents working hourly wage jobs, single-income households, or those with limited savings.

Public and Commercial Building Exposure Across Event Types and Averaged Annualized Loss




Projected Impacts on Agricultural Lands
Impacts in 2020
Impacts in 2080
Lower Impacts
Higher Impacts

Agricultural Lands

Coastal Virginia's rich soils and water access allowed its early and continued development of agricultural production. The Commonwealth's food and agricultural systems produce, process, and distribute sustenance to people and businesses within coastal Virginia and beyond.

Exposure – Today, more than 25,000 acres of agricultural land are exposed to chronic flooding. Some land may become unusable or unproductive if it is permanently inundated or rising water tables lead to declining soil health. The number of acres inundated by chronic flooding is projected to grow to over 53,000 acres by 2080, more than doubling compared to 2020. By 2080, major flood events will affect nearly 70,000 acres, an increase of 70% compared to 2020.

Vulnerability & Risk – The agricultural industry represents an important economic sector, employing nearly 5,400 people and generating roughly $645 million in gross domestic product in 2019.[76,77] Agriculture's vulnerability to coastal hazards will depend on the type of soil or crop affected and when a flood occurs in the growth cycle. Inundation of agricultural land can destroy food products, soils, and vital equipment. Floods can even result in increased soil salinity, potentially harming crop health and viability to harvest for years after a flood. These effects may lead to reduced profits, interruptions to the supply chain, and damage agricultural ways of life, leading to economic and social impacts locally and regionally.

Professional Perspectives: What We Heard about Agricultural Impact

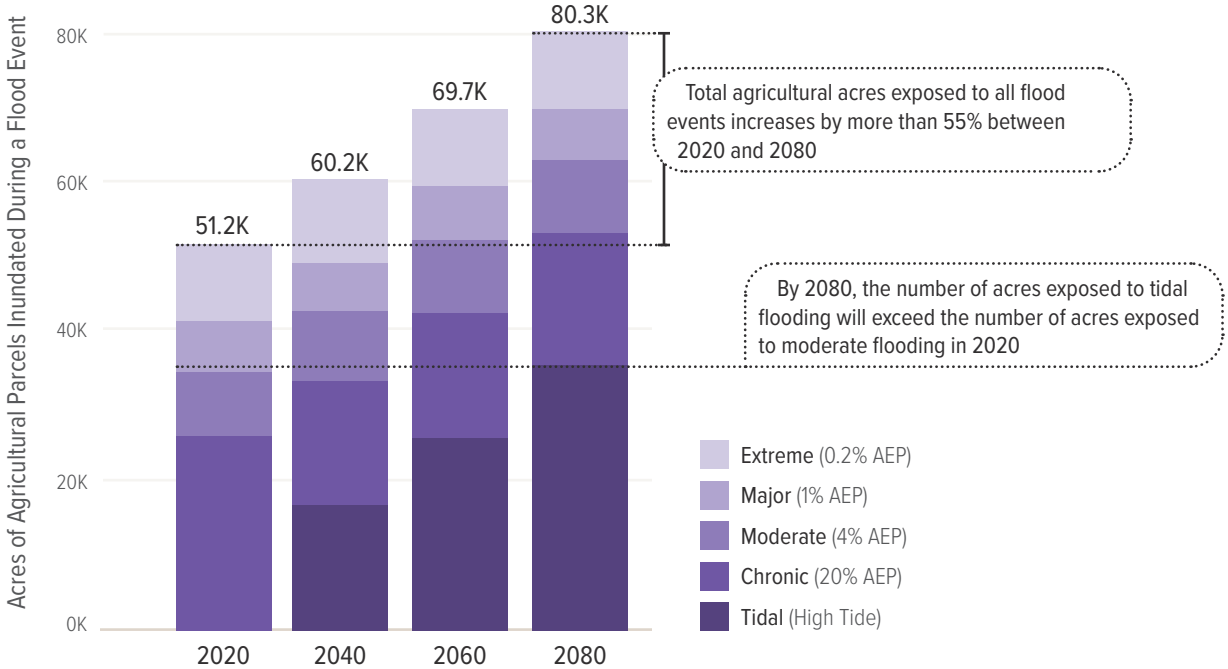
Nearly 100 representatives from government and partner organizations responded to a survey with questions related to their professional experiences. Of those respondents:

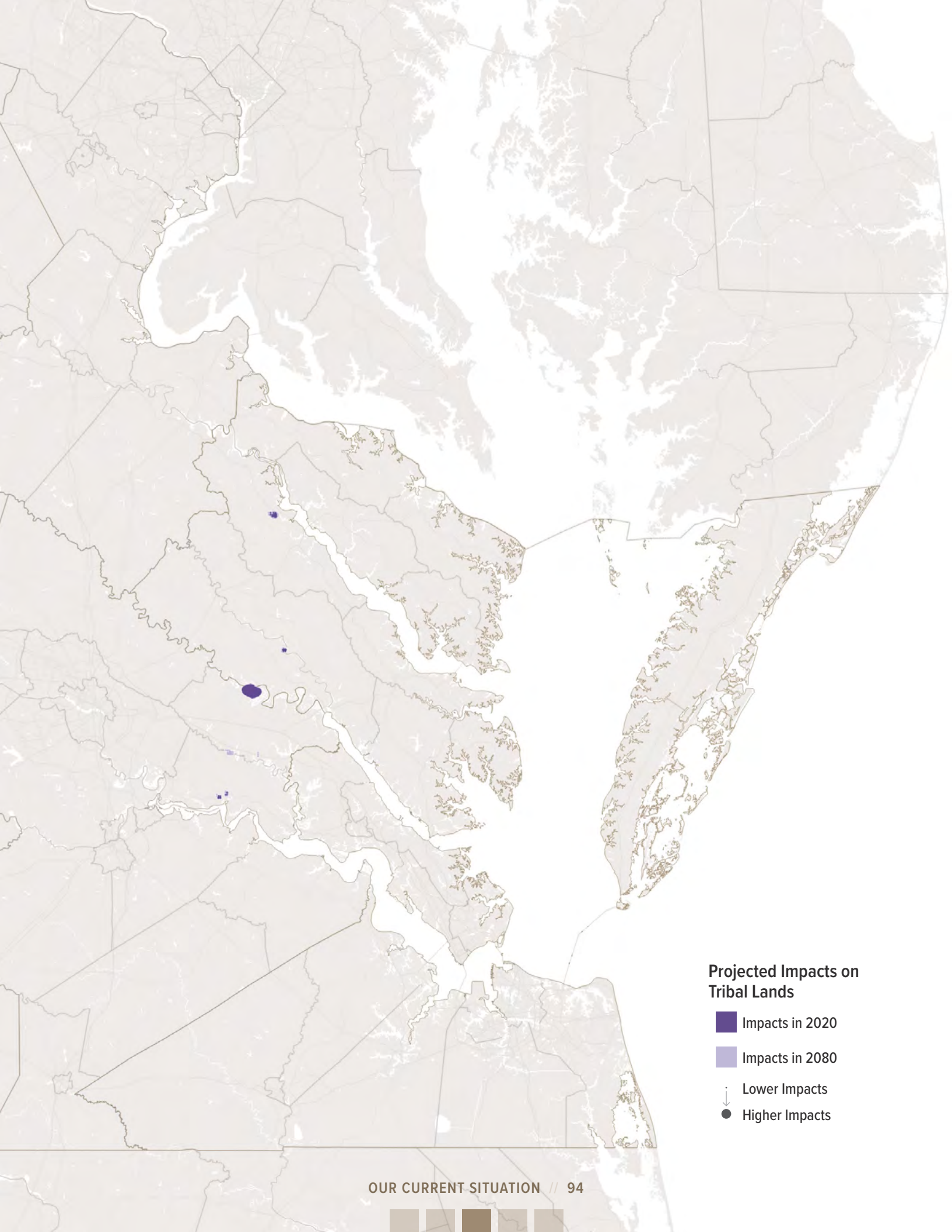
42% believe their community's agricultural industry is particularly vulnerable to climate change and coastal hazards.

Impacts to Agrarian Ways of Life

In rural agrarian communities, amplified coastal flood hazards may damage or irreparably harm crops, equipment, or structures. Agriculture is more than an economic driver, but also a way of life for these communities that is threatened by coastal flooding and other climate-influenced hazards.

Agricultural Land Exposure Across Event Types




Projected Impacts on Tribal Lands
Impacts in 2020
Impacts in 2080
Lower Impacts
Higher Impacts

Tribal Lands

Many tribal reservations and sacred lands are increasingly exposed to coastal flooding, and some may experience permanent inundation in the coming decades. Data on tribal lands and culturally-significant assets is limited, and the locations of important tribal sites are often sensitive. This first phase of the Master Plan conducted a preliminary assessment of tribal lands using Census Bureau data on the boundaries of federally and state-recognized tribal organizations and nations.

Exposure – Between 2020 and 2080, the number of tribal-owned land acres exposed to major coastal floods will grow from 280 to over 700, an increase of nearly 150%. By 2080, an additional 290 acres of tribal-owned land are projected to be inundated during high tide, effectively lost to open water. This land loss affects the Pamunkey Indian Tribe (230 acres), Rappahannock Indian Tribe (50 acres), Mattaponi Tribe (5 acres), and Chickahominy Indian Tribe (3 acres). This analysis is limited in scope by data availability and does not account for all tribal lands in Virginia, so these numbers likely underestimate the true extent of impacts.

Vulnerability & Risk – For many tribal communities, land represents historical and cultural significance, community connectivity, and access to natural resources used for recreation, livelihoods, and traditions. In low-lying areas, it may be challenging to adapt valued tribal lands to changing conditions and be permanently inundated due to sea level rise. Chronic flooding of tribal lands and sacred cultural sites may limit tribal members' access to these locations. These effects may hinder the continuation of cultural practices and the ability of tribal members to transfer certain traditions to future generations. Economic models or assessed market values do not readily capture the cumulative value of these lands and their histories.

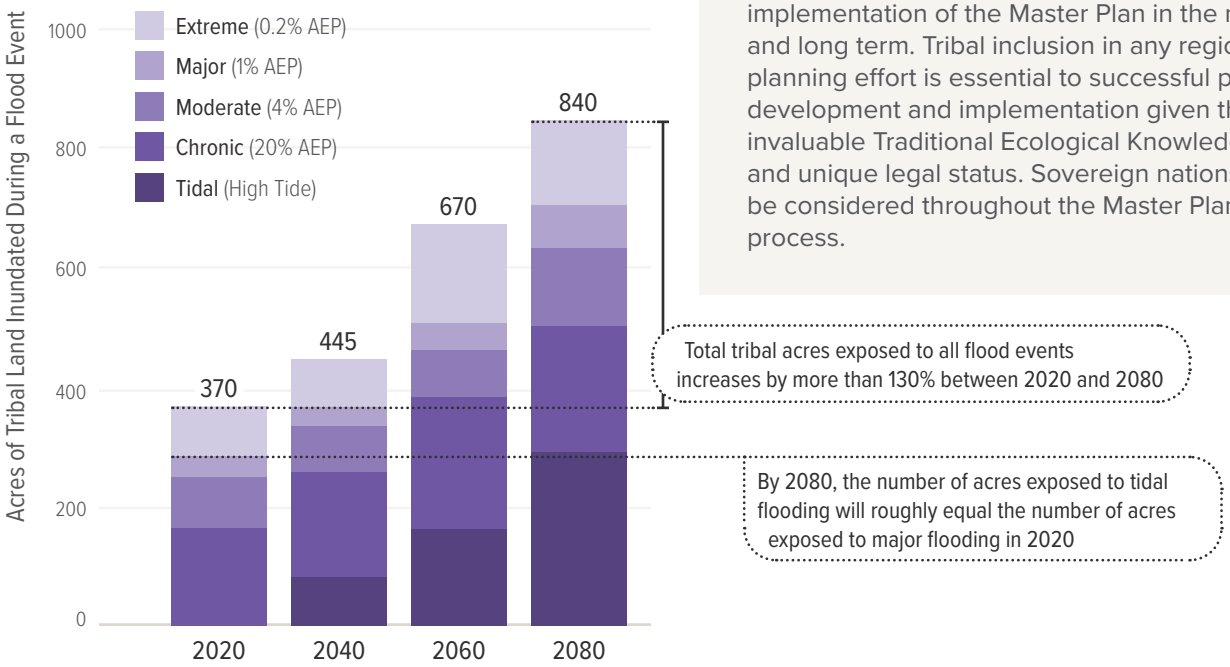
Community Vulnerability & Capacity

Due to centuries of discriminatory policies and practices, Native American people today are more likely to exhibit factors that correlate with high social vulnerability, like lower incomes or higher disability rates. Further, tribes often face added barriers to accessing federal grant programs for various reasons, from technology requirements, difficulty securing matching dollars, or programs not being culturally appropriate for tribal needs.

Expanding Tribal Engagement

The Commonwealth recognizes that Tribal engagement is requisite to the successful implementation of the Master Plan in the near and long term. Tribal inclusion in any regional planning effort is essential to successful project development and implementation given their invaluable Traditional Ecological Knowledge (TEK) and unique legal status. Sovereign nations must be considered throughout the Master Planning process.

Tribal Land Exposure Across Event Types



Photos courtesy of Dewberry and Aileen Devlin of Virginia Sea Grant (VASG).

Historic Resources

Water access was a critical advantage to early settlements, so today, many of Virginia's oldest and culturally significant resources lie in the coastal region. Virginia's historic resources are irreplaceable drivers of tourism and economic activity that contribute to the education, culture, and quality of life for communities across the Commonwealth.

These resources have largely withstood the test of time, but as older structures, they were designed and built under different environmental conditions. Today, these structures may be more sensitive to damage and degradation if exposed to flooding.

Virginia has many significant historic and cultural resources that the Commonwealth has gone to great lengths to restore and protect. Some of these sites, like Jamestown, Fort Monroe, and Henricus, are recognized on the National Register of Historic Places. Coastal Virginia is also home to Pocahontas Island, one of the Commonwealth's earliest free African American settlements. Other resources include historic waterfront communities, like Tangier Island and Gwynn Island, as well as designated historic districts in increasingly flood-prone areas, like Olde Towne Portsmouth, Hampton Downtown Historic District, and Norfolk's Freemason District. Still, other localities have historic structures that serve important community functions, the value of which is challenging to quantify. Collectively, these resources represent our shared past and culture. What we protect and preserve says a great deal about who or what we value today.

That said, the Master Plan focuses on people, property, and reducing risk to communities and the economy. When possible, historical places of the highest significance may warrant consideration in the context of these focal areas, but the Commonwealth does not aim to offer additional protection for these sites through the Master Plan.

What We Heard about Impacts on Historic Resources

Through meetings and surveys, both residents and practitioners across the Master Planning Regions contributed their perspectives about Historic Resources.

> "We need safe coastal neighborhoods and the safety of coastal historic and cultural assets." – *Resident, Accomack-Northampton PDC*

> "We have some historical buildings and properties that we need to make resilient." – *Resident, Hampton Roads PDC*

Community Resource Hotspots:

Hampton Roads

Community Resources in Hampton Roads

Hampton Roads' communities are among the Commonwealth's oldest settlements. Some of these communities transformed into densely developed cities, like Norfolk, that support varied economies and industries. The region has many federal military installations, and defense-related spending is key to its larger economy.

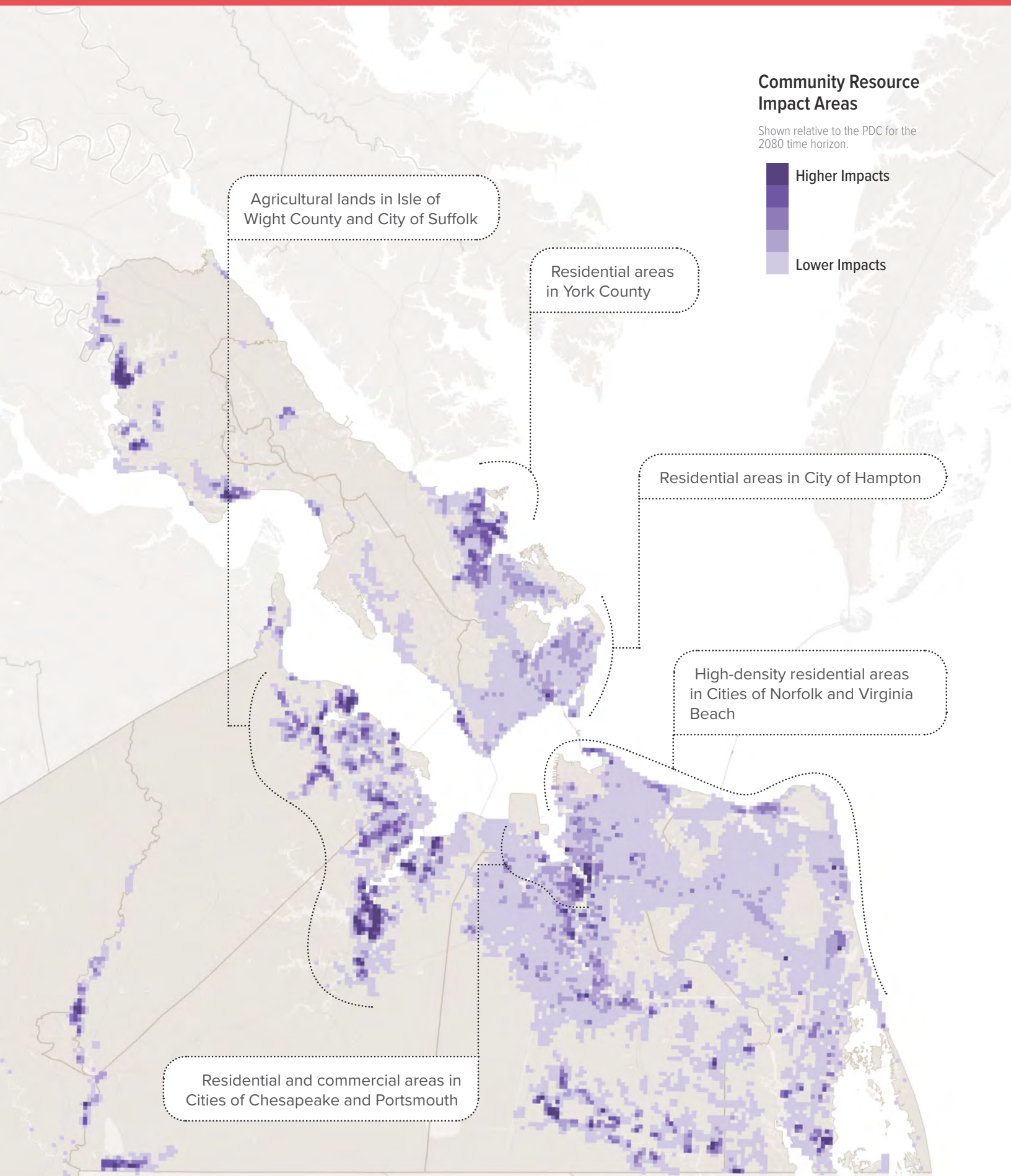
Residential Population Exposed		2020	2080	Change
Hampton Roads PDC	High tide	980	64,700	+ 6485%
	Extreme flood	319,500	869,700	+ 172%

Annualized Structure Losses*		2020	2080	Change
Hampton Roads PDC	Residential	$231M	$3,110M	+ 1245%
	Non-Residential	$205M	$1,510M	+ 639%

* Projected average annualized losses due to damages to structures and contents.

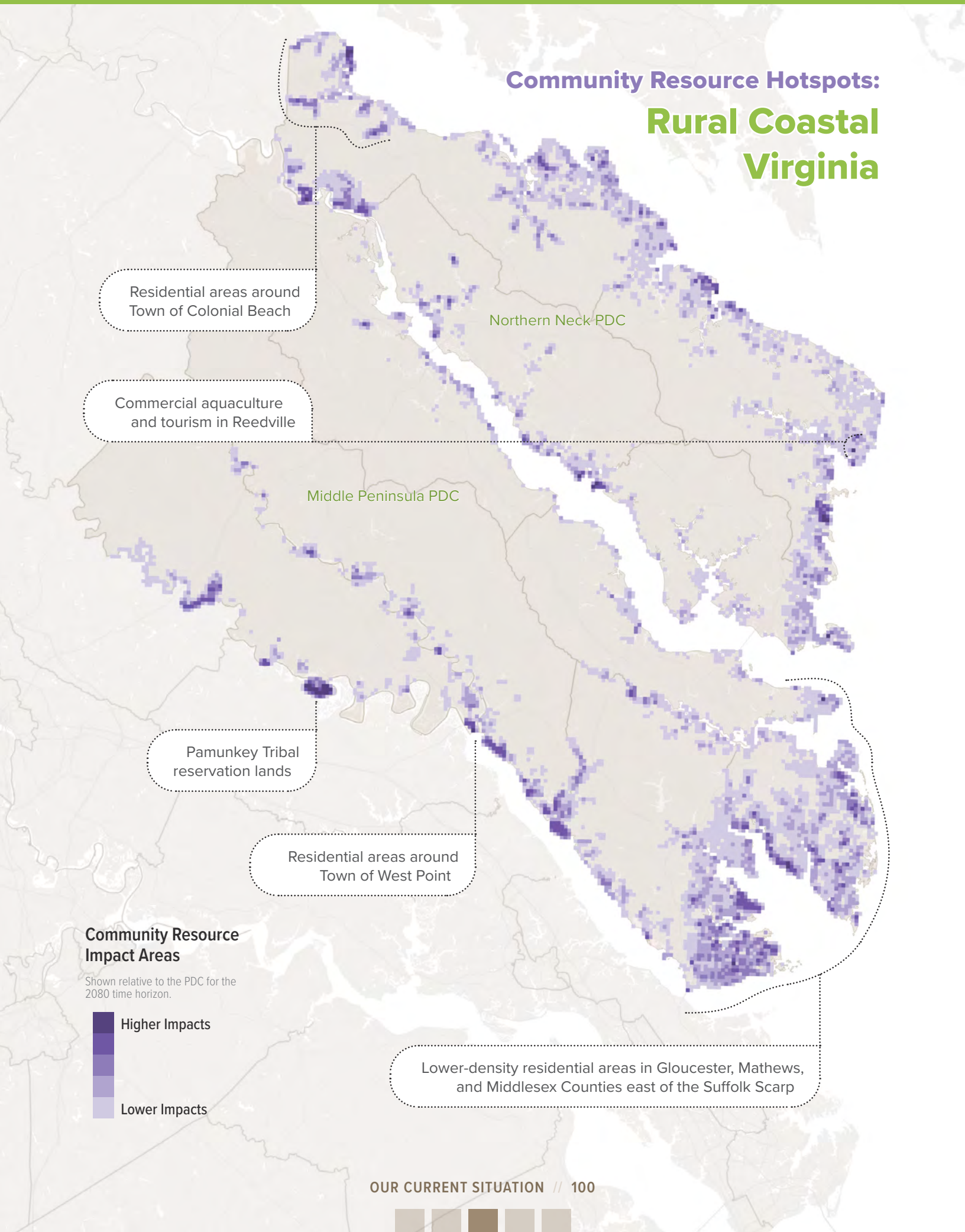
Agricultural Land Acres Exposed		2020	2080	Change
Hampton Roads PDC	High tide	3,100	10,700	+ 250%
	Extreme flood	13,600	21,200	+ 56%

Differences in asset exposure numbers and percentage changes can be attributed to rounding for presentation. Percentage changes reflect exact exposure numbers.


Community Resource Impact Areas
Shown relative to the PDC for the 2080 time horizon.
Higher Impacts
Lower Impacts
Agricultural lands in Isle of Wight County and City of Suffolk
Residential areas in York County
Residential areas in City of Hampton
High-density residential areas in Cities of Norfolk and Virginia Beach
Residential and commercial areas in Cities of Chesapeake and Portsmouth

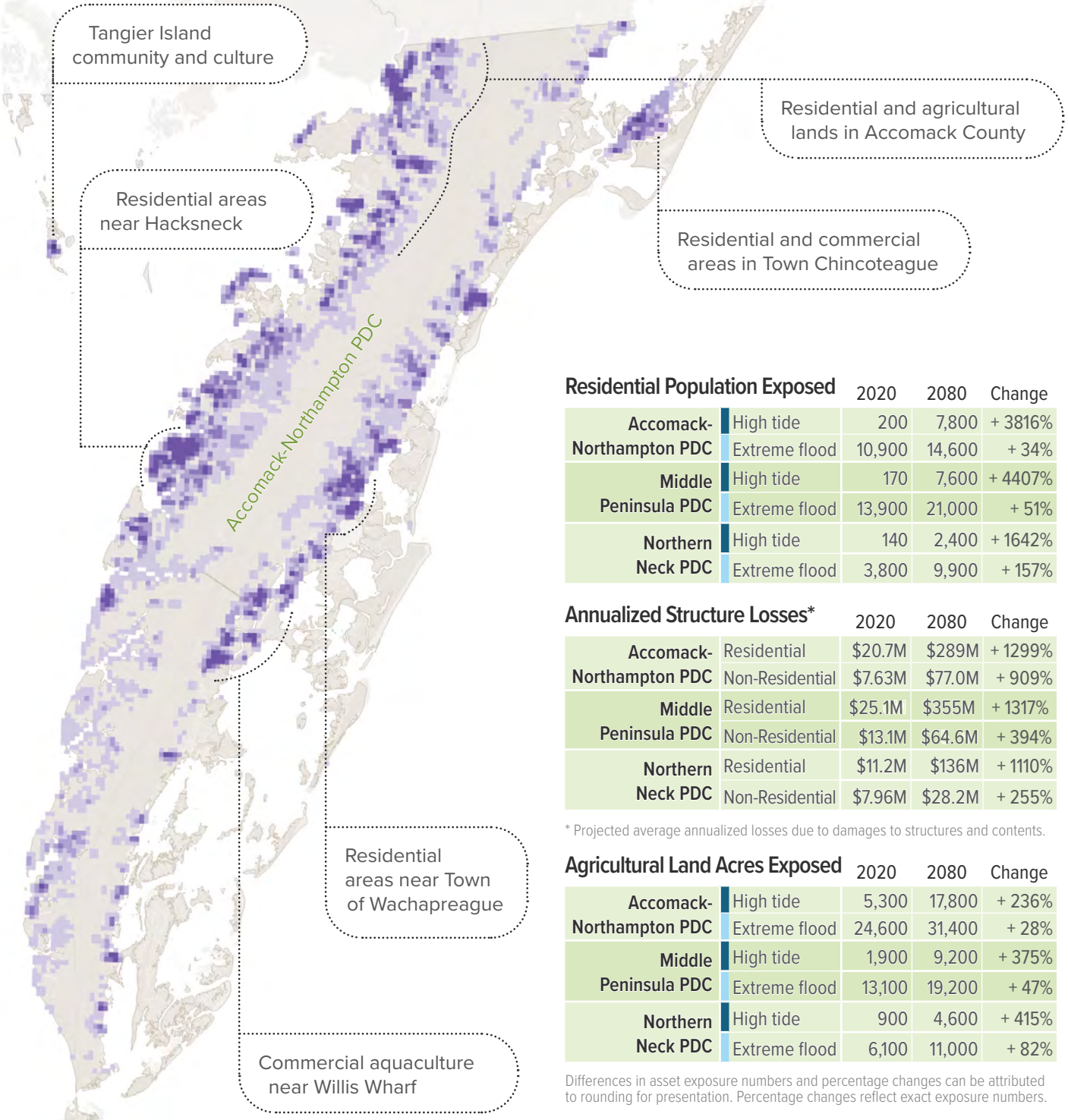
Community Resource Hotspots:

Rural Coastal Virginia



Community Resources in Rural Coastal Virginia

Some residential neighborhoods in Rural Coastal Virginia are built close to the water's edge, where structures face risks from both coastal flooding and erosion. Many localities in the region have working waterfronts and water-based economies, with many businesses that directly engage in or benefit from aquaculture, coastal agriculture, and ecotourism.



Residential Population Exposed		2020	2080	Change
Accomack-Northampton PDC	High tide	200	7,800	+ 3816%
	Extreme flood	10,900	14,600	+ 34%
Middle Peninsula PDC	High tide	170	7,600	+ 4407%
	Extreme flood	13,900	21,000	+ 51%
Northern Neck PDC	High tide	140	2,400	+ 1642%
	Extreme flood	3,800	9,900	+ 157%

Annualized Structure Losses*		2020	2080	Change
Accomack-Northampton PDC	Residential	$20.7M	$289M	+ 1299%
	Non-Residential	$7.63M	$77.0M	+ 909%
Middle Peninsula PDC	Residential	$25.1M	$355M	+ 1317%
	Non-Residential	$13.1M	$64.6M	+ 394%
Northern Neck PDC	Residential	$11.2M	$136M	+ 1110%
	Non-Residential	$7.96M	$28.2M	+ 255%

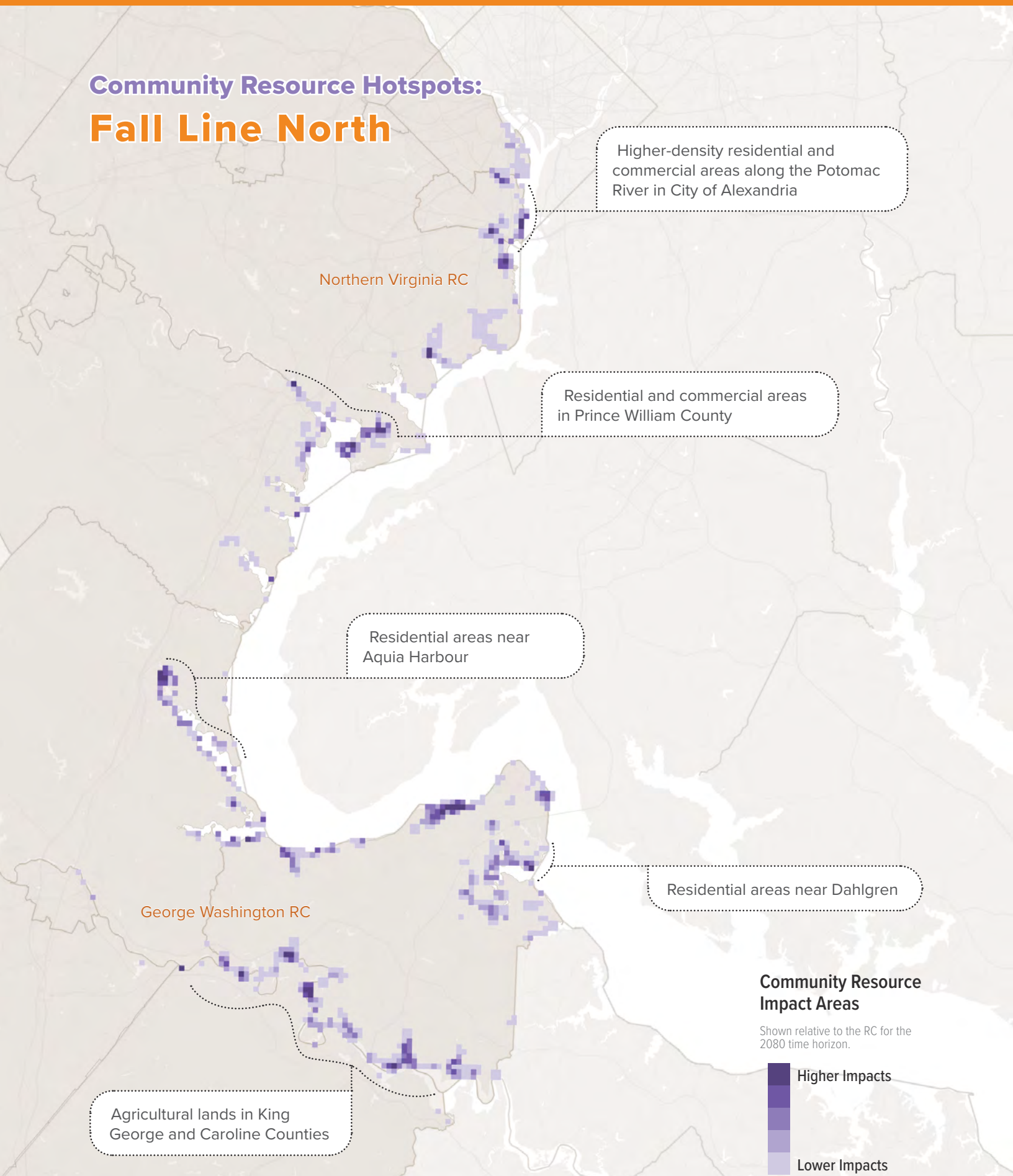
* Projected average annualized losses due to damages to structures and contents.

Agricultural Land Acres Exposed		2020	2080	Change
Accomack-Northampton PDC	High tide	5,300	17,800	+ 236%
	Extreme flood	24,600	31,400	+ 28%
Middle Peninsula PDC	High tide	1,900	9,200	+ 375%
	Extreme flood	13,100	19,200	+ 47%
Northern Neck PDC	High tide	900	4,600	+ 415%
	Extreme flood	6,100	11,000	+ 82%

Differences in asset exposure numbers and percentage changes can be attributed to rounding for presentation. Percentage changes reflect exact exposure numbers.

Community Resource Hotspots:

Fall Line North



Community Resources in Fall Line North

Fall Line North contains dense corridors of residential and commercial development, particularly around Washington, D.C. Access to major rivers, like the Potomac River, remains critical to its economic strength, but also poses upland flooding issues for communities containing tidally influenced water bodies. The region is also home to many historic communities and sites, which draw visitors from all over the country.

Residential Population Exposed		2020	2080	Change
George Washington RC	High tide	10	200	+ 1709%
	Extreme flood	580	1,500	+ 161%
Northern Virginia RC	High tide	20	1,600	+ 9406%
	Extreme flood	9,200	22,900	+ 149%

Annualized Structure Losses*		2020	2080	Change
George Washington RC	Residential	$0.68M	$7.09M	+ 936%
	Non-Residential	$0.15M	$0.84M	+ 468%
Northern Virginia RC	Residential	$1.77M	$23.8M	+ 1242%
	Non-Residential	$7.93M	$37.2M	+ 369%

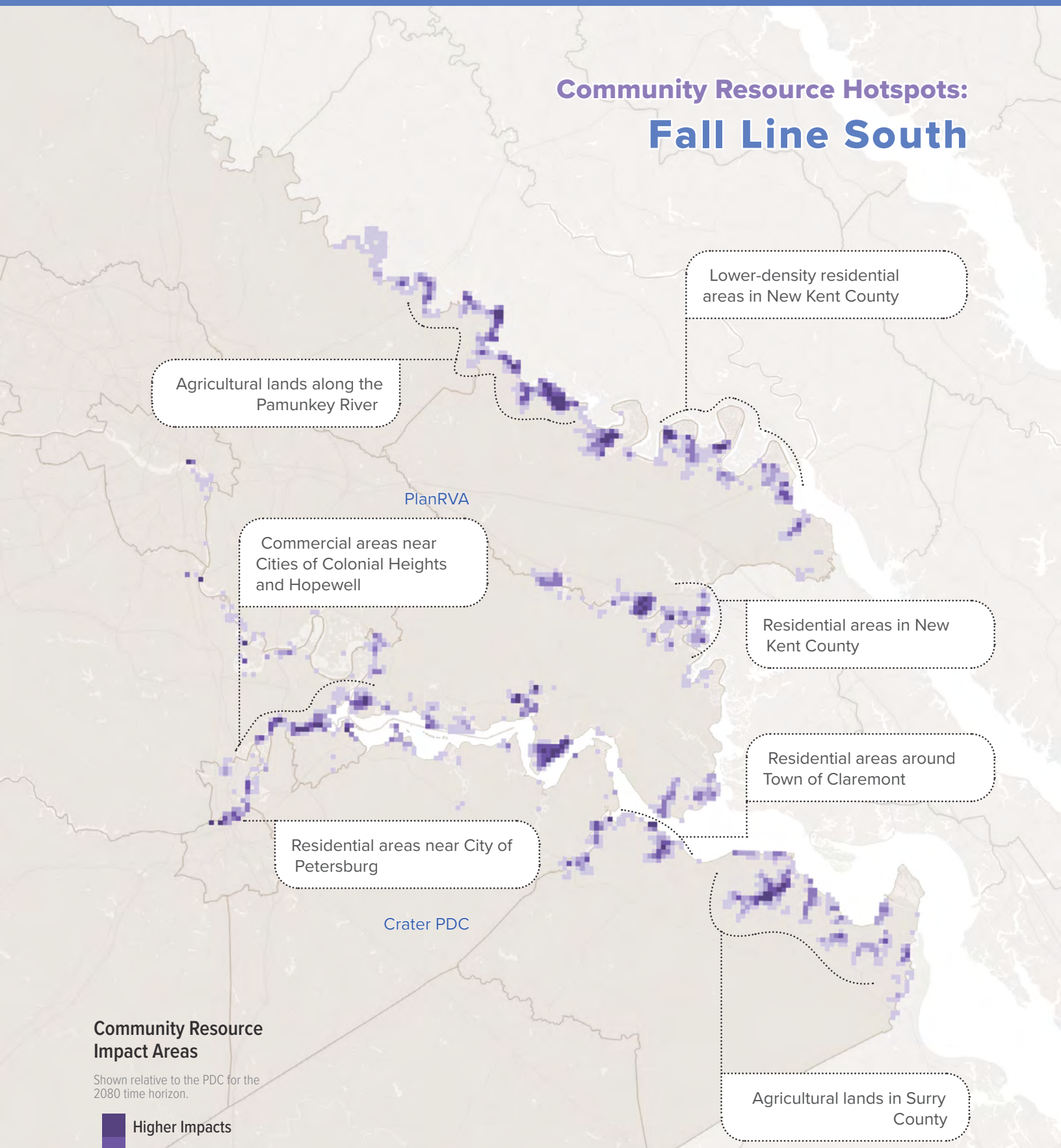
* Projected average annualized losses due to damages to structures and contents.

Agricultural Land Acres Exposed		2020	2080	Change
George Washington RC	High tide	380	1,300	+ 236%
	Extreme flood	1,680	2,300	+ 36%
Northern Virginia RC	High tide	80	160	+ 105%
	Extreme flood	180	250	+ 34%

Differences in asset exposure numbers and percentage changes can be attributed to rounding for presentation. Percentage changes reflect exact exposure numbers.

Community Resource Hotspots:

Fall Line South



Community Resources in Fall Line South

Fall Line South contains a mix of urban, suburban, and rural development, including significant agricultural lands along the James River. The region is home to the Commonwealth's capital, Richmond, and holds several treasured sites, including Pocahontas Island, a historical freedom community settled and built predominantly by free African American residents in the 18th and 19th centuries.

Residential Population Exposed		2020	2080	Change
Crater PDC	High tide	< 5	80	+ 2700%
	Extreme flood	130	530	+ 302%
PlanRVA	High tide	20	500	+ 2495%
	Extreme flood	1,100	2,200	+ 105%

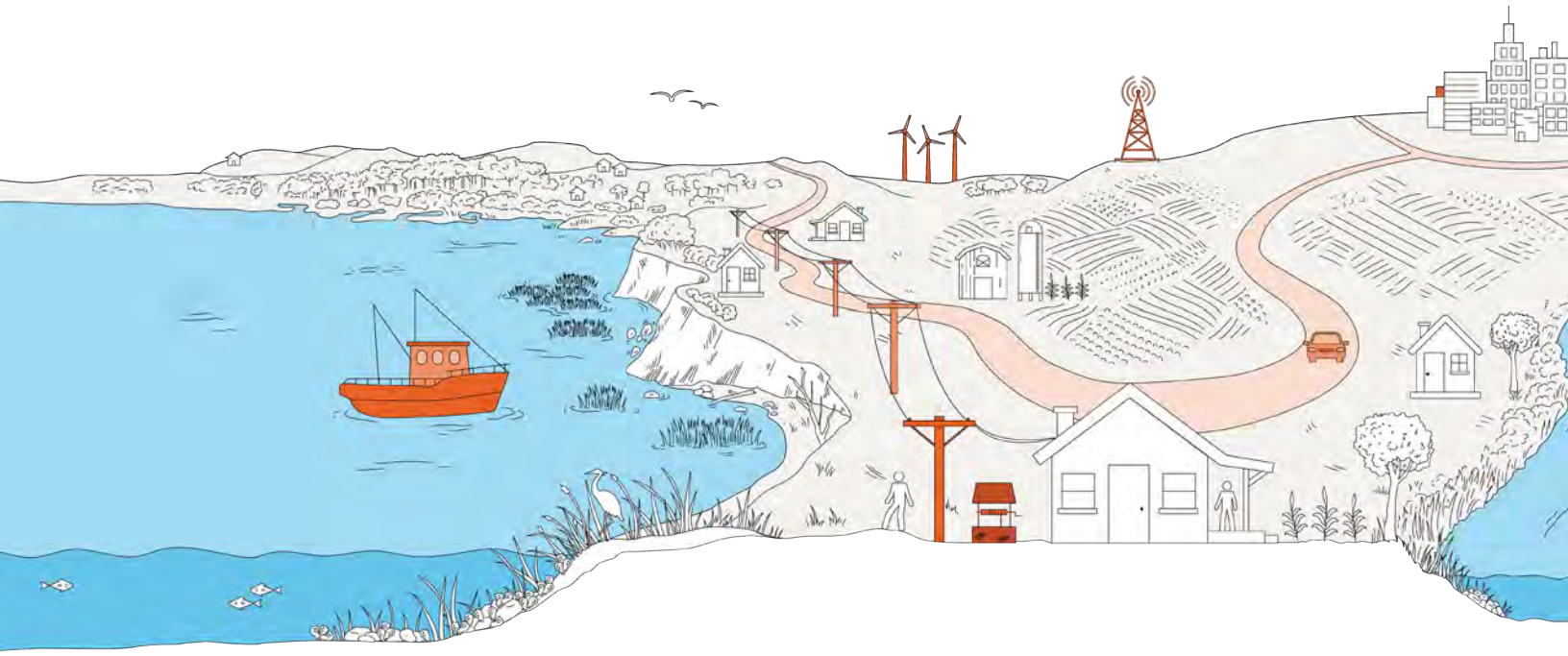
Annualized Structure Losses*		2020	2080	Change
Crater PDC	Residential	$1.62M	$7.46M	+ 360%
	Non-Residential	$0.69M	$6.00M	+ 765%
PlanRVA	Residential	$3.30M	$14.2M	+ 331%
	Non-Residential	$13.0M	$27.40M	+ 111%

* Projected average annualized losses due to damages to structures and contents.

Agricultural Land Acres Exposed		2020	2080	Change
Crater PDC	High tide	480	1,300	+ 176%
	Extreme flood	1,500	1,900	+ 23%
PlanRVA	High tide	2,400	4,500	+ 86%
	Extreme flood	5,300	7,500	+ 41%

Differences in asset exposure numbers and percentage changes can be attributed to rounding for presentation. Percentage changes reflect exact exposure numbers.

Impacts on Critical Sectors



Critical Sectors refer to the structures and systems vital to regional, state, and national functions. If these assets are damaged, destroyed or otherwise cannot perform their essential purpose, coastal Virginia would experience debilitating effects on its economy, public health, safety, or security.[78] Critical Sectors include networks and systems that depend on multiple facilities, like communication towers or roadways.

The resilience of coastal Virginia's Critical Sector assets is also crucial to ensure that the businesses and communities can continue to function even as coastal flood hazards intensify over time. If these assets can no longer reliably function or are badly damaged due to flooding, some companies and residents may eventually decide to relocate outside of coastal Virginia, resulting in social and economic ramifications throughout the region. Projecting the adverse effects to Critical Sectors is essential to identifying the need for resilience strategies to adapt and protect the structures and systems that enable coastal Virginia to be a thriving hub for residents and businesses alike.

The following sections summarize impacts on Critical Sectors by asset type and by Master Planning Region. For each Master Planning Region, impact hotspots are presented to illustrate areas projected to experience higher impacts relative to the rest of the region. See Appendix E for details on how impact metrics and hotspots are calculated.

What Is a Critical Sector Hotspot?

An impact hotspot refers to an area that contains a concentration of identified assets projected to be affected by coastal flooding.

Each Critical Sector asset is affected differently by coastal flood hazards. These potential impacts are measured using unique metrics. To illustrate hotspots, these metrics are standardized to aggregate and compare impacts across different assets, both statewide and within the Master Planning Regions.

Limitations to Modeling Critical Sector Impacts

Critical Sector assets include many types of facilities and structures for which data availability and accuracy varies. The Technical Study's impact assessment does not consider degrees of criticality, susceptibility, or adaptive capacity across assets, nor does it account for whether asset owners have already implemented mitigation measures. Assuming these variables as constant allows the Commonwealth to assess asset exposure in "no-action" scenarios where flood hazards increase while no mitigating actions are implemented and the physical landscape remains unchanged.

Public and Professional Perspectives: Lived Experiences with Critical Sector Impacts

Over 1,300 Virginians responded to a public online survey with questions relating to their lived flooding experiences. Of those respondents:

73% said they have seen or experienced transportation disruptions due to flooding.

54% have lost electricity due to flooding.

Nearly 100 representatives from government and partner organizations responded to a survey with questions related to their professional experiences. Of those respondents:

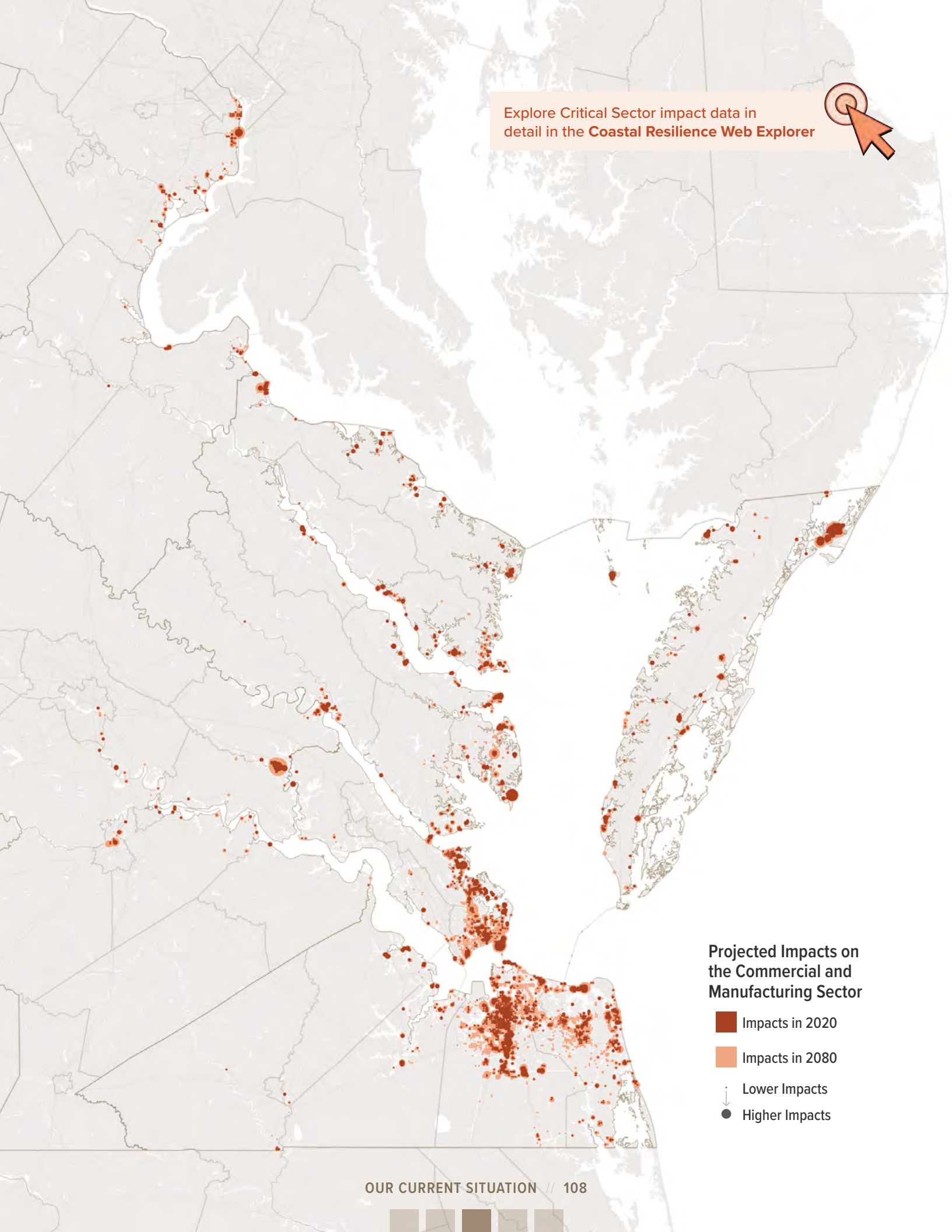
36% believe that their community's utilities, energy, and telecommunications industries are vulnerable to climate change and coastal hazards.

What Virginians Are Saying about Impacts on Critical Sectors

Through meetings and surveys, both residents and practitioners across the Master Planning Regions contributed their perspectives about Critical Sector assets.

> "We have one sole source aquifer. If it gets drained or has saltwater intrusion, we will not have freshwater." – *Resident, Accomack-Northampton PDC*

> "This is a disaster waiting to happen. If one of our roadways collapses, it will cause over 2,000 people to be inaccessible by emergency services as well as strand those folks from being able to go to work or school or buy food and supplies for their families. This is urgent." – *Resident, George Washington RC*


Explore Critical Sector impact data in
detail in the **Coastal Resilience Web Explorer**
Projected Impacts on
the Commercial and
Manufacturing Sector
Impacts in 2020
Impacts in 2080
Lower Impacts
Higher Impacts

Commercial and Manufacturing

Commercial and manufacturing facilities include privately-owned sites that produce, process, store, and distribute goods and services. Flooding of these facilities could lead to direct economic losses, like damage to raw materials and products, and indirect ones, like supply chain disruptions and losses of jobs or wages.

Exposure – Today, 7,700 commercial and manufacturing facilities are exposed to major flood events. By 2080, the number of facilities exposed to major coastal flood events is projected to grow to 20,900, an increase of 170%.

Manufacturing facilities refer to sites that handle biological, chemical, pharmaceutical, and other products. Today, approximately 30 manufacturing facilities are exposed to chronic flooding. By 2080, this number is projected to grow to approximately 150, an increase of more than 390%.

Food processing facilities are critical to the larger supply chain, often producing the raw materials for other sites or even the final goods for residents to buy and take home to eat. Between 2020 and 2080, the number of food processing facilities exposed to chronic flooding will grow from approximately 10 to 25, an increase of 120%, assuming no mitigating actions are taken.

Non-manufacturing commercial buildings will also experience increasing hazard exposure. Between 2020 and 2080, the number of commercial buildings with chronic coastal flood hazard exposure is projected to grow from 3,400 to 12,000, an increase of 250%.

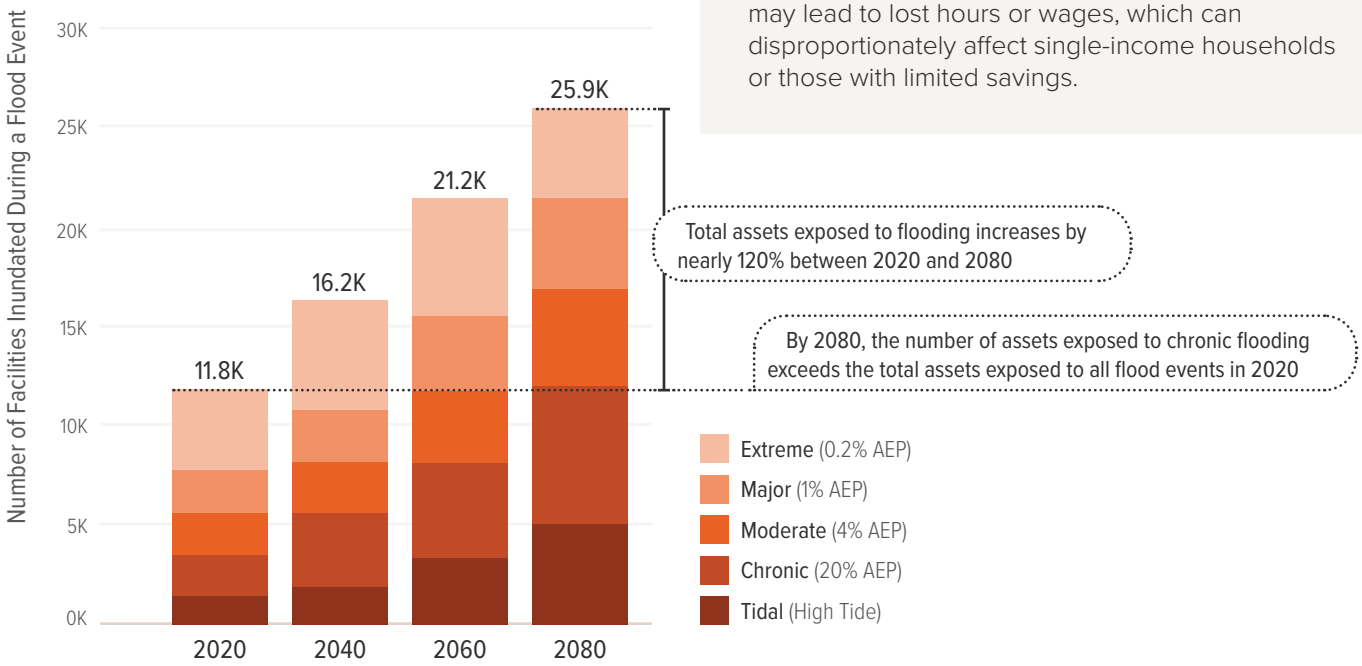
Vulnerability & Risk – Flooding of commercial and manufacturing facilities could destroy raw materials and manufactured products, potentially causing interruptions to the supply chain. Distribution facilities may experience bottlenecks after a flood, due to shortages of either vehicles or drivers or damage to other critical sector assets, like energy, communication, or transportation facilities.[79] Depending on the materials held at a facility, flooding can also lead to contamination of water supplies, soil, and air quality.

