CHARLES COUNTY, MARYLAND

ADVANCING RESILIENCE IN THE GREATER-NAVAL SUPPORT FACILITY INDIAN HEAD COMMUNITY

NOVEMBER 15, 2022

PREPARED BY

UNIVERSITY OF MARYLAND 1856
SCHOOL OF PUBLIC POLICY
CENTER FOR GLOBAL SUSTAINABILITY

PREPARED FOR

Charles County Department of Planning & Growth Management
Planning Division

ABOUT

THE NAVAL SUPPORT FACILITY INDIAN HEAD REGIONAL RESILIENCE PLANNING PROJECT

In 2021, Charles County, Maryland received a grant from the United States Department of Defense (DoD) Office of Local Defense Community Cooperation (OLDCC) to promote the long-term sustainability of National Support Facility Indian Head through improved climate change preparedness and infrastructure resilience. This report provides a summary assessment and action strategies moving forward.

FUNDING

This study was prepared under contract with the Charles County Government, with financial support from the Office of Local Defense Community Cooperation (OLDCC), Department of Defense. The content reflects the views of the University of Maryland, the sub-recipient of this grant, and does not necessarily reflect the views of Charles County Government or of OLDCC.

ACKNOWLEDGMENT

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About the University of Maryland Center for Global Sustainability

The University of Maryland (UMD) Center for Global Studies (CGS) was created in 2016 to inform global, national, and local discussions on climate, energy, economic development, and sustainability. Its location in Washington, D.C., research network, international policy expertise, and connections with key countries ensure that research has immediate and significant impact on global and national policy processes.

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EXECUTIVE SUMMARY

Naval Support Facility (NSF) Indian Head is the nation's oldest continuously operating naval ordnance station. It has played an integral role in Charles County, Maryland, for more than 130 years. Originally established as a gun test facility, it now houses world class energetics and research facilities, provides critical operational support to the United States armed forces, and is one of Charles County's largest employers. For NSF Indian Head to continue to grow and prosper, it is important to ensure that we anticipate, prepare for, and adapt to the unexpected and are resilient in the face of changing climates.

Charles County has already taken numerous steps to address climate change through both adaptation and mitigation measures. In 2020, the County released its Climate Resilience Action Strategy and the Charles County Nuisance and Urban Flood Plan, and in 2021, the County became the first in the state to establish a resilience authority capable of financing and contracting for climate change-related projects.

The purpose of this project was to take a deeper look at the challenges facing the greater NSF Indian Head community to adequately prepare for and bounce back quick when catastrophic events occur. Integral to its preparation was a fifteen month-long process of intense cross-sector discussions that led to a deeper understanding of the challenges facing the NSF Indian Head community at large. The project team took a hard look at both potential sudden shocks — like severe weather, flooding, and infrastructure failure — and reducing exposure and vulnerability over the long-term.

NSF INDIAN HEAD/COMMUNITY INTERFACE

This project gives specific focus to the infrastructure, programs, and actions that impact the communities surrounding NSF Indian Head: the Town of Indian Head and the nearby communities of Potomac Heights and Bryans Road. Community resilience planning involves the formulation of long-range visions, policies, and goals in the face of ever-changing threats, hazards, and pressures. Planning for and executing an effective response to climate hazards and threats requires accounting for a complex and comprehensive matrix of issues and potential actions. This process becomes even more complex within a regional context, where the goals and needs of multiple communities must be incorporated into long-term action strategies.

CLIMATE ADAPTION AS A COMPONENT OF COMMUNITY RESILIENCE

Resilience planning requires incorporating action strategies with an array of environmental, social, and cultural needs. This project focused on addressing those actions necessary to mitigate, respond to, and recover from the impacts of climate change. The assessment process and associated recommendations centered on the anticipated impacts of climate change and climate hazards to the project communities. This work focused on how best to achieve climate resilience within the structures of community economic, health, environmental, and social vitality and development. Long-term resilience will require mitigating those hazards broadly and comprehensively.

COUPLING MITIGATION, EMERGENCY RESPONSE, AND RECOVERY

A primary focus was to optimize three core elements of community resilience actions: long-term mitigation and risk reduction; emergency response and management; and long-term disaster recovery. Effectively preparing for the likely impacts of climate hazards requires a flexible management and implementation approach that addresses the temporally varied nature of climate change. This required an assessment process centered on three core climate hazard intervention and management approaches:

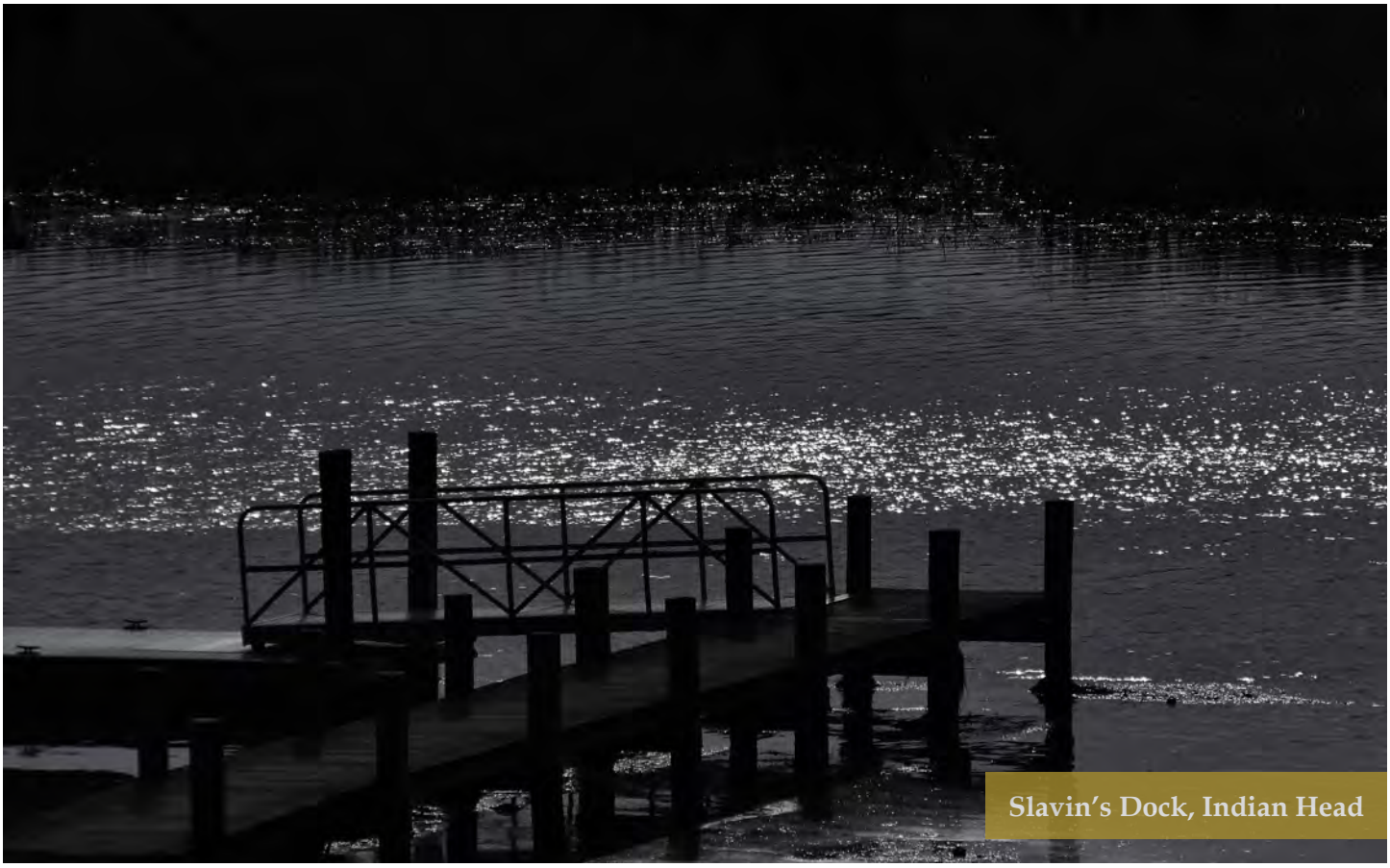
- *Mitigating climate threats in advance of anticipated impacts*. Climate adaptation and resilience aim to reduce vulnerabilities posed by climate change. This requires investing in climate-mitigation infrastructure like sea walls, levees, and natural systems (e.g., green and blue infrastructure). Mitigation also requires maintaining and upgrading existing infrastructure assets and systems to make them more resilient to climate impacts.
- *Responding to climate-related crises and disasters*. Emergency preparedness and the capacity to respond to acute and catastrophic events and hazards is vital. Projections for more intense and frequent extreme weather events need to be integrated within disaster and emergency management planning (Temmer et al. 2017). Emergency preparedness planning must ensure the safety and wellbeing of all citizens. This project focused on emergency preparedness on the Indian Head Peninsula. However, local disaster and emergency management must be informed by broader planning and implementation activities throughout Charles County.
- *Recovering from climate impacts and events*. Climate disasters are inevitable. How communities bounce back from these disasters is what ultimately defines long-term climate resilience. The costs and the impact of disaster recovery are often much broader than people anticipate, and recovery takes much longer than people often assume it will (Baillie, 2021).

ASSESSMENT SUMMARY

NSF Indian Head and surrounding area are vulnerable to climate risks and hazards. The location of the Town of Indian Head and NSF Indian Head — i.e., on a peninsula surrounded by tidal water — exposes the region's critical assets and services to a variety of climate hazards including sea level rise and coastal erosion, severe storm events, and widely varying precipitation patterns. While climate threats and exposure to hazards will increase over time, in the short-term, the peninsula could best be described as relatively resilient in that there are no current major disruptions to daily life and critical infrastructure systems. As a result, there is an opportunity for leaders within the Town, NSF Indian Head, and Charles County to proactively address likely future climate threats to ensure long-term resilience moving forward.

There is a lack of redundant climate adaptation infrastructure and processes. Effective resilience programs require redundant systems that protect against the failure of any single asset or infrastructure resource The NSF Indian Head region lacks multiple mechanisms to achieve service delivery goals within critical infrastructure systems is primarily the result of two key dynamics. First, the location of the installation and the Town restricts development and implementation options within key infrastructure systems, including transportation and potable use. Second, over-reliance on the installation as the region's economic driver impacts the climate resilience redundancy of other infrastructure systems at risk.

There is an opportunity to manage climate risks proactively and effectively. While there are clear long-term climate threats to NSF Indian Head and the Town, each has the capacity — if not



Slavin's Dock, Indian Head

the appropriate programs and processes — to address existing climate hazards. Many of the region's long-term resilience programmatic and infrastructure needs are addressed through multiple planning processes. These include comprehensive plans for both the Town of Indian Head and the County; the Joint Land Use Study that addresses Installation-Town-County land use decisions and interactions; and economic development plans for the Town of Indian Head. These efforts demonstrate a collective desire and capacity to address climate resilience needs moving forward. Achieving long-term resilience goals will require a coordinated multi-jurisdictional approach to address climate hazards.

Long-term resilience will require addressing economic and social issues in addition to mitigating climate impacts. In addition to mitigating climate hazard impacts, long-term community resilience will require addressing key economic and social issues and needs. Some of these issues are localized and directly impact the Indian Head community, such as the need for a grocery store. Other issues will impact the NSF Indian Head Base, the Town of Indian Head, and Charles County equally, such as the need for a long-term landfill facility.

KEY RECOMMENDATIONS

The anticipated impacts of climate change are well documented, and the implications for communities across the country are significant. Addressing the resilience challenge will require local action. This report includes three key recommendations.

1. Establish the NSF Indian Head Resilience Action Collaborative (the Collaborative) to provide a consistent and sustained forum for advancing climate resilience policies, programs, and infrastructure development projects across the Cornwallis Neck region.
2. Create a comprehensive resilience project portfolio and action strategy to coordinate and guide long-term resilience investment.
3. Establish a coordinated community resilience implementation and financing strategy.

This report includes a suite of thirteen action strategies to help launch and accelerate resilience project planning and implementation.

INTRODUCTION

Naval Support Facility (NSF) Indian Head is a 3,500-acre installation in Charles County, Maryland. Located thirty miles south of the nation's capital, it contains 16.5 miles of shoreline surrounded by the Potomac River, Mattawoman Creek, and Chicamuxen Creek (Charles County, 2016). NSF Indian Head has had a presence in Charles County since it was first established in 1890 as a Naval Proving Ground. Initially founded for the proving or testing of guns and armor, today NSF Indian Head is a national leader in energetics research. The installation supports a diverse mix of research, development, testing, and evaluation activities of energetics and their systems. It also provides operational support programs that protect all branches of the military from terrorist threats.

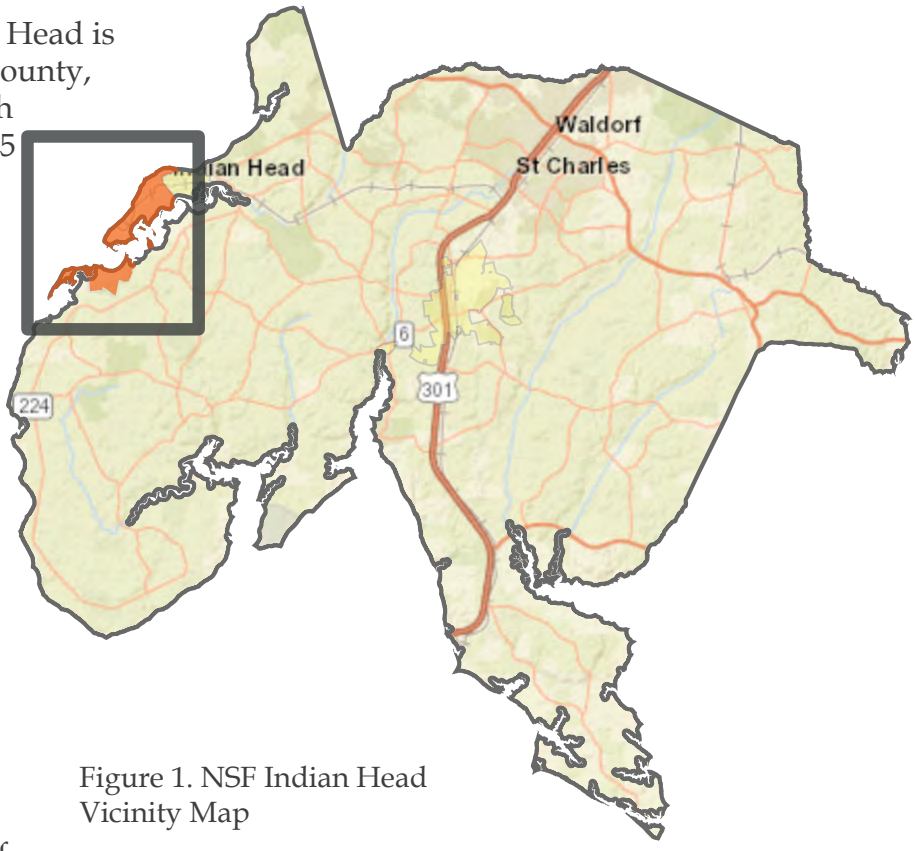


Figure 1. NSF Indian Head Vicinity Map

In 2021, Charles County, Maryland, received a grant from the United States Department of Defense (DoD) Office of Local Defense Community Cooperation (OLDCC) to promote the long-term sustainability of NSF Indian Head through improved climate change preparedness and infrastructure resilience. From March 2021 to May 2022, members of Charles County, DoD, NSF Indian Head, the Town of Indian Head, and the University of Maryland Center for Global Studies (UMD CGS) held a series of strategic meetings (see Appendix 1). The purpose was to identify and discuss risks, hazards, and vulnerabilities of concern to the missions of NSF Indian Head that could be mitigated through investments and solutions outside the fence line in the community. Subject experts from and representatives of the greater NSF Indian Head community were also active participants. The following report is a product of these dialogues.

BACKGROUND

NSF Indian Head is located next to the Town of Indian Head. It is one of two naval installations that is under the command of Naval Support Activity South Potomac — with the other being Naval Support Facility (NSF) Dahlgren, Va. The relationship between NSF Indian Head, the Town of Indian Head, and Charles County is symbiotic and intertwined. In addition to its military value, NSF Indian Head is one of Charles County's largest employers. NSF Indian Head employed more than 3,800 military personnel, federal civilian employees, and support contractors in Fiscal Year 2020, with 54.2% of all military personnel and federal civilian employees residing in Charles County (DoD, 2021). The region's economic, cultural, and environmental infrastructure

systems are integral to the mission success of the installation and the quality of life in the surrounding community.

Climate change, sea level rise, and extreme weather events can negatively impact the infrastructure of DoD installations and the communities surrounding them, directly affecting installation functions. Climate change is already having an observable impact on NSF Indian Head. In 2019, DoD issued its *Report on Effects of a Changing Climate to the Department of Defense*. This report identified climate change as a national security issue to DoD operations and installations. DoD analyzed climate-related events at various military installations to determine if any of the following vulnerabilities posed a current or potential threat over the next 20 years: recurrent flooding, drought, desertification, wildfire, and/or thawing permafrost. NSF Indian Head was included in the analysis. Current and potential vulnerabilities identified for NSF Indian Head included:

- Recurrent flooding, which may include coastal flooding from storm surge and sea level rise, nuisance flooding during high tides, and riverine flooding; and
- Drought conditions, which can have implications for base infrastructure and impair testing and training activities.

The location of NSF Indian Head and the surrounding community suggests that climate hazards such as nuisance and urban flooding, sea level rise, shoreline erosion, temperature increases, and drought will increase over time. The purpose of this project was two-fold. First was to collaboratively identify and assess the risks, hazards, and vulnerabilities of highest concern as it relates to the ability of NSF Indian Head to carry out its missions. Second was to propose and prioritize investments and solutions outside the fence line necessary to strengthen NSF Indian Head, reduce risks, mitigate harm, and improve the ability of NSF Indian Head to quickly recover when disruptions are experienced. In doing so, Charles County will ensure that it continues to be an attractive place for the military to operate and that NSF Indian Head remains a lasting part of the community.

SCOPE AND ORGANIZATION

Identifying a robust resilience strategy is essential for maintaining long-term mission success of the NSF Indian Head and the economic, cultural, and environmental resilience and viability of the community. Its focus is not limited to emergency management. It serves to assess, prioritize, and propose actions and next steps for the multiple challenges and opportunities facing the community, including aquatic and natural resource protection and restoration, economic and social equity, and housing. The following report was prepared to collaboratively assess, prioritize, and propose actions and next steps to advance resilience in the greater-Naval Support Facility Indian Head community.

The report begins with an overview of the NSF Indian Head focus area. It provides information on who lives there, how the population is changing over time, and the demographic, socioeconomic and land use trends that affect vulnerability to climate hazards. This is followed by an overview of existing climate trends and extreme weather events that stress the area's natural, physical, and cultural resources and economic interests. Together, these sections illuminate vital data to help identify clear actions necessary to mitigate risks as well as to foster, protect, and enhance military installation sustainability. The report ends with a list of recommendations and implementation strategies to bring the resilience planning to fruition.

COMMUNITY CONTEXT

NSF Indian Head is comprised of five distinct areas: Cornwallis Neck, Stump Neck Annex, Bullit Neck, Marsh Island, and Thoroughfare Island (see Figure 2). Cornwallis Neck — also known as "Main Side" — includes an operational area and a restricted area in the southern part of the peninsula. Testing and evaluation of energetics and energetics material are performed at designated facilities and ranges located on the restricted portions of Cornwallis Neck and on Stump Neck Annex. The testing of explosive devices and projectiles no longer occurs at either location. The Navy uses several key tools to promote land use

