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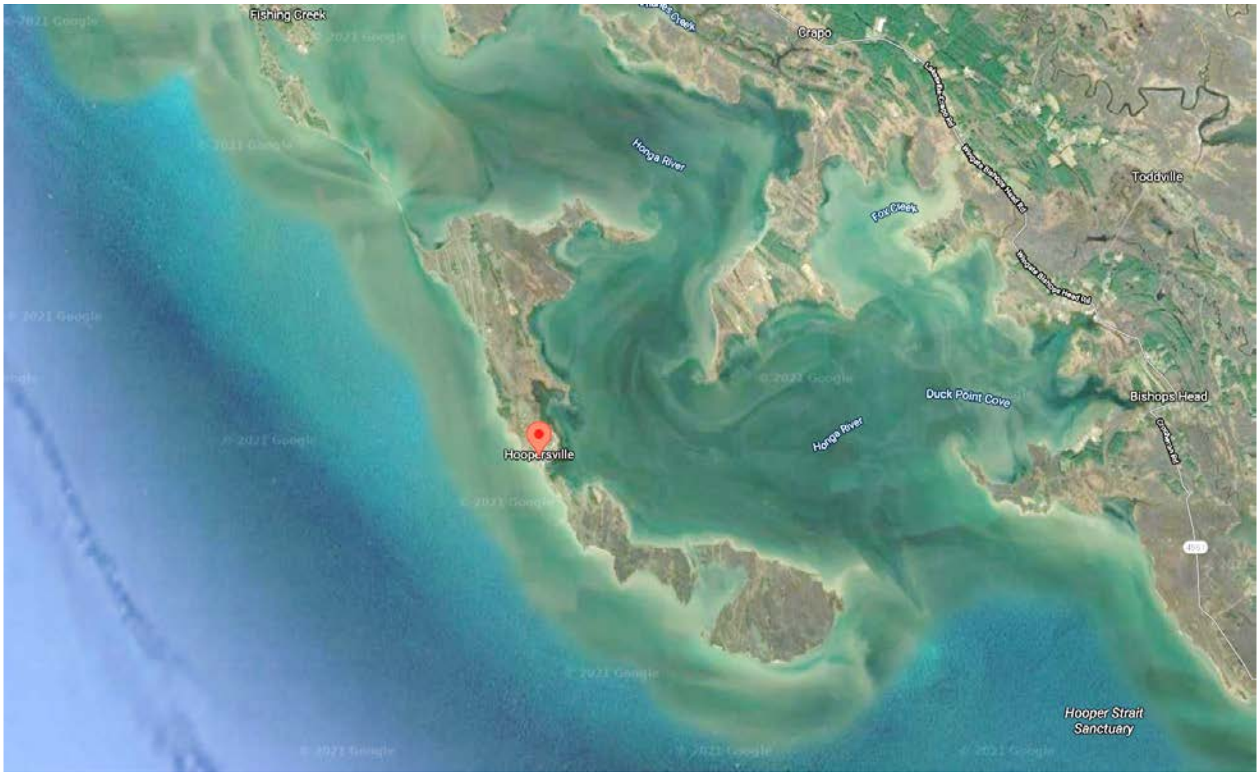
Prepared for

Dorchester County Department of Planning and Zoning

Hoopersville Coastal Resiliency Study



May 2022

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EXECUTIVE SUMMARY

This report was prepared by BayLand Consultants & Designers (BayLand) using Federal funds under award number NA20NOS4190206 from NOAA, U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of NOAA or the U.S. Department of Commerce.

Middle Hoopers Island, locally known as Hoopersville, is a 1,420-acre residential island located in Dorchester County, Maryland. The island has approximately 7 miles of shoreline along the Chesapeake Bay and 13 miles of shoreline along the Honga River. In July 2021, the Dorchester County Department of Planning and Zoning (County) along with the Maryland Department of Natural Resources (DNR) tasked BayLand Consultants & Designers, Inc. (BayLand) in developing a Coastal Resiliency Study defining areas of Hoopersville that are most susceptible to coastal resiliency stressors, the impacts these stressors will have on the island's assets, and mitigation strategies for reducing the impacts of these stressors. The study is divided into three phases:

- Phase 1 – Data Collection and Analysis
- Phase 2 – Vulnerability Assessment
- Phase 3 – Adaptation Plan

Phase 1 examined site conditions at Hoopersville including the existing natural shoreline and shoreline protection measures, elevations, habitats, and infrastructure. The island was divided into six areas with similar characteristics to evaluate the impacts of the coastal resiliency stressors, identified as:

- Coastal Erosion
- High Tide Flooding
- Storm Surge Flooding
- Saltwater Intrusion
- Flooding due to Inadequate Drainage

The impacts of these coastal resiliency stressors were evaluated for current and future conditions using 1.7 feet of sea level rise (SLR) by 2050 to represent the 'high tolerance for risk' condition for areas near the NOAA Tide Station 8571421 at Bishops Head, MD.

During the Phase 2 Vulnerability Analysis, the vulnerability of each area was defined by assessing the exposure, sensitivity, and adaptive capacity to each coastal resiliency stressor for current and future conditions. A risk assessment then prioritized the areas of Hoopersville for project implementation, as shown in Table 1.

Phase 3 describes the Adaptation Plan developed for implementing projects based on the prioritization table. Risk Management Strategies including risk avoidance, risk prevention, risk transfer and risk reduction were evaluated and compared in a decision

Table 1 – Prioritization Table				
Priority	**Assessment Area**	**Cumulative Vulnerability to Stressors**	**Cumulative Vulnerability to Stressors w/ SLR**	**Risk**
1	Hoopersville Rd	Very High	Very High	Very High
2	Village District	Very High	Very High	Very High
3	Rural Residential	Very High	Very High	Very High
4	Northwest Marsh	High	Very High	Very High
5	Northeast Marsh	Medium	Very High	High
6	Southern Marsh	Medium	High	High

matrix based on feasibility, effectiveness, socio-economic impacts, environmental impacts, and costs to determine the preferred alternatives for each area.

Finally, an Implementation Plan was developed using the preferred alternatives for the areas prioritized in the Prioritization Table. The Implementation Plan divided projects into Immediate Implementation, Short-Term Implementation, Long-Term Implementation and Future Action (Monitor).

The Immediate Implementation Plan includes raising the lowest 3,530-foot portion of Hoopersville Road to the projected 2050 mean high water (MHW) elevation, providing coastal erosion protection in the form of a living shoreline along the Chesapeake Bay shoreline for the Village District and Northwest Marsh, and aiding home and business owners in implementing property improvements to reduce impacts to infrastructure.

The Short-Term Implementation Plan includes raising 6,060 feet of Hoopersville Road to the 2050 MHW elevation and nourishment of approximately 225 acres of coastal marshes in the Northwest Marsh through beneficial use of dredged material from neighboring channels.

The Long-Term Implementation Plan proposes to raise 2,700 feet of Hoopersville Road to the 2050 MHW elevation, nourishment of approximately 640 acres of coastal marshes in the Northeast Marsh through beneficial use of dredged material from neighboring channels, and construction of a living shoreline along the Northwest Marsh.

The Future Action Plan recommends monitoring the Southern Marsh area. Based on the projected impacts, this area is less vulnerable and, therefore, no adaptation plan is proposed. The area should be assessed in the future to determine the best strategy for adaptation.

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1. Introduction

Middle Hoopers Island, locally known as Hoopersville, is a 1,420-acre residential island located in Dorchester County, Maryland. The island has approximately 7 miles of shoreline along the Chesapeake Bay and 13 miles of shoreline along the Honga River. It is the central island of a three-island chain, referred to as Upper, Middle, and Lower Hoopers Islands. The island chain was originally settled by Henry Hooper in the late 1600's and was once the primary seafood processing hub on the Chesapeake Bay. Today, many of the current residents are still watermen by trade, taking part in oyster farming, crabbing, and chartering fishing boats.

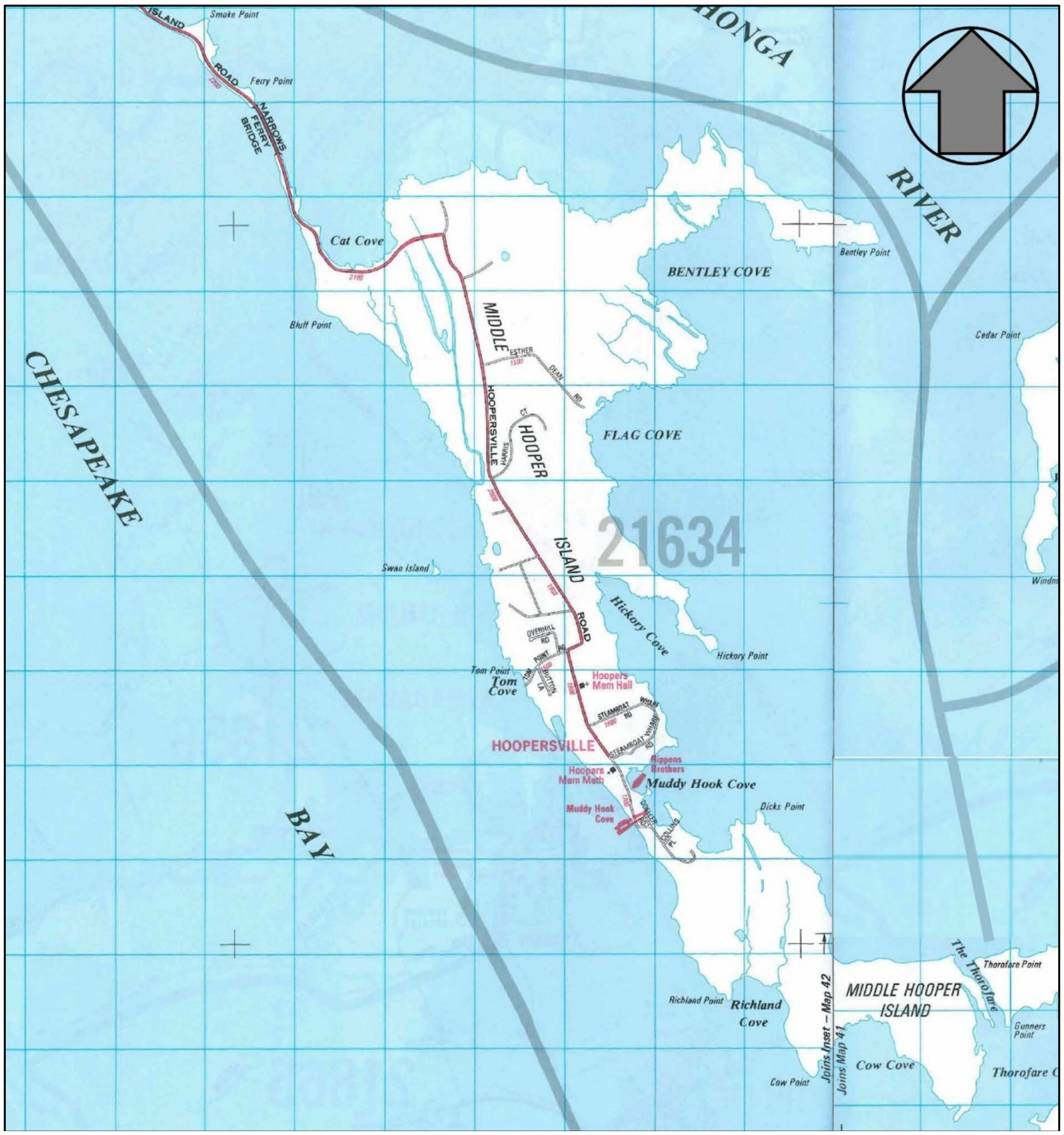

Figure 1 - Vicinity Map of Hoopersville

In July 2021, the Dorchester County Department of Planning and Zoning (County) along with the Maryland Department of Natural Resources (DNR) tasked BayLand

Consultants & Designers, Inc. (BayLand) with providing a coastal resiliency assessment defining areas of Hoopersville that are most susceptible to coastal stressors, the impacts coastal resiliency stressors will have on these areas, and mitigation strategies for reducing the impacts of these risks. The following assessment will identify areas based on physical characteristics and susceptibility to coastal stressors. These areas will be prioritized based on their vulnerability, the magnitude of impacts, and their value to the community. Once prioritized, strategies for reducing the risk posed by coastal stressors will be developed for each area. The conclusion of this assessment will involve developing an adaptation plan that lays out the framework for implementing the preferred mitigation strategies.

The assessment consists of three Phases:

- **Phase 1 – Data Collection and Analysis**: This part of the assessment evaluates historic and present conditions at Hoopersville to determine site characteristics, the coastal resiliency stressors that impact the site, the magnitudes of those stressors and how the magnitude and frequency will change with SLR.
- **Phase 2 – Vulnerability Assessment**: In this phase, the island is divided into assessment areas with similar site conditions and use. The vulnerability and risk tolerance of each area to the coastal resiliency stressors identified in the previous phase is defined. These areas are then prioritized for project implementation based on need.
- **Phase 3 – Adaptation Plan**: The final phase compares multiple risk management strategies in an Alternatives Analysis and refines a design based on the preferred strategy. The final product consists of an Adaptation plan that outlines the cost and characteristics of the preferred strategies and the implementation timeframe.

2. Phase 1 – Data Collection and Analysis

Data specific to Hoopersville was collected and analyzed to provide an understanding of the current state of the island, how coastal stressors impact the site, and how these stressors will continue to impact the site in the future with SLR. Data Collection and Analysis was completed through two tasks: 1. Review of Site Conditions and 2. Assessment of Coastal Resiliency Stressors. Results of these tasks are outlined below.

2.1. Review of Site Conditions

The Site Conditions evaluated as part of this assessment include:

- Existing Natural Shoreline and Shoreline Protection Measures
- Hoopersville Elevations
- Existing Habitats
- Existing Infrastructure

The site conditions are described in the subsequent paragraphs.

2.1.1. Hoopersville Shoreline

The total length of the shoreline surrounding Hoopersville is approximately 20 miles, including 13.4 miles of the eastern shoreline along the Honga River and 6.6 miles along the Chesapeake Bay. Currently, a majority of the shoreline (~16.5 mi.) is coastal marshes. Based on 2019 aerial imagery, approximately 3.5 miles of shoreline stabilization are in place in the form of revetments, breakwaters, bulkheads, and rubble shore protection. The western shoreline accounts for less than half of this protection despite its exposure to long fetches across the Chesapeake Bay. Pockets of sandy beaches occur in multiple locations along the island, and a few stretches of shoreline still contain forested areas. Examples of the shoreline protection measures are shown Figure 2.

Photos taken during the July 27th, 2021 site visit are provided in Photo 1 through Photo 12 and depict the various conditions of the shoreline and shoreline protection measures.

2.1.1. Island Elevations

Based on 2013 Light Detection and Ranging (LiDAR) data, the ground elevations across Hoopersville range from -1.0 feet to +10.5 feet NAVD88, with elevations above +2.0 feet (1.3 feet above Mean High Water [MHW]) making up only 13% of the site. The remaining 87% of the island is below +2.0' NAVD88 and accounts for residential area, farmland, marsh lands, and forested areas. The varying elevations across the island are depicted in Figure 3 - Island Elevation.

The majority of the land with elevations below +1.0' NAVD88 (0.3 feet above MHW) consists of coastal marshes. Elevations between +1.0 feet and +3.0 feet NAVD88 make up approximately 1,375 acres of the island and consist coastal marshes and residential areas. The higher elevations of the island (over +3 feet NAVD88) make up only 45 acres of the island and are comprised of residential areas, forest, and cleared open space.