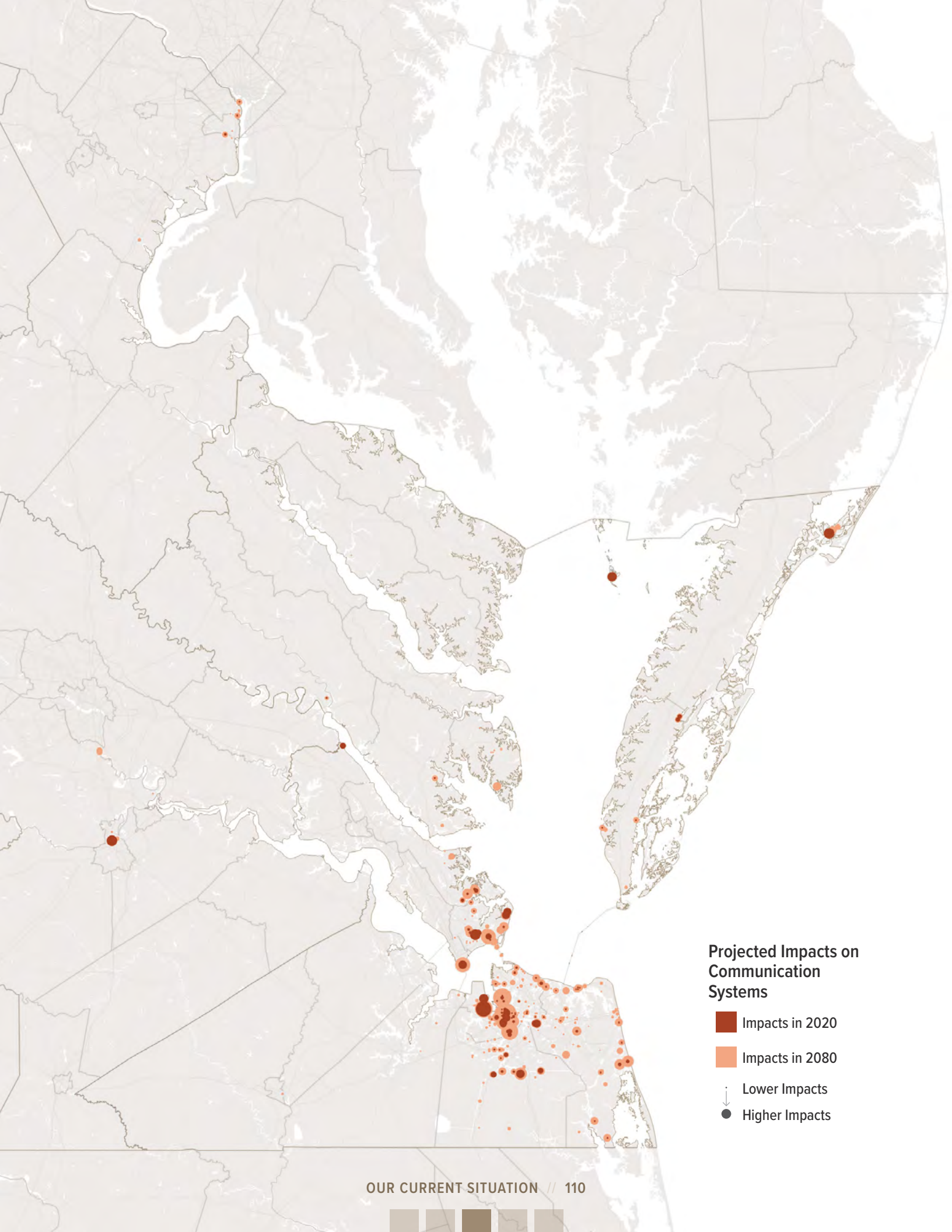
A flood can damage commercial and manufacturing facilities so that they are no longer safe to occupy or work in, leading to temporary or extended closures. If these closures lead to employers cutting or reducing hours following a flood, these closures could lead to compounding economic impacts, like lost revenues or even wages.

Community Vulnerability & Capacity

Closures of commercial and manufacturing facilities may lead to lost hours or wages, which can disproportionately affect single-income households or those with limited savings.

Commercial and Manufacturing Facility Exposure Across Event Types




Projected Impacts on Communication Systems
Impacts in 2020
Impacts in 2080
Lower Impacts
Higher Impacts

Communication Systems

Many service towers, transmitters, and broadcast stations are sited throughout coastal Virginia, allowing the distribution of information by radio, telephone, television, and the internet. The clustering of these assets often corresponds with concentrations of population centers, military installations, and economic activity.

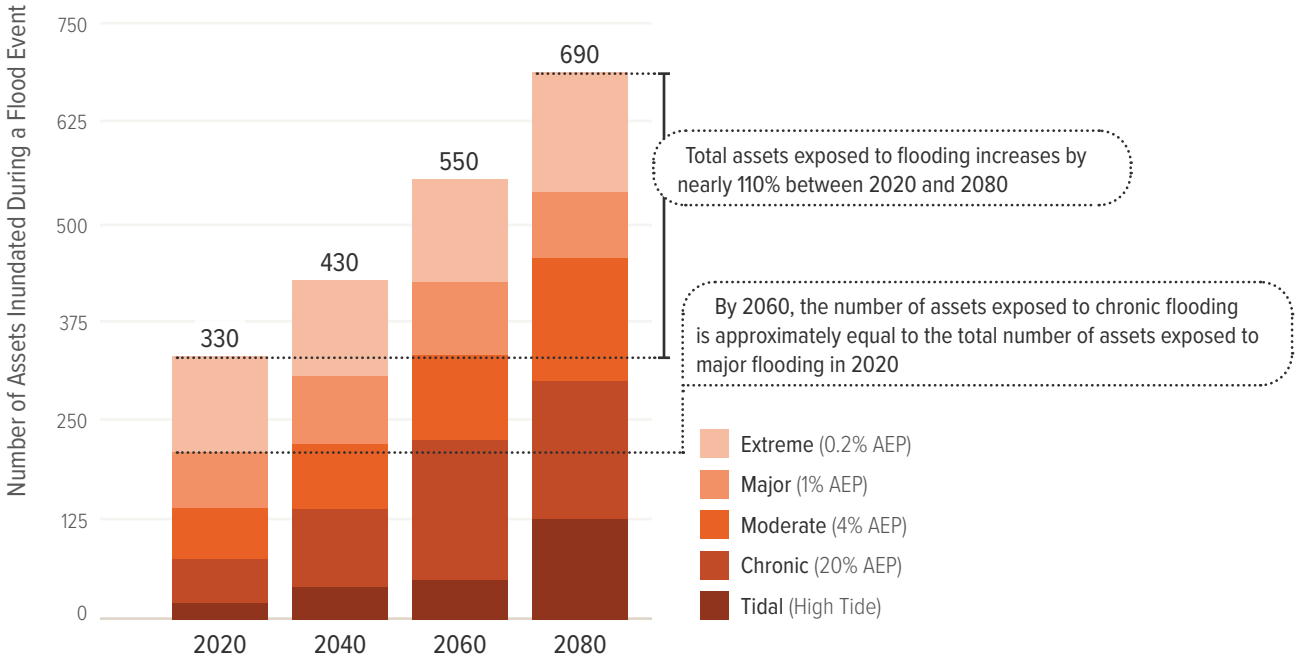
Exposure – Today, approximately 210 communication assets would be exposed during a major coastal flood. Of those, nearly 75 are exposed to chronic flooding. By 2080, the number of assets exposed to chronic flooding is projected to grow to 350, an increase of more than 360%.

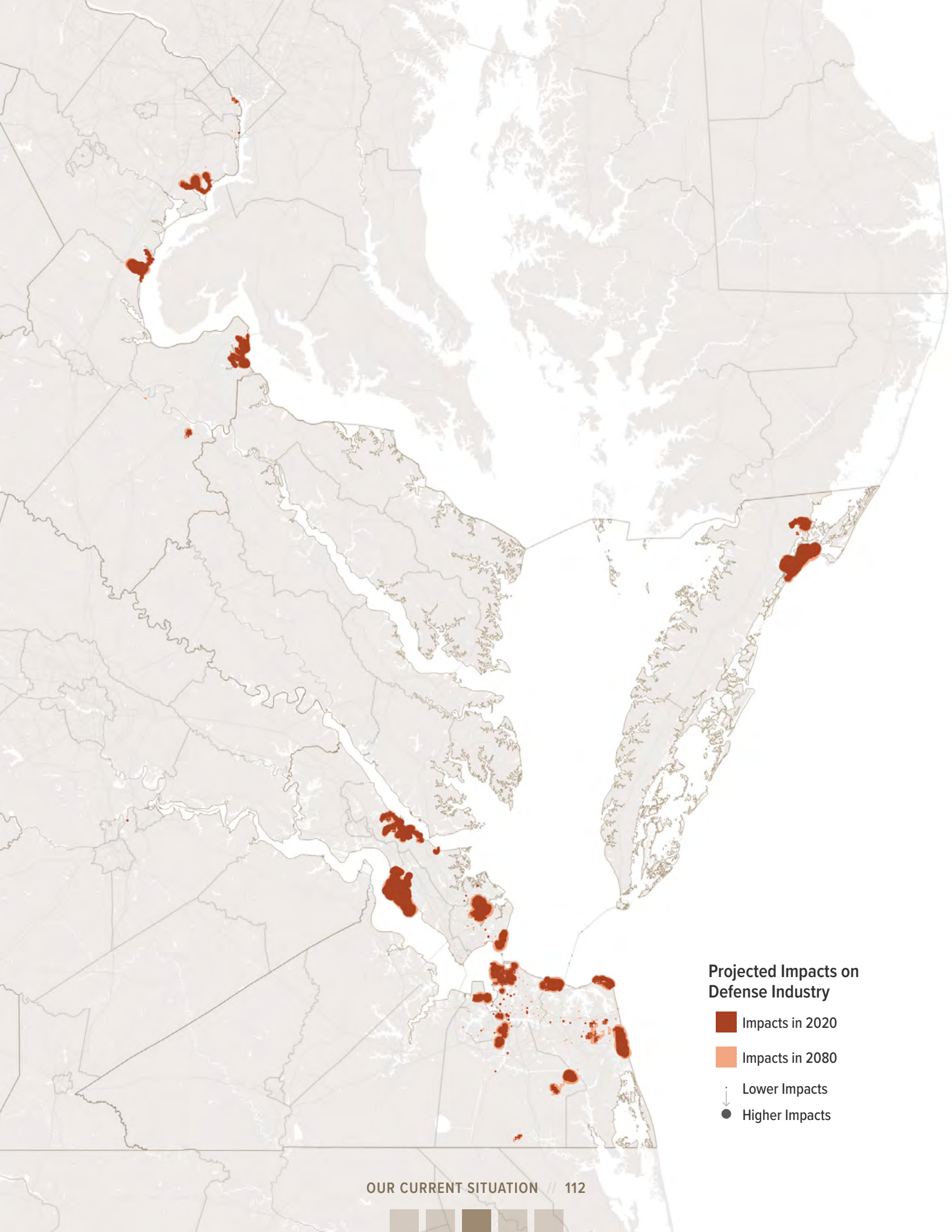
Vulnerability & Risk – The vulnerability of an individual communication facility will vary based on its unique combination of elevation, location of its critical electronics, availability of a backup generator. Also, some facilities may have already adopted resilience measures, like hardening or elevating the asset, that will affect its ability to withstand potential flood damage.

The flooding of communication systems could lead to temporary interruptions in information transmission or structural damage that results in more extended outages. Disruption to communication systems could cut some communities off from critical information, especially during emergencies.

Some facilities may be critical to service provision for a larger region, and damage to those assets may lead to wider interruptions in communications. Remote coastal communities, where there may be fewer towers and transmitters, may be more vulnerable to disruption of communication infrastructure.

Communication Asset Exposure Across Event Types




Projected Impacts on Defense Industry
Impacts in 2020
Impacts in 2080
Lower Impacts
Higher Impacts

Defense Industry

Coastal Virginia is home to 30 military installations, including the nation's largest naval base, Naval Station Norfolk. This analysis focuses on the number of acres owned by the U.S. Department of Defense (DoD). It does not assess effects on individual structures and assets located on these lands.

Exposure – By 2040, an additional 4,000 acres of lands owned by the DoD are projected to be inundated during daily high tides, if no mitigating actions are taken. By 2060, this acreage would increase to 6,400, and by 2080, to 9,600. Between 2020 and 2080, the number of DoD-owned acres exposed to extreme floods is projected to rise from 17,600 to 25,600, an increase of 45%.

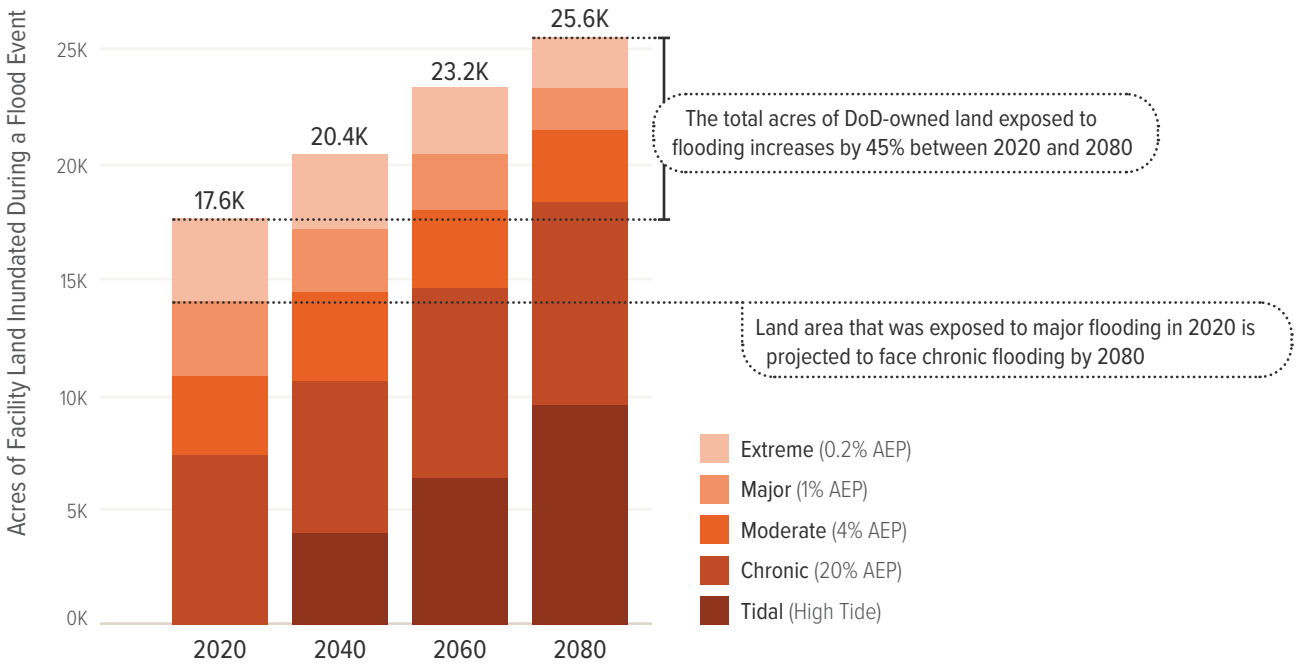
Vulnerability & Risk – Military sites support both national security and Virginia's economy, but they are increasingly vulnerable to flooding and coastal hazards due to their proximity to water. Nearly 9% of the Commonwealth's annual gross domestic product comes from defense spending, the highest of any state.[80] Damage to or destruction of military installations may have significant cascading economic impacts beyond structural or content damage.

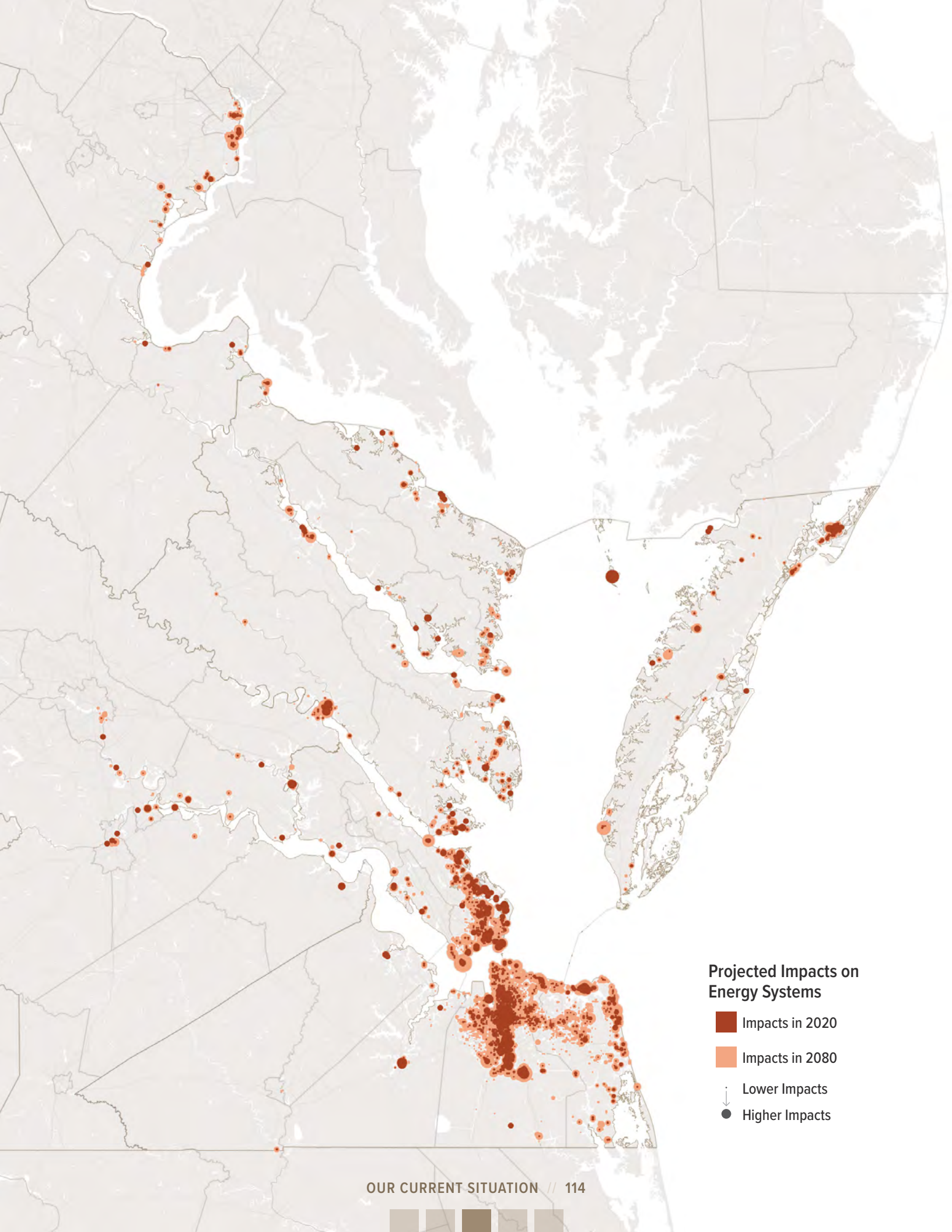
Daily and chronic flooding is likely to disrupt critical operations and correlate with high protection or response costs. Increasing the coastal resilience of these assets is of the utmost priority to the DoD. Adapting these large installations and their equipment to increasing flood hazards may be challenging, but these facilities benefit from their access to federal resources. Collaboration between military representatives and surrounding localities will be necessary to protect the safety and longevity of both the installation and the community.

Partnering with Federal Installations

Coordination among federal and state agencies, communities, and other partners can ensure that ongoing projects efficiently address the most critical resilience needs. The Federal Installation Partnerships Subcommittee identified the Sentinel Landscapes Partnership as one potential opportunity to leverage federal programs and expertise to further the Commonwealth's efforts. This program is a coalition of federal agencies, state and local governments, and non-governmental organizations that works with private landowners around military installations and ranges. The partnership's goal is to advance sustainable land management through land protection and natural resource restoration projects.

Defense Facility Exposure Across Event Types




Projected Impacts on Energy Systems
Impacts in 2020
Impacts in 2080
Lower Impacts
Higher Impacts

Energy Systems

The distribution, generation, and processing of power and fuels are essential to keeping Virginia's economy and communities moving and thriving. Like other types of infrastructure, energy facilities, including power plants and substations, are sited throughout the region but tend to be clustered around concentrations of population centers, military installations, and economic activity.

Exposure – Between now and 2080, the number of electricity assets, including generating units, substations, and power plants, exposed to a major coastal flood event is projected to rise from approximately 40 to 100, an increase of nearly 170%.

Oil and biofuel assets, including petroleum ports, tank facilities, release sites, and terminals, are also projected to see an increase in hazard exposure. The number of oil and biofuel assets exposed to a major coastal flood is projected to grow from approximately 1,700 today to 5,500 in 2080, an increase of nearly 220%. By 2080, about 2,900 oil and biofuel assets are projected to be exposed to chronic coastal flooding.

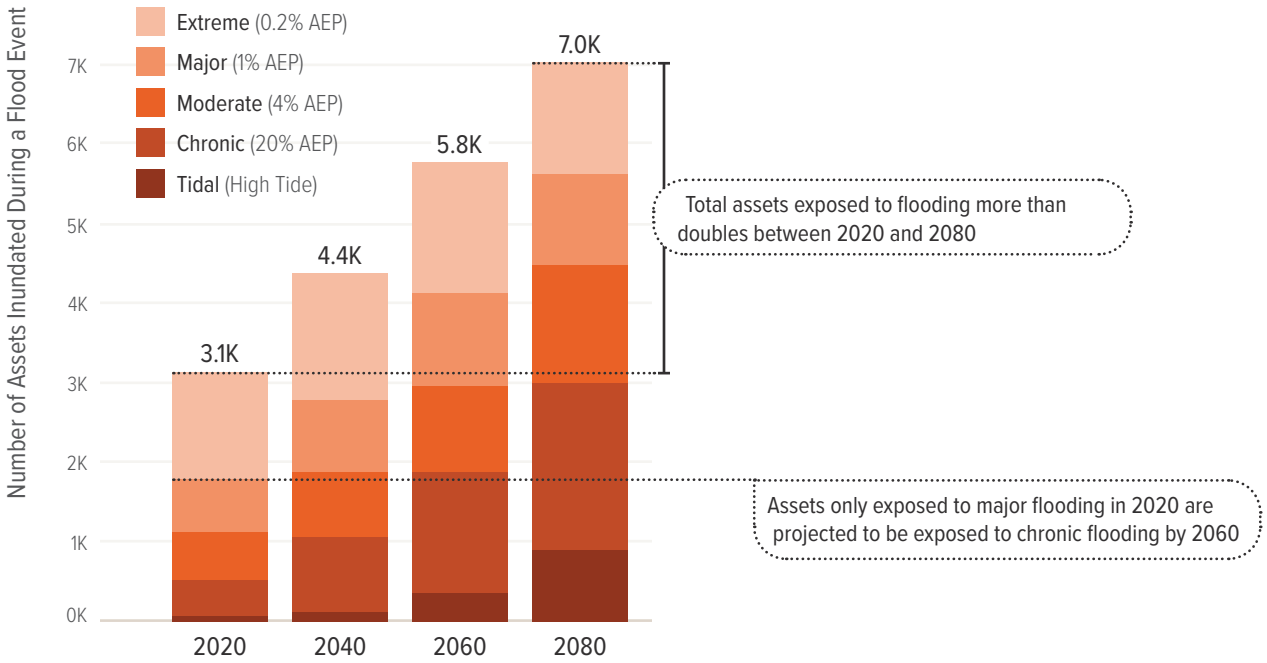
Vulnerability & Risk – Many power plants and substations were designed to coastal flooding standards that did not reflect how climate change, sea level rise, or other factors would influence these hazards over time. As they age, these facilities may become increasingly susceptible to potential damage from changing flood frequency and intensity. Flooding of energy facilities could cause temporary power outages that disrupt residents' everyday lives and businesses' ability to operate. Structural damage to energy infrastructure can lead to extended outages or material spills.

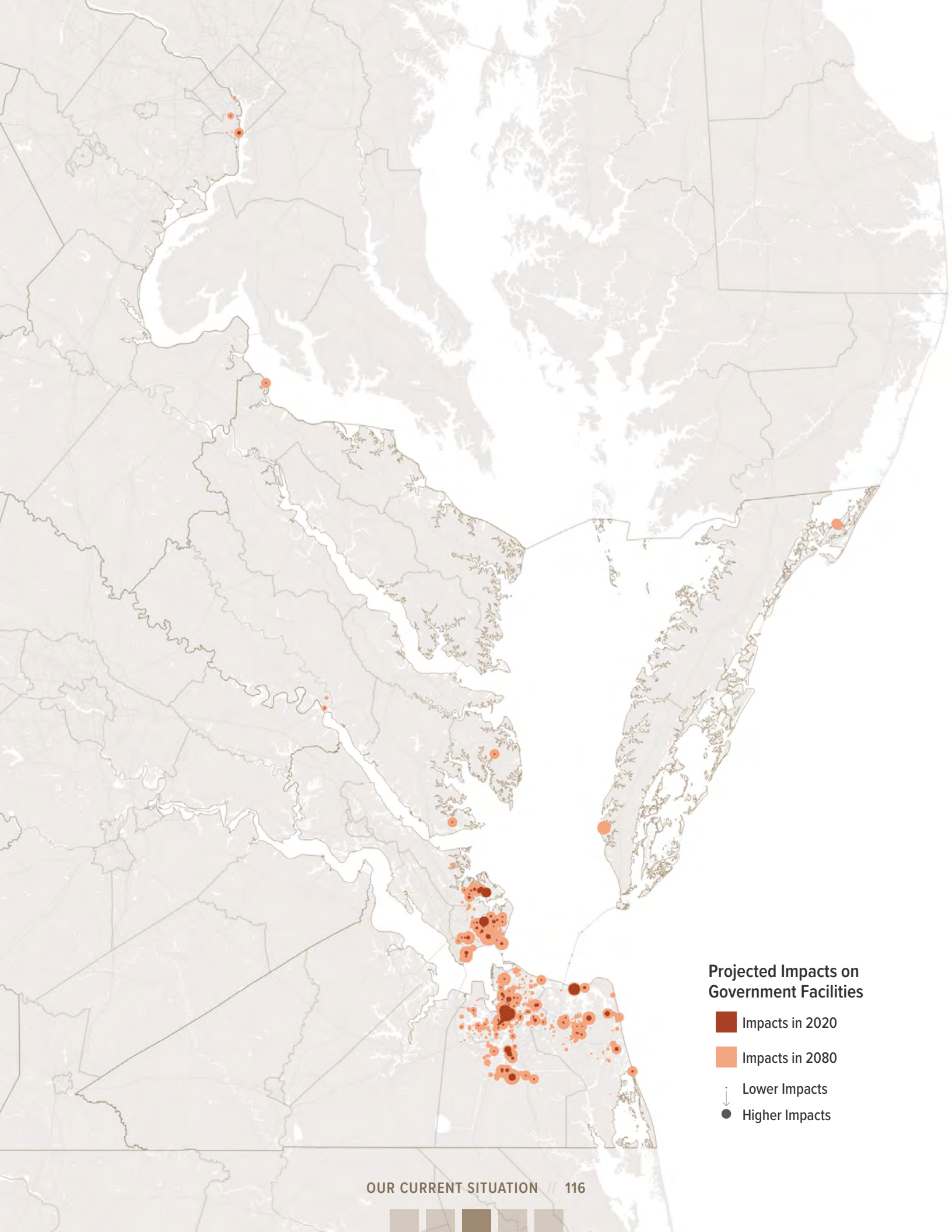
Compounding Impacts

Power outages may lead to business and academic closures that pave the way for indirect and compounding impacts, like wage loss and school absences. Power outages may also rapidly intensify the health risks for individuals who may rely on power-generated medical support, like oxygen tanks.

Additionally, hurricanes and tropical storms typically occur in the warmers months, from late spring through the fall.[81] Outages could disrupt cooling systems, like air conditioning or fans, and elevate the risk for heat-related illnesses for vulnerable individuals, like the elderly, or those with underlying conditions.

Energy Asset Exposure Across Event Types




Projected Impacts on Government Facilities
Impacts in 2020
Impacts in 2080
Lower Impacts
Higher Impacts

Government Facilities

Government facilities include buildings owned or leased by federal, state, and local governments. These structures include educational facilities, state and federal government buildings, and courthouses. Some of these buildings may be open to the public for use, while others may be closed to the public and contain highly sensitive activities and materials.

Exposure – Today, 60 schools, including childcare centers, colleges and universities, and public and private schools, are exposed to major coastal floods. By 2080, this number is projected to rise to nearly 390, an increase of approximately 540%.

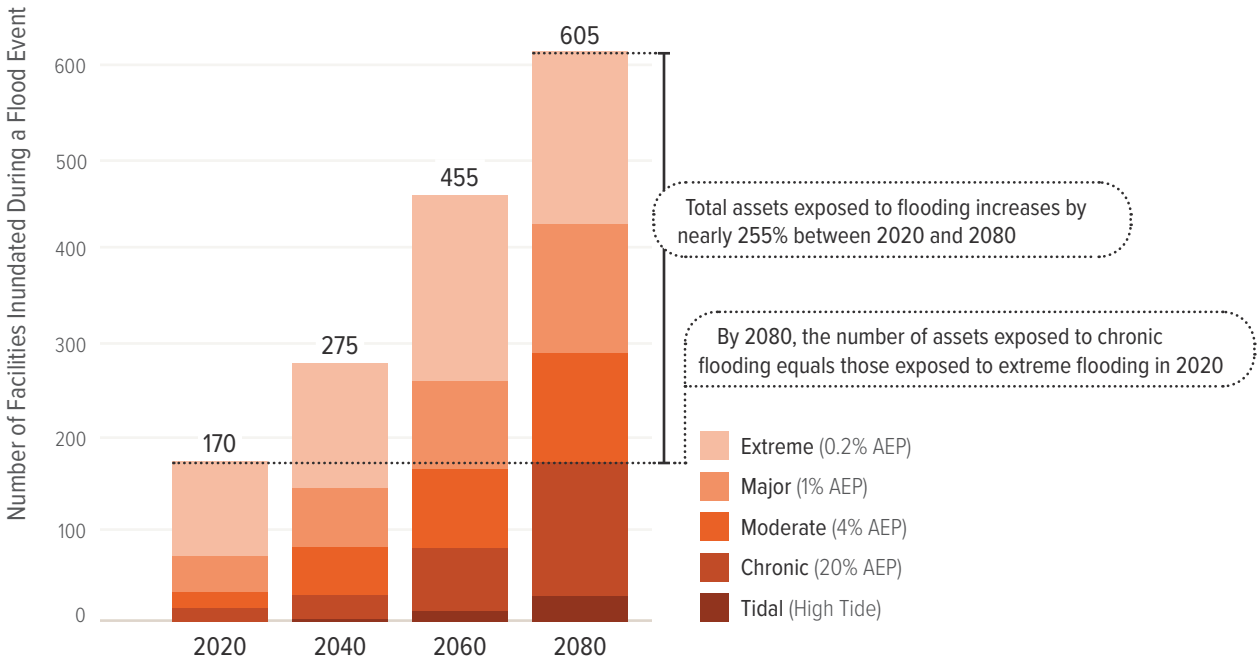
Between 2020 and 2080, the number of government buildings exposed during a major coastal flood is projected to rise from 70 to 420, an increase of about 510%. The total number of government buildings exposed to chronic flooding is projected to grow from under 20 today to approximately 170 in 2080, an increase of 1,040%.

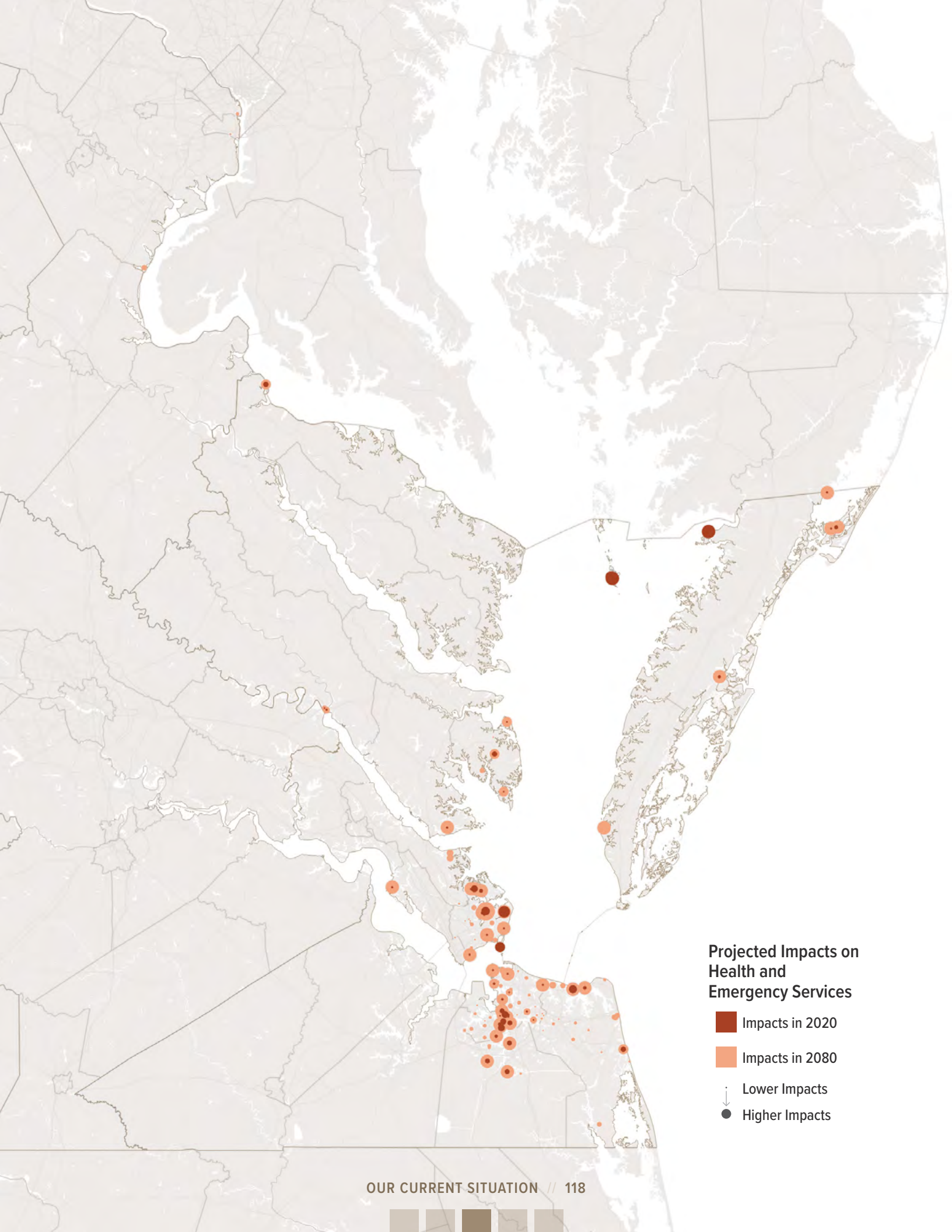
Vulnerability & Risk – Each facility's sensitivity and capacity to adapt to worsening flood hazards depends on its exact location, age, and construction materials. The potential risk to government facilities extends beyond monetary losses to structures or contents, as these sites often serve additional community functions, such as emergency operations centers, evacuation centers, and community meeting spaces. Further, some of Virginia's government buildings may also be considered historically and culturally significant resources, the value of which is difficult to capture in economic terms.

Compounding Impacts

Government facilities can serve multiple functions, like schools offering free information or resources to residents or setting up public cooling centers during the summer months. The potential loss or disruption of these services can have outsized effects on affected communities, particularly socially vulnerable populations who may rely on these resources.

Government Facility Exposure Across Event Types




Projected Impacts on Health and Emergency Services
Impacts in 2020
Impacts in 2080
Lower Impacts
Higher Impacts

Health and Emergency Services

Health and emergency services are essential to keeping all Virginians healthy and safe. These facilities include hospitals, emergency medical services, fire stations, emergency operation centers, and local law enforcement.

Exposure – Hospitals have overall low coastal flood hazard exposure today. If an extreme coastal flood occurred today, seven hospitals would be exposed to flooding. By 2080, these seven hospitals are projected to experience chronic flood exposure. At this point in time, approximately 15 hospitals are projected to be exposed during extreme coastal floods, an overall increase of nearly 90%.

Emergency service facilities will also see an increase in flood exposure. Between now and 2080, emergency services facilities exposed to major coastal floods are projected to grow from nearly 50 to 165, an increase of approximately 240%, and facilities exposed to chronic flooding are projected to rise from approximately 10 to 80, an increase of nearly 640%.

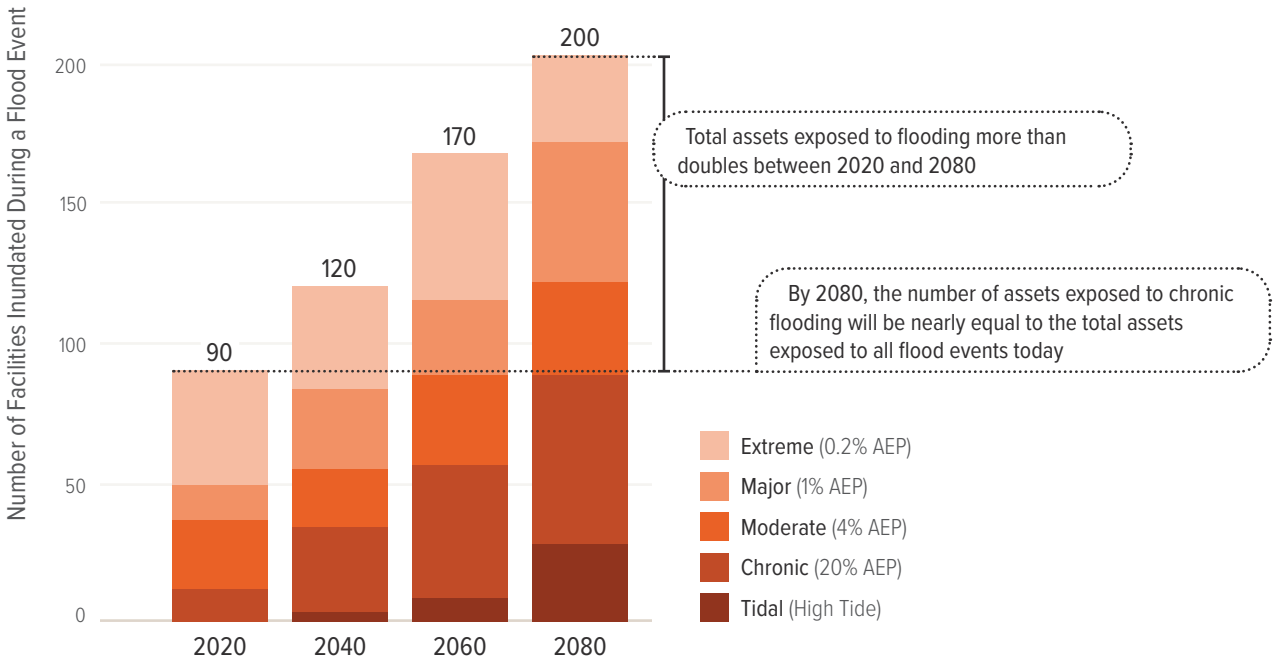
Vulnerability & Risk – Hospitals and emergency medical service stations often rely on critical electric equipment that may be vulnerable if located at or below ground level. Fire stations, emergency operation centers, and local law enforcement serve as central locations for services that respond to community needs, and if damaged, may disrupt essential services to their communities.

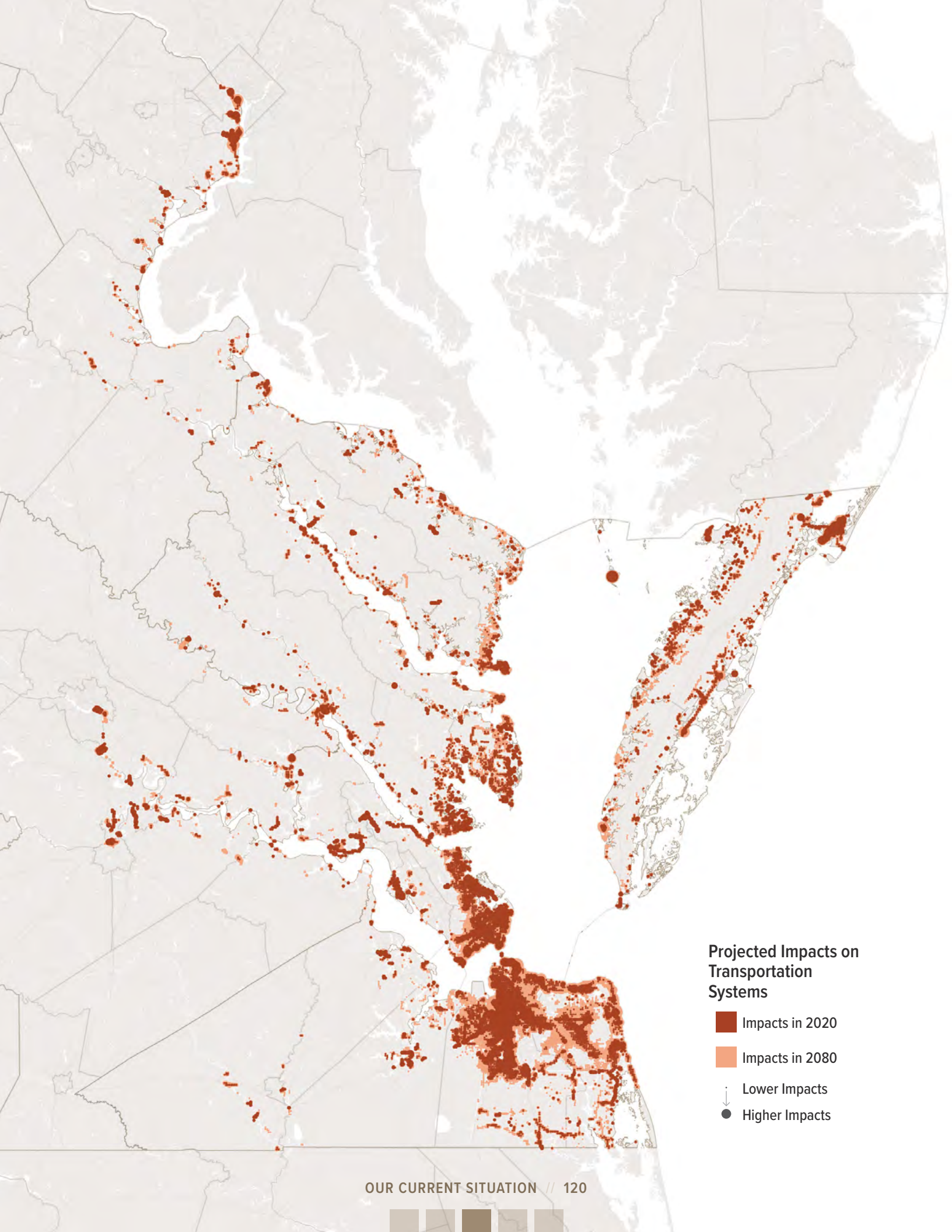
Linkages to Transportation Systems

Health and emergency services facilities require safe and clear roadways to perform their necessary functions. If responders' vehicles are damaged or unable to pass floodwaters, then there can be severe consequences to public health and safety.

Flooded roadways can also prevent residents from reaching health facilities and local law enforcement locations. In addition to adapting facilities, jurisdictions may need to spend time and money to protect other critical sector assets to ensure that health and emergency services can properly function.

Health and Emergency Service Facility Exposure Across Event Types




Projected Impacts on Transportation Systems
Impacts in 2020
Impacts in 2080
Lower Impacts
Higher Impacts

Transportation Systems

Coastal Virginia contains a dense network of roads, bridges, railways, ports, post offices, transit facilities, and airports. These interconnected assets allow for the movement of goods and people, and provision of many essential services. This section focuses specifically on airports, shipping and freight facilities, ports, and railways. The following page presents impacts to roadways separately.

Exposure – Today, nearly 1,600 combined transportation assets — including airports, freight, port, and shipping facilities, and railways — are exposed to major coastal floods. By 2080, the number of assets exposed to major coastal floods will grow to almost 2,500, an increase of 55%.

Many other transportation assets are projected to be exposed to chronic flooding. By 2080, chronic flooding is projected to affect roughly 20 airports, nearly 150 mail and shipping facilities, almost 990 port facilities, and 760 railroad segments.

Multi-modal transportation is an essential component of Virginia's economy and a high number of transportation assets assessed as exposed to tidal and chronic flooding today is reflective of the many port and shipping facilities that are located in or adjacent to bodies of water.

Vulnerability & Risk – Flooding of transportation networks and systems may cause structural damage and service disruption that have wide-ranging and potentially compounding effects that can disrupt emergency management, public health, businesses, and the energy sector, among others.

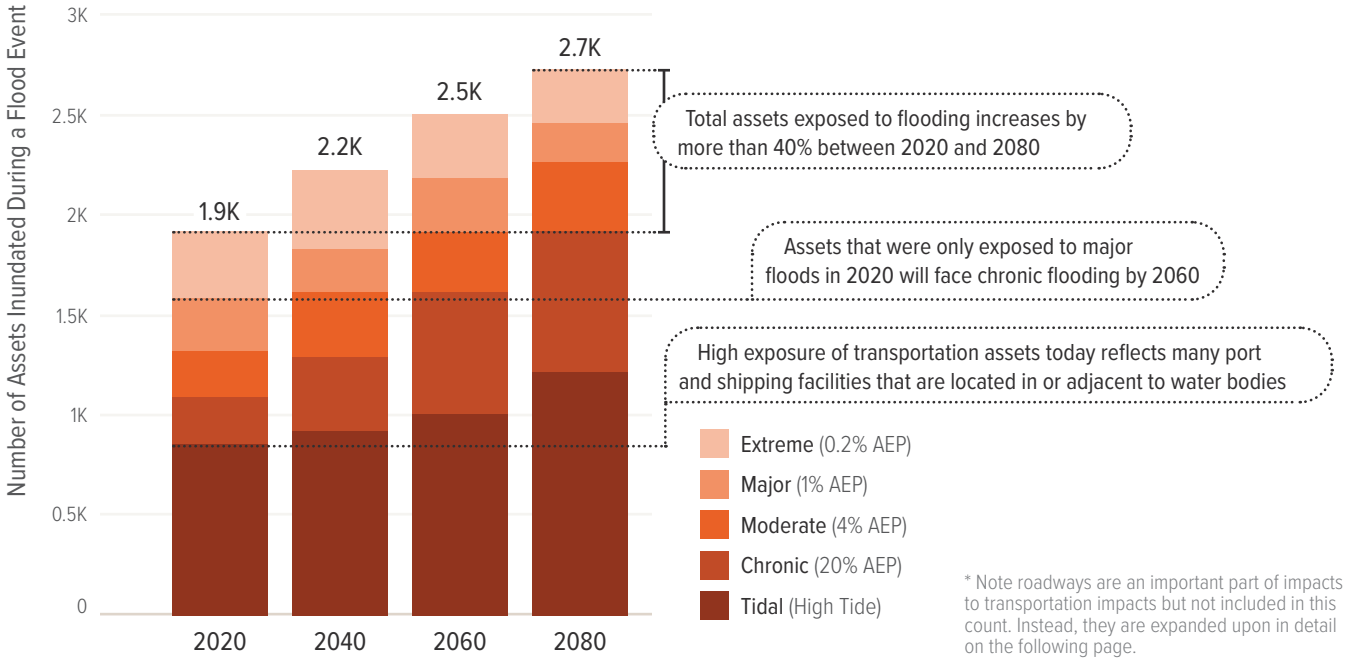
Some transportation assets may be more critical than others and, therefore, a greater potential source of risk.

Community Vulnerability & Capacity

Repeated disruptions to transportation networks in under-resourced communities could exacerbate certain inequities over time by preventing residents from accessing education, work, healthcare, and other essential services.

Further, residents without reliable access to a personal vehicle may be unable to safely reach their destinations if floodwaters block transit routes, sidewalks, or bikeways.

Airports, Port, Freight, and Shipping Facilities, and Railway Asset Exposure Across Event Types*



* Note roadways are an important part of impacts to transportation impacts but not included in this count. Instead, they are expanded upon in detail on the following page.

Impacts on Roadways

Roadways allow the movement of people and goods throughout coastal Virginia and beyond and are critical to the Commonwealth's economy. Already, some communities experience regular flooding of roadways that disrupt residents' lives, supply chains, essential services, and more. This first phase of the Master Plan considers impacts to primary roadways (two or more lanes that connect across communities), secondary (local), and frontage roadways, but excludes impacts to bridges and tunnels.

Exposure – Approximately 1,650 miles of roadways would be flooded during a major flood today. Between 2020 and 2080, nearly 3,200 additional miles are projected to be exposed to a major flood, an increase of almost 200%. Similarly, many more roadways will be exposed to more frequent flood events, including tidal and chronic floods. The number of roadway miles exposed to chronic flooding is projected to increase by approximately 460% between 2020 and 2080, from about 500 miles to nearly 2,800 miles. And by 2080, over 920 miles of roadway may be fully unusable, as they are on land projected to become open water or inundated by daily high tides.

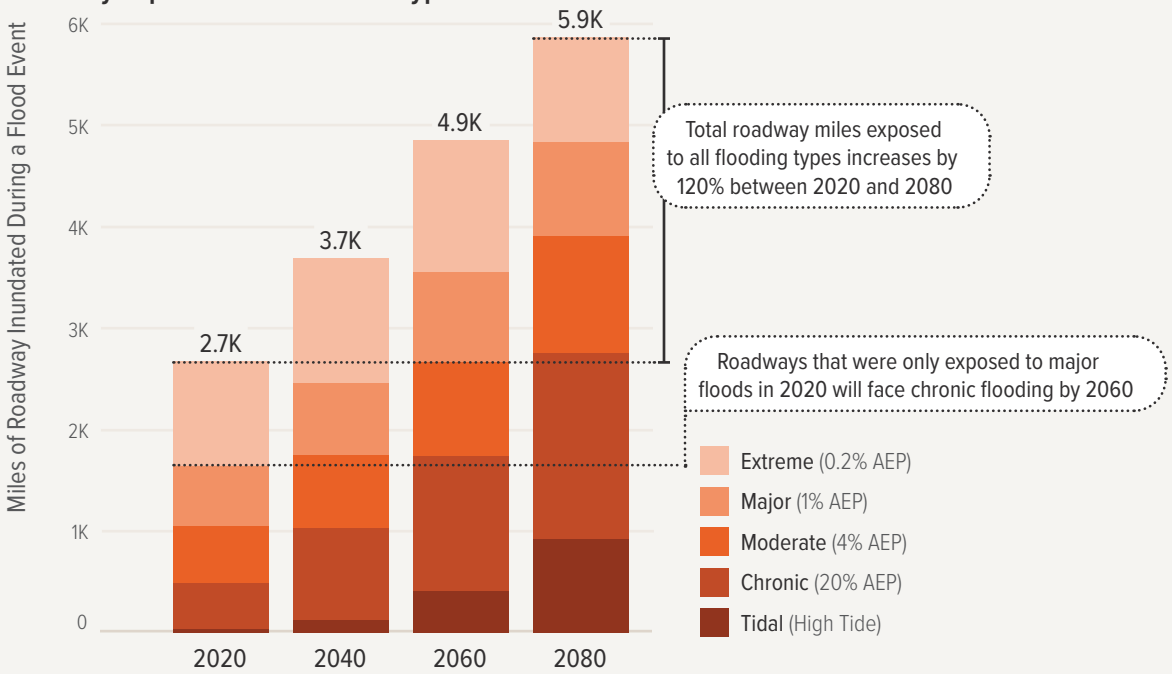
The extent of this disruption to roadways due to flooding likely extends far beyond these mileage numbers as if one part of a road is impassable due to floodwaters, the entire roadway segment is unusable.