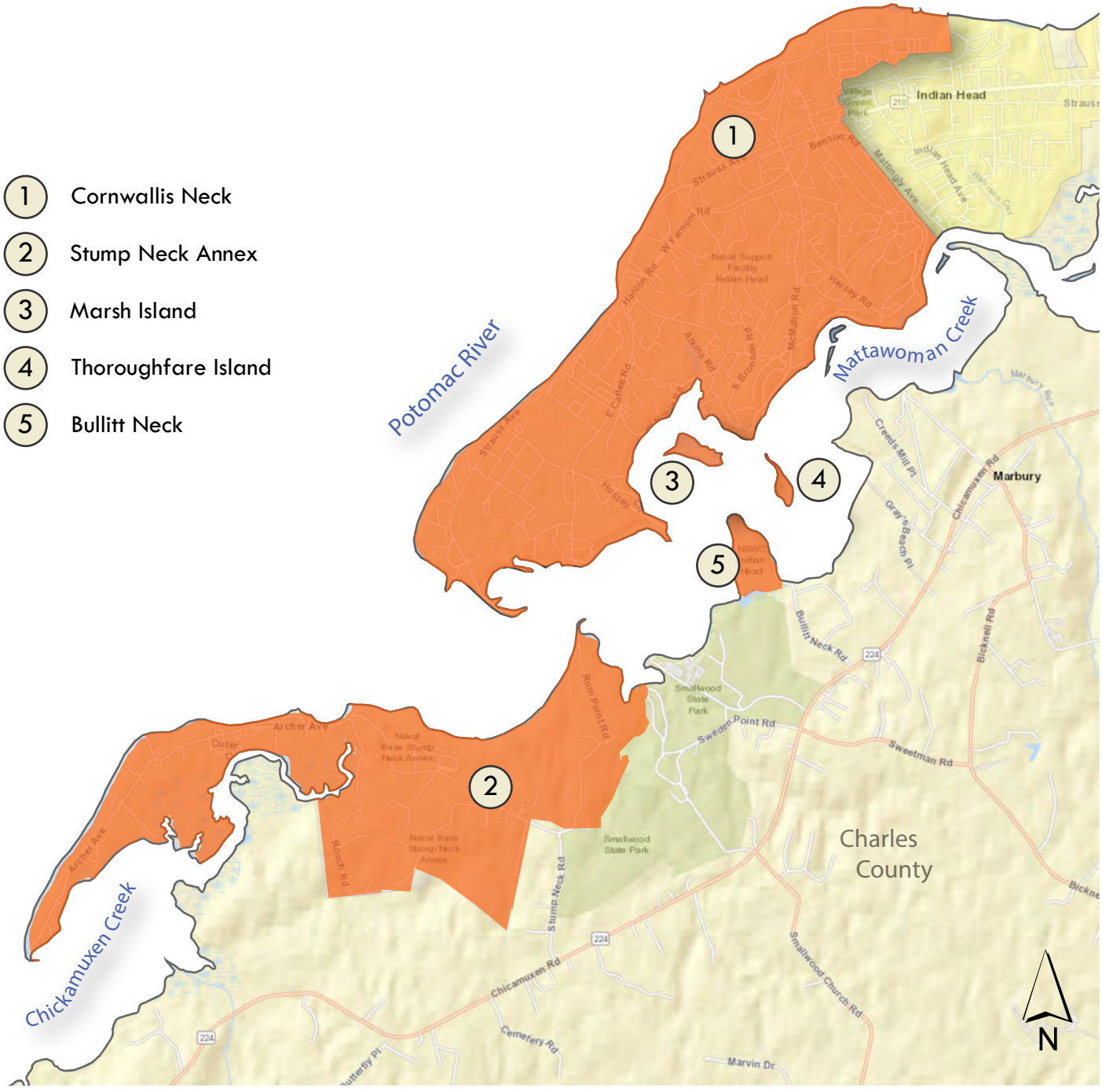


Figure 2. Properties comprising the NSF Indian Head installation

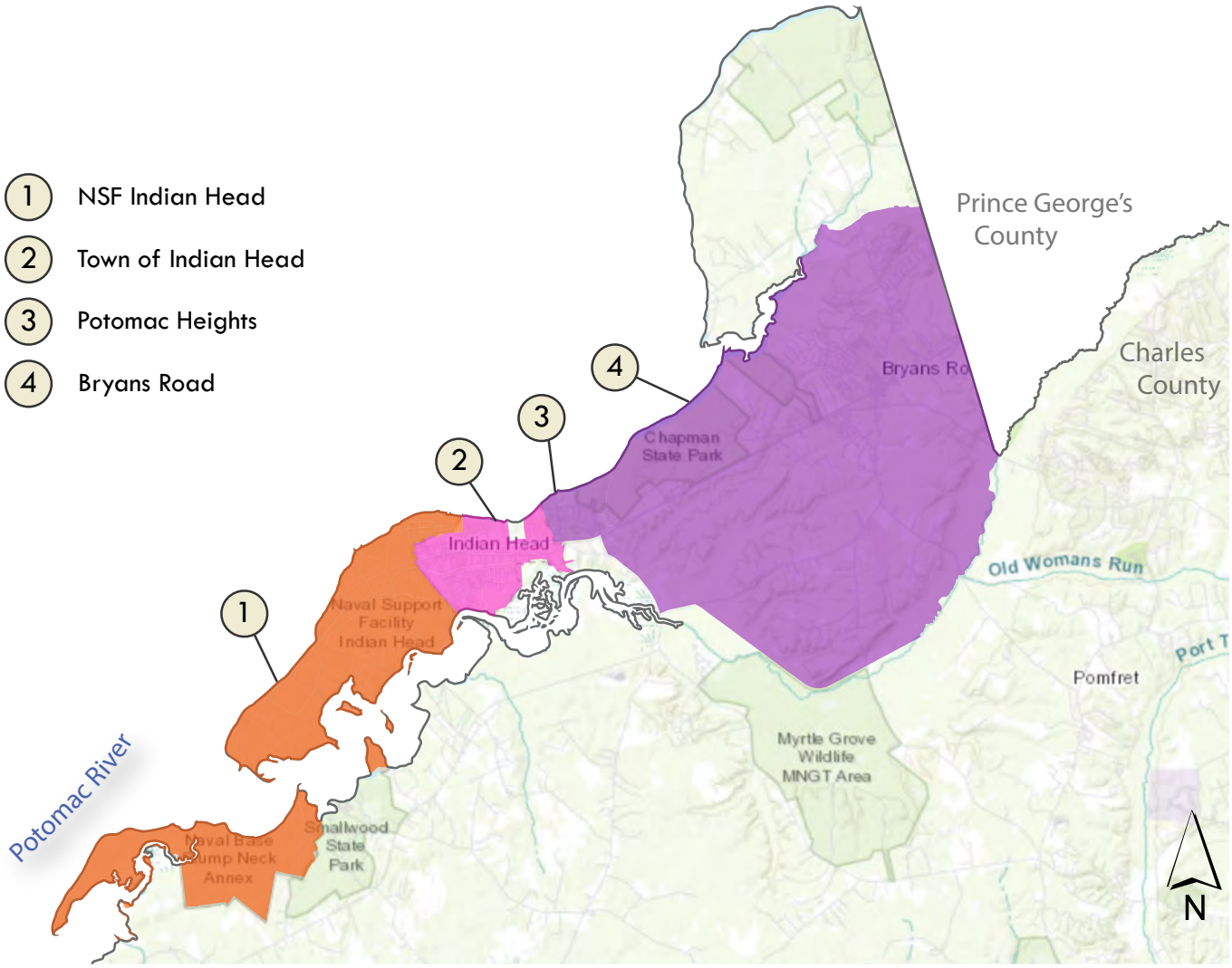


Figure 3. NSF Indian Head Focus Area

compatibility and minimize operational impacts on the surrounding communities. These include preparing numerous studies to address range safety and maintain compliance with state and federal regulations and participating in cooperative planning efforts with the Town of Indian Head and Charles County, such as the Joint Land Use Study (Charles County, 2016).

FOCUS AREA

The primary focus area for the military installation resilience review includes NSF Indian Head and the Town of Indian Head as well as two nearby communities: Potomac Heights and Bryan Road. The Town of Indian Head is directly adjacent to Cornwallis Neck. Revitalization of the Town of Indian Head has been a leading priority for the Charles County Economic Development Department. The Town is one of four designated Sustainable Communities in Charles County and is one of three County areas that was identified as a federally designated Opportunity Zone in 2018 (*Note*: This designation provides tax incentives for investment in distressed communities over a 10-year period). A little further to the north and east, the Bryans Road community includes a unique mix of historic villages, residential subdivisions, federal facilities, and commercial properties centered along MD 210 (see Draft Bryans Road Sub-Area Plan, June 27, 2022). Potomac Heights is nestled between the Town of Indian Head and Bryans Road. Both Bryans Road and Potomac Heights fall under the jurisdiction of Charles County.

DEMOGRAPHICS

The community around NSF Indian Head is growing, and demographics are shifting. In 2020, the total population in the NSF Indian Head study area was 14,018, and the largest racial or ethnic group was Blacks or African Americans, followed by Whites (Figure 4).

The area experienced rapid population growth between 2010 and 2020. The population grew 60.3% over the ten-year period, compared to a 13.7% growth rate for the rest of Charles County over the same time period (Figure 5).

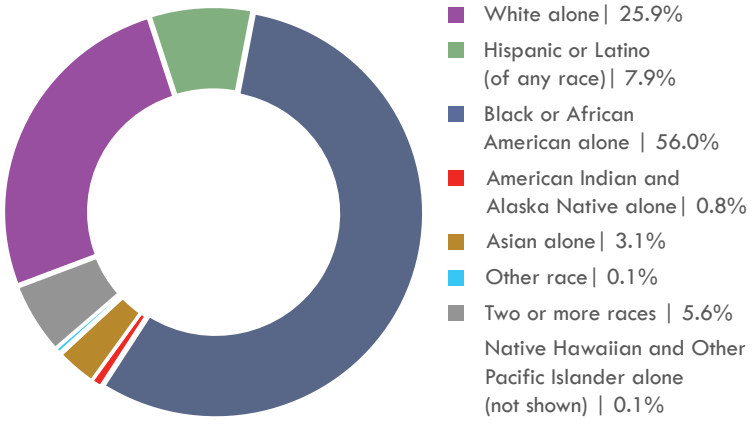
All major racial or ethnic groups increased in population over the decade, but communities of color lead the area's growth. The population identifying as White grew at the lowest rate, although at a 15.1% growth rate (adding 475 residents), which was still at a rate higher than the overall County growth rate of 13.7%. County-wide, the White population declined by 19.8% over the decade.

The population identifying by Some Other Race grew at the fastest rate in the study area, growing from 5 to 55 residents in a decade. In terms of sheer numbers of residents, the Black or African American population increased by 3,274 residents with a growth rate of 70.4%. The number of Hispanic or Latino residents increased by 752 people, at a growth rate of 210.1%. These demographic shifts are expected to continue.

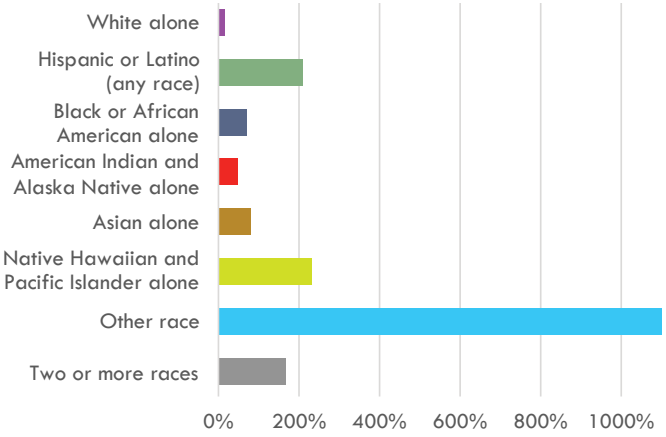
Five-year estimates from the 2015-2019 and 2016-2020 American Community Survey (ACS) were collected to better understand the area's social, economic, housing, and demographic make-up. Identifying potentially vulnerable populations may help determine a community's capacity to absorb, endure and/or recover from a disaster.

FOCUS AREA DEMOGRAPHICS

Race / Ethnicity in 2020



Growth Rates of Major Racial / Ethnic Groups 2010 - 2020



Focus area population in 2020: 14,018
Focus area population in 2010: 8,747

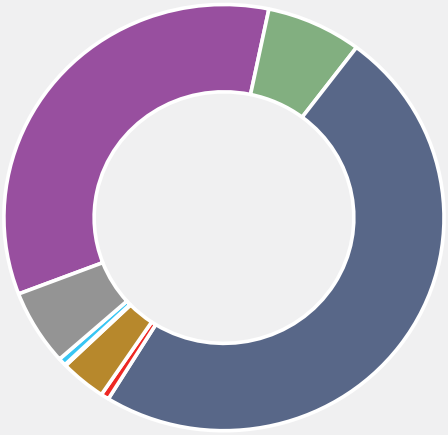
Percent change 2010 - 2020: 60.3%

Figure 4. Focus Area Demographics

Prepared by UMD CES from U.S. Census Bureau P.L. 94-171 data. Released August 12, 2021.

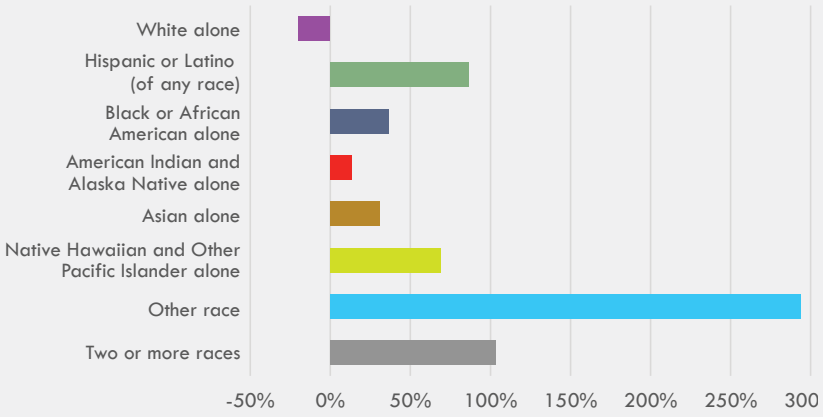
CHARLES COUNTY DEMOGRAPHICS

Race / Ethnicity in 2020



- White alone | 34.1%
- Hispanic or Latino (of any race) | 7.0%
- Black or African American alone | 48.5%
- American Indian and Alaska Native alone | 0.6%
- Asian alone | 3.4%
- Other race | 0.6%
- Two or more races | 5.7%
- Native Hawaiian and Other Pacific Islander alone (not shown) | 0.1%

Growth Rates of Major Racial / Ethnic Groups 2010 - 2020



Focus area population in 2020: 166,617

Focus area population in 2010: 146,551

Percent change 2010 - 2020: 13.7%

Figure 5. Charles County Demographics

Prepared by UMD CES from U.S. Census Bureau P.L. 94-171 data. Released August 12, 2021.

POPULATION AND HOUSEHOLD CHARACTERISTICS

There are a variety of risk factors that can impact an individual's or household's ability to access resources or cope with a disaster. These include the number of people aged 65 and older and the number of people with disabilities.

Of the total population living in the focus area in 2020, the median age was 38.7 years. Approximately 11.6% of the population was aged 65 years and older, and 8.9% of the total population had some type of disability posing a constraint to significant life activity.

Statistics for potential risk factors over two five-year periods (2015-2019 and 2016-2020) are provided in Table 1. The selected risk factors align with those identified in the U.S. Census Bureau's Community Resilience Equity metric (U.S. Census Bureau, 2021), which are intended to provide easy-to-understand metrics for how at-risk a community may be to disasters.

Table 1. Risk factors impacting community resilience in NSF Indian Head focus area

Factor*		Percent	
		2015-2019 ACS	2015-2019 ACS
Percentage of families with income at or below 125% of the poverty level		7.6%	8.0%
Percent population without health insurance		3.5%	5.3%
Percent population over 16 years in labor force that is unemployed		2.6%	4.8%
Single householder with children under 18 years		7.1%	8.8%
Communication Barrier:			
	Percent of population 5 years and over that speaks English less than "very well"	3.3%	2.9%
	Percent of population over 25 years without a high school diploma or GED equivalent	5.0%	5.6%
Percent population with a disability posing constraints to significant life activity		8.9%	10.2%
Percent population aged 65 years and above		11.6%	12.4%
Percent households without a vehicle		3.1%	5.2%
Percent households without broadband internet subscription		16.6%	17.9%

*Note: Prepared by UMD CES from U.S. Census Bureau 2015-2019 American Community Survey and U.S. Census Bureau 2016-2020 American Community Survey data.

While it is unclear of the overall impact associated with the COVID-19 pandemic, it has undoubtedly affected the community. From the 2015-2019 to the 2016-2020 ACS reporting period, the percent population over 16 years in the labor force that was unemployed increased from 2.6% to 4.8%, the percent of families at or below 125% of the poverty level increased from 7.6% to 8.0%, and the percent of population without health insurance increased from 3.5% to 5.3%. In fact, all of the risk factors provided in Table 1 show an increase with the exception of the percent of population aged 5 years or older that is not fluent in English. Charles County should continue to evaluate these factors over time.

CLIMATE HAZARDS AND TRENDS

The climate in Charles County is changing. Excessive heat waves are increasing in occurrence and severity. High-intensity rain events are more frequent. Sea levels are rising, and flood risks are rapidly changing. In order to adequately prepare for this changing climate, it is important to understand the risks facing Charles County and the NSF Indian Head community.

Over the past year, the NSF Indian Head Military Installation Resiliency leadership and consultant team evaluated likely changes to determine what vulnerabilities posed a current or potential community threat. The results are summarized below. It is anticipated that as Charles County undergoes its greenhouse gas emissions inventory for government operations and climate action planning in 2022, the County will further refine this information and establish a process to measure and track climate risks over time.

American bald eagle on Potomac River, Charles County

RISING TEMPERATURES

Average area temperatures have risen over time. Climate modeling data from historical and future projections were obtained from the USGS National Climate Change Viewer (NCCV) for two Representative Concentration Pathways (RCP) greenhouse gas (GHG) emission scenarios developed for the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Alder and Hostetler, 2013).

The RCPs project the trajectory of average mean temperatures to 2100 and make different assumptions about future human population, economic activity, and fossil fuel use. RCP 4.5 and 8.5 are two common scenarios used for planning. Where RCP 4.5 assumes some level of climate change mitigation will occur, RCP 8.5 does not. Both scenarios show that average annual temperatures are rising, heat waves are becoming more intense and longer lasting (Figure 6).

Table 2. How high will average temperatures rise?

	Mean temperature (and percentile range) for specific years in degrees Fahrenheit		
Scenario	2040	2080	2099
RCP 4.5	60.77 (58.49–64.05)	61.94 (59.78–63.82)	63.25 (59.54–65.97)
RCP 8.5	60.79 (58.68–62.74)	65.15 (63.32–67.72)	67.39 (64.71–70.64)

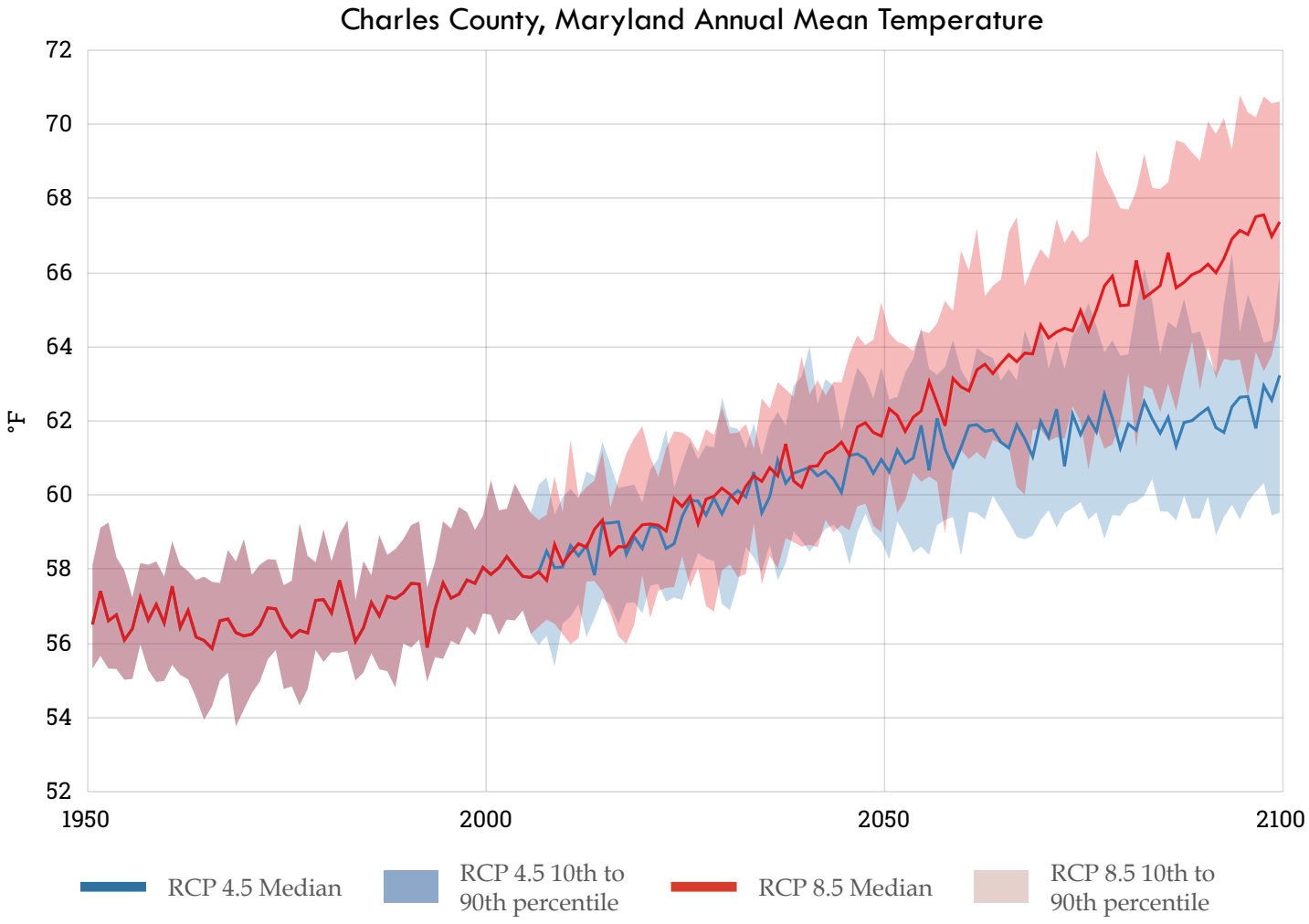


Figure 6. Historical temperatures and future trends for Charles County

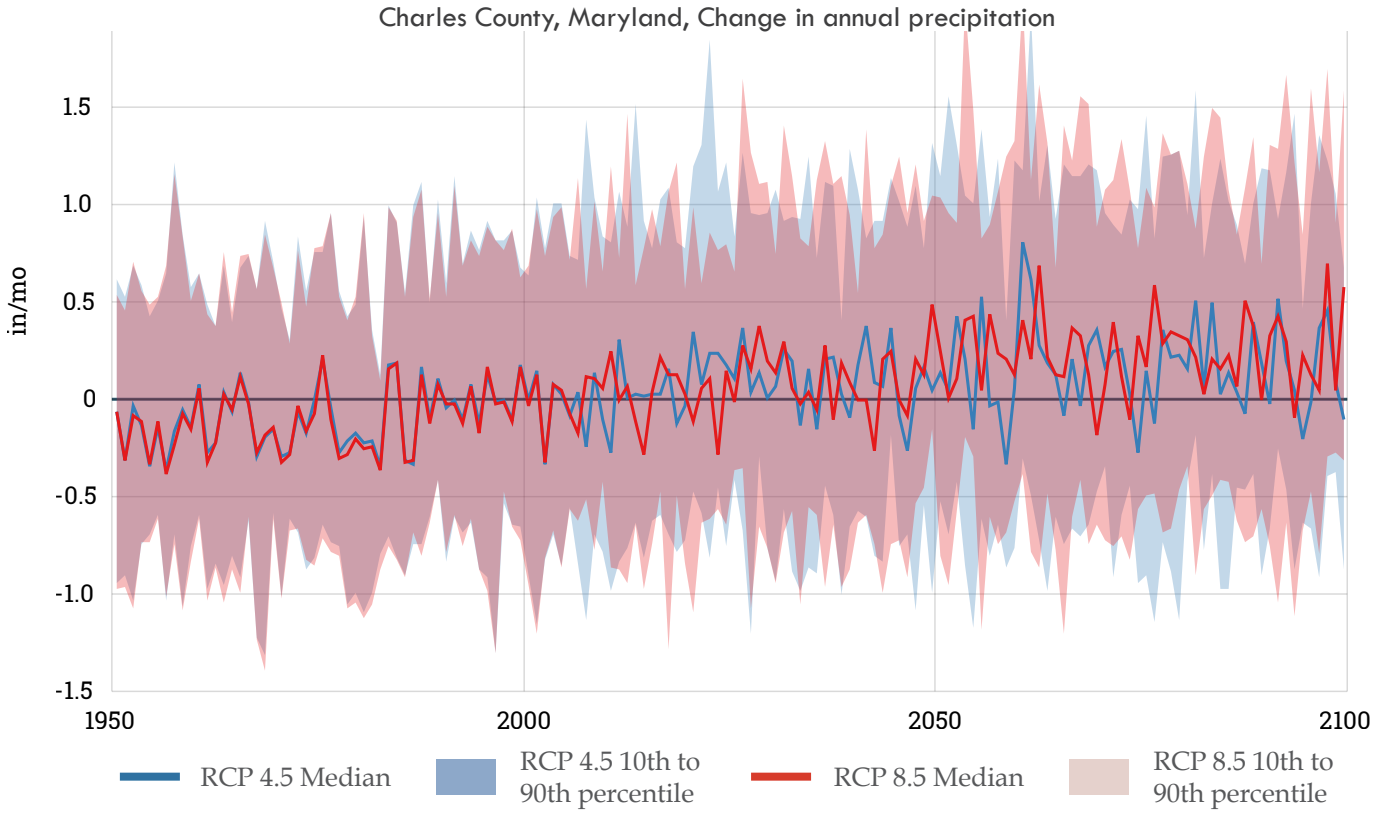


Figure 7. Change in annual precipitation relative to 1981-2000 (Alder and Hostetler, 2013)

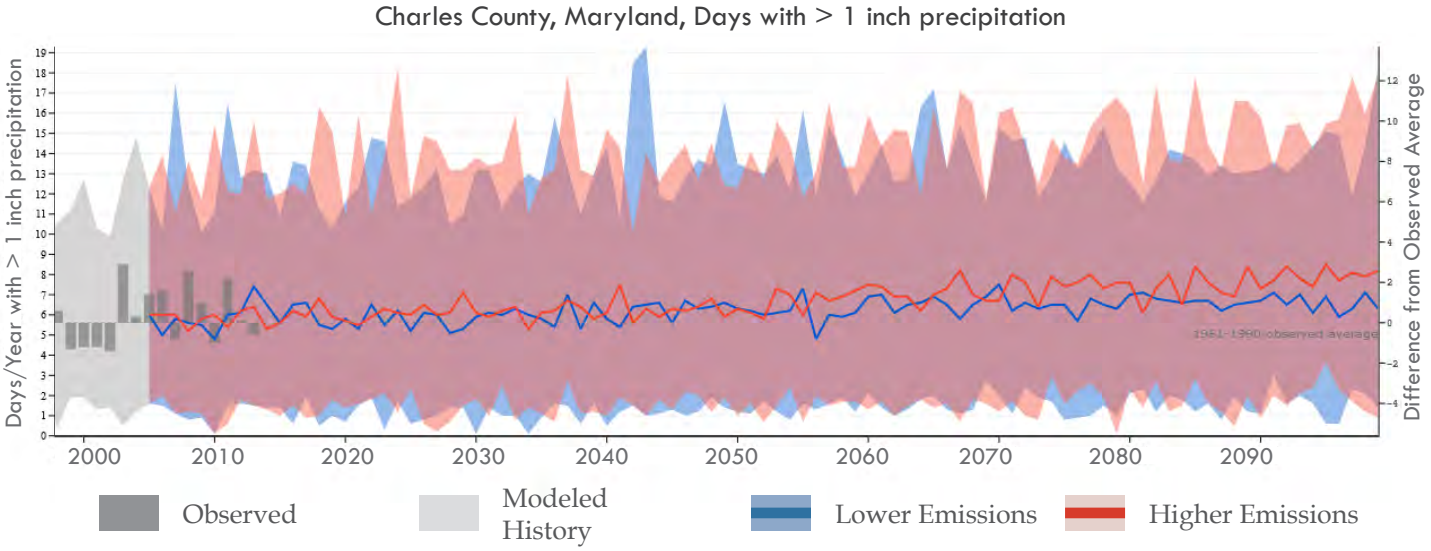


Figure 8. Days per year with more than 1 inch of rainfall (U.S. Climate Resilience Toolkit Climate Explorer)

INCREASING RAINFALL

Rainfall totals in Maryland are rising. Between 2000 and 2020, precipitation in Maryland increased 2.63 inches per decade (NOAA, 2022). Seasonal and annual rainfall amounts are expected to continue to rise over time (Figure 7). The frequency and intensity of precipitation events is also expected to continue to grow over time (Figure 8). Such events stress existing storm drain infrastructure and can lead to local, urbanized flood events.