Figure 2 - Shoreline Stabilization Measures


Photo 1 - Marsh along Honga River


Photo 2 - Duck Blind within Marsh Area


Photo 3 - Interior Marsh Area


Photo 4 - Erosion of Coastal Marshes


Photo 5 - Sandy Beach Area


Photo 6 - Stone Breakwaters Protecting against Coastal Erosion

Photo 7 - Shoreline Protected with Revetment

Photo 8 - Unprotected Eroded Bluff

Photo 9 - Forested Area along Shoreline

Photo 10 - Bulkhead

Photo 11 - Rubble Protection along Road

Photo 12 - Stone Revetment Protection along Road

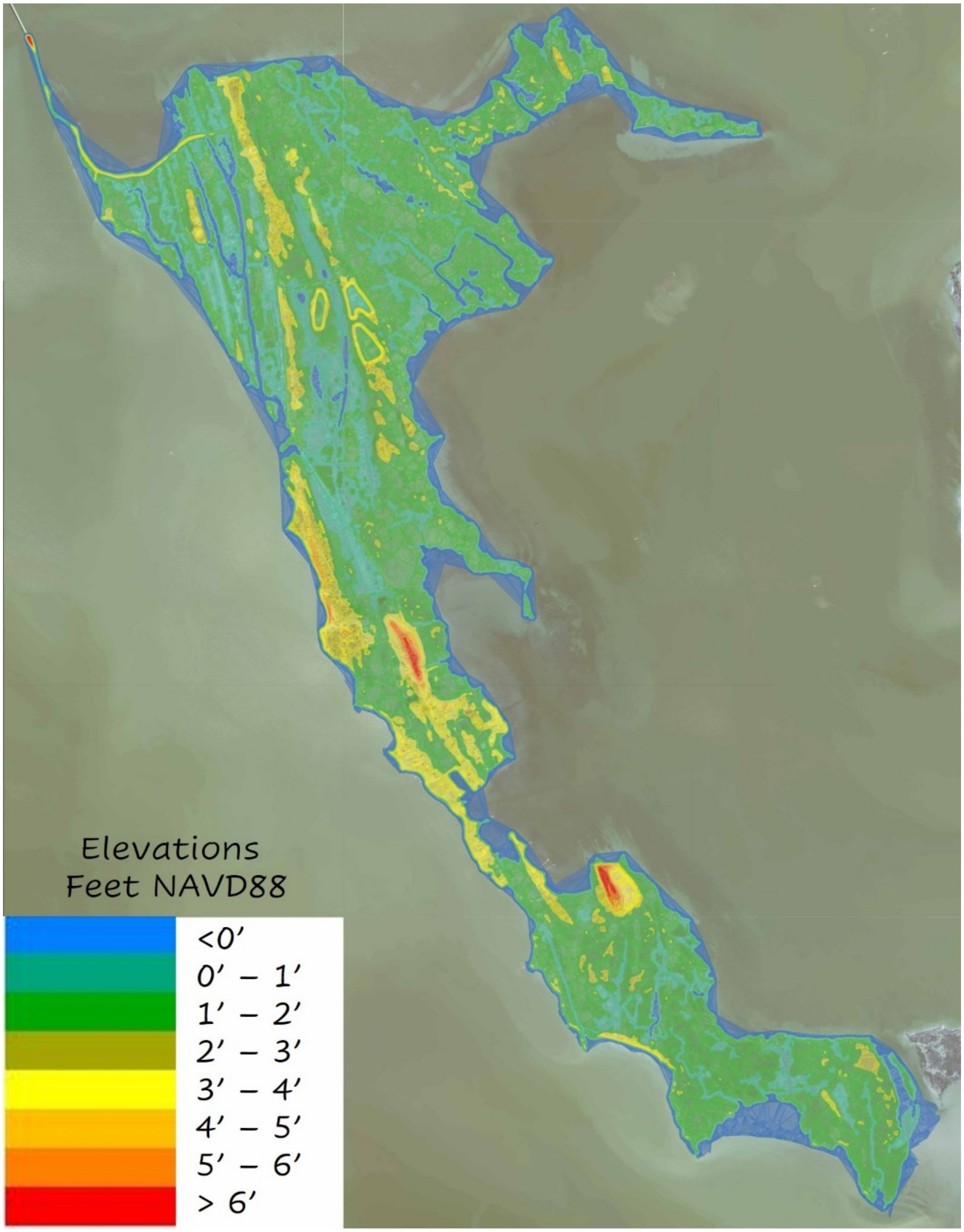

Figure 3 - Island Elevation

2.1.2. Existing Habitats

Hoopersville contains more than 1,140 acres of natural habitats such as forests, marshes, and beaches. Coastal marshes make up the majority of this area at approximately 1,120 acres. The marsh consists of multiple natural runnels and man-made ditches that were cut through the marsh in order to improve tidal flushing and prevent standing water in the inland areas of the island. This area has high ecological value for many native waterfowl and wading birds, plants, mammals, invertebrates, and reptiles such as the Diamondback Terrapin. Many areas throughout Hoopersville have been identified by the Maryland DNR as Targeted Ecological Areas (TEAs) which are of high priority for conservation and natural resource protection. These areas are shown in Figure 4.

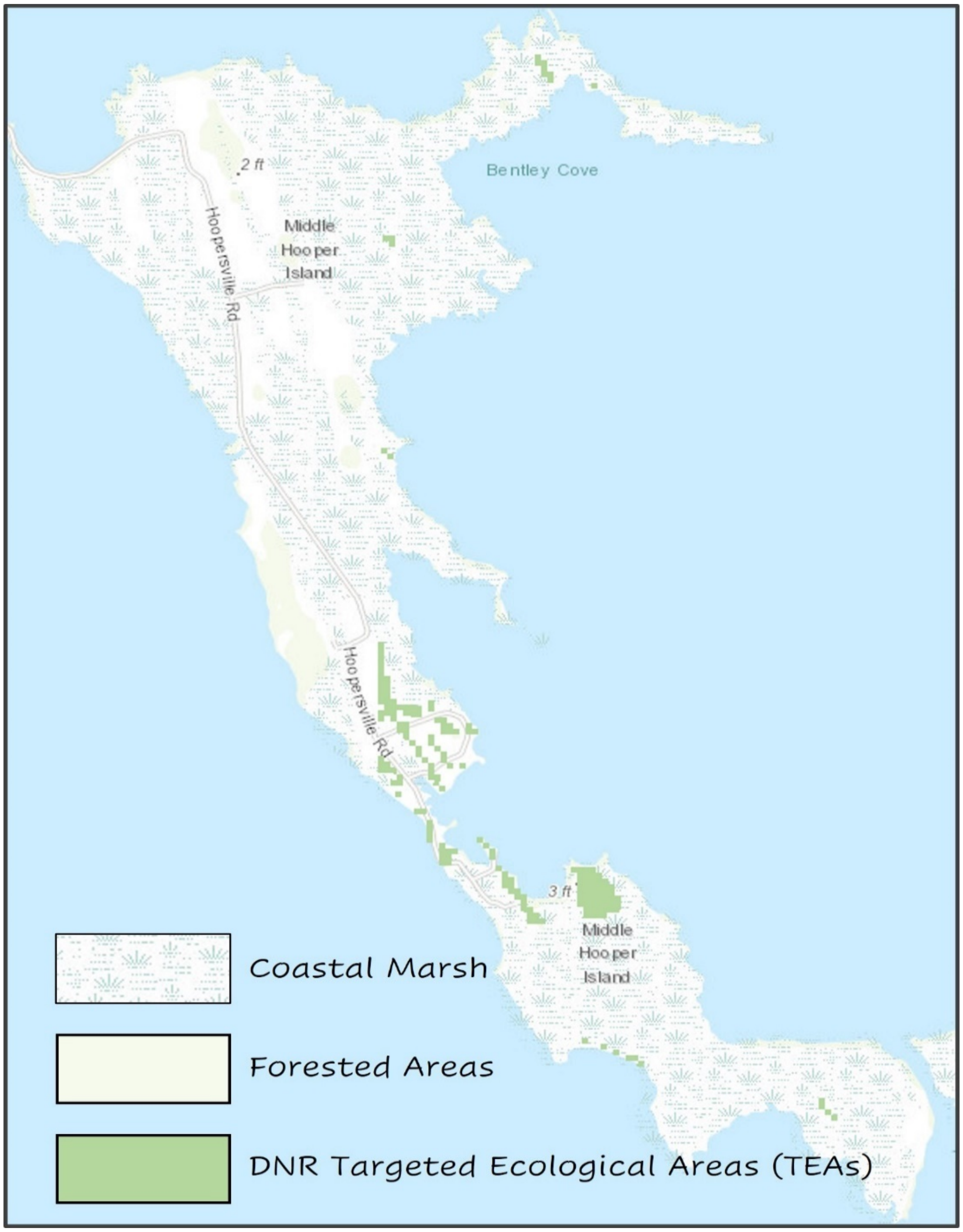

Figure 4 - Habitat Along Hoopersville (Source: MERLIN)

Forested areas consist of areas with dense tree canopy coverage. Forests play a significant role in helping to trap pollutants and nutrients from runoff. Streamside forests, also known as riparian buffers, line many of the coastal marshes and ditches within Hoopersville. These forested areas have the added benefit of providing habitat, nesting sites and safe migration paths for multiple land and water species. Based on 2019 aerial imagery, approximately 60 acres, or 5% of the island's natural habitat consists of forested areas.

Beaches consist of stretches of sandy shoreline where the wave energy is too high to support marsh habitat or other forms of vegetation. These areas are typically very dynamic and can change day to day. Sand is moved both cross shore (up and down) the beach and longshore (along) the beach depending on the direction of the waves. These areas serve as spawning habitat for horseshoe crabs as well as critical nesting habitat for migratory birds such as the threatened piping plover. Areas with natural sandy beaches along the Hoopersville shoreline include Bluff Point, shoreline north of Tom Point and near Tom Cove, Richland Cove and some pocket beaches along Bentley Cove. Currently, Hoopersville only has just over ¾ of a mile of beach habitat along its 20 miles length.

Additionally, Maryland Coastal Atlas current and historic records indicate that Submerged Aquatic Vegetation (SAV) has been recorded in the near-shore waters of the island every year since 1996. Other natural habitats seaward of the shoreline include waterfowl areas, public shellfishery areas, and oyster sanctuaries and historic repletion areas. These areas are shown in Figure 5.

2.1.1. Infrastructure

The northern half of Hoopersville contains a rural residential area and farmland surrounded by coastal marshes. An area covering approximately 150 acres around the narrowest point of the island contains most of the residences and businesses. This area is zoned a 'Village District' and contains approximately 90% of the homes and businesses in Hoopersville. Of these homes, approximately 40% of them are located along the shoreline. The town contains two churches and three graveyards. Businesses located on the island include Rippons Brother's Seafood Inc., Coastal Seafood Inc., Simmons Chesapeake Seafood and the Riverside Lodge Resort. There is one primary road, Hoopersville Road, with multiple roads leading from it to properties and businesses.

Marine infrastructure is present around the island in the form of personal piers, marina structures for loading/unloading and docking of commercial vessels servicing the multiple picking houses on the island.

Some areas within Middle Hooper Island have been highlighted as historic. The Maryland Historical Trust has named Hoopers Island in the Maryland Inventory of Historic Properties (MIHP)[1], and the Dorchester County Office of Tourism has identified it as part of the Heart of Chesapeake Country Heritage Area.[2]

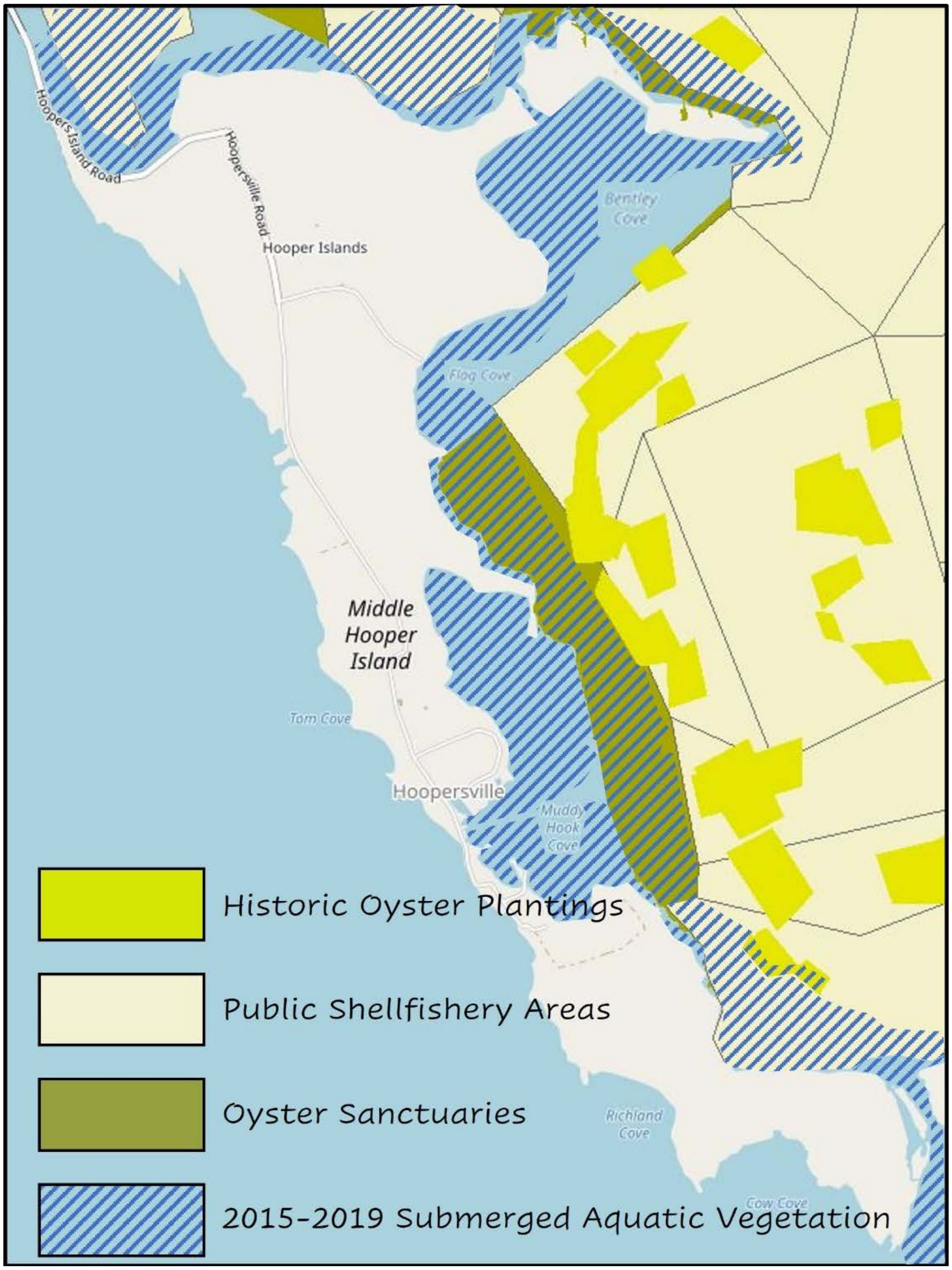

Figure 5 - Aquatic Living Resources near Hoopersville

Drainage within Hoopersville generally consists of roadside and non-roadside swales and ditches that discharge directly into the waterways or coastal marshes. The absence of tide gates at major outfalls allows perpetual backwatering of the swales and ditches which creates the lack of hydraulic head required to drain rainfall runoff. Residents have observed that both stormwater and tidal water backflowing through the ditches will pond on or near the roads, homes, and other infrastructure due to its inability to drain. Additionally, high tailwater conditions, which are only anticipated to increase with SLR, also prevent flow and result in stagnant water within the ditches.

2.2. Coastal Resiliency Stressors

Coastal resiliency stressors are defined as the natural processes that pose a risk to the natural or built environment. For Hoopersville, the resiliency stressors that have been identified to pose a risk of damage to infrastructure and existing habitat or a disruption to life in Hoopersville include:

- Coastal Erosion
- High Tide Flooding
- Storm Surge Flooding
- Saltwater Intrusion
- Flooding due to Inadequate Drainage

2.2.1. Coastal Erosion

Coastal erosion is the process of waves and/or high flows destabilizing the sediments along the natural shoreline. The sediments are then moved offshore or to another location. Along the Hoopersville shoreline, wind-waves are the predominant drivers of coastal erosion. While some portions of the shoreline are protected by shoreline stabilization measures, the majority of the island is exposed and susceptible to erosion.

Photo 13 - Eroded Bank

Photo 14 - Eroded Marsh Bank

Fetch, defined as the distance that wind and waves travel across open water without obstruction, plays an important role in the ability for waves to erode shorelines. Fetch distances less than one mile will typically have low wave action. Fetch distances between 2 and 5 miles are classified as having moderate wave action and any fetch distances larger than 5 miles are classified has high wave action areas. For the eastern shore of the island along the Honga River, fetch distances are largest from the southeast, reaching approximately 9 miles. The western side of the island is exposed to the Chesapeake Bay and has a maximum fetch of approximately 90 miles from the south.