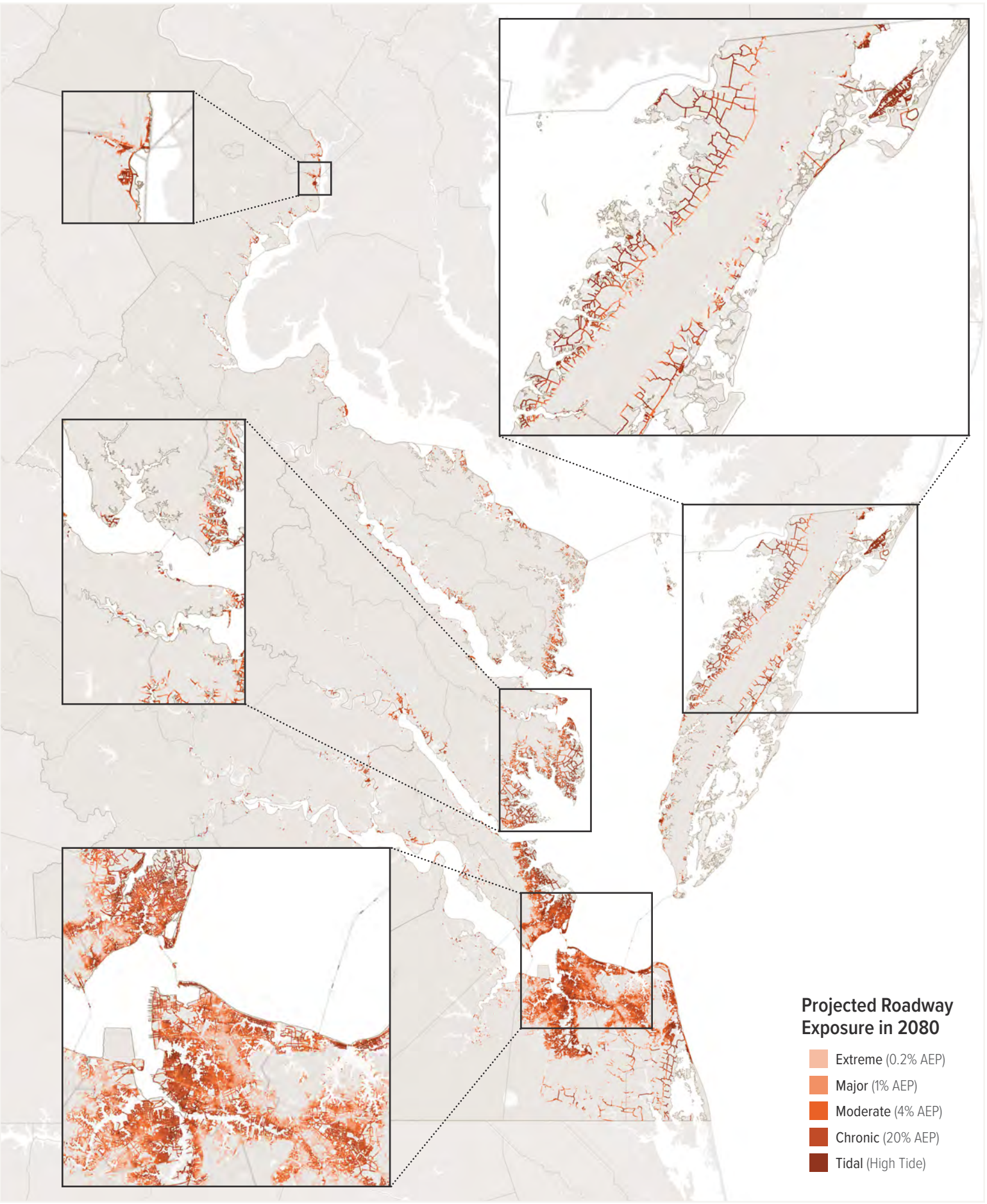
Vulnerability & Risk – As flooding worsens, not only will the number of miles exposed to floodwaters increase, but the depth of flooding will increase as well, causing more dangerous roadway conditions.

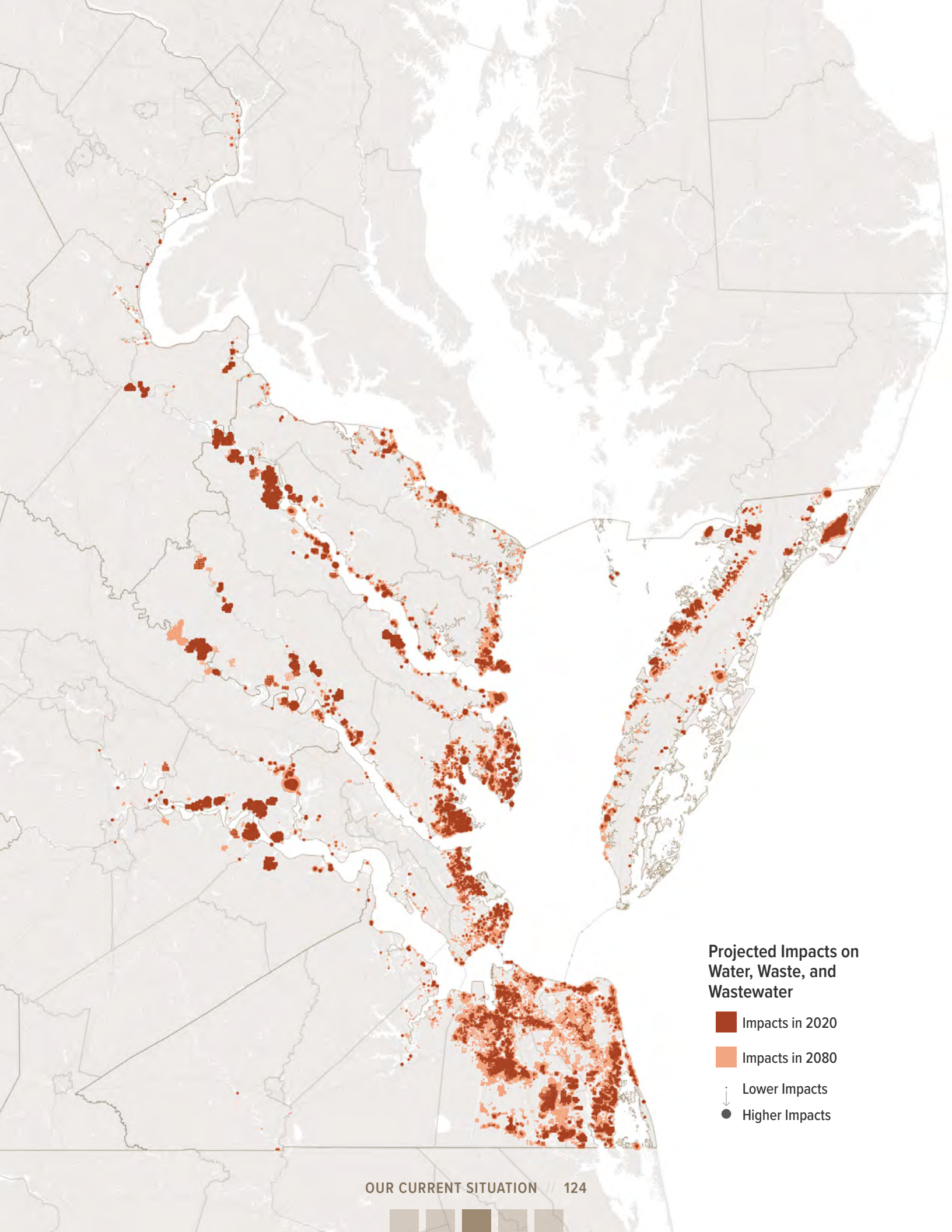
Many localities in coastal Virginia are already seeing increasingly frequent and severe flooding of roadways. For roadways that serve as hurricane evacuation or emergency service routes, increasingly frequent flooding poses additional risks to surrounding communities. Other roadways may serve as the only access to remote communities.

Bridges, tunnels, culverts and other related infrastructure can also be significantly impacted by flood hazards but were not considered in this analysis.

Roadway Exposure Across Event Types




Projected Roadway Exposure in 2080
Extreme (0.2% AEP)
Major (1% AEP)
Moderate (4% AEP)
Chronic (20% AEP)
Tidal (High Tide)


Projected Impacts on Water, Waste, and Wastewater
Impacts in 2020
Impacts in 2080
Lower Impacts
Higher Impacts

Water, Waste, and Wastewater

Water, waste, and wastewater facilities ensure that Virginia's communities are clean and healthy by protecting water supplies and managing refuse. These assets include drinking water wells, septic systems, solid waste facilities, and wastewater treatment facilities, among other relevant assets.

Exposure – The number of waste sites, including hazardous waste generators and solid waste facilities, exposed to major coastal floods is projected to grow from 270 today to nearly 900 by 2080, an increase of 230%. Of those, about 430 sites would experience chronic flooding, up from approximately 80 sites in 2020, increasing by 430%.

At the same time, the number of wastewater assets, including biosolid areas, septic systems, and wastewater treatment facilities, exposed to major flooding is projected to grow from 3,600 in 2020 to 8,400 in 2080, an increase of nearly 130%. The number of assets exposed to chronic flooding is expected to rise from 1,300 to 5,700, an increase of nearly 330%.

Between 2020 and 2080, the number of drinking water wells exposed to major coastal floods is projected to grow from almost 4,000 to over 13,000, rising by 230%. Those exposed to chronic flooding is projected to grow from 930 to 7,300, increasing by nearly 690%.

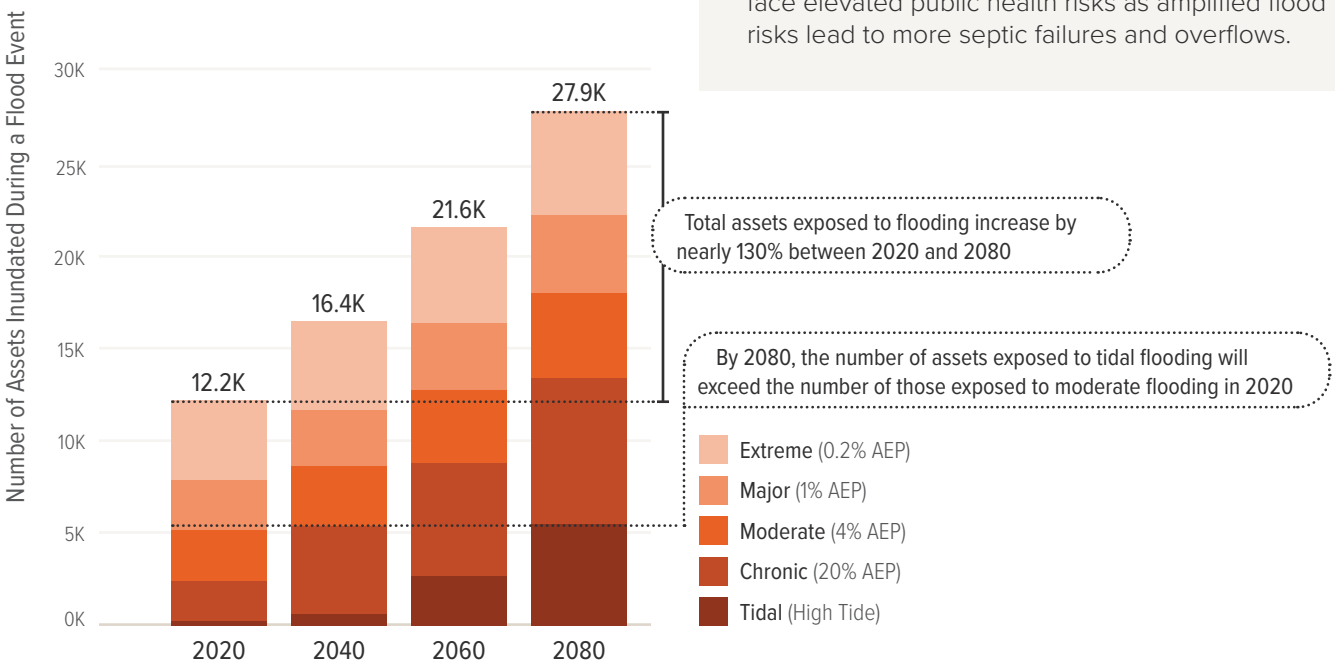
Vulnerability & Risk – The vulnerability of these sites depends on their exact location, the materials held, and the structural integrity of the individual facility. For septic specifically, aging and unmaintained systems may be increasingly susceptible to backups and overflows that can cause significant property and soil damage, as well as potential health risks.[82] Some water supplies may face additional threats to quality due to compounding factors, like changes in groundwater and salinity. These potential adverse impacts can have rippling economic and social implications if they impair Virginians' ability to swim or fish safely.

Flooding of these sites may cause structural damage or system failures that contaminate water and soil supplies. Specifically, floodwaters may carry refuse and potentially harmful substances from waste facilities into residential areas or water bodies, creating potential health and environmental risks. Flood damage can also cause water treatment facilities to reduce service or shut down, causing a potentially significant loss of access to potable water to people and businesses. For wastewater treatment plants specifically, relocation may not be an option because these facilities must be located near water bodies to discharge treated liquids.

Public Health Implications

Rural communities that depend on septic systems face elevated public health risks as amplified flood risks lead to more septic failures and overflows.

Water, Waste, and Wastewater Asset Exposure Across Event Types



Critical Sector Hotspots:

Hampton Roads

Critical Sectors in Hampton Roads

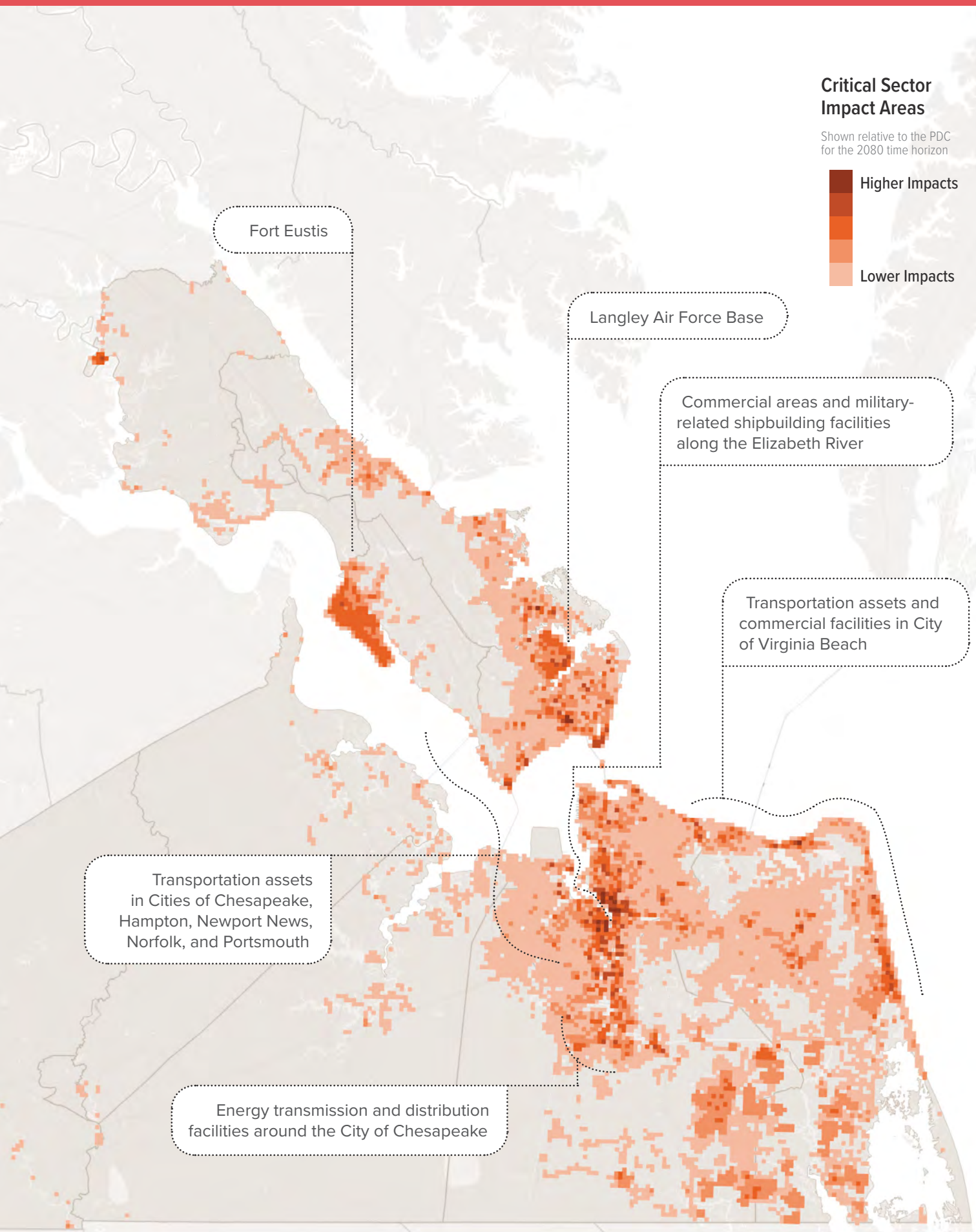
Hampton Roads requires a robust network of infrastructure to support its regional economy. The region contains several port facilities, including three terminals in Norfolk, Portsmouth, and Newport News that make up the Port of the Virginia. The region's roadways are known to flood regularly, particularly during intense rainfall events, which affects even inland and upland areas.

Energy Assets Exposed		2020	2080	Change
Hampton Roads PDC	High tide	25	615	+ 2273%
	Extreme flood	2,670	6,190	+ 132%

Roadway Miles Exposed		2020	2080	Change
Hampton Roads PDC	High tide	20	435	+ 2075%
	Extreme flood	1,855	4,435	+ 139%

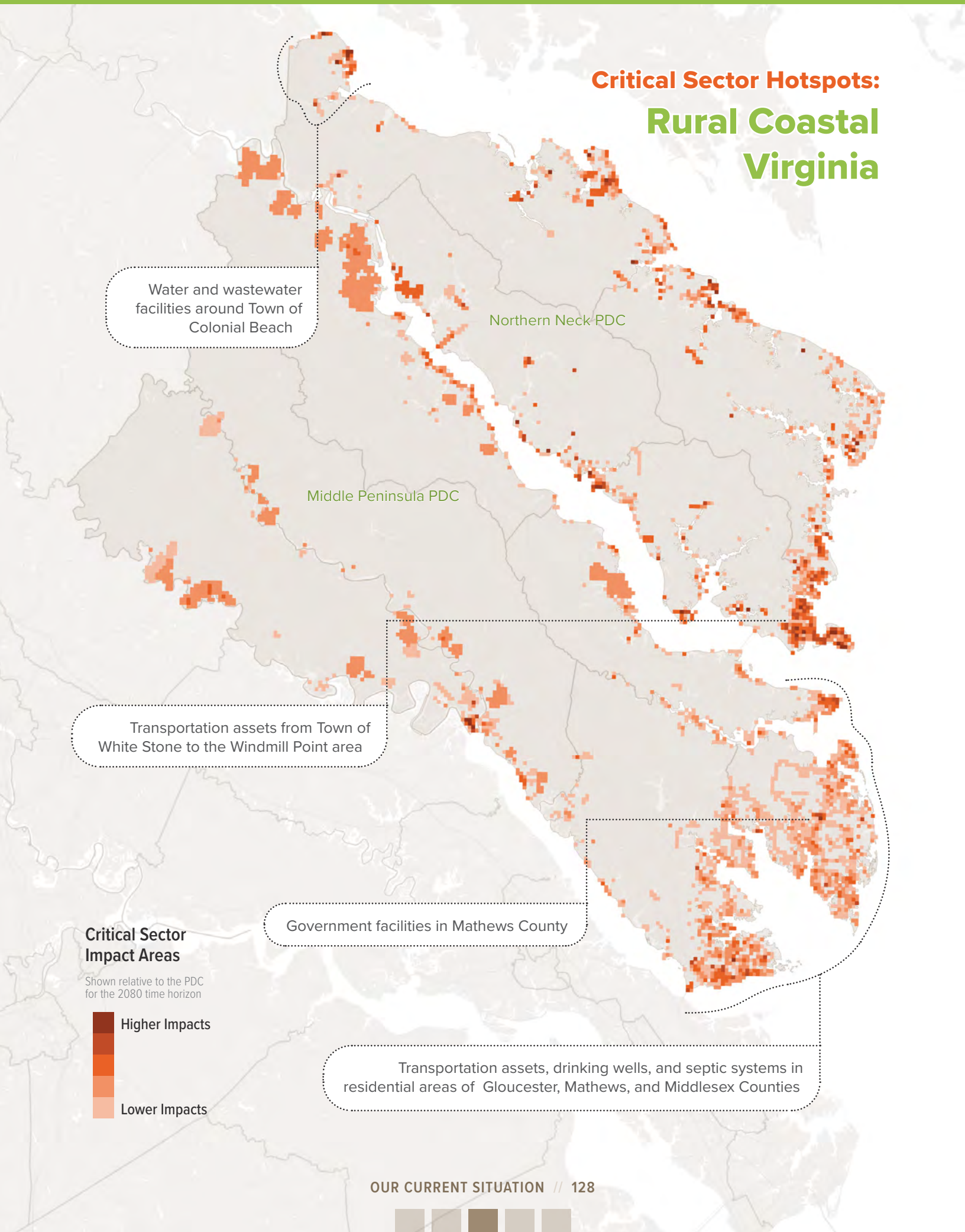
Water, Wastewater, and Waste		2020	2080	Change
Hampton Roads PDC	High tide	60	1,800	+ 2954%
	Extreme flood	6,450	18,550	+ 188%

Differences in asset exposure numbers and percentage changes can be attributed to rounding for presentation. Percentage changes reflect exact exposure numbers.


Critical Sector Impact Areas
Shown relative to the PDC for the 2080 time horizon
Higher Impacts
Lower Impacts
Fort Eustis
Langley Air Force Base
Commercial areas and military-related shipbuilding facilities along the Elizabeth River
Transportation assets and commercial facilities in City of Virginia Beach
Transportation assets in Cities of Chesapeake, Hampton, Newport News, Norfolk, and Portsmouth
Energy transmission and distribution facilities around the City of Chesapeake

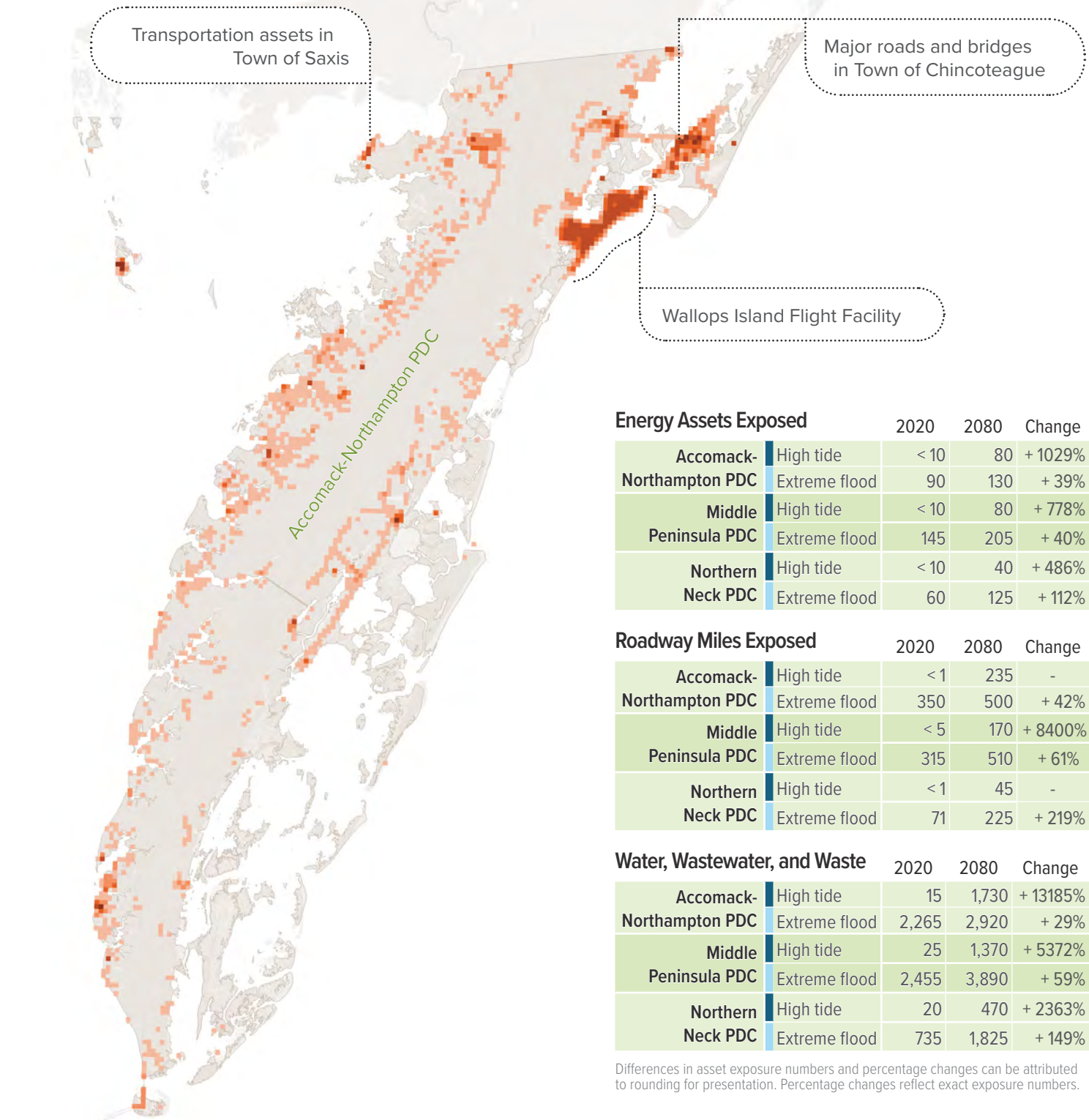
Critical Sector Hotspots:

Rural Coastal Virginia



Critical Sectors in Rural Coastal Virginia

Rural Coastal Virginia contains many major thoroughfares and transportation corridors that connect its dispersed residential communities. The region also contains defense sites, including the NASA Wallops Flight Facility, in remote areas that face increasing coastal flood hazards. Rural Coastal Virginia communities tend to rely on septic systems, which, if inundated, can pose human health risks.



Energy Assets Exposed		2020	2080	Change
Accomack-Northampton PDC	High tide	< 10	80	+ 1029%
	Extreme flood	90	130	+ 39%
Middle Peninsula PDC	High tide	< 10	80	+ 778%
	Extreme flood	145	205	+ 40%
Northern Neck PDC	High tide	< 10	40	+ 486%
	Extreme flood	60	125	+ 112%

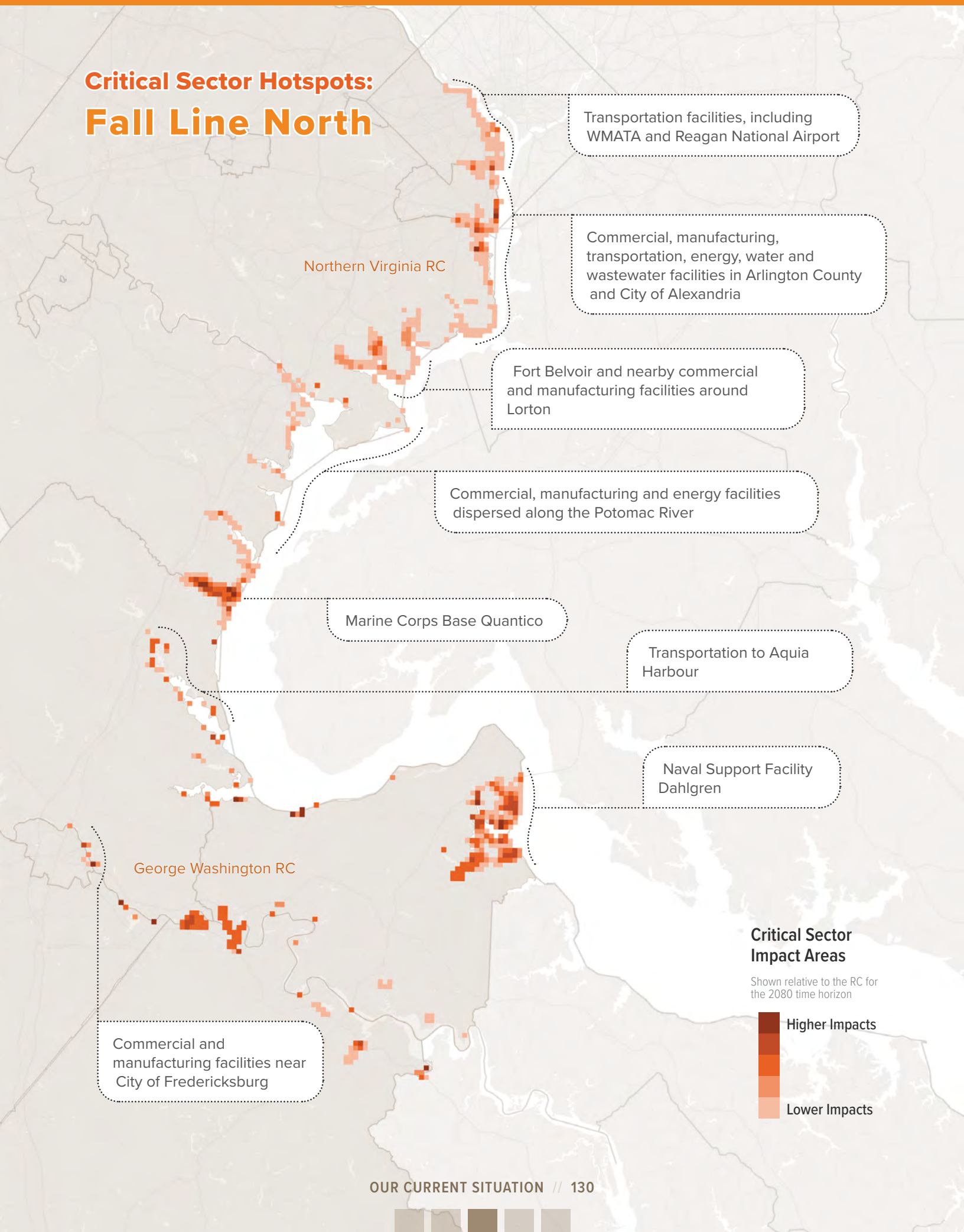
Roadway Miles Exposed		2020	2080	Change
Accomack-Northampton PDC	High tide	< 1	235	-
	Extreme flood	350	500	+ 42%
Middle Peninsula PDC	High tide	< 5	170	+ 8400%
	Extreme flood	315	510	+ 61%
Northern Neck PDC	High tide	< 1	45	-
	Extreme flood	71	225	+ 219%

Water, Wastewater, and Waste		2020	2080	Change
Accomack-Northampton PDC	High tide	15	1,730	+ 13185%
	Extreme flood	2,265	2,920	+ 29%
Middle Peninsula PDC	High tide	25	1,370	+ 5372%
	Extreme flood	2,455	3,890	+ 59%
Northern Neck PDC	High tide	20	470	+ 2363%
	Extreme flood	735	1,825	+ 149%

Differences in asset exposure numbers and percentage changes can be attributed to rounding for presentation. Percentage changes reflect exact exposure numbers.

Critical Sector Hotspots:

Fall Line North



Critical Sectors in Fall Line North

Fall Line North's dense and intense development patterns requires significant supporting physical infrastructure. The region's proximity to Washington, D.C. has also made it an attractive location for federal facilities and defense sites, including multiple military bases. Many of these facilities and systems were constructed in low-lying areas along the Potomac River, which is increasingly at risk of overflowing.

Energy Assets Exposed		2020	2080	Change
George Washington RC	High tide	0	< 10	-
	Extreme flood	< 10	15	+ 114%
Northern Virginia RC	High tide	< 5	30	+ 2900%
	Extreme flood	100	235	+ 139%

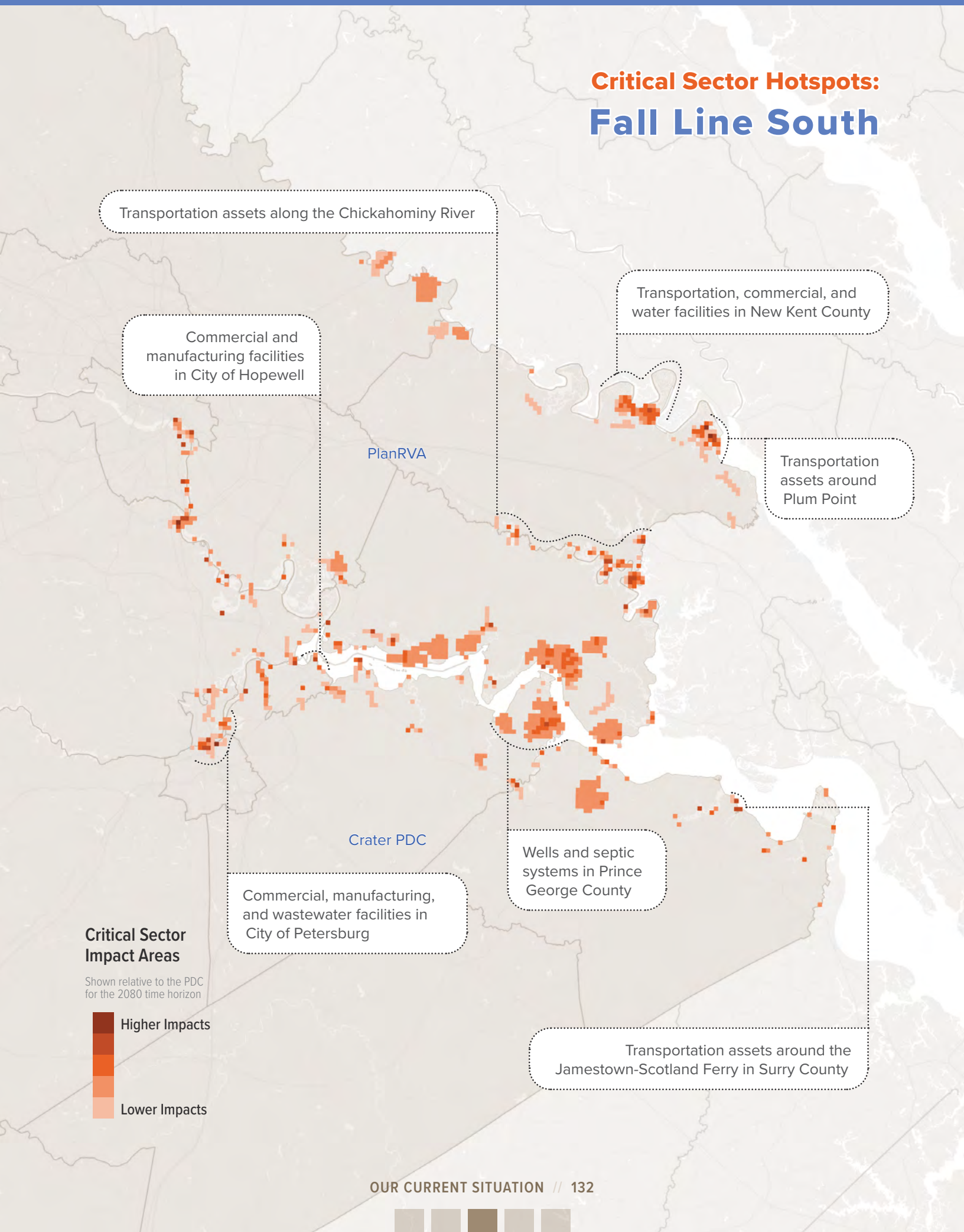
Roadway Miles Exposed		2020	2080	Change
George Washington RC	High tide	< 1	< 5	+ 675%
	Extreme flood	< 10	20	+ 225%
Northern Virginia RC	High tide	< 5	20	+ 947%
	Extreme flood	40	105	+ 148%

Water, Wastewater, and Waste		2020	2080	Change
George Washington RC	High tide	< 5	15	+ 550%
	Extreme flood	30	75	+ 178%
Northern Virginia RC	High tide	< 5	10	+ 900%
	Extreme flood	20	45	+ 120%

Differences in asset exposure numbers and percentage changes can be attributed to rounding for presentation. Percentage changes reflect exact exposure numbers.

Critical Sector Hotspots:

Fall Line South



Critical Sectors in Fall Line South

Fall Line South contains roadways, rail lines, airports, and ports that move both people and goods throughout the region and beyond. Many government facilities are in and around Richmond, the Commonwealth's capital city. The region already experiences significant rainfall-driven flooding, affecting suburban and rural communities with more limited access to infrastructure and other critical sector facilities.

Energy Assets Exposed		2020	2080	Change
Crater PDC	High tide	< 10	10	+ 120%
	Extreme flood	20	25	+ 42%
PlanRVA	High tide	< 10	10	+ 100%
	Extreme flood	30	80	+ 152%

Roadway Miles Exposed		2020	2080	Change
Crater PDC	High tide	< 1	< 5	+ 403%
	Extreme flood	< 10	20	+ 219%
PlanRVA	High tide	< 5	< 10	+ 275%
	Extreme flood	20	50	+ 122%

Water, Wastewater, and Waste		2020	2080	Change
Crater PDC	High tide	< 5	20	+ 850%
	Extreme flood	40	55	+ 39%
PlanRVA	High tide	10	55	+ 367%
	Extreme flood	195	565	+ 192%

Differences in asset exposure numbers and percentage changes can be attributed to rounding for presentation. Percentage changes reflect exact exposure numbers.

Impacts on Natural Infrastructure

Natural Infrastructure refers to native coastal and aquatic environments that provide fish and wildlife habitat, protect water quality, reduce potential flood risks, and numerous other ecosystem services and co-benefits to coastal Virginia.

These natural landscapes support tourist- and recreation-driven economies and hold cultural significance to local communities. Virginia's natural assets draw in tourists who spend over $5.2 billion every year.[83] If these assets were damaged or destroyed by a flood, nearby communities may experience impaired recreation, like fishing, hunting, swimming, or hiking. These habitats also provide ecosystem services, like protecting water quality and serving as natural flood buffers. Damage to these assets could lead to impaired water quality, heightened flood risks, and even diminishing property values and municipal tax revenues over time. Understanding these potential impacts is vital to safeguard coastal Virginia's natural beauty, ecosystem services, and economy. The following sections summarize impacts on Natural Infrastructure by asset type and by Master Planning Region. For each Master Planning Region, impact hotspots are presented to illustrate areas projected to experience higher impacts relative to the rest of the region. See Appendix E for details on how impact metrics and hotspots are calculated.

What Is a Natural Infrastructure Hotspot?

An impact hotspot refers to an area that contains a concentration of identified habitats or lands projected to be affected by coastal flooding.

Each ecosystem responds differently to rising sea levels and modeling these complex and dynamic relationships is challenging. These potential impacts are measured using unique metrics. To illustrate hotspots, these metrics are standardized to aggregate and compare impacts across different assets, both statewide and within the Master Planning Regions.

Limitations to Modeling Natural Infrastructure Impacts

Coastal and aquatic ecosystems are complex and dynamic systems that naturally respond to changes in their surroundings, like rising sea and salinity levels. The Technical Study's impact assessment does not consider habitat migration or accretion that would offset ecosystem loss or external factors, like coastal geomorphology or development pressures. This assessment provides a first-order approximation of the risk to Natural Infrastructure assets to help the Commonwealth identify potential statewide resilience needs and opportunities. Future phases of the Master Plan may leverage more robust and dynamic state-wide modeling to refine these analyses.

Public and Professional Perspectives: Lived Experiences with Natural Infrastructure Impacts

Over 1,300 Virginians responded to a public online survey with questions relating to their lived flooding experiences. Of those respondents:

46% of residents whose properties have been damaged by a flood have witnessed soil washout or erosion.

Nearly 100 representatives from government and partner organizations responded to a survey with questions related to their professional experiences. Of those respondents:

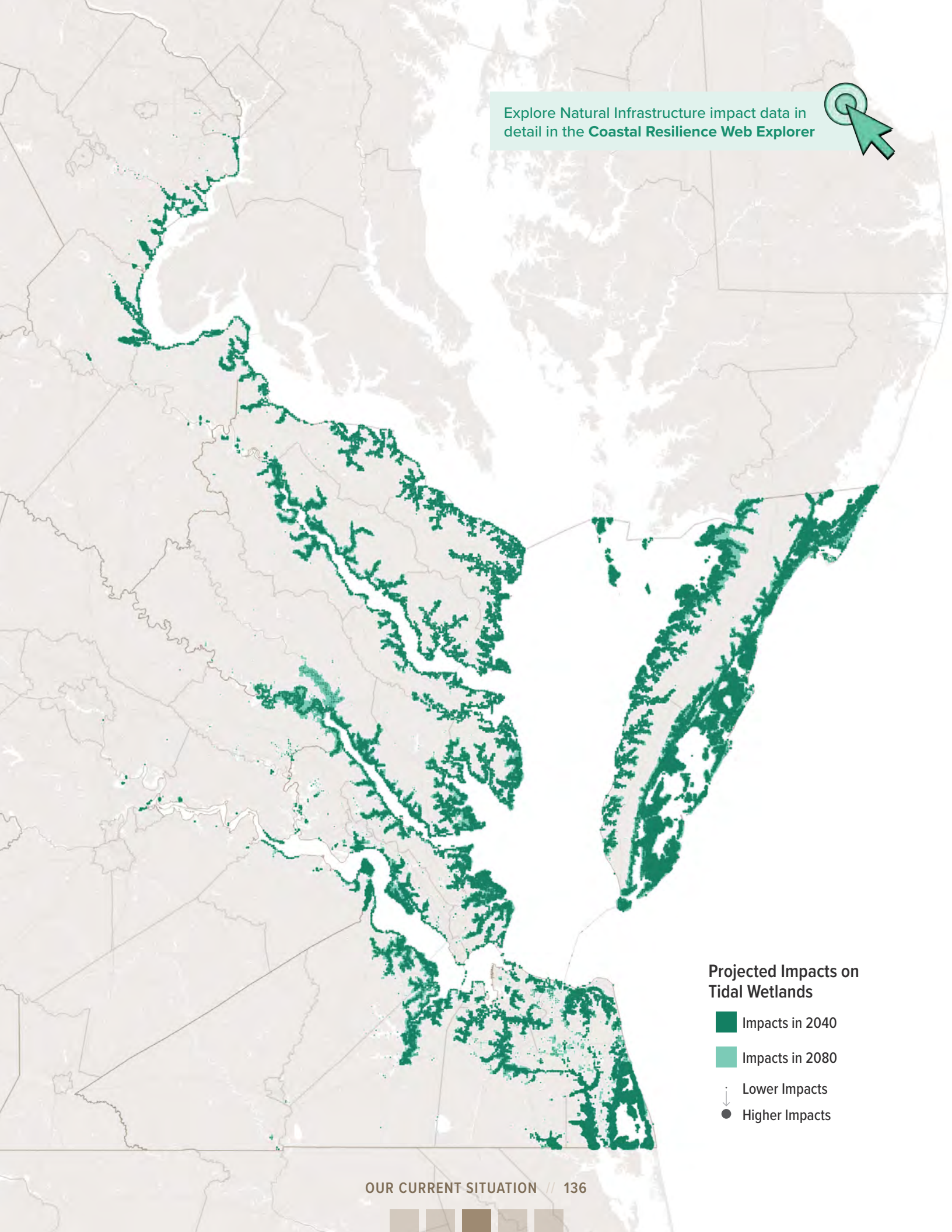
42% believe that their community's hospitality industry is particularly vulnerable to climate change and coastal hazards.

What Virginians Are Saying about Impacts on Nature Infrastructure

Through meetings and surveys, both residents and practitioners across the Master Planning Regions contributed their perspectives about Natural Infrastructure assets.

> "Eastern Shore is huge for eco-tourism. Losing access to natural assets will result in huge hit on tourism. Nature trails are all along the coastline" – *Resident, Accomack-Northampton PDC*

> "We need stronger wetlands protections – they're first-line buffers for storm surge." – *Resident, George Washington RC*


Explore Natural Infrastructure impact data in detail in the **Coastal Resilience Web Explorer**
Projected Impacts on Tidal Wetlands
Impacts in 2040
Impacts in 2080
Lower Impacts
Higher Impacts

Tidal Wetlands

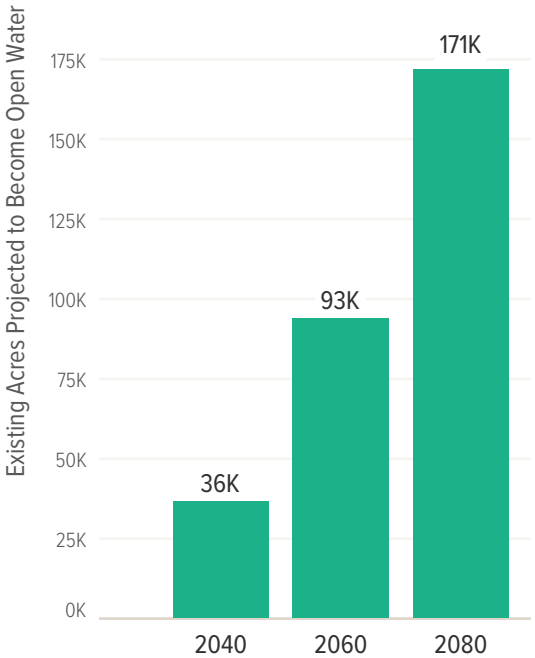
The Commonwealth's coastal areas boast an expansive network of tidal wetlands along the shorelines of bays and rivers. These ecosystems filter nutrients and pollutants, provide habitat and food for various species important to conservation, and serve as natural flood buffers.

Exposure – Spanning more than 190,000 acres across Virginia, tidal wetlands provide an essential first line of defense during tidal and storm events by reducing wave energy along the shoreline. Tidal wetlands, including saltwater and brackish marshes, occur at the low-lying transition zone between land and water. Saltwater marshes are found along the bay shorelines and directly inland of beaches, dunes, and barrier islands. Brackish wetlands are located upstream of saltwater marshes where saltwater and freshwater mix, such as within the upper reaches of tidally influenced rivers.

Vulnerability & Risk – Tidal wetlands can respond to sea level rise in various ways depending on their condition, surrounding landscapes, and flood exposure. Marshes can migrate landward if slopes are gentle and not blocked by development. These systems can also grow vertically if there is an adequate sediment supply. If the amount of sediment input cannot offset the sea level rise, marshes can eventually drown. The loss of these habitats can expose upland communities, infrastructure, and habitats to an increased vulnerability to flooding, while also risking the loss of ecosystem services, like water quality protection.

Tidal Wetland Habitat Loss

Relative to habitat in 2020



As sea levels rise, the acreage of tidal marshes loss to permanent inundation increases dramatically. By 2040, roughly 36,000 acres of today's tidal wetlands are projected to become open water, representing a 19% loss of existing habitat. By 2060, this figure is projected to rise to 93,000 acres, a 49% loss of habitat. By 2080, roughly 171,000 acres of today's tidal wetlands are projected to become open water, an 89% loss of habitat. These figures do not capture the potential expansion of tidal marsh migration.

Tidal Marsh Modeling

Modeling the response of tidal wetlands to sea level rise requires sophisticated calculations that consider land slope, and sediment accretion, erosion, among factors. However, simple land cover change models can identify vulnerable areas. The model assumes that wetlands can exist with a certain amount of water and salinity. As sea levels rise, low-lying wetlands may become effectively "lost" to open water. Wetlands at higher elevations may experience more frequent inundation but may be able to migrate landward.

Future iterations of the Master Plan will look to refine tidal marsh modeling. Ongoing work by the University of Virginia Department of Environmental Sciences exemplifies how this refined modeling could be accomplished. For more information visit the Virginia Coast Reserve Long-Term Ecological Research website and the Virginia Institute of Marine Sciences' Center for Coastal Resources Management's webpage on the Tidal Marsh Model.


Projected Impacts on Beaches and Dunes
Impacts in 2040
Impacts in 2080
Lower Impacts
Higher Impacts

Beaches and Dunes

Beaches and dunes provide a buffer zone that protects upland areas during flood events. They dampen and absorb the energy from a wave before it reaches upland development, especially if dune systems have healthy vegetation. These features also provide habitats for many different coastal animals, including sea turtles, crabs, and shorebirds, and improve local water quality by filtering nutrients and pollutants.

Exposure – More than 10,000 acres of natural and engineered beaches and dunes exist along Virginia's Atlantic shoreline, the bay shorelines of the Chesapeake Bay and its tributaries, and the Albemarle watershed coastlines and the Back Bay National Wildlife Refuge.

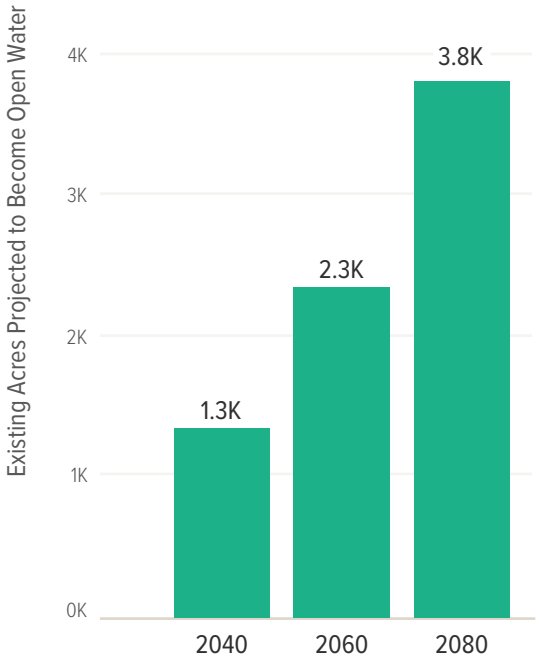
Vulnerability & Risk – Dunes and beaches dynamically respond to higher sea levels and storm events based on their existing surroundings. Virginia's Atlantic and Chesapeake Bay beaches tend to erode in areas of development backed by low-lying coastal plains, shallow bays, or saltmarshes. Dunes may be able to naturally migrate landward in response to rising sea levels given adequate sediment supply.

However, beaches backed by hard infrastructure, such as roads or seawalls, are likely to shrink in the future due to sea level rise. Without the room to migrate landward, these beaches will likely experience "coastal squeeze," resulting in narrow or altogether lost beaches. The loss of these natural buffers will place existing infrastructure and habitats at risk of more frequent inundation. Storm surge flooding may overtop, breach, or even drown barrier islands. As barrier islands retreat, marshes and communities face more exposure to erosion, potentially triggering habitat degradation. Degradation of beaches and dunes from sea level rise and storm events can affect the habitats of many different ecologically significant species. The health of these systems also provides ecosystem services to nearby communities, like water quality benefits. Beaches and dune systems along less developed and stabilized shorelines can migrate landward, given adequate sediment supply and room for retreat.

By 2040, approximately 1,300 acres of beach and dune habitats are projected to be permanently lost to high tide flooding. This estimate represents a 13% loss of existing habitat. By 2060, the number of acres lost is projected to rise to roughly 2,300, a 23% loss of habitat. By 2080, this figure is projected to reach 3,800 acres, a 38% loss of existing habitat.

Beach and Dune Habitat Loss

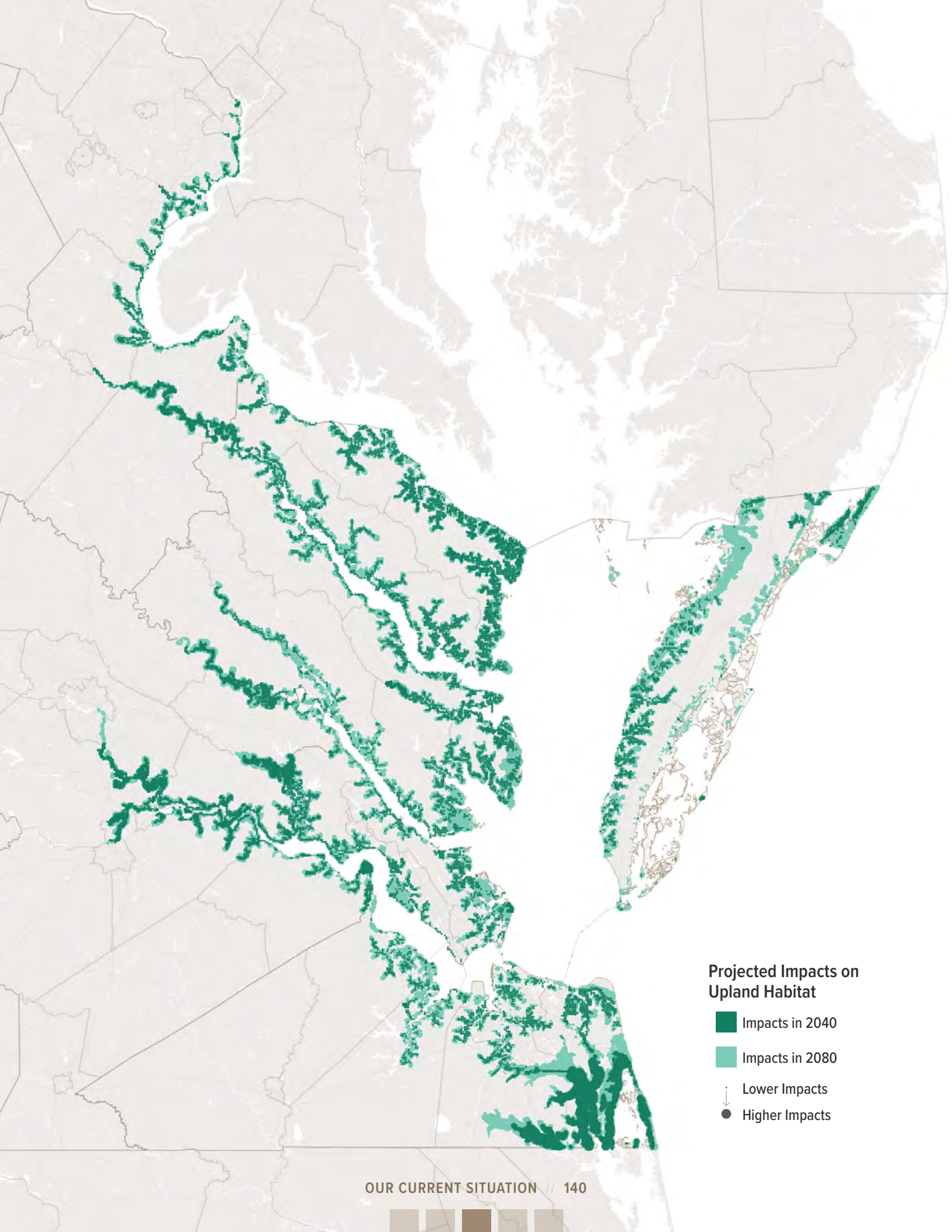
Relative to habitat in 2020



Virginia Barrier Islands

The Virginia Barrier Islands are the nation's longest stretch of undeveloped barrier islands. The Nature Conservancy manages and preserves the barrier islands through the Volgenau Virginia Coast Reserve* and facilities low-impact recreational uses by the public. These habitats' undeveloped landscapes and long-term protection will likely help them adapt to sea level rise.