Data collected as part of the Charles County Nuisance and Urban Flood Plan was reviewed to determine whether urbanized flood events, due to increased precipitation, were currently impacting the transportation network (Charles County, 2020). Discussions were also held with the NSF Indian Head Military Installation Resiliency leadership team. Presently, the road network and nearby properties do not appear to be majorly impacted by urban flooding.

SEA LEVEL RISE

Sea levels are rising worldwide, with increases driven by climate change. In 2022, the National Oceanic and Atmospheric Administration (NOAA) released new sea level rise projections for U.S. states and territories, available for viewing on the NOAA Sea Level Rise Viewer.

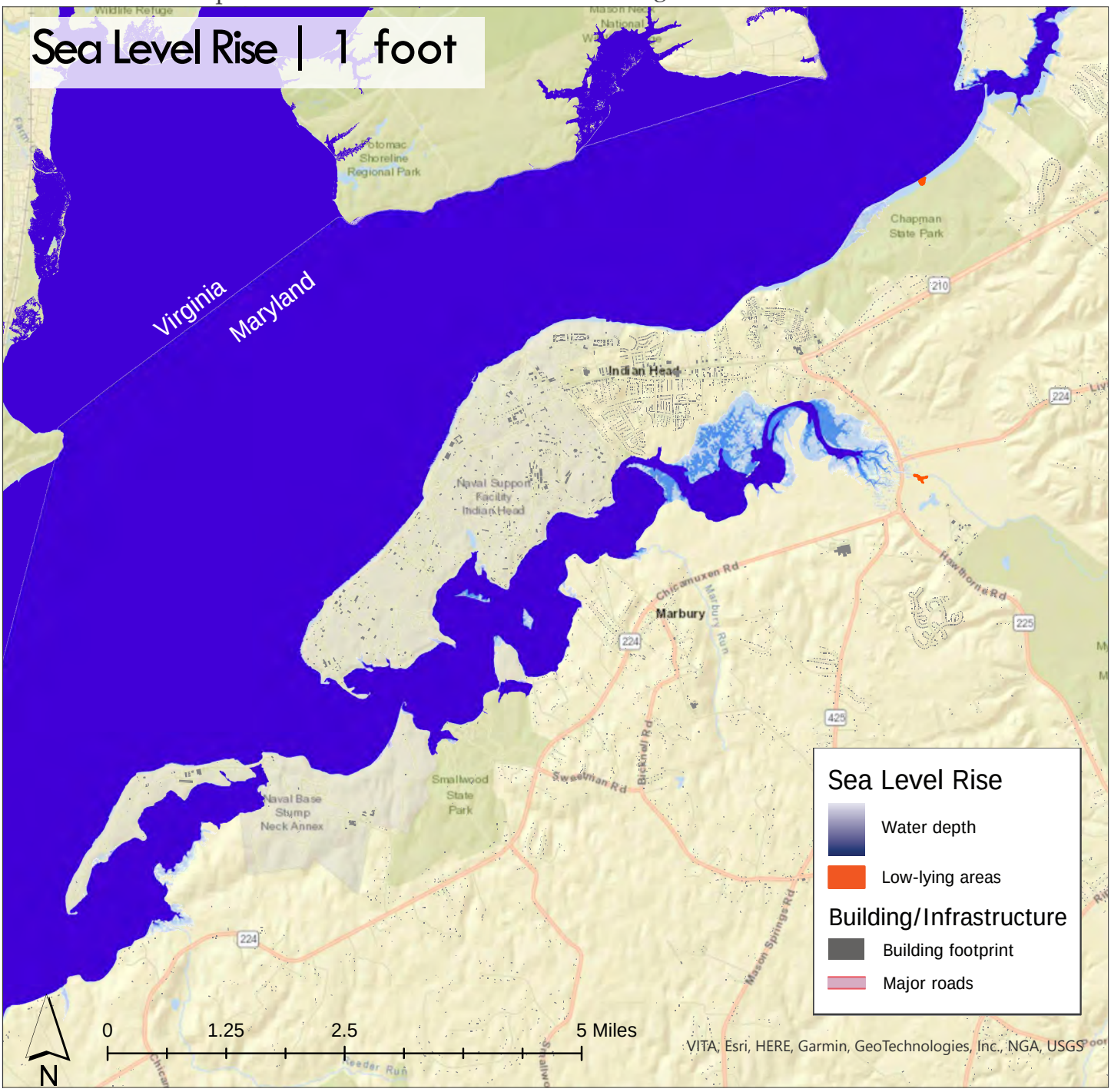


Figure 9. NOAA Sea Level Rise Projection — 1 Foot

Table 3. How high will sea levels rise (2022 projections)?

Year	Local sea level rise scenario (in feet), based on Washington, DC*			
	Intermediate Low	Intermediate	Intermediate High	High
2040	0.95 feet	1.02 feet	1.08 feet	1.15 feet
2080	2.00 feet	2.62 feet	3.41 feet	4.36 feet
2100	2.49 feet	3.90 feet	5.18 feet	6.66 feet

*Source: NOAA Sea Level Rise Viewer v 3.0.0.

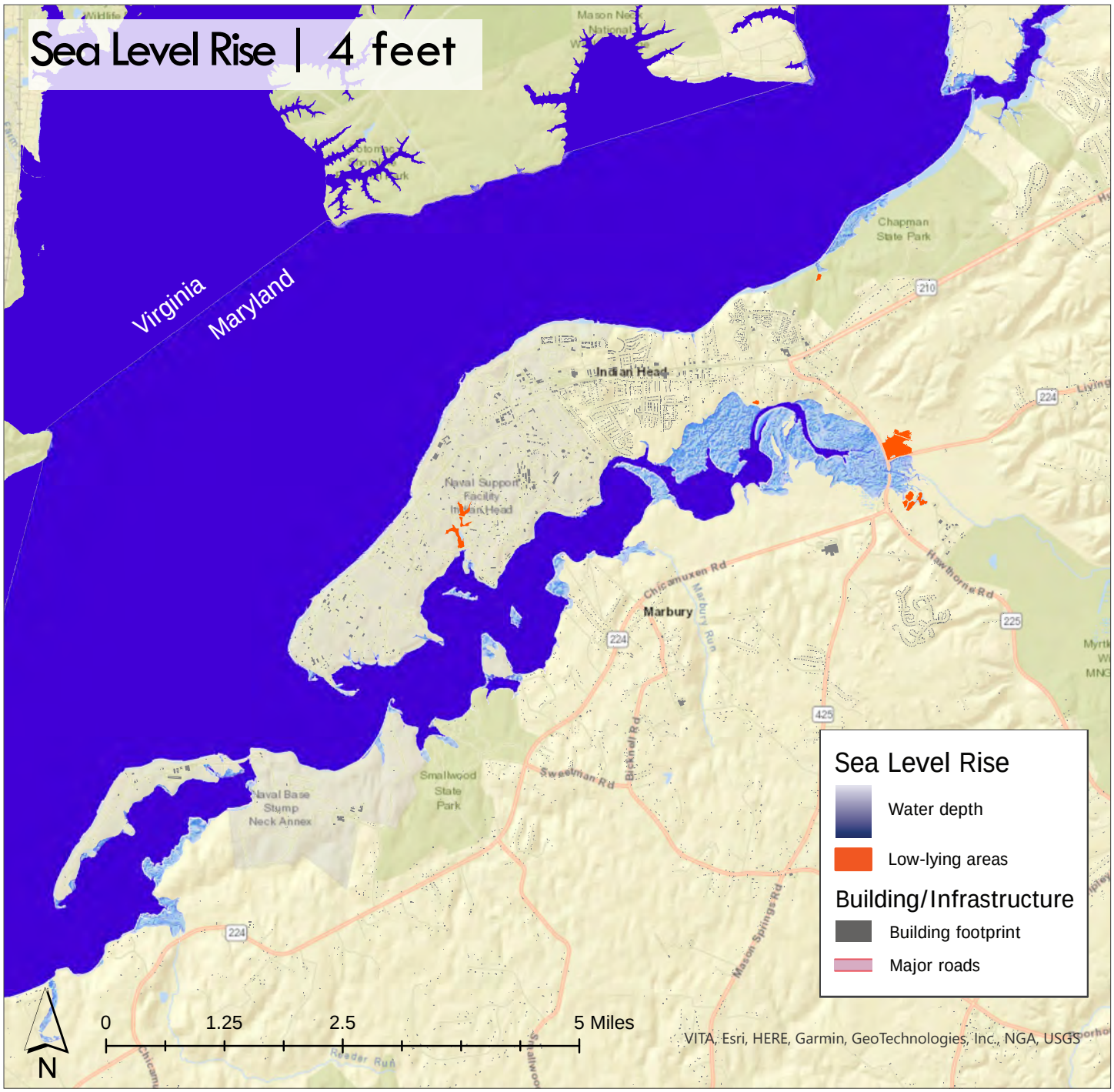


Figure 10. NOAA Sea Level Rise Projection — 4 Feet

The updated projections and associated technical report indicates that the United States will likely experience as much sea level rise by the year 2050 as occurred in the previous hundred years (Sweet et al., 2022). The projections are based on a combination of tide gauge and satellite observations and new scientific information from the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Multiple federal agencies —including DoD — partnered with NOAA to update the sea level rise projections.

Table 3 provides the updated local sea level rise projections for the NSF Indian Head area based on the four sea level rise scenario projections for Washington, DC, with a baseline year of 2000. The NSF Indian Head area is expected to experience between 0.95 to 1.15 feet of sea

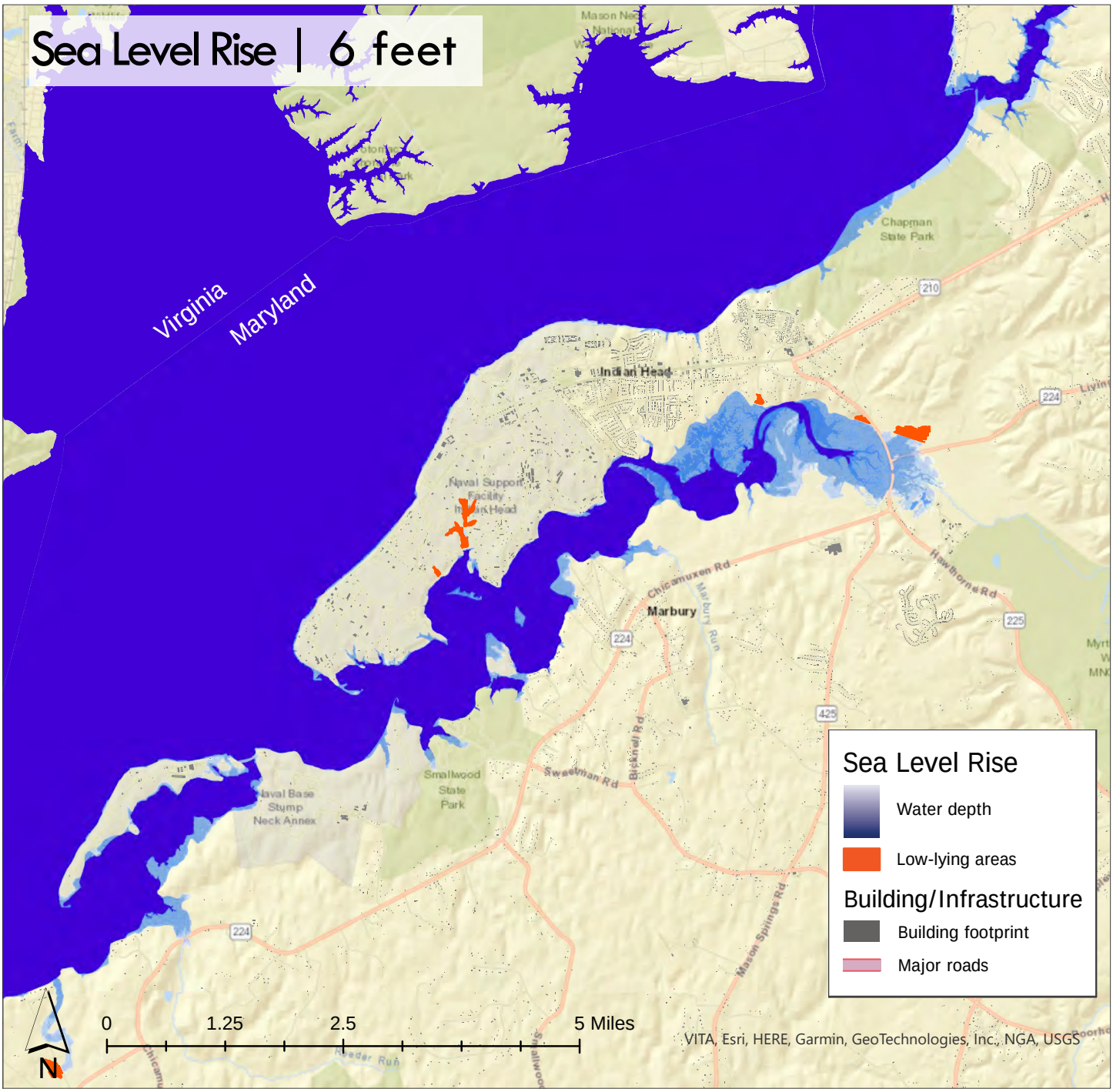


Figure 11 NOAA Sea Level Rise Projection — 6 Feet

level rise by the year 2040 as compared to the year 2000. By year 2080, sea levels will increase between 2 to 4.36 feet, and by year 2100, sea levels will increase 2.48 and 6.66 feet. While all scenarios show that sea levels will continue to rise, greenhouse gas emission levels matter. This means that efforts Charles County and other jurisdictions take to curb greenhouse gas emissions means should make a difference in the level of acceleration.

Continuously tracking how and why sea level is changing is an important part of informing future adaptation plans for Charles County. Figures 9, 10, and 11 provide planning-level views of sea level rise and coastal flooding impacts at one foot, four feet, and six feet, respectively, based on NOAA's 2022 projections. These help estimate the sea level rise impacts so that Charles County can prioritize actions. At one foot of sea level rise, the western tip of Stump Neck Annex noticeably shrinks and becomes isolated from the rest of the annex. The outer limits come exceedingly close to Hawthorne Road (SR-225), with one low-lying areas prone to minor flooding located on the eastern side of Hawthorne Road. Affected areas extend to the southernmost edges of neighborhoods south of Piscataway Highway (Route 210), adjacent to the Mattawoman Creek Natural Area. It also impacts properties abutting the Potomac River, most noticeably along Chapman State Park and Pomonkey Creek.

At four feet of sea level rise, the tip of Stump Neck Annex becomes slightly smaller and more isolated. The areas impacted by sea level rise extend past Hawthorne Road and compromise the intersection between Hawthorne Road and Livingston Road (SR-224). Low-lying areas prone to minor flooding appear east of the Charles County Department of Public Works Utilities and Mattawoman Waste Water Facility. Low-lying areas prone to minor flooding also appear within Cornwallis Neck. The footprint of impacted areas along the Potomac River, Mattawoman Creek, and Pomonkey Creek expands.

At six feet of sea level rise, the area impacted by sea level rise along Hawthorne Road extends even further, encroaching upon the intersection between Hawthorne Road and Chickamuxen Road (SR-224). The northwestern-most section of Charles County Department of Public Works Utilities and Mattawoman Waste Water Facility is compromised. The areas within Stump Neck Annex and along Mattawoman Creek, the Potomac River, and Pomonkey Creek impacted by sea level rise expands.

The presence of protected natural areas along the Potomac / Mattawoman / Pomonkey coastline help shield a good portion of the greater NSF Indian Head community's coastline from the impacts of sea level rise. Protected areas include the Mattawoman Creek Natural Area, Chapman State Park, and the Ruth B. Swann Memorial Park. Other protected areas include one property protected by Environmental Trust Easements, one property protected by an Agricultural Land Preservation Foundation easement, one property protected by Environmental Trust Easements, and one property protected by a Transfer Development Rights.

NUISANCE AND URBAN FLOODING

The Charles County Nuisance and Urban Flood Plan, which was completed in 2020, defines nuisance flooding as flooding associated with high tides causing storm drain backflow, groundwater inundation, and direct marine flooding. The plan noted that tide gauge measurements show that the sea level along Maryland's coastline has risen at an average rate of 3-4 mm per year (one foot per century) (Charles County, 2020).

At present, the Charles County Nuisance Flood Plan does not any nuisance or urban flood areas within the greater NSF Indian Head study area that are of great concern. As sea level rise changes the coastline, critical infrastructure that was previously not at risk may face a greater chance of nuisance flooding due to storm surge. More frequent and intense coastal flooding may impact infrastructure and facilities near the coastline, potentially causing damage, disruptions, and economic loss.

STORM SURGE

Warming oceans and sea level rise are fueling more intense tropical storms and hurricanes. While the total number of such events may decrease or remain the same, the precipitation rates and intensity of individual events is projected to increase. Globally, the proportion of intense (category 3 or higher) hurricanes and tropical storms has grown by about 5% per decade since 1979. The proportion of very intense (category 4 & 5) storms is projected to increase substantially in a warming climate (Knutson et al., 2021). Figures 9 and 10 depict storm surge flooding vulnerability for hurricane-prone coastal areas produced by NOAA NWS using the SLOSH (Sea, Lake, and Overland Surges from Hurricanes) model.

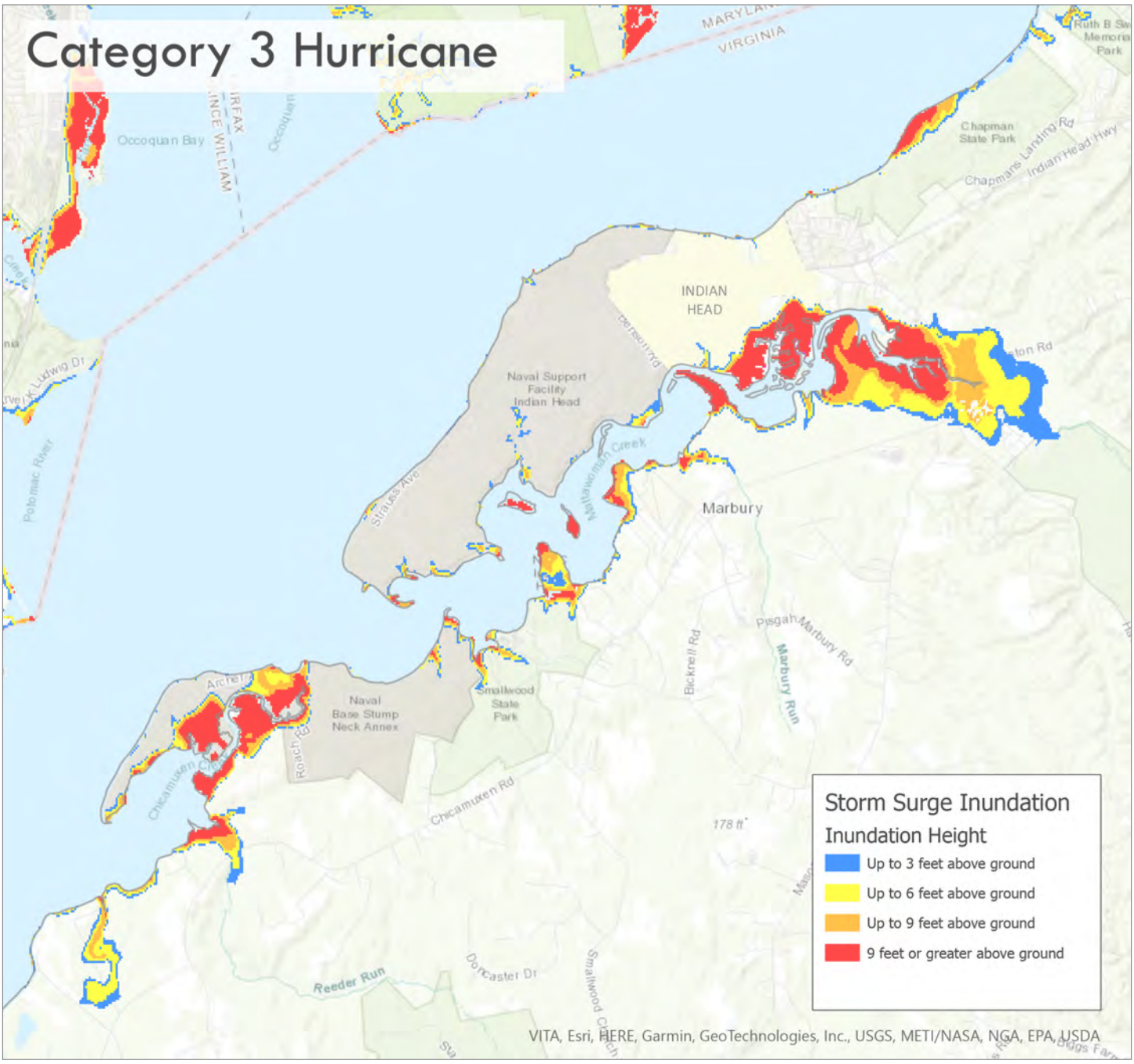


Figure 12. Storm Surge Flooding Vulnerability - Category 3

Storm surge is defined as an "abnormal rise of water generated by a storm, over and above the predicted astronomical tides" (NOAA, No date). Flooding from storm surge depends on factors such as the track, intensity, size, and forward speed of the hurricane and the characteristics of the coastline where it comes ashore or passes nearby. For planning purposes, a representative sample of hypothetical storms is used to estimate the near worst-case scenario of flooding for each hurricane category.