Due to the large fetch and the frequency of winds from the South, wind-generated waves are resulting in higher rates of erosion along the shorelines exposed to this direction. Erosion rates presented in this study were provided by the developed by the Eastern Shore Regional GIS Cooperative (ESRGC) in partnership with the Maryland DNR Critical Area Commission (CAC) and Dorchester County, which compared shorelines between 1988 and 2016 to estimate average rates of erosion. Local rates for different areas of the island have been assessed and are presented in subsequent sections of this assessment. Based on this data, the western shore of Hoopersville has eroded between 100 and 300 feet and the eastern shoreline has eroded 30 to 100 feet for this timeframe. More details on the specific erosion rates will be given for each 'Assessment Area,' discussed in subsequent sections of this report.

2.2.2. Flooding

Given the low elevations of the island, flooding occurs multiple times a year. The National Weather Service (NWS), in conjunction with the National Atmospheric and Oceanic Administration (NOAA) has identified certain flooding thresholds for areas surrounding the NOAA Tide Station 8571421 at Bishops Head, MD, located approximately 8 miles southeast of Hoopersville. These flood elevations are graphically represented for Bishops Head overlain on the October 2021 water level measurements, shown in Figure 6. The number of times these flood events have occurred between 2006 and 2020 is presented in Table 1.

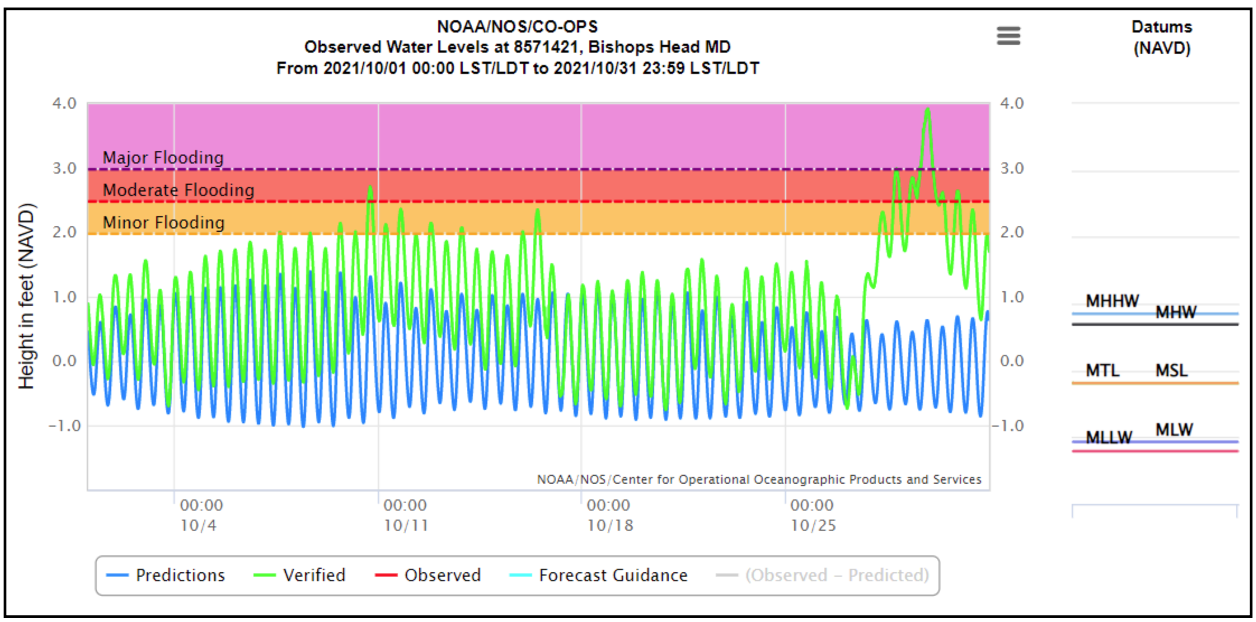

Figure 6 - Flood Elevations at Bishops Head, MD (source: NOAA Tides and Currents)

For the purposes of this study, nuisance flooding has been defined as by the 'Minor Flooding' threshold of 2 – 2.5 feet above NAVD88 (approximately 1.3 – 1.8 feet above MHW). Based on the water level measurements at Bishops Head, nuisance flooding occurs an average of 84 times per year. A flood elevation of +2 feet NAVD88 will inundate approximately 86% of the island.

Moderate flood events occur with a water elevation of 2.5 – 3.0 feet above NAVD88 or 1.8 – 2.3 feet above MHW. This flood event occurs approximately 13 times per year, on average. This flood elevation will flood approximately 93% of the island.

Major flood events are defined as flood elevations exceeding 3 feet above NAVD88 or 2.3 feet above MHW. This water level or higher averages one occurrence per year and will results in 97% of the island being flooded.

Table 1 - Number of Flood Events at Bishops Head, MD

Year	No. of Minor Flood Events	No. of Moderate Flood Events	No. of Major Flood Events	Total No. of Flood Events
2006	44	10	0	54
2007	17	0	0	17
2008	28	5	1	34
2009	70	4	0	74
2010	55	9	0	64
2011	94	18	1	113
2012	46	16	2	64
2013	35	1	0	36
2014	53	13	0	66
2015	78	7	0	85
2016	72	16	1	89
2017	95	7	0	102
2018	143	35	4	182
2019	150	24	11	185
2020	61	7	0	68
2021	62	28	10	100

SLR will result in these flood elevations occurring more frequently in the future. In fact, Table 1 shows the number of flood events per year has nearly doubled from an average of 57 flood events per year between 2006 – 2013 to an average of 110 flood events between 2014 – 2021. The plot of the number of flood events per year shown in Figure 7 shows a clear indication that the frequency of the flood events, especially nuisance flooding events, has increased over the last fifteen years.

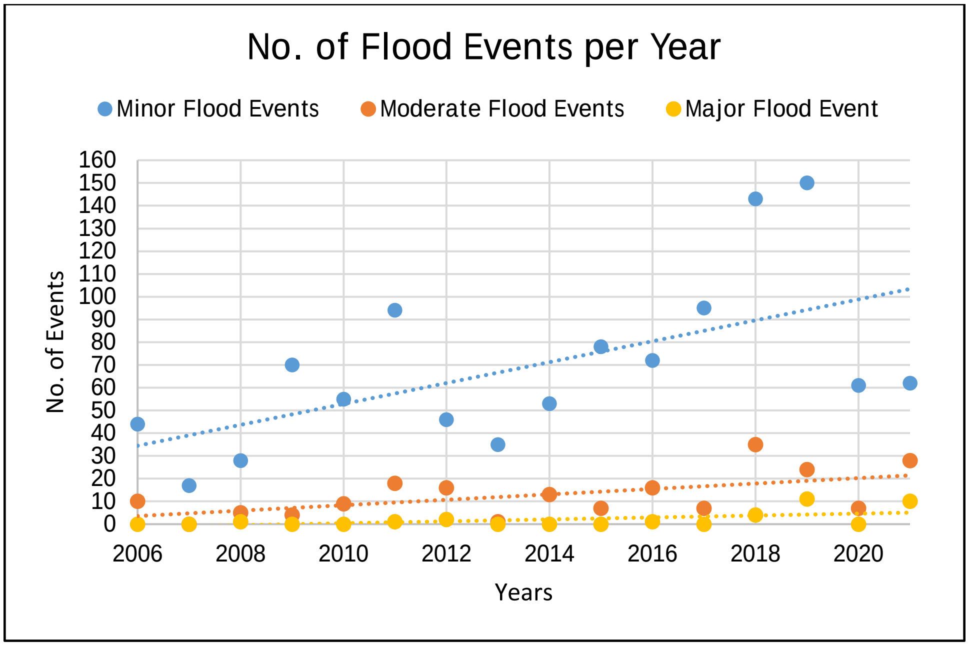

Figure 7 - No. of Flood Events at Bishops Head between 2006 - 2021

More details on the flood extents for each Assessment Area will be discussed in subsequent sections of this report.

2.2.3. Saltwater Intrusion

Saltwater intrusion refers to water with a higher salinity encroaching on areas with lower salinities. Salinity of the water plays a significant role in determining the habitat and species that can survive and prosper. Increasing the salinity can have detrimental impacts on freshwater species of plants and animals. This can already be seen by the loss of forested areas along the shoreline, as shown in Photo 15 and Photo 16.

Photo 15 - Decline of Tree Clusters around Island

Photo 16 - Dead Trees along Shoreline

Photo 15 and Photo 16 show the decline of the forested areas within and landward of the marshes. Trees located closer to the shoreline or located at lower elevations have been impacted by the frequent coastal flooding. With SLR, these low-lying forested areas will continue to convert to coastal marshes. More details on the loss of forested areas for each Assessment Area will be discussed in subsequent sections of this report.

2.2.4. Drainage

Low-lying, flat areas such as Hoopersville can often experience issues when draining stormwater from rainfall events. Stormwater runoff will often pond in flat areas and remain in place long after the rainfall has ceased. Additionally, drainage ditches or swales can offer an inlet for coastal waters to reach inland areas during significant high-water levels. These factors can often lead to habitat degradation due to saltwater intrusion or flooding. It can also result in flooding of low-lying areas inland of the shoreline. Photo 17 shows an example of a drainage ditch between the road and an adjacent property.

Photo 17 - Drainage Ditch along Hoopersville Road

These ditches require maintenance to removed sedimentation. Sedimentation along the bottom of the ditch can also cause flooding by decreasing the discharge capacity within the ditch. Erosion of the side slopes during high flows could also results in land encroachment and deposition of the material along the bottom of the bank.

Similar to the other coastal resiliency stressors discussed in this section, the deficiencies in drainage will only increase with SLR. Higher tailwater levels may result in backwatering and lack of hydraulic head required to drain rainfall runoff. Higher tailwater will also perpetuate tidal waters traveling up the ditches to upland areas. More details on the drainage deficiencies for each Assessment Area will be discussed in subsequent sections of this report.

2.2.5. Sea Level Rise

SLR is the increase of average water levels. It is divided into two categories based on contributing factors:

1. Global Sea Level Rise – increase in the global sea level based on the thermal expansion of water (the size of saltwater molecules increases as it warms up) and ice melt from the glaciers and continental ice masses adding a significant amount of freshwater into the world's oceans.
2. Relative Sea Level Rise – increase in the local sea level along a specific coast based on global SLR land subsidence (sinking of land), tectonic plate movements and other local factors.

According to data from NOAA Tide Station 8571892 – Cambridge, MD, sea levels in Dorchester County have increased approximately 1.27 feet over the last 100 years, as shown in Figure 8. This historic SLR trend results in an average annual increase in water levels of 0.15 inches/year.

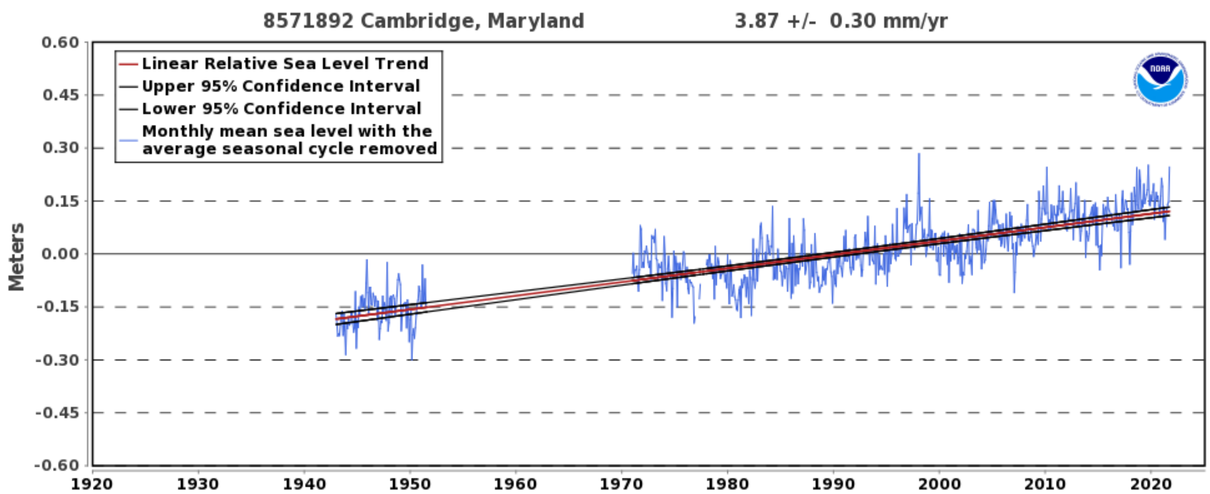

Figure 8 - SLR Trends at NOAA Tide Station 8571892 Cambridge, MD (Source: NOAA Tides and Currents)

The latest climate science indicated that sea levels will continue to rise at a potentially higher rate in the future. A graphical representation of SLR projections for Baltimore is provided in Figure 9.

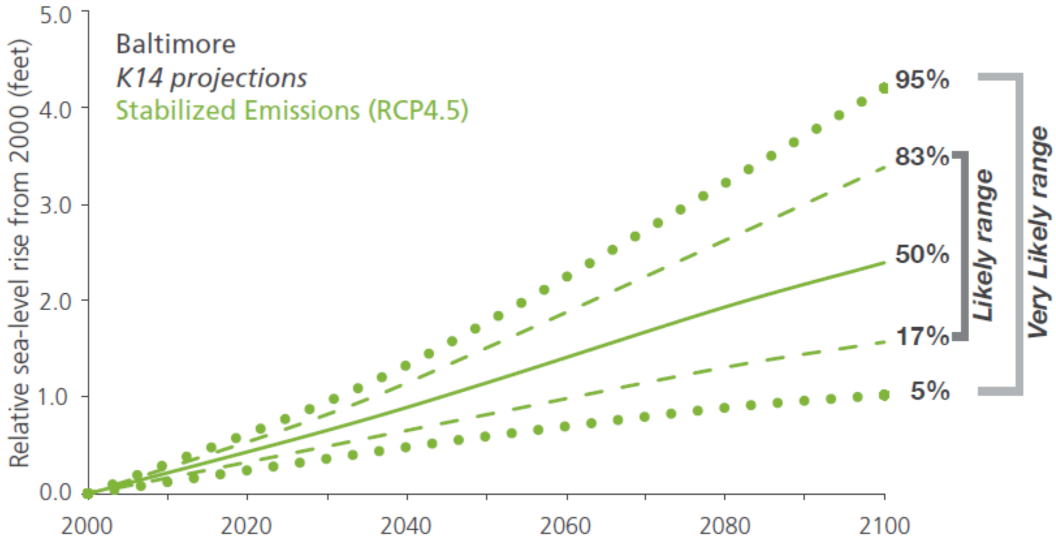

Figure 9 - SLR Projections based on SLR Projections for Maryland 2018

SLR will exasperate the impacts caused by the resiliency stressors discuss in the previous section in the following ways:

- Coastal Erosion – larger water depths will result in larger waves that have more energy to erode a shoreline;
- High Tide Flooding – higher base water elevations will result in higher high tide events that can flood low lying areas more frequently;
- Storm Surge Flooding – higher base water elevation will result in higher storm surge elevations;
- Saltwater Intrusion – higher water levels can penetrate further into marshes or other natural areas where salinity is lower;
- Drainage impacts – higher tailwater conditions may prevent stormwater from draining properly and tailwater may flow into inland areas through channels cut through the marsh.

Given the impact induced on the stressors by SLR, the vulnerability of areas and/or assets within Hoopersville will increase with future conditions. The University of Maryland Center for Environmental Science (UMCES) has developed the *Sea-Level Rise Projections for Maryland 2018* which provides likely ranges, central estimates and the 5% and 1% probability estimates for SLR relative to the water levels experienced in 2000. Additionally, representatives of the Maryland DNR and Maryland Sea Grant Extension are developing guidance on how to utilize the SLR projections based on an area's risk tolerance to impacts. The values presented in Table 2 present the SLR projections for Cambridge, Maryland assuming greenhouse gas emissions are stabilized by 2050 (RCP 4.5). These projections are intended for use when conducting studies or developing designs for areas or assets subject to the impacts for SLR and will be applied to the Hoopersville assessment areas discussed in subsequent paragraphs of this study.