* Note the Volgenau Virginia Coast Reserve consists of 14 undeveloped barrier and marsh islands protected by The Nature Conservancy. The U.S. Fish and Wildlife Service, Virginia Department of Conservation and Recreation and Virginia Department of Wildlife Resources each protect additional barrier or marsh islands along the Virginia coast.


Projected Impacts on Upland Habitat
Impacts in 2040
Impacts in 2080
Lower Impacts
Higher Impacts

Upland Habitats

Upland habitats are areas adjacent to coastal habitats encompassing various ecosystems, including freshwater wetlands, riparian buffers, and areas dominated by trees and shrubs. These habitats buffer inland areas by absorbing and dampening fast-moving floodwaters and can facilitate wetland migration as sea levels rise.

Exposure – Coastal Virginia is home to approximately 140,000 acres of non-tidal marsh habitat and 148,000 acres of woodland and shrub-scrub habitat along rivers and bays.

Several coastal communities across the Commonwealth have already begun initiatives to preserve these valuable upland habitats and create forest networks near at-risk areas.

Vulnerability & Risk – Upland habitats buffer inland areas against flooding through their ability to absorb and dampen the velocity of floodwaters. These areas also allow wetlands to migrate as sea and salinity levels rise. This assessment projects how much upland habitat is vulnerable to permanent inundation due to sea level rise.

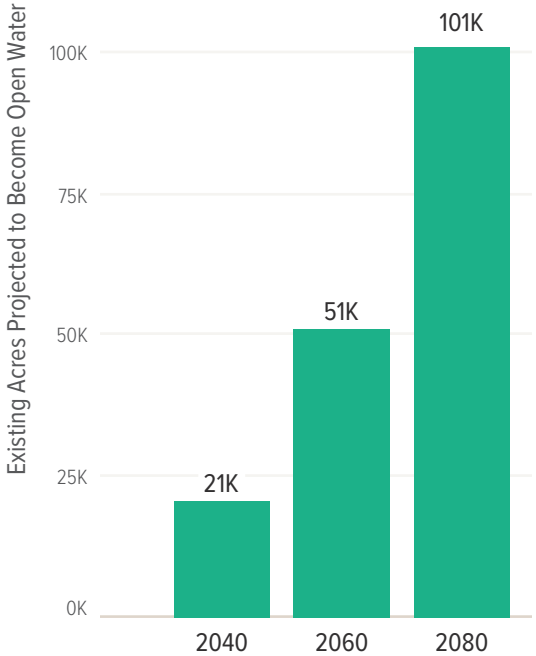
By 2040, approximately 19,000 acres of non-tidal marshes are projected to be lost to permanent tidal inundation, a 13% loss in habitat. This figure is projected to rise to 43,200 by 2060, a 29% loss of habitat. By 2080, roughly 75,500 acres of non-tidal marshes are projected to be permanently inundated, with an overall 51% loss in existing habitat.

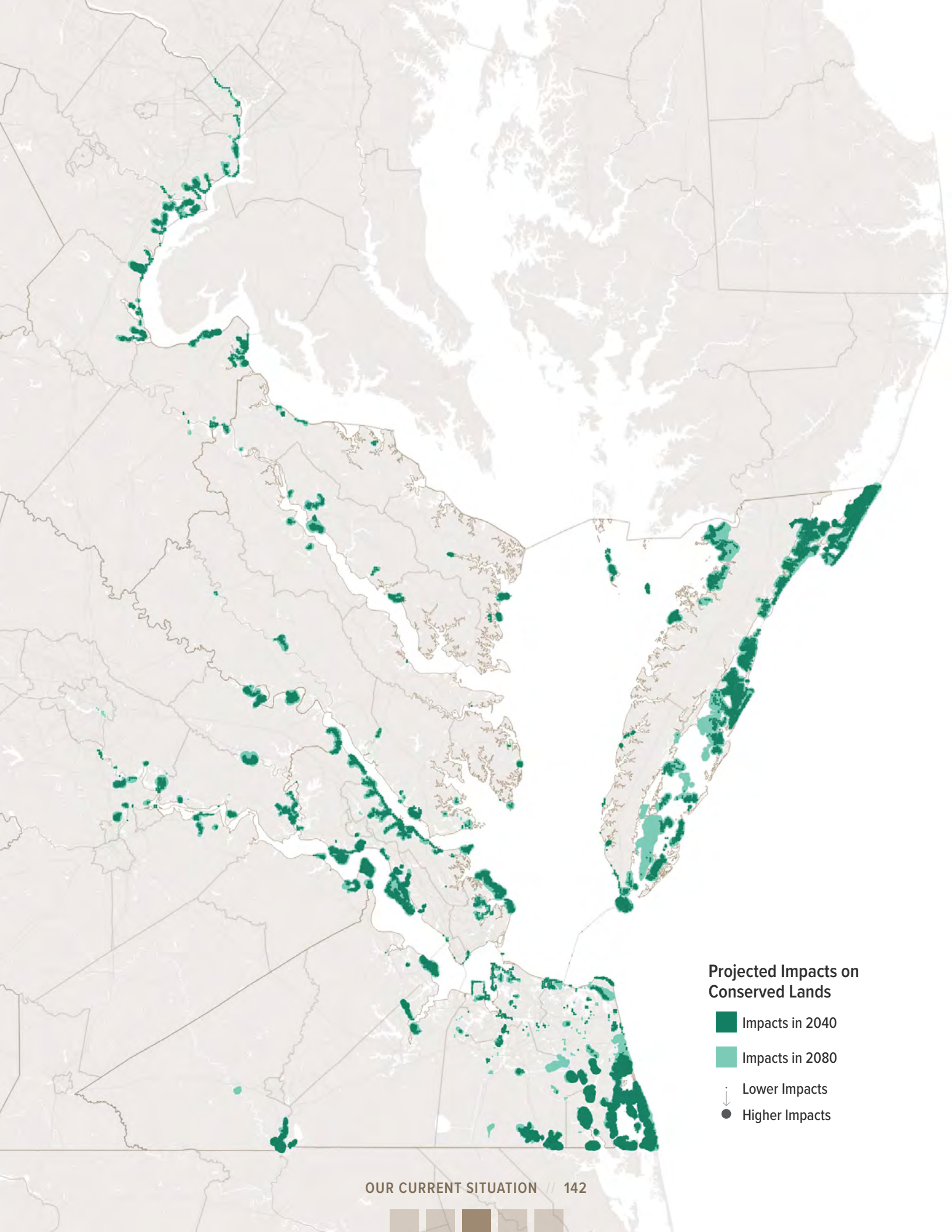
Tree and shrub roots can act like sponges that absorb rain and recharge groundwater supplies. Without them, floodwaters can move more quickly through the landscape, eroding sediment.

By 2040, around 1,800 acres of these habitats are projected to be lost to permanent tidal inundation. This figure is projected to rise by 7,800 acres by 2060, representing a 6% loss in total habitat. By 2080, shrub-scrub is projected to lose 25,400 acres to permanent tidal flooding, an 18% loss in existing habitat.

Upland Habitat Loss

Relative to habitat in 2020




Projected Impacts on Conserved Lands
Impacts in 2040
Impacts in 2080
Lower Impacts
Higher Impacts

Conserved Lands

Conserved lands include public parks and wildlife areas that support recreation activities and tourism throughout coastal Virginia. These assets primarily benefit Virginians by facilitating access to the outdoors and spaces for active recreation. Public parks and wildlife areas also provide essential wildlife habitats and co-benefits through ecosystem services, such as natural flood buffers.

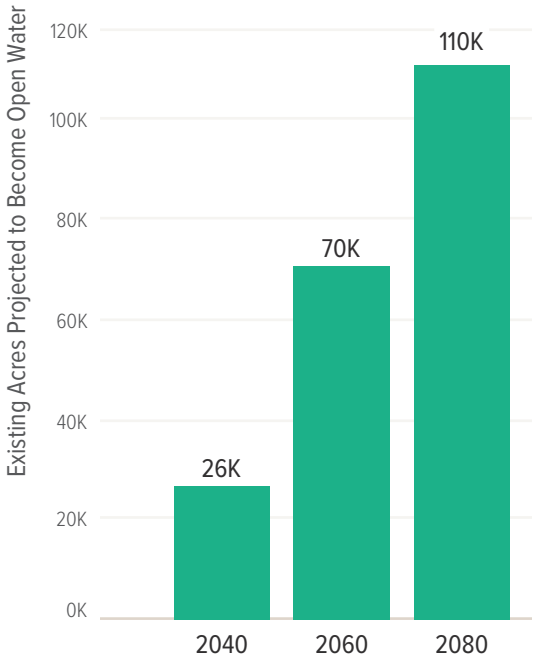
Exposure – The Commonwealth boasts an expansive network of publicly owned conservation lands that remain protected in perpetuity from further development. The coastal regions contain nearly 658,000 acres of public conservation lands managed by local, state, and federal entities. Many conservation lands are located along coastal waterways to provide access to the water for recreational, research, and wildlife preservation purposes.

Vulnerability & Risk – In undeveloped areas, land is able to absorb and convey floodwaters through natural processes, providing an critical ecological service. Public conservation lands may be chronically or even permanently inundated during future tidal events, leading to the permanent loss of these natural flood buffers. Beyond damage to ecosystems, permanent flooding may prevent visitor access or hinder recreation activities like fishing or hiking. Nearby localities with robust recreation and tourist economies may experience compounding economic impacts, like revenue loss, if fewer visitors travel to these sites.

By 2040, approximately 26,500 acres of public parks and wildlife areas are projected to be permanently inundated by daily tidal flooding, representing a 4% loss of habitat. By 2060, roughly 70,500 acres are projected to experience permanent inundation, a total loss of 11%. By 2080, this figure is projected to reach 110,800 acres, resulting in a potential 17% overall loss of existing conserved lands.

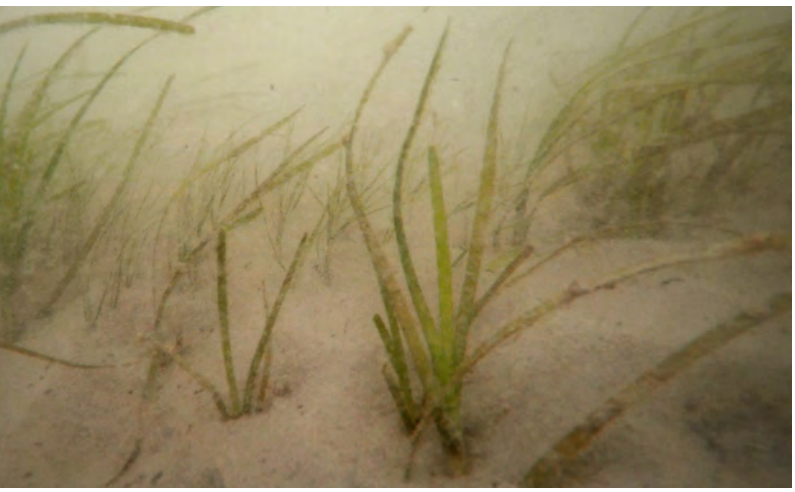
Conserved Land Loss

Relative to land in 2020



Aquatic Vegetation

Underwater grasses, known as submerged aquatic vegetation (SAV), play a vital role in the health of Virginia's coastal waters. These habitats slow down floodwaters, improve water quality and clarity, provide recreational and economic value, and serve as nursery habitats for crabs, fish, waterfowl, and many other aquatic species.



Photos courtesy of Aileen Devlin of Virginia Sea Grant.

Researchers at the Virginia Institute of Marine Science have monitored the Bays' changing underwater grass coverage since 1978. Based on annual survey data, about 72,000 acres of underwater grasses were mapped along the Chesapeake Bay and shallower portions of the Potomac, Rappahannock, Mattaponi, Pamunkey, Chickahominy, and James rivers.

Many stressors affect underwater grasses, including salinity, light, temperature, nutrient levels, sediment type, wave energy, and current velocity.[85] Underwater grasses respond to these stressors and changes differently, depending on their species and whether they live in fresh- or saltwater.

Comprehensive projection of the precise response of these habitats to sea level rise would require robust scientific study, as well as significant time and resources. The first phase of the Master Plan does not project impacts to underwater grasses but will look to quantify these impacts in future phases.

Ongoing Restoration Efforts

The Chesapeake Bay Program aims to increase underwater grasses in the Bay to 130,000 acres by 2025.[84]

Oyster Reefs

Oyster reefs support wildlife, fisheries, aquaculture, and coastal tourism, as well as animal life in the mudflats of salt and brackish marshes. These habitats generate significant economic activity: Virginia's commercial and recreational fisheries and aquaculture support nearly 15,000 jobs and $1 billion in sales.[86] Impacts on the oyster population could adversely impact Virginia's commercial and recreational fisheries and aquaculture, as well as eco-tourism.

Photos courtesy of Aileen Devlin of Virginia Sea Grant.

Across the Commonwealth, there are approximately 170,000 acres of mapped oyster habitat areas.[87,88] These areas include open harvest areas, state and private oyster ground leases, public oyster grounds, oyster restoration sites, and oyster sanctuaries.

Oyster reefs are sensitive to changes in salinity and water depth. More frequent intense and enduring rainfall events can also increase runoff, lowering salinity levels. These changes may lead to losses in oysters, specific fish species, and other wildlife that are essential pillars of Virginia's coastal economy.

Projecting impacts to oyster reefs would require significant time and resources. Additionally, this phase of the Technical Study focuses on sea level rise, not changes to salinity levels, which is a key factor in oyster reefs' ability to adapt to changing conditions. The first phase of the Master Plan does not project impacts to oyster reefs but will look to quantify these impacts in future phases.

Ongoing Restoration Efforts

Oyster reef restoration efforts are already underway. Today, the Chesapeake Bay contains approximately 9,000 acres of reef restoration in Virginia.[89]

An additional 3,000 acres of oyster sanctuaries exist along Virginia's Eastern Shore, including the Smith Island, Box Tree, Paramore, Hilcrest, and Cobb Island Oyster Sanctuaries.[90]

Natural Infrastructure Hotspots:

Hampton Roads

Natural Infrastructure in Hampton Roads

Hampton Roads is an intensely developed region, but it also has many ecologically valuable ecosystems, like the Back Bay and Great Dismal Swamp National Wildlife Refuges. These habitats provide essential ecosystem services, like natural flood protection, for nearby communities.

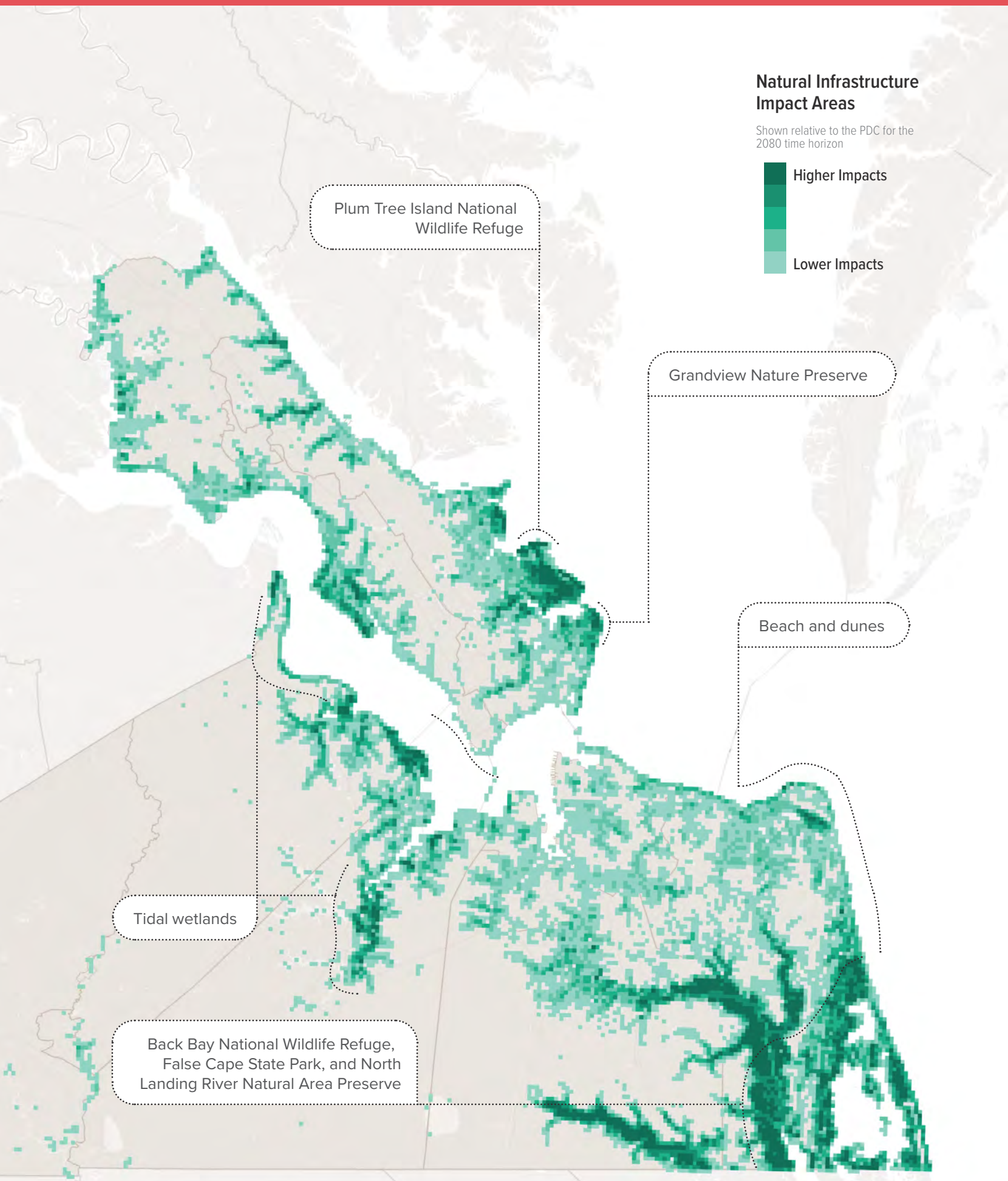
Tidal Wetlands	2020 Acres	2080 Acres	Change
Hampton Roads PDC	40,600	2,940	- 93%

Beaches and Dunes	2020 Acres	2080 Acres	Change
Hampton Roads PDC	2,290	1,780	- 22%

Upland Habitat	2020 Acres	2080 Acres	Change
Hampton Roads PDC	109,200	65,400	- 40%

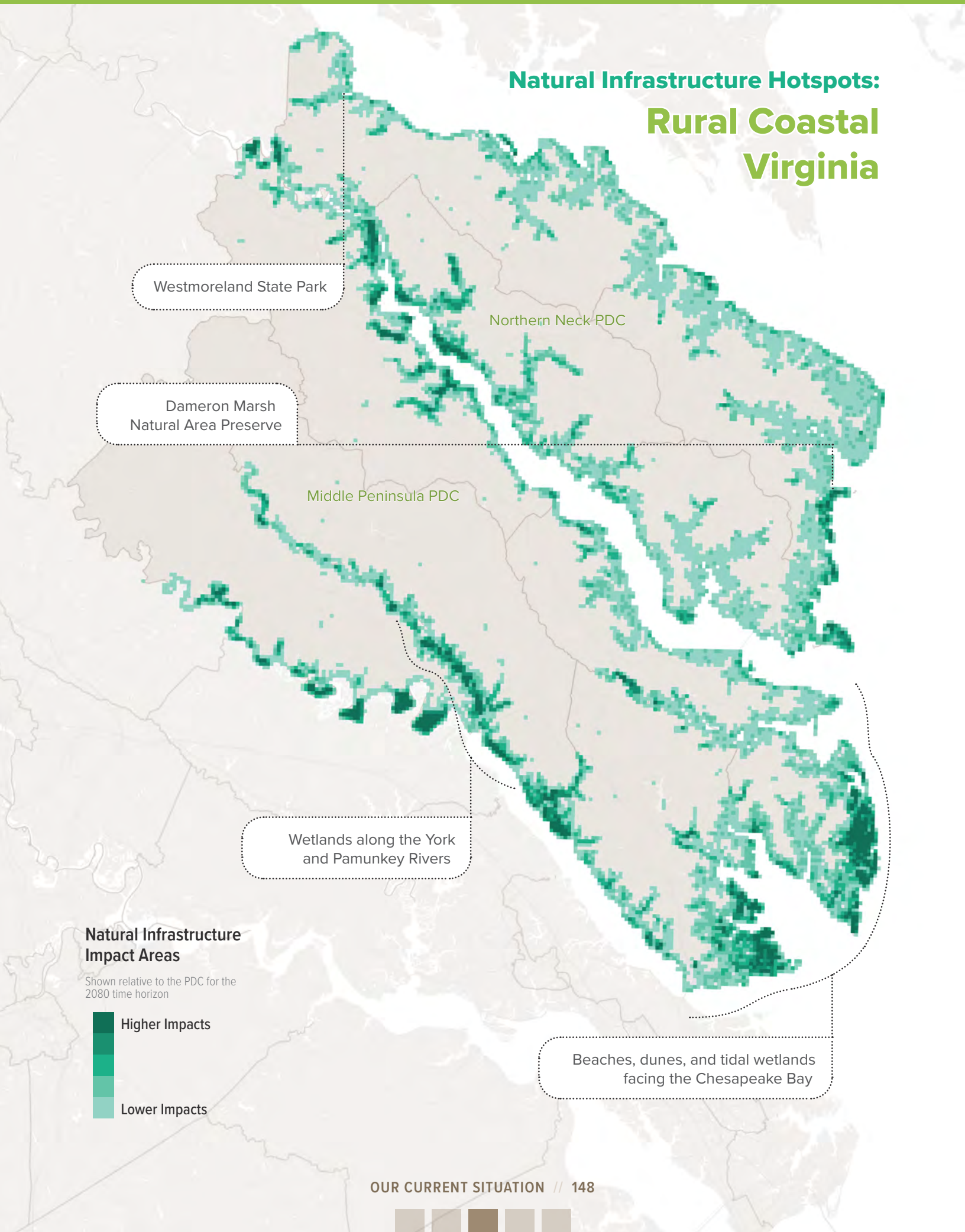
Conserved Lands	2020 Acres	2080 Acres	Change
Hampton Roads PDC	223,400	187,200	- 16%

Differences in asset exposure numbers and percentage changes can be attributed to rounding for presentation. Percentage changes reflect exact exposure numbers.


Natural Infrastructure Impact Areas
Shown relative to the PDC for the 2080 time horizon
Higher Impacts
Lower Impacts
Plum Tree Island National Wildlife Refuge
Grandview Nature Preserve
Beach and dunes
Tidal wetlands
Back Bay National Wildlife Refuge, False Cape State Park, and North Landing River Natural Area Preserve

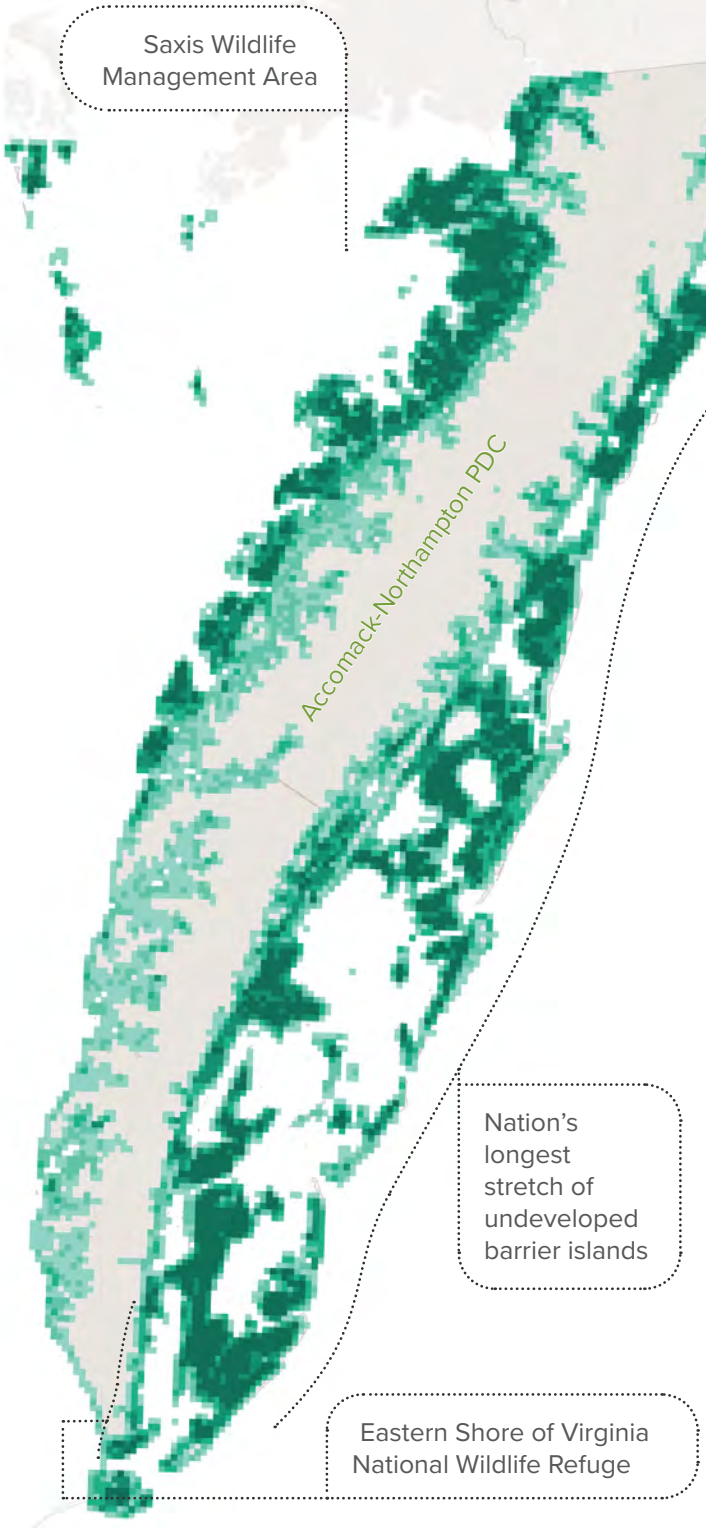
Natural Infrastructure Hotspots:

Rural Coastal Virginia



Natural Infrastructure in Rural Coastal Virginia

Rural Coastal Virginia has abundant and unique ecosystems, including the nation's longest stretch of undeveloped barrier islands. The region's natural landscapes are fundamental to its identity, attracting visitors and new residents alike. These ecosystems also support Rural Coastal Virginia's economy through commercial fishing and aquaculture, and ecotourism.



Tidal Wetlands	2020 Acres	2080 Acres	Change
Accomack-Northampton PDC	110,900	13,500	- 88%
Middle Peninsula PDC	22,500	2,030	- 91%
Northern Neck PDC	9,100	1,230	- 87%

Beaches and Dunes	2020 Acres	2080 Acres	Change
Accomack-Northampton PDC	6,700	4,300	- 36%
Middle Peninsula PDC	370	85	- 76%
Northern Neck PDC	380	75	- 81%

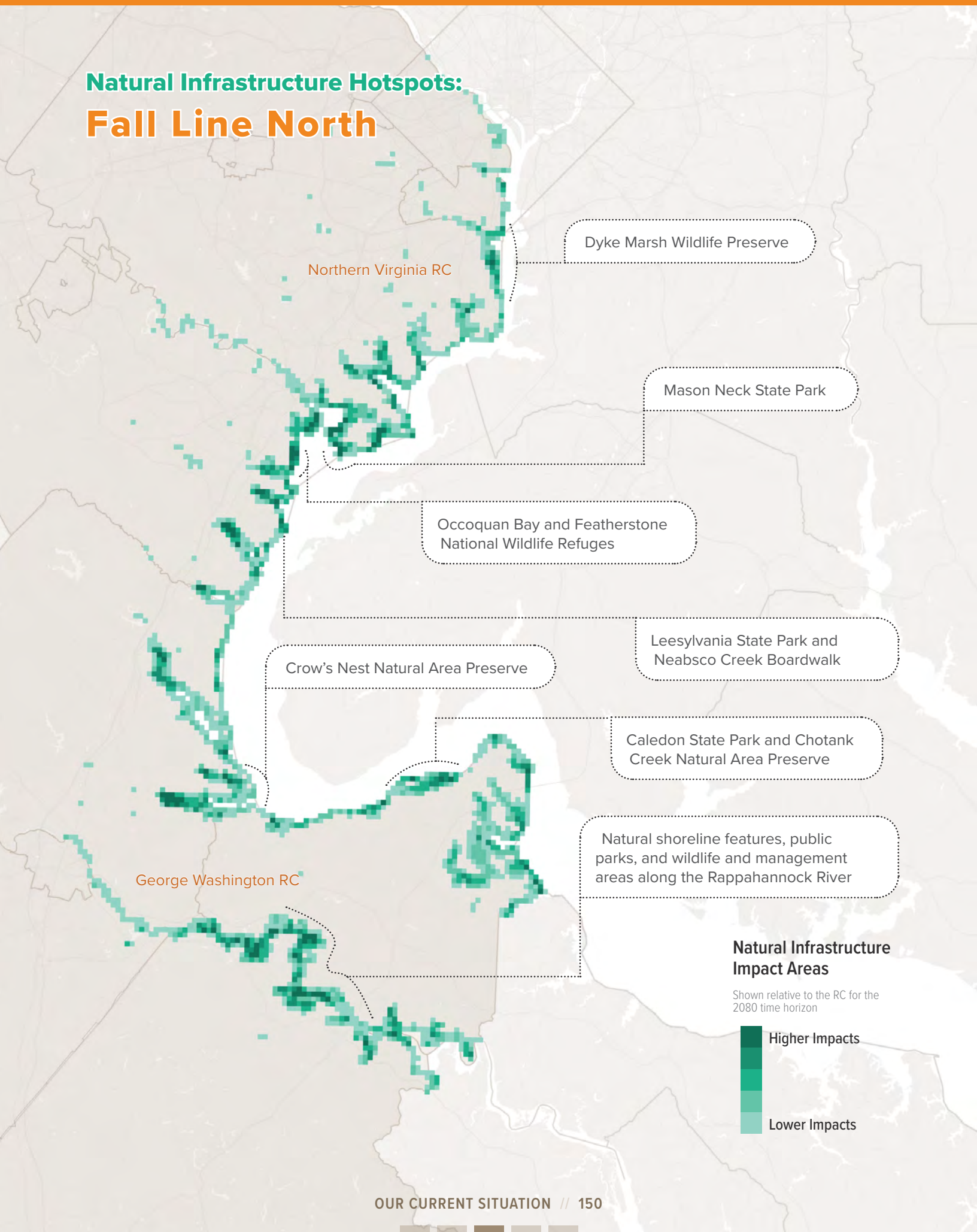
Upland Habitat	2020 Acres	2080 Acres	Change
Accomack-Northampton PDC	58,200	44,400	- 24%
Middle Peninsula PDC	59,400	44,300	- 25%
Northern Neck PDC	24,400	17,400	- 29%

Conserved Lands	2020 Acres	2080 Acres	Change
Accomack-Northampton PDC	65,000	6,770	- 90%
Middle Peninsula PDC	19,600	16,600	- 15%
Northern Neck PDC	10,300	7,880	- 24%

Differences in asset exposure numbers and percentage changes can be attributed to rounding for presentation. Percentage changes reflect exact exposure numbers.

Natural Infrastructure Hotspots:

Fall Line North



Natural Infrastructure in Fall Line North

Fall Line North contains several ecologically significant wetlands and woodlands, particularly along the upper reaches of the Potomac River. Stretches of the region's waterfront have been hardened to protect critical sector assets and intensely developed communities. Additional habitat may be lost or irreparably harmed as sea levels rise and salinity increases.

Tidal Wetlands	2020 Acres	2080 Acres	Change
George Washington RC	2,450	350	- 86%
Northern Virginia RC	1,100	165	- 85%

Beaches and Dunes	2020 Acres	2080 Acres	Change
George Washington RC	60	< 5	- 93%
Northern Virginia RC	20	< 5	- 94%

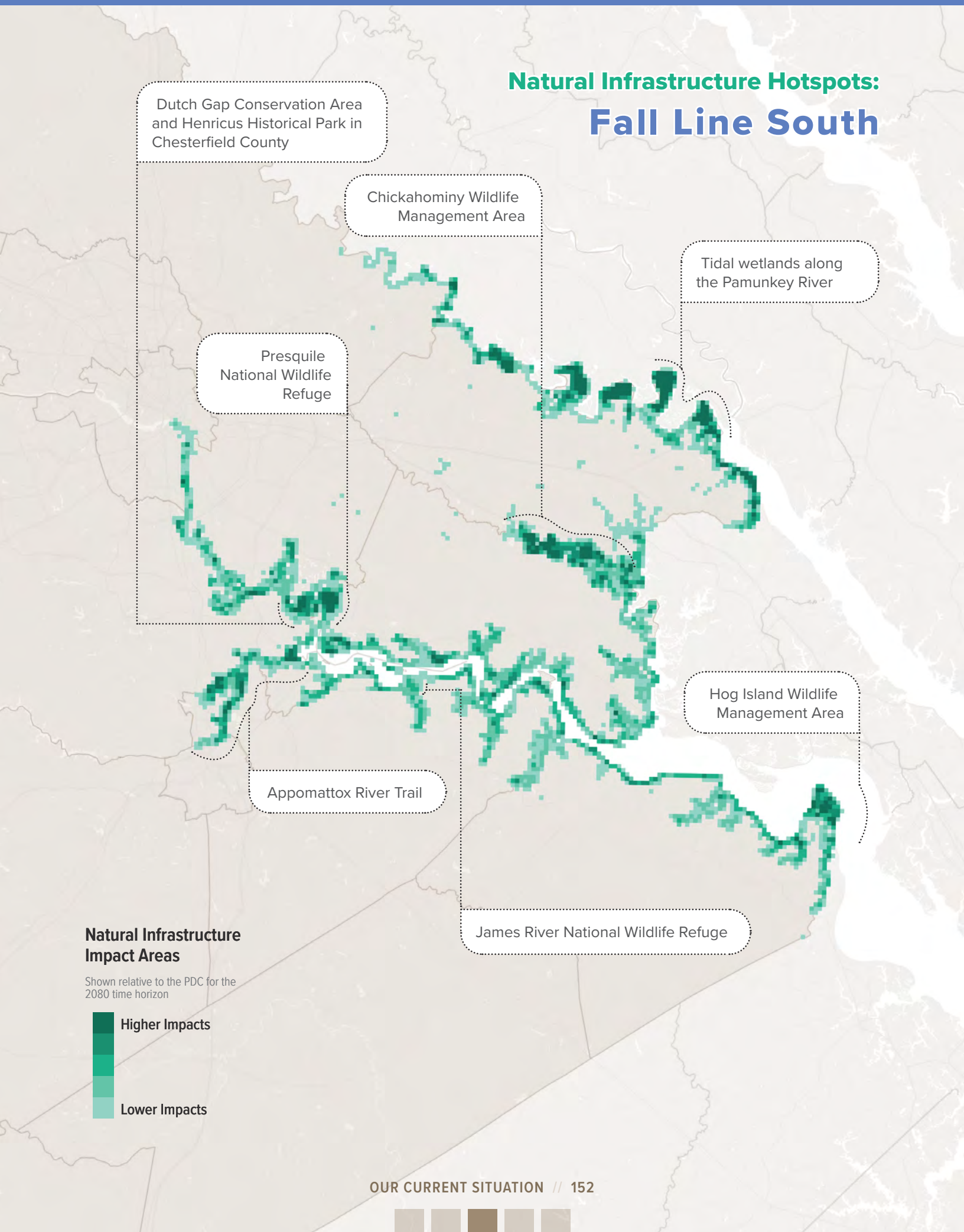
Upland Habitat	2020 Acres	2080 Acres	Change
George Washington RC	8,500	4,040	- 53%
Northern Virginia RC	2,480	1,160	- 53%

Conserved Lands	2020 Acres	2080 Acres	Change
George Washington RC	141,800	140,150	- 1%
Northern Virginia RC	111,130	108,600	- 2%

Differences in asset exposure numbers and percentage changes can be attributed to rounding for presentation. Percentage changes reflect exact exposure numbers.

Natural Infrastructure Hotspots:

Fall Line South



Natural Infrastructure in Fall Line South

Fall Line South contains several ecologically valuable habitats, including freshwater wetlands along the James and Chickahominy Rivers. These natural landscapes provide critical ecosystem services, like natural flood protection and water quality protection, as well as many recreational opportunities. Rising seas, salinity levels, and accelerated erosion threatens habitats along the tidal James River.

Tidal Wetlands	2020 Acres	2080 Acres	Change
Crater PDC	1,090	85	- 92%
PlanRVA	4,150	340	- 92%

Beaches and Dunes	2020 Acres	2080 Acres	Change
Crater PDC	165	15	- 91%
PlanRVA	45	< 10	- 84%

Upland Habitat	2020 Acres	2080 Acres	Change
Crater PDC	6,680	3,030	- 55%
PlanRVA	19,000	7,200	- 62%

Conserved Lands	2020 Acres	2080 Acres	Change
Crater PDC	39,800	38,000	- 5%
PlanRVA	46,700	42,000	- 10%

Differences in asset exposure numbers and percentage changes can be attributed to rounding for presentation. Percentage changes reflect exact exposure numbers.

Technical Study Process Improvements

The Master Plan's Technical Study was designed to be improved and updated over time. Many elements and outputs within to the Technical Study's impact assessment were aligned with the short-term timeline of this initial Master Plan. The following section summarizes identified improvements organized by and aligned with the first three steps of the Technical Study process introduced in Chapter 1. Improvements to the remaining steps of the Technical Study are discussed in Chapter 4.

Characterize Communities

The characterization of natural and built infrastructure and the social fabric is the foundation for understanding hazard impacts and project priorities for the Master Plan. Improvements for this study include better data resources and an increased understanding of critical resources to each region and locality. This Master Planning process identified several dataset or fidelity shortfalls and needed improvement, specifically for demographics and assets.

Demographics – Existing federal and state databases largely focus on the census tract or block-group levels of data, which is insufficient to adequately ensure our equitable advancement of resilience activities in the Commonwealth. A common dataset that draws on a federal source refined to the census block-level is essential to ensuring the socio-economic needs of coastal communities are understood. Creating a common coastal and statewide dataset would allow a more granular assessment of coastal communities so the Commonwealth can assist in developing equitable solutions and opportunities.

The current Master Plan used 2018 American Community Survey data, but this is outdated and likely leads to underestimating population exposure and displacement. The 2020 Census data showed, in aggregate, that Virginia has grown by almost 8% in population since 2010. Updated socioeconomic impact analysis should be conducted with the 2016-2020 American Community Survey data as it becomes fully available. Further, assessing future demographic impacts and population displacement metrics could include future population estimates such as the EPA's Integrated Climate and Land Use Scenarios, which provide population projections at a county level into 2100.[91]

Additionally, data to support metrics related to Community Resources and the community context is currently limited. This element could be supplemented with additional data and findings acquired through surveys and tailored outreach. Virginia Economic Development Partnership Opportunity Zones data could also be included in future analyses.

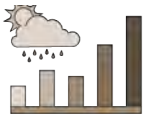
Parcel Data – The initial Master Plan was able to draw from publicly available Commonwealth parcel-level datasets. Third-party vendor data with license constraints augmented this dataset. Still, the data had varying degrees of fidelity, accuracy, and currency. The Commonwealth needs standardized datasets and sources to support the long-term planning and resilience of its localities and counties. Specifically, reliable and comprehensive sources on parcel information, building structures, and first finished floor elevations are crucial datasets and woefully inadequate at present. State agencies understand this need, and many have embarked on creating their own sources for localities to use. However, these efforts are not streamlined and can be duplicative or result in conflicting outcomes. A common statewide dataset and collection process that is aligned with statewide data sharing protocols and supported across agencies and localities is essential to future phases of the Master Plan as well as many other Commonwealth planning and public support needs.

Expanding Tribal Engagement and Understanding of Cultural Resources – The Commonwealth could further consider culturally significant places and associated historically marginalized populations. A starting point for such an evaluation may be identifying the number and portion of designated historic areas associated with historically marginalized populations within the Commonwealth. Future efforts can engage with tribal representatives to better understand culturally important sites, accompanying privacy considerations, and represent all state and federally recognized tribal lands.

Asset Data – The first Master Plan relied on federal Homeland Infrastructure Foundation-Level Data (HIFLD) and a limited selection of Commonwealth agency-provided datasets for the Technical Study's Impact Assessment. The national dataset is not fully comprehensive and has limitations on the spatial accuracy of infrastructure. Several agency-provided datasets were compiled in a short time frame and lacked needed attributes. Like the parcel data, state agencies should support improvements to the accessibility and completeness of geospatial data for the benefit of the Commonwealth.

Asset Criticality – Using existing public data sources, the Master Plan identifies built and natural infrastructure assets associated with either defined critical sectors or natural habitat typologies. However, the criticality of the asset from the perspective of the local, regional, and statewide scale is not determined in our current work. To identify long-term prioritization procedures, the Commonwealth will develop a process to rate the criticality of built and natural infrastructure using objective and subjective inputs. Criticality is a time-dependent variable and must be reviewed and updated periodically. Direct stakeholder engagement over a more extended period would support a more nuanced understanding of asset criticality — at a community, regional, and Commonwealth level. Improved engagement and knowledge of infrastructure in the context of the existing and future hazards could also allow for an assessment of adaptive capacity in future iterations of the Master Plan.

Photo courtesy of Dewberry.



Understand Hazards

The Virginia Coastal Resilience Master Plan began development in late 2020 with planned completion in late 2021. Recognizing this short time frame, the Commonwealth focused this first assessment on the impacts of tidal, chronic, and storm surge coastal flooding. Although the coastal hazard information could be improved with dynamic modeling of future conditions, we know many other types of hazards threaten coastal Virginia. Establishing and integrating an understanding of those hazards is the priority for refining future Master Planning efforts.

Our goal is to understand and identify the challenges coastal Virginia faces from the total flood hazard, consisting of tidal flooding, storm surge flooding, stormwater flooding, riverine flooding, and the compound flooding factors as they interact. To address this, the Commonwealth will continue to expand its hazard assessment to better capture future conditions. The combined effects of increased rainfall, combined with rising sea levels, nuisance flooding, and coastal storm impacts are complex and require additional research to model with accuracy.

Rainfall-Driven Flooding – The Commonwealth heard from many practitioners and members of the public that rainfall-driven stormwater flooding is a near-term priority for many localities. Although this first Master Plan does not address stormwater flooding, additional data collection and further refinement of flood hazard modeling will help to better understand stormwater flood hazards in upland coastal areas, and especially where stormwater interacts with tides and storm surge to create compound flooding challenges, both today and in the future.

Riverine Flooding – The expansive network of rivers and streams in Virginia can pose a severe flooding threat to coastal communities. Prolonged or intense rainfall can cause river systems to overflow, and sea level rise and changes in seasonal precipitation can raise receiving water levels, holding water in, and increasing flood risk. Additional data collection, modeling, and mapping are essential to understand and assess the impacts of future riverine flooding.

Coastal Erosion – Virginia's coastlines are already threatened by erosion which will only worsen as sea levels rise. Higher groundwater tables can saturate and destabilize shorelines. Higher water levels allow additional wave energy to impact the coast, accelerating shoreline retreat. While many buildings

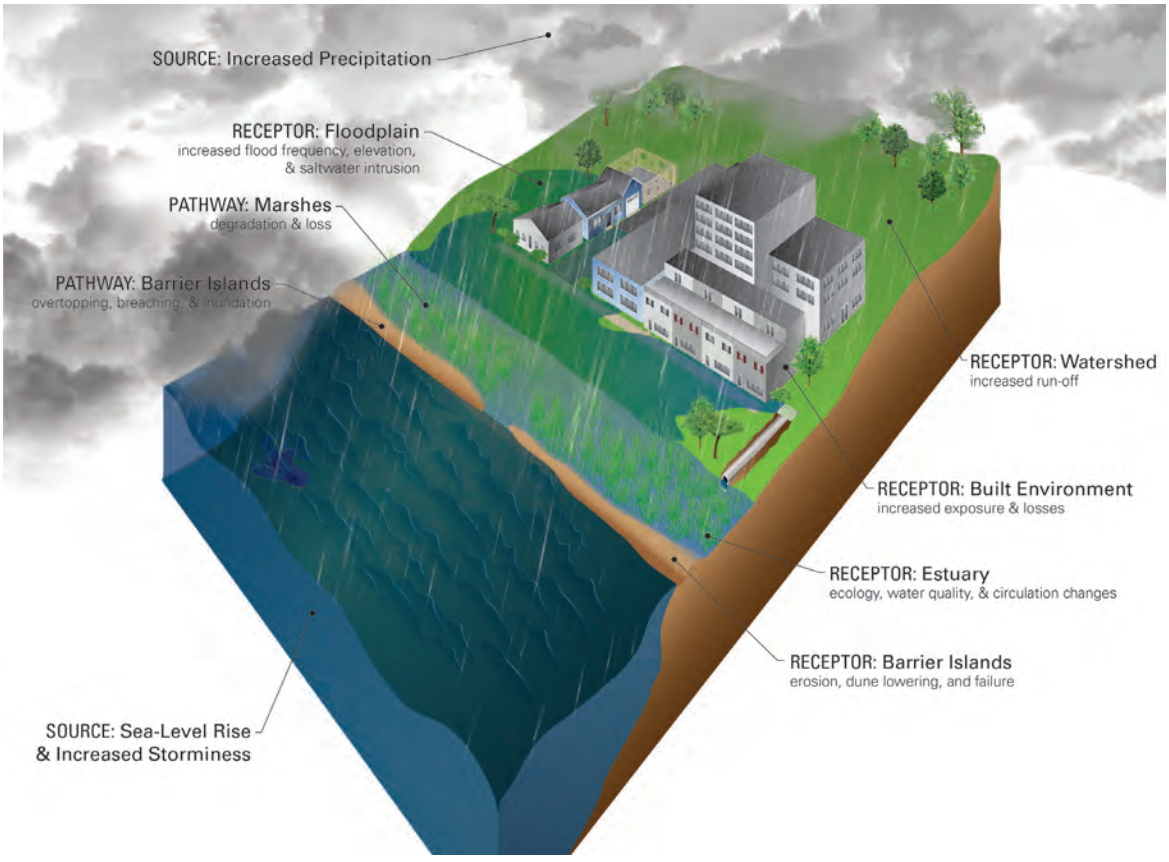
and assets are not exposed to existing flooding, the gradual retreat of the coast may threaten their sustainability. The Commonwealth should support analyses and map product development to help stakeholders recognize and plan for this additional hazard. Coordination with stakeholders to identify the best path forward for such products, in consideration of existing data, planned improvements, and overall Commonwealth agency needs is essential.

Groundwater Impacts – Rising subsurface groundwater levels contribute to an expanding number of challenges across coastal infrastructure. The Commonwealth wants to learn more to better understand impacts to utility, water, and sewage/septic infrastructure, in addition to agricultural and transportation impacts across the coastal region. Additional data collection and analysis is needed to understand these impacts.

Compounding Factors – Ideally, full consideration of future hazards and impacts should encompass the many inter-related factors that determine the potential future. One way to describe this is through a Source, Pathway, Receptor (SPR) framework. In the SPR framework, sources refer to climate or weather events (e.g., sea level rise, hurricanes) that drive flood hazards; pathways are the routes that sources take to reach receptors, such as coastal landforms and flood control structures that convey floodwaters that originate as weather events to places where they may impact receptors; and receptors are the people, industries, and built and natural environments affected by the flooding hazard.

The change in flood hazard is related to changes in both the source and pathway elements, and sometimes the receptor elements. For coastal flooding future conditions, aspects of the flood pathway encompass the extent and elevation of the coastal landscape and in greater detail, can include processes like barrier island evolution and shoreline retreat. The coastal landscape is dynamic, so all of these elements are expected to respond to projected increases in sea level. Additionally, higher groundwater, increased rainfall, changes to impervious area, and the interaction of rainfall-runoff with increased water levels will influence the future hazard condition.

The future hazard condition is best understood if inter-connected aspects are identified and represented in the hazard and impact modeling efforts. All-inclusive modeling of these diverse elements is complex, time-consuming, and costly. Ignoring these processes may result in underestimating the challenge ahead. As the Master Plan evolves, the technical effort to continually recognize and integrate related aspects to provide improved estimates of both future hazards and impacts.



Compounding Flood Factors

Source: FEMA, 2017[92]

The flood hazard and risk for future conditions is dependent on the combination of changes in the flood source forcing factors, the flood pathway and the flood receptors.

Assess Impacts

A thorough understanding and refinement of the most critical and vulnerable impact areas related to coastal flooding are necessary. This improvement will allow for updating of the project evaluation, project prioritization, and project gap analysis to ensure areas vulnerable to coastal and other flood hazards are prioritized as significant in the Commonwealth's coastal adaptation and protection efforts.

The Technical Study's impact assessment aimed to provide an initial analysis of exposure and impacts to the Commonwealth's social, natural, and built assets. Parts of the approach were limited by the time, data, and resources available, but future phases of the Master Plan can use different approaches to improve understanding of impacts and refine the assessment's outcomes.

Built Infrastructure – The Commonwealth should move from exposure to vulnerability and risk assessments for built infrastructure as the source data improves. Initial improvements from exposure to vulnerability could be realized through developing qualitative and semi-quantitative flood depth and frequency relationships to potential impacts and disruptions. Network approaches between asset types could be applied to improve understanding of disruptions and cascading impacts. Where possible, the Commonwealth should advance analyses to economic-based risk metrics to support benefit-cost analysis and communication of overall risk to potential sources of resilience project funding.

Natural Infrastructure – Due to time limitations, potential impacts to natural infrastructure were assessed primarily through first-order approximations using simple metrics. These approaches captured the loss of natural resources but not net change.

