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Increasing use of natural and nature-based features to build resilience to storm-driven flooding, Final Report

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Final Report

NOAA Coastal Resilience
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Prepared by: Center for Coastal Resources Management
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Acknowledgement & Project Team

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Introduction

Recognition of the importance of natural and nature-based features (NNBF) to provide ecosystem services valued by society has been codified in scientific research and actionable application of science to policy. Community resilience to storm-driven coastal flooding is improved with the presence of natural and nature-based features (NNBFs) such as wetlands, wooded areas, living shorelines, and beaches. These natural and created features can provide multiple benefits for a local community, including mitigating the impacts of storm surge and sea-level rise and allowing communities to take advantage of co-benefits such as programmatic incentive programs like FEMA's Community Rating System and nutrient reduction crediting.

There has been so much attention to the threats and potential consequences of storm driven flooding in coastal communities that almost no local government official is unaware of the issue. Most also have some general understanding of actions that can lower risks and increase resilience. The problem is that the resources required to undertake those actions are limited and, in the face of competing interests, it is difficult to rationalize making them a priority. One solution to accelerating the pace of building resilience is to find ways to address multiple needs with each action, taking advantage of the co-benefits available from carefully planned projects.

In coastal Virginia today, local governments are dealing with recurrent flooding driven by coastal storms, exacerbated by rising sea level and increased frequency of intense rain events. At the same time, they are confronted with:

- regulatory requirements to manage stormwater and control erosion;
- requirements to achieve reductions in non-point source loads of sediments and nutrients entering surface waters;
- increasing expectation that the Chesapeake Bay states should incorporate additional pollutant reduction measures in their watershed implementation plans, such as the establishment of local area planning targets;
- regulatory requirements to protect wetlands and policy directives to maximize use of nature-based solutions to manage shoreline erosion;
- needs for infrastructure maintenance, particularly for road networks;
- requirements for floodplain management and multiple hazards mitigation;
- agreements and mandates for species and habitat restoration;
- demands for increased participation in the National Flood Insurance program; and
- demands for increased quality of life amenities such as open space and recreation opportunities.

There are myriad of programs addressing each of these issues, providing requirements in many cases and funding opportunities in a few. The challenge for local officials is two-fold: finding projects that can provide multiple benefits; and knowing exactly how to design and report those projects to achieve credit or to attract funding for them.

We have used existing work on coastal issues here in Virginia to assemble data, create a priority ranking and restoration targets as guidance for Virginia coastal communities which identifies opportunities for localities to take advantage of the co-benefits some of these projects can provide. The analyses of local opportunities to increase community resilience to extreme weather, specifically flooding events, focused on the provision of flood mitigation benefits and two co-benefits that provide possible financial, funding, and partnerships as incentives: 1) water quality and 2) potential qualification for Community Rating System (CRS) credits in the Federal Emergency Management Agency (FEMA) National Flood Insurance Program (NFIP).

Despite ongoing efforts in Virginia to promote use of NNBFs, significant and wide spread commitment to use of NNBFs for building resilience is still lacking. Interviews with local officials suggest that absent "cookbook" guidance on how to design, site, and demonstrate benefits – particularly economic benefits that accrue to the locality, most see the use of NNBFs to be an unnecessary challenge.

In this project, we focused on increasing the use of natural and nature-based features (NNBFs) to increase resilience of coastal communities to flooding caused by extreme weather events. The project effectively addresses two problems:

- The natural capital of coastal communities is generally declining, and is projected to decline at an accelerating rate due to sea level rise and current land use practices.

- The use of NNBFs to sustain or increase resilience in coastal communities is restricted by the many competing needs for limited local resources.

We have sought to address these problems with a twofold approach:

1. Develop a ranking system to focus attention of the multiple benefits provided by existing NNBFs and

2. Identify opportunities for NNBF projects which could maximize provision of those same multiple benefits.

Seeking to reflect the needs and inform the decision-making process, we conducted focus group/ focused conversations with local, regional and state entity representatives to solicit input and feedback. We also sought to maximize project outputs use by developing a map viewer for data visualization, creating a dedicated webpage, serving the data for download and implementing an outreach plan to communicate with Virginia coastal decision-makers.

We have completed the analyses and provide the output in a form that is spatially explicit and includes information specific for each locality in Virginia's coastal zone. The project outputs are readily available in a map viewer on Adaptva.com, described and detailed on the Center for Coastal Resources Management website.

Study Area

The study area for this project is the Virginia coastal zone roughly approximated by all lands east of Interstate Route 95. The study area was further refined to portions of the coastal zone with the greatest vulnerability to storm-driven tidal flooding. This was set to be all areas of land surface elevation of 10 feet of less using LiDAR data (NAV88) Within the study area, over 170,00 primary building (Fig. 1) and 350,000 NNBF polygons were mapped (Fig. 2). Across coastal Virginia, approximately 8% of upland acreage of the localities falls within the study area. This varies significantly among individual localities; from 100 percent in the City of Poquoson, to approximately 50% of Accomack County, to less than 10% in the Cities of Richmond and Fredericksburg.

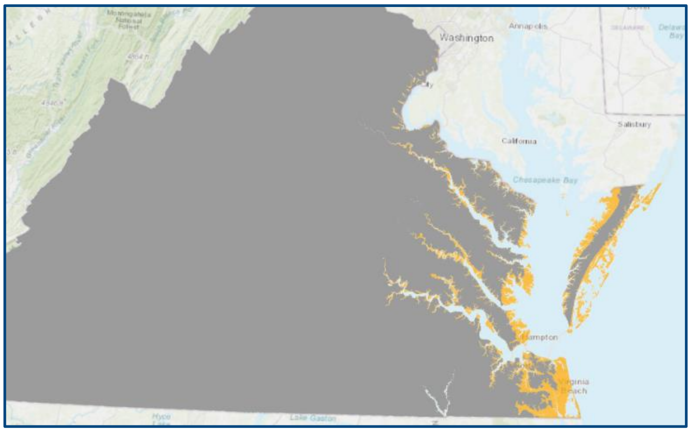

Figure 1. Study Area. Coastal Zone of Virginia areas with land elevation of 10 feet or less. Gold dots represent primary buildings in the study area.