Table 2 - Recommended SLR Projections*			
Year	**High Tolerance for Risk**	**Medium Tolerance for Risk**	**Low Tolerance for Risk**
2030	0.9 ft	1.1 ft	1.3 ft
2040	1.2 ft	1.5 ft	1.8 ft
2050	1.7 ft	2.0 ft	2.4 ft
2060	1.9 ft	2.3 ft	2.9 ft
2070	2.3 ft	2.8 ft	3.5 ft
2080	2.7 ft	3.3 ft	4.2 ft
2090	3.1 ft	3.8 ft	5.0 ft
2100	3.5 ft	4.3 ft	5.7 ft

** Based on projections at Cambridge per design year and risk tolerance for RCP 4.5 – Stabilized Emissions*

2.3. Assessment Areas

To facilitate assessing the vulnerability and risk as well as developing mitigation strategies for Hoopersville, the island was divided into areas, herein referred to as 'Assessment Areas,' based on similar use and site characteristics. These areas are presented in Figure 10 and are as follows:

- Northeast Marsh
- Northwest Marsh
- Rural Residential Area
- Village District
- Southern Marsh
- Hoopersville Road

A description of each area and the coastal resiliency stressors is presented in the following paragraphs. The impacts of each coastal resiliency stressor on the assessment areas were evaluated as follows:

- Coastal Erosion – data provided by the ESRGC on estimated erosion rates between 1994 and 2016 was evaluated to each area.
- Saltwater Intrusion – specific data on saltwater intrusion was not obtained, therefore, impacts of saltwater intrusion were qualitatively assessed by comparing the size and location of forested areas from aerials taken in different years. A reduction in forested area may be the result of coastal erosion, saltwater intrusion, or development. Since an assessment or tree survey was not conducted to determine the amount and cause of reduction, information presented in this report should not be considered conclusive on this issue.
- High Tide and Storm Surge Flooding – Flood extents were determined by overlaying the flooding thresholds onto existing topographic data. Because the first-floor elevations of home or buildings was not assessed, it is unknown whether the flood elevations on property parcels will inundate homes.

- Drainage – Inadequate drainage was assessed through photographs and communications with residents. An assessment of the drainage system was not performed.

2.3.1. Northeast Marsh

The area referred to as the ‘Northeast Marsh’ encompasses approximately 360 acres of coastal marshes along the Northeast corner of Hoopersville. This area includes Bentley Cove and Bentley Point, an area of historical significance to Dorchester County. The entire area is zoned as a Resource Conservation Area (RCA) and consists of two property parcels. Average elevations of this area range between 0 and 4 feet above NAVD88, with over 99% of the area below +2 feet NAVD88.

- Coastal Erosion

Based on the erosion data developed by ESRGC, the shoreline has recessed an average of 43 feet between 1994 and 2016. Some areas have eroded over 415 feet in this time frame. The average erosion rate based on the 22 years of data approximately 2 feet/year with a maximum average of 18 feet/year. Figure 11 shows the area lost to coastal erosion within the Northeast Marsh. The 1972 shoreline is also shown and depicts the additional acreage of marsh lost between 1972 and 1994.

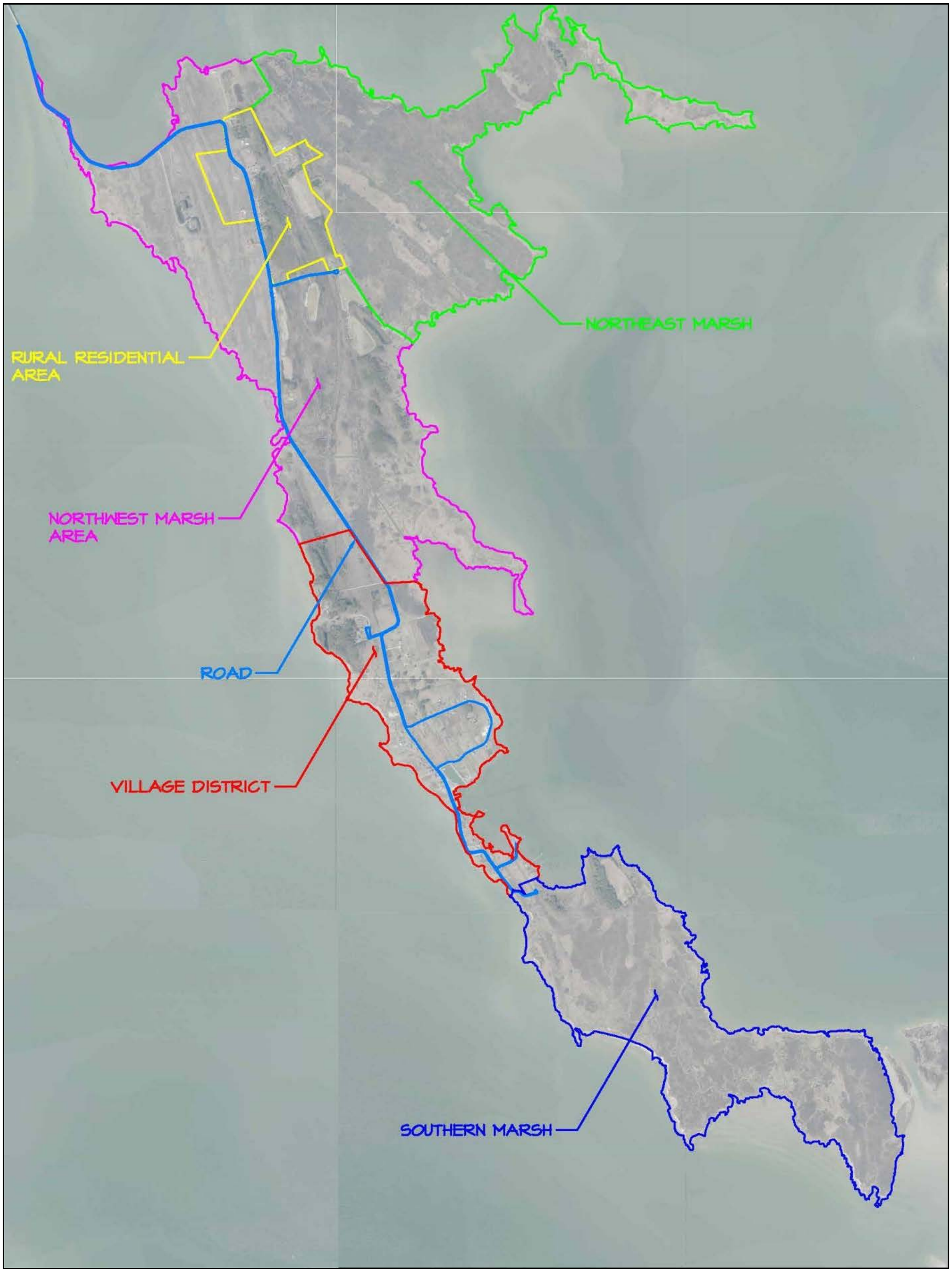

Figure 10 - Assessment Areas

❖ Forested Area Lost to Saltwater Intrusion

Given the loss of shoreline and higher water levels inundating further into the marsh, the habitat of this area has been impacted by the changing salinity. Though the majority of the area are coastal marshes that adapt well to a wide range of salinity, loss of forested areas was observed inland of the shoreline. Based on aerial photography, the area depicted in Figure 11 was a half-acre of dense forest habitat in 1994. When compared to recent aerials from 2019, this area has diminished to only a few remaining trees.

❖ High Tide and Storm Surge Flooding

Figure 12 depicts the areas within the Northeast Marsh that are inundated based on the flooding thresholds discussed in Section 2.2.2. As this is a coastal marsh, the vast majority is below the minor flooding threshold of +2 feet NAVD88. The entire area will be inundated during major flood events. Increases in flooding frequency will result in changes to plant species or hydrology. Damage to habitat may result if the marsh becomes too 'wet' or becomes inundated too frequently for its survival.

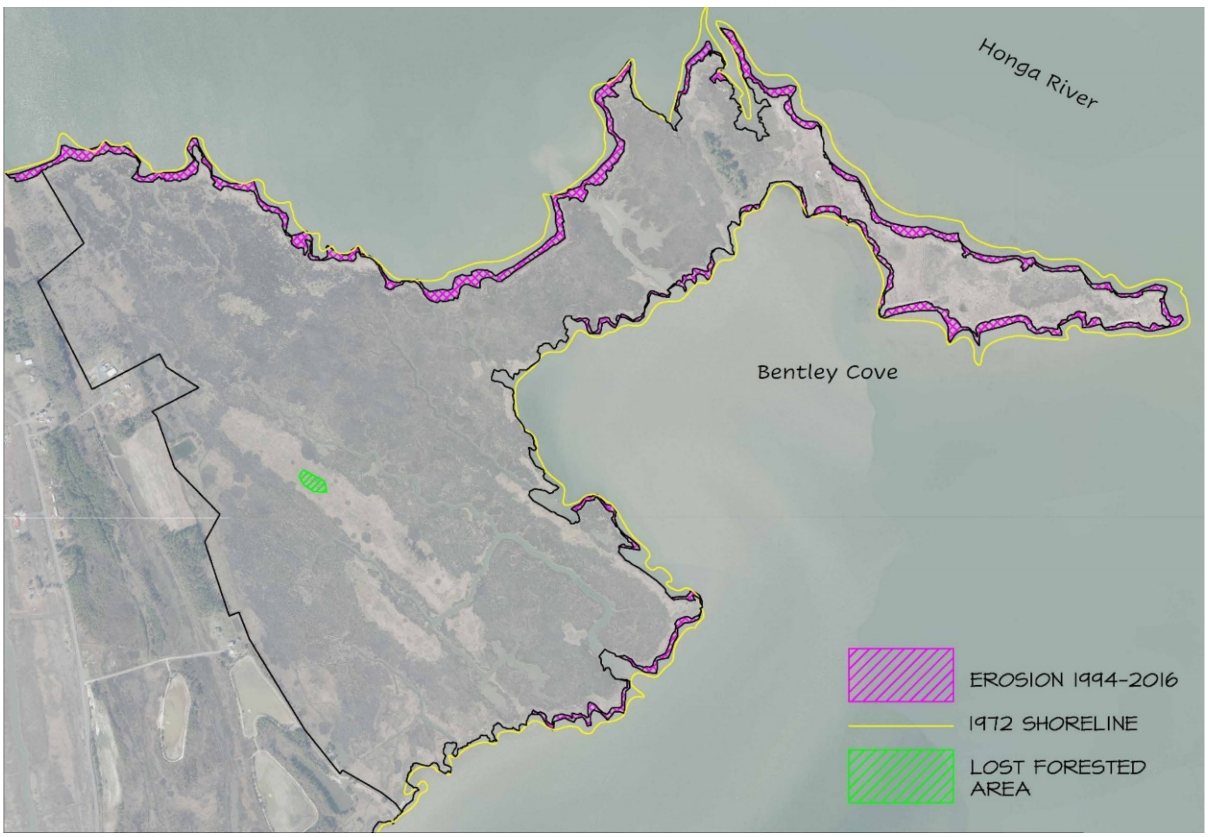

Figure 11 - Erosion and Lost Habitat along the Northeast Marsh Area

❖ Drainage

Because of the lack of development in this area, drainage as a coastal resiliency stressor does not apply to this area.

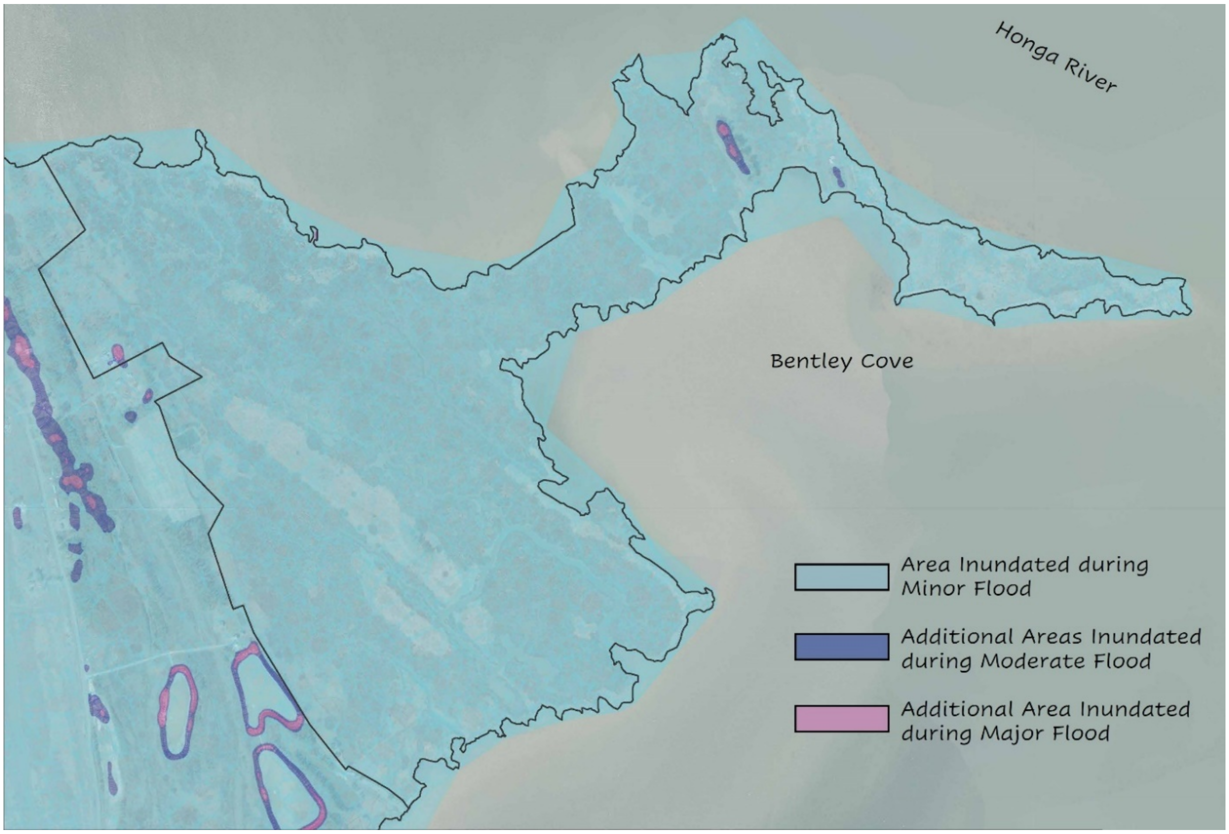

Figure 12 - Flooded Areas along the Northeast Marsh

2.3.2. Northwest Marsh

The Northwest Marsh encompasses the marsh area along the Northwestern part of the island and the marsh south of the Rural Residential area and the Northeast marsh. This area encompasses over 450 acres. There are approximately 10 property parcels within this area and 2 homes. The entire area is zoned as a Resource Conservation Area.

- Coastal Erosion

The area has total shoreline length of 6.3 miles, of which 4 miles is along the Chesapeake Bay and 2.3 miles is along the Honga River. Of the 6.3 miles of shoreline, approximately 4.8 miles was classified as eroding by the ESRGC analysis, shown in Figure 13. This has resulted in a loss of more than 29 acres of land since 1994. The average shoreline recession over this time was approximately 75 feet, which averages to 3.4 feet/year. The maximum shoreline recession was approximately 455 feet which has resulted in the shoreline now being adjacent to Hoopersville Road, discussed in Section 2.3.6.

- Forested Area Lost to Saltwater Intrusion

This area contains a significant amount of forest that has been lost to either development or saltwater intrusion. Based on a comparison of aerial photography between 1994 and 2019, approximately 43 acres of forested area has been lost. Today, approximately 30 acres of forested area remains within the Northwest marsh.

- High Tide and Storm Surge Flooding

Areas flooded during the flooding scenarios discussed in Section 2.2.2 are shown in Figure 14. Similar to the Northeast marsh, the majority of this area is coastal marshes and will be inundated regularly. Of the two homes present within this area, flood water will reach one of the homes at water levels greater than 2.5 feet above NAVD88 and the other with water levels above 3 feet NAVD88. All area within the Northwest marsh will be flooded for the flooding scenarios presented. Hydrology and plant species may be impacted by increased flooding. If flooding becomes too frequent, the coastal marsh will convert to open water.

- Drainage

Because of the lack of development in this area, drainage as a coastal resiliency stressor does not apply to this area.