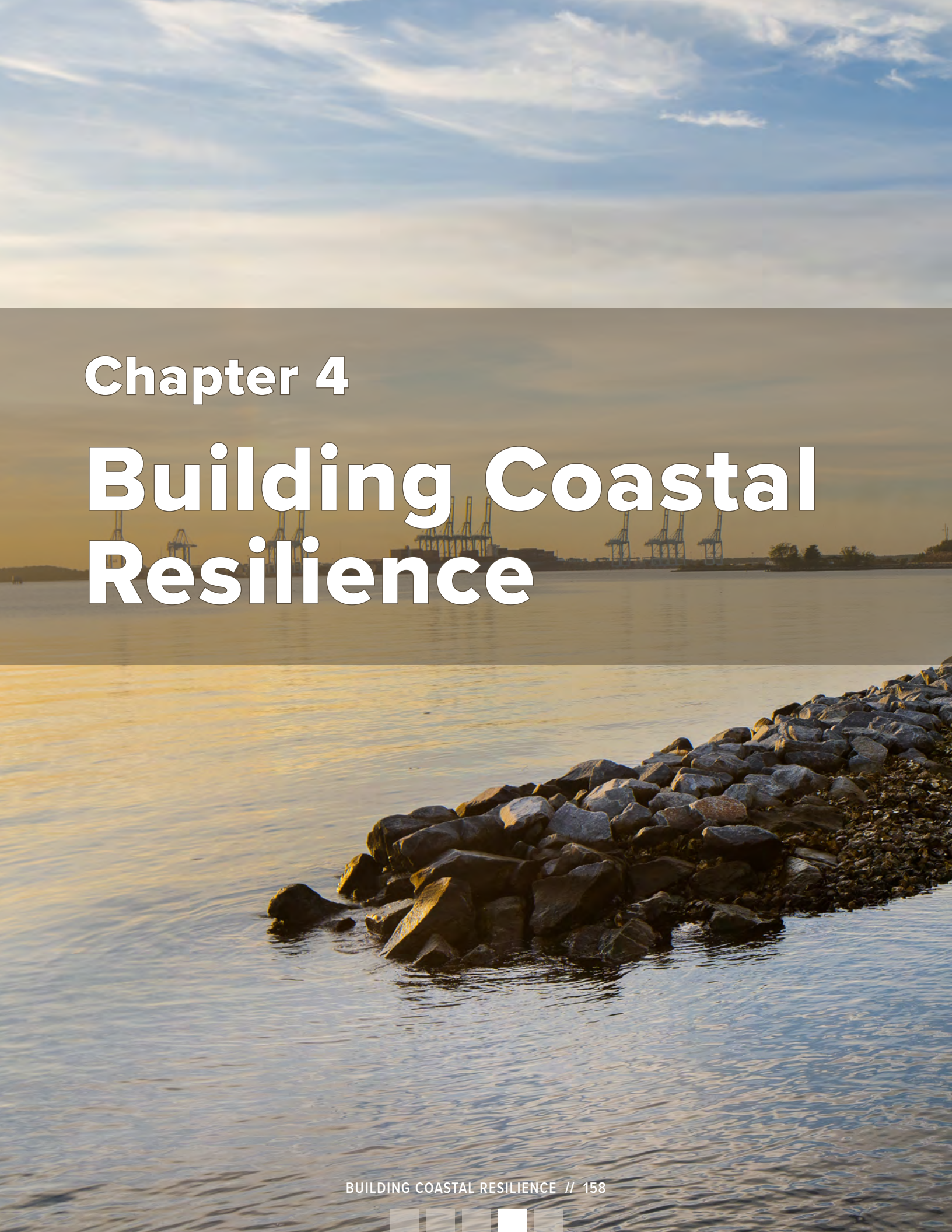
The outcomes of the analyses help communicate the challenges ahead for the Commonwealth, but significant improvements are needed to support actionable planning and decision-making. Initial actions can include leveraging and adapting the recent marsh migration analysis completed by the Virginia Institute of Marine Science into the Master Plan.

A more complete picture of coastal habitat loss can be captured by quantifying the ecosystem services lost. Several existing approaches and sources for the valuation of ecosystem services were reviewed. However, the Technical Advisory Committee felt that insufficient research or case study evidence allowed the formulation of a defensible Virginia-specific approach at this time. Future iterations may consider this more comprehensively.

Improved and Expanded Economic Loss Modeling – The initial analyses in the Master Plan included annualized loss estimates for residential and commercial buildings. These analyses were limited to direct losses to the buildings and their assumed contents. The Commonwealth can improve the accuracy of this analysis with better building data attribution, especially by enhancing estimates or direct measurements of first-floor elevations of exposed buildings.

The Commonwealth could benefit from a more complete analysis of the economic exposure to future hazards. Existing outputs could be augmented with indirect loss analysis, considering displacement and loss of function. Such analysis could also be extended to Critical Sectors over time with sufficient data development. Broader economic models could be applied to gain a more comprehensive insight into economy-wide impacts from the projected future losses and disruptions. Understanding the complete picture of economic exposure would improve risk communication to stakeholders and help justify and spur investment in resilience strategies.

Photo courtesy of Northern Neck PDC.



Chapter 4

Building Coastal Resilience

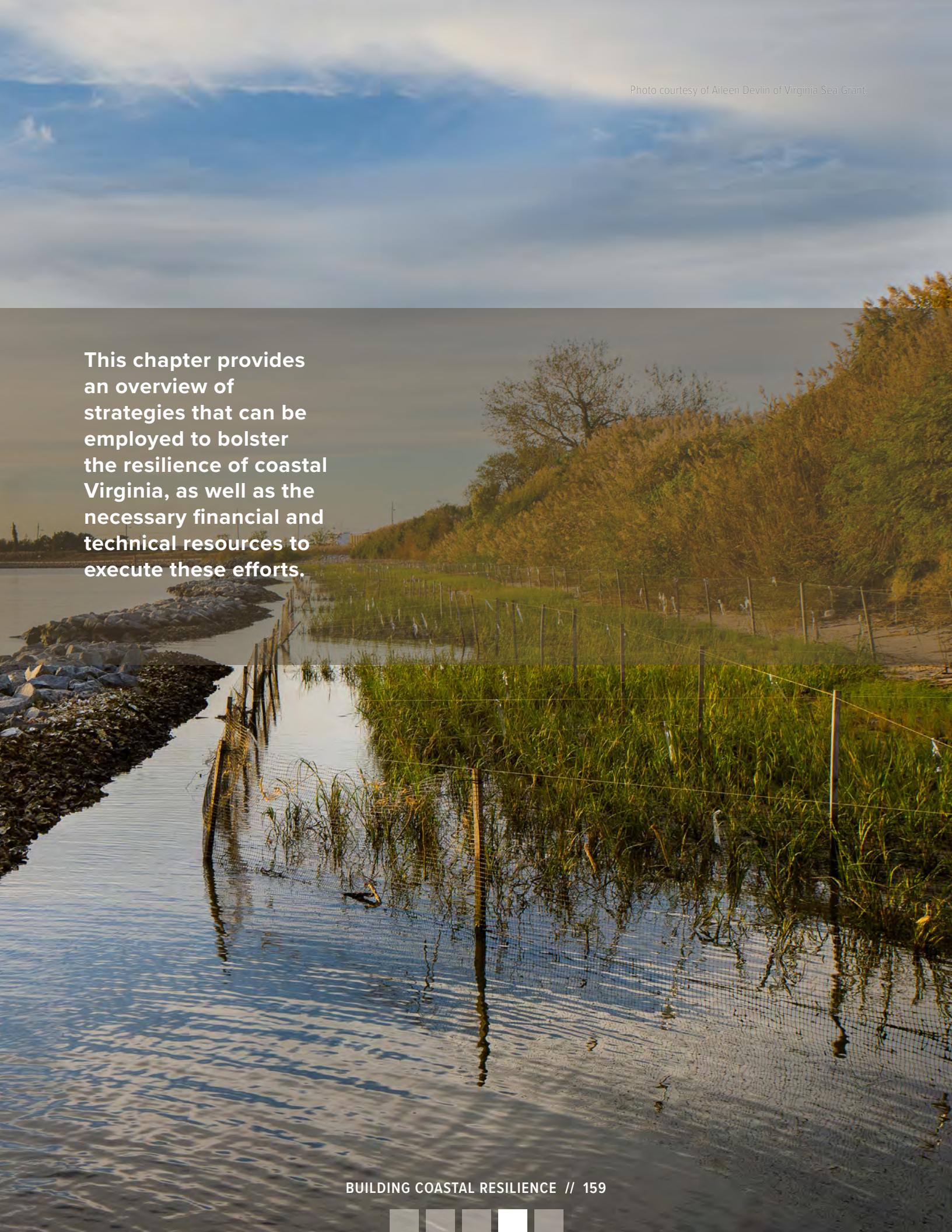


Photo courtesy of Aileen Devlin of Virginia Sea Grant.

This chapter provides an overview of strategies that can be employed to bolster the resilience of coastal Virginia, as well as the necessary financial and technical resources to execute these efforts.

Our Approach to Coastal Resilience

The Technical Study demonstrates how necessary it is to understand that each coastal region faces different exposures and risks due to sea level rise. With a greater understanding of what is at stake, all regions and localities can engage in planning for actionable and practical strategies that reduce risks to their community's assets. Policies, programs, and physical projects can be directed towards critical areas with higher projected coastal hazard impacts to maximize benefits from long-term resilience investments. Although risks will never be entirely eliminated, building coastal resilience improves the capability of communities to anticipate, prepare for, respond to, and recover from coastal hazards, thereby minimizing damage to social well-being, health, the economy, and the environment.

Protection and adaptation in the face of evolving flood risks are a key part of the Commonwealth's approach to coastal resilience. Communities in coastal Virginia have many options for building resilience to increasing coastal threats, including the construction of systems that protect at-risk assets from floodwaters, adaptation of assets to accommodate increased floodwaters, and relocation of assets to less flood-prone areas. Specific projects may incorporate numerous approaches and use "**gray**" structural methods, "**green**" natural or nature-based features, or a **hybrid** of the two.

Resilience needs and priorities vary across the Commonwealth, and regions and localities need flexibility in determining which strategies work best for their communities and the specific risks they face. However, identifying, planning, and implementing on-the-ground resilience projects is a complex, time-consuming, and costly task. In addition to understanding the hazards and impacts, it requires significant time, investment, and technical knowledge. Some localities and organizations have little experience with or resources dedicated towards resilience efforts, and the Commonwealth intends to support localities to help build such capacities, develop funding strategies, and assist in securing funding. Building capacity and planning for resilience are dynamic and continuous processes that require refinement as science, policies, communities, and the physical landscape continue to evolve.

The following sections build off the assessment of impacts presented in Chapter 3 to outline capacity-building and planning initiatives, coastal resilience projects, funding programs, and financing opportunities for coastal communities. Each section calls attention to the needs and opportunities identified through the Technical Study.

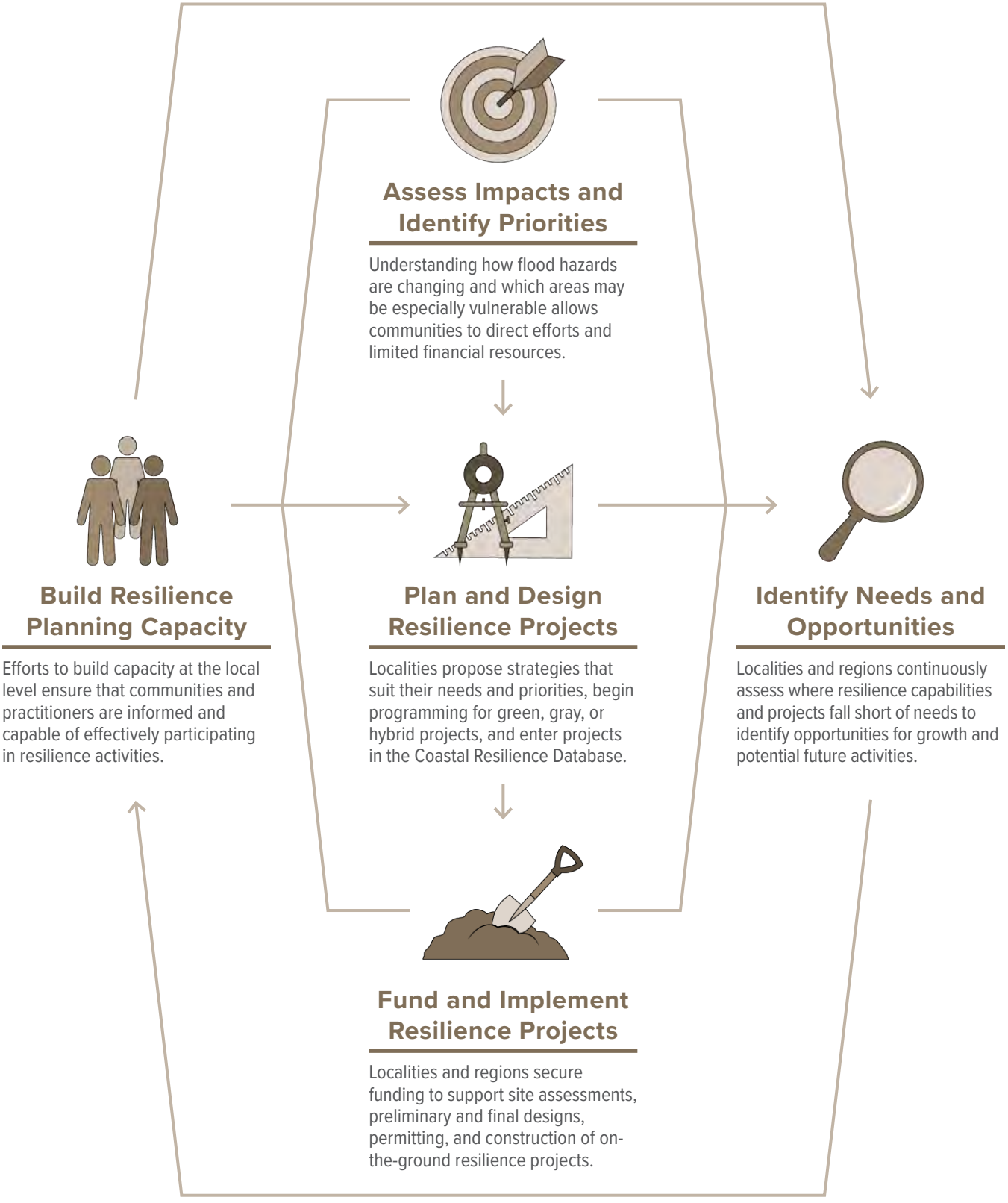
Economic Development through Resilience

Our coastal communities are facing urgent new risks that require innovative and cost-effective solutions. The Aligning Economic Development Subcommittee worked closely with state, regional, and local practitioners to identify opportunities that align coastal resilience and economic development efforts. The Subcommittee developed a survey to better understand how flooding affects economic development efforts and what barriers to aligning economic development and resilience efforts exist. The survey received responses from representatives of state agencies, PDCs and RCs, regional economic development organizations and agencies, and local governments.

Based on this survey, the Subcommittee learned that flooding can hinder economic potential, but risks related to flooding have also served as a catalyst for new economic opportunities. Taking advantage of these opportunities likely requires new polices and revenue streams to support innovation and keep costs down. Respondents highlighted the need for financial and regulatory support of emerging industries around resilience, assistance for businesses affected by flooding, and capacity-building support for local governments to bolster their resilience. Identified barriers to aligning economic development and resilience include lack of local awareness and prioritization of coastal flooding resilience and acknowledgment of the economic risks of flooding. Additionally, respondents noted that some regulations make it challenging or costly for working waterfront or recreational uses to expand in coastal areas.

Process for Building Coastal Resilience

Achieving coastal resilience requires a continuous process of building capacity, implementing resilience projects, and identifying outstanding needs and opportunities, aligned with Commonwealth oversight to collaborate, coordinate, and communicate across and between localities and regions to achieve consistent results.



Assess Impacts and Identify Priorities

Understanding how flood hazards are changing and which areas may be especially vulnerable allows communities to direct efforts and limited financial resources.

Build Resilience Planning Capacity

Efforts to build capacity at the local level ensure that communities and practitioners are informed and capable of effectively participating in resilience activities.

Plan and Design Resilience Projects

Localities propose strategies that suit their needs and priorities, begin programming for green, gray, or hybrid projects, and enter projects in the Coastal Resilience Database.

Identify Needs and Opportunities

Localities and regions continuously assess where resilience capabilities and projects fall short of needs to identify opportunities for growth and potential future activities.

Fund and Implement Resilience Projects

Localities and regions secure funding to support site assessments, preliminary and final designs, permitting, and construction of on-the-ground resilience projects.

Capacity Building and Planning

The ability to recognize future flood threats and implement physical resilience projects that adequately reduce these risks requires significant money, time, and expertise. Coastal localities have varying levels of resources available to them that affect their capacity to propose, develop, implement, and manage resilience projects. Capacity-building and planning initiatives give regions and localities the tools they need to efficiently and effectively understand their risks and take concrete actions to protect their residents and assets from the threats posed by coastal hazards.

The Commonwealth presents three categories of capacity-building and planning initiatives that support coastal resilience efforts: Studies and Data Tools; Programs, Plans, and Policies; and Technical Assistance. Each category aims to build a specific and necessary resource that practitioners and organizations need to understand evolving flood risks and develop cost-effective resilience projects. While not an exhaustive list, the following section outlines the three categories and summarizes different types of strategies that can be employed.

Public Perspectives: Capacity Building and Planning Needs

Over 1,300 Virginians responded to a public online survey with questions relating to their lived flooding experiences and preferences for how to increase resilience in their community. Of those respondents:

61% said their community would benefit from local resilience planning.

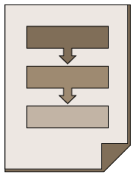
56% said their community would benefit from public education and outreach.

Studies and Data Tools

Studies and data tools include efforts that improve the localities' understanding and knowledge of relevant current and future coastal flood hazards, vulnerabilities, and risks, and options to adapt to future risks to improve outcomes for community, economic, and ecosystem resilience.

Data Collection and Management is the collection, processing, management, or publication of data relating to coastal flood hazards and resilience to support informed decision-making, planning, and design, or to increase public data accessibility through the development of tools.

Studies are structured research efforts that enhance a localities' understanding of coastal hazards, vulnerabilities, risks, or effective resilience projects.



Programs, Plans, and Policies

Programs, plans, and policies include efforts that improve the localities' ability to engage and implement in coastal resilience planning.

Resilience Planning refers to the creation of resilience plans or the integration of coastal resilience and climate change planning considerations into existing plans, programs, and government functions. Planning efforts may include community and stakeholder engagement, intergovernmental coordination, best practice research, project design, and strategy development.

Policies and Standards can incorporate resilience principles that consider future conditions into land use codes, ordinances, zoning, development and design standards, incentive programs, or other policies.

Financial Programs are coordinated activities that facilitate the funding and financing of resilience projects. Specific programs may include bonds, taxes, fees, and revolving loan funds.

Public Education and Outreach are initiatives aimed at educating and empowering the public in relation to coastal flood hazards and resilience. Activities may include the development of educational materials, hosting public meetings and workshops, conducting surveys, building community partnerships, establishing community-based programs, and analyzing and incorporating findings into relevant planning efforts and programs.

Buyout Programs are coordinated activities that facilitate the acquisition of properties that have been damaged by or may be prone to recurring damage caused by flooding or storm-related flooding, or the acquisition of land or property that may buffer or protect other lands from such damage. Note that efforts to create, staff, and manage a sustainable program are capacity-building activities, but implementation is not.

Technical Assistance

Technical assistance includes efforts to improve the localities' ability to execute and fund coastal resilience efforts.

Staffing involves hiring a full-time employee (such as a Chief Resilience Officer) or dedicating staff time to focus on advancing coastal resilience objectives, including project management and program coordination.

Training is any effort to institutionalize resilience within an organization or agency by educating staff and partners on the principles of climate change, coastal hazards, vulnerability, or resilience, and how to apply such principles in their professional roles.

Grant and Loan Application Development is any effort that supports technical writing and application development that improves a localities' capability of securing project funding from federal or non-profit grant programs.

Capacity Needs and Opportunities

Many coastal localities recognize the growing challenges facing their communities and the need for dedicated resources, staff, and programs to implement resilience projects. Robust capacity-building and planning initiatives are essential to execute resilience projects that are cost-effective and adequately protect communities.

The Commonwealth sought input across all levels of government to better understand the progress coastal communities have already made to build capacity and plan for resilience. Through a data call, practitioners were asked to identify proposed, planned, and ongoing capacity-building and planning initiatives and to self-assess their organization's existing capacity to engage with and plan for coastal resilience. Respondents provided information on initiatives in their localities, including descriptions, estimated costs, and expected benefits, among other details. Capacity-building and planning initiatives were collected from July 28, 2021 through August 31, 2021, but the web portal remains open to collect initiatives for inclusion under future phases of the Master Plan.

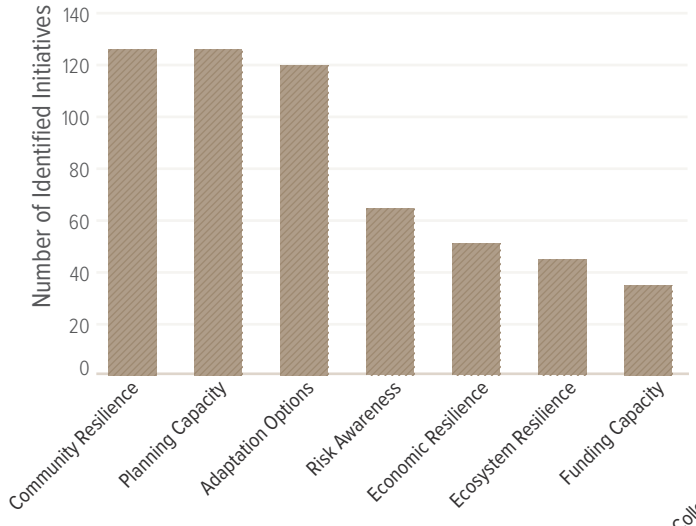
The data call identified more than 80 capacity-building and planning initiatives in coastal Virginia, many of which are related to ongoing resilience projects. These efforts aim to meet needs related to community, economic, and ecological resilience, risk awareness, and funding and planning capacities. The Commonwealth also conducted a data call to identify resilience projects (discussed later in this chapter) and of these projects, nearly 80 submissions were determined to better align with the Master Plan's definition of capacity building. This section therefore presents the 160 initiatives identified through the capacity-building data call and screened from the project data call.

These capacity-building and planning initiatives are inventoried in the Commonwealth's Coastal Resilience Database where they will be maintained and updated over time. At present, they provide a snapshot of where progress may be underway, but do not illustrate the full picture of all ongoing efforts in coastal Virginia. Not every locality was able to participate in the data call due to limited staff capacity or insufficient resources allocated to resilience efforts. The Commonwealth will continue to engage with these localities to understand these needs.

Areas that lack identified capacity-building and planning initiatives may require additional outreach to fully characterize that region's ability to plan for resilience and determine if additional state resources and support are needed and can be applied. By identifying areas with low capacity or those lacking initiatives, the Commonwealth can determine where to direct resources and better facilitate regional and statewide coordination. To identify these areas, the Commonwealth conducted a gap analysis, which is discussed later in this chapter.

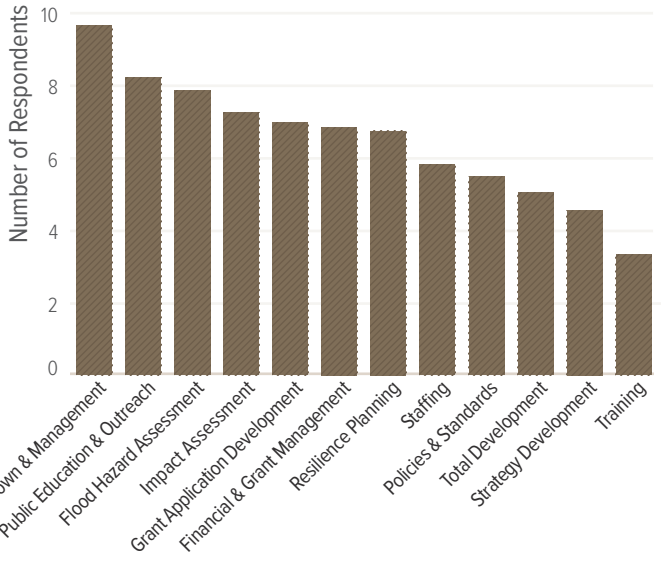
Coastal practitioners also self-evaluated their organizations' existing and outstanding capacities to plan and implement resilience projects. The most common needs identified included data collection, public education and outreach, flood hazard and impact assessment, and grant application development and management.

Capacity-Building and Planning Needs Addressed through Identified Initiatives*



* Note most initiatives identified more than one type of capacity-building and planning need.

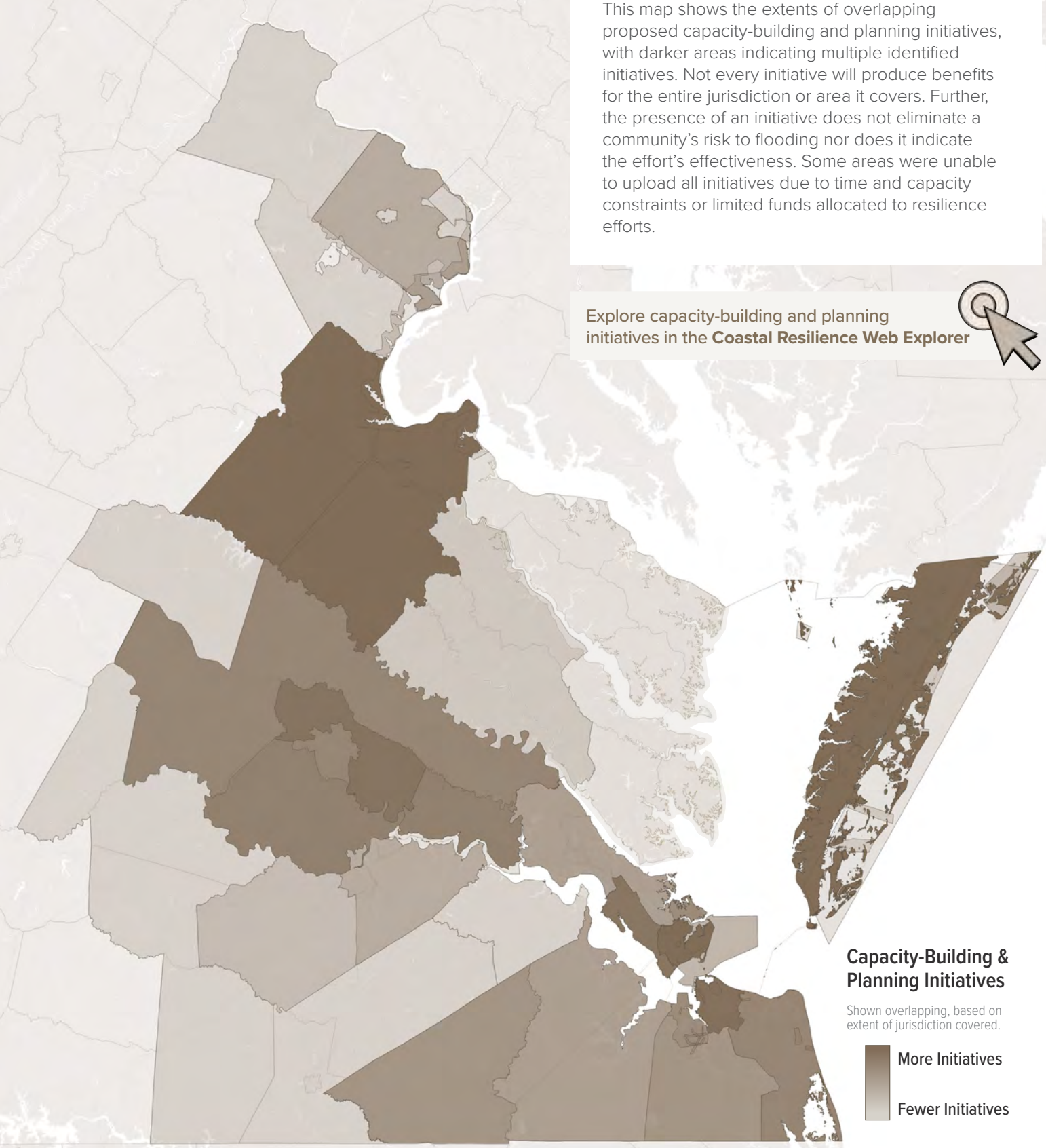
Identified Outstanding Capacity-Building and Planning Needs**

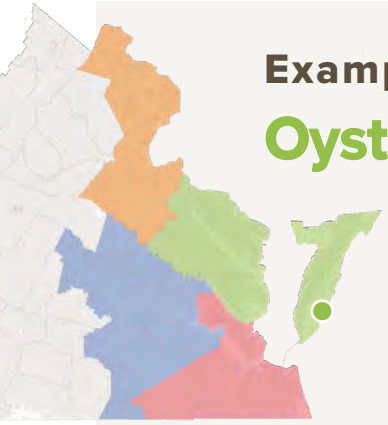


** Note this chart summarizes responses collected by the capacity-building data call. Respondents submitted outstanding needs only once per locality.

This map shows the extents of overlapping proposed capacity-building and planning initiatives, with darker areas indicating multiple identified initiatives. Not every initiative will produce benefits for the entire jurisdiction or area it covers. Further, the presence of an initiative does not eliminate a community's risk to flooding nor does it indicate the effort's effectiveness. Some areas were unable to upload all initiatives due to time and capacity constraints or limited funds allocated to resilience efforts.

Explore capacity-building and planning initiatives in the **Coastal Resilience Web Explorer**





Example Capacity-Building and Planning Initiative:

Oyster Coastal Adaptation and Resilience Plan

A contracted engineering firm, partners, and an Oyster Resilience Steering Committee will lead the development of the Oyster Coastal Adaptation and Resilience Plan which will (1) document and analyze existing conditions and characterize the extent of Oyster's vulnerability to sea level rise and recurrent flooding; (2) recommend strategies and projects, with an emphasis on nature-based solutions, that will enhance Oyster's long-term resilience; and (3) facilitate the implementation of the *2004/2011 Oyster Vision Plan* and employ Eastern Shore of Virginia Coastal Resilience Tool in a community-based adaptation planning project.

Location

Oyster, Northampton County, Accomack-Northampton PDC

Owner

Northampton County and The Nature Conservancy (TNC)

Cost

$500,000

Status

Partially Funded

Resilience Strategies Employed

Programs, Plans, and Policies (Resilience Planning)

Coastal Hazards Addressed

Oyster Village, located on the Northampton County seaside on the Eastern Shore of Virginia, is a working waterfront and residential community that is highly vulnerable to rising seas and recurrent flooding. The Oyster Coastal Adaptation and Resilience Plan will address these hazards.

Anticipated Project Benefits

The Oyster Plan will provide a framework for the path forward toward resilience by providing a list of prioritized projects with specific details, cost estimates, and targeted funding. It will thus guide the funding and implementation of adaptation and resilience projects to benefit the community and habitat of Oyster Village. The Plan will define projects in such a way that they are construction-ready and have funding opportunities identified.

Notable Characteristics

Oyster's low-lying shoreline areas and nearby uplands approaching 30 feet above sea level provides opportunities for coastal resilience projects. Oyster's diversity of assets coupled with its high risk and vulnerability to flooding means that a variety of solutions and methods will need to be developed. While providing solutions that are critical to protect this rural community from imminent threats, projects implemented here will serve as a prototype to other areas on the Eastern Shore, Virginia and coastal United States.

Resilience strategies will target both flooding mitigation for the community infrastructure as well as preparing the landscape to be more resilient to rising seas. The plan will outline specific projects and provide options for increasing resilience. These may include, but are not limited to, living shorelines, marsh protection, natural public areas designed for flood control, innovative ideas for current infrastructure that must remain waterfront (such as boat access), and reconfiguring roads/drainage. Additionally, TNC owns large parcels of land within the community of Oyster that are 30 feet above sea level. One of the strategies could involve moving infrastructure from the low-lying areas to this higher ground.

Photos courtesy of The Nature Conservancy.

Coastal Resilience Projects

A resilient coastal Virginia will require the implementation of cost-effective coastal resilience projects that protect and sustain the essential functions of coastal communities and assets for years to come. As identified in the Framework, these resilience projects can utilize three different approaches: adaptation, protection, and relocation.[93] Each advances a different path to adapting to sea level rise and changing coastal flood hazards.

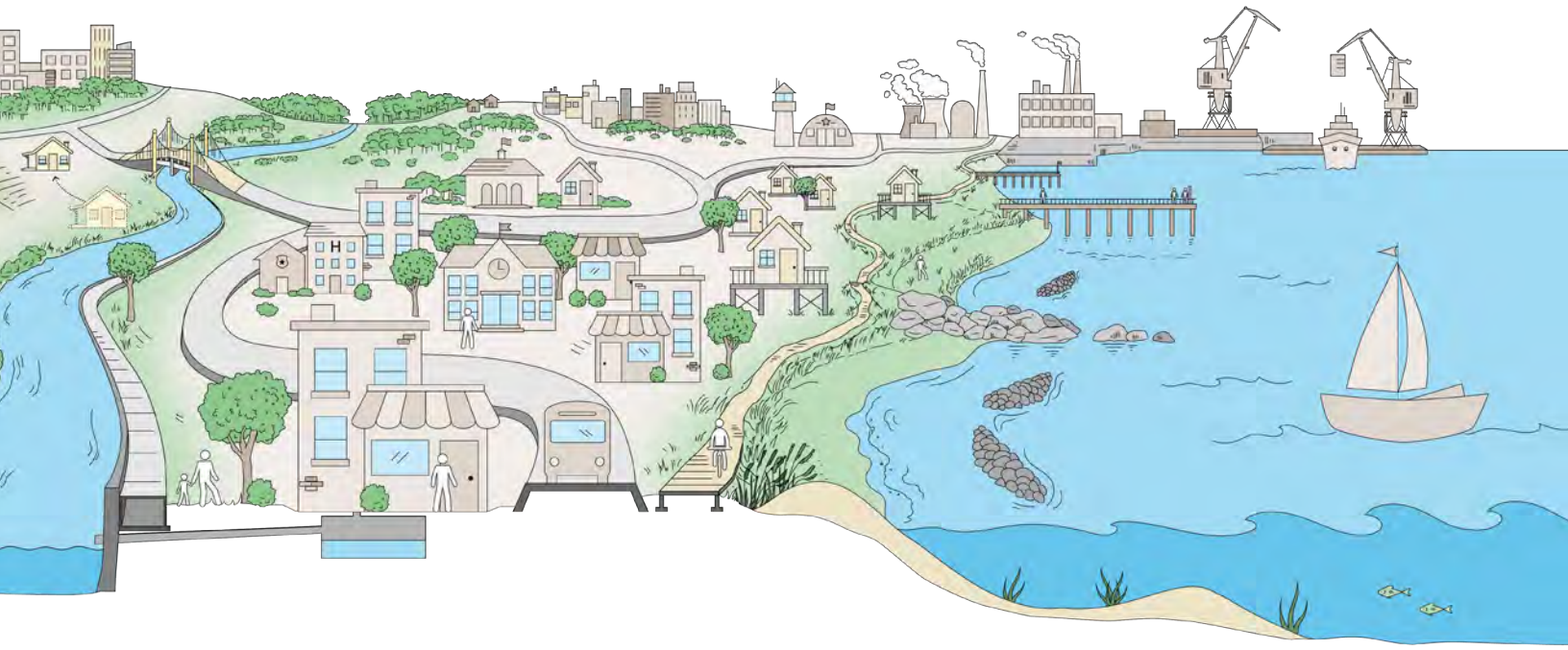
Adaptation – Adaptation strategies allow existing infrastructure to endure increased or amplified flooding. Rather than block floodwaters, these strategies adapt existing built or natural systems in ways that decrease their susceptibility to flooding hazards. Adaptation strategies include restoration projects that allow natural infrastructure to withstand higher sea levels and site-level projects that enable existing built structures to withstand a certain magnitude of flooding.

Protection – Where adaptation is impractical, protection strategies can maintain the functions and benefits of existing infrastructure by absorbing or diverting floodwaters. They include defensive engineered structures and systems that have the potential to protect large areas from a wide variety of flood events but are often costly to design, construct, and maintain.

Relocation – For areas facing increasingly severe and frequent flooding, the necessary scale of protection or adaptation strategies may become prohibitively expensive or otherwise impractical. Relocation strategies preemptively reduce risk by moving existing highly vulnerable assets to safer areas, facilitating migration of wetlands and other natural infrastructure systems, and restricting development in flood-prone areas. This approach anticipates that future flood damages will exceed today's costs for acquisition and relocation.

Beginning a Dialogue on Strategic Coastal Relocation

The Commonwealth recognizes that community-scale relocation is a long-term and complicated resilience strategy that requires extensive additional planning, outreach, and other community, locality, and regional considerations. As such, the Commonwealth is committed to starting and sustaining a dialogue on strategic coastal relocation. As part of Goal 4 of the state's broader coastal resilience strategy outlined in the Framework, the Commonwealth plans to develop a publicly available Introduction to Strategic Relocation handbook. Through this introduction to coastal relocation the Commonwealth hopes to start a dialogue and empower localities and individuals to make informed decisions.



Achieving resilience through adaptation, protection, and relocation approaches can use natural or nature-based ("**green**") features, structural ("**gray**") measures, or a combination of the two measures ("**hybrid**"). The Commonwealth organized projects into three classes: natural and nature-based projects, structural projects, and hybrid projects.

Natural or nature-based projects often serve as the first line of defense to slow advancing floodwaters and reduce the strength of incoming waves while also providing ecosystem services. Structural resilience projects can physically shield specific assets or large inland areas from floodwaters or rising sea levels. Hybrid projects use both green and gray components to maximize the potential benefits of both types of intervention.

Each project need requires a site-specific and community-specific solution. The level of adaptation and protection provided by any project is a function of the scale of the project, the local landscape, and the type and severity of existing and future flood hazards. A given project may include a mixture of green and gray components to address the complex challenges faced and strive to align with the Framework's guiding principles.

The following pages introduce the project classes, with descriptions of the types of resilience projects and strategies fitting into each class. Each project class overview is followed by illustrative projects inventoried in the Coastal Resilience Database. The Commonwealth selected these projects in cooperation with Technical Advisory Committee members and advisors to show examples of existing or planned work in each project class. These examples do not represent a prioritized project list. The prioritization of resilience projects is discussed later in this chapter.

Natural and Nature-Based Projects

Natural and nature-based resilience projects aim to preserve, restore, create, or mimic risk-mitigating features that occur naturally in the landscape through the engineering and construction of features that replicate or enhance natural conditions. Projects that employ natural or nature-based features along waterways can reduce the risks of erosion and flooding in inland areas while also providing additional economic, environmental, and social benefits.

In line with the goals and principles of the broader statewide coastal resilience strategy, the Commonwealth recognizes the importance of protecting and enhancing natural infrastructure and seeks to encourage and prioritize projects that use natural and nature-based features.

The Commonwealth identified three types of natural and nature-based projects that support coastal resilience: natural features, nature-based features, and conservation and adaptation. Each type consists of various natural and nature-based resilience strategies that a project can employ.

The following section presents these natural and nature-based project types and strategies followed by example projects that employ them. Additional natural and nature-based projects are located in the Coastal Resilience Database and can be viewed in the Coastal Resilience Web Explorer. See Appendix G for additional information on strategy types and their suitability for various project needs.

Natural Features

Natural features are created and evolve over time through natural processes.[94] Natural coastal features take a variety of forms, including reefs, barrier islands, dunes, beaches, wetlands, and maritime forests. These natural features can either be restored in areas where they existed previously or created in areas where they have not existed in recent history.

Habitat Creation involves the construction of a new wetland or dune system, or other ecosystems with natural processes and functions that can slow coastal erosion and attenuate floodwaters as well as provide wildlife habitats, water quality improvements, and recreation opportunities.

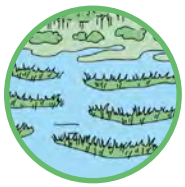
Habitat Restoration involves the manipulation of degraded aquatic vegetation, barrier island, beach, dune, floodplains, maritime forests, wetland, or other ecosystems to reestablish or stabilize natural processes to improve flood resilience.

Public Perspectives: Community Benefits from Natural and Nature-Based Projects

Over 1,300 Virginians responded to a public online survey with questions relating to their lived flooding experiences and their views on what types of projects would increase resilience in their community. Of those respondents:

61% believe their community would benefit from nature-based shoreline stabilization.

57% said their community would benefit from habitat creation and restoration.



Nature-Based Features

Nature-based features mimic characteristics of natural features, but are created by human design, engineering, and construction to provide specific services such as coastal risk reduction.[95]

Living Shorelines are created through the strategic placement and management of plants, stone, sand fill, and organic structural materials that collectively stabilize shorelines, control erosion, and attenuate floodwaters, as well as provide recreation opportunities.

Green Infrastructure is often used interchangeably with nature-based solutions but can also refer to more specific concepts that fall under the larger nature-based solutions umbrella. Typically, green infrastructure projects are used in urban settings at a landscape- or site-specific scale to control stormwater and minimize runoff. Retaining and slowing infiltration of water in upland areas can reduce discharge to downstream coastal receiving waterbodies. Examples of green infrastructure include reducing impervious surfaces through green roofs or permeable pavements, rain gardens, and stormwater ponds.

Conservation and Adaptation

Conservation and Adaptation include activities that remove flood-exposed infrastructure, conserve natural flood buffers, allow for flood inundation, or provide migration potential for natural systems.

Buyout or Acquisition Programs facilitate the acquisition of properties that have been damaged or are prone to damage caused by storms or flooding, or acquisition of land and properties that may protect other lands or assets from potential damage.

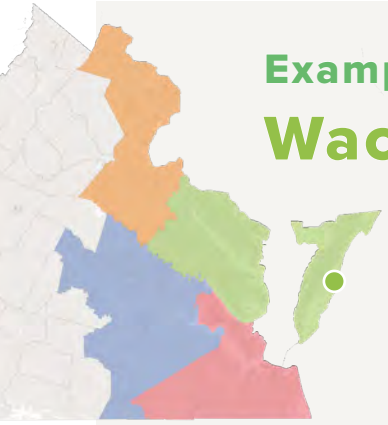
Conservation Easements are voluntary legal agreements between a property owner and a public agency or private entity that permanently limit the uses of the land to protect its ecological processes and reduce flood damage.

Land Acquisition is the acquisition of land for flood protection, prevention, and conservation purposes, or public access.

Public Facility Removal involves removal of a flood-prone public facility, allowing for migration of natural assets into the newly undeveloped area.

Undeveloped Land Conservation is the permanent conservation of undeveloped lands identified as having flood resilience value by ConserveVirginia's Floodplain and Flooding Resilience layer or similar data-driven analytics.

Explore natural and nature-based projects in the **Coastal Resilience Web Explorer**



Example Nature-Based Project:

Wachapreague Reef Restoration

Through support from a National Fish and Wildlife Foundation National Coastal Resilience Grant, The Nature Conservancy (TNC) is constructing an oyster reef using new restoration techniques to reduce erosion of a marsh adjacent to Wachapreague Harbor, on the main channel of Bradford's Bay.

Location

Town of Wachapreague, Accomack-Northampton PDC

Owner

TNC, in partnership with the University of Virginia, Accomack-Northampton PDC, and the Town of Wachapreague

Cost

$1,400,000

Status

Construction and Implementation

Resilience Strategies Employed

Habitat Restoration (Oyster Reef Restoration)

Coastal Hazards Addressed

The constructed oyster reef aims to protect the marsh system adjacent to Wachapreague Harbor, which is one of the last barriers between the Town of Wachapreague and the open ocean. Over the past decade, Wachapreague Inlet has widened, exposing the town to the open ocean through this inlet, as well as marsh systems that were once protected by the south end of Cedar Island. This marsh system has been actively eroding due to the increased exposure. If it disappears, the town and its docks and waterways will become more vulnerable to storms and wave action. Additionally, the loss of this ecosystem would also mean the loss of habitat for wildlife that depend on exposed marsh systems for survival.

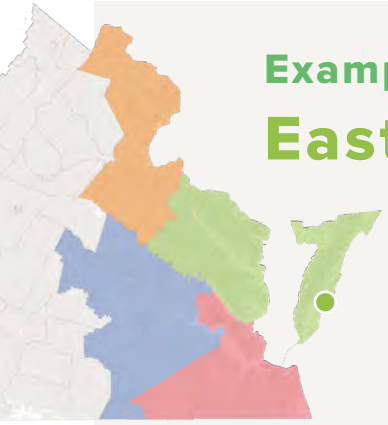
Anticipated Project Benefits

Oyster reefs lessen wave action, reducing shoreline erosion while also capturing sediment and building up the shoreline. The proposed reefs will reduce the impacts of waves, which cause erosion of marshes that buffer the mainland, while creating new suitable habitat for fish and wildlife.

Notable Characteristics

The Commonwealth recognizes the importance of protecting and enhancing natural infrastructure like oyster reefs. The Wachapreague Reef Restoration exemplifies a project that involves robust pre- and post-construction monitoring that will advance our understanding of which types of oyster reef techniques provide the greatest shoreline stabilization benefits. The project team is applying different types of oyster reef techniques depending on the shoreline properties at the site. Stacked oyster castles are being installed along the sandy, relatively hard, and flat shorelines. For steep and unstable (muddy) shorelines where oyster castles would sink and not be effective, an innovative oyster structure is being installed. After construction, the project will be monitored to evaluate the effectiveness of the different approaches. Effective practices will be shared with local, regional, and state stakeholders.

Photos courtesy of The Nature Conservancy.



Example Nature-Based Project:

Eastern Shore Marsh Migration

This project involves leveraging The Nature Conservancy's (TNC) Coastal Resilience Tool to create a land acquisition and conservation easement program to target locations most prone to sea level rise and recurrent flooding, marsh migration, and other resilience measures. TNC's land protection program at the Volgenau Virginia Coast Reserve (VVCR) includes purchasing land directly, assisting local, state, and federal conservation partners with land acquisition, and helping private owners protect their land with conservation easements.

Location

Eastern Shore, Virginia, Accomack-Northampton PDC

Owner

TNC, in partnership with Virginia Eastern Shore Conservation Alliance, and Accomack-Northampton PDC

Cost

$1,000,000

Status

Construction and Implementation

Resilience Strategies Employed

Conservation Easements, Land Acquisition

Coastal Hazards Addressed

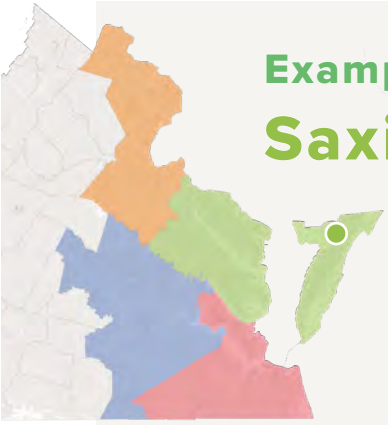
Conservation easements can reduce or limit development in areas vulnerable to flooding. When land is protected along the shoreline with a conservation easement, fewer houses and accessory structures are built close to the water and in the flood zone. Protecting the natural features, such as riparian buffers, further protects those structures and developed areas located behind the buffer and conserved land. Protecting the natural features of the land also provides space for migration of habitats as sea levels rise.

Anticipated Project Benefits

This project is anticipated to increase community resilience along Virginia's Eastern Shore through reduced development in fragile and flood-prone areas and protecting existing landward development. Easements will also support habitat resilience protecting the spaces these systems usually migrate into. In addition to resilience, conservation easements on the Eastern Shore protect the quality of life and rural and agricultural character of the community. Conservation easements have a positive impact on water quality, protecting the water with which the community lives, works, and plays.

Notable Characteristics

This project exemplifies regional-scale planning initiative that brings many benefits at multiple scales: individual, community, and the larger region. An easement property continues to provide economic benefits for the area in the form of jobs, economic activity and property tax while simultaneously reducing flood risks and enhancing habitat resiliency. A study released in 2017 from George Mason University's Center for Regional Analysis and Urban Analytics, Inc. highlighted the positive impact conserved land has on the economies of both Northampton and Accomack Counties in Virginia.



Example Nature-Based Project:

Saxis Living Breakwaters

Saxis Island is a historic fishing village located on the tip of the Freeschool Marsh peninsula. The western boundary of Saxis Island is eroding at about five feet per year. The physical vulnerability of the island continues today, with only a short portion of the western boundary protected by a broken concrete revetment. The Town of Saxis is constructing 30 large concrete oyster structures offshore near its pier along the wharf, with beach nourishment behind the structures

Location

Saxis Island, Accomack-Northampton PDC

Owner

Town of Saxis

Cost

$2,500,000

Status

Final Design and Permitting

Resilience Strategies Employed

Offshore Breakwaters, Habitat Restoration (Oyster Reef Restoration)

Coastal Hazards Addressed

Breakwaters are not designed to prevent flooding directly, but reduce the impacts of waves that can lead to flooding.

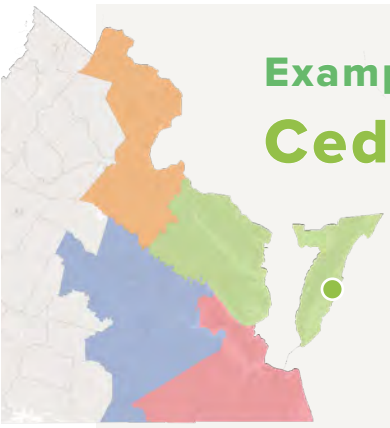
Anticipated Project Benefits

The living breakwaters and beach nourishment will slow wave action along the wharf shoreline. Reefs will attract both oysters and fishermen but also slow wave action.

Notable Characteristics

The Saxis Living Breakwater project demonstrates how to address the coastal protection needs of the individual community while also building regional coastal resilience. The living breakwater system will adapt to sea level rise through colonization of oysters, thereby building the elevation and resilience of the system. The oyster habitat and improved water quality will help contribute to the restoration of the crabbing and fishing grounds vital to the historical fishing village of Saxis Island.

Photo courtesy of the Town of Saxis.



Example Nature-Based Project:

Cedar Island Implementation

Through support from a National Fish and Wildlife Foundation Coastal Resilience grant, Virginia Institute of Marine Sciences has developed preliminary, science-based engineering design plans for the construction of more than 200 acres of marsh along southern Cedar Island. The goals of the project are to protect against future breaching of the island and to evaluate the relationship between barrier islands and adjacent marshes that may naturally increase overall system resiliency.

Location

Cedar Island, Accomack-Northampton PDC

Owner

Virginia Institute of Marine Sciences (VIMS)

Cost

$10,000,000

Status

Final Design and Permitting

Resilience Strategies Employed

Habitat Creation and Restoration (Barrier Island Restoration, Wetland Creation and Restoration)

Coastal Hazards Addressed

Barrier islands and their backbarrier marshes — meaning, marshes located on the bayside of the barrier islands — have a symbiotic relationship. Sediment from the beaches and dunes is transported to the marshes through wind and storm processes. This sediment allows for marsh development on the landward sides of islands, and marshes form a platform onto which islands can migrate. The rollover of islands onto the marsh platforms slows their migration and can work to stabilize the island, reducing the likelihood of inlet breaching over time with wind and wave action.

This project leverages these natural symbiotic feedbacks to support the management and restoration of backbarrier marshes. Construction of a new marsh platform to the west of Cedar Island will protect the southern portion of the island which serves as an important buffer for the Town of Wachapreague This project will reduce wave and tidal energy and storm surge reaching the backbarrier marshes and mainland, thereby reducing erosion and flooding.

Anticipated Project Benefits

This project will benefit nearby habitats, slow the migration of the barrier island, and prevent breaching of the island. Ultimately, this project will enhance the resilience of Cedar Island, its backbarrier marshes and lagoons, and the mainland town of Wachapreague, home to a U.S. Coast Guard station, regional fire and rescue services, the VIMS Eastern Shore Lab, and a vibrant tourism- and aquatic-resource-based economy.

Notable Characteristics

This project underscores the importance of prioritizing protection of the Commonwealth's unique and vulnerable coastal environments. This design approach could be applied elsewhere along the Virginia Barrier Islands system.

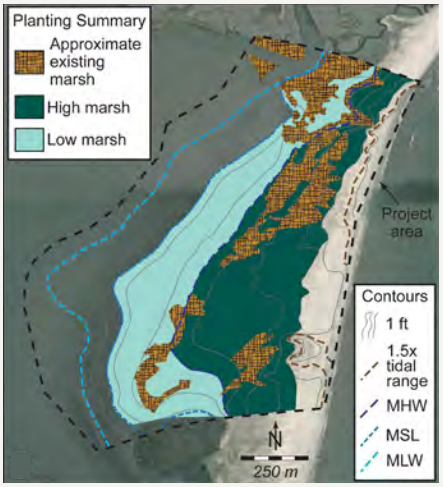
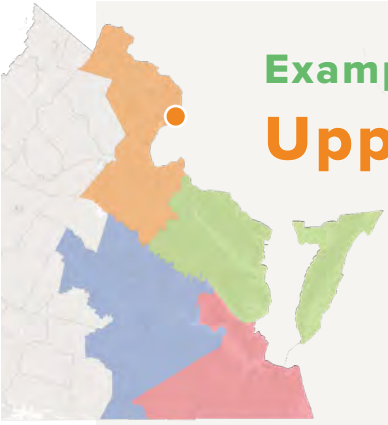


Image courtesy of VIMS.



Example Nature-Based Project:

Upper Potomac Conservation

This project focuses on Northern Virginia Conservation Trust's long-term goals of estuarine and shoreline conservation of critical small bays and estuaries along the Alexandria, Fairfax and Prince William County coastlines, focusing particularly on the mouths of Hunting and Little Hunting Creek, Dogue Creek, the Mason Neck peninsula, Belmont Bay and Neabsco Creek. It involves ongoing and future targeted land conservation through easement and fee acquisitions that allow for buffering of stream corridors, transition of habitats inland as sea levels rise, and avoidance of shoreline development in vulnerable areas.

Location

Northern Virginia Coastlines, Northern Virginia RC

Owner

Northern Virginia Conservation Trust, Northern Virginia RC

Cost

$8,500,000

Status

Programmed

Resilience Strategies Employed

Conservation Easements, Land Acquisition and Conservation, Habitat Restoration (Wetland Restoration)

Coastal Hazards Addressed

The project will reduce coastal hazards by reducing the amount of coastal development subject to tidal and storm-surge flooding, providing buffers between infrastructure and the shore, and ensuring monitoring of coastal erosion.