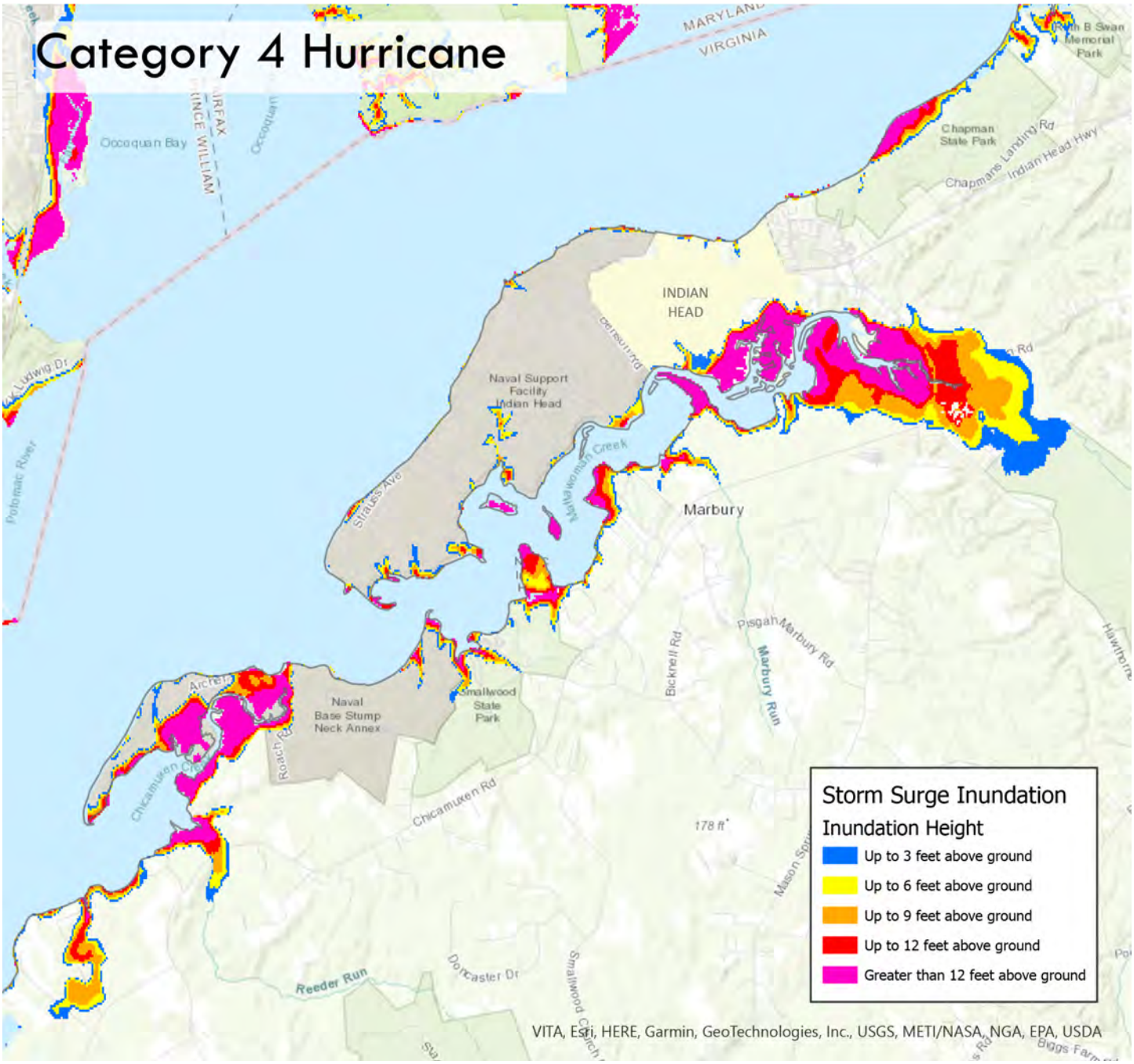


Figure 13. Storm Surge Flooding Vulnerability - Category 4 Hurricane

ASSET VULNERABILITY AND RISK ASSESSMENT

Climate resilience planning is founded on a thorough inventory of critical community assets, resources, and services. Assets such as physical infrastructure and economic and social systems serve two critical roles in the community planning and resilience process. First, they provide the foundation of livable and vibrant communities. Second, many community assets and infrastructure systems provide the foundation for achieving long-term resilience goals. Many community assets, resources, and services not only provide for the long-term livability and vitality of a community, but they also serve as the foundation for the resilience efforts necessary to achieve a more sustainable future. Understanding threats and vulnerabilities provides a starting point for creating a corresponding mitigation and protection strategy. To that end, the project team assessed the anticipated climate impacts to those assets within the NSF Indian Head study area and the potential role those assets serve in the resilience and adaptation process.

THE ASSESSMENT PROCESS

The Intergovernmental Panel on Climate Change defines climate change vulnerability as how susceptible a species, system or resource is to the negative effects of climate change and other stressors (IPCC, 2007; MCAP, 2015). This includes three components:

- *Exposure*, or the amount and rate of change a system experiences from the direct or indirect impacts of climate change;
- The *sensitivity* of a system that is dependent on specific environmental conditions and the degree to which it will likely be affected by climate change; and
- The *adaptive capacity* of a system to cope and persist under changing conditions.

Climate vulnerability assessments (CVAs) are tools and/or processes used to measure these components. CVAs help to determine the susceptibility of natural or human infrastructure systems to sustaining damage from climate change. Effective CVAs must consider adaptive management or policy responses that may lessen negative impacts (or enhance positive impacts) of climate change (USDA, no date).

The NSF Indian Head assessment process involved two primary tasks. The project team first compiled an inventory of key assets and resources within the NSF Indian Head area and conducted a desktop review of the vulnerabilities and risks to climate hazards and threats. The results are summarized in the Climate Hazards and Trends section. The team then engaged experts and community stakeholder groups to develop a thorough understanding of the local on-the-ground issues and conditions regarding each. Assets were then evaluated based on the specific goals of this project, the needs within the partner communities, and three community resilience parameters.

- NSF Indian Head / community interface;
- Climate adaptation as a component of community resilience; and
- Coupling mitigation, response, and recovery.

RESILIENCE PARAMETER 1: NSF INDIAN HEAD/ COMMUNITY INTERFACE

Specific focus was given to the infrastructure, programs and actions that impact the NSF Indian Head/community interface. Community resilience planning involves the formulation of long-range visions, policies, and goals in the face of ever-changing threats, hazards, and pressures. Long-term plans must include strategies for achieving economic, environmental, and social goals and outcomes. Planning for and executing an effective response to climate hazards and threats requires accounting for a complex and comprehensive matrix of issues and potential actions. This process becomes even more complex within a regional context, where the goals and needs of multiple communities must be incorporated into long-term action strategies.

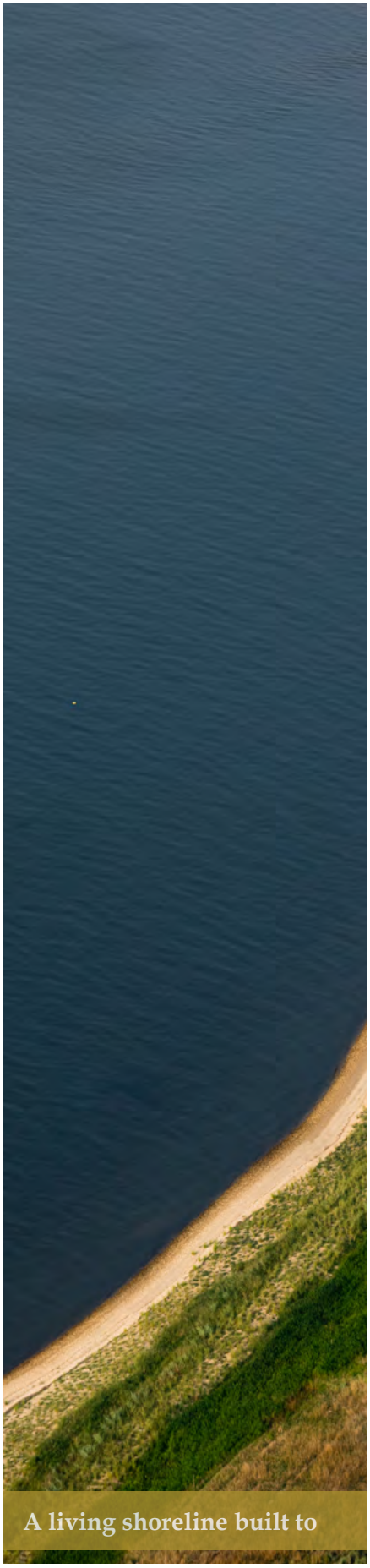
RESILIENCE PARAMETER 2: CLIMATE ADAPTATION AS A COMPONENT OF COMMUNITY RESILIENCE

The project team addressed climate adaptation and resilience within the context of long-term social, environmental, and economic sustainability. The project focused on addressing those actions that are necessary to mitigate, respond to, and recover from the impacts of climate change. The assessment process and associated recommendations center on the anticipated impacts of climate change and climate hazards to the project communities. The team focused on how best to achieve climate resilience within the structures of community economic, health, environmental, and social vitality and development. Long-term resilience requires mitigating those hazards broadly and comprehensively.

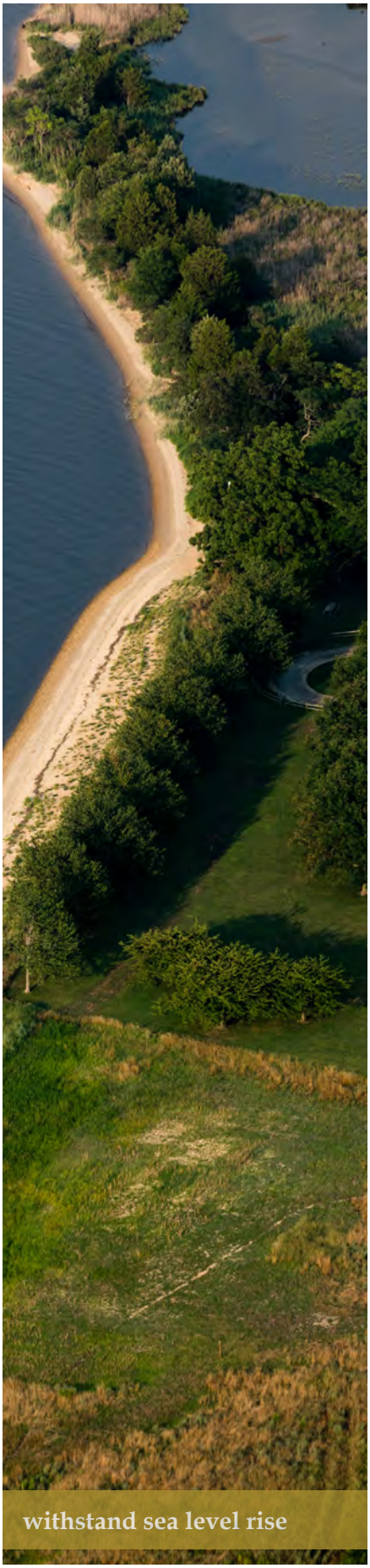
RESILIENCE PARAMETER 3: COUPLING MITIGATION, RESPONSE, AND RECOVERY

The final parameter was to optimize three core elements of community resilience actions: long-term mitigation and risk reduction; emergency response and management; and long-term disaster recovery. Preparing for the likely impacts of climate hazards requires a flexible management and implementation approach that addresses the varied nature of climate change, including long-term systemic events such as sea level rise and tidal flooding as well as acute events such as catastrophic storms. This required an assessment process centered on three core climate hazard intervention and management approaches.

- *Mitigating climate threats in advance of anticipated impacts.* Climate adaptation and resilience aims to reduce the risks or vulnerabilities posed by climate change. This requires investment in climate-mitigation infrastructure such as sea walls, levees, and natural systems such as green and blue



A living shoreline built to



withstand sea level rise

infrastructure. In addition, mitigation requires maintaining and upgrading existing infrastructure assets and systems to make them more resilient to climate impacts.

- *Responding to climate related crises and disasters*. Climate resilience action planning often begins with addressing emergency preparedness and the capacity to effectively respond to acute and catastrophic events and hazards. Projections for more intense and frequent extreme weather events need to be integrated within disaster and emergency management planning (Temmer et al., 2017). In addition, emergency preparedness planning must occur within a regional context to ensure the safety and well-being of all citizens. This project focused on emergency preparedness of the Indian Head peninsula; however, local disaster and emergency management must be informed by broader planning and implementation activities throughout Charles County.
- *Recovering from climate impacts and events*. Climate disasters are inevitable. How communities bounce back from these disasters is what ultimately defines long-term community resilience. The costs and the impact of disaster recovery are often much broader than people anticipate, and recovery takes much longer than people often assume it will (Baillie, 2021). Anticipating and planning for disaster recovery is a core element of resilience planning in general, and our analysis framework more specifically.

ASSET CATEGORY 1: THE BUILT ENVIRONMENT

The built environment—housing, commercial buildings, and other hard infrastructure—is often the focal point of local resilience planning and implementation efforts. When extreme weather or other hazardous events occur, the most obvious and costly impacts are to the built environment. In addition, many "hard" infrastructure systems are essential for mitigation, emergency management, and long-term disaster recovery. This assessment addressed three asset categories integral to community livability and resilience: transportation and physical connectivity; buildings and structures; and communications and digital connectivity.

TRANSPORTATION AND PHYSICAL CONNECTIVITY

A resilient transportation system is defined by the ability to move people efficiently and consistently in the face of systemic threats to the system as well as extreme acute events. Climate impacts have the potential to threaten the safety, reliability, and sustainability of transportation infrastructure. Conversely, a well-designed and

maintained transportation system is an integral component of resilient communities, impacting livability and emergency management. Factors such as designated emergency evacuation routes, parking, congestion, and can all impact the planning and execution of evacuation efforts and community mobility.

NSF INDIAN HEAD/COMMUNITY INTERFACE

Transportation is a uniquely important issue to NSF Indian Head, the Town, and the surrounding area. Spatial issues put added importance on efforts by the Town, the County, and the installation to mitigate the impacts of climate hazards on transportation assets. NSF Indian Head and the Town are located on the Mattawoman/Cornwallis Neck peninsula, which is bounded by the Potomac River and Mattawoman Creek. As a result, transportation corridors are limited. MD Route 210 serves as the primary transportation route onto and off the peninsula. Climate resilience on the peninsula will require overcoming a lack of additional viable transportation routes and redundancy in the transportation system.

CLIMATE ADAPTATION

The viability of the region's transportation system is *highly important*. While transportation systems are vital to the economic and social resilience of virtually every community, they are especially important to coastal communities like Indian Head and NSF Indian Head. Because these communities are located on a peninsula, it is difficult to create redundancy within infrastructure systems. This means that long-term transportation resilience will require innovative planning and collaboration.

MITIGATION, RESPONSE, AND RECOVERY

Transportation is one of those key assets that touches on all three of the community climate resilience needs: mitigation, emergency management, and long-term recovery.

- *Mitigation*. The need to mitigate the potential impacts of climate hazards on the peninsula's transportation system represents an *emerging issue* for the Town of Indian Head and NSF Indian Head. At present, climate impacts on the peninsula's transportation system are manageable. Severe storms and weather events are likely to increase in frequency and intensity in the future, causing localized flooding and traffic pattern disruptions. This, in turn, has the potential to impact the region's climate resilience. A joint transportation planning process is already in place. In addition, NSF Indian Head, the Town of Indian Head, the County, and the State all have their own planning processes that include transportation issues and needs. However, to-date, there is no codified regional transportation plan that addresses the current and future transportation/resilience needs on the peninsula.
- *Disaster management and response*. The viability of the region's transportation system has a *high impact* on disaster management and response. The physical constraints and limitations on the peninsula's transportation system have the potential to impact emergency management in disaster situations due to the limited number of evacuation routes available. Overcoming these constraints will require continued communication and

MD Route 210 is the primary transportation route onto and off the peninsula.

collaboration among the various entities. Emergency management represents an area of collaboration between the Town, the County, and NSF Indian Head. The Town of Indian Head manages emergency services on the peninsula, including for the base. This collaboration should extend to climate disaster response.

- *Long-term event recovery and growth*. The capacity of the installation and the Town to recover from future catastrophic climate events may be hampered by current funding priorities. Climate change will adversely impact land-based transportation systems, including roads and bridges. Excessive heat and severe rain events will require accelerated road maintenance which, in turn, will require additional funding. However, road maintenance funding is often at odds with the realities of climate change and the need for resilience. County transportation districts focus primarily on short-term operations and maintenance needs as opposed to long-term structural changes that will be necessary to address climate impacts. This tends to put local maintenance activities at odds with regional climate resilience goals.

COMMUNICATIONS AND DIGITAL CONNECTIVITY

Communications and digital connectivity are often-overlooked components of community climate resilience. Digital and cellular communications have become essential to modern life, but the impacts of climate change have resulted in significant threats to the digital communications system that all Americans rely on. For example, increasingly severe weather events have resulted in a corresponding 300% increase in internet blackouts in just the past decade. This is very likely to worsen over the next few decades. Complicating the problem is the fact that cloud computing has heightened our society's data dependence just as climate change threatens that data system.

Communications and digital connectivity networks are inherently redundant. NSF Indian Head and the Town/County operate and maintain separate communications and digital connectivity systems. If the commercial digital communications system that the community outside the base relies on were to be catastrophically impacted, it is possible that the installation's communications system will be unaffected.

NSF INDIAN HEAD/COMMUNITY INTERFACE

While digital communications are a concern for both the installation and the community, addressing ongoing digital communications and connectivity needs will require a mutually exclusive approach at times. Therefore, *the NSF Indian Head/Community Interface is relatively low*. NSF Indian Head has its own digital broadband system and is not dependent on commercial systems. As a result, digital communications are an ancillary resilience issue. It is important for the long-term economic development and viability of the community, but it is not an issue that impacts the installation's security or mission. In contrast, the outside community relies on commercial systems and, as a result, communications and connectivity are more susceptible to the impacts of climate hazards.

CLIMATE ADAPTATION

Communications and digital connectivity are *moderately vulnerable* to climate change impacts. The internet's redundancy makes it inherently resilient to physical climate threats. If part of the network goes down, data can be rerouted. In some respects, the disconnected nature of digital communication systems between NSF Indian Head and the surrounding community expands that redundancy. As a result, the primary climate hazard and risk associated with the region's commercial communications systems is to the Town of Indian Head. The internet infrastructure was constructed in the 1980s and 1990s using systems and buildings

in places designed to withstand the climate of the past (Gellerman, 2021). The climate of the future is already disrupting that system (ODNI, 2017). Climate change is increasingly stressing these systems, and those stressors in vulnerable communities like NSF Indian Head and the Town are especially at risk. Climate threats to coastal communities make the resilience of the internet susceptible.

MITIGATION, RESPONSE, AND RECOVERY

Communications capacity during disaster response is a primary concern. In the short-term, *robust communication systems are essential for disaster and emergency management*. Effective public communication of hazard information during crises is a critical factor for minimizing casualties and economic loss and in ensuring local communities recover successfully (ODNI, 2017). Broadband networks and communications systems also have a *significant impact on the long-term capacity* of communities to recover from acute events. Reliable high-speed connections are necessary for education, health, safety, and economic development. Natural disasters pose ongoing threats to broadband networks, which underscores the importance of linking NSF Indian Head and Town/County resiliency planning in broadband deployment strategies.

HOUSING AND STRUCTURES

Housing stability will be increasingly under threat as climate change intensifies. Housing is the primary determinant of people's financial security and generational wealth in the US. Housing is also the largest expense for families. Over 38 million US households live in housing that is not affordable to them. Unaffordable and insecure housing leaves families less able to cope with unexpected expenses. Both the frequency and recurrence of climate-related disasters have exacerbated affordable housing crises in areas prone to disasters. Without significant intervention, areas prone to climate-related disasters will continue to face housing instability (Gauthier, 2021).

The age of the housing and building stock on the peninsula exposes residents and business owners to climate risk. Though new homes are built with advanced technologies that make them more resilient than older homes, the lack of economic development on the peninsula means that many older homes and structures will be exposed to climate risks because of their location on the Cornwallis Neck peninsula.

NSF INDIAN HEAD/COMMUNITY INTERFACE

Housing has an indirect yet significant impact on the NSF Indian Head /Community Resilience Interface. The resilience of housing stock on the peninsula is *highly important*. Housing and structures must be able to withstand systemic and acute climate impacts, including catastrophic storm events, nuisance flooding, fire, and sea level rise. The susceptibility of structures to these hazards is in large part determined by their location.

CLIMATE ADAPTATION

Housing resilience is *directly connected* to climate adaptation; these connections are especially important in coastal communities. In addition to the inherent risk to structures and housing located in coastal communities, the quality and age of housing has a significant impact on structural resilience. Older structures, specifically those built before 2000, are less likely to have been built with state-of-the-art materials and standards that make buildings more resilient. Though local regulations requiring resilient building practices will transform the capacity of new structures to withstand climate threats over time, established communities like the NSF Indian Head study area — where most of the housing stock is older and built with less reliant technologies — will remain exposed to risk. There were nearly 5,700 homes in the Indian Head-Potomac Heights-Bryans Road-NSF Indian Head area according to the 2016-2020 American Community Survey (U.S. Census Bureau, 2022). Approximately 80% of the housing stock in the United States was constructed prior to the development and adoption of the 2000 International Residential Code (IRC) and subsequent editions. Within the study area, 75% of the housing was built prior

to 2000. The benefits of retrofitting older existing homes and structures to improve their resistance and resilience to climate hazards exceed that of increasing code requirements for newer builds (FEMA, 2020).