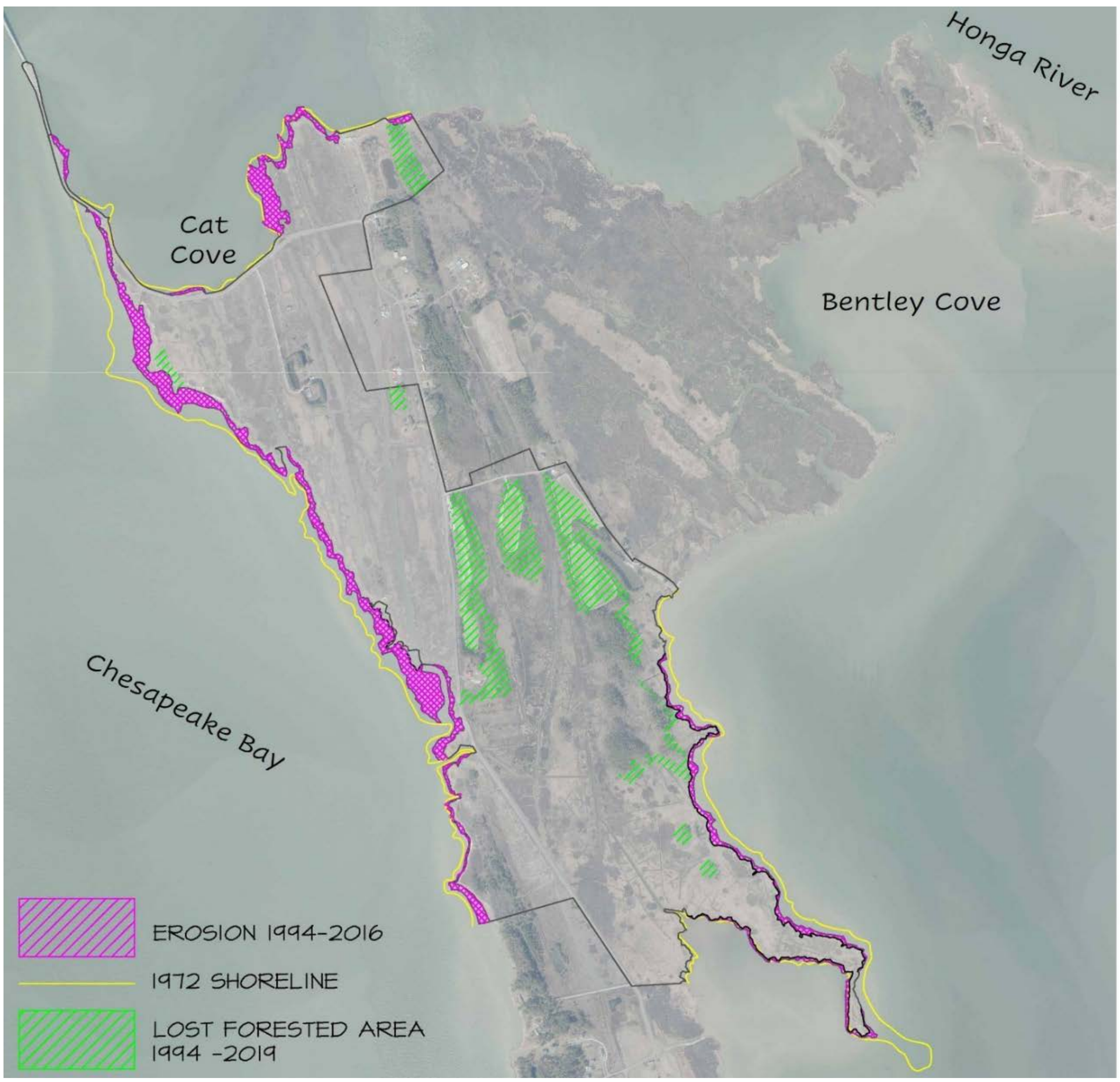

Figure 13 - Erosion and Lost Forested Area within the Northwest Marsh Area

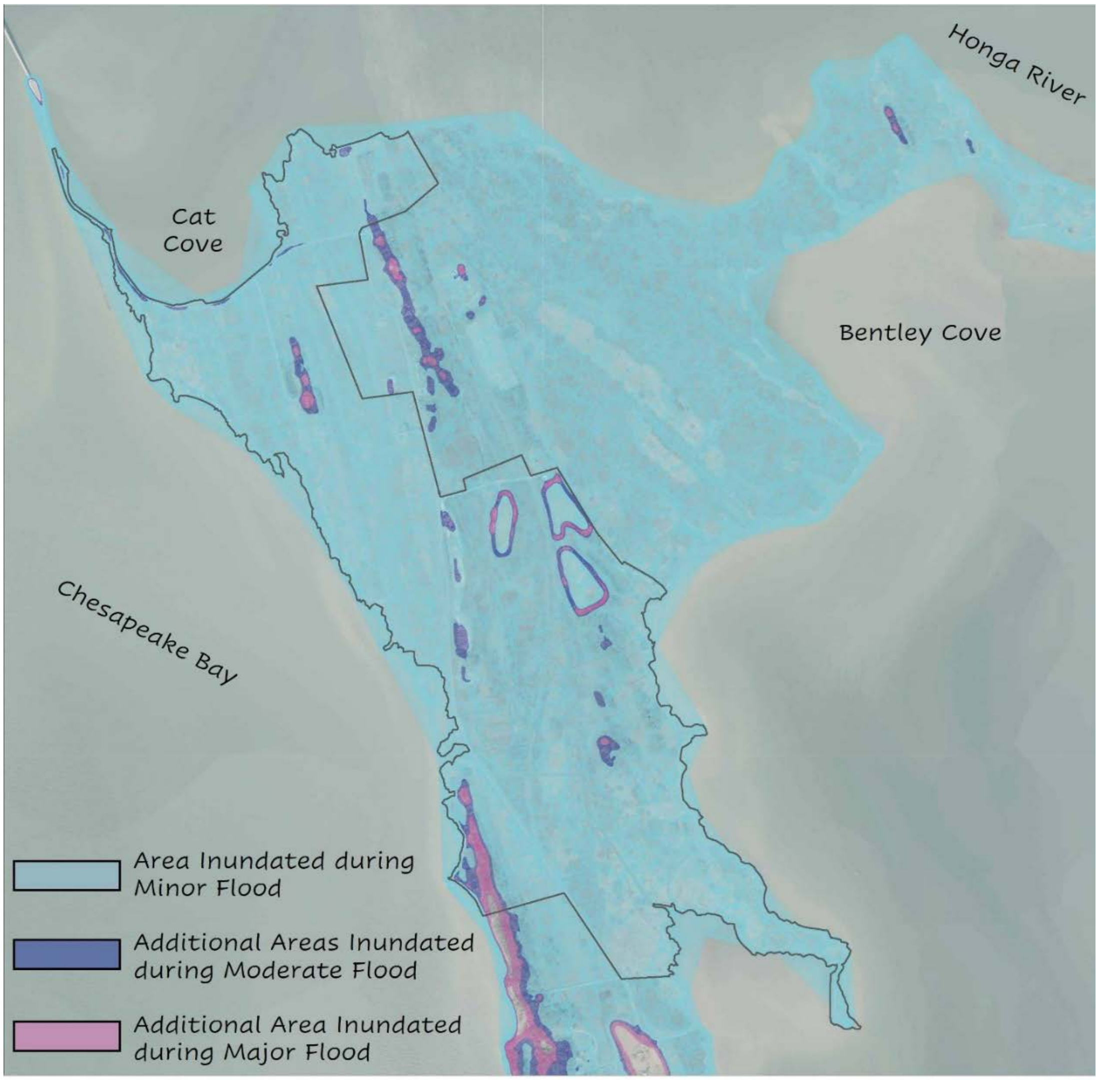

Figure 14 - Flooded Areas within the Northwest Marsh

2.3.3. Rural Residential Area

The Rural Residential Area is located in the northern extent of the island between the Northwest Marsh and Northeast Marsh. It is surrounded by land on all sides and does not have any shoreline. It is zoned as a 'rural residential' area with approximately 25 property parcels within its boundaries. Approximately 10 homes are located within this area.

- Coastal Erosion

Because of the lack of shoreline in this area, coastal erosion as a coastal resiliency stressor does not apply to this area.

Figure 15 - Lost Forested Areas within the Rural Residential Area

- Forested Area Lost to Saltwater Intrusion

Figure 15 shows the lost forested area within the Rural Residential area since 1994. Though it is evident that some clearing of forested area for development along Hoopersville Road, a significant portion of the lost forested area is located along the edge of coastal marshes adjacent to natural runnels or ditches. Of the 11 acres of forested area lost since 1994, it is estimated that approximately 8.5 acres have been lost to saltwater intrusion. Today, approximately 18 acres of forested area remains within the Rural Residential area.

- High Tide and Storm Surge Flooding

Figure 16 shows the extent of flooding within the Rural Residential area based on the flooding thresholds presented in Section 2.2.2. The majority of the homes within this area are built along the elevated area in the center of the Rural Residential area. Approximately half the homes are on land with elevations above 2.5 feet NAVD88 and will not risk flooding until the moderate flood elevation is reached. Two to three homes will not experience flooding risk until the major flooding threshold is reached.

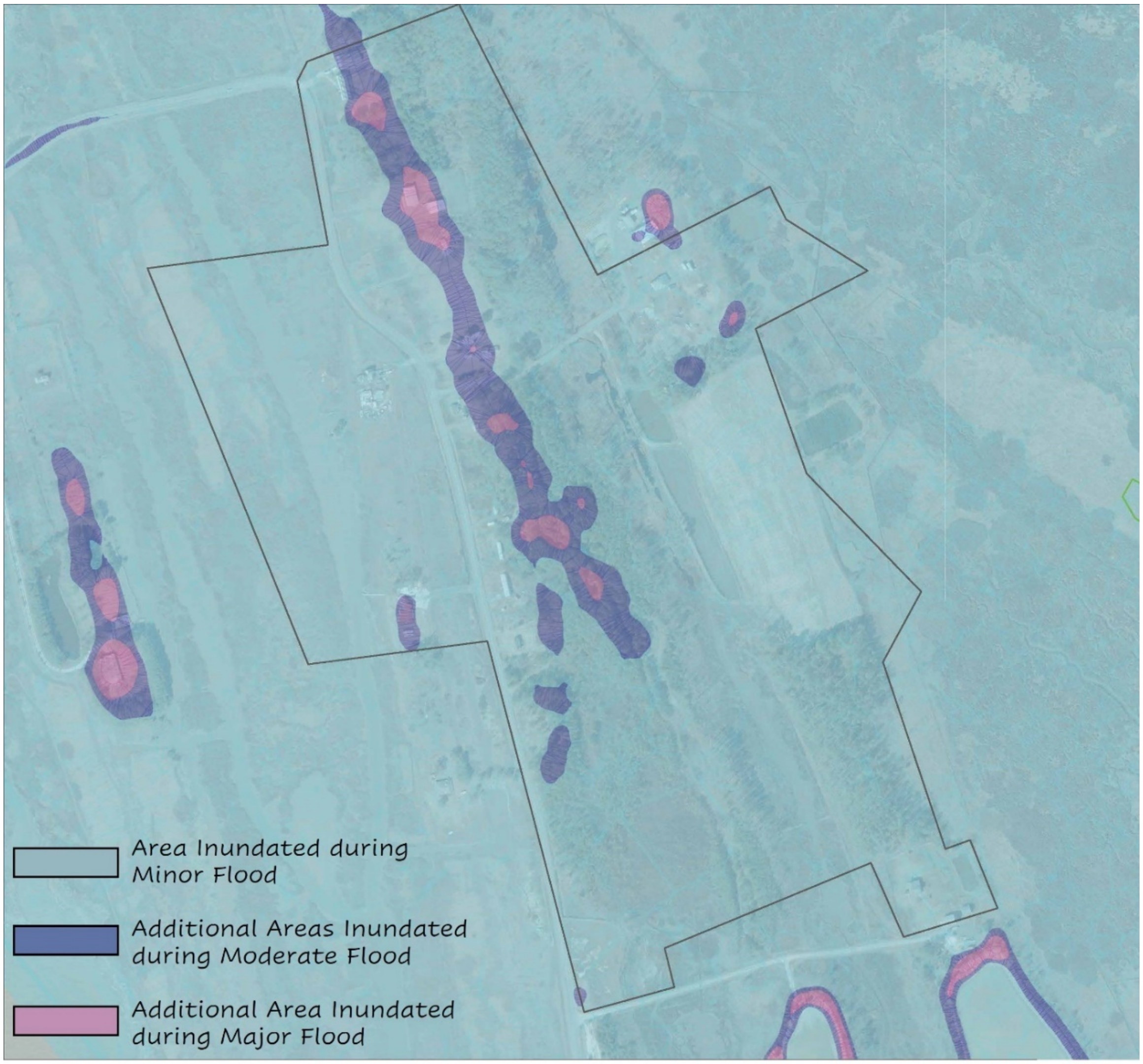

Figure 16 - Flooded Areas within Rural Residential Area

- Drainage

Stormwater runoff within this area drains directly into the coastal marshes or ditches within the marsh. Ditches alternate along either side of Hoopersville Road to help facilitate drainage. Given the low elevations, water is nearly always present within these ditches. With high tailwater conditions during or after a storm, these ditches are often not able to drain runoff. Additionally, as the ditches are not maintained regularly and accumulate sediment and debris, the capacity decreases within them and leads to more flooding potential.

2.3.4. Village District

The Village District is an approximate 192 acre area within Hoopersville where the majority of homes and business are located. It is zoned as a Village District within

Dorchester County and also designated as a Priority Funding Area by the State. This area contains more than 85 property parcels, over 60 residential properties, 3 crab and/or oyster processing facilities, the Hoopers Island Memorial Church and the Riverside Lodge Resort. A portion of this area is outside of the FEMA floodplain.

❖ Coastal Erosion

The Village District has shoreline on both the Chesapeake Bay and Honga River. The ESRGC analysis examined the coastal erosion along on the Chesapeake Bay side between 1994 and 2016, shown in Figure 17. Through visual inspection of aerial photography in 1994 and 2019, a large segment of shoreline along the Honga River side of this area appears to be stabilized or naturally protected by adjacent land.

The data indicates that approximately 16 acres of land along the Chesapeake Bay shoreline has been lost during the 22-year analysis period. The shoreline has receded an average of 99 feet, giving an approximate 4.5 feet of erosion a year. Some areas have eroded as much as 295 feet, or 13 feet/year, between 1994 and 2016. The 1972 shoreline, shown in Figure 17, indicates that significant erosion along the Chesapeake Bay shoreline has been on-going for decades.

❖ Forested Area Lost to Saltwater Intrusion

Though a significant amount of forest has been lost along this area, the majority has occurred due to coastal erosion and not saltwater intrusion. Many of the forested areas that existed in 1994 were located along the shoreline. The loss of land along this area also resulted in loss of forest. Approximately 1.5 acres, shown in Figure 17, of the total 7 acres of forested areas lost in this time frame could possibly be attributed to saltwater intrusion.

❖ High Tide and Storm Surge Flooding

Figure 18 shows the flood extents of the flooding thresholds discussed in Section 2.2.2. Elevations along this area are higher than other areas on the island. Approximately 2 – 3 homes within the Village District are at ground elevations higher than the flooding thresholds and would only experience flood risk in extreme storm surge and wave events. An additional 8 – 10 homes would only risk flooding in major flood events. Only one or two homes or businesses appear to be at ground elevations below the ‘minor flooding’ threshold. The majority of the homes, approximately 80%, will experience flood risk for a moderate flood elevation or higher.