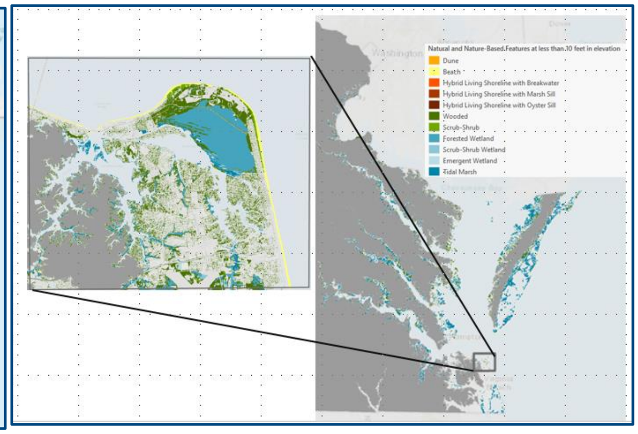

Figure 2. Mapped Natural and Nature-based features in the study area. Over 350,000 NNBFs

NNBFs can include many feature types. We selected land and shoreline based features for this assessment based on the modeling approach we used to assess the NNBFS. The NNBFs selected for our study are listed and defined as:

- Forests & Trees — Upland areas covered by trees greater than 20 feet tall
- Scrub-Shrub — Upland areas covered by woody vegetation less than 20 feet tall
- Beaches & Dunes — Sandy areas next to tidal waters
- Forested Wetlands — Tidal and non-tidal wetlands covered by trees greater than 20 feet tall
- Scrub-Shrub Wetlands — Non-tidal wetland areas covered by woody vegetation less than 20 feet tall
- Non-Tidal Marsh — Non-tidal wetland area covered by herbaceous plants
- Tidal Marsh — Wetland area in tidal waters covered by herbaceous plants or shrubs
- Marsh Sills — Low-profile stone structures to maintain tidal marshes
- Offshore Breakwaters — Large gapped structures offshore to maintain beaches & dunes
- Oyster Sills — Low-profile reef structures for wave attenuation

Methods

In order to begin the assessment of the relative benefits of existing and new NNBFs for tidal flooding, we needed to develop an approach to link coastal development and tidal flood water sources. We selected an approach to use primary coastal buildings as the unit for flood risk assessment. In order to evaluate the likely tidal flooding risk to coastal buildings, using ArcGIS 10.6.2, we applied an elevation-based linear path representing the lowest elevations connecting each building and tidal waters (Fig 3). These Inundation Pathways (IPs) are used to determine which NNBFs are most likely to offer flood mitigation benefits to buildings within our study area, are used in ranking the NNBFs for provision of flood benefits and other co-benefits of water quality and potential CRS credit and also to identify targets for new NNBFs creation or restoration projects to provide flooding mitigation and co-benefits services.

The IPs are used to identify which and how many NNBFs provide services for each building. They also can identify which, and how many, buildings are benefited by each NNBF. These relationships were used to establish a ranking for provision of flood benefits by existing NNBFs and the co-benefits for water quality provisioning and potential CRS credit.

Ranking for Existing NNBFs

Flood Mitigation Benefits

To evaluate the provision of flooding mitigation services for each NNBF type, we developed a we developed a scoring system that considers both the capacity of an NNBF type to mitigate flooding damage to buildings, and the opportunity that these features have to provide those services. Capacity scoring reflects the morphology and structure of each NNBF type to provide flood services. The criteria considered in our capacity assessment are: permeability, surface roughness, and vegetation roughness. Permeability reflects the ability for flood waters to soak into the ground. Features that have substrate that are large grained, mineral based (non-organic, sandy) like beaches and dunes rank highest, as do upland (non-wetland) features with mineral/ organic soils as in wooded and scrub-shrub. Surface roughness and vegetation roughness are both factors that affect the flow of water across the feature. Features with complex surficial micro-topography, vegetative duff (dead and decaying vegetative material laying on the land surface) and dense vegetation with high stem density, all create greater friction thus slowing flood waters. These criteria were rank scored 1 (low), 2 (medium) or 3 (high) for each of the criteria and totaled for a capacity score (Fig 4).

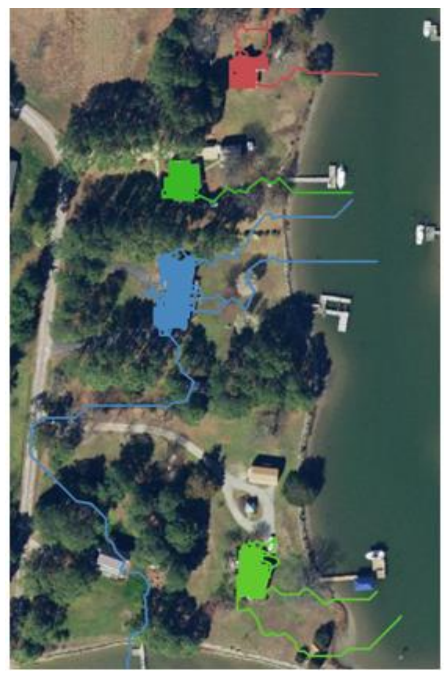

Figure 3. Depiction of Inundation Pathways. Color coded for each building. Note: Buildings may have multiple pathways.

Capacity Scoring				
	1 = low, 2 = medium, 3 = high		2=soft, 3 = woody	
Feature Type	**Permeability**	**Surface Roughness**	**Vegetation Roughness**	**Total**
Beach	3	1	0	**4**
Dune	3	2	2	**7**
Wooded	3	2	3	**8**
Scrub-Shrub	3	3	3	**9**
Non-Tidal Forested Wetlands	2	3	3	**8**
Non-Tidal Scrub-Shrub Wetlands	2	3	3	**8**
Non-Tidal Emergent Wetlands	2	3	2	**7**
Tidal Marsh	2	3	2	**7**
Hybrid Living Shoreline: Marsh Sill	0	3	0	**3**
Hybrid Living Shoreline: Oyster Sill	0	3	0	**3**
Hybrid Living Shoreline: Breakwater	0	3	0	**3**

Figure 4. Capacity scores for NNBF types based on the ability to mitigation coastal flooding. Values were assigned based on the permeability of the ground surface, surface roughness, and vegetation roughness.

The scoring for opportunity was based on the modeled frequency that the NNBF had to intercept flood waters based on elevation of the feature. A 19-year water level data set was analyzed to generate the frequency of water level occurrence, in one foot increments, converted to percentages. The percentage of flood events by elevation was converted to an integer as the opportunity score (Fig 5). The capacity and opportunity scores were multiplied to generate the rank score for total flood capacity.

Water Elevation	Percentage of flooding events that reach elevation	Opportunity Score
>5 ft	**0.1%**	0.001
>4 ft	**0.3%**	0.003
>3 ft	**1.0%**	0.01
>2 ft	**10.0%**	0.1
>1 ft	**100.0%**	1

Figure 5: Opportunity is scored based on how often an individual NNBF is likely to encounter flooding waters. Calculated from 19 years of tidal gage data.