Anticipated Project Benefits

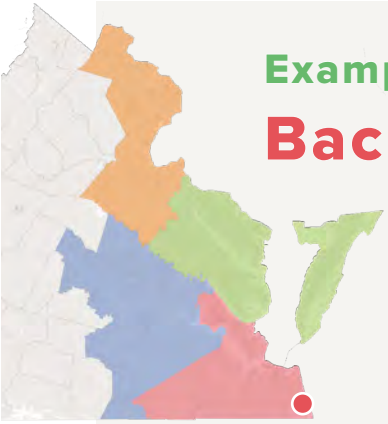
Conservation of vulnerable coastal lands will enhance wetlands and riparian areas while buffering them from development as well as allowing them to buffer critical infrastructure farther inland. In particular, this project will protect a critical rail line through the region. With adequate resources the project may conserve up to an additional six to 12 significant properties over a five-year time frame.

Notable Characteristics

Land conservation projects such as these will be critical to not only keeping structures out of future floodplains, but also protecting habitat, biodiversity and recreation benefits as other coastal sites are impacted and lose their capacity to provide those functions.

Little Hunting Creek

Photo courtesy of Northern Virginia Conservation Trust.



Example Nature-Based Project:

Back Bay Marsh Terraces

The Back Bay Marsh Terrace project involves design, environmental assessment, and permitting of marsh terraces within Back Bay National Wildlife Refuge. Marsh terraces are narrow man-made islands that are arranged across areas that were historically marsh but are now shallow, open water. The project is aligned with restoration objectives of the Back Bay National Wildlife Refuge and Virginia Department of Wildlife Resources and local, regional, and state stakeholders are highly engaged with project design and implementation.

Location

Virginia Beach, Hampton Roads PDC

Owner

City of Virginia Beach

Cost

$20,775,000

Status

Final Design and Permitting

Resilience Strategies Employed

Habitat Restoration (Wetland and Aquatic Vegetation Restoration)

Coastal Hazards Addressed

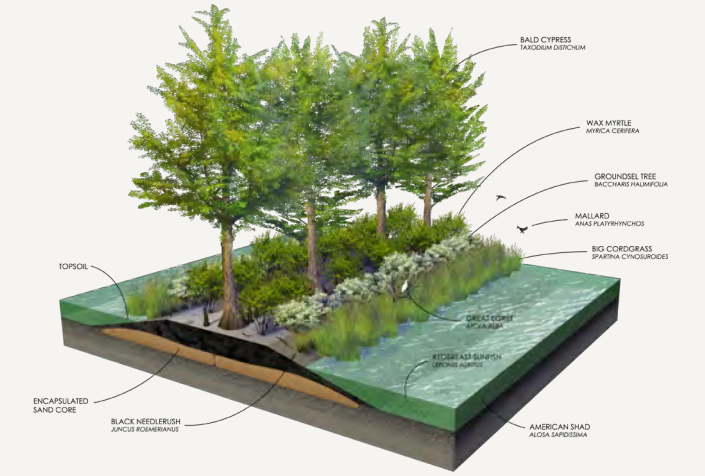
The project site was strategically selected because it offers an opportunity to restore approximately 260 acres of marsh island habitat in northern Back Bay. This area has historically provided both environmental and flood reduction benefits to the surrounding community. Restoring vegetation in these marsh island systems will work to protect these habitats from the impacts of storms, thereby protecting adjacent communities. This project is the first step in a more comprehensive vision of restoration in Back Bay and the larger Albemarle-Pamlico estuary to strategically advance restoration objectives.

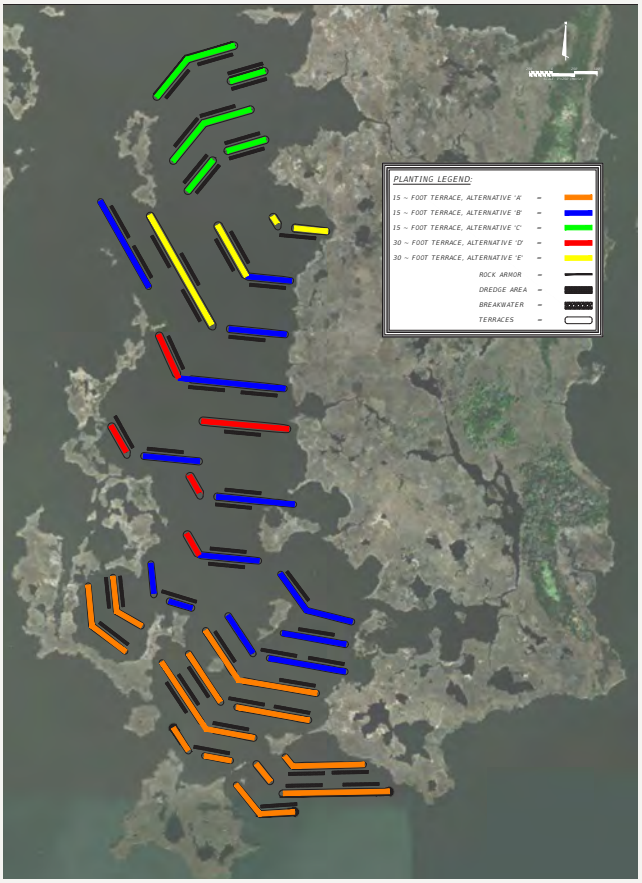
Anticipated Project Benefits

The proposed project would stabilize several critically eroding marsh islands from further degradation, promote the growth of aquatic vegetation, and provide flood risk reduction benefits.

Notable Characteristics

This project represents the first-ever application of marsh terraces in the mid-Atlantic region, a testament to the City of Virginia Beach's commitment to implementation of innovative nature-based approaches. This project demonstrates how multiple streams of funding can come together to implement a large-scale nature-based project. The design and permitting for this project is funded through the City's Capital Improvement Program and a National Fish and Wildlife Foundation National Coastal Resilience Grant. Construction will be funded from increased real estate taxes generated from an approved stormwater bond referendum.





Images courtesy of the City of Virginia Beach.

Structural Projects

Structural interventions prevent coastal or riverine floodwaters from passing into inland areas through the protection of individual assets or the blocking of flood pathways. Structural interventions include large-scale structures that protect larger areas or critical infrastructure, structural shoreline stabilization features that protect the shoreline and can reduce inland consequences, and smaller-scale methods that adapt existing assets to avoid exposure or reduce damage.

The Commonwealth identified three types of Structural projects that support coastal resilience: flood risk reduction structures, structural shoreline stabilization, and community infrastructure. Each Structural project type consists of project subtypes, or measures.

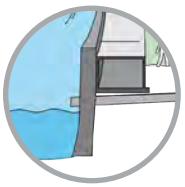
The following section presents these structural project types and strategies followed by example projects that employ them. Additional structural projects are located in the Coastal Resilience Database and can be viewed in the Coastal Resilience Web Explorer. See Appendix G for additional information on strategy types and their suitability for various project needs.

Public Perspectives: Community Benefits from Structural Projects

Over 1,300 Virginians responded to a public online survey with questions relating to their lived flooding experiences and their views on what types of projects would increase resilience in their community. Of those respondents:

81% believe their community would benefit from stormwater drainage improvements.

42% believe their community would benefit from structural shoreline protection, including floodwalls, levees, or tide gates.



Flood Risk Reduction Structures

Structural flood risk reduction involves the placement of structures that block flood pathways or divert water from one area to another.

Floodwalls are vertical barriers that contain coastal or riverine floodwaters and are typically used when space or land use constraints are present.

Tide Gates are fixed devices closed ahead of spring tides and anticipated flood events to restrict the upstream movement of tidal waters, can prevent saltwater intrusion, and are relatively smaller than other protective structures, like storm surge barriers.

Storm Surge Barriers are large-scale barriers or gates closed ahead of anticipated storms and flood events to prevent water from reaching the protected area behind the structure.

Levees and Dikes are compacted earth structures that confine and block floodwaters from moving into targeted areas, and depending on design, can stabilize shorelines and provide recreation opportunities.

Pump Stations are power-generated devices that divert large volumes of water away from wastewater and sewer systems.

Deployable Flood Protection utilizes movable barriers placed in advance of a flood or storm and removed when floodwaters subside.

Structural Shoreline Stabilization

Structural shoreline stabilization involves using engineered structures to provide protection of a shoreline from existing of future erosion.

Seawalls are barriers that run parallel to the shore to reduce shoreline erosion, as well as prevent floodwaters, strong waves, or storm surges from overtopping onto dry land.

Revetments are sloped structures typically constructed of two layers of large, heavy stones that anchor the base of an upland bank to attenuate wave overtopping and floodwaters, as well as stabilize shorelines behind the structure.

Offshore Breakwaters are large gapped structures placed strategically offshore to maintain beaches and dunes. Offshore breakwater systems provide shoreline protection by intercepting incoming waves and creating stable pocket beaches in between the fixed stone structures.

Community Infrastructure

Community infrastructure project types involve protection of public assets such as roadways and bridges, public facilities, and our stormwater drainage system.

Building Elevations involve renovation to raise the lowest floor of a building to reach or exceed the area's base flood elevation in order to prevent floodwaters from damaging the building structure or contents.

Road and Bridge Elevations are structural modifications, such as pier additions, embankment reinforcement, low and high chord retrofits, or bridge replacements, to raise roads and bridges above floodwaters to allow continuity of access and use and to avoid pressure flow and scour.

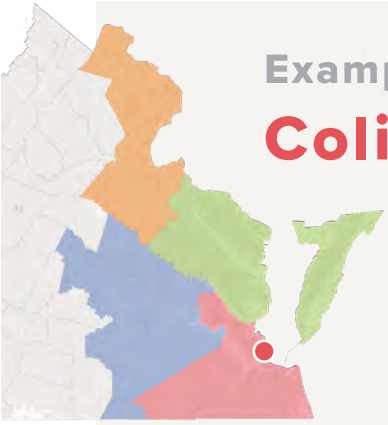
Stormwater Drainage and Utility Improvements are retrofits to increase conveyance and fluid capacity of drainage infrastructure, such as catch basins, outfalls, conduits, and stormwater controls.

Wet Floodproofing are structural modifications to a building that allow floodwaters to pass through specific enclosed areas that greatly reduce the potential for damage.

Dry Floodproofing involves the installation of materials that prevent floodwaters from entering enclosed areas of a structure.

Public Facility Relocation involves moving a public building or other public infrastructure out of reach of existing or future coastal floodwaters, allowing for migration of natural assets into the newly undeveloped area.

Explore structural projects in the **Coastal Resilience Web Explorer**



Example Structural Project:

Coliseum Lake Weir Replacement

The Hampton Coliseum sits on Coliseum Lake and attracts tourism and a wide range of events, stimulating economic growth in the surrounding areas. Coliseum Lake, originally built as a borrow pit during the construction of Interstate 64, has been used as a regional stormwater retention basin with water quality retrofits added in 2015. The facility manages stormwater discharge from approximately 400 acres of area upstream of the lake. The project involves replacing the existing weir at Coliseum Lake with a tide gate that will create a storm surge barrier and block tidal flows encroaching upon the available storage for stormwater in the lake.

Related Projects: Lake Hampton, North Armistead Avenue Improvements

Location

Hampton, Hampton Roads PDC

Owner

City of Hampton

Cost

$1,800,000

Phase

Site Assessment and Preliminary Design

Resilience Strategies Employed

Storm Surge Barrier, Tide Gate

Coastal Hazards Addressed

Coliseum Lake currently experiences the inflow of tidal waters which reduce the overall storage capacity in the lake available to mitigate precipitation-driven flooding. This creates the potential for flooding in upstream areas which feed the lake during intense rainfall events. The new tide gate will prevent tidal inflow into the lake and upstream drainage system, and will allow the City of Hampton to maintain an optimal water storage capacity to accommodate upstream watershed drainage during intense rainfall events.

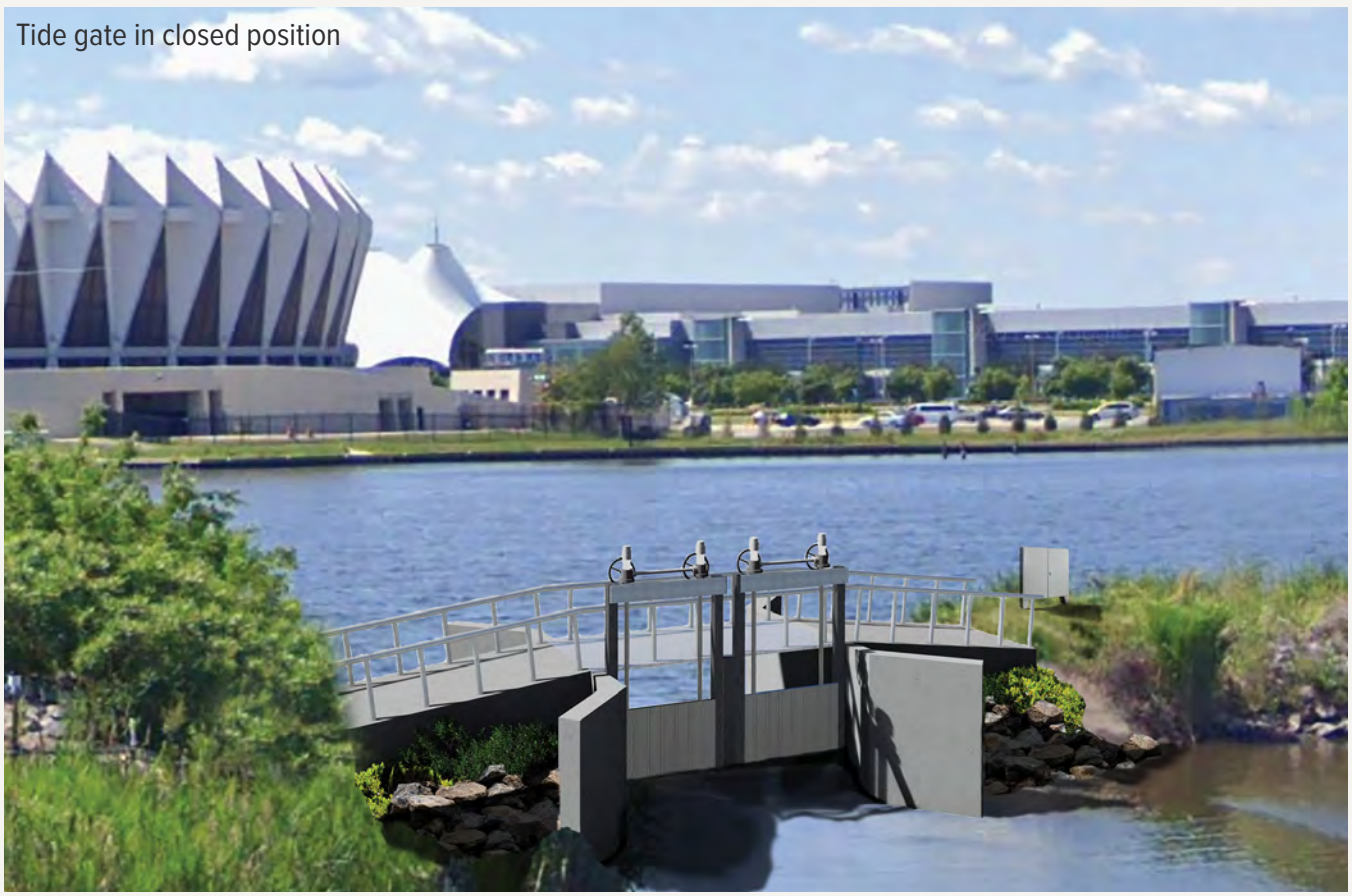
Anticipated Project Benefits

The project will reduce flood risk to areas upstream of the lake, including the Coliseum Central Business Improvement District which contains multiple commercial developments, including malls and hotels, which are key economic centers within the City. Additionally, the project will reduce flood risk to the interchange at I-64 and West Mercury Boulevard, a critical piece of the regional transportation infrastructure network

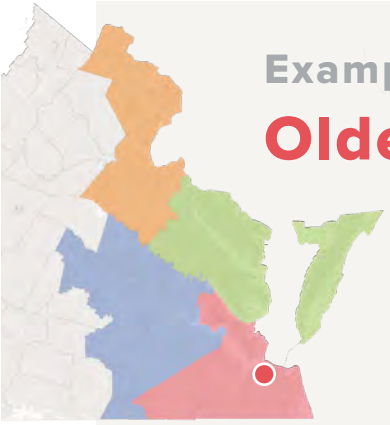
Notable Characteristics

This project is a notable example of how adaptive design strategies can be integrated into tide gate design. Currently, the tide gate height is designed to be at four feet to withstand mid-term sea level rise, but the gates are designed to accommodate replacement in the future to a height of up to seven feet to adapt to longer-term sea level rise. Additional resilient measures include complete automated/remote operation capabilities and battery back-up of 72 hours in case of power loss.

The tide gate is an adaptation to sea level rise, allowing the city to keep the tide out, ensuring more storage during rain events and slowing the draw down to coincide with the receding tide.



Images courtesy of Kimley-Horn.



Example Structural Project:

Olde Towne Stormwater Pump Station

To address localized flooding in the City of Portsmouth's Olde Towne Historic District, the City is designing a stormwater pump station that will function as an integral part of the City's flood protection program. The Olde Towne Pump Station design applies hydrologic modeling, pipeline hydraulics, and stormwater pump intake design while also being responsive to community issues. The project includes a pump station, natural gas generator, stormwater structures, and six pumps, which will equip the pump station to manage flows from 90% of rainfall events in the drainage area.

Location

Olde Towne Portsmouth, Hampton Roads PDC

Owner

City of Portsmouth

Cost

$12,000,000

Status

Final Design and Permitting

Resilience Strategies Employed

Pump Stations

Coastal Hazards Addressed

The City of Portsmouth's Olde Towne Historic District experiences localized flooding throughout the drainage area due to aging infrastructure and changing environmental conditions. In the lowest portion of the drainage area, rainfall events as small as 0.1 inches of rain in 24 hours combined with high tides can flood streets with one foot of water at the curb.

Anticipated Project Benefits

It is estimated that this project will reduce the flooding risk for the entire Olde Towne Historic District, including 210 buildings, and protect an area of approximately 23 acres.

Notable Characteristics

The stormwater pumping station is the final project in a three-part series to address flooding in the Olde Towne drainage basin. The first two phases included the replacement of the Crawford Bay Seawall, completed in 2011, and raising Crawford Parkway to reduce flooding and ponding on the road, as well as the replacement of the tide gate on the box culvert that serves at the main outfall.

The stormwater pumping station design takes rainfall intensities into consideration along with sea level rise. The pumping station will cover a drainage basin of 135 acres, across mixed-use and under-resourced communities in downtown Portsmouth.

The project showcases how federal funding can be used to support the construction of critical flood mitigation projects. The City recently received a FEMA Hazard Mitigation Grant for $7.45M, which will allow the construction of the station to be accelerated.

Crawford Bay Seawall

Tide gates on stormwater outfall

Construction on Court Street to connect pumping station

Images courtesy of the City of Portsmouth.

Hybrid Projects

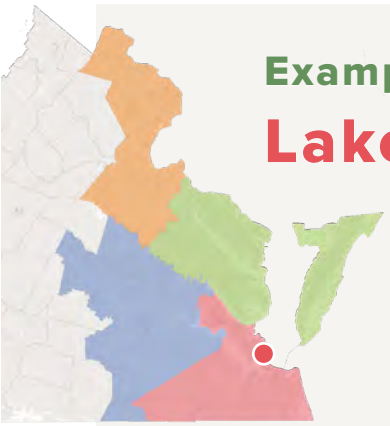
Hybrid projects combine both natural and nature-based features with structural features. Implementing both natural and nature-based and structural strategies can maximize the potential benefits of each intervention for the benefiting area.

The level of protection provided by any project will depend on the size of the intervention, the local landscape, and the type and severity of local flood hazards. To address compounding hazards, a locality may use a mix of strategies to maximize the overlapping benefits of each intervention.

Using both natural and nature-based and structural methods can create a system of layered defenses. Natural and nature-based features can absorb floodwaters and wave action to a certain degree, but during major or extreme coastal floods, these structures alone may not adequately protect affected communities. Instead, layering both interventions or using multiple methods can prolong structural measures' useful life and provide the environmental and social co-benefits of natural and nature-based projects. For example, a living shoreline can abate fast-moving floodwaters, so a storm surge barrier can more effectively intercept the water from inundating dry land.

The following pages provide a select sample of example hybrid projects. Additional hybrid projects are located in the Coastal Resilience Database and can be viewed in the Coastal Resilience Web Explorer.

Explore hybrid projects in the **Coastal Resilience Web Explorer**



Example Hybrid Project:

Lake Hampton

This project will increase the water storage capacity of an existing retention pond located adjacent to the North Armistead Road Raising project and Newmarket Creek. Additional water storage will be accomplished by raising an existing embankment at the southern edge of the lake, replacing culverts and outlet pipes to reduce tidal backflow from Newmarket Creek into the lake, and installing a series of dry swales at the north edge of the lake to capture and store stormwater runoff before it reaches the lake. The project will also create new wetlands in the lake and expand an existing walking trail around the lake's perimeter.

Related Projects: North Armistead Avenue Improvements, Coliseum Lake Weir Replacement

Location

Lake Hampton, Hampton, Hampton Roads PDC

Owner

City of Hampton

Cost

$6,800,000

Status

Final Design and Permitting

Resilience Strategies Employed

Natural and Nature-Based: Green Infrastructure, Habitat Restoration and Creation (Wetland Restoration and Creation)

Structural: Levees, Stormwater Drainage and Utility Improvements

Coastal Hazards Addressed

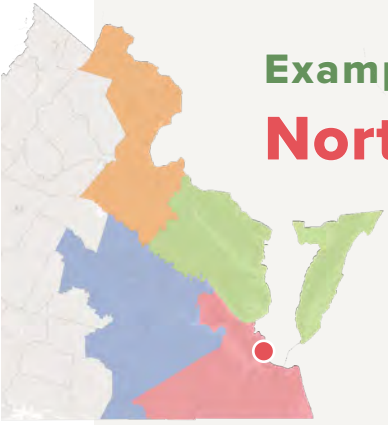
The project will protect the North Armistead critical transportation corridor from precipitation-based flooding by receiving and storing stormwater runoff from the road.

Anticipated Project Benefits

This project is anticipated to create more than 17 acre-feet of new water storage capacity in Lake Hampton. It will install 1,500 linear feet of trail, including two boardwalks to bring visitors over the lake's edges, connected to an existing community resource, the Waterwalk Trail. The project will also create and enhance native habitat, including by transforming an existing peninsula into a bird sanctuary island, and creating a half-acre of wetlands on the lake's shores.

Notable Characteristics

Lake Hampton is an example of using resilient design criteria, and connecting flood mitigation projects to multiple community benefits. The project design team utilized rainfall event modeling under both historic conditions and anticipated increases in rainfall created by climate change. These models were used to determine the additional needed storage capacity to achieve.



Example Hybrid Project:

North Armistead Avenue Improvements

North Armistead Avenue is a critical stretch of roadway in Hampton. It serves as a major connector of Joint Base Langley-Eustis, Downtown Hampton, and the Coliseum Central District, and also connects to key evacuation routes. This project will elevate a vulnerable half-mile stretch of North Armistead Avenue that is adjacent to Newmarket Creek to a minimum height of 7.5 feet above sea level. It will also retrofit the roadway to better utilize medians and rights of way to increase water storage capacity and improve water quality, and will create sidewalks and a shared-use trail.

Related Projects: Lake Hampton, Coliseum Lake Weir Replacement

Location

North Armistead Avenue, Hampton, Hampton Roads

Owner

City of Hampton

Cost

$15,700,000

Status

Final Design and Permitting

Resilience Strategies Employed

Natural and Nature-Based: Green Infrastructure

Structural: Road or Bridge Elevation, Stormwater Drainage Improvements

Coastal Hazards Addressed

This project will address tidal flooding, storm surge flooding, and stormwater flooding. The project will reduce hazards by preventing road inundation from tidal and storm surge flooding from Newmarket Creek by raising the elevation of a river- and wetland-adjacent stretch of roadway between Findley Street and the North Armistead Avenue bridge over Newmarket Creek. As a result of its low-lying position next to the creek, the road saw an average of 92 hours of flooding each year between 2015 and 2019, affecting approximately 45,000 vehicles annually.

By installing green infrastructure along the roadway, the project will also address stormwater flooding by creating increased runoff storage. Bioswales will be used in the median and between the southbound traffic lanes and a new shared use path. Where the road is adjacent to Lake Hampton, stormwater runoff will be fed through the Lake's new "treatment train" of dry swales (vegetated channels that filter stormwater through soil and storm drains) before reaching the Lake itself (see Lake Hampton project).

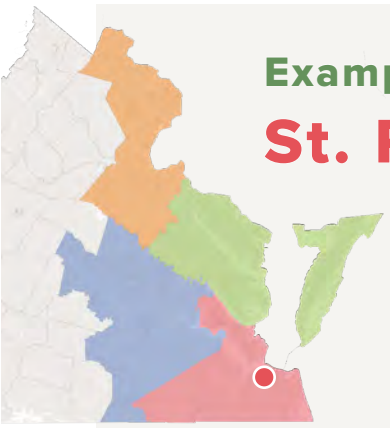
Anticipated Project Benefits

This project seeks to nearly eliminate existing flooding challenges that occur along this stretch of roadway during tidal events and storm surges in the short term. It is not possible to mitigate all flooding at this location, though the changes will reduce the frequency and duration of road impassibility, ultimately protecting a critical transportation asset and ensuring community connectivity. The project will also create approximately one mile of new sidewalk and mixed-use trail where none currently exists, which is eventually planned to connect to the regionally-envisioned Birthplace of America Trail.

Notable Characteristics

The project is using forward-looking design criteria to ensure long-term resilience. The road will be elevated to a minimum of 7.5 feet above sea level to ensure protection from future tidal flooding with sea level rise. The project employs a hybrid approach to resilient design by integrating green infrastructure for stormwater capture and treatment.

Images courtesy of Waggonner & Ball and Moffat & Nichol.



Example Hybrid Project:

St. Paul's Tidewater Gardens

The project will address nuisance and storm flooding from tidal and precipitation events as part of the St. Paul's Area Redevelopment, a mixed use, mixed income development project. Drainage infrastructure will be installed throughout the newly redeveloped area, all tying into a central blue-greenway stormwater wetland to manage water quality and quantity, with further tidal protection where the project meets into the Tidewater Drive Drainage Improvement Project and downstream Harbor Park Flood Barrier.

Location

St. Paul's Neighborhood, Norfolk, Hampton Roads PDC

Owner

City of Norfolk

Cost

$18,000,000

Status

Final Design and Permitting

Resilience Strategies Employed

Natural and Nature-Based: Parcel-Level Flood Adaptation, Green Infrastructure, Floodplain Restoration

Structural: Pump Stations, Stormwater Drainage and Utility Improvements, Bridge Elevation, Public Facility Relocation

Coastal Hazards Addressed

The project will install a combination of gates and valves to prevent tidal backflow into the St. Paul's redevelopment area during abnormally high tides and storm events. Full protection from sea level rise and resulting higher storm surge events will rely on eventual construction of additional flood barriers along the Harbor Park and Downtown shoreline.

The upgraded roadway infrastructure, parcel-level water retention, and the blue-greenway stormwater wetland will reduce stormwater-based flooding and the gates and valves will help to reduce impacts from tidal flooding events. The stormwater wetland will create an open space corridor woven through the community, creating numerous opportunities for recreation and gathering spaces. It will also serve as a regional stormwater facility to address water quality from the adjacent and upstream communities.

Anticipated Project Benefits

The project will protect the St. Paul's Area, currently under full redevelopment due to recurrent flooding and failing infrastructure. Project elements will also provide significant community open space and environmental quality benefits. An area largely devoid of natural features will be significantly upgraded through green infrastructure approaches.

Notable Characteristics

This project is a great example of an integrated system employing multiple layers of resilience to address combined coastal-stormwater flooding. The green infrastructure elements work together with the structural elements to provide the needed level of flood reduction while also providing environmental benefits to the surrounding community.

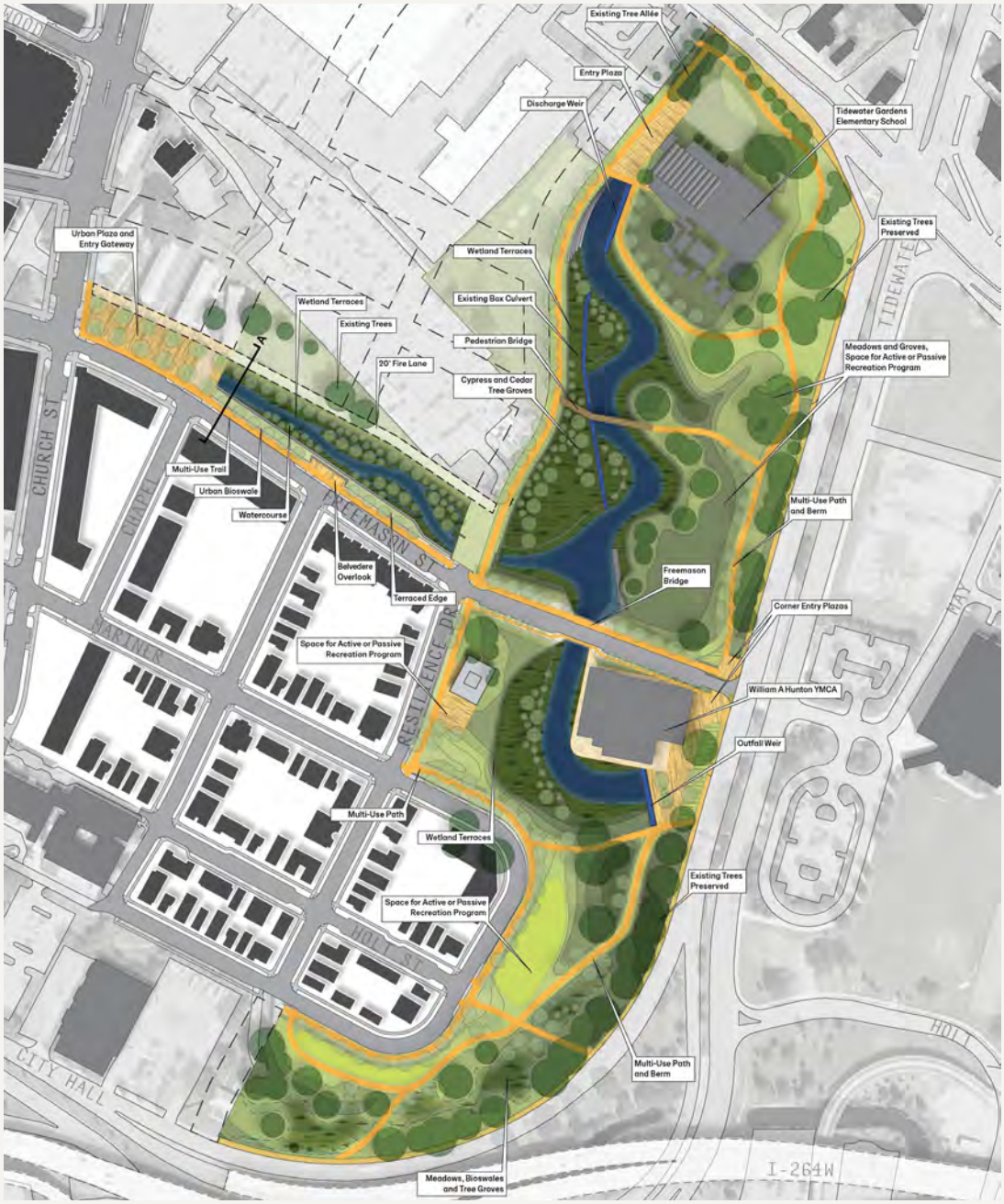
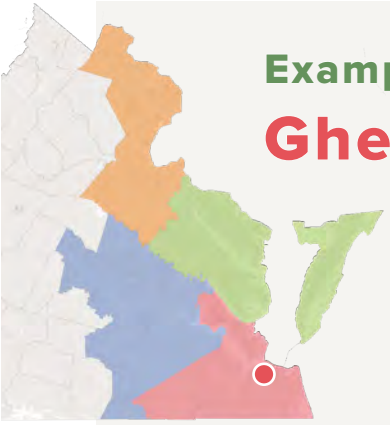


Image courtesy of the City of Norfolk.



Example Hybrid Project:

Ghent Harbor Park Barrier System

This project was identified as a potential flood mitigation strategy as part of Norfolk's Coastal Storm Risk Management Study, which provided a comprehensive investigation of flood-risk management problems and solutions in the city. The proposed project involves creation of a structural barrier that would span from Historic Ghent along the Downtown Norfolk waterfront properties, as well as complementing reef structures.

Location

Ghent Downtown, Norfolk, Hampton Roads PDC

Owner

City of Norfolk

Cost

$442,733,000

Status

Proposed

Resilience Strategies Employed

Natural and Nature-Based: Habitat Creation

Structural: Floodwall

Coastal Hazards Addressed

This hybrid approach, combining natural and built features, will enhance coastal resilience to extreme events and reduce the risk of coastal flooding for the city. The natural and nature-based design elements will serve as the primary protection during small to medium storm events, which due to their greater frequency, can be costlier over time than more rare larger storms, while "hard" structures provide protection during major storm events. Also, reef structures will be used as a supplement to floodwalls and surge barriers. These nature-based features act as secondary support to "hard" engineered structures, protecting them from additional hazard exposure thereby reducing operational, maintenance, and repair costs.

Anticipated Project Benefits

Behind the flood protection system lies important infrastructure such as the region's only Tier 1 trauma hospital, the region's children's hospital, emergency services, the region's only medical school, critical transportation corridors used for evacuation, city hall, the city institutional network, cultural assets, and adjacent historic districts as well as public housing.

Notable Characteristics

The Commonwealth seeks to focus on the most cost-effective solutions for the protection and adaptation of our communities, businesses, and critical infrastructure. The City of Norfolk's Coastal Risk Management Study provides a good example of how to use benefit-cost analysis to evaluate and prioritize resilience projects, and account for the co-benefits of natural and nature-based design elements.

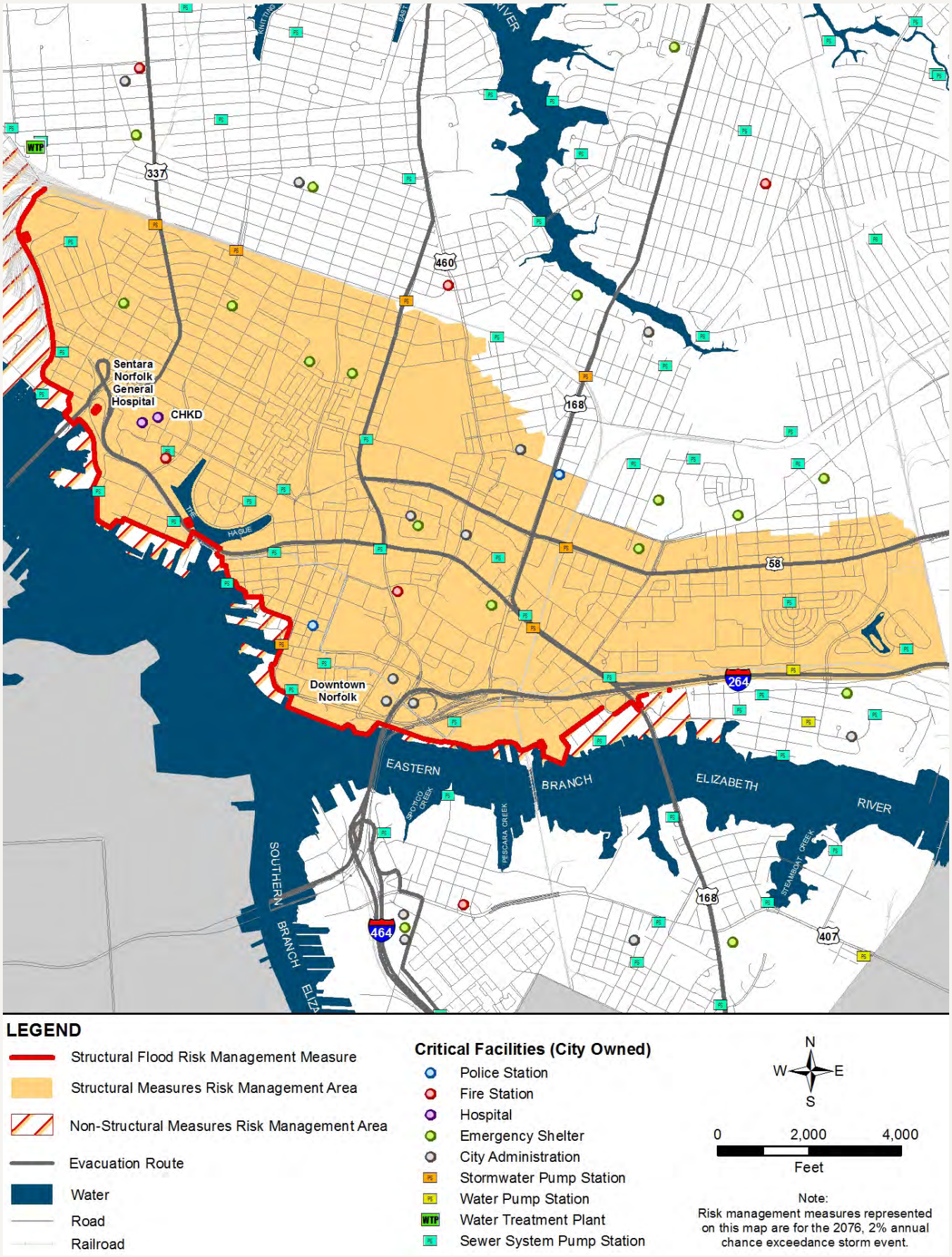
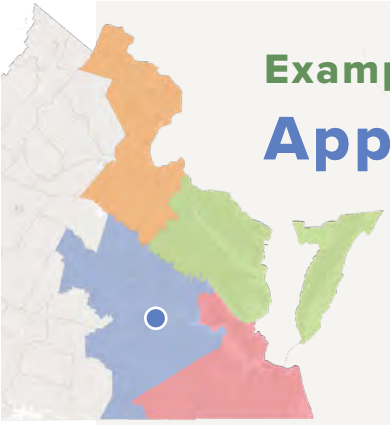


Image courtesy of the City of Norfolk.



Example Hybrid Project:

Appomattox River Trail

The Friends of the Lower Appomattox River (FOLAR) is championing the Appomattox River Trail, a 25-mile blueway and greenway that will span through six localities bordering the lower Appomattox River. The area encompasses the counties of Chesterfield, Dinwiddie and Prince George, and the cities of Colonial Heights, Hopewell and Petersburg. This project will conserve riverfront land, improve the quality of life of the region, provide safe alternative transportation and increase the economic development of the region. This recreation and transportation facility will also help protect sensitive riverfront lands to serve as a buffer to flooding and sea level rise.

Location

Appomattox River Shorelines, Crater PDC

Owner

FOLAR, in partnership with six localities

Cost

$25,000,000

Status

Multi-Phased

Resilience Strategies Employed

Natural and Nature-Based: Land Acquisition and Conservation, Habitat Restoration (Forest Restoration), Floodplain Restoration, Green Infrastructure

Structural:: Stormwater Drainage and Utility Improvements

Coastal Hazards Addressed

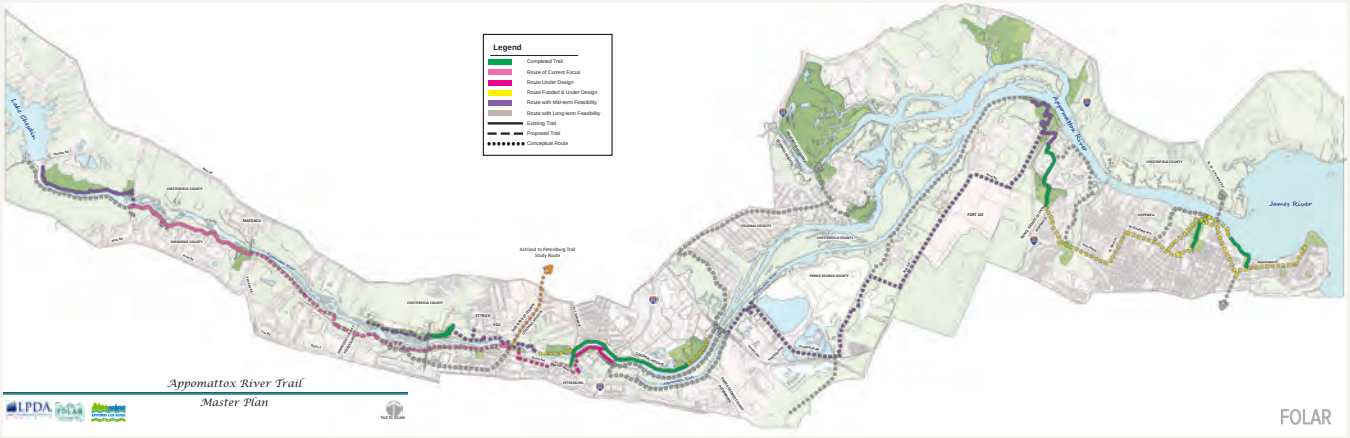
A greenway is a protected stream corridor and open space managed for conservation and recreation. By conserving the land along the river and in some cases restoring the land, the greenway system will help reduce hazards by preserving green space and acting a buffer between the water and development for hazards such as sea level rise, storm-surge flooding, shoreline erosion and inland flooding from stormwater. Riparian buffers will be managed for invasive species, making the native forest healthier and more resilient to change.

Anticipated Project Benefits

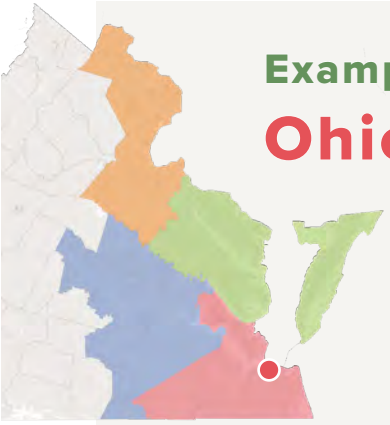
The project features several resilient design elements including living shorelines, stream restoration, upgrades to stormwater drainage systems, and other techniques that will work together to improve flood storage capacity along the river. This additional capacity will act as a buffer during flood events and help protect several community assets located along the river, such as wastewater treatment facilities and railroad infrastructure. In addition, the trail and new bike and pedestrian bridges will increase alternative transportation and mobility options for a community with high poverty and low car ownership, providing social benefits. Because this project is permanently protecting land, this project will have long-term benefits for the community, both from an ecological and societal resilience standpoint.

Notable Characteristics

The project aligns with the Commonwealth's vision to address socioeconomic inequities and work to enhance equity through coastal resilience efforts. The project is being designed to bring multiple and intersecting benefits to a population that is socially vulnerable and under-resourced. Public education and awareness will be a major component of the project.



Images courtesy of the Friends of the Lower Appomattox River (FOLAR) and Ken Newman (KN).



Example Hybrid Project:

Ohio Creek Watershed Project

Norfolk was awarded a $112 million federal grant from the National Disaster Resilience Competition for the Ohio Creek Watershed Project. The Ohio Creek Watershed includes two residential, predominantly African American neighborhoods with civic leagues and a strong community identity. Historic Chesterfield Heights has over 400 houses on the Historic National Register, and Grandy Village includes a public housing community with more than 300 units. The project is exploring various landscape and hardscape options to reduce flooding, provide public access to the waterway and connections to the rest of the city.

Location

Ohio Creek, Norfolk, Hampton Roads PDC

Owner

City of Norfolk

Cost

$112,660,000

Status

Construction and Implementation

Resilience Strategies Employed

Natural and Nature-Based: Habitat Restoration (Wetland Restoration), Green Infrastructure, Living Shorelines

Structural: Pump Stations, Roads or Bridge Elevation, Stormwater Drainage and Utility Improvements

Coastal Hazards Addressed

The Ohio Creek Watershed experiences tidal and precipitation flooding. Only two roads process access to the community. One road is completely impassable during regular nuisance flood events. Residents have expressed concerns about being cut off from the rest of the city, as well as about shoreline erosion that exacerbates river flooding and prevents recreational activity.

The project features an integrated coastal flood protection, including a tidal control gate/pump, living shoreline, earthen berm and open tidal exchange.

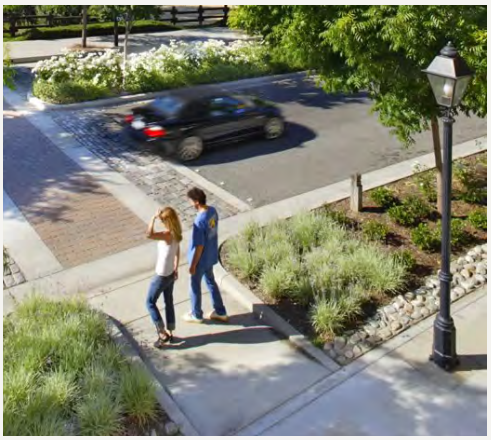
Anticipated Project Benefits

The project will not only protect Historic Chesterfield Heights and Grandy Village from increasing tidal and precipitation flood hazards but will also provide new amenities through the development of a stormwater resilience park. The Resilience Park connects the Grandy Village and Chesterfield Heights neighborhoods and includes a flood berm, a restored tidal creek and wetland and other environmental features as well as a multi-use sports field and places for community gatherings, sports and play.

Notable Characteristics

This project demonstrates how integrated flood protection can also include features that extends beyond infrastructure to encompass community and economic development. The Ohio Creek Watershed Project is part of Norfolk's Resilience Strategy and supports its three goals:

- Design a coastal community capable of dealing with the increased risk of flooding
- Create economic opportunity by advancing efforts to grow existing and new industry sectors
- Advance initiatives to connect communities, de-concentrate poverty, and strengthen neighborhoods



Images courtesy of the City of Norfolk.

Related Example Nature-Based Project:

Grandy Village Living Shoreline

The project will restore 2,200 feet of eroding shoreline behind the Grandy Village Community. Living shorelines with high rock sills will tie into existing marshes and buffers.

Location

Ohio Creek, Norfolk, Hampton Roads PDC

Owner

City of Norfolk

Cost

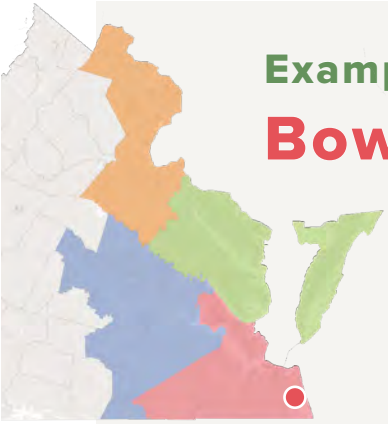
$3,000,000

Status

Site Assessment and Preliminary Design

Resilience Strategies Employed

Living Shoreline and Habitat Restoration (Oyster Reef Restoration)



Example Hybrid Project:

Bow Creek Stormwater Park

The City of Virginia Beach has developed a plan to use the approximately 121-acre, City-owned Bow Creek Golf Course for flood mitigation. The vision for the project is to convert the land from a golf course to a multi-use park facility that will provide significant stormwater storage. The stormwater park will include active and passive recreational amenities, in addition to open tidal waters, and shoreline, floodplain, and upland forest and meadow ecosystems.

Location

City of Virginia Beach, Hampton Roads

Owner

City of Virginia Beach

Cost

$83,600,000

Status

Site Assessment and Preliminary Design

Resilience Strategies Employed

Natural and Nature-Based: Floodplain Restoration

Structural: Stormwater Drainage Improvement

Coastal Hazards Addressed

The Windsor Woods, Princess Anne Plaza, and The Lakes neighborhoods in Virginia Beach are located in what was once the undeveloped headwaters of the Lynnhaven River. According to aerial photos from 1949, the area was originally forest surrounded by farmland and much of the area has relatively low elevations. Low elevations, coupled with increasing sea levels and the increasing frequency of storms with significant tides and rainfall amounts, have resulted in severe flooding of the neighborhoods during extreme events. These neighborhoods experienced extensive flooding in 2016 when the remnants of Hurricane Matthew hit Virginia Beach. The project will increase the capacity of the stormwater pipes to provide additional storage capacity, construct new stormwater pump stations, and include the construction of barriers and gates to minimize tidal flooding.

Anticipated Project Benefits

The project will protect the adjacent communities from flooding and restore natural systems, while still providing active and passive recreation benefits.

Notable Characteristics

A creative, phased construction approach will allow the area to be gradually converted from a golf course to a stormwater park. For example, during construction of the first phase, a portion of the golf course will remain open to the public for passive recreation. The existing cart paths will be re-purposed as walking trails while the work on the other side is underway. Once complete, the public will have access to the trail networks and wildlife viewing.

Images courtesy of the City of Virginia Beach.

Resilience Project Inventory

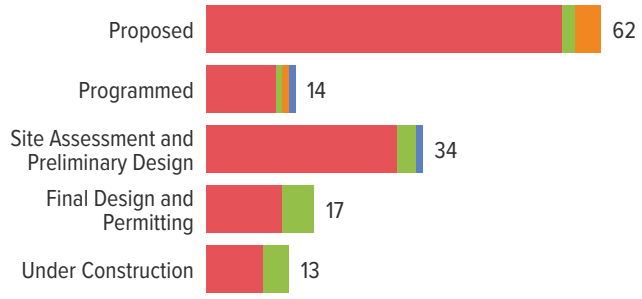
Many coastal communities understand the risks they face and are currently developing or implementing resilience projects. These local efforts are critical to achieve a resilient coastal Virginia. To chart the path forward, it is important to understand where these projects stand so others that may benefit from additional financial or technical support can be identified.

The Commonwealth worked with local governments, Planning District and Regional Commission staff, and other stakeholders to inventory existing and proposed projects in the Coastal Resilience Database. Through a data call, project owners identified ongoing and proposed resilience projects in their localities, providing information on the project purpose, strategy types, estimated costs, and expected benefits, among other details. The data call was open for submissions from July 28, 2021 through August 31, 2021 but remains open to collect projects for inclusion under future phases of the Master Plan. This effort identified over 350 projects in coastal Virginia, 140 of which are resilience projects related specifically to coastal flood hazards aligning with the guiding principles of the Commonwealth's broader resilience strategy as outlined in the Framework. The following section focuses on these 140 projects.

The collected projects represented here provide a small sample of the considerable overall project needs within the Commonwealth. The data call was open for a relatively short time frame, which did not allow for all project owners to respond or all projects to be submitted. Some localities and regions were unable to submit resilience projects due to time constraints, limited staff capacity, and insufficient resources allocated to resilience efforts. For example, Middle Peninsula PDC has over 100 projects and related capacity-building initiatives, but the short time frame and lack of necessary staff capacity prevented the submission of these efforts.

The collection of locally developed resilience projects in the Coastal Resilience Database represents a critical step forward for achieving our vision of resilient coastal Virginia. By creating a catalog of known work projects, the Commonwealth can take a broad view to prioritize projects and initiatives that provide the most benefits in and across localities and regions for future financial and technical support, as well as identify best practices that can be shared across coastal localities. Further, the Commonwealth can determine which, if any, areas or assets lack projects and initiatives and require additional resources to bolster their resilience in the future.