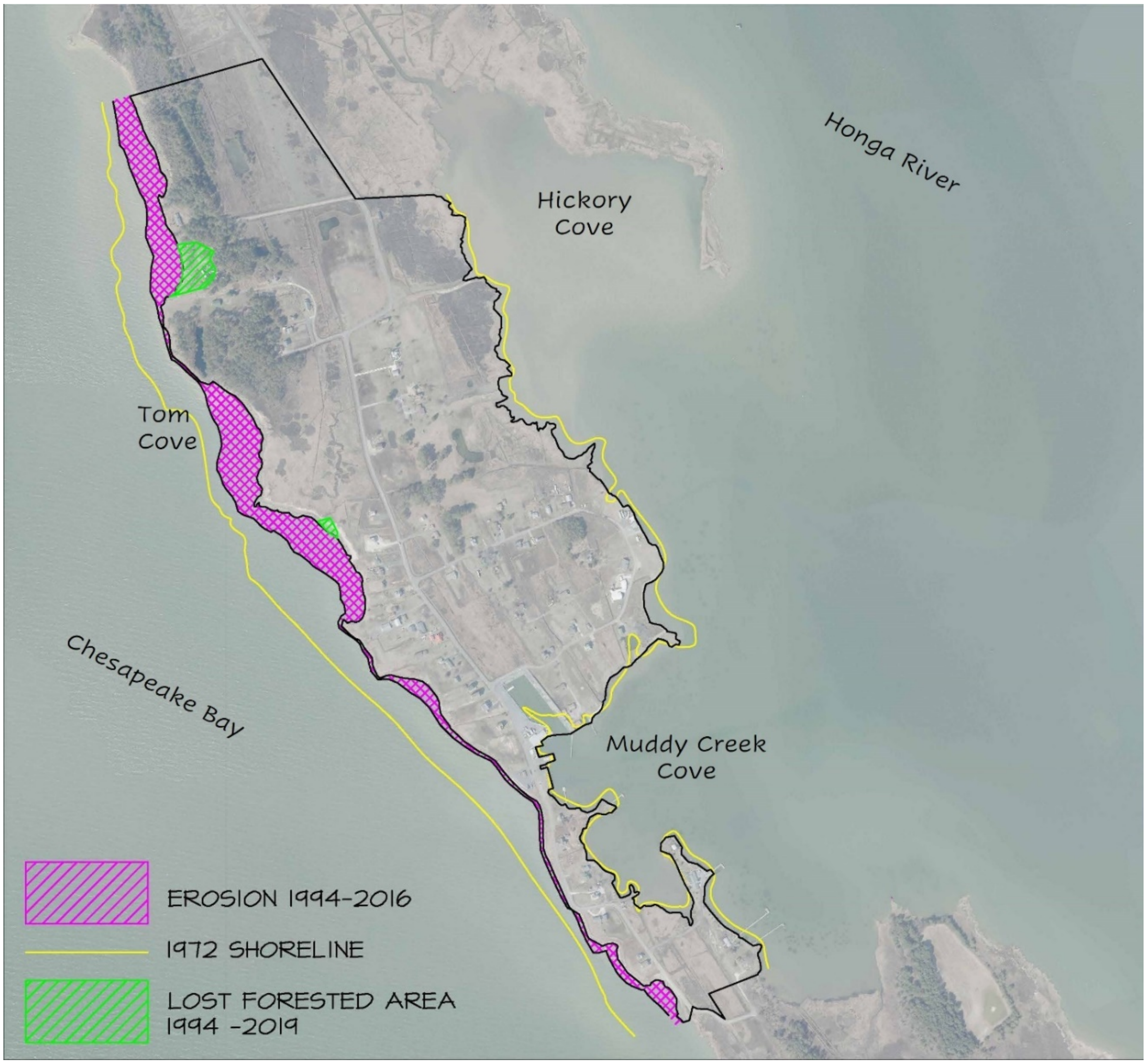

Figure 17 - Erosion along the Village District Shoreline

❖ Drainage

Similar to the Rural Residential Area, runoff is discharged into the waterways or coastal marshes through ditches along the roadside. Deficiencies in the system arise due to sedimentation in the ditches and lack of maintenance to remove the sediment or debris. Inadequate drainage along this area has been reported by property owners as a concern, especially with tailwater conditions only anticipated to increase with SLR.

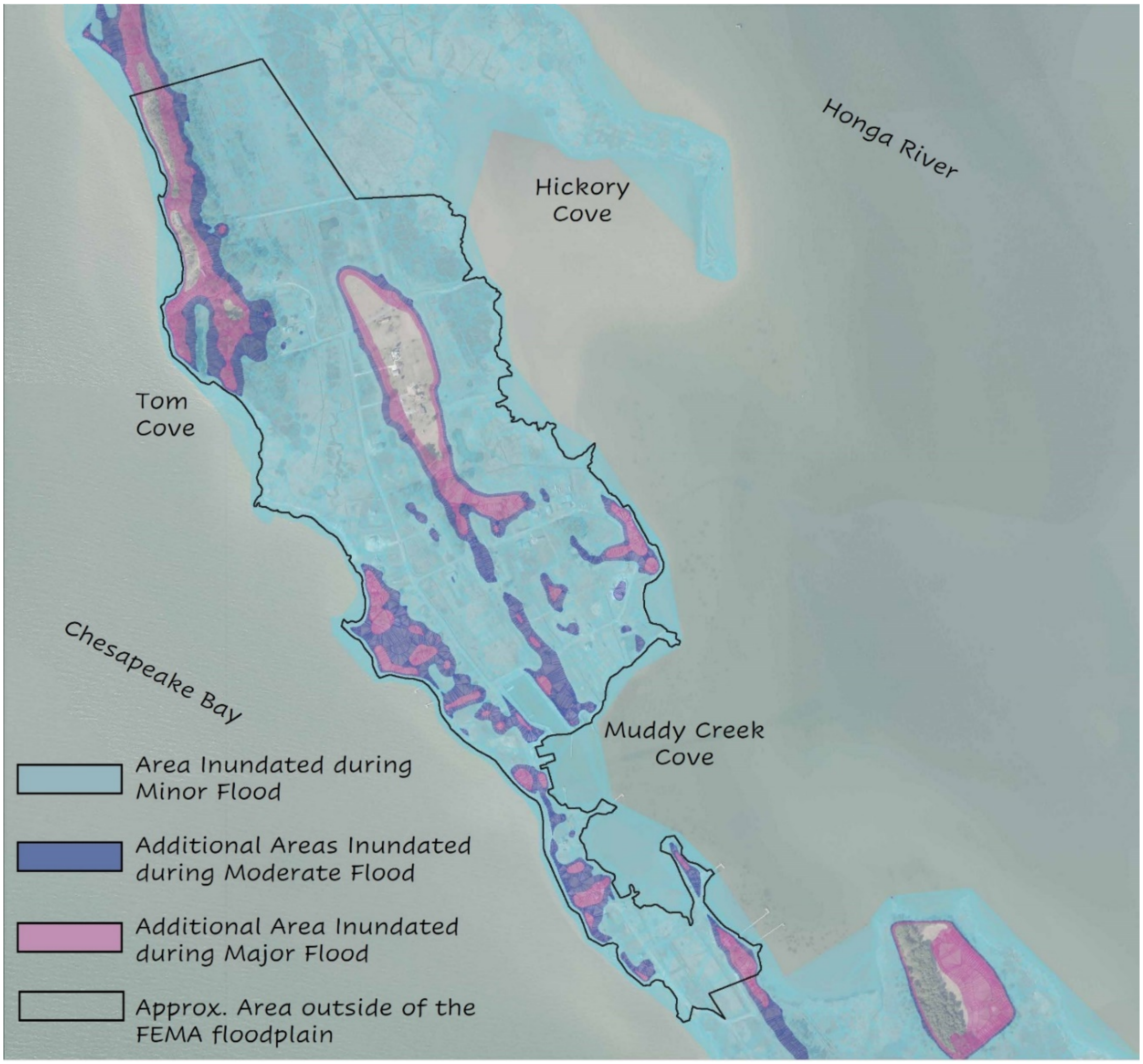

Figure 18 - Flooded Areas within the Village District

2.3.5. Southern Marsh

The Southern Marsh area consists of approximately 330 acres of coastal marshes along the southern end of Hoopersville. The entire area is zoned as a Resource Conservation Area. There are no homes and only two property parcels within the Southern Marsh.

❖ Coastal Erosion

According to the ESRGC analysis, erosion of the marsh has occurred on both the Chesapeake Bay side and the Honga River side of this area. The average rate of erosion is approximately 3.3 feet/year for an average shoreline recession of approximately 75 feet between 1994 and 2016. Erosion along the Chesapeake Bay has reached as high as over 12 feet/year. Over 275 feet of shoreline recession has occurred in some areas of the Southern Marsh. The erosion as well as the approximate location of the 1972 shoreline is shown in Figure 19.

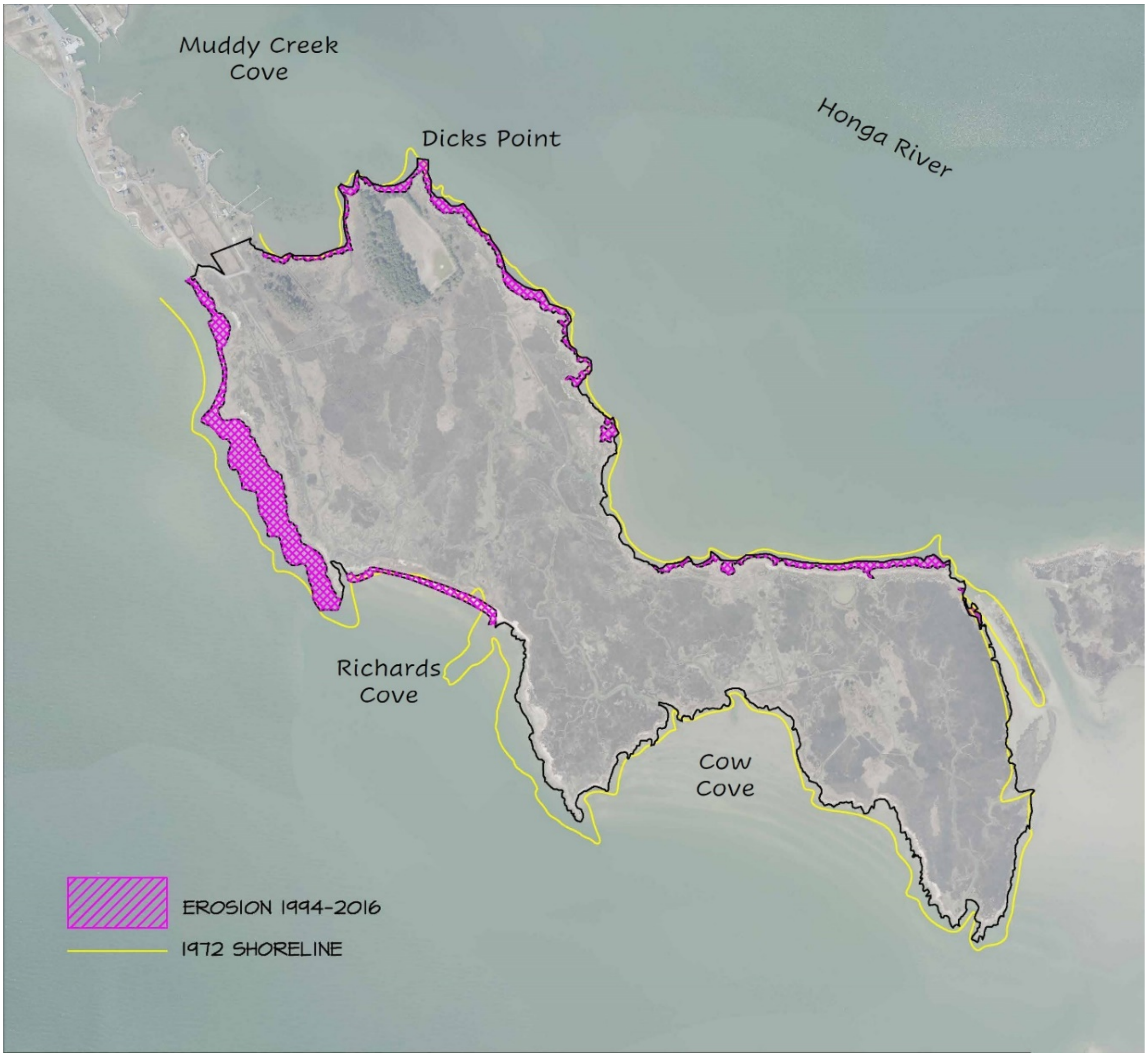

Figure 19 - Erosion along the South Marsh Shoreline

- ❖ Forested Area Lost to Saltwater Intrusion

Currently, approximately 7.8 acres of forested area exist within the northeast corner of the Southern Marsh. Examining aerial photography, this area appears to have remained intact since 1994. The elevation data presented in Figure 3 indicates that the forested areas within the South Marsh have some of the highest elevations for this area. Therefore, it appears that saltwater intrusion has not yet impacted the forested habitat, though continued coastal erosion could result in saltwater intrusion infiltrating this forested area.

- ❖ High Tide and Storm Surge Flooding

Given that over 95% of the Southern Marsh areas is coastal marshes below +2 feet NAVD88, this area is regularly inundated. The only elevated areas are the two forested areas discussed in the previous section, a flat area near Dick's Point that may have been cleared and filled in the past, and an approximate 1,500 linear foot stretch of beach along Richland Cove. This beach appears to be backed by a sandy dune with elevations greater than +3 feet NAVD88.

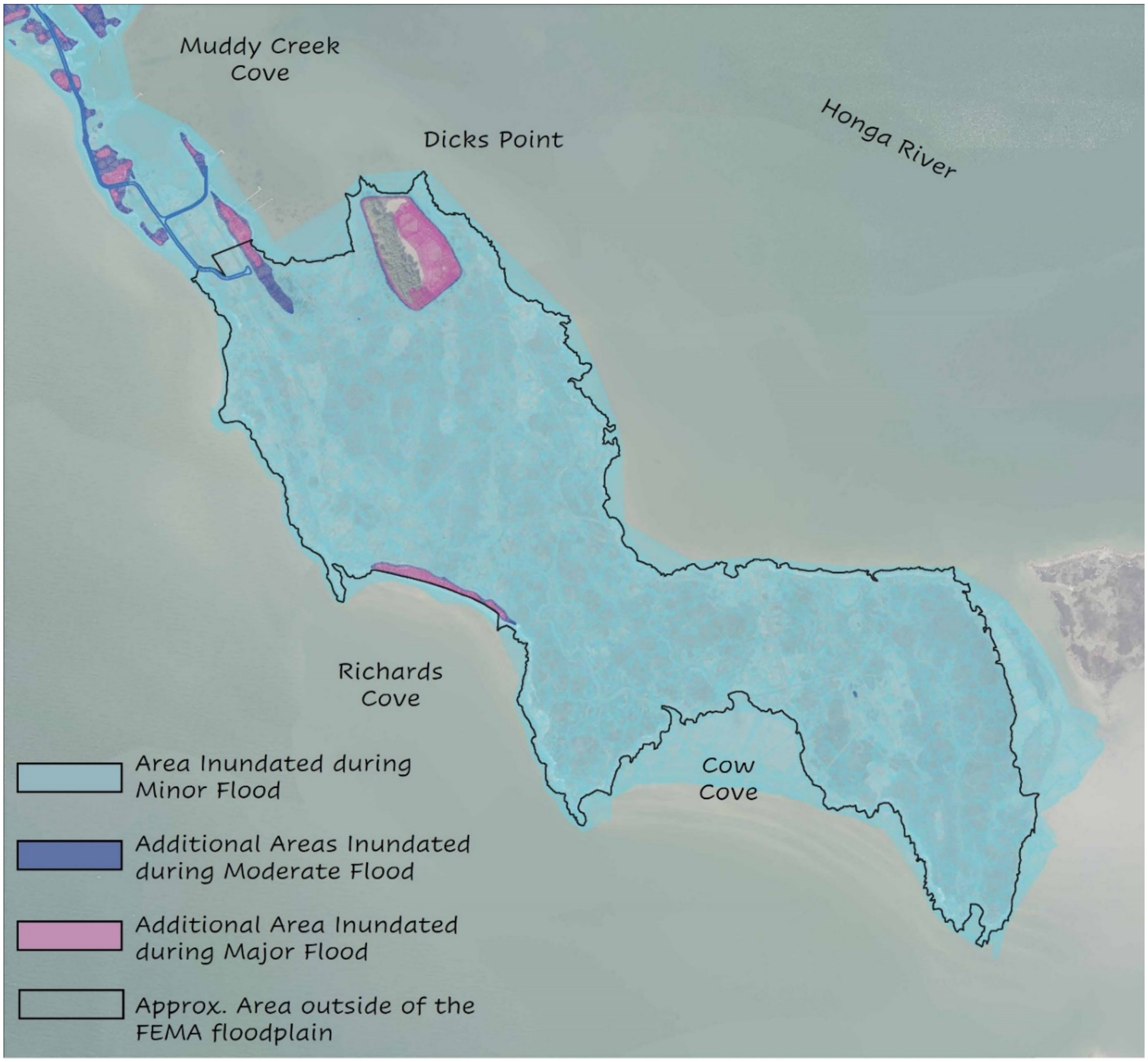

Figure 20 - Flooded Areas within South Marsh

- Drainage

Similarly, to the other marsh areas around the island, the lack of development in this area precludes drainage as a coastal resiliency stressor for the Southern Marsh.