Buildings designed and constructed to modern building codes withstand the effects of natural hazards better than buildings that are not. A 2019 study by the National Institute of Building Sciences found that adopting model building codes saves $11 per $1 invested (NIBS, 2019). In practice, FEMA estimates that approximately 70% of all new buildings are constructed to model buildings standards. The average annual losses avoided (AALA) from post-2000 buildings built to these higher building standards is $1.6 billion. If the remaining post-2000 buildings were built to model standards, the current AALA would double to $3.2 billion. If the remaining 80% of pre-2000 buildings were built to model standards, AALA would increase to $15 billion (FEMA, 2020). As the momentum for new buildings increases, the County can further strengthen new buildings using zoning mechanisms that require them to be built in locations that would last at least 50 years based on continued documented erosion rates.

MITIGATION, RESPONSE, AND RECOVERY

Housing and structures will be *directly impacted* by climate hazards. However, there are also additional indirect relationships between housing and community resilience. The quality of housing stock in Indian Head is in large part a result of the economic development issues that have defined the community for decades. The Town of Indian Head was once a thriving small town during the World War II years and up until the late 1960s. The construction of St. Charles, a large, planned community south of nearby Waldorf, brought with it retail chains and big-box stores, which eventually led to the demise of local businesses within the Town of Indian Head (ULI, 2016). Because Indian Head has struggled to attract new business and industries, there is little incentive on the part of real estate owners to revitalize current buildings and structures, which in turn makes them more susceptible to climate hazards and impacts.

ENERGY GENERATION AND DELIVERY

A climate-resilient energy generation and delivery system capable of recovering from natural hazards provides energy security. Electricity is an integral part of virtually every community, supporting a range of critical services. As a result, a secure supply of electricity is an important element of every community resilience action plan. Climate change directly affects every segment of the electricity system altering generation potential and efficiency, testing physical resilience of transmission and distribution networks, and changing demand patterns. Effective policy measures and coordinated action among key actors play a central role in building resilience to climate change (IEA, 2021).

NSF INDIAN HEAD/COMMUNITY INTERFACE

Energy generation and delivery have a *high impact* on the community interface. NSF Indian Head maintains its own energy infrastructure to support specific activities. However, the installation and community largely depend on the commercial grid for energy. That grid is vulnerable to disruption from aging infrastructure, weather related events, and possibly direct attack.

Approximately 70-75% of NSF Indian Head's electricity and 100% of electricity at the Stump Neck Annex is provided by the Southern Maryland Electric Cooperative (SMECO) (J. Bossart, Personal Communication, May 3, 2021). Additional electricity at NSF Indian Head is provided by an on-site natural gas cogeneration facility which was installed in 2015 to replace a previous coal-fired Goddard Power Plant. The new cogeneration facility provides steam, compressed air, and 3.5 megawatts of electricity. The Draft Environmental Assessment clarifies that this is a decentralized supply and distribution system with one primary nodal plant and seven secondary steam nodal plants. The new system was expected to "cut… water consumption by 75 percent, and steam requirements by 80 percent" (Naval Support Activity South Potomac, 2013, p. 2). The primary purpose of the cogeneration facility is to produce steam that is utilized in the explosive

manufacturing process, with heating as a secondary use. The new system also cut energy use by approximately 40% (J. Bossart, Personal Communication, May 3, 2021).

CLIMATE ADAPTATION

Electricity generation and delivery have a high impact on community climate adaptation and resilience efforts. Power grid resilience refers to how well the grid can function when one or some of its components are disrupted. Research shows that an updated power grid might be able to withstand disruptions, such as from extreme weather events or even nefarious attacks, in the performance of some of its components (Hébert, 2021).

MITIGATION, RESPONSE, AND RECOVERY

A climate-resilient electricity system that is able to recover from adverse climate impacts provides greater energy security. Climate change directly affects every segment of the electricity system altering generation potential and efficiency, testing physical resilience of transmission and distribution networks, and changing demand patterns. Effective policy measures and coordinated action among key actors play a central role in building resilience to climate change (IEA, 2021). A resilient power system, as defined by the U.S. Department of Energy (DOE)'s Grid Modernization Initiative and the National Academy of Sciences, must be capable of lessening the likelihood of long-duration electrical outages occurring over large service areas, limiting the scope and impact of outages when they do occur, and rapidly restoring power after an outage (DOE, no date).

ASSET CATEGORY 2: ECOSYSTEMS AND NATURAL ASSETS

Natural assets such as forests, wetlands, and coastlines are increasingly being recognized as important tools for climate change adaptation and mitigation (Shaw et al., 2020). Sustainable and resilient communities require sustainable and resilient natural systems. Natural systems are important for the ecosystem services they provide, which benefits not just wildlife but human and community systems. Their capacity to absorb changes and pressures ensures that communities can sustain a reasonable flow of benefits over time.

Solar panels cover the roof of a store in a commercial development in Middle River, MD

Mattawoman Natural Environmental Area in Charles County, MD

Climate change is impacting natural systems in ways that are not fully understood. Policies intended to address these challenges fall into one of three categories: 1) natural resource management; 2) linking natural resource management with broader community development goals; and 3) monitoring long-term sustainability. This assessment addresses climate impacts to critical natural assets within two broad categories: aquatic ecosystems and land use and development.

AQUATIC ECOSYSTEMS

Aquatic ecosystems include wetlands, coastal zones, and streams. Nature-based solutions for coastal resilience include protecting natural resources plus adding engineered habitats and restoration practices where development has replaced natural features. Coastal forests, wetlands, beaches, dunes, restored streams, riparian buffers and living shorelines provide multiple benefits for coastal communities, including storm protection, soaking up floodwaters, improving water quality, providing recreation areas and maintaining important habitats (CCRM VIMS, 2021).

NSF INDIAN HEAD/COMMUNITY INTERFACE

Aquatic and natural resource restoration and protection is *directly connected* to the region's resilience efforts. Much of the Indian Head peninsula lies within the Mattawoman Creek watershed — a regionally unique and pristine ecosystem located primarily within Charles County. As a result, the installation and the Town are in large part defined by coastline. More than 16 miles of coastline borders the installation, and 31 miles lie around the Town of Indian Head. NSF Indian Head has stabilized approximately 17,100 linear feet of shoreline, providing protection for critical infrastructure and testing areas. The shoreline stabilization also protected environmental benefits for water quality and enhanced wildlife habitat.

CLIMATE ADAPTATION

Coastal erosion has a direct impact on regional resilience. It is likely to be the most pressing climate threat to the peninsula and its natural resources — particularly around NSF Indian Head. Stormwater management and flooding are also likely to become more significant threats. However, the processes for restoring

and protecting these resources are often not integrated. The installation, the Town, and the County have active conservation and restoration activities and projects in place, yet there has historically been a lack of coordination among those disparate programs. In addition, these restoration efforts lack a cohesive, consistent, and robust financing and funding strategy, thereby making implementation completely dependent on sporadic state and federal funding programs.

MITIGATION, RESPONSE, AND RECOVERY

It will be important for Charles County to continue its shoreline restoration efforts as identified in its 2018 Assessment and Shoreline Management Plan (Southern Maryland RC&D, 2018) — reviewing and amending as-needed to ensure that new and improved data on sea level rise and other local circumstances are incorporated. It is also important that NSF Indian Head, the Town, and the County work collaboratively on these efforts. Around NSF Indian Head, in particular, care should be taken to ensure that potentially contaminated sites in close proximity to the shoreline are evaluated and mitigated to eliminate the potential to contaminate high tide water as sea levels rise.

ASSET CATEGORY 3: KEY COMMUNITY SERVICES

As extreme weather exacerbated by climate change continues to disrupt the delivery of potable water, power, and other services, government agencies must prioritize climate resilience and the ability to respond, recover, and adapt to the adverse effects of climate change. Agencies and public service providers are institutionalizing climate resiliency by linking climate action to their missions, future-proofing critical infrastructure, embedding environmental justice in their programs, collaborating with public and private partners to unlock collective action, and enhancing their data analytics capabilities to prepare for future climate disruptions (Chew et al., 2022). This assessment addresses community services that are essential for the immediate response to climate disasters as well as the long-term sustainability and continuity of community development. Key services include emergency management; access to safe potable water; solid waste management; stormwater management; and flood mitigation.

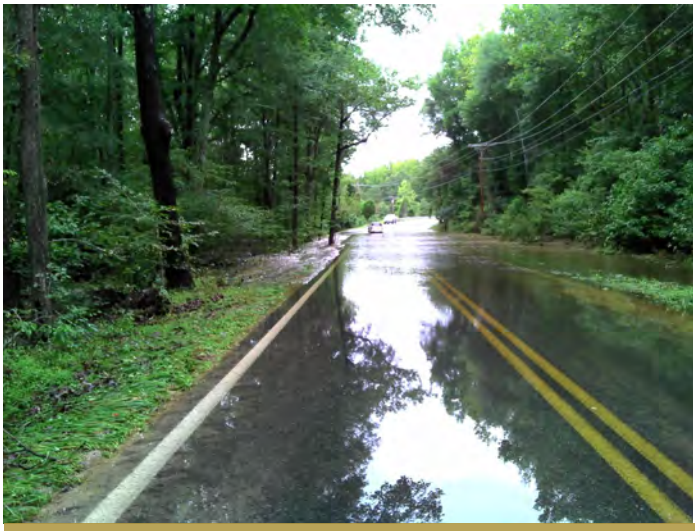
STORMWATER MANAGEMENT AND FLOOD MITIGATION

Many of the current and projected climate change impacts within coastal communities will increasingly exacerbate flood risks. More intense rainfall and increases in precipitation mean flooding is and will remain a key concern for municipalities. Counties and municipalities are fully or partly responsible for managing many of the assets and drainage systems that make our everyday life across the region possible. Local governments also influence where buildings get located and how they are built; therefore, local governments play a central role in determining if and how communities will address flooding issues and risks moving forward.

NSF INDIAN HEAD/COMMUNITY INTERFACE

While current stormwater management and flooding conditions are manageable within the community, there is the *potential for significant resilience impacts in the future*. The draft Charles County Climate Resilience Work Group report issued in 2020 states that the County, and by extension the NSF Indian Head area, can expect to experience more severe flooding from extreme weather events and sea level rise over the next decade. During significant flooding events, NSF Indian Head's operations at Stump Neck Annex can be impacted as was the case in the early 2000s, when the Fire Department was relocated to minimize flooding impacts.

In recent years, high-intensity, quick duration storm events have become more frequent and impactful. These storm events bring quick, heavy rains and high winds. As the severity of these storms increases, so too will be the impacts to the County's residents and businesses. All planned and future development is generally



Urban flooding in Charles County, MD

sited external to tidal floodplains and areas known to be prone to significant flooding. Stormwater programs are so heavily focused on water quality it can compromise flood control.

CLIMATE ADAPTATION

Charles County released the Charles County Nuisance and Urban Flood Plan in October 2020. That plan directly addresses the impacts of flooding and stormwater management at the community level, including flooding hazards that are exacerbated by climate change. The plan's purpose was "to identify sources of nuisance and urban flooding, analyze flood hazards, and recommend actions to reduce flooding and increase community resiliency" (Charles County, 2020, p. 1). The plan defines nuisance flooding as flooding associated with high tides causing storm drain backflow, groundwater inundation, and direct marine flooding.

Nuisance flooding is becoming an increasing problem in Charles County as sea levels rise. The plan noted that tide gauge measurements show that the sea level along Maryland's coastline has risen at an average rate of 3-4 mm per year (one foot per century). Based on 2018 Sea Level Rise Projections for Maryland, future rates of sea level rise along this coastline are expected to rise by 2 to 4.2 feet by 2100 from the baseline year of 2000 if greenhouse emissions continue to increase.

MITIGATION, RESPONSE, AND RECOVERY

Nuisance and tidal flooding are likely to impact community resilience moving forward. As a result, the County's Nuisance and Urban Flood plan is directly connected to the 2018 Charles County Hazard Mitigation Plan (HMP) Update, specifically as it relates to anticipated sea level rise impacts across the County. As per the HMP update, some areas of Charles County have the potential to experience 5-to-10-foot inundation. Sea level rise impacts are projected to be the greatest in the areas surrounding the Mattawoman Creek, the Nanjemoy Creek, the Potomac River, and the Wicomico River. The mitigation plan update also shows that the shoreline is highly vulnerable to nor'easters, tropical storms and hurricanes, particularly when lasting 24 to 48 hours and accompanied by high winds and storm surges.

POTABLE WATER USE

Climate change manifests itself through changes in the water cycle. As the climate changes, droughts, floods, melting glaciers, sea-level rise and storms intensify or alter, often with severe consequences (IUCN, 2015). With heavier downpours and rising sea levels, the resulting floods could mean more potable water — or drinking water — contamination. Heavy rain led to more than one billion gallons of sewage overflow in 2015-2016 in the U.S., according to a 2016 Climate Central report (Kenward et al., 2016). As climate change supercharges the water cycle, major downpours will happen more — as seen in the rainfall records this winter and last year. On the coasts, rising seas can accelerate the push of saltwater into underground wells (USGS, 2019).

NSF INDIAN HEAD/COMMUNITY INTERFACE

Water resources are critical to both NSF Indian Head and the surrounding community. The region's water resources are primarily controlled by Charles County and the State of Maryland. To date, the County, its communities, and NSF Indian Head have relied primarily on groundwater resources from deep aquifers for drinking water. More than 80% of the County's potable water is supplied by deep-water aquifers that are recharged in Fairfax, Prince William, and Stafford Counties. The remaining 20% (approximately 1.4 million gallons per day) is supplied by surface water purchased from the Washington Suburban Sanitary Commission (WSSC).

In the future, this ratio will shift. The County's agreement with WSSC allows it to purchase an additional 5 million gallons per day of surface water. In addition, the County is currently evaluating the feasibility of establishing a new surface water source on the Potomac River. The result will be a more redundant and resilient water system. Both NSF Indian Head and the Town of Indian Head previously drilled deeper wells for drinking water to free up water in the upper aquifer. The Joint Land Use Study states that "[g]roundwater use is limited due to aquifer drawdown, impacting both the Town of Indian Head and NSF Indian Head. Increased demand and development in the aquifer could influence water availability in the future and put more pressure on the Navy to find alternative solutions" (Charles County, 2016, p. ES-2). The anticipated increase in surface water use will reduce groundwater withdrawals County-wide, which will make the water sources that NSF Indian Head, the Town, and the larger study area rely on more sustainable.

It should be noted that shifting to an over-reliance on surface water can expose these communities to additional risks. Specifically, surface water systems are susceptible to the impacts of drought, heat, and algal blooms. A redundant and diverse water system will ultimately prove to be the most resilient.

CLIMATE ADAPTATION

While climate change represents a moderate threat to water resources on the peninsula, the County has developed a long-term water use plan that will shift its almost singular reliance on groundwater to a surface water system. This in turn will take pressure off the aquifers that both NSF Indian Head and the Town rely on, which in turn will create long-term redundancy and resilience in the region's water use system.


Mattawoman Creek in Charles County, MD

RECOMMENDATIONS

The NSF Indian Head community has a strong foundation in place to develop a long-term resilience action plan. The collective planning and implementation processes among the installation, the Town, and the County provide the capacity to address existing and short-term infrastructure, social, and environmental needs. However, the anticipated scale and complexity of addressing future climate change impacts will require each community to make changes in how long-term planning and project implementation are coordinated. This will be especially important as the need for joint resilience infrastructure protection and implementation become more likely as the impacts of climate change increase. In addition, the strategy provides next steps associated with addressing climate hazards that will likely impact the built environment; natural resources; and key community services.

RECOMMENDATION 1

Establish an NSF Indian Head Resilience Action Collaborative (Collaborative) to provide a consistent and sustained forum for advancing climate resilience policies, programs, and infrastructure development projects across the Cornwallis Neck region.

Over the past 18 months, the greater NSF Indian Head community has established a process to assess the risks and opportunities associated with climate resilience. Formally launching the Collaborative will enable this process to continue. Its purpose should not be to replace existing collaborations and partnerships or to create administrative redundancies. Rather, the Collaborative should be designed to build on existing processes by advancing environmental, economic, and social interventions that result in a civic infrastructure development system which is genuinely resilient into

the future. Characteristics of this system include the following:

- Informed by science and data. The NSF Indian Head resilience system must be informed and reflective of the science, trends, and the unique nature and experiences of each community partner. The Collaborative should be a forum for continually assessing the most up-to-date science and trends impacting the region's infrastructure and economy.
- Integrated. The system must be able to integrate the needs, issues, concerns, and opportunities of each jurisdiction. In addition, the decisions, deliberations, and recommendations that result from the Collaborative's processes and discussions must be informed and embraced by the highest-level decision-makers within each community. Collaboration has defined this project from its inception and should continue as it evolves into a more formal system.
- Resourceful and efficient. The region's community resilience planning efforts must be able to leverage and combine the resources and capabilities of each jurisdiction. This is perhaps the greatest opportunity and challenge facing the Collaborative and the region's leaders: leveraging mutually exclusive yet complementary resources and capacities.
- Redundant and robust. The climate resilience policy and decision-making system must be redundant to ensure that the region's long-term economic, social, and environmental viability are not disproportionately reliant on relatively few infrastructure systems. Redundancy is essential for long-term resilience but can be inefficient if not approached purposefully.

THE ROLE AND FUNCTION OF THE COLLABORATIVE

The primary role of the Collaborative should be to ensure that resilience planning and implementation systems represent and advance the community's key needs and characteristics. This will require the Collaborative to focus on three core functions:

- Provide continuing dialogue among key entities. The most important outcome associated with this project was the consistent dialogue and engagement of the key entities: NSF Indian Head, the Town of Indian Head, and the County, which represented the unincorporated areas of Potomac Heights and Bryans Road and the county-at-large. While reports, data, and information are essential for informing decision-making, coordinated decision-making requires genuine dialogue and interaction. These interactions should be continued and facilitated by the Collaborative.
- Coordinate resilience planning and implementation. Each jurisdiction has capacities and resources to address many acute and long-term climate resilience needs. However, individually, no one community has the capacity and resources that are required for ensuring long-term resilience across the peninsula. This will require pooling capacity.
- Advance project funding and financing processes. While coordinated planning is essential, the Collaborative provides a unique opportunity for ensuring collective action. This includes identifying appropriate funding and financing resources in support of critical climate resilience programs and infrastructure projects. It is likely in the long-term that joint funding and financing will be necessary to mitigate the impacts of climate hazards and to address emergency management and disaster recovery needs. The Collaborative can serve as an

important mechanism for negotiating and executing multi-jurisdictional project development, implementation, and financing processes. In the short-term, the Collaborative has the potential to be an effective mechanism to secure grant funds.

COLLABORATIVE STRUCTURE

There are several approaches that can be used to structure and manage the Collaborative. For example, the three entities could establish a formal institutional collaboration. While these types of collaborations do not require establishing and incorporating a new institution, they often function in much the same way. For example, the Greater Miami and the Beaches (GM&B) collaborative was launched by Miami Dade County, the City of Miami, and the City of Miami Beach through the support of a grant from the Rockefeller Foundation. Leadership is provided by the resilience directors/officers within each jurisdiction. Advice and technical support is provided by community leaders, academic institutions, and community-based nonprofits from across the region. The implementation and financing of infrastructure projects and programs is the responsibility of each jurisdiction. Resilience planning and inter-jurisdictional coordination is guided by the Resilient 305 plan produced by GM&B and its partners.

A formal institutional collaborative would provide extensive capacity and structure; however, it would also require significant fiscal and human resources relative to other structural and organizational options. Long-term funding and resource needs can be reduced by establishing a project-focused collaborative, such as the Joint Land Use Study (JLUS) process. The JLUS process brings together multiple jurisdictions, entities, and stakeholders within a defined study area. As is the case with the GM&B, the JLUS process resulted in action plans to be implemented by the community. While the JLUS process may lead to further collaborations, it does not require the establishment of an independent institution.

Perhaps the most cost-effective approach is a program-focused collaborative that require a program or department within one of the participating institutions to serve as the secretariat and organizing entity. The program approach provides the structure and long-term capacity like the institutional approach without the expense and resources of launching a new venture. The Charles County Resilience Authority is well suited for organizing and managing the NSF Indian Head Resilience Action Collaborative.

RECOMMENDATION 2

Expand upon the existing regional climate resilience and community planning process by developing a multi-jurisdictional climate resilience project portfolio and action strategy.

The Collaborative's first step should be to establish a multi-jurisdictional portfolio of climate resilience projects and programs. The strategy should be designed to accelerate action around the built environment, natural resources and assets, and key services and community functions. It should accelerate project implementation associated with the three key resilience priorities: proactively mitigating the impact of climate hazards; ensuring robust emergency response to disasters and catastrophic events; and facilitating and incentivizing long-term recovery after catastrophic events.

An effective action strategy and project portfolio will include a combination of planning and coordinating activities that are directly implemented by the Collaborative, as well as recommendations for structural and capital infrastructure projects to be implemented by the three entities. The Collaborative's action strategy should build upon existing planning processes such as the Joint Land Use Study, County and Town comprehensive plans, and the Charles County Hazard Mitigation Plan by providing an expanded resilience overlay. The Collaborative should further coordinate with the Resiliency Authority to prioritize projects and efforts.

The project portfolio will evolve over time as climate impacts intensify and the resilience priorities are refined. In the short-term, the project team identified ten specific action strategies to provide a starting point for a regional resilience process.

PORTFOLIO STRUCTURE

Establishing a project portfolio based on a risk and vulnerability assessment, coupled with the asset inventory, will enable local and Base leaders to codify a resilience plan of action. The action plan should be organized around three key elements: (1) project and programs typology, (2) the anticipated timing of impacts and associated project implementation, and (3) the expected cost of taking action.

RESILIENCE PROJECT TYPOLOGY

Local resilience projects can take a myriad of forms. From a management perspective, they can be categorized based on three typologies.