The NNBF Total Capacity, a flooding mitigation potential score was calculated for each NNBF by multiplying capacity and opportunity scores. Scores were then grouped into 3 classes - low, medium, and high (Fig. 6)

Coastal Buildings Impacted

Each NNBF was assessed for the number of individual building IPs that crossed the feature. A statistical distribution found NNBFs with IPs ranging from 0 to over 100. Meaning that NNBFs in the study area might provide few flood benefits to any coastal buildings or a single NNBF may provide benefit to over one hundred buildings. This analysis included consideration of development density in that we compared NNBF IP intersection in subgeographies of the study area to look for differences between rural, suburban and urban landscapes. And while the actual number, and size, of NNBFs was greater in rural and suburban settings, all landscapes had a significant number of buildings that had zero NNBFs along their IPs. It was also common to the differing development levels to have many NNBFs impacting only one building. In the end, we applied a ranked score of zero (low; no buildings benefited), one (medium; one building benefited) or 2 (high; 2 or more building benefited).

Critical Facilities Impacted

To capture the relative import of certain buildings for response and recovery from a storm or coastal flooding events, we identified and ranked critical facilities. These facilities were selected using the USGS National Structure Database and include; emergency response and law enforcement, hospitals and medical facilities and educational facilities (often used as shelters in emergency situations). If an NNBF intersected the IP for any of these facilities, it was coded as yes and ranked high. If not, coded no and ranked low.

Co-Benefits Potential

We assessed two possible co-benefits for each NNBF; water quality services, and potential CRS credits.

CRS credits. We selected the open space element of the CRS for our analysis. This element relies on a calculus of: 1) all non-developed (pervious) lands, and 2) also protected from development, as a portion of the locality landarea that is in the Special Flood Hazard Area (floodplain) to determine points toward a total CRS score. The protection of open space may be either ownership (fee simple or easement) or legal protection. FEMA considers the Chesapeake Preservation Act Program (CPA) a provision limiting development. While the CBPA includes tidal and non-tidal adjacent wetlands as protected features they are both subject to other state law, the element relevant to the CRS system is the riparian buffer requirements. The CBPA establishes a buffer, or no less than 100 feet, landward of the wetlands and tidal shores as a provision to protect water quality. All development within the buffer requires a permit. Where the RPA and the SFHA intersect, the undeveloped land can be counted as protected and applied to the area of undeveloped land in the SFHA. In order to tackle this analysis, we generated two necessary data layers.

1. RPA buffer layer. This is the 100’ buffer landward of the RPA features tidal wetlands, and nontidal adjacent wetlands.
2. CRS “eligible” lands layer. This included all NNBFs that intersect or overlay any portion of the RPA buffer and the SFHA, OR any NNBF that would be considered an RPA feature.

Where a locality has already created digital mapped layers for the RPA buffer, we have used those (n=11). For the remaining localities, we created a mapped RPA buffer layer. We chose to map the RPA buffer for all areas of each CBPA locality rather than only for those areas wherein the RPA buffer and SFHA intersect. While this choice resulted in production of mapped data that was not necessary for the determination of the CRS co-benefit, we concluded it was the most expeditious approach. First, where the mapped buffer extent did not already exist, Virginia coastal decision-makers lacked information relevant to many decision touch-points, and second, application of the GIS rules to the entire coastal area of Virginia was more efficient the trying to “clip”, or separate out, certain areal extent along the thousands of miles of shoreline. The CBPA states that determination of the RPA buffer location on a parcel occurs at the time of a proposed activity. The RPA buffer maps generated are not intended to assert jurisdiction, but are for planning purposes and to inform decision making, in this case, relevant to the CRS program.

<u>Water Quality Credits</u> We selected the all the vegetated features to be ranked for water quality credits. The Total Maximum Daily Load (TMDL) requirements include use of best management practices (BMPs) to improve water quality. In accounting for project activity toward the achievement of the TMDL, many practices, structural and nonstructural are approved as BMPs. Both tidal wetland and nontidal wetland creation and restoration qualify, as does riparian buffer vegetation restoration and certain other landscape practices to establish vegetation. Dunes, while generally vegetated, were not ranked as the location of the vegetation on the face, crest, and backslope are less likely to intercept overland runoff, tidal waters, or groundwater meaning that the opportunity to provide water quality service is low.

The provision of co-benefits by each NNBF was ranked as low (neither co-benefit provided), medium (one co-benefit provided) or high (both co-benefits provided).

The final priority ranking for each NNBF was a simple arithmetic sum where in each element ranked 1, 2 or 3, was totaled with an equal contribution to the NNBF score (Fig.6). The final rakings were categorized as some, many and most benefits. Figure 7 shows the NNBF ranking data layers from the Adaptva.com interactive map viewer.

Overall NNBF Score for Priority Ranking: *Add score for each category*	**low**	**medium**	**high**
1. NNBF Total Capacity *Flooding mitigation potential based on elevation and feature type.*	0-0.0008 (1-33 percentile)	0.008-0.4 (33-66 percentile)	>0.4 (66-100 percentile)
2. Number of buildings impacted *Number of buildings that the NNBF benefits.*	0	1 building	>= 2 buildings
3. Critical Facility Benefit *Does the NNBF benefit a community critical facility?*	no		yes
4. Co-Benefits Potential *Potential for NNBF to be used in incentive programs.*	0	1 cobenefit	>=2 cobenefits
Score	**1**	**2**	**3**

Figure 6. Overall NNBF Score total for four ranked criteria.