2.3.6. Hoopersville Road

Hoopersville has just over 5 ¼ miles of roadway within the island. Just under 4 miles of this total is Hoopersville Road, which runs from the causeway to the northern end of the Southern Marsh. All vehicular ingress/egress to the island travels along Hoopersville Road. Other roads within Hoopersville include Esther Dean Road, Steamboat Wharf Rd and Doeller Rd.

The majority of Hoopersville Road has elevations between +1 to +2.5 feet NAVD88. Certain stretches of road, such as the approximate 1600 linear feet of road just north of Tom Point, have elevations less than +1 foot above NAVD88. Further south near the Village District, elevations increase to approximately +2.5 feet NAVD88.

- Coastal Erosion

Multiple areas along Hoopersville Road are directly adjacent to the shoreline and at risk from coastal erosion. Figure 21 through Figure 24 show the location of these areas. The first area occurs upon exiting the causeway onto Hoopersville Road (Figure 22). The shoreline along the Honga River at Cat Cove has riprap protection along the road in all but one short stretch, which is shown to be eroding. Breakwaters constructed in the late 80’s/early 90’s appear to have slowed the erosion along the Chesapeake Bay side, however, erosion has continued and threated the road. Riprap was added to the narrowest portion of shoreline to offer further protection to the road. The average erosion rate on the Chesapeake Bay side is approximately 1.6 feet/year. For the Cat Cove side, the average erosion rate is approximately 1 foot/year.

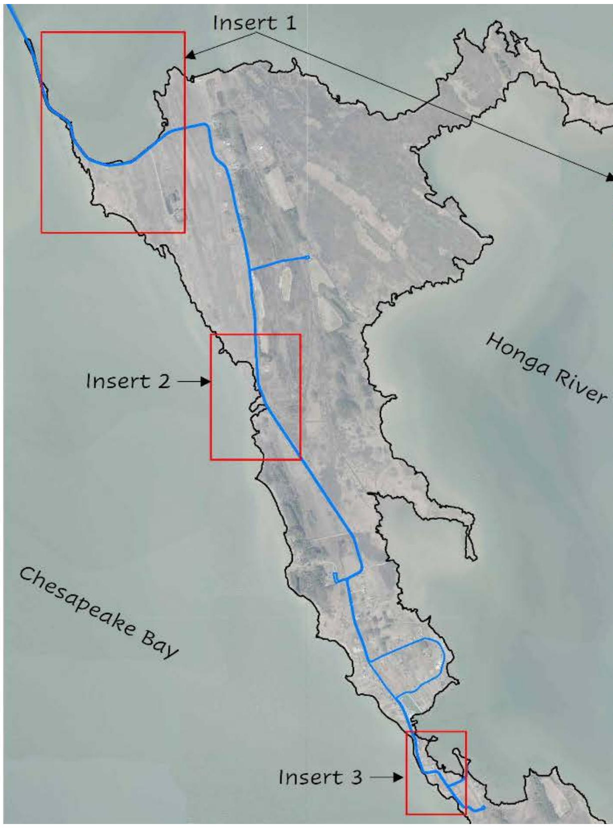

Figure 21 - Areas where Erosion Threatens the Road

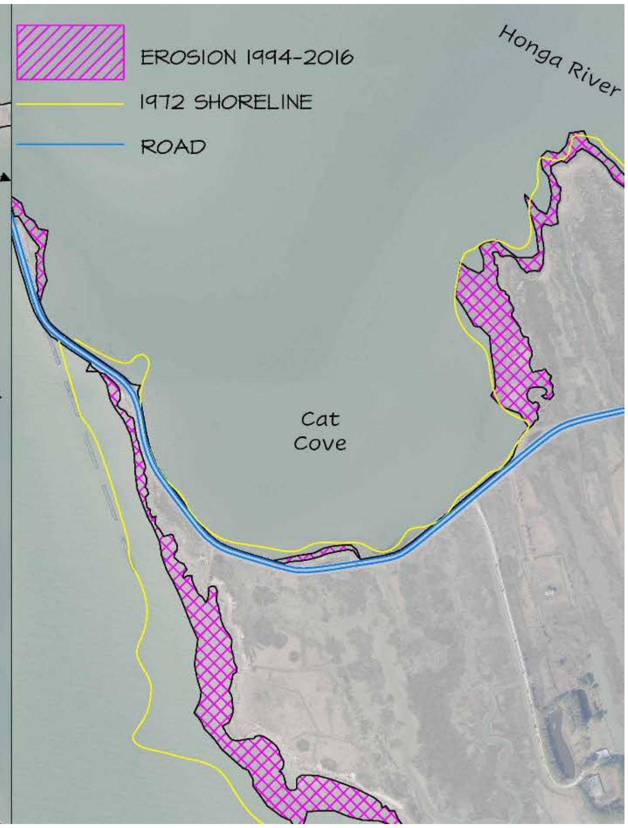

Figure 22 - Insert 1 Road Area at Risk due to Erosion

The second area where continued shoreline erosion is could impact the road occurs north of Tom Point (Figure 23). This area has experienced some of the highest erosion rates on the island. The area nearest the road was classified as erosive at a rate of 2.6 feet/year, however, it appears that riprap was placed along this area to prevent washout of the road which may have stabilized this shoreline in recent years.

Finally, stretches of road along the Village District are located in close proximity to the shoreline (Figure 24). The data provided by the ESRGC indicated this shoreline has eroded, on average, approximately 30 feet. However, a revetment was constructed along this area which has stopped further erosion.

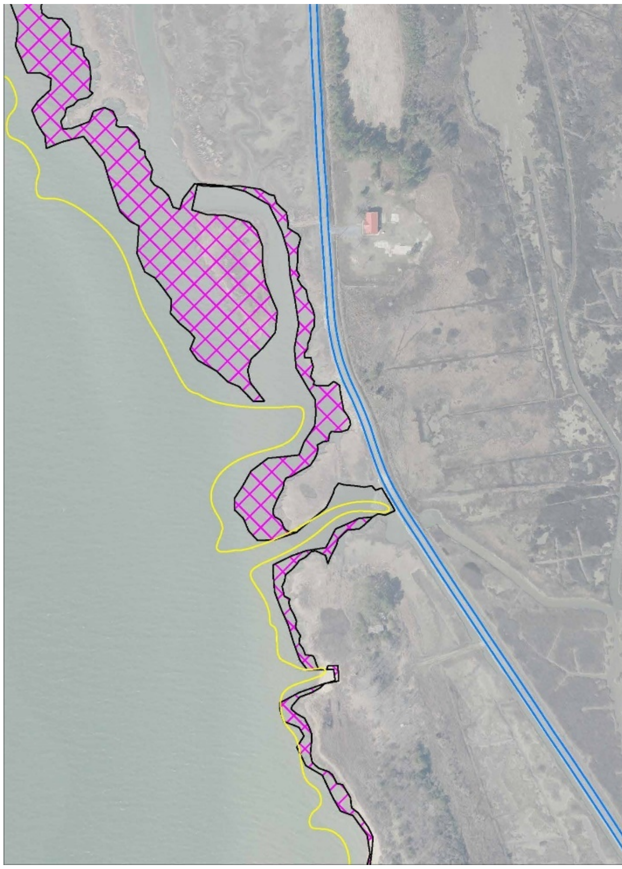

Figure 23 - Insert 2 Road Area at Risk due to Erosion

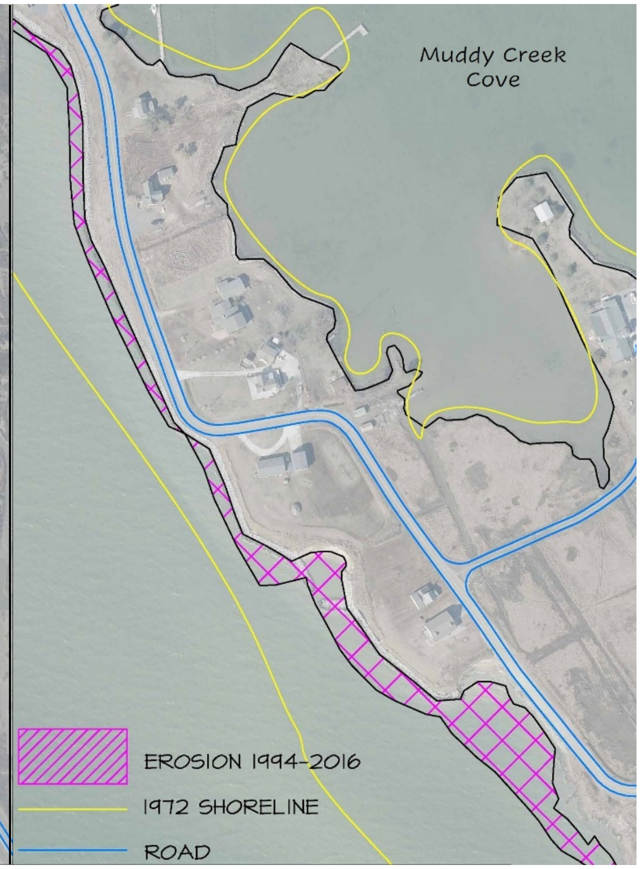

Figure 24 - Insert 3 Road Area at Risk due to Erosion

❖ Forested Area Lost to Saltwater Intrusion

For Hoopersville Road, saltwater Intrusion does not apply as a coastal resiliency stressor.

❖ High Tide and Storm Surge Flooding

Given the low elevations of the road, flooding occurs frequently for multiple stretches. Table 3 shows the length of road that will be inundated when the water levels exceed the flooding thresholds discussed in Section 2.2.2. The location of the flooded areas is shown in Figure 25.

Table 3 - Percent of Road Inundated during Flood Events

Flooding Threshold	Total Length (Miles)	% of Total Road Length
Minor	3.3	84%
Moderate	3.7	96%
Major	3.8	97%

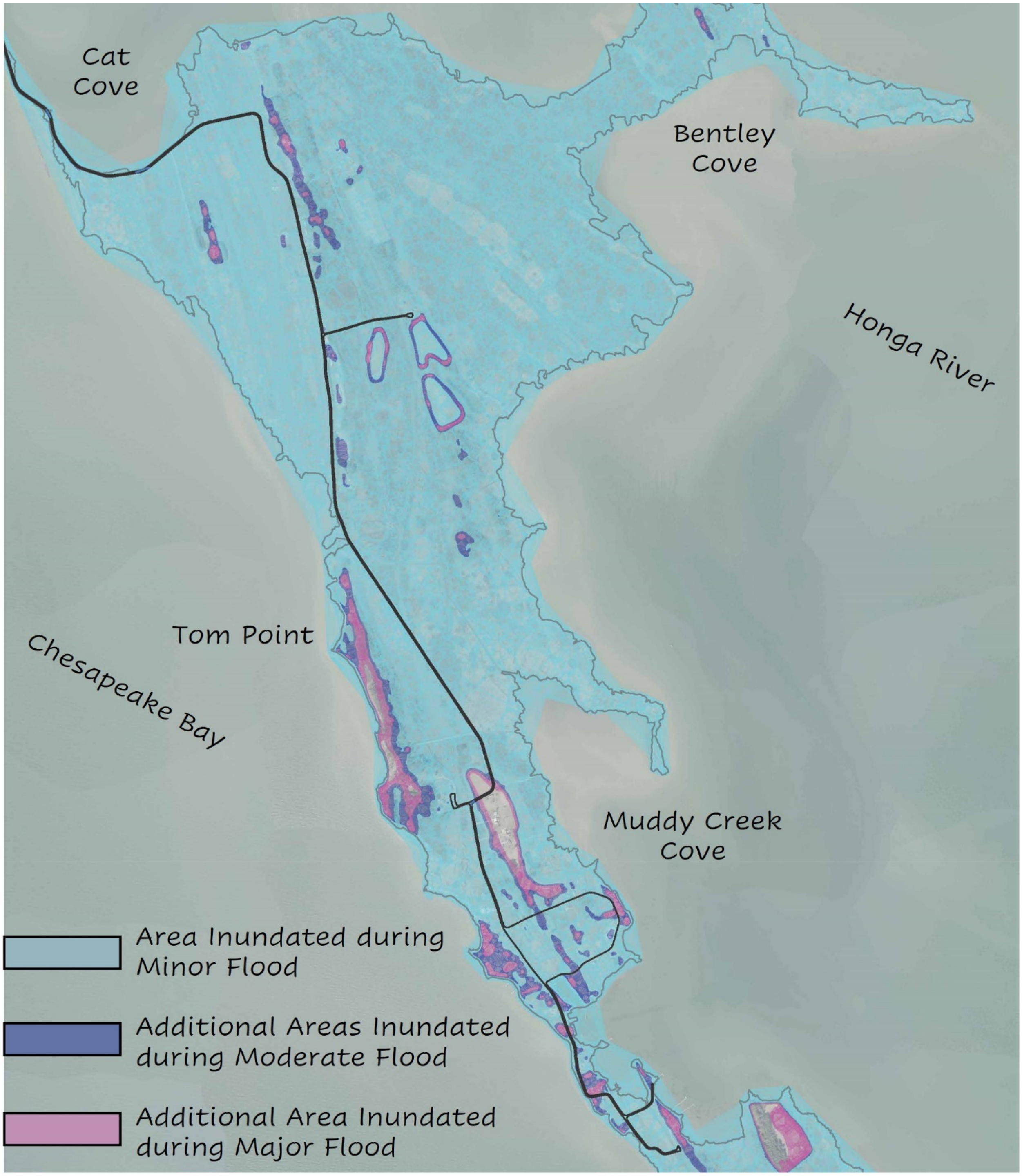

Figure 25 - Flooded Areas of Road

For the lowest 1600-foot length of road above Tom Point, a minor flood event will result in a minimum of 1.5 feet of water on the road. Because this road is the only vehicular ingress/egress to the Village District, residents would not be able to traverse this length of road for this flood condition.

- Drainage

Residents of Hoopersville have expressed concerns regarding inadequate drainage after rainfall events leading to standing water on the road. High tailwater conditions and lack of maintenance to remove sedimentation within the drainage ditches is likely the cause of road flooding on the road from deficiencies within the drainage system.

3. Phase 2 – Vulnerability Assessment

The Vulnerability Assessment will measure each Assessment Areas' ability to avoid the risk or withstand the impacts of the coastal stressors. The analysis entails examining the three components of vulnerability:

1. *Exposure* – how exposed is the area to the stressor?
2. *Sensitivity* – is the area sensitive to the impacts of the stressor?
3. *Adaptive Capacity* – can the area be easily adapted to avoid impacts from the stressor?

Figure 26 provides a visual of how the three components interact to determine the area's vulnerability to each coastal stressor.