1. Baseline projects and programs provide structure to the region's resilience system, including staffing support, necessary studies and assessments (such as ongoing risk and vulnerability analyses), as well as project implementation.
2. Enterprise or outcome-based projects and programs focus on essential local government services. Conversations with key experts during this project's discovery phase indicate that climate resilience projects will overlap a variety of enterprise programs and outcome-based needs, especially at the county level. This includes wastewater/watershed management, drinking water management and delivery, emergency services, and stormwater/drainage mitigation. Each of these is codified through an established enterprise program/fund and will be impacted by collective resilience implementation processes.
3. Capital and infrastructure projects are a primary focus of the resilience financing process. These projects can be embedded within baseline or enterprise processes, but they are often implemented because of specific community needs, including:
   - Protecting essential assets. The most targeted project approach is associated with protecting assets threatened by climate change. Within the NSF Indian Head study area, this includes mitigating built infrastructure — including roads and structures — and addressing coastal erosion.
   - Protecting an asset class or system. Many community resilience projects are designed to protect a suite of assets within a system. This may include protecting road and transportation networks, residential and commercial buildings, or essential public utilities. Projects designed to protect an asset class are often coupled with regulatory or permit changes (e.g., building codes, floodplain management).
   - Protecting threatened geographies or communities. Large-scale resilience projects are often designed to protect specific communities or neighborhoods from climate hazards and threats. Projects can include flood mitigation/abatement and transportation enhancements.
   - Incentivizing outcomes. Finally, resilience projects may be designed to address a particular hazard or a desired outcome. These projects are often associated with enterprise fund activities, but they can also include other community priorities such as habitat restoration and protection.

PROJECT TIMING

Climate impacts are expected to evolve and intensify over time. Responses will also need to evolve. This requires that the resilience systems and processes — including financial — be dynamic. The project portfolio should address short-, mid-, and long-term implementation

needs and time horizons. Categorizing projects in this way will be critical for creating a sustainable revenue plan.

- Short-term (0-3yrs). This category represents the immediate infrastructure and financing needs. The financing components necessary to address short-term needs include:
  - Codified, stable funding streams, supported by general obligation bonds and general funds or through enterprise programs and dedicated fees; and
  - A clear understanding of the project's useful life, i.e., how long the project will sufficiently address changing resilience needs.
- Mid-term (3-15yrs). The mid-term category includes infrastructure or systems to replace or augment existing ones. This category will likely get larger over time. Revenue streams to support mid-term needs are not necessarily required immediately, but the processes for generating future revenue and investment should be put in place now.
- Long-term (15yrs+). This category includes investments in major infrastructure projects to address the most significant climate impacts such as sea-level rise, temperature and precipitation changes, and catastrophic storms. Community leaders should begin establishing the necessary financing systems and processes in the short-term with a vision towards the long-term. This includes establishing the conditions necessary for investment, identifying anticipated revenue streams, and building capacity by establishing appropriate financing institutions.

ANTICIPATED PROJECT COSTS

Cost estimation is the process of forecasting the fiscal resources needed to complete a project within a defined scope. It accounts for each project element to determine a project's overall budget. Cost estimates for projects within each category will be needed to estimate revenue needs and to project scheduling. As climate resilience infrastructure projects move through the design and implementation process, it is essential to accurately account for all direct and indirect expenses, including labor, materials and equipment, facilities, and all associated risk. However, the initial resilience planning and implementation processes require a high-level or cursory evaluation of project costs, within each category over time. This high-level evaluation will enable the Collaborative to identify the appropriate institutional and revenue systems necessary for achieving long-term resilience.

PORTFOLIO ACTION STRATEGY

BUILT ENVIRONMENT

Action Strategy 1: Develop a comprehensive transportation resilience plan with a specific focus on Route 210.

Route 210 functions as the main route onto and through the peninsula. Priority should be given to establishing a long-term resilience plan for Route 210 as well as alternative ancillary roads and arteries across the peninsula. A long-term regional transportation resilience plan would enable NSF Indian Head, the Town, the County, and state transportation officials to ensure the long-term viability of Route 210 and a connected road network.

In the short-term, the County should evaluate local design storm criteria and ongoing operations and maintenance activities to account for the anticipated impacts of climate hazards, including excessive heat, precipitation, and catastrophic storm events. In the mid- to long-term, the County should address the land constraints within the peninsula that limit the ability to establish a multi-modal transportation network (including walking, cycling, and public transit). Track new technologies and transportation options as they evolve. This includes water-based public transportation such as a regional ferry system.

Action Strategy 2: Assess the risk and vulnerability of key emergency response assets to the impacts of climate hazards.

Emergency response assets are the foundation of the greater NSF Indian Head community's climate resilience capacities. Establishing a plan to protect emergency response structures and associated assets is critical. This includes the three fire stations that serve the peninsula:

- Indian Head Volunteer Fire Department and Rescue Squad/EMS (Company 9);
- Potomac Heights Volunteer Fire Department and Rescue Squad/EMS (Company 7); and
- Naval District Washington Fire Department and EMS (Station 20).

It also includes Indian Head Town Hall, which houses the Town's emergency response systems. These four structures represent the region's primary capacity to respond to disasters and the acute impacts of climate change. In the short-term, the assessment should address the vulnerability of the structures to catastrophic flooding and storm events and their capacity to withstand excessive heat and prolonged power outages. It should also provide the basis for a detailed plan to ensure the long-term resilience of each structure.

Action Strategy 3: Conduct a survey of commercial and residential buildings — both public and private — to identify those that were built prior to 2000.

Ensuring the resilience of key emergency response assets is a top priority. However, the Collaborative should also address the long-term resilience of the greater NSF Indian Head's public and private structures. According to the 2016-2020 American Community Survey results, 75% of all housing in the project study area was built prior to 2000, potentially making them more prone to damage in weather-related disasters. In the short-term, it is recommended that a survey of the region's structures be conducted to better understand the location and age of structures to determine their susceptibility to loss from natural disasters, including catastrophic storms, excessive heat and temperature extremes, and nuisance flooding.

A study should also be conducted to determine potential flood risks facing individual properties — both inside and outside the designated 100-year floodplain —including an analysis on prior weather-related damage and how that risk may change into the future. Nuisance and urban flooding are not currently widespread problems within the area. However, given the proximity to water, the poor drainage of the soils in many areas, projected precipitation increases, and sea level rise, this is expected to become more problematic. Particular attention should be paid to the potential impact to affordable housing units and low-income homes. Tracking and identifying mitigation and financing options should be a priority. Many of these impacts will occur on private property, making them difficult to address through public stormwater and flood reduction programs. The County's Resilience Authority is likely to play an increasingly important role.

Action Strategy 4: Develop and implement a public outreach awareness program associated with addressing climate risks and vulnerabilities on private property.

An important outcome of the survey of public and private structures is a much clearer understanding of where resource needs exist among residents and businesses. This will enable the Collaborative to establish a targeted community outreach and engagement program to connect residents and businesses to resources and opportunities to make residences and other structures more resilient and secure. Outreach efforts should focus on creating awareness regarding acute hazards and catastrophic event preparation and relaying information on actions that home and business owners can take to protect buildings and structures. It is also important to connect homeowners to potential funding resources that may help support resilient projects and building upgrades.

Action Strategy 5: Develop a regional resilient energy strategy.

The greater NSF Indian Head community relies almost exclusively on the regional electric grid for its energy needs. As the co-generation facility on NSF Indian Head demonstrates, there are options for the community to improve the resilience, security, and long-term reliability of the region's energy delivery system. A first step is to create a regional energy resilience plan under the Collaborative's guidance. The purpose is to identify opportunities to reduce energy usage and create system redundancy to buffer potential weather-related impacts to the grid itself. The focus is two-fold:

1. Identify energy reduction and renewable energy options that reduce energy usage of and costs to the Town of Indian Head municipal government, local businesses, and residents. The Collaborative should work in partnership with regional renewable energy contractors to create awareness of the benefits and options associated with on-site solar energy and back-up power systems. Given the age of many structures on the peninsula, implementing energy efficiency actions on a building-by-building basis will make homes and structures more resilient and efficient regarding energy usage, resulting in a decrease in costs associated with hazard recovery and long-term energy needs. This, in turn, will make housing more affordable moving forward and reduce carbon emissions.
2. Commission a study to determine the potential value of an emergency microgrid system to support key community functions during disaster situations. A microgrid is a small, controllable power system with one or more generation units connected to nearby load that can be operated either with or independently from the local distribution and bulk transmission system. Microgrids can run on a variety of power sources such as renewables or emerging sources such as fuel cells (C2ES, 2017). A microgrid would enhance community resilience, especially in disaster situations, by providing power to fire stations, emergency communications centers, and nearby cell towers. If the main grid shuts down, a microgrid can operate in island mode, keeping the power on. In short, a microgrid would enable the three entities to protect public safety and minimize hardships to their residents and businesses during power outages. Finally, a microgrid would enable residents and businesses, as well as the NSF Indian Head Base and the Town of Indian Head government to reduce long-term energy costs by reducing peak energy demands from the grid.

There are a variety of funding and technical assistance programs available related to renewable energy options, back-up energy systems, and long-term energy resilience and security. Information on the resources available to residential and commercial customers can be relayed through the public outreach program (Action Strategy #4).

AQUATIC ECOSYSTEMS

Action Strategy 6: Create and implement a multi-jurisdictional aquatic resources restoration and protection plan.

Coastal and low-lying areas are at a greater risk of flooding as sea levels rise. Charles County will also experience increased coastal erosion, higher water tables, and salt water intrusion. Hardening shorelines can help guard against coastal erosion and protect low lying areas, but they can also negatively impact aquatic and wildlife habitat and leave other areas at greater risk. Softer shoreline protection measures use materials such as aquatic vegetation, sand, and stone to absorb wave energy to minimize coastal erosion. They also provide valuable fish and wildlife habitat (MD DNR, No date).

NSF Indian Head, the Town, and the County have all have experience establishing living shoreline projects along the coastline. Furthermore, in 2018, Charles County commissioned a comprehensive shoreline assessment and management plan to identify and prioritize public and private shorelines in need of restoration to help the County meet its stormwater permit goals (Southern Maryland RC&D, 2018). It is recommended that the plan be updated to incorporate sea level rise projections in the assessment and prioritization process to ensure that the shoreline is more resilient to sea level rise. This plan should be utilized to seek design and implementation funds, starting with high priority projects. Establishing preservation or conservation areas in highly vulnerable areas may also minimize the risk of their future development. The County and Town should also coordinate with the NSF Indian Head Environmental Restoration Program on aquatic and shoreline restoration projects along NSF Indian Head's border.

COMMUNITY SERVICES

Action Strategy 7: Create a long-term water resource access plan. There are no resilience issues more important than those associated with access to water resources.

Water resource management is complex and influenced by a variety of institutional, geological, and environmental conditions. Ensuring the long-term viability of NSF Indian Head and its mission and the economic resilience of the Town and surrounding community requires a long-term planning approach and horizon. The Collaborative's goal should be to facilitate a conversation to address likely long-term needs, the resources and technologies necessary to address them, and the projected impact of climate change on the supply and delivery of water resources.

The withdrawal and use of surface and groundwater is controlled by the state. NSF Indian Head, the Town, and the County coordinate individually with the state on water use permit. As demands grow due to population and climate change, it is desirable for the three entities to work together to ensure water use and availability is equitable and sustainable. Recently, the Charles County government worked with consultants to establish near- and long-term plans for the future of the county's water supply. The purpose is to improve the resilience of the system well into the future. Given the importance of this resource to the NSF Indian Head community at large and the likely economic and financial impacts of anticipated changes and modifications to that system, continued dialogue amongst NSF Indian Head, the Town, and County leaders is essential. The Collaborative would provide an effective forum for continuing these important discussions moving forward.

EMERGING ISSUES

Action Strategy 8: Create an ongoing forum and dialogue regarding emerging economic, social, and environmental issues.

In addition to its serious impacts on infrastructure and the environment, climate change poses a threat to people and economic stability. It is recommended that the Collaborative track ongoing economic and social issues that are most likely to impact community resilience within the greater NSF Indian Head community. There are four issues that emerged from this project that should be addressed moving forward.

- Local economic development. The Town and NSF Indian Head have taken great strides to expand economic development. One immediate need is convenient access to a grocery store. Indian Head is a small community located on a peninsula. There is limited through-traffic to drive commercial and retail activity. The area has lacked a grocery store for over 20 years. Two opportunities discussed during this project's outreach process were the making connections with local agricultural producers and the imminent opening of a fresh food market old Algonquin building.

- Solid waste management and landfill capacity. Solid waste services are managed by Charles County. The county's current landfill may reach capacity within the next 7-10 years, at which point the County must either open a new landfill or export its solid waste (Charles County, 2021). Given the importance solid waste management services have on growth and development within Bryans Road and the Town, in particular, the Collaborative should support continued dialogue amongst the Town and County jurisdictions and NSF Indian Head. Ongoing conversations should address the impact of growth and opportunities to reduce demand on existing landfill capacity.
- Route 301 bridge expansion. The expansion of the Harry W. Nice Memorial Bridge (Route 301) will not directly impact NSF Indian Head. However, there are anticipated issues associated with its expansion that will indirectly impact the community. Specifically, it is expected that the amount of hazardous material transported through the region will increase. The Collaborative should work with each jurisdiction, the state, and possibly Virginia agencies and communities to establish a long-term plan to effectively manage this evolving community and environmental risk.
- Regional economic development / Morgantown Generating Station. The closure of the region's last coal-fired power plant has been hailed a victory by environmentalists. There is a need, however, to promote job-creating investments and spark new economic activity to counteract the loss of jobs. The site's proximity to NSF Indian Head and NSF Dahlgren make it ideal for encouraging defense-based economic development opportunities such as supporting innovation or providing manufacturing capacity to benefit the missions of the federal facilities.

RECOMMENDATION 3

Develop a long-term regional climate resilience implementation funding and financing strategy.

Finally, the Collaborative should help identify, organize, and acquire funding necessary for resilience activities. Most of the funding and financing activities associated with implementing regional climate resilience projects will be the responsibility of the individual jurisdictions. While there may be opportunities for co-financing projects in the future, the Collaborative's role will likely be associated with coordination and joint planning activities. That said, there are immediate and significant opportunities for the Collaborative and the three jurisdictions to secure federal, state, and philanthropic grant funding to launch critical resilience infrastructure projects.

THE COLLABORATIVE'S ROLE

Local governments have traditionally paid for community services, programs, and capital projects by tapping into an array of complex local, state, and federal funding sources and an equally complex system of private financing mechanisms. Private financing mechanisms include bonds, public/private partnerships, and grant funding. Addressing the impacts of climate change has and will continue to increase the complexity of these financing processes.

Effectively mitigating climate impacts will result in significant pressure on already-stretched public budgets and fiscal resources. There is just not enough public revenue available for local governments to address existing infrastructure development needs. Mitigating the impacts of climate change has the potential to add pressure to existing revenue shortages. More new revenue sources will be needed to address climate impacts rather than just reallocating those sources that already exists. Most of this new money must ultimately come from the public sector.

Further exacerbating the scarcity of public revenue will be the increased risk and

uncertainty associated with climate change impacts. Uncertainty disrupts funding and financing processes, including revenue flow. In addition, there are real uncertainties associated with the performance of capital projects over time. This uncertainty extends to the scale and nature of future climate impacts as well as the potential benefits of infrastructure investments. The greater NSF Indian Head community must work collaboratively to make some very difficult and nuanced policy decisions. For example:

- Balance cost and benefit. Resilience infrastructure projects designed to anticipate and mitigate future climate impacts require balancing very significant short-term costs with equally significant long-term gains. It is difficult to transform avoided costs into cash flow, which again puts significant pressure on local revenues.
- Achieve fairness in the financing system. Fairness regarding infrastructure financing assumes that the cost burden reflects the benefits received from a project. This is difficult to achieve when public revenues create significant private benefit in very specific places. This challenge is heightened when multiple jurisdictions support project financing collaboratively.
- Ensure equity in the financing and implementation process. Similar to fairness, achieving equity in the financing system has the potential to complicate resilience efforts. The ability of all citizens to pay for public funding projects is a persistent issue regarding infrastructure financing, and it is often at odds with achieving fairness.
- Expand cooperation. Addressing climate change will requires a level of cooperation among two jurisdictions (Town of Indian Creek and Charles County) and one federal facility (NSF Indian Head). The communities must engage within a complex system that includes intra-community collaboration among agencies (planning, budgeting and finance, operations, legal) as well as inter-community engagement and implementation.

This is the policy environment in which the Collaborative must engage. In short, the role of the Collaborative will be to work in partnership with County, City, and NSF Indian Head leaders to develop funding and financing policy, improve communication and community action, and to work collaboratively to bring the best and most efficient projects through the planning and implementation process. This in turn will require the following (Berkowitz, 2014):

- Work across government departments to help a city improve internal communications and collaboration.
- Bring together a wide array of stakeholders to learn about local challenges and help build support for individual initiatives, and for resilience building in general. These stakeholders include government officials, and it is critical that representatives from the private sector, non-profits, and civil society are also included.
- Lead local resilience strategy development, thereby engaging a wide variety of stakeholders, to help identify the city's resilience challenges, its capabilities and plans to address them, and then to identify the gaps between these two.
- Act as the community's "resilience point of contact," ensuring that County, City, and NSF Indian Head leaders apply a resilience lens so that resources are leveraged holistically and projects planned for synergy. This will enable local leaders to implement and finance the most efficient projects, potentially achieving multiple resilience goals with one project.
- Identify a broad array of local, state, and federal government funding sources.

With these five organizational functions as a foundation, we recommend implementing the following financing actions strategies.

Action Strategy 9: Identify and respond to grant funding opportunities.

An important role the Collaborative can provide is to identify and coordinate responses to public and private grant funding opportunities. What makes regional resilience a challenge — i.e., the need to coordinate the actions of multiple jurisdictions — is in fact an asset regarding grant funding programs. Federal and even private/philanthropic grant programs often incentivize regional program and infrastructure implementation, especially when those infrastructure systems rely on and natural resources and processes. An important first step in developing a grant funding program is to understand where the opportunities are and the timing of application deadlines, matching requirements, etc. To that end, the Collaborative should develop a grant funding database, and the first step should be to identify all of the potential funding opportunities associated with the Bipartisan Infrastructure Bill (BIL). The BIL has resulted in an unprecedented amount of federal funding supporting myriad of infrastructure priorities. As a result, there are funding opportunities associated with all of the resilience priorities identified through this project. Appendix 3 provides an initial and comprehensive list of federal funding programs, categorized by issue and/or assets.

FUNDING HIGHLIGHT: FEDERAL GRANT OPPORTUNITIES TO WATCH

Rebuilding American Infrastructure Sustainably and Equitably (RAISE) – This Department of Transportation (DOT) competitive grant program funds projects to build or repair freight and passenger transportation networks (road, rail, transit and port) that have a significant local or regional impact.

Safe Streets and Roads for All (SS4A) – The DOT SS4A grant program was established by the Bipartisan Infrastructure Law to distribute $5 billion over a 5 year period. The purpose is to support local government efforts to advance "vision zero" plans and other complete street improvements to reduce crashes and fatalities, especially for cyclists and pedestrians.

Rural Surface Transportation - The DOT Rural Surface Transportation grant program is a relatively new competitive grant program that supports projects in rural areas that improve and expand surface transportation infrastructure to increase connectivity, improve the safety and reliabile movement of people and freight, generate regional economic growth, and improve quality of life.

Building Resilient Infrastructure and Communities (BRIC) – The Federal Emergency Management Agency (FEMA) BRIC program supports hazard mitigation projects that reduce the risks communities face from disasters and natural hazards. Eligible activities include capability- and capacity-building; encouraging and enabling innovation; promoting partnerships; enabling large projects; maintaining flexibility; and providing consistency.

Flood Mitigation Assistance (FMA) – FMA is a competitive FEMA grant program that provides funding for projects that reduce or eliminate the risk of repetitive flood damage to buildings insured by the National Flood Insurance Program. Recipients are chosen based on the proposed project's ranking, eligibility, and cost-effectiveness.

Brownfields Remediation Program – The Environmental Protection Agency's (EPA) Brownfields Remediation Program provides grants and technical assistants to communities to assess and safely clean-up contaminated properties and offer job training programs. Communities are able to request funding for Targeted Brownfields Assessments through their regional EPA office.

Once the database is established and refined, the Collaborative can connect funding opportunities to specific project needs that are identified as the project portfolio is developed.

Action Strategy 10: Develop a long-term regional resilience revenue strategy.

While a grant funding process within the Collaborative will serve as an effective starting point to support a regional resilience project portfolio and action strategy, in the long-term, a more sustainable and comprehensive revenue system must be established. The purpose of a revenue plan is not to establish the Collaborative as a supply of income or a mechanism to manage revenues. These are activities and responsibilities that reside with the entities, including the new Charles County Resilience Authority. Rather, the Collaborative's role should be to identify when and where gaps in regional revenue flows will occur and to guide conversations regarding how those gaps and funding/revenue needs will be met in the future.

There are any number of potential revenues sources in the form of fees, taxes, and grants that have the potential to provide either temporary or permanent support for regional resilience projects and activities. Key issues to consider when assessment the potential efficacy of a revenue source include:

- *The connection to long-term resilience issues*. The most sustainable and scalable revenue sources are those that are directly connected to the community infrastructure or programmatic need. Examples include enterprise funds or value-added taxing systems.
- *The potential scale of the revenue source*. Successfully financing community resilience in the long-term will likely require a suite of funding resources to support a variety of infrastructure and programmatic needs. As the project portfolio is developed, each asset class and project within that asset class must be connected to a revenue source(s) that is sufficient to achieve desired outcomes. In addition, just as redundancy is a central tenant of community resilience, so too is the need for redundancy in the financing system. Communities should have several funding options associated with achieving infrastructure financing goals (Jones, 2021).
- *The potential longevity of the revenue source*. While securing short-term grant funding may be an obvious first step, in the long-term, it will be necessary for Charles County and the Town of Indian Head specifically to establish permanent, dedicated, and long-term revenue streams.
- *The impacts – good or bad – on the community* (specifically how the revenue source impacts fairness and equity).

Within these funding considerations, there are a number of revenue sources and options available to consider. These include property taxes (specifically using special taxing districts and tax incremental financing districts); impact fees/excise taxes on new development; private capital through P3s (public/private partnerships) and concession agreements; private and nonprofit philanthropic investment, including donations, grants, and program investments; and finally, the most common source of funding, general fund revenues from partner jurisdictions, either in the form of annual payments or an endowment that is initially capitalized.

The assumption when developing a revenue plan to support resilience project priorities should be that existing local revenues are limited, and as a result any new funding needs and priorities will require new or expanded funding resources. If new revenues are not identified and leveraged, then resilience projects will be in competition with existing community programs and capital infrastructure projects. The Collaborative's focus should be to estimate the expected increases in public funding necessary to implement the project portfolio and to facilitate an ongoing conversation among the three jurisdictions and Collaborative partners

regarding revenue options moving forward. The appropriate sources of revenues will be determined by each jurisdiction as the project portfolio is developed.

The process of identifying and securing sufficient revenue streams highlights the importance of establishing an actionable project portfolio. It is tempting to begin the planning process by identifying a specific revenue source, usually in the form of a tax or a fee. The complexity and anticipated scale of achieving long-term climate resilience will require an array of revenue and funding sources, and the scale of each of these potential sources will be determined by the expected projects to be included in the portfolio and the estimated costs of implementation. It is important to note that the assessment indicates that while the greater NSF Indian Head area must contend with several anticipated climate hazards in the future, there were no acute issues are projects that require immediate funding. The Collaborative has the opportunity to create a thoughtful revenue strategy that is founded on the details of the project portfolio.