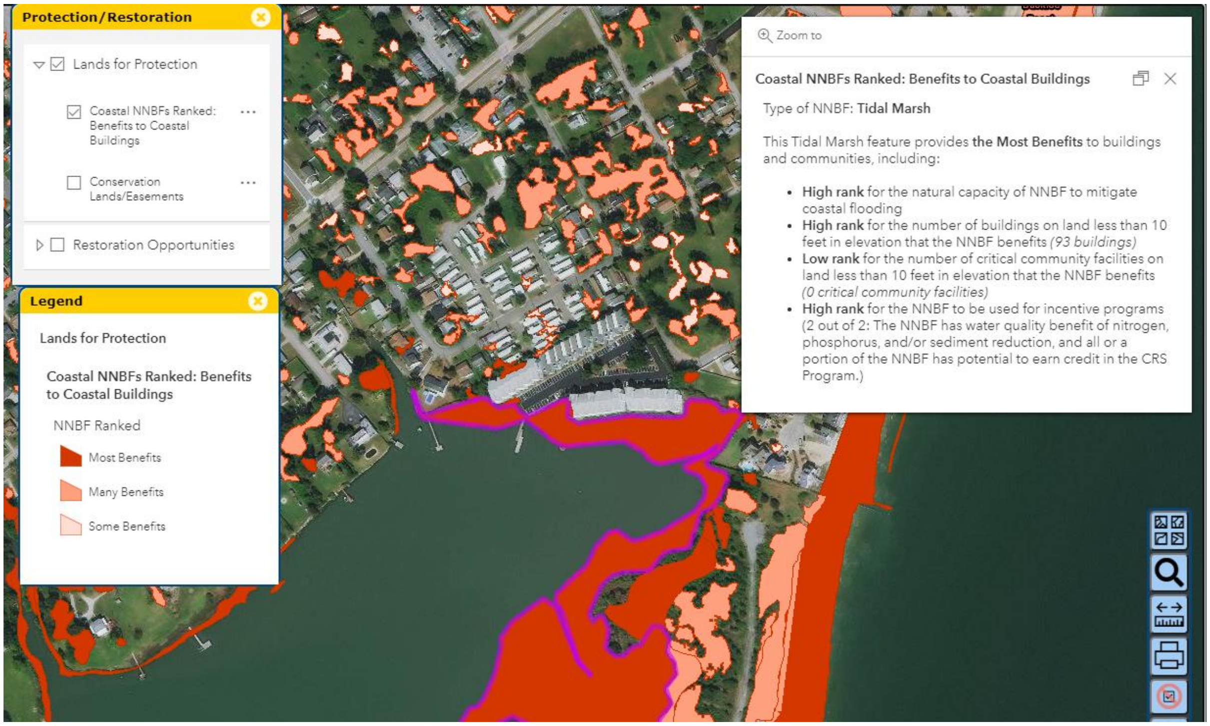

Figure 7. Adaptva map view showing NNBF ranking. Click to select NNBF and the rank criteria are displayed

NNBF Restoration/ Creation Targets

The companion effort to increase the use of NNBFs for coastal resilience was the development of an analysis to identify opportunities for NNBF creation or restoration. Any landarea though which an IP passess that isn't already an NNBF is a potential opportunity for creation or restoration. Argueably, the increase in natural features would provide possible flood, water qaulity and CRS credits anywhere within the study area. Nevertheless, we chose to focus the target location to the shoreline. This makes sense for several reasons. First, NNBF projects along the shoreline are most likely to be within the CBPA RPA buffer area. This means maximizing opportunity for both water quality BMP credit and CRS credit. Secondly, with decades of work on the science of shoreline systems and development of guidance and decision-support tools, CCRM is able to provide information to support decisions rearding NNBF project implementation in the target area,specifically, the CCRM Shoreline Management Model (SMM). The SMM is a GIS model that applies decision tree logic to derive the best management practices for a shoreline and where living shorelines are suitable. In the current version (v 5.1) there are 6 possible shoreline best management practices: 1) non-structural living shoreline, 2) plant marsh with sill, 3) groin field with beach nourishment, 4) maintain beach or construct offshore breakwater with beach nourishment, 5) revetment, and 6) revetment/bulkhead toe revetment (https://www.vims.edu/ccrm/ccrmp/bmp/index.php). Four of the SMM has 4 recommendations include NNBF elements of marsh or beach and can include dunes and riparian woody vegetation. Thirdly, placing new or restoring NNBFs along the shoreline can enhance the connectivity of valuable shoreline habitats and riparian buffers.

The next decision point was to set a thresdhold for how the targets would be defined within the IP context. We considered options from a range of IP number (as in where many buildings shared on IP, perhaps 10 or more) and other approaches like targets for all critical infrastructure. Using the data analyses from the NNBF ranking regarding the distribution of IPs and NNBF intersections, we already knew that the occurance of IPs with no NNBFs was common throughout the study area. So in order to for the project to offer the most immediate information, we selected targets for IPs that had no NNBFs intersects. We set the size of the target areas for mapping purposes to 100 foot diameter centered on the mapped shoreline (Fig 8). This means that the targets are:

1. Placed on IPs lacking any NNBFs
2. Located along the tidal shoreline
3. Sized at 100 feet diameter.

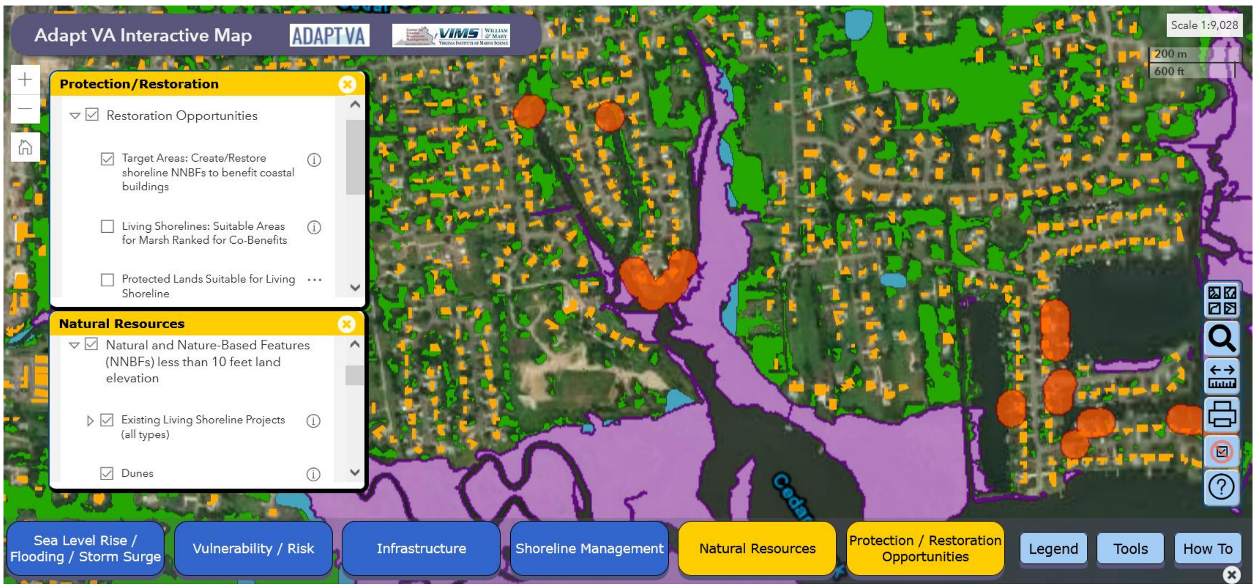

Figure 8. NNBF creation/ restoration project targets. Targets are sized to 100 foot diameter circles located at the shorelines on building IPs which have no NNBF intercepts.

Many elements to be considered in the implementation of an NNBF project in the target area were identified and analized to inform project decisions. The target areas attributes includes how many IPs cross the target (how many buildings would receive benefits from a project). The Landuse/ Landcover within the targets was assessed to identify those landcovers which could be converted to NNBFs, namely turf and developed (structures were not specified, but paved areas were). We also incorporated consideration of existing NNBF type as an indicator of existing conditions and likelihood for NNBF project success, the recommendation from the SMM and finally, the opportunites for water quality and CRS credit co-benefits.