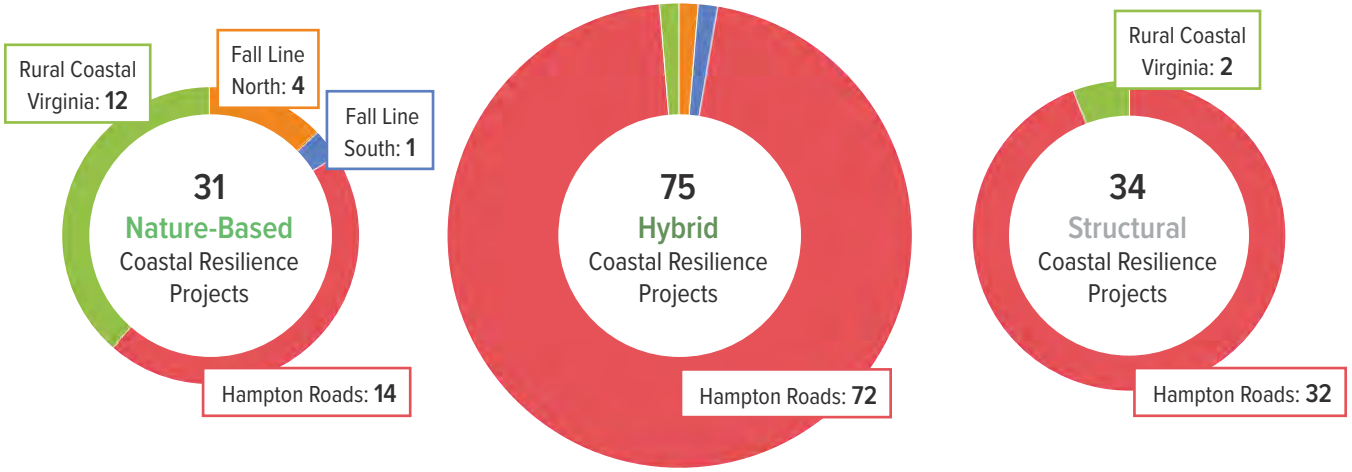
Coastal Resilience Projects by Status and Region

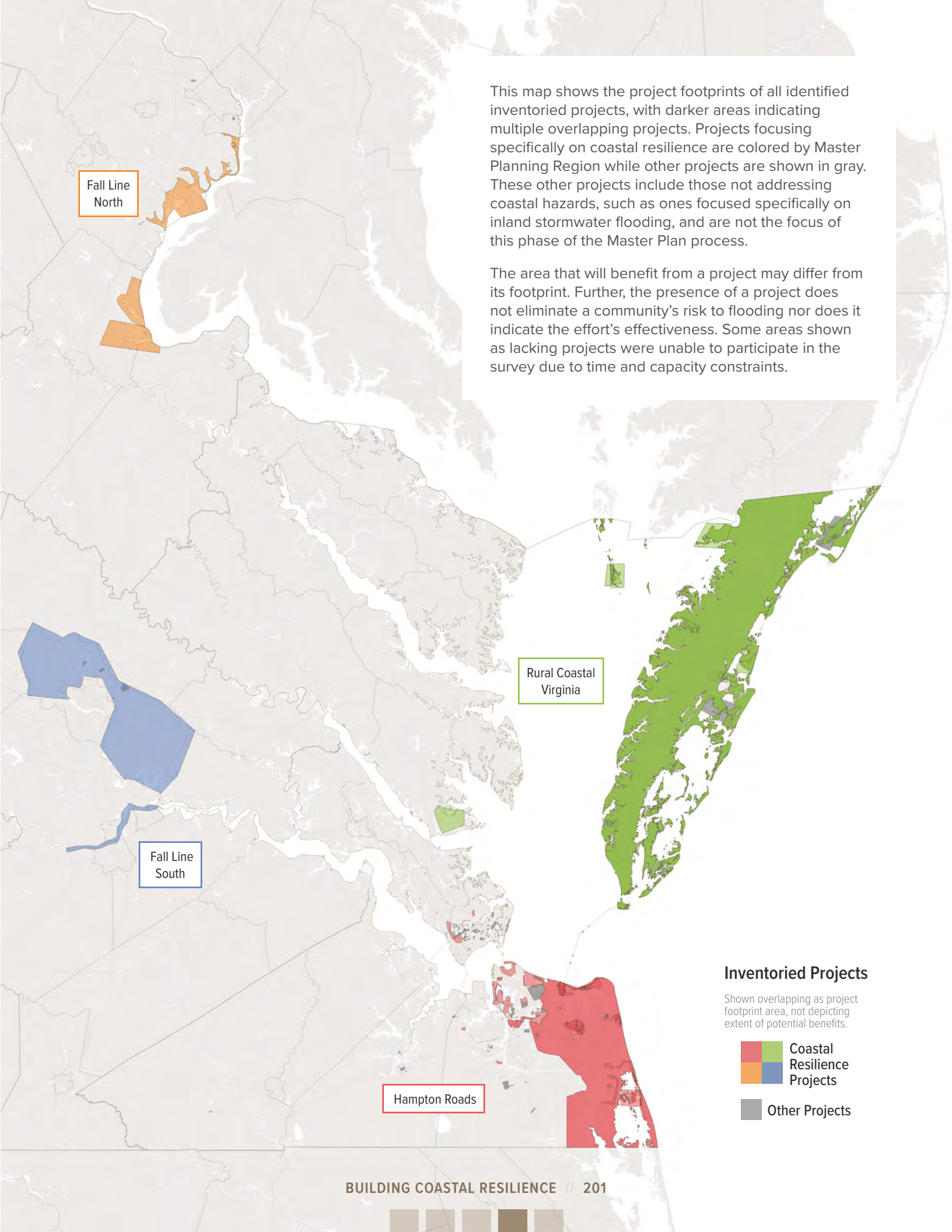


Explore resilience project information in detail in the **Coastal Resilience Web Explorer**

Cataloged Coastal Resilience Projects by Class and Region

Breakdown of the 140 coastal resilience projects that focus specifically on coastal flooding by project class and Master Planning Region.





This map shows the project footprints of all identified inventoried projects, with darker areas indicating multiple overlapping projects. Projects focusing specifically on coastal resilience are colored by Master Planning Region while other projects are shown in gray. These other projects include those not addressing coastal hazards, such as ones focused specifically on inland stormwater flooding, and are not the focus of this phase of the Master Plan process.

The area that will benefit from a project may differ from its footprint. Further, the presence of a project does not eliminate a community's risk to flooding nor does it indicate the effort's effectiveness. Some areas shown as lacking projects were unable to participate in the survey due to time and capacity constraints.

Resilience Project Prioritization

With so much at stake and finite resources, not every resilience project will be implemented. Recognizing these realities, the Commonwealth initiated the development of a prioritization approach to assess coastal resilience projects against standardized criteria that aligns with the goals and principles of the statewide coastal resilience strategy.

The prioritization approach establishes a consistent set of criteria that local and regional partners can use to develop and refine resilience projects to align with the Commonwealth's goals and principles. Resilience projects are screened and evaluated through a standard yet flexible process to identify projects for alignment with potential implementation and funding strategies. The Commonwealth tested the prioritization approach using the resilience projects inventoried in the Coastal Resilience Database and project information provided by resilience practitioners throughout coastal Virginia.

This first phase of the Master Plan does not quantitatively evaluate riverine, rainfall, and compound coastal-rainfall flooding impacts. Only projects with a coastal nexus or anticipated to contribute to coastal resilience passed the baseline screening criteria. Projects were then tested through the evaluation scoring and project tiering process. The prioritization approach was initially developed to involve more manual review of submitted projects. However, due to the Master Plan's accelerated timeline and the quantity of projects received, the Commonwealth pivoted to an automated and data-centered approach.

Representatives of the Commonwealth and the Technical Advisory Committee Subcommittees reviewed the initial list of tiered and prioritized resilience projects. Several rounds of review were completed. Based on this review of projects, the Commonwealth and stakeholders involved in the review process determined that the execution of project prioritization requires more data, time, and refinement to deliver results that can be confidently and meaningfully used to prioritize projects and allocate resources. For these reasons, the outcomes of the prioritization approach testing are not presented within this first phase of the Master Plan.

Furthermore, the Commonwealth recognizes the projects inventoried within the Coastal Resilience Database are not a complete picture of resilience efforts. Some jurisdictions were also unable to submit projects due to capacity and time constraints. Among those that did participate, there are disparities in the levels of detail provided. The prioritization approach requires significant project information, meaning that projects with insufficient data may not pass certain filters or rank highly simply due to limited or inaccurate information. A robust prioritization effort requires adequate time for vetting and refining information with project owners, and it is imperative that the Commonwealth continue to build this database and prioritize this additional work needs to ensure the accuracy of this essential tool. Additionally, the Commonwealth recognizes the need to educate project owners on how to participate in the data call and submit information to get more consistent outcomes for the prioritization approach. As the project inventory within the Coastal Resilience Database continues to grow it can also serve to enhance localities and regions own understanding of their risk and resilience landscape.

The following section outlines the preliminary process for evaluation approach, but the Commonwealth recognizes that this effort is a building block that will change and be improved over time, which will be discussed in more detail in Chapter 5.

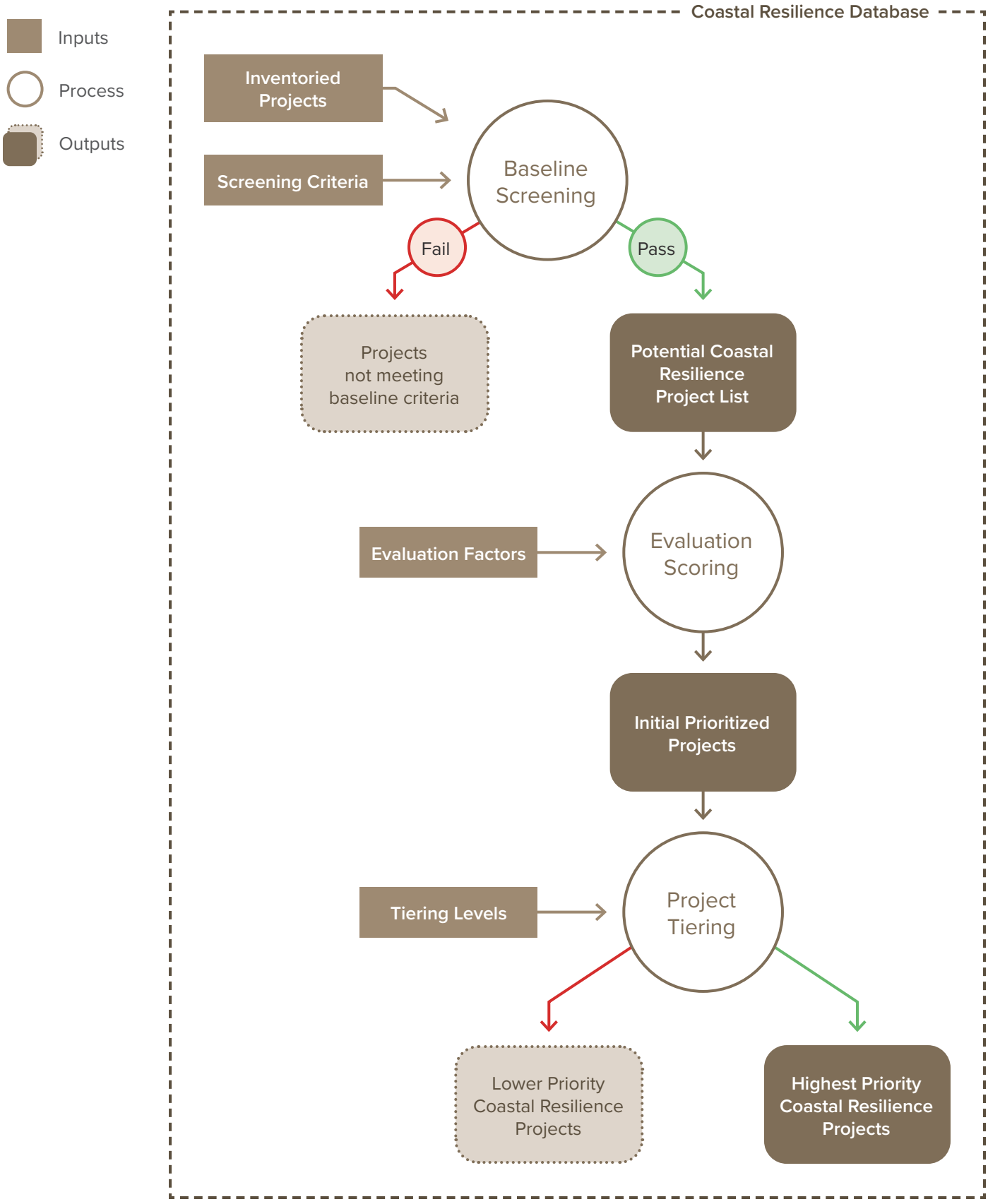
A Living and Evolving Process

The evaluation approach provides a transparent, repeatable approach that project owners can leverage to improve prioritization, funding potential, and implementation readiness. For projects that lack data, this process can identify additional planning and analysis needed to improve how well the projects align with the Commonwealth's overarching goals and principles. This process can also be used to formulate new projects and identify projects that present opportunities for alignment across localities.

For example, there may be an opportunity to develop "project packages" that yield regional benefits rather than individual projects that may not rank high when evaluated in isolation. Project packages that combine multiple smaller-scale projects must be re-evaluated to assess potential upstream or downstream impacts that might reduce their collective impact.

Project Prioritization Process

Within the Coastal Resilience Database, inventoried projects are screened, scored, and tiered.



Baseline Screening

As a first step in the project prioritization process, the inventory of projects is put through a baseline screening. Within the Coastal Resilience Database, projects are screened to determine if the required project information needed for evaluation is included in the database and to verify their alignment with the Commonwealth's broader goals and guiding principles related to coastal resilience. Projects that do not meet the baseline screening criteria remain in the database, available for future reference or additional analysis. Projects that meet the baseline screening criteria are added to the potential project list for evaluation scoring.

The baseline screening process excludes projects from further evaluation if they lack critical information, do not fall within one of the coastal regions, do not address coastal hazards, or are already completed. Future iterations of this process may incorporate additional or different screening filters, such as addressing additional flood hazards.

Evaluation Scoring

All projects on the potential project list are assessed and scored based on a standard set of criteria and metrics. These metrics are established in alignment with the Commonwealth's overarching coastal resilience guiding principles first presented in the Framework. Under each guiding principle, evaluation criteria represent achievable objectives. The Commonwealth acknowledges that there will be opportunities to refine or add additional objectives under future phases of the Master Plan. During the evaluation, each project is scored using a mix of quantitative and qualitative criteria for each factor, with one being the lowest score and ten being the highest score possible. Stakeholder engagement, expert evaluation, and community input inform the evaluation scoring process to ensure a holistic approach. Future phases of the evaluation approach could refine or add to the criteria and metrics as well as implement weighting factors based on state or regional priorities.

Tiering Projects

Based on a combination of the baseline screening and evaluation scoring results, projects are then sorted into tiers signifying their relative priority. Top tiered projects will include those that are actionable and best align with the guiding principles of the Commonwealth's broader coastal resilience strategy. Lower tiered projects may effectively support coastal resilience, but do not align completely with the guiding principles. Finally, projects receiving the lowest evaluation scores will not be tiered, but rather, set aside for further research and improvements.

Factor 1: Resilient Planning and Design

Guiding Principle: Acknowledge climate change and its consequences, and base decision-making on the best available science.

Criteria 1.A. Resilient Design: The project incorporates future conditions scenarios.

Criteria 1.B. Project Need: The project is needed to address both existing and future coastal flood exposure.

Criteria 1.C. Project Purpose: The project addresses coastal hazards and compounding stressors that exacerbate coastal hazards.

Factor 2: Equity Consideration

Guiding Principle: Identify and address socioeconomic inequities and work to enhance equity through coastal adaptation and protection efforts

Criteria 2.A. Community Resources and Capacity: The project provides benefits to communities facing lack of economic resources and capacity to address current and future increases in flooding.

Criteria 2.B. Social Vulnerability: The project has the potential to add resilience to socially vulnerable communities.

Factor 3: Nature-Based Approaches

Guiding Principle: Recognize the importance of protecting and enhancing green infrastructure, like natural coastal barriers and fish and wildlife habitat, by prioritizing nature-based solutions

Criteria 3. Nature-Based Outcomes: The project supports the Commonwealth's priorities for coastal resilience, like flood mitigation, and natural resource enhancement by protecting or enhancing natural systems through incorporation of nature-based design elements.

Factor 4: Regional Collaboration

Guiding Principle: Utilize community and regional scale planning to the maximum extent possible, seeking region-specific approaches tailored to the needs of individual communities

Criteria 4. Regional Adaptation Priorities: The project addresses regional priorities for protection or adaptation of community resources, critical sectors, and natural infrastructure.

Factor 5: Project Benefits

Guiding Principle: Understand fiscal realities and focus on the most cost-effective solutions for protection and adaptation of our communities, businesses, and critical infrastructure

Criteria 5. Project Benefits:

- **Flood Risk Reduction Structures:** The project is expected to reduce existing and future coastal flood risk.
- **Nature-Based Features and Structural Shoreline Stabilization:** The project is expected to reduce shoreline erosion.
- **Natural Features; Nature-Based Features; Conservation and Adaptation:** The project is expected to protect and/or enhance natural systems critical for natural habitat and ecosystem diversity, flood resilience, scenic preservation, and water quality improvements.
- **Community Infrastructure:** The project is expected to provide community-scale benefits to the populated area surrounding the project.

Gaps in Coastal Resilience Projects

Areas with projected coastal flood impacts will face significant and worsening risks unless coastal resilience projects are implemented. Identifying areas that lack proposed or ongoing resilience efforts allows the Commonwealth to determine where additional support or assistance is needed to develop or implement projects that increase resilience among communities and their assets.

To identify these areas, the Commonwealth conducted a gap analysis to locate areas that are projected to experience relatively high impacts from coastal flooding and lack identified resilience projects. Impacts are determined using metrics calculated across various asset types and metrics as calculated in the Technical Study. Geographic areas expected to experience higher impacts relative to its respective Planning District or Regional Commission are identified as impact hotspots. Impacts and hotspots are summarized by theme: Community Resources, Critical Sectors, and Natural Infrastructure.

These impact hotspots can be intersected with the footprints of identified resilience projects. When impact hotspots fall outside of project footprints, then a "no-action" scenario is assumed for the geographic area, and a project gap is identified. Different project types provide different benefits and protection to assets, so project types were aligned to the three impact themes based on the specific strategies they employed. Projects often provide multiple co-benefits, and multiple themes were identified for many project types.

These projects represent opportunities to reduce flood risks for many coastal Virginians. However, even if all proposed projects captured in the Coastal Resilience Database are implemented, significant gaps would remain. And we know the compiled projects do not represent an exhaustive list of all resilience efforts in the Commonwealth. Not every jurisdiction was able to submit resilience projects during the Master Planning Process due to time and capacity constraints.

Further, the existence of a resilience project overlapping with an impact hotspot does not eliminate a community's risk for potential flood damage nor does it indicate actual effectiveness to reduce potential flood damage. Project footprints are estimates, and flood risk reduction efficacy varies by project type and design and local conditions. Additionally, there is no guarantee that a proposed project will be funded and implemented.

Capacity-building and planning initiatives are crucial to the implementation of cost-effective and pragmatic resilience projects. Recognizing this need, the Commonwealth also conducted a gap analysis to locate area that lack both identified capacity-building and planning initiatives and resilience projects. These areas may require additional resources to augment their capacity to plan for resilience and implement projects in the future.

Due to data limitations, the capacity gap analysis does not consider whether initiatives target coastal hazards or resilience specifically. These initiatives also do not have unique project footprints like resilience projects. Instead, these initiatives are assumed to benefit the entire jurisdiction within which it exists. Further, like the project gap analysis, the efficacy of identified initiatives is not considered, and not every jurisdiction was able to participate in the data call, despite ongoing efforts.

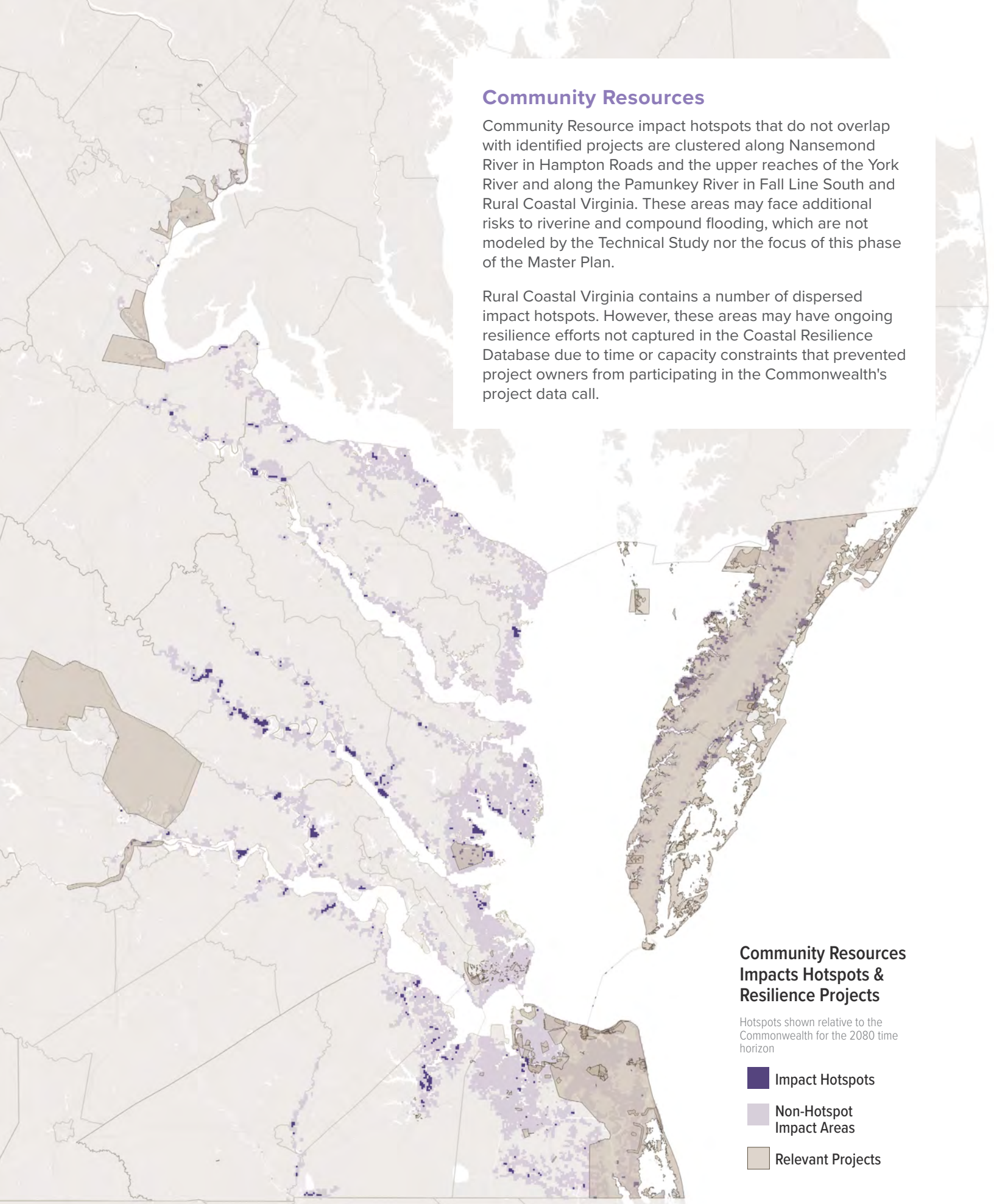
This gap analysis represents a foundational effort to identify areas that may benefit from additional resources to protect their communities, assets, and ways of life. Future phases of the Master Plan will refine this analysis as the Commonwealth continues to expand its understanding of coastal hazards and impacts, resilience projects, and capacity-building needs.

Photos courtesy of Northern Neck PDC (NNPDC) and Aileen Devlin of Virginia Sea Grant (VASG).

Community Resources

Community Resource impact hotspots that do not overlap with identified projects are clustered along Nansemond River in Hampton Roads and the upper reaches of the York River and along the Pamunkey River in Fall Line South and Rural Coastal Virginia. These areas may face additional risks to riverine and compound flooding, which are not modeled by the Technical Study nor the focus of this phase of the Master Plan.

Rural Coastal Virginia contains a number of dispersed impact hotspots. However, these areas may have ongoing resilience efforts not captured in the Coastal Resilience Database due to time or capacity constraints that prevented project owners from participating in the Commonwealth's project data call.



Community Resources Impacts Hotspots & Resilience Projects

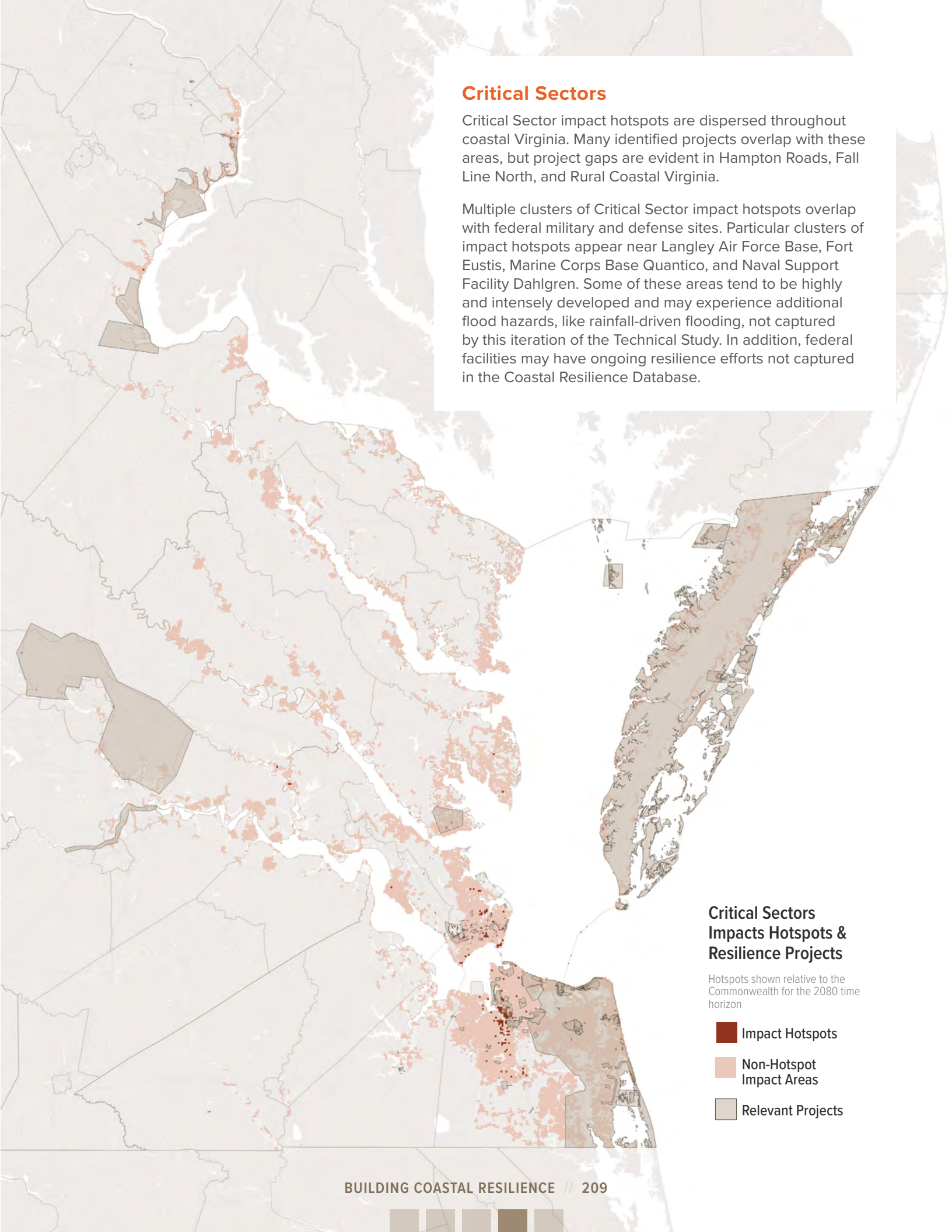
Hotspots shown relative to the Commonwealth for the 2080 time horizon

- Impact Hotspots
- Non-Hotspot Impact Areas
- Relevant Projects

Critical Sectors

Critical Sector impact hotspots are dispersed throughout coastal Virginia. Many identified projects overlap with these areas, but project gaps are evident in Hampton Roads, Fall Line North, and Rural Coastal Virginia.

Multiple clusters of Critical Sector impact hotspots overlap with federal military and defense sites. Particular clusters of impact hotspots appear near Langley Air Force Base, Fort Eustis, Marine Corps Base Quantico, and Naval Support Facility Dahlgren. Some of these areas tend to be highly and intensely developed and may experience additional flood hazards, like rainfall-driven flooding, not captured by this iteration of the Technical Study. In addition, federal facilities may have ongoing resilience efforts not captured in the Coastal Resilience Database.

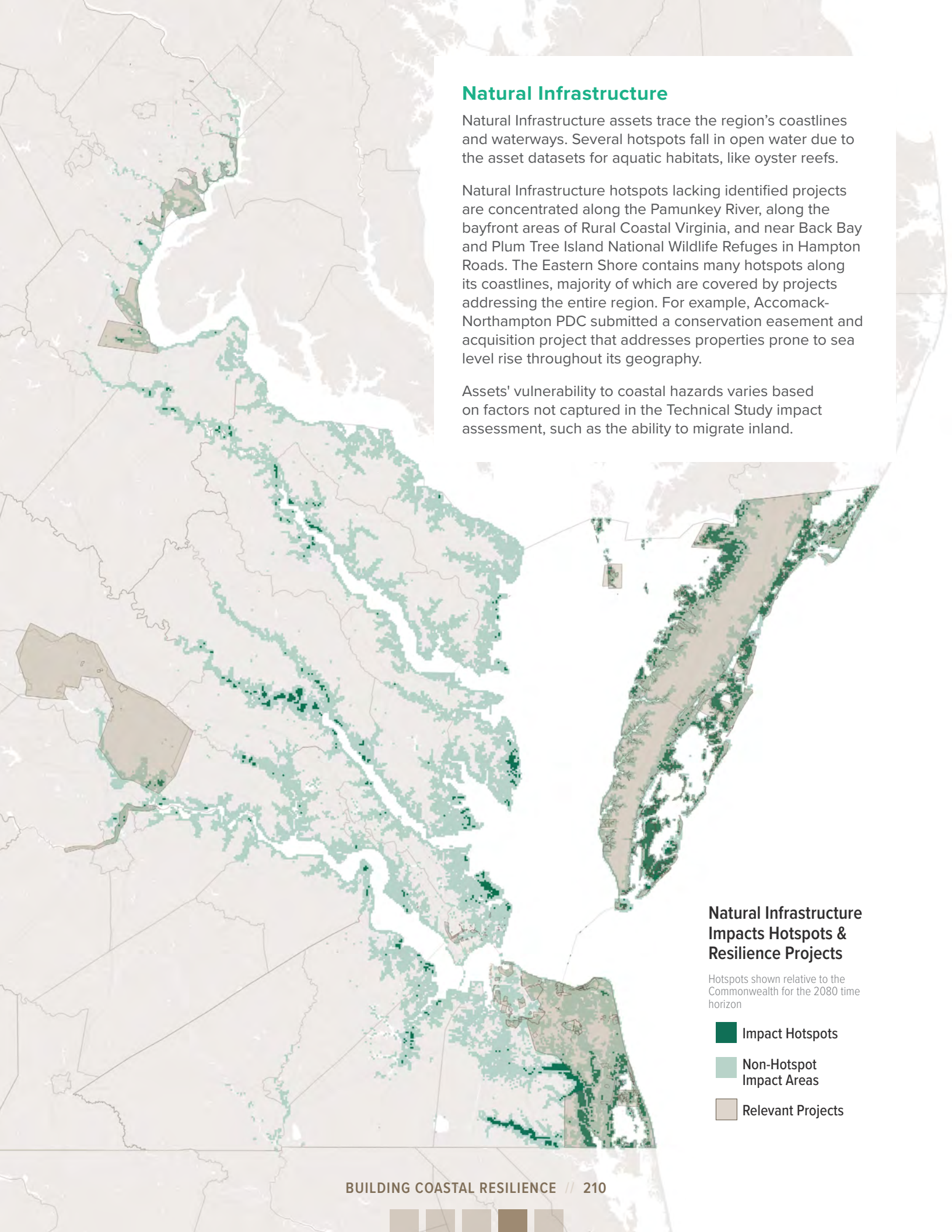


Natural Infrastructure

Natural Infrastructure assets trace the region's coastlines and waterways. Several hotspots fall in open water due to the asset datasets for aquatic habitats, like oyster reefs.

Natural Infrastructure hotspots lacking identified projects are concentrated along the Pamunkey River, along the bayfront areas of Rural Coastal Virginia, and near Back Bay and Plum Tree Island National Wildlife Refuges in Hampton Roads. The Eastern Shore contains many hotspots along its coastlines, majority of which are covered by projects addressing the entire region. For example, Accomack-Northampton PDC submitted a conservation easement and acquisition project that addresses properties prone to sea level rise throughout its geography.

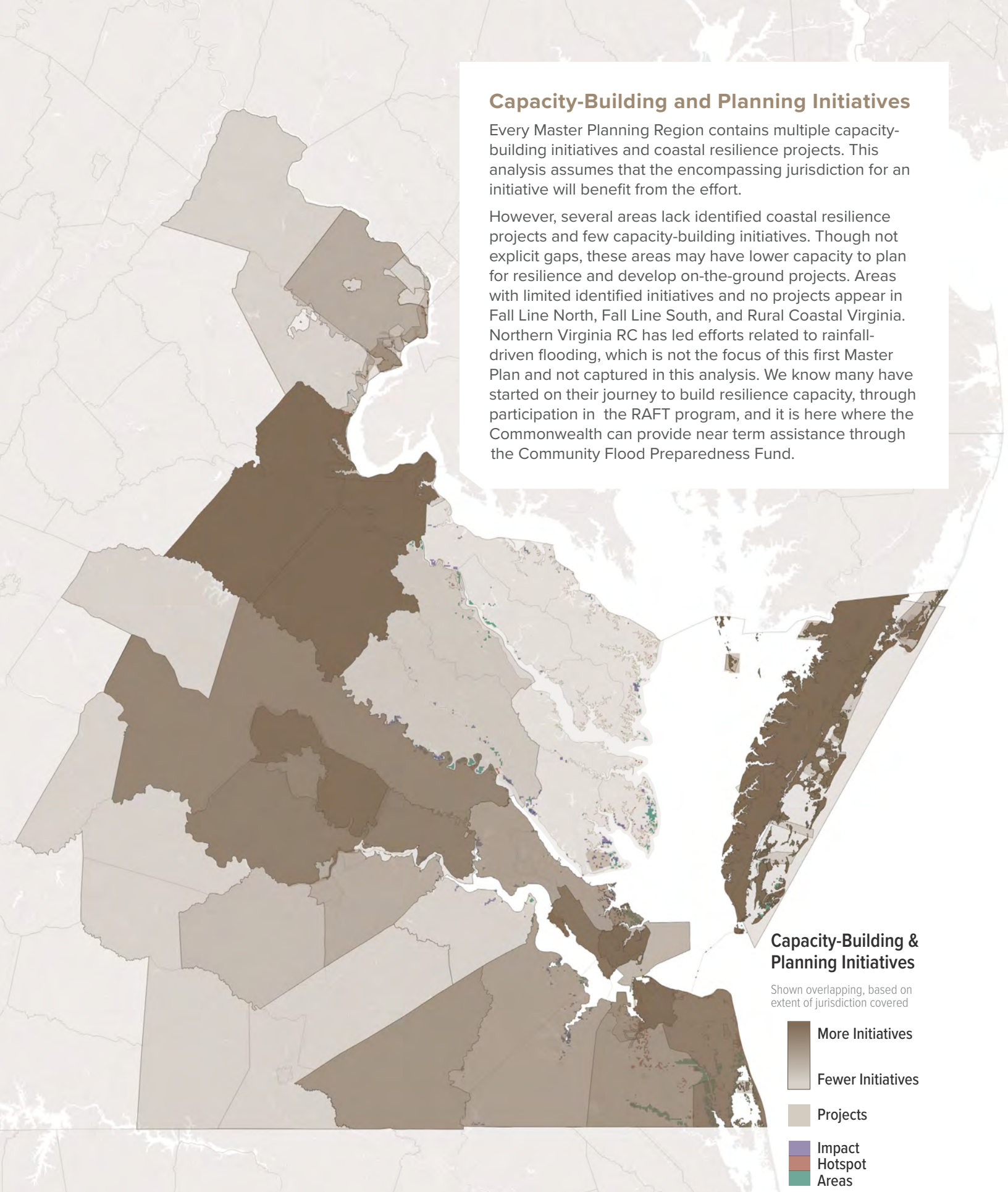
Assets' vulnerability to coastal hazards varies based on factors not captured in the Technical Study impact assessment, such as the ability to migrate inland.



Capacity-Building and Planning Initiatives

Every Master Planning Region contains multiple capacity-building initiatives and coastal resilience projects. This analysis assumes that the encompassing jurisdiction for an initiative will benefit from the effort.

However, several areas lack identified coastal resilience projects and few capacity-building initiatives. Though not explicit gaps, these areas may have lower capacity to plan for resilience and develop on-the-ground projects. Areas with limited identified initiatives and no projects appear in Fall Line North, Fall Line South, and Rural Coastal Virginia. Northern Virginia RC has led efforts related to rainfall-driven flooding, which is not the focus of this first Master Plan and not captured in this analysis. We know many have started on their journey to build resilience capacity, through participation in the RAFT program, and it is here where the Commonwealth can provide near term assistance through the Community Flood Preparedness Fund.



Opportunities to Fund Resilience Efforts

Achieving a resilient coastal Virginia will require more resources than currently exist. The total cost for making coastal Virginia resilient to sea level rise and other coastal hazards has yet to be fully quantified, but we do know it is well into the billions of dollars. The projects and initiatives inventoried within the Coastal Resilience Database reveal only a portion of the ongoing work and needs. Some regions were unable to submit their projects and initiatives due to the short turnaround to participate in the Commonwealth's data call, while others did not have the staff or the resources to compile the necessary information. Even then, we know the database does not represent the totality of what is needed to protect our coastal communities.

Yet the cost of doing nothing is also expensive. Investing in mitigation in advance of a disaster saves a minimum of $6 for every $1 spent.[96] A cost-effective resilience strategy means being proactive and implementing projects sooner rather than later. To maximize finite resources, the Commonwealth should understand what funding and financing opportunities exist to identify potential sources for coastal resilience projects and capacity-building and planning initiatives.

The ability to find applicable funding opportunities remains a significant obstacle to implementing resilience projects. Recognizing this need, the Commonwealth collected grant and loan programs that support coastal resilience efforts to establish a starting point for localities to find funding for identified or potential projects.

Previously, the Virginia Coastal Zone Management Program compiled grant and other funding programs that support coastal resilience efforts. The Commonwealth leveraged this previous work to identify, research, and analyze additional grant and loan programs that support the implementation of resilience projects and capacity-building efforts that focus on coastal resilience. This effort identified 95 federal, state, regional, and private funding opportunities, pulling information on eligibility, application requirements, maximum funding available, cost-share requirements, and the grant cycle. The inventory of grant and loan programs is contained in the Coastal Resilience Database.

This collection of funding resources does not represent the entire universe of opportunities available, but it does shed light on the path ahead. Even if localities secured one award from each program, the total funding received would not come close to covering all the implementation costs for the limited sample of identified resilience projects in this first Master Plan. Further, not every project is applicable for every program, and the projects' implementation costs neither exhaustively illustrate all efforts nor all of coastal Virginia's needs. Yet, the message is clear: our needs far outstrip our current resources.

We cannot afford to rely only on traditional ways to pay for resilience efforts. Some coastal localities have strategically maximized limited grant and loan programs while also generating local sources of revenue. We can learn from these communities to begin to narrow the funding gap ahead of us.

Explore resilience grant and loan programs in detail in the **Coastal Resilience Web Explorer**

Practitioner Perspectives: How Localities Have Paid for Resilience

Nearly 100 representatives from government and partner organizations responded to a survey with questions related to their professional experiences in securing funding for resilience. Of those respondents:

- **43%** of those who have sought funding applied for federal grants and loans, more than any other funding source.
- **9%** have used bonds.
- **9%** have used taxes or fees.
- **5%** have used public-private partnerships.

Federal Funding Sources

Federal agencies can provide much more significant funding for a wide range of projects and initiatives. But securing these funds can be a challenge for localities, from deciphering grant requirements to obtaining the necessary matching dollars even to be competitive. The most competitive jurisdictions have extensively studied infrastructure needs and robust capacity to apply for and manage these funds. For under-resourced communities, the application process can be burdensome. Further, the extended timeline between receiving and spending funds as well as the reimbursable nature of most federal grants can cost even more staff time and resources.

However, the amount of federal funding available can vary between administrations, as can the types of projects eligible for specific programs. Even throughout the development of this plan, several critical shifts at the federal level have opened new opportunities to fund resilience in Virginia. In August 2021, the White House and FEMA announced an additional $4.6 billion for crucial pre-disaster mitigation programs.[97] Of these funds, Virginia will receive $62 million through the Hazard Mitigation Grant Program and $5 million through Flood Mitigation Assistance. In November 2021, Congress passed a $1.1 trillion infrastructure bill dedicating nearly $47 billion for climate resilience.[98, 99]

Many federal programs do not explicitly focus on coastal resilience, but they will fund coastal resilience projects and initiatives. The following table highlights federal funding sources applicable to coastal resilience efforts, but it does not provide an exhaustive list of all potential opportunities.

Alignment between Federal Funding Sources and Resilience Strategies

Highlighted federal funding programs by agency and relevant coastal resilience initiative and project types.

Federal Agency	Program	Capacity Building and Planning	Natural and Nature-Based Features	Structural	Hybrid
U.S. Army Corps of Engineers	Continuing Authorities Program		X	X	X
Federal Emergency Management Agency	Building Resilient Infrastructure and Communities	X	X	X	X
	Hazard Mitigation Grant Program			X	
	Flood Mitigation Assistance	X	X	X	X
National Oceanic and Atmospheric Administration	Coastal Zone Management Program	X	X		
U.S. Department of Agriculture	Natural Resources Conservation Services	X	X		
U.S. Department of Defense	Joint Land Use Studies	X			
	Readiness and Environmental Protection Integration		X		
	Sentinel Landscapes	X	X		
U.S. Department of Housing and Urban Development	Community Development Block Grants			X	
U.S. Fish and Wildlife Service	National Coastal Wetlands Conservation Grants		X		
	Coastal Grants Program	X	X	X	X
Environmental Protection Agency	Clean Water State Revolving Fund			X	
	Drinking Water Revolving Fund			X	
	Water Infrastructure Finance and Innovation Act		X	X	X
	Chesapeake Bay Implementation Grants	X		X	

FEMA's Building Resilient Infrastructure and Communities (BRIC)

In 2020, FEMA launched a new pre-disaster mitigation grant program called Building Resilient Infrastructure and Communities (BRIC). This program aims to support states, local communities, tribes, and territories to undertake hazard mitigation projects, reducing the risks they face from disasters and natural hazards.

BRIC replaces the Pre-Disaster Mitigation Grants, but there are several core differences between the two programs. BRIC's guiding principles are to support communities through capability- and capacity-building, encourage and enable innovation, promote partnerships, enable large projects, maintain flexibility, and provide consistency. The program also specifically supports nature-based solutions and hybrid projects that use both natural and structural measures. BRIC's focus on climate and community resilience aligns with the Commonwealth's coastal resilience efforts, which may become a critical funding source for many coastal jurisdictions.

State Funding Sources

When localities cannot fund resilience projects and initiatives on their own, state funding resources are a critical tool to fill local gaps. The Commonwealth's agencies administer many funding programs, some of which can be leveraged to implement coastal resilience projects. In 2018, Governor Northam issued Executive Order 24, directing the setting of standards to plan for rising seas and a number of additional actions across state agencies, including an assessment of pre-disaster mitigation actions and funding, to expand their focus on coastal adaptation and protection.

The primary state-level funding mechanism for flood resilience projects and capacity-building initiatives is the Virginia Community Flood Preparedness Fund. Other state programs can support coastal resilience projects, despite not focusing on coastal resilience. For instance, resilience projects addressing rainfall-driven flooding are eligible for funding from the Stormwater Local Assistance Fund, while those considering enhancing natural flood buffers through open space could leverage the Virginia Land Conservation Grants. Localities can apply to grant programs that do not explicitly focus on resilience, but it is recommended they begin with targeted and dedicated sources of funding for specific needs when such programs exist.

The Commonwealth's role is more than just directing money to projects. State-led support can ensure consistency and coordination among and between localities and regions, so coastal resilience projects align with the goals and principles of broader statewide resilience efforts. The Commonwealth can also direct resources so all communities, especially those who are under-resourced, can access the necessary tools to implement projects and bolster their capacity to engage in resilience planning.

The table on the following page outlines state funding sources applicable to coastal resilience efforts, but it does not represent all programs administered or offered by the Commonwealth.

Virginia Community Flood Preparedness Fund (CFPF)

The Virginia Community Flood Preparedness Fund (CFPF) provides a permanent and dedicated funding stream to finance resilience projects and planning efforts, capacity-building initiatives, and related studies throughout the state. The Fund was enacted in 2021 and is capitalized using 45% of auction proceeds from carbon dioxide emissions credits sold through the Regional Greenhouse Gas Initiative. At present, Virginia's membership in the Regional Greenhouse Gas Initiative proceeds are expected to generate approximately $80 million annually for the Fund. The first two grant rounds offered a cumulative $35 million to communities through grants for capacity-building efforts and flood prevention projects. Future cycles may allow funding for loans, which will create the possibility for longer term use of funds as loans are repaid.

The Commonwealth designed the Fund to fill pressing needs. No less than 25% of funds disbursed each year must go to projects in low-income areas, and low-income communities can receive additional financial assistance through reduced match requirements. Further, the Fund prioritizes community-scale hazard mitigation activities that employ nature-based solutions through lower cost-share requirements. The Commonwealth also plans to adjust the Fund's scoring procedures to give additional incentives for initiatives and projects identified through the Master Planning process.

Alignment between State Funding Sources and Resilience Strategies

Highlighted state funding programs by agency and relevant coastal resilience initiative and project types.

State Agency	Program	Capacity Building and Planning	Natural and Nature-Based Features	Structural	Hybrid
Department of Conservation and Recreation	Community Flood Preparedness Fund	X	X	X	X
	Land Conservation Foundation Grants		X		
	Virginia Land Preservation Tax Credit		X		
	Land and Water Conservation Fund Grants		X		
	Dam Safety, Flood Prevention, and Protection Assistance Fund	X		X	
	Virginia Natural Resource Commitment Fund	X	X		
Department of Environmental Quality	Clean Water Revolving Loan Fund			X	
	Stormwater Local Assistance Fund	X	X	X	X
Department of Forestry	Virginia Trees for Clean Water		X		
Secretary of Natural and Historic Resources	Water Quality Improvement Fund		X	X	X
Virginia Marine Resources Commission	Marine Habitat and Waterways Improvement Fund			X	
Virginia Port Authority	Virginia Waterway Maintenance Grant Fund	X		X	
Virginia Resources Authority	Virginia Pooled Financing Program	X	X	X	X

Photo courtesy of Dewberry.

Local and Regional Funding Sources

Some coastal localities have already taken steps to fund resilience efforts through locally driven mechanisms, such as bonds, fees, and revolving loans. Locally driven sources can generate dedicated revenues to fill budget gaps or secure matching dollars to compete for state or federal funding. The following table outlines locally driven funding sources applicable to coastal resilience projects and initiatives but is not an exhaustive list of potential mechanisms.

Local and Regional Funding and Financing Sources

Example local and regional funding and financing programs with highlighted case examples.

Local and Regional Source	Description	Case Examples
Catastrophe, Environmental Impact, and Resilience Bonds	Debt instrument through which governments and investors establish pre-determined outcomes and benchmarks tied to resilience that dictate when and how much of a return on investment an investor will receive.	Hampton's Environmental Impact Bond
Commercial Property Assessed Clean Energy (C-PACE)	Loan program enabled through local ordinances that finance resiliency and energy efficiency improvements at fixed rates for up to 30 years.	Fairfax County C-PACE and Resiliency Financing Program
Green Banks	Financial institutions that attract private investment into environmental infrastructure, like clean energy or climate resilience, and leverage limited cash into bigger investments, much like a traditional bank.	Montgomery County (MD) Green Bank
Revolving Loan Funds	Self-sustaining financial instruments that use collected interest and principal payments from former loans to issue new ones and can be a flexible source of gap financing.	Middle Peninsula PDC Revolving Loan Program
Special Service Districts	Special-purpose governmental units established by localities to provide additional, more complete, or more timely government services to a designated area or an entire locality, and the services of which are funded by fees, which can be used to adapt facilities to rising sea levels.	Norfolk Special Service District Policy for Flood Protection Virginia Beach's Sandbridge Special Service Tax District and Neighborhood Channel Dredging Fee
Tax Increment Financing	Land use mechanism captures the anticipated property tax increases generated by a project to pay for its capital costs and can be used to finance resilience projects in coastal or flood risk-prone areas with high development interest.	Virginia Beach's Sandbridge Beach Restoration Program
Taxes and Fees	Revenue collected by local or county governments for general funds or specific services.	Norfolk's Resilience Penny Alexandria's stormwater utility fees[100]

The Resilience Penny

The City of Norfolk increased property taxes by one cent per $100 assessed value in what they have termed the "Resilience Penny." These funds will be used for resilience efforts and are expected to generate roughly $1.8 million in revenue annually. This money may be insufficient to fund large infrastructure projects. Still, it could help pay the interest on a bond issuance or feed into a local revolving loan fund. Additional borrowers could obtain loans as the program is repaid through previous repayments.

Other Funding Opportunities

Even between local, state, and federal programs, some funding gaps will remain. Philanthropic support from national, regional, and community foundations can offer more flexible funding and often have less demanding application requirements. Philanthropic support can also provide the needed funds for communities to build their staff capacity and technical expertise to implement on-the-ground resilience projects in the future. Other organizations may support pilot or demonstration programs for innovative resilience projects that may be ineligible under existing public sources.

Several private foundations already provide funding for coastal resilience initiatives. For example, the National Fish and Wildlife Foundation is a private grant-making institution that is chartered by Congress and distributes funds from both federal and non-federal sources. Non-federal sources include funds from regulatory actions or legal settlements. NFWF's Resilient Communities Program recently distributed $2.9 million nationwide to help communities address the risks of flooding, droughts, rising sea levels, and longer hurricane and wildfire seasons. The program also provides funding through the Chesapeake Bay Stewardship Fund, Five Start and Urban Water Restoration Program, and its Emergency Coastal Resilience Fund. In 2020, the Chesapeake Bay Stewardship Fund awarded more than $4.6 million in grants for 12 projects in coastal Virginia for restoration and outreach initiatives.[101]

Climate and coastal resilience solutions are urgently needed, and increasingly, philanthropic organizations are turning their focus to support resilience projects and capacity building. Moving forward, the Commonwealth can help localities leverage these opportunities to fill outstanding funding gaps.

Photo courtesy of Aileen Devlin of Virginia Sea Grant.

Maximizing Funding and Financing

The Commonwealth occupies a strategically significant role between federal and local governments and can request, influence, and generate funding to support a comprehensive approach to coastal resilience.

The identification of ongoing projects and initiatives throughout coastal Virginia allows the Commonwealth to understand project needs, obstacles to securing funding, and outstanding gaps in existing efforts. The Commonwealth can focus on securing additional federal resilience funds through annual appropriations and periodic disaster supplementals for priority projects. State agencies can support jurisdictions lacking projects or capacity through state-led grant programs, especially the Community Flood Preparedness Fund, which has scoring procedures that can be adjusted to encourage or incentivize projects identified in the Master Plan. Further, the Commonwealth can learn from persisting gaps in projects, capacity, and funding to inform new grant programs and financing mechanisms to address these needs.

Aligning Funding Sources

To achieve a resilient and thriving coastal Virginia, the Commonwealth recognizes the need to connect identified resilience projects with sources of revenue. Matching projects with potential funding sources is key to implementing many planned or proposed initiatives and realizing their benefits to the community or region.

The Commonwealth used the inventory of grant and loan programs to align identified resilience projects with potential funding sources. This inventory of programs was structured to align with projects submitted by localities, regions, and other stakeholders. The alignment of funding to projects is an initial exercise to provide regions and localities with additional insight into what specific funding sources may be available to fund their projects.

The alignment process began by examining the eligibility criteria of the funding source, such as eligible applicants, applicable project phase, and supported project strategies and types. These criteria were compared to a project's owner, phase, and type to determine if a project is potentially eligible for a specific program. This alignment process eliminated sources for which a project would not receive funds based on the information available.

A project's likelihood to receive funding, however, depends on more than eligibility. Recognizing this, the alignment process rated the relative appropriateness of a project for a specific funding source. The feasibility of receiving funding was determined by an applicant's ability to raise necessary matching funds, ability to afford application costs, progress on procuring permits, and the project's costs relative to the maximum funding amount. This project information was collected through the Commonwealth's data call, though it was not a requirement that localities provide such information. The feasibility of a project receiving funds is a preliminary assessment of whether the effort is ready to apply or a suitable candidate for funding.

The alignment process offers a starting point for localities, regions, and other project owners to more quickly identify potential funding sources for proposed resilience projects that need or would benefit from additional financial resources.

Explore projects and their potential funding sources in the **Coastal Resilience Web Explorer**

Photo courtesy of Aileen Devlin of Virginia Sea Grant.

Challenges to Securing Funding

The ability to secure funds remains a core obstacle to many jurisdictions. Often, the most significant obstacle for local and regional jurisdictions to pay for resilience projects is sourcing staff time and expertise to find and apply for grant programs.

For some localities, limited staff capacity and institutional knowledge hinder their ability to submit competitive applications. For others, securing enough matching funds, demonstrating cost-effectiveness, or relying on reimbursement grants for out-of-pocket costs can be demanding. Funding challenges often persist even after securing grants because managing project funds requires both financial and legal literacy. Many lower-resources communities lack this expertise and the time to learn it, much less can afford to hire additional support.

The Commonwealth seeks to understand these challenges to develop solutions to alleviate them. The Community Flood Preparedness Fund represents a substantial step forward to begin addressing these issues. Still, the fund does not have the capacity to meet the order of magnitude of the projects and initiatives identified even through the Commonwealth's data call for the Master Plan, which only addressed projects in the eight coastal regions. Moving forward, the Commonwealth may look to gather success stories and lessons learned from the coastal regions and beyond to share knowledge that increases our success of securing funding and implementing resilience efforts.