Action Strategy 11: Develop a long-term cash-flow management and financing plan.

It is unlikely that the Collaborative will be developed as a financing or funding institution. Rather, its role should be to coordinate funding and financing activities in support of projects that will benefit the greater NSF Indian Head area, focusing specifically on the long-term viability of the NSF Indian Head installation. That said, each of the entities should work together to create an inventory of potential financing and cash-flow mechanisms that can support projects that make up the NSF Indian Head Project Portfolio. Potential financing mechanisms include the following.

- *Value capture* is a type of public financing that recovers some or all of the value that public infrastructure generates for private landowners. The public sector is often responsible for the infrastructure required to support urban development. This infrastructure may include road infrastructure, parks, social, health and educational facilities, social housing, climate adaptation and mitigation tools, and more. Such infrastructure typically requires great financial investment and maintenance, and often the financing of such projects leans heavily on the government bodies themselves.

  Public entities, tasked with creating and maintaining this infrastructure, are constantly in search of mechanisms to allow for fiscal support of these investments. Value capture schemes secure and recover a portion of the benefits delivered by public investments, in order to offset the costs of the investment itself. Value capture strategies operate under the assumption that public investment often results in increased valuation of private land and real estate. By "capturing" the subsequent increase in value, governments are able to recuperate funds, which can ultimately be used to generate additional value for communities in the future. Specific types of value capture financing mechanisms include the following.

  - *Special assessment districts*. Special district governments are independent, special purpose governmental units, other than school district governments, that exist as separate entities with substantial administrative and fiscal independence from general purpose local governments. Special district governments provide specific services that are not being supplied by existing general purpose governments. Most perform a single function, but in some instances, their enabling legislation allows them to provide several, usually related, types of services. The services provided by these districts range from such basic social needs as hospitals and fire protection, to the less conspicuous tasks of mosquito abatement and

upkeep of cemeteries.

- *Tax increment financing (TIF)*. TIF is a tool used by municipal governments to stimulate economic development in a targeted geographical area. TIFs are used to finance redevelopment projects or other investments using the anticipation of future tax revenue resulting from new development. When a TIF district is established, the "base" amount of property tax revenue is recorded using the status quo before improvements. To the extent that such efforts are successful, property values rise, leading to an increase in actual property tax receipts above the base. While the base amount of property tax revenue (the level before redevelopment investments) continues to fund city services, the increase in tax revenue is used to pay bonds and reimburse investors and is often captured as city revenue and allocated toward other projects.
- *Joint development*. Joint development projects involve integrated development of public infrastructure improvements, with projects physically or functionally related to commercial, residential, or mixed-use development. Public and private investments are coordinated between agencies and developers to improve land owned by a public agency. The projects are designed to benefit both public and private entities as well as share costs among project partners.

▪ *Alternative bonds and debt financing tools*. The most common form of infrastructure financing is a municipal bond. A bond is a fixed-income instrument that represents a loan made by an investor to a borrower (in this case governmental). It can be thought of as an I.O.U. between the lender and borrower that includes the details of the loan and its payments. Bonds are used by companies, municipalities, states, and sovereign governments to finance projects and operations. While traditional municipal and revenue bonds are appropriate for many infrastructure projects, the disparate nature of climate resilience will require a broader array of debt financing tools, such as:

- *Grant anticipation revenue vehicle bonds (GARVEEs)*. In the broadest sense, a GARVEE is a type of anticipation vehicle, which are securities (debt instruments) issued when moneys are anticipated from a specific source to advance the upfront funding of a particular need. In the case of transportation finance, the anticipation vehicles' revenue source is expected Federal-aid grants. Developed within the transportation industries, GARVEEs enable a government to accelerate construction timelines and spread the cost of an infrastructure project over its useful life rather than just the construction period. The use of GARVEEs expands access to capital markets as an alternative or in addition to potential general obligation or revenue bonding capabilities. The upfront monetization benefit of these techniques needs to be weighed against consuming a portion of future years' receivables to pay debt service. This approach is appropriate for large, long-lived, non-revenue generating assets.
- *Green bonds*. A green bond is a type of fixed-income instrument that is specifically earmarked to raise money for climate and environmental projects. These are typically asset-linked and backed by the issuing entity's balance sheet, so they usually carry the same credit rating as their issuers' other debt obligations. A green bond is a

fixed-income instrument designed specifically to support specific climate-related or environmental projects. These bonds may come with tax incentives to enhance their attractiveness to investors.

- *Alternative financial arrangements*. Alternative financial arrangements include public-private partnerships (P3s). P3s involve collaboration between a government agency and a private-sector company that can be used to finance, build, and operate projects, such as public transportation networks, parks, and convention centers. Financing a project through a public-private partnership can allow a project to be completed sooner or make it a possibility in the first place. P3s often involve concessions of tax or other operating revenue, protection from liability, or partial ownership rights over nominally public services and property to private sector, for-profit entities. P3s allow large-scale government projects, such as roads, bridges, or hospitals, to be completed with private funding (The World Bank, No date).

Action Strategy 12: Establish the Charles County Resilience Authority as the NSF Indian Head Resilience Collaborative Secretariat.

Revenue sources and financing mechanisms are the primary components of any infrastructure financing system and process. Foundational to the system is institutional structure. Given the importance of project and program funding and financing to the success of the region's resilience goals, the logical secretariat for advancing, administering, and managing the Collaborative is the Resilience Authority.

The Authority is effectively structured to lead the resilience financing process, including creating the project portfolio, identifying and securing revenue streams, and financing projects either through debt or innovative procurement processes. In addition, the Authority by design has the capacity to engage multiple jurisdictions, which makes it uniquely appropriate for managing the Collaborative's regional project activities. Because the Authority is directly connected to County government systems, it can effectively engage relevant agencies and leaders as necessary.

Action Strategy 13: Connect homeowners and business owners to funding resources that will support private resilience actions and projects.

Engaging private landowners, residents, and businesses in the resilience financing process is essential. The resilience financing system described in this report is representative of the roles and responsibilities of the public sector in developing and implementing community infrastructure. Local and regional resilience financing plans that are established and implemented by state and local governments are by necessity targeted primarily, if not exclusively, on protecting public assets and supporting infrastructure projects on public lands. The most significant and costly climate impacts will often occur on private property.

While it is not the responsibility of the public sector to finance private resilience projects, there is an opportunity for the Collaborative to reduce the overall community risk and cost of resilience by educating incentivizing homeowners and businesses to act. An important component of the greater NSF Indian Head area resilience financing program should be to encourage and facilitate private investment in resilience activities. This includes connecting homeowners and business leaders with funding and incentive programs that can support retrofits to homes and properties. Over the time, the Collaborative, in partnership with the Town of Indian Head and the Charles County Resilience Authority can investigate the possibility of managing financial incentive programs directly targeted

the private sector. The most immediate opportunities are associated with incentivizing energy efficiency and resilience. These include the following.

- *Accelerate local energy resilience and efficiency by connecting residents and businesses to rebates, tax credits, and savings programs.* A variety of federal incentives are available to offset the cost of energy efficient improvements and renewable energy technologies. This includes federal residential tax credits for renewable energy and efficiency.
- *Connect homeowners and businesses to energy efficiency financing when buying, selling, refinancing, or remodeling homes*. This can include connecting homeowners to information regarding federal programs, as well as providing technical assistance related to financing applications and obtaining credit.

In the long-term, the Collaborative should develop a broader incentive program that targets an array of structural resilience needs across the region.

CONCLUSION

This project enabled the three partner entities—NSF Indian Head, the Town of Indian Head, and Charles County—to take important steps towards addressing the challenges facing the region and to adequately prepare for and bounce back quick when catastrophic events occur. This fifteen month-long process included an intense series of cross-sector discussions that led to a deeper understanding of the challenges facing the region. The resulting recommendations will serve as the foundation for achieving a more resilient and sustainable future for the larger NSF Indian Head community into the future.

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APPENDIX

APPENDIX 1 | ENGAGEMENT PROCESS

The following is an overview of the key questions, themes, meetings, events, topics, and stakeholders engaged during the 18-month project.

KEY QUESTIONS THAT GUIDED EVERY MEETING

- What is the essential service or asset that needs to be protected and/or maintained?
- What is the risk and vulnerability of climate change to that service or asset?
- What needs to be done to mitigate the risk to the asset?
- How will it be paid for?

THEMES COVERED

- **Master Planning**. A focus was on the short, medium, and long-term time frame used to plan for projects and the implementation measures that impact future plans.
- **Utility Systems and Services**. A focus was on the Morgan Power Plant, Southern Maryland Electric Cooperative, fiber optics, broadband, and alternative energy systems.
- **Environmental Vulnerabilities (Water Focus)**. A focus on stormwater, surface and groundwater.
- **Land Use**. A focus was on smart growth and climate migration.
- **Management of Natural Resources**. A focus was on the Potomac River, Mallows Bay, wetlands, agriculture lands and food security, forests, marsh, shoreline, fish, wildlife, habitat, stream restoration, conserved and protected land, public access, and green space.
- **The Built Environment**. A focus was on roads and transportation issues, radio and cell towers, emergency response and preparedness, and airports.
- **Solid Waste Disposal**. A focus was on landfills, recycling, and solid waste disposal management.
- **Design and Construction**. A focus was on local ordinance, state regulations, and critical area concerns.
- **Community and Economic Development/Social Concerns**. A focus was housing, community character, historic preservation, scenic roads and landscapes, cultural resources and community amenities, economic development, and equity.
- **Public Health**. A focus was on health risks and access to healthcare.

MEETING DATES, TOPIC, AND PARTICIPANTS

Meeting Date	Topic	Participants
March 9, 2021	Project Coordination	Charles County and UMD
March 23, 2021	Project Coordination	Charles County and UMD
March 30, 2021	Kick-off External Stakeholder/Work Group Meeting	Charles County, UMD, NSF Indian Head, and external members of workgroup
April 5, 2021	Project Coordination	Charles County and UMD
April 6, 2021	Project Coordination	Charles County and UMD
April 19, 2021	Military Meeting	Charles County, UMD, and NSF Indian Head
April 29, 2021	Project Coordination	Charles County and UMD
May 3, 2021	Military Meeting (Water Resources)	
May 6, 2021	Project Coordination	Charles County and UMD
May 13, 2021	Project Coordination	Charles County and UMD
May 20, 2021	Project Coordination	Charles County and UMD
May 24, 2021	Call with Naval Academy, Annapolis	UMD and Naval Academy representative
May 27, 2021	Project Coordination	Charles County and UMD
June 3, 2021	Internal Work Group Meeting	Charles County, UMD, Indian Head and NSF Indian Head
June 10, 2021	Project Coordination	Charles County and UMD
June 15, 2021	Military Meeting	Charles County, UMD, and NSF Indian Head
June 17, 2021	Project Coordination	Charles County and UMD
June 24, 2021	External Stakeholder/Work Group Meeting	Charles County, UMD, NSF Indian Head, and external members of workgroup
July 1, 2021	Project Coordination	Charles County and UMD
July 12, 2021	Military Meeting	Charles County, UMD, and NSF Indian Head
July 15, 2021	Project Coordination	Charles County and UMD
July 22, 2021	Project Coordination	Charles County and UMD
July 27, 2021	Project Coordination	Charles County and UMD
July 29, 2021	Project Coordination	Charles County and UMD
August 9, 2021	Master Planning Discussion	Charles County, Indian Head, UMD, NSF Indian Head

Meeting Date	Topic	Participants
August 12, 2021	Project Coordination	Charles County and UMD
Augusts 19, 2021	Project Coordination	Charles County and UMD
August 23, 2021	Military Meeting on Utility Systems and Services	Charles County, Indian Head, UMD, NSF Indian Head
August 26, 2021	External Stakeholder/Work Group Meeting	Charles County, UMD, NSF Indian Head, and external members of workgroup
September 2, 2021	Project Coordination	Charles County and UMD
September 8, 2021	Energy Systems	Charles County and UMD
September 16, 2021	Project Coordination	Charles County and UMD
September 20, 2021	Military Meeting on Communications/ Information Systems	Charles County, UMD, NSF Indian Head
September 23, 2021	Project Coordination	Charles County and UMD
September 27, 2021	Military Meeting on Stormwater	Charles County, UMD, NSF Indian Head
September 29, 2021	MWCOG Project Coordination	UMD and MWCOG
September 30, 2021	Stormwater Management and Drainage Systems	Charles County and UMD
September 30, 2021	OLDCC Regional Collaboration Meeting	OLDCC Awardees in Mid-Atlantic, State representatives, nonprofits, workgroup members, UMD, Charles County, Military representatives
October 4, 2021	Environmental Vulnerabilities (Stormwater focus)	Charles County, Indian Head, UMD, NSF Indian Head
October 7, 2021	Project Coordination	Charles County and UMD
October 14, 2021	Project Coordination	Charles County and UMD
October 18, 2021	Military Meeting on Land Use, Agriculture, Land Preservation, Smart Growth and Climate Migration	Charles County, Indian Head, UMD, NSF Indian Head
October 21, 2021	External Stakeholder/Work Group Meeting	Charles County, UMD, NSF Indian Head, and external members of workgroup
October 28, 2021	Natural Resources and Agriculture	Charles County and UMD
November 1, 2021	Military Meeting on Management of Natural Resources	Charles County, Indian Head, UMD, NSF Indian Head
November 4, 2021	Project Coordination	Charles County and UMD

Meeting Date	Topic	Participants
November 15, 2021	Management of Natural Resources	Charles County, Indian Head, UMD, NSF Indian Head
November 17, 2021	Project Coordination	Charles County and UMD
November 29, 2021	Built Environment (Transportation)	Charles County, Indian Head, UMD, NSF Indian Head
December 2, 2021	Project Coordination	Charles County and UMD
December 9, 2021	External Stakeholder/Work Group Meeting	Charles County, UMD, NSF Indian Head, and external members of workgroup
December 13, 2021	Built Environment	Charles County, Indian Head, UMD, NSF Indian Head
December 16, 2021	OLDCC MIRR Regional Coordination Meeting	OLDCC Awardees in Mid-Atlantic, State representatives, nonprofits, workgroup members, UMD, Charles County, Military representatives
January 6, 2022	Project Coordination	Charles County and UMD
January 10, 2022	Solid Waste Disposal	Charles County, Indian Head, UMD, NSF Indian Head
January 13, 2022	Project Coordination	Charles County and UMD
January 20, 2022	Project Coordination	Charles County and UMD
January 24, 2022	Design and Construction	Charles County, Indian Head, UMD, NSF Indian Head
January 27, 2022	Military Check-in call	Charles County, UMD, Indian Head, and military representatives
February 3, 2022	Project Coordination	Charles County and UMD
February 7, 2022	Community and Economic Development (Housing)	Charles County, Indian Head, UMD, NSF Indian Head
February 17, 2022	Project Coordination	Charles County and UMD
February 24, 2022	Project Coordination	Charles County and UMD
March 3, 2022	OLDCC MIRR Regional Collaboration meeting	Charles County and UMD
March 7, 2022	Community and Economic Development	Charles County, Indian Head, UMD, NSF Indian Head
March 10, 2022	Project Coordination	Charles County and UMD

Meeting Date	Topic	Participants
March 17, 2022	Project Coordination	Charles County and UMD
March 21, 2022	Health Risks	Charles County, Indian Head, UMD, NSF Indian Head
March 24, 2022	Project Coordination	Charles County and UMD
March 31, 2022	Project Coordination	Charles County and UMD
April 4, 2022	Health Risks	Charles County, Indian Head, UMD, NSF Indian Head
April 7, 2022	Project Findings (Internal)	UMD Team
April 18, 2022	Review of Findings and Preliminary Recommendations	Charles County, Indian Head, UMD, NSF Indian Head
April 21, 2022	Project Coordination	Charles County and UMD
April 28, 2022	Project Coordination	Charles County and UMD
May 2, 2022	Project Coordination	Charles County and UMD
May 5, 2022	Project Coordination	Charles County and UMD
May 12, 2022	External Stakeholder Meeting	Charles County, UMD, NSF Indian Head, and external members of workgroup
May 16, 2022	Review of Findings and Preliminary Recommendations	Charles County and UMD
May 26, 2022	Water Resources Follow-Up	Charles County and UMD
June 9, 2022	OLDCC MIRR Regional Coordination Meeting	OLDCC Awardees in Mid-Atlantic, State representatives, nonprofits, workgroup members, UMD, Charles County, Military representatives, invited guests
June 13, 2022	Final Project Overview, Findings and Recommendations Meeting to Prior to Release of Final Report	Charles County, UMD, Military representatives
July 7, 2022	Report Discussion	Charles County and UMD

APPENDIX 2 | NSF INDIAN HEAD LITERATURE REVIEW

DATE: JUNE 20, 2021

CONTENTS

1 BACKGROUND

In 2021, Charles County received a grant from the U.S. Department of Defense (DoD) Office of Local Defense Community Cooperation (OLDCC) to promote the long-term sustainability of Naval Support Facility (NSF) Indian Head through improved climate change preparedness and infrastructure resilience. NSF Indian Head is in Charles County, adjacent to the Town of Indian Head. The project's objective is to collaboratively assess, prioritize, and propose actions and next steps to actively ensure that NSF Indian Head remains a lasting part of the surrounding communities of Indian Head and Charles County. This literature review was prepared in support of that effort.

The DoD *Climate Change Assessment Roadmap* (DoD, 2017) identifies four climate change trends that negatively impact DoD operations and infrastructure: rising temperatures, changing precipitation patterns, sea level rise, and more extreme weather events. Many of these are expected to increase in frequency, intensity, and/or duration over time. The Climate Change Assessment Roadmap identified three broad adaptation goals established by DoD:

1. Identify and assess the effects of climate change on DoD.
2. Integrate climate change consideration across DoD and manage associated risks.
3. Collaborate with internal and external stakeholders on climate change challenges.

DoD has issued several directives and guidance documents to outline roles and responsibilities of DoD facilities to adapt to climate change. DoD Directive 4715.21, *Climate Change Adaptation and Resilience* (2018), identifies overarching roles and responsibilities to assess and manage climate change risks. It emphasizes the need for deliberate, collaborative planning efforts among multiple sectors to improve climate preparedness and resilience; the need to safeguard the economy, infrastructure, environment, and natural resources; and the need for the continuity of DoD operations, services, and programs. The *Unified Facilities Criteria for Installation Master Planning* (UFC 2-100-01), which details the master planning process requirements for military installations, has received multiple updates over the past nine years to provide guidance on the need for incorporating climate change into the planning process. UFC 2-100-01 – first issued in 2005 – was updated in 2012 to require that climatic conditions be considered along with other variables during the master planning process. In 2019, UFC 2-100-01 was again updated to require that each installation identify and assess the risks to the installation from the effects of climate change and extreme weather and develop plans to address those risks. And in 2020, it was most recently updated to provide guidance on the use of climate projections in facilities design standards.

Another important document providing guidance specific to naval institutions and operations is the *Climate Change Planning Handbook: Installation Adaptation and Resilience*. This handbook was released in 2017 by the Naval Facilities Engineering Command (NAVFAC) and provides the analytical framework, tools, and other guidance, to help planners assess climate impacts and evaluate adaptation options to consider in the existing Installation Development Plan (Master Plan) process. It contains an extensive set of worksheets to be used in documenting the results of planners' assessment and evaluation, including economic analyses of adaptation alternatives. Future updates to the handbook are anticipated in response to DoD Directive 4715.21, which directs DoD Component heads update the installation master

planning process as needed to ensure climate change risks to built and natural infrastructure are assessed and managed.

2 KEY DEFINITIONS

DoD Directive 4715.21, *Climate Change Adaptation and Resilience* (2018), provides the following definitions for climate change and resilience:

- Climate Change: "Variations in average weather conditions that persist over multiple decades or longer that encompass increases and decreases in temperature, shifts in precipitation, and changing risk of certain types of severe weather events" (p. 11).
- Resilience: "Ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions" (p. 11).

UFC 2-100-01 *Installation Master Planning* (2020) further refines the definition of climate change to specify certain threats. It is defined as "the variation in average weather conditions for a particular locale or region that persists over several decades or longer and encompasses increases or decreases in average temperatures, shifts in precipitation, and an altered risk of certain types of weather events" (U.S. DoD, 2020, p. 11). Examples include sea level rise, changes in precipitation or temperature patterns, wildfires, flooding, and extreme temperatures. The impact of these phenomena differs based on a DoD installation's location. Climate resilience is achieved by ensuring military installations are safe and secure to operate effectively under multiple plausible future conditions, even when there's uncertainty in how much and how quickly change may occur.

Two additional terms of importance are "climate vulnerability" and "adaptive capacity." A.O. Pinson et al. (2021) define these as follows when responding to Executive Order (EO) 14008, "Tackling the Climate Crisis at Home and Abroad."

- Climate Vulnerability: "[E]xposure of the asset or activity to one or more climate hazards, the sensitivity of the asset or activity to the hazards, and the degree of adaptive capacity to reduce this exposure and sensitivity" (p. 3).
- Adaptive Capacity: "[T]he ability of installations to adjust to climate disruptions, take advantage of opportunities, or to respond to consequences" (p. 4).

3 CLIMATE CHANGE TRENDS IMPACTING NSF INDIAN HEAD

DoD issued its *Report on Effects of a Changing Climate to the Department of Defense* in 2019. This report identified climate change as a national security issue to DoD operations and installations. DoD analyzed climate-related events at 79 different military installations to determine if any of the following vulnerabilities posed a current or potential threat over the next 20 years: recurrent flooding, drought, desertification, wildfire, and/or thawing permafrost. NSF Indian Head was one of the 79 installations included in the analysis. Current and potential vulnerabilities identified for NSF Indian Head included:

- Recurrent flooding, which may include coastal flooding from storm surge and sea level rise, nuisance flooding during high tides, and riverine flooding; and

- Drought conditions, which can have implications for base infrastructure and impair testing and training activities.

DoD began development of the DoD Climate Assessment Tool (DCAT) in mid-fiscal year 2019. DCAT is a screening-level climate hazard assessment geospatial tool. The recently released *Installation Exposure to Climate Change at Home and Abroad* (Pinson et al., 2021) states that its purpose is to provide a screening-level assessment of installation exposures to eight climatic hazards. These are: drought, coastal flooding, riverine flooding, heat, energy demand, land degradation, wildfire, and historical extreme weather events. It delivers assessments of lower future warming and higher future warming scenarios for two 30-year epochs of projected climate, centered at 2050 and 2085. Drought was identified as the dominant climate hazard for Navy installations while Climate exposure was ranked highest for the Atlantic Coast, the Gulf Coast, the Middle East, and islands in subtropical waters. Coastal and riverine flooding were also identified as dominant hazards in the Eastern U.S. (DoD, 2021).