Focus Interviews/ Groups

We held focus groups to "test" the project output and solicit comments of approaches to serving and communicating the information. We have held 6 focus group meetings, which included representation from at least 9 localities and about 40 individuals. We were intentional toward selection of localities with a range of geographies (more and less prone to flooding) and population density (urban and rural). Our goal was to garner this input to inform the next steps of data service and project communication outreach efforts. Despite the state-wide Covid19 restrictions placed in late March, we were able to meet our goal for the focus group effort. The focus group effort was a collaborative process of Wetlands Watch, Virginia Coastal Policy Center and CCRM/VIMS with CCRM providing coordination. The following lists the focus group conversations:

1. March 6, 2020. City of Portsmouth: Brian Swets (Comp Plan, Planning Administrator), Meg Pittenger (Environmental Manager, Floodplain Manager), Stacy Porter (Senior Planner, CBPA & Wetlands Board), Julie Chop (Planner, zoning permits).
2. February 21, 2020. Mathews County: Thomas Jenkins (Director Planning, Zoning & Wetlands), James Knighton (Planner), February 10, 2020 James City County: Darryl Cook (Assistant Director Stormwater & Resource Protection), Deirdre Wells (Chief Civil Engineer, Stormwater & Resource Protection), Toni Small (Director Stormwater & Resource Protection), Tom Coghill (Director Building Safety and Permits Division), Christy Parrish (Zoning Administrator)
3. November 20, 2019. Community Rating System Workgroup N=17 minimum 6 localities York, Poquoson, James City County, Norfolk, Newport News, Hampton
4. October, 2019. personal interview with Hank Morrison, Planner, City of Norfolk
5. October, 2019. Watershed Management Task Force, City of Norfolk

Data

The project relied on many existing data from various sources including CCRM data, as well as other data from state and federal sources (Fig 9). The data created from the analyses, including metadata, are available on W&M Scholarworks https://scholarworks.wm.edu/data/442/.

Layer	Source
Beaches	Land Use Land Cover 2017 + CCI VA_beaches_1998-2017
Dunes	Shoreline Studies Dune Inventory Reports and Dune Evolution Reports
Wooded	2017 Land Use Land Cover
Scrub-Shrub	2017 Land Use Land Cover
Wetlands	TMI combined data 1999-2017 NWI 2017
Living Shoreline + Oyster Permit Projects	CCRM Permit Database
ALL NNBF LAYER	
Buildings	VGIN: building footprints, CAI buildings, 2017 land use land cover
Study area mask	CB_TBDEM

Upland Shoreline polygons	CCI Inventory Upland Shoreline minus TMI
RPA Buffer/Floodplain	TMI 2010-2017 (added newest counties) NWI 2017 NHD flowlines
FEMA Floodplain	FEMA. Fema.nfhl/nfhl_51_20151119.gdb
fetch	SMM v5
Conserved Lands	DCR Conserved Lands Database/Layers DCR Conservation Easements layer
Developed Lands	using land cover impervious surfaces
Open Space Credit Layers	above conserved, developed

Figure 9. Existing Data used for NNBF Analyses

Project Outcomes

The project information and outputs are served via two websites: Adaptva.com and VIMS.edu/CCRM. The project team also provided training and outreach (described in another section of the report below). The project outputs are served online:

1. NNBF GIS data layers incorporated into the interactive map viewer on Adaptva.com
2. New webpage at VIMS.edu/ CCRM with project description and outreach materials
    a. a factsheet for each NNBF on the flood, water quality and CRS benefits
    b. an NNBF factsheet for each locality within the study area with areal extent of NNBFs, targets and co-benefit services.
3. Data sets created are found on W&M Scholarworks https://scholarworks.wm.edu/data/442/

Map Viewer Adaptva

The visualization of the project data is possible using the interactive mapper on AdaptVa.com. The data layers that are being served on the viewer, the status of the data regarding whether it was developed for this project, modified from existing data for this project, or incorporated as existing data, and the location in the mapper, are listed in Figure 10. A visual depiction of these layers in shown in Figure 11. Data was incorporated into 3 existing tabs in the viewer and a 4th tab – Protection/ Restoration was created to serve project data.

Layer	Data Status	Located in Map
Beaches	New, enhanced	Added into the Natural Resources tab
Dunes	Created digital data layer	Added into the Natural Resources Tab
Wooded	Modified for project: created from several layers	Added into the Natural Resources tab
Scrub-Shrub	Clipped to study area	Added into the Natural Resources tab
Tidal Marsh	Existing	Already in the Natural Resources Tab
Living Shoreline	Created layer from access database at CCRM	Added into the Natural Resources tab

Wetlands less than 10 feet	Clipped to study area	Added into the Natural Resources tab
Buildings	Clipped to study area	Added to Infrastructure
Study area mask	Created	Added to Infrastructure
RPA Buffer	Existing and created	Added into Shoreline Management tab
Pervious Special Flood Hazard Area (floodplain) in buffer	Created	Added to Shoreline Management
Pervious area in RPA buffer	Created	Added to Shoreline Management
Target Areas for NNBFs	Created. Any coastal building with no NNBFs	Created New Tab: Protection/ Restoration. Added here
Coastal NNBFs Ranked	Created.	Created New Tab: Protection/ Restoration. Added here