Stacking Funds

A single stream of funding or financing cannot often cover a large-scale resilience project that may be developed or constructed over many years. The concept of "stacking funds" involves using multiple funding streams to collectively fund a project entirely.

Many federal and state grants require jurisdictions to provide matching funds to be considered eligible. Some of these programs, particularly federal ones, place restrictions on the sources of matching funds. For lower-resources jurisdictions, this requirement can be a significant obstacle or deterrent to applying for needed resources. Recognizing this barrier, the Commonwealth developed the Community Flood Preparedness Fund to be a flexible funding source that localities can use to close these types of funding gaps.

GO Virginia: Supporting Innovation for Coastal Resilience Solutions

Rising sea levels pose challenges, but also opportunities for innovation and economic development — to launch a Virginia-based industry cluster and innovation ecosystem, from applied research and workforce development to entrepreneurship and business incubation and acceleration. Individuals and localities need new technology, products and services, designs, and expertise to prepare for changing coastal hazards and build resilience. GO Virginia — a state-funded economic development initiative — has recognized and supported these opportunities.

GO Virginia invested $2.9 million in the Coastal Resilience Adaptation Economy initiative led by Virginia Sea Grant (VASG) to foster innovation and growth in a water adaptation economy, including a business competition led by RISE Resilience Innovations, Inc. that offers grants to entrepreneurs addressing rural coastal challenges. Leveraging additional funds, RISE expanded the rural business competition with a parallel urban competition for a total $3 million funding opportunity. VASG, leveraging NOAA funding, offers universities $1 million to work with competition winners to validate and improve performance of innovations. VASG and Virginia Tech are co-funding an Extension position to facilitate university-industry research and development. Rappahannock Community College supplies apprentices to the RISE business winners. Old Dominion University is facilitating a business consortium to share best practices and build connections between coastal rural and coastal urban Virginia businesses.[102]

Additionally, GO Virginia funded VASG to lead a stakeholder-driven Action Plan for a resilience and adaptation economy in the coastal rural Middle Peninsula, Northern Neck, and the Fredericksburg area. The Action Plan recommends a Resilience Innovation Center, fostering public-private research and development and workforce development, and leveraging a network of publicly owned properties as field stations, as an essential element of an innovation ecosystem underpinning the Commonwealth's adaptation economy.[103]

The Virginia Academy of Science, Engineering, and Medicine recommended "continued economic development investments in Virginia's resilience and adaptation economy."[104] With such investment, Virginia could become a hub for novel adaptation solutions and be poised to build businesses, innovations, and workforce for the future of coastal communities worldwide.

Technical Study Process Improvements

Throughout this planning process, the Commonwealth and technical support team identified improvements for future phases of the Technical Study and Master Plan. Chapter 3 discusses improvements specifically to the first three steps of the Technical Study introduced in Chapter 1. The following section summarizes the identified improvements for future phases of the last three steps of this process.

Inventory Resilience Strategies

The Master Plan aims to identify and prioritize ongoing and proposed resilience projects that further the Commonwealth's broader resilience goals and principles. The initial Master Plan effort established a project classification schema, an inventory of resilience projects and capacity-building initiatives, and project evaluation approach. The Technical Advisory Committee vetted these processes; however, the time limitations of the initial effort limited a thorough iterative improvement process addressing broader stakeholder feedback. Nevertheless, the established process provides a solid building block for refinement as the Commonwealth works towards the next phase of the Master Plan. The process of identifying and evaluating projects and analyzing potential risks hotspots highlights several areas for essential improvements.

Resilience Needs Database –The adaptation project and capacity building surveys for the initial Master Plan had a short time frame to allow for a comprehensive inventory across the Commonwealth. Project owners were asked to focus on their priority projects. Capacity within the submitting entities influenced the number and quality of submissions. Some entities were only able to provide limited responses, while others lacked the capacity to respond at all.

To complete a more comprehensive inventory of resilience projects and capacity building initiatives within the state, the Commonwealth can advance several improvements. Examples include gathering and submitting project information, providing training, and example entries to improve consistency with project data entries, and reviewing and vetting the project entries.

Many localities have yet to progress to identified resilience projects. Initial and sustained capacity building is needed to advance these communities forward through the resilience-building process. The Commonwealth should continue supporting these efforts. The Community Flood Preparedness Fund has become a mechanism to provide financial assistance for this process.

The Resilience Adaptation Feasibility Tool (RAFT), advanced by a partnership under Virginia Sea Grant involving the University of Virginia, the William and Mary Law School, and Old Dominion University, has proven effective at advancing resilience planning in several communities across the Commonwealth. Integration of Master Plan hazard and impact outputs could allow for this process to be cost- effectively extended to additional localities.

Project Evaluation – The Commonwealth developed the project evaluation process alongside the adaptation project identification survey. The project evaluation process requires qualitative analysis of the project owners' data and quantitative analysis using data gathered and produced by the Master Plan. Executing the initial project evaluation revealed the need for improved data inputs and analyses to understand and evaluate a project's effectiveness accurately. This need is addressed in the improvements to the project and capacity building data gathering process. Also, a review team of independent technical experts should be established to assist and review the evaluation process.

The project benefit area is critical to understanding what exposure and impacts the project will address. A standardized methodology is needed to identify and map the project benefit area for each project type. The benefit area also should be attributed to a design flood elevation related to the Master Plan's time horizon and water level frequency framework.

The project evaluation approach sought to create a process that could be applied across a range of project types, including nature-based, structural, and hybrid projects. The initial outcomes did not bias any particular project class, but it was noted that evaluating projects

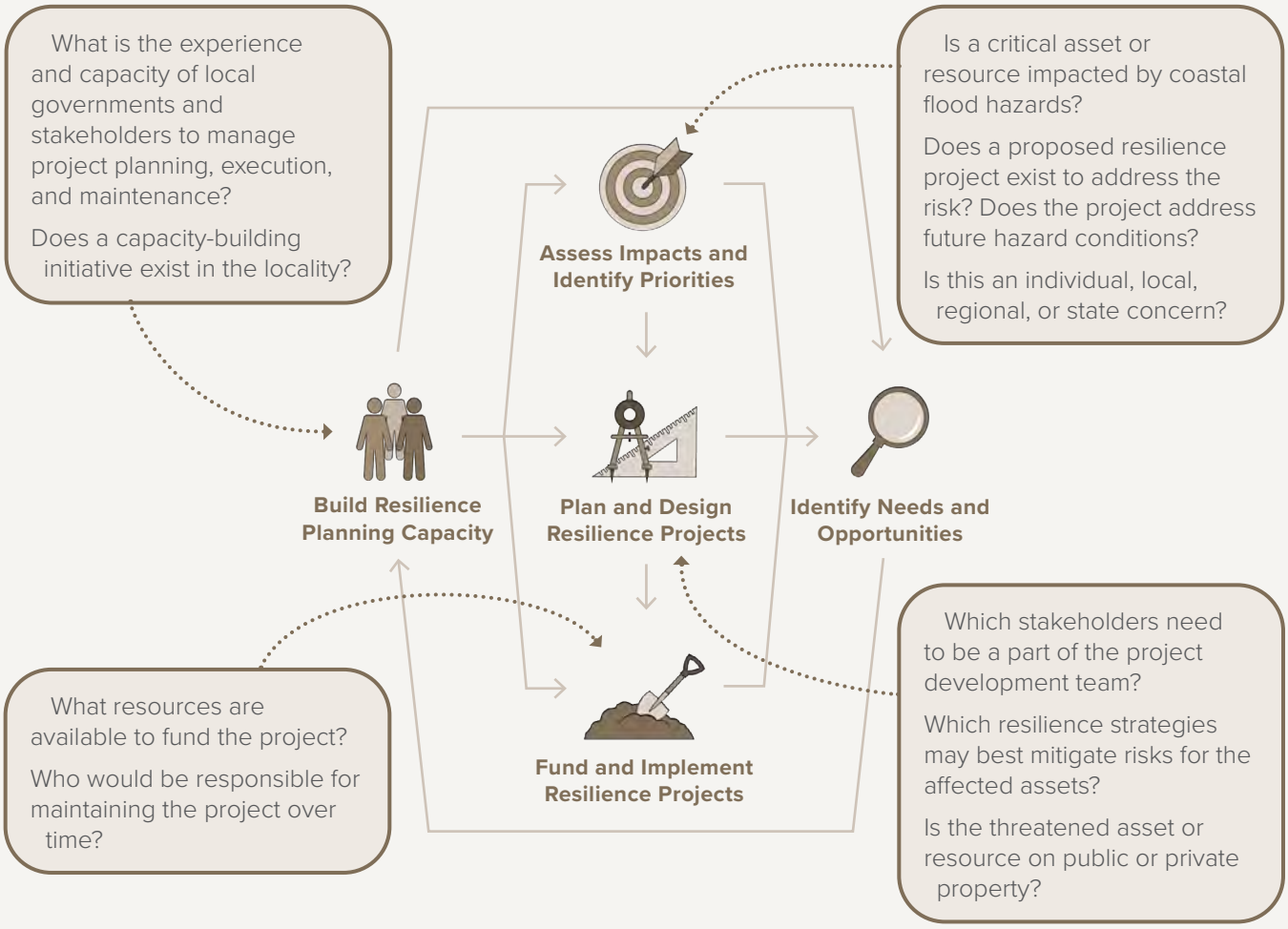
within discrete classes may simplify the evaluation process. To this end, future iterations of the project evaluation approach may require hybrid projects to select a primary project class.

Some projects were submitted with multiple entries for distinct portions or phases of the effort, and some capacity-building initiatives were submitted in connection to an identified adaptation project. Effectively evaluating these related projects and initiatives posed some challenges to executing the evaluation approach. In the future, the Master Plan must work to capture relationships and anticipated sequencing of capacity building and project efforts within the database. A mechanism and protocol for identifying and resolving conflicting efforts with project owners should be identified. Additionally, initial prioritization of projects by owners would provide critical understanding for the Commonwealth as it evaluates projects against state guiding principles.

An initial process was established to consider evaluating high-scoring projects against funding opportunities. In concept, this process would allow the Commonwealth to identify a subset of the ranked projects for near-term implementation. Further development of this process would benefit regular advancement of highly ranked projects to implementation.

Identifying and Developing Projects for Impact Hotspots

Future phases of the Master Plan must establish a standardized process for developing projects for impact hotspots that lack ongoing or proposed efforts. The process should leverage the preliminary project evaluation approach to determine priority impact areas and relevant adaptation strategies that are best suited to protect the affected assets. The following graphic illustrates some of the considerations this process should account for and how it may relate to the development of resilience projects and capacity-building initiatives.



Align Funding Sources

The Master Plan leveraged efforts by the Coastal Zone Management Program to develop a database of funding sources and align those sources with identified projects. These efforts will benefit the Commonwealth and project owners but it is essential that the funding database is regularly maintained.

In addition to facilitating greater access to existing funding sources, the Commonwealth needs to work with stakeholders to develop innovative funding opportunities. Opportunities exist for potentially combining locality and regional funding to gain better access to capital.

Finance Subcommittee Recommendation: Establish a Resiliency Revolving Loan Fund

Throughout the Master Planning process, the Finance Subcommittee sought to understand how the Commonwealth can leverage and align existing revenue streams and how to create new ones to support resilience efforts. To that end, the Subcommittee researched funding programs and financing strategies that can be used by local and regional entities to pay for resilience efforts.

Based on these efforts, the Finance Subcommittee recommends that the Commonwealth consider establishing a resiliency revolving loan fund to create an additional perpetual funding source for resiliency projects in Virginia separate from that of the Community Flood Preparedness Fund. This revolving loan fund could finance projects that fall outside of the scope of the Community Flood Preparedness Fund or, due to capacity constraints, cannot be funded from the Fund at a given time.

A Resiliency Revolving Loan Fund could be modeled after the Virginia Airports Revolving Fund, which offers maximum application and loan flexibility to borrowers. The Resiliency Fund could be established with a direct appropriation from the General Assembly or from another identified funding source. Other funding mechanisms could include special purpose taxes administered or delivered through an entity similar to a Transportation Planning Organization. Loans made from the Resiliency Fund could be used to meet matching requirements of other funding sources, to provide gap financing needs for projects that have not identified all of the needed project costs from other sources, or to provide more flexibility in funding resilient elements of efforts that are not otherwise resilience projects.

The Resiliency Fund also could establish an alternative fund in the event that proceeds derived from the Regional Greenhouse Gas Initiative auctions significantly decline in the future. Additionally, interest earnings from loans made through the Resiliency Revolving Fund could potentially provide grant funds for regional planning completed by planning district commissions.

Photo courtesy of Dewberry.

Determine Gaps in Capacities, Projects, and Funding

The Master Plan aims to identify and prioritize ongoing and proposed resilience projects that further the Commonwealth's broader resilience goals and principles. The Commonwealth identified localities that did not submit resilience projects to the data call, but where impacts due to coastal hazards are projected to be severe. The goal of this effort was to complete an initial identification of where coastal adaptation and protection projects are needed in order to improve the resilience of social, natural, and built assets, with particular consideration to the needs of under-represented communities.

The identification of these areas is an initial step to integrate and advance equity in the Commonwealth's resilience planning efforts. In the coming months and years, the Department of Conservation and Recreation and the Technical Advisory Committee will complete a more detailed impact assessment that includes the development of a detailed outreach and engagement strategy to ensure a sustained public planning process.

Next, we will work with affected communities and stakeholders to develop capacity building and project proposals that address identified challenges and align with Framework guiding principles and goals. In the future, the planning, design, and construction of these projects will receive priority consideration for resources from the Community Flood Preparedness Fund. Additional assistance may be provided through the methods outlined in the Master Plan funding and financing strategy. The Commonwealth will offer to provide technical support for these efforts, particularly for areas that lack proposals for planning- or capacity-building. As these project advance, they will be included in future versions of the Master Plan.

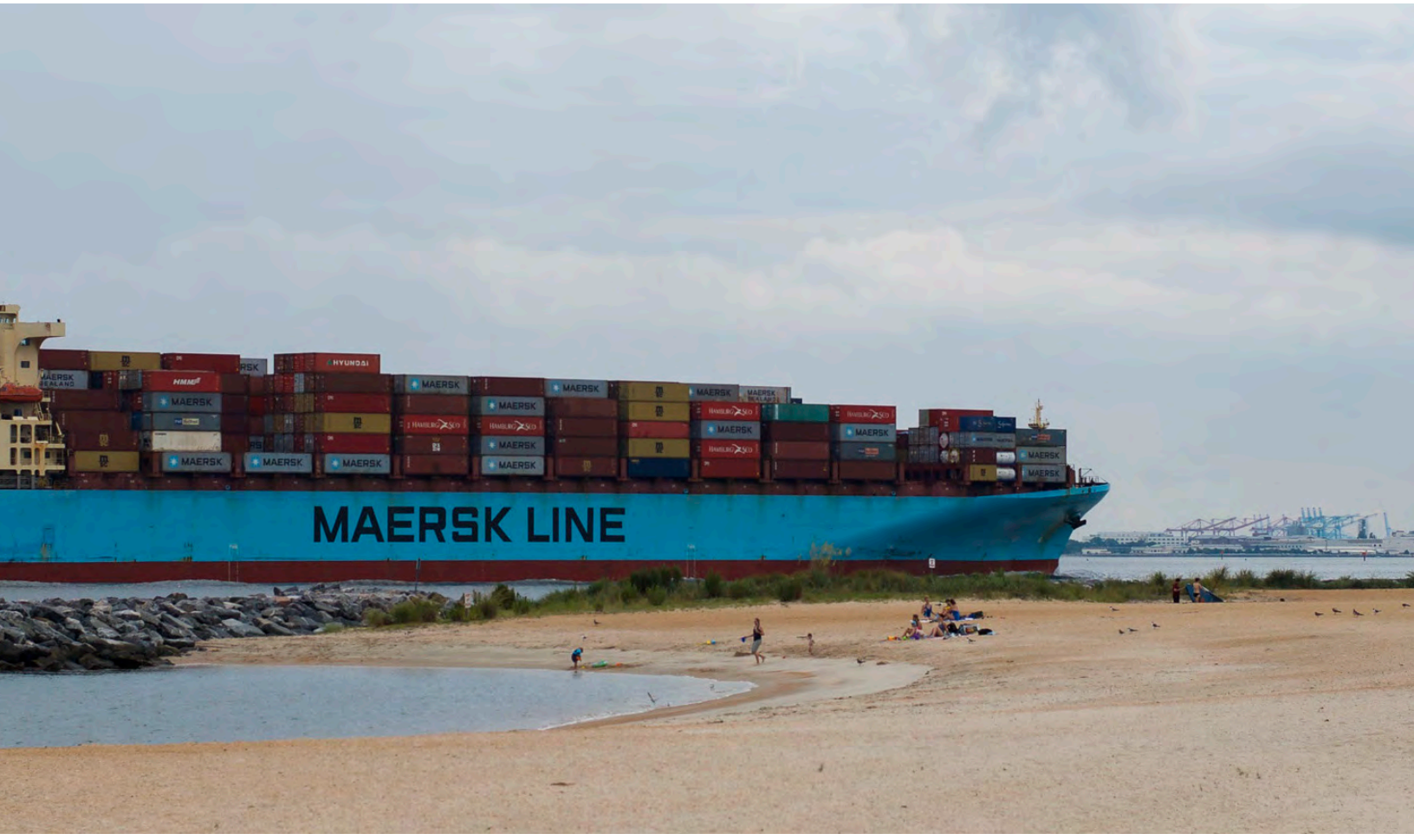


Photo courtesy of Aileen Devlin of Virginia Sea Grant.

Chapter 5

Achieving a Resilient Coast

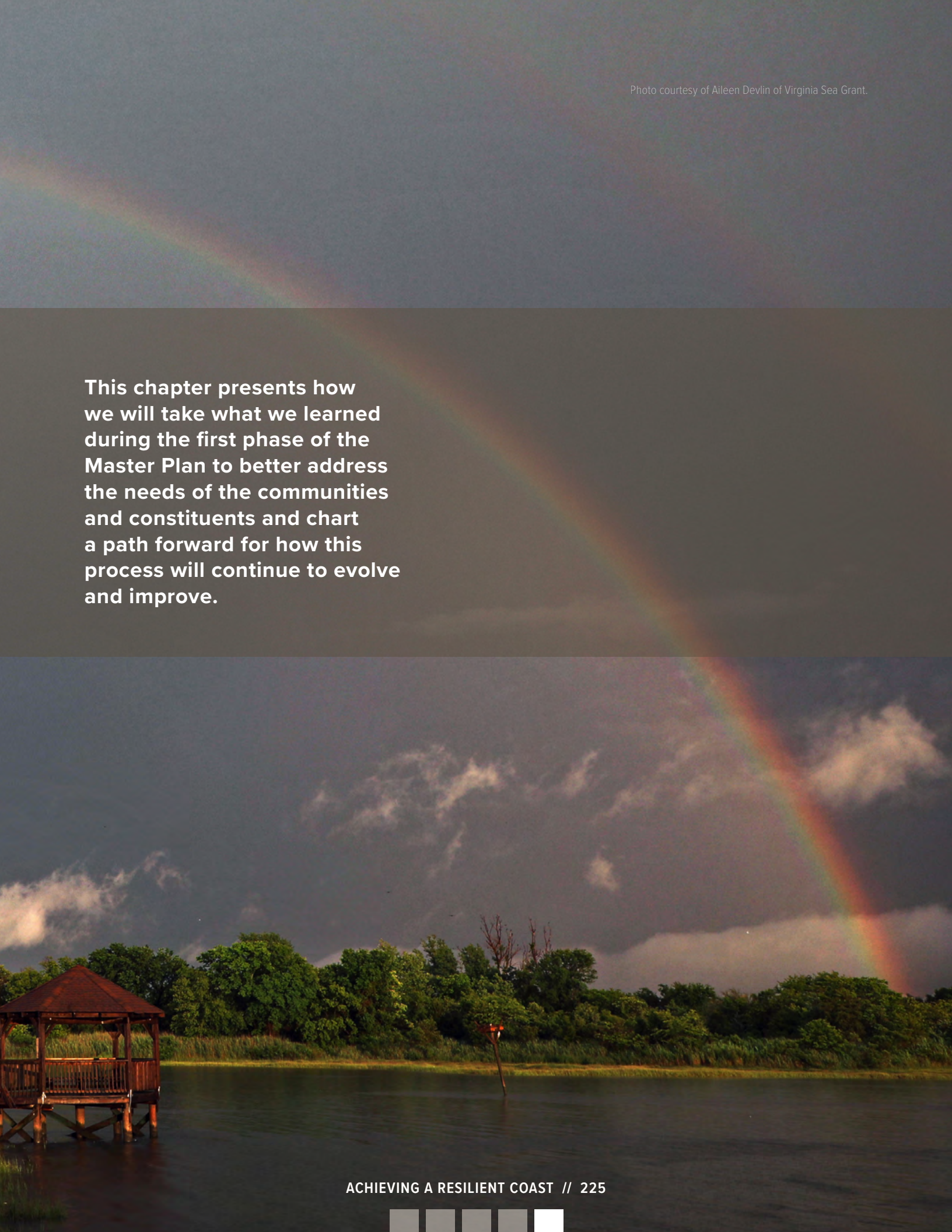


Photo courtesy of Aileen Devlin of Virginia Sea Grant.

This chapter presents how we will take what we learned during the first phase of the Master Plan to better address the needs of the communities and constituents and chart a path forward for how this process will continue to evolve and improve.

Continuing the Work

The completion of the Virginia Coastal Resilience Master Plan Phase One is a call to action for the Commonwealth — its regions, localities, communities, and many other stakeholders — to continue this work. With this Master Plan, the Commonwealth embarks on a long journey to continue the development of activities to adapt and protect Virginia's valuable coast. In considering the 6 million people who live in our coastal regions and the impact this work has on the Commonwealth's economy, we have learned over the course of the past year how essential this work is and how much more there is to do.

Photos courtesy of Dewberry and Aileen Devlin of Virginia Sea Grant (VASG).

Guided by this first phase of the Master Plan, and by the goals and principles outlined in the Framework, Virginia's Coastal Resilience Master Planning process will be a continued and sustained effort. It will evolve as our understanding of challenges and response options improves through time and experience.

We intend for this to be a collaborative work, aided by clear principles which emphasize a strong preference for long-term effectiveness in actions undertaken and prioritize adaptation and avoidance strategies over exclusively defensive structural solutions.

While we know structural solutions will be needed, the Commonwealth's focus must be on how best to position our people, property, and infrastructure such that they are out of harm's way wherever possible.

Our enduring efforts will center on a set of desired characteristics, including a sustainable public planning and implementation process, with clear objectives, time-bound tasks, defined accountability, transparent monitoring of progress, and actionable evaluation.

With these priorities in mind and with the goals and principles outlined in the Framework, this chapter defines what the Commonwealth sees as its responsibilities, summarizes the outcomes accomplished during Phase One of the Master Plan, and outlines how Phase Two will move us ahead, together, to adapt and protect Virginia's coast.

The Commonwealth's Role in Resilience

First and foremost, we see the Commonwealth's role as one of leading by example, and providing critical coordination across and between federal partners and agencies, state agencies, regions, localities, communities, and other stakeholders, to support ongoing coastal adaptation and protection efforts.

This includes setting standards for climate and sea level rise adaptation planning for state-owned infrastructure — which we have done through Executive Order 45, discussed in Chapter 2 and in the Framework. It also includes providing capacity-building opportunities for those localities and regions who cannot do this work alone; providing data and impact assessment analysis to facilitate additional work by Commonwealth agencies, localities, and regions; and identifying and developing strategies to help fill gaps where there is clear risk and need but limited ability or capacity to move forward to adapt or protect from that risk.

As delineated in the guiding principles, the Commonwealth further sees its responsibilities as:

- Ensuring the use of the **best available science** to acknowledge and project future climate impacts across coastal and coastal Virginia;
- Ensuring **equity** across and between communities and localities so that underrepresented communities have a voice in the outcomes and protections that best support their needs;
- Encouraging **green infrastructure solutions** as preferred and used wherever possible, understanding that gray infrastructure may be necessary, and in that case, hybrid solutions should be encouraged to bring as much ecosystem service capability and capacity as possible;
- Considering **regional- and community-based solutions** tailored to the needs of communities and encompassing cross-jurisdictional projects where possible and feasible;
- And finally, **coordinating financing solutions**, encouraging and expanding opportunities with the assistance of the Virginia Community Flood Preparedness Fund where appropriate, and identifying other funding resources to enable regions, localities, and communities to make progress in the work they know they must do to build coastal resilience.

Photo courtesy of Aileen Devlin of Virginia Sea Grant.

Accomplishments of Phase One

With this first phase of the Master Plan, the Commonwealth, guided by the Technical Advisory Committee, completed the first-ever full coastal assessment of Virginia's coastal regions.

Key accomplishments of this effort include:

- Determined current and future land **exposure to coastal flooding hazards**, and identified anticipated changes in future coastal flood frequency across the Commonwealth.
- Used the modeled the coastal flood hazard information to estimate **impacts** to Community Resources, Critical Sectors, and Natural Infrastructure.
- Identified areas with both high **social vulnerability** and coastal flood hazard exposure to determine areas with the greatest potential needs and risks.
- Conducted **workshops** with Planning District and Regional Commissions, localities, and communities to refine the assessment of impacts due to coastal flooding with local knowledge and understanding.
- Established an inventory of locally-driven coastal **resilience projects** that address regional and statewide needs, and a process for understanding, tracking, and collecting data on ongoing and future proposed resilience projects
- Developed an initial data-driven approach to **evaluate and prioritize projects** based on how well efforts align with the guiding principles of the Commonwealth's coastal resilience strategy outlined in the Framework, and developed an initial mechanism to align identified coastal resilience projects with potential funding sources.
- Leveraged and augmented previous work supported by the Virginia Coastal Zone Management Program to establish an **inventory of grant and loan programs** relevant to resilience efforts to assist regions and localities with securing financial resources.
- Created the **Coastal Resilience Database and Web Explorer** which makes data on coastal flood hazards, impacts, ongoing and proposed projects and initiatives, funding programs, and other relevant information publicly available to support resilience efforts at the state, regional, and local levels.
- Collected information on proposed and ongoing **capacity-building and planning initiatives** related to resilience, and identified the needs of localities and regions across coastal Virginia to advance their resilience efforts.
- Initiated a **public planning process** and established a baseline understanding of public perspectives and on-the-ground knowledge of coastal flood hazards and preferred strategies to adapt and protect coastal Virginia through workshops with regions, localities, and members of the public.

Expanding Our Understanding of Coastal Hazards

The Virginia Coastal Resilience Master Plan began development in late 2020 with planned completion in late 2021. Recognizing this short time frame, the Commonwealth focused this first assessment on the impacts of tidal and storm surge flooding on the coastal Virginia. Although the coastal hazard information will be improved with dynamic modeling of future conditions, we know many other types of hazards threaten coastal Virginia. Establishing and integrating an understanding of those hazards is a priority for refining future Master planning efforts.

Sustaining the Master Planning Effort

Over the course of the past year, the Commonwealth has worked to ensure that the Master Planning process is sustained and continues over time.

To facilitate and oversee this work, the Commonwealth codified the Chief Resilience Officer, and designated the Chief Resilience Officer as the Secretary of Natural and Historic Resources. It further codified and expanded the duties and responsibilities of the Special Assistant for Coastal Adaptation and Protection and Chief Resilience Officer to include participation in the oversight of the Community Flood Preparedness Fund and the coordination of Commonwealth Flood Protection Programs as designated in Virginia Code Section § 10.1-659.

In addition, the Commonwealth established the Technical Advisory Committee under Executive Order 71, signed by Governor Northam in December 2020. The Technical Advisory Committee and its seven subcommittees convened multiple times to advise and guide the Commonwealth as it moved forward to create and complete Virginia's first Coastal Resilience Master Plan. The Commonwealth will update Executive Order 71 to codify the Technical Advisory Committee to permanently continue the its role in supporting the Commonwealth as it develops long-term strategies to adapt and protect its coast.

The Commonwealth has elevated the Virginia Coastal Zone Management Program such that it now reports directly to the Secretary of Natural and Historic Resources. This continued direct access ensures that the work of the Program is coordinated with the Master Planning process. Each can leverage the capacity and opportunities provided by the other.

The Commonwealth is committed to continuing to build a sustainable public outreach and engagement process that engages communities at every level. Localities, nonprofit organizations, community groups, and other stakeholders should all have an opportunity to participate and educate the Commonwealth on the needs of their specific communities. This includes working directly with Virginia's seven federally-recognized and four state-recognized tribes, to further expand and enhance their resilience, particularly for those tribes residing in Virginia's coastal regions.

Photo courtesy of Aileen Devlin of Virginia Sea Grant.

Photos courtesy of Dewberry and Aileen Devlin of Virginia Sea Grant (VASG).

Aligned with this work, the Commonwealth has also incorporated climate change projections and building elevation standards into state agency programs through the implementation of Executive Order 45, signed by Governor Northam in November 2019. The implementation of this initiative includes developing processes and guidance documents to help state agencies comply with these new freeboard standards and sea level rise planning standards. It also provides a methodology for all state-owned infrastructure to comply with these standards in the future.

The Commonwealth amended the Chesapeake Bay Preservation Act to incorporate consideration for climate change and sea level rise, coordinating with the Department of Environmental Quality and the State Water Control Board to update regulations to promote coastal resilience and adaptation. NOAA, through the Virginia Coastal Zone Management Program, funded a Project of Special Merit to enable the Virginia Coastal Policy Center and the Department of Environmental Quality to develop guidance, work with stakeholders, assist localities in implementing this new regulation.

In addition, the Commonwealth amended the Tidal Wetlands Act to accommodate the migration of tidal wetlands as sea levels rise by directing the use of living and natural shorelines as the preferred solution for shoreline resilience, where suitable and feasible. The Virginia Marine Resources Commission has issued guidelines to support this amendment.

The Commonwealth coordinated with the Chesapeake Bay Trust, EPA, and RAND to participate in the Chesapeake Bay Rainfall Intensity Duration and Frequency modeling project. This effort made statewide data on intensity, duration, and frequency of rainfall events publicly available, for localities to use to understand future rainfall projections.

Also, the Commonwealth partnered with the States of North Carolina, Maryland and Delaware to update Atlas 14 Volume 2, the federal stormwater planning standard which was last updated in 2004. The new Atlas 14 Volume 13 will be completed in late Fall of 2023.

The Commonwealth is also working to develop an Introduction to Strategic Coastal Relocation document, with the assistance of the Studies, Research, and Best Practices Subcommittee of the Technical Advisory Committee, which will be released in the near future. This work will begin an honest and proactive dialogue about moving private and public assets to higher ground, considering the conversations underway in other states as well as the specific circumstances unique to Virginia. Community relocation efforts have been successful in riverine contexts in the

Commonwealth and beyond, but understanding the considerations for coastal communities remains elusive. Yet we know there is a need, and feel that by releasing this Introduction document, the dialogue may advance in earnest so communities can begin to consider options and make choices for themselves.

As outlined in the Framework, Goal 5 of the Commonwealth's broader coastal resilience strategy aims to have all localities in our coastal regions participate in the Resilience Adaptation and Feasibility Tool (RAFT) process. Through the course of 2021, Northern Neck PDC completed a RAFT process with many of its localities, and has begun work to help build resilience throughout these communities, as described in earlier chapters. Middle Peninsula PDC will soon start the RAFT process, and both Crater PDC and PlanRVA are in the process of preparing for the RAFT process in the future.

At the request of localities and Commissions that previously completed the process, the RAFT program developed a self-scoring toolkit that allows localities to assess their ongoing planning and resilience processes. This toolkit was created for localities and regions who have previously completed the RAFT and want a refresher or for those who feel that they may not need specialized, in-person assistance of the RAFT team, but would like to verify their resilience processes and procedures. This resource will be available on the Department of Conservation and Recreation's Virginia Coastal Resilience Master Plan website for download and use by interested localities.

The Chief Resilience Officer and Special Assistant for Coastal Adaptation and Protection will continue to work with the Virginia Coastal Zone Management Program, the Virginia Sea Grant Program, the University of Virginia's Institute for Environmental Negotiation, and the Virginia Coastal Policy Center, to encourage participation in the RAFT process, and to find avenues to institutionalize the resources to support these activities.

The following sections outline the Commonwealth's anticipated vision as we continue to build coastal resilience in Virginia. First, we present feedback from the Technical Advisory Committee, then break out the Commonwealth's priorities for Phase Two of the Master Plan, including proposed improvements to the Technical Study Process, previously discussed in Chapters 3 and 4, and related non-technical activities. Next, we present proposals for expanding on coastal efforts to advance statewide flood hazard mapping, modeling, and gauge data. Finally, we give an initial list of priorities for improvements leading to the next Master Plan.

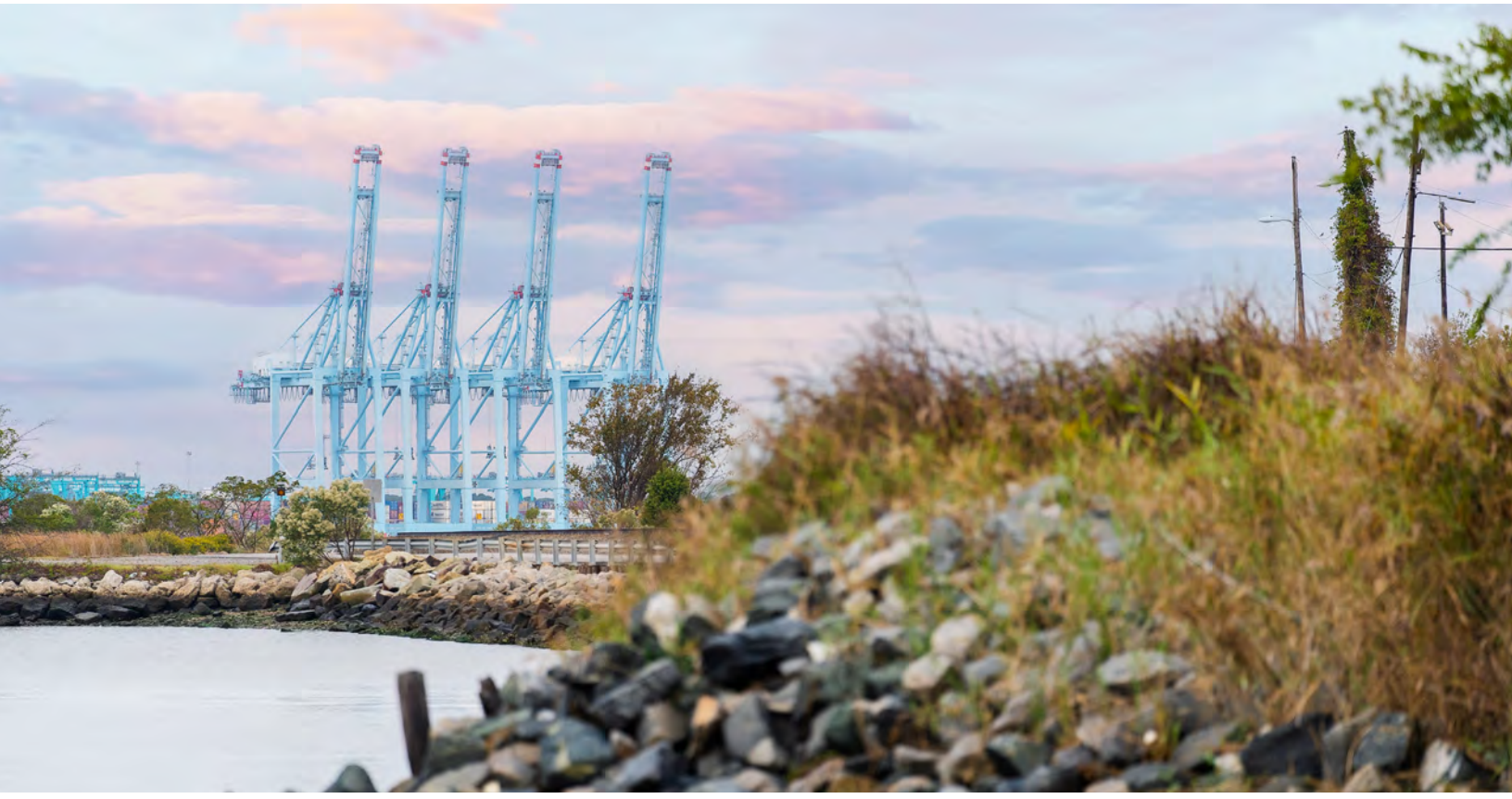


Photo courtesy of Dewberry.

Technical Advisory Committee Recommendations

The members of the Technical Advisory Committee served as essential counselors to the Commonwealth throughout the development of this first Master Plan. We thank the members for their gracious support of this effort. The Commonwealth asked the committee to provide suggestions to improve future phases of the Master Planning process. Key themes of the Technical Advisory Committee's recommendations are summarized below, organized without regard to priority. For more detailed subcommittee recommendations, please see Appendix A.

Future of the Special Assistant to the Governor for Coastal Adaptation and Protection – The Finance and Studies, Research, and Best Practices Subcommittees recommend that the Special Assistant to the Governor for Coastal Adaptation and Protection be maintained and provided funding for additional staff. The Finance Subcommittee recommends that this position should be elevated to a cabinet-level position.

State Collaboration – The Studies, Research, and Best Practices Subcommittee recommend the need for a collaborative effort between state agencies regarding retreat strategies. The Federal Installation Partnerships Subcommittee provided a similar recommendation promoting a resources roadmap tied to state agency representatives. The roadmap would close a resource gap between the Commonwealth, localities, and federal partners.

Formalized Regional and Local Resilience Networks – The Commonwealth should take a more formalized approach when networking with localities and Planning District and Regional Commissions. The Federal Installation Partnerships Subcommittee recommends that more action be taken regarding collaboration between the Commonwealth and localities regarding resilience measures. Similarly, the Community Outreach Subcommittee recommends that planning district and regional commissions should work closer with the subcommittee as facilitators of outreach efforts.

Locality Support – Both the Federal Installation Partnerships and Project Identification Subcommittees recommended further support for localities in the Commonwealth. The Project Identification Subcommittee recommend actions to encourage local governments to prepare for and educate their citizens about flooding. Related, the Federal Installation Partnerships Subcommittee recommend that the Master Plan support localities in their resilience efforts by sharing information, providing technical assistance, advocating for federal programs, and providing funding. The Aligning Economic Development Subcommittee provide similar sentiments, noting the need to educate stakeholders and create tools for economic development in coastal communities.

Expanded Community Outreach – The Community Outreach Subcommittee offered several recommendations on how outreach can be improved. These include integrating data collection efforts with outreach, making the Outreach Subcommittee the outreach facilitator, and expanding membership of the committee. The Studies, Research, and Best Practices Subcommittee recommended acknowledging the limited outreach time frame for the initial Master Plan and that a sustained outreach effort should be carried out by state agencies.

Prioritization of Natural and Nature-Based Features – Both the Project Evaluation and Studies and Research and Best Practices subcommittees recommend that natural and nature-based infrastructure be prioritized and invested in further in the next iteration of the Master Plan. The Studies, Research, and Best Practices Subcommittee recommends that natural infrastructure be categorized as critical infrastructure in its own right.

Project Evaluation Process – The Project Evaluation Subcommittee recommends that there should be a comprehensive needs assessment undertaken to bring projects into the plan. Further, the interpretation of provided project information for scoring should be standardized to reduce subjectivity. The Studies, Research, and Best Practices Subcommittee recommends that future projects be screened for best practices and new practices and divest from old practices. Additionally, the Project Identification Subcommittee recommends that projects chosen for the Master Plan should reflect the needs of the whole Commonwealth.

Phase Two of the Master Plan

Phase One of the Master Plan is a foundational first step towards a resilient coastal Virginia. However, this process must evolve and grow as priorities, needs, and data change over time.

As recommended by the Framework and addressed throughout this document, the Commonwealth intends to use Phase One of the Master Plan as a catalyst to continue building our analysis, data collection, risk and impact assessment and planning, and most importantly, to continue to build and sustain a public engagement process.

We are planning successive updates of the Master Plan on a five-year cycle, managed by the Department of Conservation and Recreation in consultation with the Technical Advisory Committee. What we have learned during Phase One drives the need to continue this work and complete Phase Two in a shorter cycle to fully develop a Coastal Resilience Master Plan for Virginia.

Continuous maintenance and enhancements are essential to incorporate new data, analysis, projects, and funding opportunities between iterations of the Master Plan for the Commonwealth. In recognition of this need, key recommendations for Phase Two include:

- Broaden the analysis and characterization of hazards, by including **rainfall-driven, riverine, and compound flooding** in the Technical Study's coastal hazard and impact assessment.
- Expand and improve the inventory of resilience projects. Continue to add **proposed and planned projects** and expand the **data collection and assessment categories** to better analyze and understand the full scope and impact area of projects as developed by the Commonwealth, localities, and other stakeholders, including the stewards of state-owned property.
- Revise and expand the **project evaluation and prioritization approach**, based on the risks and impacts identified in the Technical Study's updated impact assessment and gap analysis.
- Identify options and opportunities to develop **adaptation and protection solutions** for identified gaps in high risk and vulnerable areas.
- Develop and implement a **sustainable public planning, outreach, and engagement process**.
- Expand the Coastal Resilience Database and Web Explorer beyond the coastal region to encompass **statewide resilience planning needs**.

These initial steps will allow us to better understand the full risk to our coastal region as soon as possible, beginning the future condition rainfall and riverine flooding analysis in early 2022 with anticipated completion by 2023.

During this time, the Commonwealth will work with coastal localities and solicit advice from the Technical Advisory Committee to further develop and expand the project inventory and to better understand the capacity-building needs of coastal communities. We will also consider expanding the Coastal Resilience Database statewide, with the coordination of the Department of Conservation and Recreation.

With the second risk and impact assessment complete, and armed with the broadened and more complete inventory of project and capacity-building needs, the Commonwealth will begin a second gap analysis. This gap analysis will compare projects and capacities against risks, to understand where adaptation and protection needs are most acute. Where no solutions are planned for high-need areas, the Commonwealth will work with stakeholders to identify and recommend solutions to address those risks. We anticipate completion of Phase Two of the Master Plan by the end of calendar year 2024.

Photo courtesy of the Buckingham Branch Railroad (Norfolk Division).

Sustained Non-Technical Activities

In addition to the specific steps outlined above, the work of the Commonwealth includes numerous activities outside of the scope of the Technical Study Process that require long term oversight, maintenance and funding to ensure progression of the overall Master Planning effort. Of highest priority amongst those activities is the continued development of the Web Explorer, outreach with community stakeholders, and coordination with the Technical Advisory Committee.

Coastal Resilience Web Explorer

The Coastal Resilience Web Explorer supports the end-use of many of the analytical products of the Master Plan by stakeholders. The application must be maintained and updated with improved data and analyses as they become available. Further, the Commonwealth will solicit stakeholder feedback to identify how to improve accessibility and end-use of the data products.

Community Outreach

The Master Plan is a living document with an ongoing planning process that requires meaningful input, public education, broad exposure, and continual support.

In addition to expanded research and analyses, the Commonwealth will continue this work and develop a strategic outreach and engagement process and guidelines to create and maintain a sustained public planning process. This effort will strive for meaningful involvement by ensuring that affected and vulnerable community residents have access and opportunities to participate in the full cycle of the decision-making process about development and updates of the Master Plan, and that decision-makers will seek out and consider such participation, allowing the views and perspectives of community residents to shape and influence decisions. This strategy will include routine public engagement with coastal Planning District and Regional Commissions, affected localities, vulnerable communities, federal installation partners, and other relevant stakeholders.

Technical Advisory Committee

As addressed widely in this document, the Commonwealth will continue the Technical Advisory Committee, which will advise on the best available science, data, and analytical processes to support state-wide initiatives. This effort would ensure Commonwealth-supported products can be used consistently by state agencies, localities, Planning District and Regional Commissions, and residents, to streamline flood and climate resilience planning.

Community Outreach and Engagement

The community outreach efforts undertaken by the Commonwealth began by identifying vulnerable communities historically subject to flooding and natural hazards, and then comparing those to identified areas that exhibit both moderate and high social vulnerability and flood exposure.

The Commonwealth held public engagement sessions at each of the eight Planning District and Regional Commissions, and then began a program to focus on community scale engagement opportunities, initially focusing on the Hampton Roads, Accomack-Northampton, and Middle Peninsula PDCs, and later adding the George Washington RC at their request. The COVID-19 pandemic drove these sessions to larger venues to add distancing space, but also supported hybrid meetings, which increased opportunities for community members and other stakeholders to participate virtually. While these modifications allowed for some increased participation, they limited the amount of direct, in person feedback. In spite of the challenges related to COVID and the limited time available, the Commonwealth heard and learned from community members and localities at every session — most urgently, that the needs are great, and this work must continue.

Future community outreach efforts will prioritize outreach to tribes, community organizations, non-government organizations, and other stakeholder groups to ensure that vulnerable and under-represented communities are fully able to participate and provide sustained public feedback to inform planning and decision-making processes.

Expanding on Coastal Efforts

While this Master Plan focuses on the coastal regions, many of the goals and accomplishments of this planning effort have the potential to benefit stakeholders across the entirety of the Commonwealth, including in inland areas where rainfall and riverine flooding is of immense and increasing concern. Advancing resilience in the face of climate change is a statewide need and priority.

Statewide Mapping and Modeling

The Commonwealth recognizes the need for predictive floodplain mapping to assist localities with understanding future risk. Future iterations of the Master Plan will focus on coastal floodplains, but the need for improved floodplain mapping is statewide.

With the improved precipitation data, including intensity-duration-frequency Modeling and Atlas 14 updates discussed earlier in this chapter, the Commonwealth will be able to, among other statewide flood impact data, update Probable Maximum Precipitation modeling to better prepare for the impact of rainfall flooding on many assets, including federally-owned, state-owned, and privately-owned dams.

The Master Plan presents an opportunity to establish a centralized database and web application that provides localities with consistent data to support flood resilience planning and project development. This model could be used to support a more comprehensive, state-wide, climate resilience strategy that would address additional threats, including extreme temperatures, drought, and wind.

Statewide Gauge Data

In the interest of continuing to build statewide flooding data, the Commonwealth needs a full riverine and coastal gauge indication and warning system. Updated gauge data would support the future iterations of the Master Plan, and this data can support planning and decision-making in inland areas as well.

Currently, the Department of Emergency Management manages the Commonwealth's Integrated Flood Observed and Warning Systems (IFLOWS), which is a partial network that tracks flood risks in real-time. This system only covers portions of the Shenandoah Valley and inland Virginia. The U.S. Geological Survey is installing a riverine gauge system in the Rappahannock River, but that work remains in progress.

Overall Virginia has relatively few coastal gauges and even fewer that have data over a usable timespan showing accurate trends. In the Coastal region, the Virginia Institute of Marine Science supports the development of the Tidewatch Network, which aims to connect and analyze coastal gauge data in the Hampton Roads region.

None of the gauge systems mentioned above are complete, predictive, or able to communicate with one another. Further, the existing gauges do not fully meet the requirements for emerging parametric insurance offerors to develop opportunities to enter the Virginia market.

Both coastal and inland Virginia need a better understanding of how flooding already affects roads and other infrastructure, and the need for predictive gauge and sensor modeling is growing. This will help localities assess how fast and high riverine waters may reach, depending on upstream precipitation. A comprehensive coastal and riverine gauge system can give localities, planners, emergency managers, engineers, businesses and residents the tools they need to monitor and prepare themselves for changing flood risks. More and better-integrated data is critical to anticipate the severity of flood events, a growing need for coastal communities experiencing nuisance flooding, and the effects of sea level rise.

Next Steps

The accomplishments of this first phase of the first Virginia Coastal Resilience Master Plan mark the first substantive, coast-wide collaborative effort to model coastal flood hazards, assess impacts and risk, develop and build a coastwide resilience project inventory, and provide data and other resources to regions, localities, communities, residents, businesses, and stakeholders across the Commonwealth's Coastal region. The Commonwealth recognizes that additional and continued public input, data analysis and proposed projects can and will strengthen this Plan and that this continued, iterative work must be done.

We anticipate completion of Phase Two of the Master Plan by the end of calendar year 2024. Subsequent master plan updates are planned for completion every five years, managed by the Department of Conservation and Recreation and with oversight and guidance from the Chief Resilience Officer and the Special Assistant to the Governor for Coastal Adaptation and Protection, in consultation with the Technical Advisory Committee. The following timeline outlines actions the Commonwealth intends to execute in the short-term, long-term, and on a continuous basis.

2021

Virginia Coastal Resilience Master Plan: Phase One is released

2024

Phase Two planned for release

2028

Full Update planned for release

Short Term (1-2 Years)

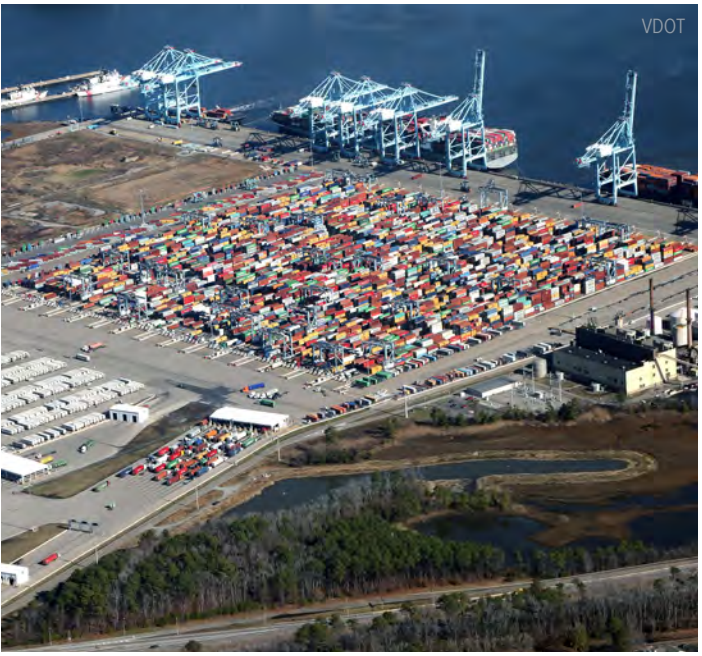
- Additional Hazard Modeling: Stormwater Flooding and Coastal Erosion
- Update Census Data and Revise Community Resources Impacts
- Refined Project Development

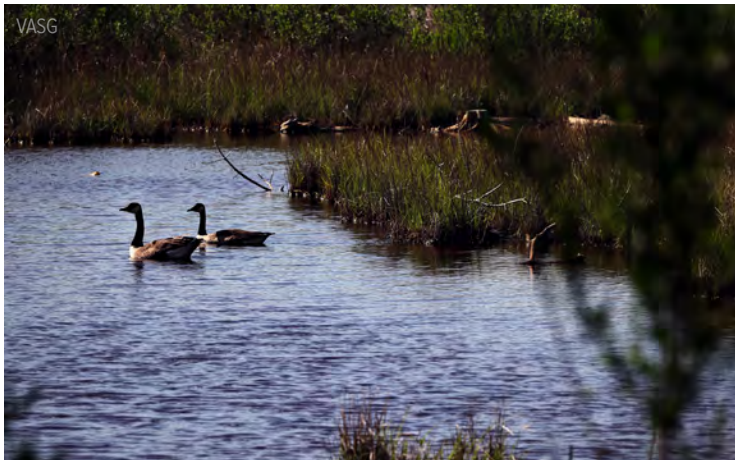
Long Term (3-5 Years)

- Additional Hazard Modeling: Riverine Flooding and Coastal Compound Factors
- Project Development and Evaluation

Continuous

- Capacity Building across Coastal Communities
- Master Plan (Resilience) Database and Web Application Maintenance and Enhancements
- Funding Monitoring and Update
- Sustained Outreach: Additional Meetings with Under-Resourced Communities, and Coastal PDCs, RCs, and Localities
- Technical Advisory Committee: Scientific Advice and Support; Outreach and Engagement; and Legislative and Other Recommendations





Photos courtesy of Dewberry, Aileen Devlin of Virginia Sea Grant (VASG), and the Virginia Department of Transportation (VDOT).

Acknowledgments

We would like to extend special thanks to the Technical Advisory Committee, Appointed and Invited members, Designated Alternates, Ex Officio members, and Advisors. We would particularly like to thank Subcommittee Chairs and Vice Chairs for their work and leadership over these many months, and Subcommittee Members and Advisors for their participation and advice throughout this process. We would also like to thank our Staff Advisors for their coordination and meeting oversight and guidance; our Department of Conservation and Recreation Master Planning Staff, for their advice, diligence, and attention to detail; and finally, the Department of General Services Staff and our Advising Partners from Coastal Region localities for their technical expertise, sound advice, and perspective throughout this work. Finally, we were fortunate to have Dewberry and Team on board to provide professional engineering and planning services throughout this process. This marks the beginning of a long journey for the Commonwealth to adapt and protect Virginia's Coast — we are fortunate to have you all on board!

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VIRGINIA COASTAL RESILIENCE MASTER PLAN

2021