3.1 Recurrent Flooding

Charles County released the *Charles County Nuisance and Urban Flood Plan* in October 2020. The plan's purpose was "to identify sources of nuisance and urban flooding, analyze flood hazards, and recommend actions to reduce flooding and increase community resiliency" (p. 1). The plan defines nuisance flooding as flooding associated with high tides causing storm drain backflow, groundwater inundation, and direct marine flooding. Nuisance flooding is becoming an increasing problem in Charles County as sea levels rise. The plan noted that tide gauge measurements show that the sea level along Maryland's coastline has risen at an average rate of 3-4 mm per year (one foot per century). Based on 2018 Sea Level Rise Projections for Maryland, future rates of sea level rise along this coastline are expected to rise by 2 to 4.2 feet by 2100 if greenhouse emissions continue to increase.

The plan also pulls relevant information from the recent 2018 *Charles County Hazard Mitigation Plan Update* to depict the potential sea level rise impacts on Charles County. As per the HMP update, some areas of Charles County have the potential to experience 5-to-10-foot inundation. Sea level rise impacts are projected to be the greatest in the areas surrounding the Mattawoman Creek, the Nanjemoy Creek, the Potomac River, and the Wicomico River. The mitigation plan update also shows that the shoreline is highly vulnerable to nor'easters, tropical storms and hurricanes, particularly when lasting 24 to 48 hours and accompanied by high winds and storm surges. Areas of moderate, low, and very low shoreline erosion rates from the Hazard Mitigation Plan updated are depicted in Figure 3.3.3-1 of the HMP.

Urban flooding also poses a challenge for Charles County. The plan identifies the causes of urban flooding as increased impervious area; the disruption of natural watershed functions; an undersized, aging storm drain system; and changing weather patterns which put more pressure on the system. Areas with known, recurrent flooding problems were mapped, providing valuable information to NSF Indian Head for anticipating whether any challenges may exist, for example, in keeping roadways continuously open and usable to NSF Indian Head and emergency responders. The Charles County Nuisance and Urban Flood Plan also identifies courses of action Charles County is taking to make itself more resilient to climate change. These include efforts to:

- Mitigate roads for current and future flood predictions;
- Protect roadways from future flood events;
- Fortify vulnerable roadways against flooding and sea level rise by raising the roadbed;

- Improve drainage/stormwater management in the public right-of-way; and
- Improve drainage/stormwater management in flood-prone areas.

Additional climate action and resiliency efforts identified by Charles County included the following:

- Reduce greenhouse gas emissions through utilizing appropriate landfill covers, upgrading the current passive system to collect landfill gas to one that actively captures emissions, and increase recycling;
- Transition to 100% renewable electricity by adding solar arrays on county-owned land;
- Improve sustainability in county operations; and educating the county workforce on climate change mitigation and adaptation measures.
- Restore 27 miles of shorelines through implementing restoration at 153 sites.

3.2 DROUGHT

The Draft Charles County 2018 Hazard Mitigation Plan Update describes droughts as "a period of prolonged dryness that contributes to depletion of ground-water and surface-water yields" (p. 42). Droughts can cause significant adverse impacts to water supplies for human consumption, livestock, and agriculture. Droughts can also negatively impact water quality, soil conditions, and forest health, and increase the chance of forest fires.

Based on data from the Palmer Drought Severity Index (PDSI) from 1895 to 1995, Charles County and the State of Maryland are within an area where severe and extreme drought occurs 5% to 9.9% of the time. Severe and extreme drought, as defined by the National Drought Mitigation Center's Drought Severity Classifications, are as follows:

- Severe Drought: Crop or pasture losses likely; fire risk very high; water shortages common; water restrictions imposed.
- Extreme Drought: Major crop and pasture losses; extreme fire danger; widespread water shortages or restrictions.

Since the National Drought Mitigation Center began reporting in 1986, the most notable significant damage to agriculture was recorded in the years 1986, 1999, 2002 and 2007. The Hazard Mitigation Plan notes that they are considered significant years due to "persistent dry conditions, exceptional and widespread crop and pasture losses; increased fire risk; and water restrictions" (p. 44). Data from the National Oceanic and Atmospheric Administration's (NOAA) Storm Events Database shows that there have been 12 reported drought events in Charles County since 1950, with the drought of November 1998 being particularly bad. Statewide, the November 1998 drought contributed to a six-fold increase in the amount of brush fires. Since 1989, the years with the greatest amount of indemnity payments for losses suffered from drought were 2007, 2012, 2010, and 1999 (in order of payouts).

There is no commonly accepted approach for assessing risk associated with droughts. However, the County's Hazard Mitigation Plan update rates the probability of future droughts impacting Charles County as unlikely. The County feels that drought has not impacted water needs to-date, though continued population growth, increased demand for water, and the effects of land development, combined with periods of drought, could impact future water supply needs. Because Southern Maryland relies exclusively on groundwater for water supplies, possible impacts to critical facilities include the loss

of critical function due to low water supplies. The plan also notes that, while droughts typically do not directly impact critical infrastructure, droughts can indirectly impact them. Droughts combined with lowering groundwater levels can lead to deeper incisions of stream channels, which in turn leads to downcutting and stream erosion that can result in the collapse of structures along streams. A "worst-case scenario event… could involve mudslides due to heavy rains when a drought breaks, which could result in damage to structures (recent and historic) as well as archaeological sites." Of all its resources, the plan notes that agriculture is the most vulnerable to the impacts of drought in Charles County and would likely be the first areas to experience the impacts of future droughts. As per the *2017 Census of Agriculture for Charles County* (USDA, 2017), Charles County has 385 farms totaling 41,021 acres (*Note*: The Hazard Mitigation Plan provides 2012 ag census data – the 2017 information reflects the most recently available).

The United States Global Change Research Program's *Fourth National Climate Assessment* (Reidmiller, 2018) explains that surface soil moisture is projected to decrease for much of the U.S. as the climate warms. This change is driven primarily due to increased evaporation rates from warmer temperatures. This means that future droughts will likely be stronger and longer in duration, especially in the Southwest and Southern Great Plains. The assessment also notes that groundwater depletion is exacerbating drought risk, especially in the Southwest and Southern Great Plains. The assessment recommends that water management strategies that account for changing climate conditions can help manage for droughts and water supply, but implementation of such practices is limited. Charles County is similarly dependent upon groundwater. In the year 2018, 87% of Charles County's population relied on groundwater for drinking water (USGS, 2021). A 2007 report by Shedlock et al. *Water for Maryland's Future* (Wolman, 2008) states that water levels in confined aquifers in some parts of the Atlantic Coastal Plain in Southern Maryland have been declining by as much as 2 feet per year. However, Charles County is actively evaluating opportunities to supplement or supplant its current reliance on groundwater with surface water (Hazen and Sawyer, 2018).

3.2.1 Drought and Military Installations

The DoD *Report on Effects of a Changing Climate to the Department of Defense* (DoD, 2019) explains that droughts can negatively impact U.S. military installations in various ways. This includes the impact to water supplies and increased wildfire risks. Droughts can increase energy consumption, impair testing activities, increase the number of black flag days which prohibit testing and training, and contribute to heat exhaustion and heat stroke. Droughts also impact base infrastructure. DoD notes that drought conditions have caused significant reduction in soil moisture at several Air Force bases, which resulted in deep cracks in the soil. This, in turn, resulted in some ruptured utility lines and cracked road surfaces. The report specifically calls out DoD sites in the DC Area periodically experiencing extreme drought conditions in 2002 and severe drought conditions from 2002 through 2018.

4 CLIMATE CHANGE AND INFRASTRUCTURE RISKS

The U.S. Government Accountability Office (GAO) reported on the efforts of 65 military institutions identified by DoD as vulnerable to climate change and extreme weather (U.S. GAO, 2020). This list included NSF Indian Head. GAO engaged the installations to determine the extent to which each relied upon the infrastructure and support services of surrounding communities, and whether these same

installations coordinated with those communities to limit exposure. The 65 installations were asked to what extent they relied on the infrastructure and support services of surrounding communities.

Sixty-two of the 63 installations who responded stated that they fully relied upon surrounding communities for electricity, telecommunications, and access roads and/or bridges. In addition, installations reported relying heavily on surrounding communities for commodity infrastructure systems such as water pipes, sewage treatment plants, electrical substation (92%); natural gas (87%); water (76%); and wastewater (73%). GAO reported that 40 responding installations (63%) relied heavily on surrounding communities for electricity, water, wastewater, telecommunications, and natural gas combined. Separately, 81% also relied on neighboring communities for support in the operation, repair, or maintenance of on-installation commodity infrastructure systems. Reliance on 18 types of infrastructure and 4 categories of support services were assessed and ranked.

GAO asked installations whether climate change and/or extreme weather events had disrupted past community infrastructure and support services to installations. Forty-three of 63 installations (68%) responded that they had experienced disruptions in the past five years, with extreme precipitation events (31 installations) and recurrent flooding (21 installations) being the most common causes. Additional questions sought to determine how long a duration they could independently provide commodities and support services to sustain critical services if off-installation disruptions occurred. Observed and potential effects on physical infrastructure from flooding and extreme temperature were reported as follows.

Flooding:

- Coastal erosion (e.g., shoreline facilities); damage to coastal infrastructure (e.g., piers and utilities)
- Inundation of inland sites; damage to infrastructure; stormwater/ wastewater disposal issues; shifting river flows
- Impassable access roads and bridges
- Increased debris flow into harbors

Extreme temperatures:

- *Hot*: Strained electricity supply; changing demand to cool buildings; erosion, facility damage from thawing permafrost; water supply shortages; increased maintenance for runways or roads
- *Cold*: Strained electricity supply; changing demand to heat buildings; water main breaks; impassable access roads and bridges

For droughts, water supply shortages were listed as the most common observed or potential effects on physical infrastructure. The report did not specify whether such effects were reported by the facilities as having occurred within the past five years, or whether they were potential DoD-identified effects.

4.1 Infrastructure and Support Services Benefiting NSF Indian Head

The *Naval Support Facility Indian Head Joint Land Use Study* (JLUS) (Charles County, 2016) provides information on the type and status of current infrastructure and services in place – both internal and external – that support NSF Indian Head. Community infrastructure benefiting NSF Indian Head includes roads, public water supply, and sewer lines. The Charles County Adequate Public Facilities Ordinance is one tool the County uses to ensure that a reasonable level of infrastructure is in place to support existing needs before future housing or other development can be built. Information on existing

infrastructure and support services provided below stems from the JLUS, with additional details provided where indicated from the *Draft Environmental Assessment for Relocation of Chemical, Biological, and Radiological Defense Division from NSF Dahlgren to NSF Indian Head* (Department of the Navy, 2018). The Draft Environmental Assessment was prepared to evaluate two action alternatives and the No Action Alternative of relocating the mission and operations of the Chemical, Biological, and Radiological Defense Division (CBR-D) from its current location at NSF Dahlgren in Dahlgren, Virginia into facilities at NSF Indian Head. The assessment was reviewed for purposes of obtaining more up-to-date information on NSF Indian Head's existing infrastructure and water resources. Information was also obtained from Jeff Bossart in a personal communication on May 3, 2021.

- *Natural Gas*: Natural gas is provided by Washington Gas. A natural gas line that extends from Bryans Road to Indian Head along Route 210 was constructed in 2014. *Note*: A Fact Sheet (no date) provided by NSA South Potomac further specifies that this natural gas transmission line was extended from Bryans Road to NSF Indian Head when the installation's coal-fired power plant was replaced with a new natural gas cogeneration facility.
- *Electricity*: Approximately 70 to 75 percent of NSF Indian Head's electricity and 100 percent of electricity at the Stump Neck Annex is provided by the Southern Maryland Electric Cooperative (SMECO) (J. Bossart, Personal Communication, May 3, 2021). Additional electricity at NSF Indian Head is provided by an on-site natural gas cogeneration facility. The cogeneration facility was installed in 2015 to replace a previous coal-fired Goddard Power Plant. The new cogeneration facility provide steam, compressed air, and 3.5 megawatts of electricity. The *Draft Environmental Assessment* clarifies that this is a decentralized supply and distribution system with one primary nodal plant and seven secondary steam nodal plants. The new system was expected to "cut… water consumption by 75 percent, and steam requirements by 80 percent" (Naval Support Activity South Potomac, 2013, p. 2). Information provided by Naval Support Activity South Potomac further clarified that the primary purpose of the cogeneration facility is to produce steam that is utilized in the explosive manufacturing process (primarily) and for heating (secondarily). In addition, the new system cut energy use by approximately 40 percent (J. Bossart, Personal Communication, May 3, 2021).
- *Drinking/Potable Water*: Charles County currently obtains most of its drinking water from drilled wells tapping deep-water aquifers that are recharged in Fairfax, Prince William, and Stafford Counties in Virginia. Charles County is evaluating the feasibility of establishing a new surface water source (Hazen and Sawyer, 2018). Both NSF Indian Head and the Town of Indian head previously drilled deeper wells for drinking water to free up water in the upper aquifer. The JLUS states that "[g]roundwater use is limited due to aquifer drawdown, impacting both the Town of Indian Head and NSF Indian Head. Increased demand and development in the aquifer could influence water availability in the future and put more pressure on the Navy to find alternative solutions" (Charles County, 2016, p. ES-2).

  NSF Indian Head uses groundwater pumped from on-installation wells at Cornwallis Neck and Stump Neck Annex for domestic and industrial purposes. Groundwater is also used for fire protection at Stump Neck. Groundwater is pumped from four deep wells at Cornwallis Neck (Wells 1, 15, 16A, and 17A) and two wells at Stump Neck Annex (Wells SN43A and SN2012). Wells 1, 16A, 17A, and SN43A draw from the Patuxent aquifer, and Wells 15 and SN2012 draw from the Patapsco aquifer. Average groundwater usage at NSF Indian Head "is approximately 90 percent (920,000 gallons per day) of

the monthly permitted limit for wells from the Patuxent aquifer and approximately 30 percent (45,000 gallons per day) of the permitted limit for wells from the Patapsco aquifer" (Department of the Navy, 2018, p. 3-12). Groundwater is also used for fire protection at Stump Neck Annex; however, water is not withdrawn for use unless an event occurs. One of the shallower wells at Stump Neck Annex has experienced saltwater intrusion (J. Bossart, Personal Communication, May 3, 2021).

- *Non-Potable Water*: Manufacturing and operations at NSF Indian Head also require the use of water, and there is piping for steam generation throughout the installation. The JLUS states that NSF Indian Head is limiting the use of potable water for industrial processes. Utilizing river water requires the installation of reverse osmosis systems. This reduces the amount of potable ground water required for mission operations. The JLUS further states that NSF Indian Head has been installing systems that use river water for fire and rescue needs. The conversion of the coal-fired Goddard Power Plant to natural gas has also alleviated water supply pressure by reducing the amount of potable water used for steam production. The *Draft Environmental Assessment* from 2018 states that filtered river water is the source for steam and non-contact cooling water at the primary nodal steam plant and four secondary steam nodal plants. Utilizing river water through reverse osmosis is not without its challenges. Changes in sedimentation patterns can impact the filtration process; and rising water temperatures have exacerbated issues with zebra mussels in the intake (J. Bossart, Personal Communication, May 3, 2021).
- *Wastewater*: The Mattawoman Sewer Treatment Facility is the County's primary facility and has a rated capacity of 15 million gallons per day. Both NSF Indian Head and the Town of Indian Head own sewer treatment facilities. The *Draft Environmental Assessment* provides further details on sewage treatment at NSF Indian Head. NSF Indian Head has a centralized sewage treatment plant. Sanitary and processed wastewater is discharged to the Potomac River and the Mattawoman Creek.
- *Stormwater*: The JLUS does not provide information on stormwater management at NSF Indian Creek. Stormwater infrastructure is discussed in the *Draft Environmental Assessment*. The existing stormwater infrastructure "consists of a network of swales, curb inlets, culverts, manholes, and piping in addition to bioretention areas" (Department of the Navy, 2018, p. 3-68).
- *Transportation Infrastructure*: The JLUS study states that hazardous and explosive materials were previously transported to NSF Indian Head by water and then rail. Now they are transported by truck. Concerns have been raised that increased traffic and traffic control devices could impact their transport to NSF Indian Head and Stump Neck Annex. The *Draft Environmental Assessment* also confirms that the primary means for accessing NSF Indian Head is by ground. "The Navy also maintains infrastructure at the installation for limited accessibility by air (helicopter pads at Stump Neck and Cornwallis Neck golf course) and boat (marina for emergency response)" (Department of the Navy, 2018, p. 3-72).
- *Public Safety Services*: NSF Indian head has its own on-site emergency personnel for fire support and emergency services. In addition, there is a mutual aid agreement between NSF Indian Head, the Town of Indian Head, and Charles County. Personnel at NSF Indian Head are specially trained in responding to hazardous materials and explosives (Department of the Navy, 2018).

5 CLIMATE CHANGE AND ECONOMIC IMPACT

Absent significant global mitigation and regional adaptation efforts, rising sea levels, rising temperatures, increased droughts, and other climate change impacts "are expected to damage critical infrastructure and property, labor productivity, and the vitality of our communities" (Reidmiller, 2018, p. 25). Site-specific assessments on the anticipated costs of climate change are not available. However, insight into losses incurred from weather/climate disaster events may be found from the National Oceanic and Atmospheric Administration (NOAA) and other sources. NOAA's Weather and Climate Disasters database (www.ncdc.noaa.gov/billions) tracks the costs of weather/climate disaster events where losses have exceeded $1 billion starting from the year 1980. Between 1980 and 2021, there have been 22 severe storm, 4 flooding, and 9 drought billion-dollar disaster events that have affected Maryland (NOAA, 2021). These costs are borne not just by DoD but the community as a whole.

Currently, NSF Indian Head contributes significantly to the economies of Charles County and the Town of Indian Head. NSF Indian Head is one of Charles County's largest employers. The *Charles County Building a New and Better Normal: Annual Report 2020* (Charles County Economic Development Department, 2020) ranks NSF Indian Head as second only to the Charles County Board of Education in the total number of jobs it provides. In fiscal year 2019, NSF Indian Head provided approximately 554 military jobs and 3,137 federal civilian and contract employee jobs. A 2020 Impact Summary for NSF Indian Head showed that 38 percent of its personnel resided in Charles County (Naval Support Activity South Potomac, 2020).

NSF Indian Head also contributes largely to the growth and economic vitality of the Town of Indian Head, where 16.9 percent of NSF Indian Head's personnel live, as per the NSF Indian Head. In 2015, Gary Hodge of Regional Policy Advisors presented a *Town of Indian Head Economic Revitalization Strategy Report to the Indian Head Town Council*. Its purpose was to outline an economic revitalization strategy for the Town to build the local economy, reverse disinvestment patterns, and strengthen relationships between the Town and NSF Indian Head. It identified 16 strategic and 3 additional initiatives for doing so. The *2020 Charles County Government Annual Report* states that in the fall of 2020, the College of Southern Maryland's (CSM) opened the 13,000 square foot Velocity Center as "a place of innovation, learning, and collaboration among academia, business, the Navy, and the community" (Charles County, 2020, p. 30). This project was part of a concerted effort to encourage redevelopment of underutilized, vacant properties along the MD Route 210 Corridor. The Annual Report notes that the Velocity Center has already attracted attention from professional organizations and for-profit companies such as the United States Bomb Technology Association (USBTA), which moved personnel to the Town of Indian Head.

The Velocity Center and efforts to revitalize the Town of Indian Head are further discussed in *Case Study: The Velocity Center and the Revitalization of the Town of Indian Head* (Yewell, 2021). The Case Study explains that depressed economic conditions over time resulted in the vacancies of major retail businesses and multiple vacant, blighted, and underutilized properties. The Velocity Center project serves a cornerstone of the first phase to revitalize the Town and make it more attractive to NSF Indian Head and its work force. Besides the USBTA, two additional organizations are planning operations in the Town: the engineering firm ARA and a producer of nanofiber water filtration systems (Memsel). Once

fully operational, these improvements are expected to result in 126 full-time equivalent employees and $13.5 million in estimated earnings (Yewell, 2021).

5.1 Climate Resilience Enhancement Costs

Enhancing climate resilience can add additional upfront costs but can also reduce potential future costs incurred due to damage from climate-related events. A recent GAO report on federal programs and operations that are vulnerable to waste, fraud, abuse, and mismanagement found that DoD and the federal government need to better manage climate change risk to limit the federal government's fiscal exposure. GAO found that DoD needs to do more to ensure resilience by incorporate current and future projected climate-related risks and threats into its installations' master plans and by amending construction planning and design criteria to ensure that building practices and standards promote climate resilience. The GAO stated that DoD needed to update its "2014 Adaptation Roadmap to include a strategy to address the current and foreseeable effects of extreme weather and sea level fluctuations on the department's mission, including a discussion of these effects on various infrastructure, such as military installation resilience" (U.S. GAO, 2021, p. 95). In addition, guidance is needed from the Council on Environmental Quality to direct agencies to consider climate change impacts such as sea level rise in their National Environmental Policy Act of 1969 (NEPA) reviews when planning federally funded infrastructure. Implementing the January 2015 federal flood risk management standard that requires "all future federal investments in, and affecting, floodplains to meet a certain elevation level" is also key to enhancing federal flood resilience (U.S. GAO, 2021, p. 96).

The recently released DoD Installation Exposure to Climate Change at Home and Abroad (Pinson et al., 2021), which was prepared in response to Executive Order (EO) 14008, identifies resilience measures that installations can deploy to reduce vulnerabilities to climate change and extreme weather. This report provides an overview of the DoD Climate Assessment Tool (DCAT), which is briefly discussed in Section 3 of this literature review. This tool will support climate-informed decision-making by allowing DoD personnel to understand a specific installation's exposure to climate-related hazards using historical data and future climate projections at various levels or scales. The report itself provides a national to global scale view of exposure to selected climate impacts. It was announced on April 22, 2021, at the White House Climate Leaders Summit on Earth Day that DoD plans to complete climate exposure assessments on all major U.S. installations within 12 months and on all major overseas installations within 24 months using DCAT (DoD, 2021; Vergun, 2021).

The information gained from a variety of scales is intended to identify the level of vulnerability of individual installations to primary hazard exposures to determine the level of effort needed for further studies and to guide investments in future detailed analyses:

> "If the sensitivity [to a climate hazard] is low, its vulnerability may also be low and there may be little need to implement resilience measures. If the same asset is sensitive to the hazard but adaptive capacity is high, measures can be implemented to ameliorate the effects, thereby decreasing vulnerability. On the other hand, if the asset is exposed, sensitive, and the adaptive capacity is low, the adaptive measures may be limited, expensive, or difficult to implement, making it more difficult to implement measures that reduce vulnerability" (Pinson et al., 2021, p. 4).

Appendix 2 of the report by Pinson et al. provides a representative installation resilience case study of how evaluating regional to local information about sensitivity using DCAT helps to determine whether a

particular exposure poses a threat to missions or operations. Where it does, the next step is "to consider potential actions within the constraints and opportunities presented by adaptive capacity" (Pinson et al., 2021, p. 101). This information can inform the development of installation-specific resilience measures, assign cost estimates (where available), and identify cost-sharing opportunities.

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