Figure 10. NNBF data and location in the Adaptva.com map viewer

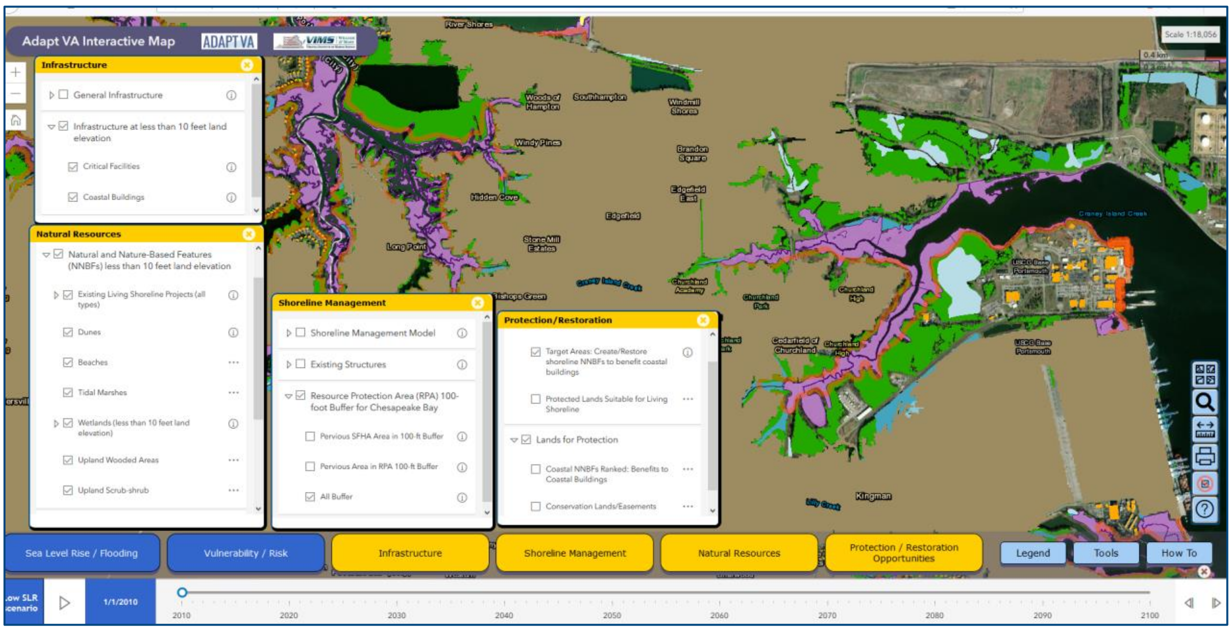

Figure 11. Display of the NNFB project data in the Adaptva viewer. Project data was added to infrastructure, Shoreline Management, Natural Resources and a new Tab called Protection/ Restoration Opportunities.

We have enabled the use of pop-up windows to access certain attributes for the data layers. Pop-up windows can be used to see the criteria for NNBF ranking and the information for the NNBF targets. (Fig.12). These windows are used to communicate information such as, number of building benefited by each NNBF, the co-benefits assigned to the NNBFs, options for landuse changes for NNBF project implementation in target areas. Also, the windows include links to supporting documentation for NNBFs factsheets on NNBF ecosystems services and incentives.

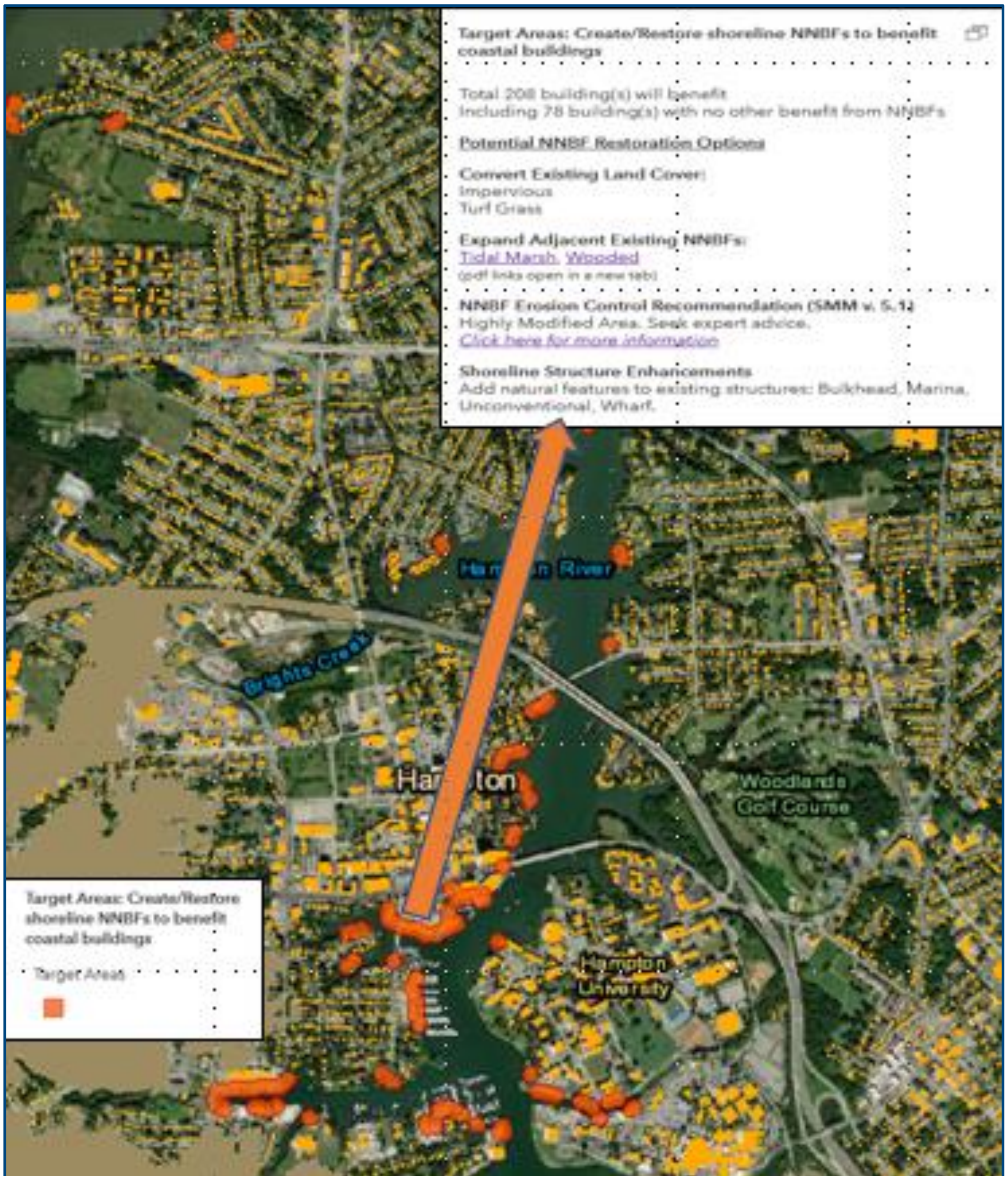

Figure 12. Example of pop-up window content for an NNBF target area. Communicates number of buildings benefited, options for NNBF project based on adjacent NNBFS and the Shoreline Management Model, and landuses present for conversion.

Project Page and Factsheets

A new webpage on the VIMS.edu/CCRM website was built to serve information on the NNBF project https://www.vims.edu/ccrm/research/climate_change/adaptation/nnbfs/index.php. For use on the page and the factsheets, Wetlands Watch created the icons for each NNBFs and co-benefit service displayed on the project website. The webpage provides links to data available for downloading on the W&M scholarship site.

The webpage provides links to the NNBF factsheets and the locality factsheets. The NNBF factsheets contain (Fig 13):

- Description of the natural feature
- Identification of the benefits provided by it
- Tips on how to restore the natural features
- Links to additional resources
- Information about earning credits towards various government programs.

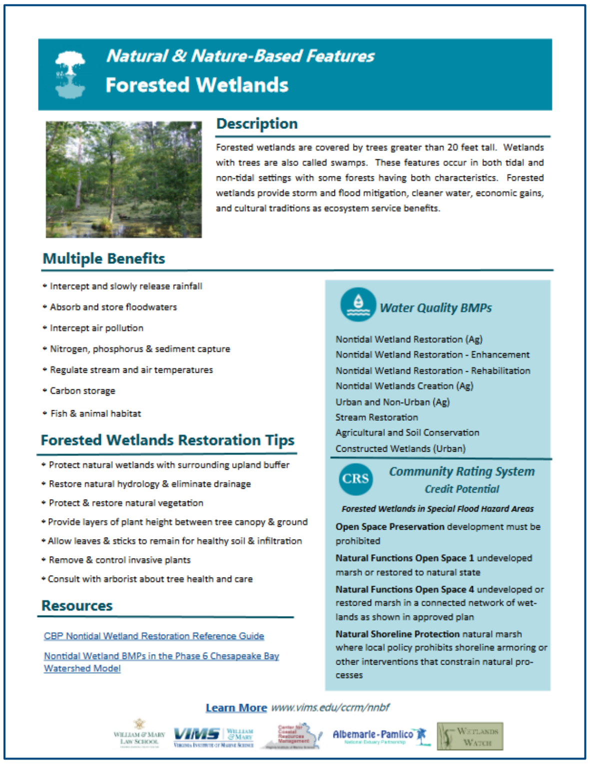

Figure 13. NNBF factsheet. Example for Forested Wetlands

The locality factsheets contain (Fig 14):

- Natural and nature-based features identified in that locality below 10-feet land elevation
- Benefits of protecting and increasing NNBFs
- NNBF targets
- Information about what's at risk.

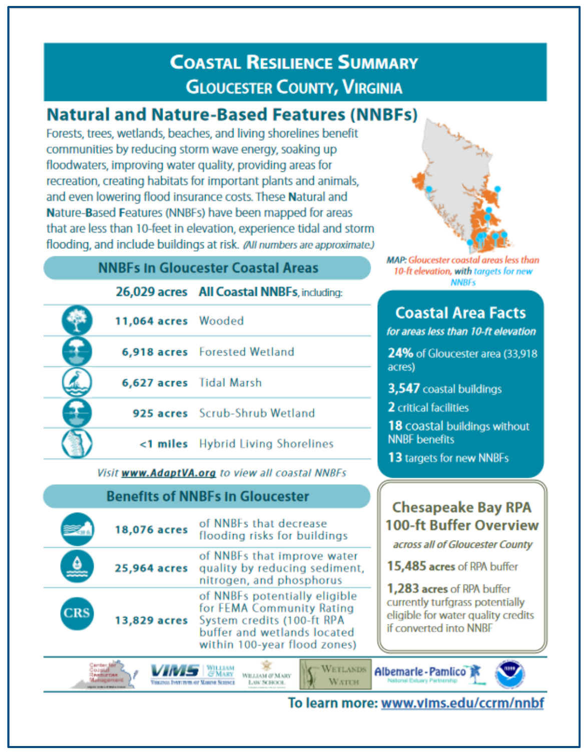

Figure 14. Locality Factsheet. Example for Gloucester County

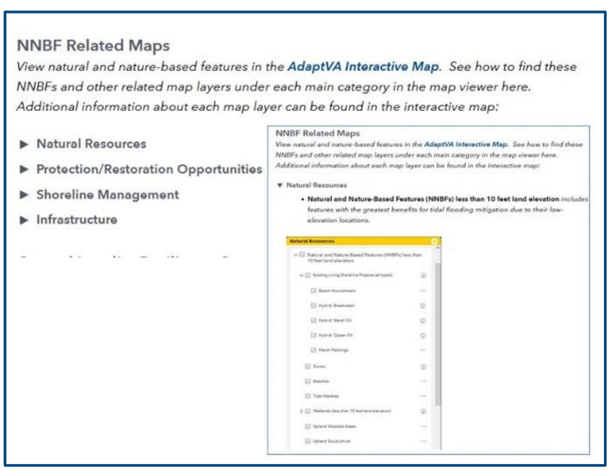

Figure 15. Display from the CCRM website NNBF project page showing where data are located within the map viewer

The CCRM webpage provides a roadmap for the NNBF data in the Adaptva interactive mapper including a simple description of the NNBF data and pictorial explanations of where the data is in order to the how to access the NNBF project data in the interactive mapper (Fig 15).

Outreach

The project team developed and implemented an outreach plan for the project. We were severely limited by COVID restrictions from the more typical outreach/ training activities of in-person meetings and presentations. The team adapted to these circumstances and switched to virtual communications efforts. Outreach was a collaboration of all team partners, with CCRM coordinating and tracking. The outreach efforts consisted of many approaches including virtual webinars offered by project partners and others, direct conversations, and scientific presentations. Outreach targets included coastal decision-makers at all levels of government, as well as non-governmental organizations with a focus on conservation, environment or coastal resilience. We used existing outreach processes, including workshops offered by CCRM and VCPC present on the project findings and products. We also used existing email distribution systems at CCRM, VCPC and WW to advertise outreach offerings. We were able to provide outreach in partnership with Virginia Department of Conservation and Recreation, Virginia Department of Environmental Quality Coastal Zone Management Program, NOAA, and FEMA. Audiences included Virginia wetlands boards and staff, NGOs, state and federal agencies, CRS localities, CBP partners and others.

Locality/ Workgroup Presentations

2020

DCR/ DEM webinar
Green Infrastructure and Hazard Mitigation Workshop Webinar for Local Communities (10 min)
CCRM Shoreline Management Webinar: Shoreline Decision Support Tools (30 min)
NOAA Science Staff (Darlene Finch meeting)

2021

May:
VCPC Tools Workshop
AdaptVA Orientation and Applications – included NNBF project (60 min)
July:
Hampton Roads Adaptation Forum (20 min + Q&A)
Virginia Coastal Policy Center: Coastal Resilience Tools for Local Governments webinar (40 min + Q&A)
CRS Workgroup (30 min + Q&A)
August:
APNEP Leadership Council Project Briefing (15 min + Q&A)
November:
Nature-Based Solutions for Coastal Hazards Virtual 101 - FEMA Region 3 (20 min + Q&A) Recorded Webinar
CZM Partners Meeting
December:
Joint meeting of the CBP Wetlands Workgroup and the Climate Resiliency Workgroup.

Scientific Conferences

1. Coastal and Estuarine Research Federation (CERF). Presentation at the Annual Meeting, October 2019. Prioritizing natural and nature-based features (NNBFs) that increase the resilience of coastal communities to flooding.
2. Delaware Wetlands Conference. January 2020. Prioritizing natural and nature-based features (NNBFs) that increase the resilience of coastal communities to flooding.
3. The National Coastal & Estuarine Virtual Summit. September 2021. Use of natural and nature-based features to provide multiple benefits increasing coastal community resilience
4. Virginia Chapter American Planning Association. AdaptVA: Evidence-based planning for a changing climate

Direct Communications

Wetlands Watch provided project information and updates via direct communications with personnel from Hampton Roads Planning District Commission (PDC), Accomac-Northampton PDC, George Washington/ Plan Richmond Virginia PDC and the Northern Virginia Regional Council (PDC).

Publications

Center for Coastal Resources Management, Virginia Institute of Marine Science. (2021) Nature-Based Solutions for Coastal Resilience. Rivers & Coast, Summer 2021, Vol. 16. Virginia Institute of Marine Science, William & Mary. doi: 10.25773/684r-pv42

Collaboration and Transferability

The project team included representation from the Albemarle Pamlico National Estuarine Program (APNEP). They were engaged as partners to reflect the developing, and now codified, relationship between Virginia and North Carolina (NC) governance, and the physical connection in the Virginia southern watershed and the APNEP geography. The partnership allowed of the consideration of the transferability of the project analytical approach to areas outside Virginia. Acknowledging that Virginia has specific drivers for increasing the use NNBFs due to the Chesapeake Bay TMDL as a water quality incentive, we explored the opportunities for co-benefits relevant to North Carolina and cross-walked data from the Virginia analyses to NC available data. The data cross-walk was done in the Fall 2019 and presented in Figure 16. Generally, there were datasets available in NC to perform an NNBF identification, and coastal building intercept analysis. The identification and selection of possible co-benefits would necessarily depend upon engagement of local communities and decision-makers.

Source:	**Virginia**	**North Carolina**	NC Link
NNBF Layers:		NC Division of Coastal Management	https://deq.nc.gov/about/divisions/coastal-management/coastal-management-data/coastal-maps-data
Beaches	Comprehensive Coastal Inventory (CCRM) and 2016 Virginia Land Cover Dataset	DCM Oceanfront Shorelines	

Dunes	Shoreline Studies Program (VIMS) Dune Inventory Reports and Dune Evolution Reports, updated with Virginia Base Mapping Program 2017 imagery	DCM databases?	
Tidal Wetlands	Tidal Marsh Inventory (CCRM), 2016 Virginia Land Cover Dataset	DCM Coastal Wetlands Spatial Data Layer	https://deq.nc.gov/about/divisions/coastal-management/coastal-management-data/setback-factor-maps-1998-shoreline/coastal-wetlands-spatial-data
		NC Wetlands	http://www.ncwetlands.org/learn/aboutncswetlands/when-where-are-our-wetlands/
Non-Tidal Wetlands	2017 National Wetlands Inventory (US FWS)	DCM Wetlands?; National Wetlands Inventory	https://deq.nc.gov/about/divisions/coastal-management/coastal-management-estuarine-shorelines/wetlands/inventory-assessment
		NC Wetlands	http://www.ncwetlands.org/learn/aboutncswetlands/when-where-are-our-wetlands/
Wooded, Scrub-shrub	2016 Virginia Land Cover Dataset	Landcover layer / NLCD 2016	2016 avail online / USGS? / DWR has copies
		NC Wetlands	http://www.ncwetlands.org/learn/aboutncswetlands/when-where-are-our-wetlands/
Living Shoreline sites	CCRM Permit Database	DCM permit database?	Brandon Pucket / NERR maintains a LS database track performance after storms / DCM has something similar where located with basic information
Infrastructure Layers:			
Buildings	VGIN 2017 Virginia Buildings Footprint Dataset, 2016 Virginia Land Cover Dataset	NC One Map??; NC Flood?	https://flood.nc.gov/ncflood/
		Flooplain mapping. recent inventory of building footprints	http://www.nconemap.com/ FIMAN database
Conserved Lands	VA Dept. of Conservation and Recreation Conservation Lands Database	NC Carolina Conservation Planning Tool	https://www.ncnhp.org/conservation/conservation-planning-tool
	VA lands needs assessment / Vanilla		KR: may have to merge a few things to get total package / may not state & federal parks
Landscape Information:			
Elevation	Chesapeake Bay Topobathy Digital Elevation Model	LIDAR Based Elevation Data for North Carolina; NC One Map?	https://www.lib.ncsu.edu/gis/elevation

	Va LIDAR data. NRCS/USGS/ USGS CoNED / 50-100 yrs old in ChesBay 2 m or less/ DEM raster output TBDEM topobathy DEM digital elevation model	KR: floodplain mapping for NC most up to date	http://nconemap.com/NCOneMapBlog/tabid/679/EntryId/32/New-elevation-data-available-via-NC-OneMap.aspx
Flood Zones	FEMA	NC Flood Maps; FEMA, FIMAN?	https://flood.nc.gov/ncflood/
Fetch	Shoreline Management Model (CCRM)	DCM databases?	Not aware of NC databse
Stream Centerlines	National Hydrography Dataset (NHD) Flowlines	NHD same?	

Figure 16. Data cross-walk Virginia Project Analyses and North Carolina possible equivalent

Project Roles and Responsibilities

CCRM/ VIMS was over all project lead. Project coordination, project team meetings and reporting documents. CCRM lead the GIS modeling including data collection and corrections, NNBF and primary building mapping. Development of the protocol for, and mapping of, the inundation path ways. Selection of the NNBF ranking criteria, ranking protocols, approach and GIS analyses. Selection of NNBF target locations and relevant criteria and decision-support information. Proposed approach for incorporation of project data into the existing Adaptva.com mapper and implementation of data incorporation. Lead on the development of the CCRM webpages. Lead with collaboration on the locality summary factsheets. Co-lead on the NNBF factsheets. Provide project data website, mapper and data service.

Wetlands Watch was lead on the focus group and focus conversations. They actively engaged in all project meetings, providing input on GIS analyses, data location and display on the interactive mapper, and outreach materials. They developed the content and first draft of the NNBF factsheets. They created the project icons. They were co-leads on the outreach process serving to coordinate, present and participate in many outreach efforts. They acted as a bridging entity for the project team to local government.

Virginia Coastal Policy Center lead the effort to compile relevant federal, state, regional and local policy on NNBFs. They actively engaged in all project meetings, providing input on GIS analyses, data location and display on the interactive mapper, and factsheet content. VCPC collaborated on the outreach efforts, served as a bridging entity to other organizations mostly state entities.

Albemarle Pamlico National Estuarine Partnership actively engaged in all project meetings, providing input on GIS analyses, data location and display on the interactive mapper from the APNEP/ NC perspective. They arranged for presentations in and to NC decision–makers and served as lead on the relevant data cross-walk between the Virginia project and SME on NC data.