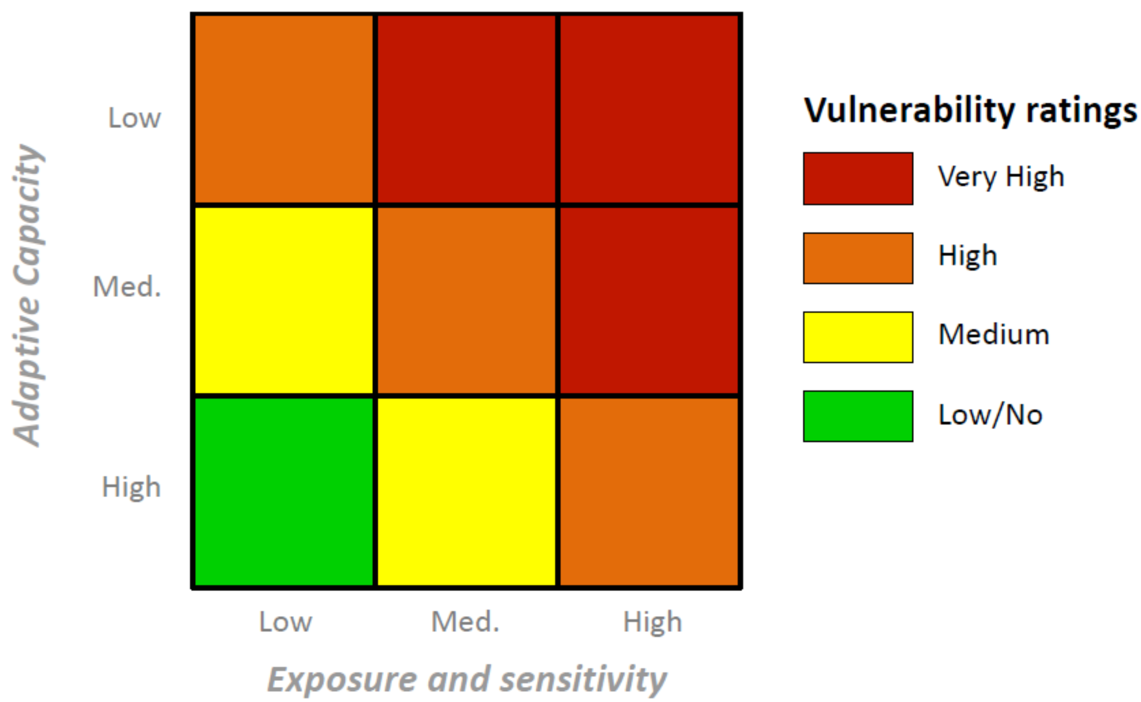

Figure 26 - Assessing Vulnerability

Understanding how vulnerable the area is to a particular stressor helps guide decision makers in choosing the best alternative for managing the risk for that area. The following paragraphs will examine the vulnerability for each areas given its potential exposure to each coastal stressor.

With sea levels anticipated to rise between 1 and 2 feet above 2000 levels by 2050, SLR will impact the vulnerability of each area. These impacts will come as a higher exposure or sensitivity to the coastal resiliency stressors. Areas that may be labeled as ‘Low’ Vulnerability could be categorized as ‘High Vulnerability’ when assessing future conditions. For that reason, the change in vulnerability for each stressor is also discussed.

3.1. Northeast Marsh

The Vulnerability of the Northeast Marsh for each coastal stressor if provided in Table 4. Table 4 also addresses how the area addresses each component of vulnerability.

Table 4 - Vulnerability of Northeast Marsh

Vulnerability Component	Coastal Resiliency Stressors				
	Coastal Erosion	High Tide Flooding	Storm Surge Flooding	Saltwater Intrusion	Drainage
Exposure	**High** No shoreline protection measures present.	**High** Low elevations of marsh results in frequent inundation	**High** Low elevations of marsh results in complete inundation during storm surge events	**High** Coastal marshes are inherently exposed to saltwater	N/A
Exposure w/ SLR	**High**	**High**	**High**	**High**	N/A
Sensitivity	**High** High current rate of average erosion of 2 ft/yr	**Low** Coastal marshes can tolerate elevated water levels	**Medium** Coastal marshes have built-in resiliency that enables them to ‘bounce back’ after flooding events	**Low** Coastal marshes tolerate a high range of salinity; mall amount of forested area	N/A
Sensitivity w/ SLR	**High**	**High** More frequent or complete inundation can ‘drown’ the marsh	**High** Marsh unable to rebound and will convert to mudflat/ open water	**High** Forested areas in jeopardy with too much salinity	N/A
Adaptive Capacity	**Low** Major construction needed to protect against erosion	**High** Coastal marshes often rebound if damage occurs.	**Medium** Though marshes due rebound, they cannot adapt naturally to prevent damage from significant flood events	**High** Coastal marshes adapt well to variations in salinity	N/A
Vulnerability	**Very High**	**Low**	**High**	**Low**	**N/A**
Vulnerability w/ SLR	**Very High**	**Very High**	**Very High**	**Low**	**N/A**

The assessment shows that the Northeast Marsh is very vulnerable to impacts from coastal erosion and storm surge flooding. The high adaptive capacity of coastal marshes to high tide flooding and saltwater intrusion decreases the marshes vulnerability to these coastal resiliency stressors. Impacts due to improper drainage do not apply to this area.

With SLR, impacts from high tide flooding and more frequent and intense storm surge flooding can result in too much inundation for the marsh to survive. It will then convert to open water.

3.2. Northwest Marsh

The Vulnerability of the Northwest Marsh and how the area addresses each component are provided in Table 5.

Table 5 - Vulnerability of Northwest Marsh

Vulnerability Component	Coastal Resiliency Stressors				
	Coastal Erosion	**High Tide Flooding**	**Storm Surge Flooding**	**Saltwater Intrusion**	**Drainage**
Exposure	**High** Few shoreline protection measures present	**High** Low elevations of marsh results in frequent inundation	**High** Low elevations of marsh results in complete inundation during storm surge events	**High** Coastal marshes are inherently exposed to saltwater	N/A
Exposure w/ SLR	**High**	**High**	**High**	**High**	N/A
Sensitivity	**High** Very high current rate of average erosion of 3.4 ft/yr	**Low** Coastal marshes have built-in resiliency that enables them to ‘bounce back’ after flooding events	**Medium** Coastal marsh may suffer significant damage after flooding but, given time, are known to rebound	**Medium** Coastal marshes tolerate a high range of salinity; forested area could convert to marsh.	N/A
Sensitivity w/ SLR	**High**	**High** More frequent or complete inundation can ‘drown’ the marsh	**High** Marsh unable to rebound and will convert to mudflat/ open water	**High** Forested areas in jeopardy with too much salinity	N/A

Table 5 - Vulnerability of Northwest Marsh					
Vulnerability Component	**Coastal Resiliency Stressors**				
	Coastal Erosion	**High Tide Flooding**	**Storm Surge Flooding**	**Saltwater Intrusion**	**Drainage**
Adaptive Capacity	**Low** Major construction needed to protect against erosion	**High** Coastal marshes often rebound if damage occurs.	**Medium** Though marshes due rebound, they cannot adapt naturally to prevent damage from significant flood events	**Medium** Coastal marshes adapt well to variations in salinity; forested area cannot adapt to too much salinity.	N/A
Vulnerability	**Very High**	**Low**	**High**	**High**	**N/A**
Vulnerability w/ SLR	**Very High**	**Very High**	**Very High**	**High**	**N/A**

The assessment for the Northwest Marsh is similar to the Northeast Marsh except for the significant difference in coastal erosion. Because a portion of the Northwest Marsh is exposed to the Chesapeake Bay, wave action along this shoreline results in a larger erosion rate and makes it more vulnerable to the impacts of coastal erosion. Additionally, given the large amount of forested areas within the Northwest Marsh, saltwater intrusion is of more concern in protecting this habitat and preventing it from converting to coastal marsh. Impacts due to inadequate drainage do not apply to this area.

With SLR, impacts from high tide flooding and more frequent and intense storm surge flooding can result in too much inundation for the marsh to survive. It will then convert to open water.

3.3. Rural Residential Area

The Vulnerability of the Rural Residential area and how the area addresses each component are provided in Table 6. The table also describes the impact SLR will have on each stressor.

Table 6 - Vulnerability of the Rural Residential Area

Vulnerability Component	Coastal Resiliency Stressors: Coastal Erosion	High Tide Flooding	Storm Surge Flooding	Saltwater Intrusion	Drainage
Exposure	N/A	**Medium** Majority of the developed area at or above the minor flood elevation	**High** Almost all development exposed to minor or moderate flood elevations	**High** Low elevations of area exposed to saltwater	**High** High tailwater conditions prevent drainage after rainfall events
Exposure w/ SLR	**Low** The loss of coastal marshes surrounding the area could cause the area to be exposed to direct wave action	**High** High tide flooding will reach farther inland as marshes are converted to open water.	**High**	**High**	**High**
Sensitivity	N/A	**Medium** High tide flooding typically results in disturbance instead of damage	**High** Storm surge flooding can result in significant damage to properties.	**High** Large areas of forest have been lost and are at stake to be lost due to saltwater intrusion	**Medium** Delay of drainage of runoff typically results in disturbance instead of damage
Sensitivity w/ SLR	**High** Without marsh, coastal erosion will encroach on inland area	**High** More frequent flooding result in higher impacts.	**High**	**High**	**High** Higher tailwater conditions will result in less drainage capability
Adaptive Capacity	**Low** Major construction needed to prevent impacts from coastal erosion due to SLR	**Low** Major construction needed to prevent impacts from high tide flooding	**Low** Major construction needed to prevent impacts from storm surge flooding	**Low** Forested area cannot adapt to too much salinity.	**Medium** Maintenance of drainage ditches will improve drainage capacity without requiring major construction
Vulnerability	**N/A**	**Very High**	**Very High**	**Very High**	**High**
Vulnerability w/ SLR	**Medium**	**Very High**	**Very High**	**Very High**	**Very High**

Because of the development present within the Rural Residential area, impacts due to flooding are more significant than marsh areas. Low levels of flooding will cause disturbance to residence and businesses such as travel or work interruptions and lack of access to certain areas of the island. Higher flood elevations can result in damage to homes and other infrastructure that can have a significant impact on life on the island. However, flooding from inadequate drainage may be improved by maintaining the ditches within this area. Additionally, saltwater intrusion will threaten the remaining forested areas. Given the lack of shoreline, coastal erosion will not directly impact this area.

With SLR, coastal marshes surrounding the Rural Residential area will be converted to open water, exposing the area to more direct impacts from coastal erosion, flooding and saltwater intrusion. Inadequate drainage will also be exasperated with higher tailwater conditions preventing stormwater runoff to drain into neighboring waterways.

3.4. Village District Area

The Vulnerability of the Village District area and how the area addresses each component of vulnerability are provided in Table 7. Changes in exposure and sensitivity due to SLR are also discussed for each stressor.

Table 7 - Vulnerability of the Village District Area

Vulnerability Component	Coastal Resiliency Stressors				
	Coastal Erosion	High Tide Flooding	Storm Surge Flooding	Saltwater Intrusion	Drainage
Exposure	**High** Though portions of the Village District are protected by shoreline protection measures, erosion continues along unprotected areas	**Medium** Majority of the developed area at or above the minor flood elevation	**High** Almost all development exposed to minor or moderate flood elevations	**High** Low elevations of area exposed to saltwater	**High** High tailwater conditions prevent drainage after rainfall events
Exposure w/ SLR	**High**	**High** High tide water levels will reach more developed areas	**High**	**High**	**High**
Sensitivity	**High** Very high current rate of average erosion of 4.5 ft/yr	**Medium** High tide flooding typically results in disturbance instead of damage	**High** Storm surge flooding can result in significant damage to properties.	**High** Large areas of forest at stake of being lost due to saltwater intrusion	**Medium** Delay of drainage of runoff typically results in disturbance instead of damage

Table 7 - Vulnerability of the Village District Area					
Vulnerability Component	**Coastal Resiliency Stressors**				
	Coastal Erosion	**High Tide Flooding**	**Storm Surge Flooding**	**Saltwater Intrusion**	**Drainage**
Sensitivity w/ SLR	**High**	**High** More frequent flooding result in higher impacts.	**High**	**High**	**High** Stormwater runoff unable to drain will increase flooding depths and extents
Adaptive Capacity	**Low** Major construction needed to protect against coastal erosion.	**Low** Major construction needed to prevent impacts from high tide flooding	**Low** Major construction needed to prevent impacts from storm surge flooding	**Low** Forested area cannot adapt to too much salinity.	**Medium** Maintenance of drainage ditches will improve drainage capacity without requiring major construction
Vulnerability	**Very High**	**Very High**	**Very High**	**Very High**	**High**
Vulnerability w/ SLR	**Very High**	**Very High**	**Very High**	**Very High**	**Very High**

The Village District has experienced some of the highest rates of erosion along the island. Though a significant amount of both the Chesapeake Bay and Honga River shoreline has been protected through hard structures such as revetments, riprap and rubble shoreline protection, bulkheads and breakwaters, erosion has continued. Given the large amount of waterfront residences and businesses within the Village District and the low adaptive capacity of developed areas, major construction is necessary to protect against coastal erosion.

Flooding in the Village District will have a greater impact due to the amount of development concentrated within this area. Since most infrastructure is located at elevations at or higher than the minor flooding threshold, high tide flooding most likely results in disturbance than damage. However, damages to infrastructure at higher flood events will be greatest here as will lost revenue due to lack of production after a flood event. The infrastructure located within the Village District has low adaptive capacity and will require major construction to mitigate the risk of flooding.

Because this area contains the largest area of forested land on the island, this area is especially vulnerable to saltwater intrusion. The Village District also has the largest number of Targeted Ecological Areas (TEAs) that are predominantly focused on preserving the forests in this area.

With SLR, all coastal stressors will increase in intensity and frequency.

3.5. Southern Marsh

The Vulnerability of the Southern Marsh for each coastal stressor if provided in. also addresses how the area addresses each component of vulnerability.

Table 8 - Vulnerability of Southern Marsh					
Vulnerability Component	**Coastal Resiliency Stressors**				
	Coastal Erosion	**High Tide Flooding**	**Storm Surge Flooding**	**Saltwater Intrusion**	**Drainage**
Exposure	**High** No shoreline protection measures present.	**High** Low elevations of marsh results in frequent inundation	**High** Low elevations of marsh results in complete inundation during storm surge events	**High** Coastal marshes are inherently exposed to saltwater	N/A
Exposure w/ SLR	**High**	**High**	**High**	**High**	N/A
Sensitivity	**High** High current rate of average erosion of 3.3 ft/yr	**Low** Coastal marshes have built-in resiliency that enables them to 'bounce back' after flooding events	**Medium** Coastal marsh may suffer significant damage after flooding but, given time, are known to rebound	**Low** Coastal marshes tolerate a high range of salinity; small amount of forested area	N/A
Sensitivity w/ SLR	**High**	**High** More frequent or complete inundation can 'drown' the marsh	**High** Marsh unable to rebound and will convert to mudflat/ open water	**High** Forested areas in jeopardy with too much salinity	N/A
Adaptive Capacity	**Low** Major construction needed to protect against erosion	**High** Coastal marshes often rebound if damage occurs.	**Medium** Though marshes can rebound, they cannot adapt naturally to prevent damage from significant flood events	**High** Coastal marshes adapt well to variations in salinity	N/A
Vulnerability	**Very High**	**Low**	**High**	**Low**	**N/A**
Vulnerability w/ SLR	**Very High**	**Very High**	**High**	**High**	**N/A**

The assessment shows that the Southern Marsh is vulnerable to impacts from coastal erosion and storm surge flooding. The high adaptive capacity of coastal marshes to high tide flooding and saltwater intrusion decreases the marshes vulnerability to these coastal resiliency stressors. Impacts due to improper drainage do not apply to this area.

3.6. Hoopersville Road

The Vulnerability of the Hoopersville Road and how the vulnerability components are defined for the road is provided in Table 9.

Table 9 - Vulnerability of Hoopersville Road					
Vulnerability Component	**Coastal Resiliency Stressors**				
	Coastal Erosion	**High Tide Flooding**	**Storm Surge Flooding**	**Saltwater Intrusion**	**Drainage**
Exposure	**Medium** Shoreline protection measures have been implemented but may be in need of maintenance	**High** Majority of road below the minor flood elevation	**High** Almost all road exposed to minor or moderate flood elevations	N/A	**High** Ditches typically located along road; water can back up and pond on road
Exposure w/ SLR	**High** Existing protection measures and natural shoreline will be less effective with higher water levels	**High**	**High**	N/A	**High**
Sensitivity	**High** Coastal erosion may compromise the stability of the road	**Medium** High tide flooding typically results in disturbance instead of damage	**High** Storm surge flooding can result in significant damage and disturbance if road is damaged or inaccessible	N/A	**Medium** Delay of drainage of runoff typically results in disturbance instead of damage
Sensitivity w/ SLR	**High**	**High** Road will be inundated too frequently for consistent use	**High**	N/A	**High** Road will be inundated too frequently for consistent use
Adaptive Capacity	**Low** Major construction needed to protect against coastal erosion or restore existing structures.	**Low** Major construction needed to prevent flooding during high tides	**Low** Major construction needed to prevent storm surge flooding	N/A	**Medium** Maintenance of drainage ditches will improve drainage capacity without requiring major construction
Vulnerability	**Very High**	**Very High**	**Very High**	**N/A**	**High**
Vulnerability w/ SLR	**Very High**	**Very High**	**Very High**	**N/A**	**Very High**

Hoopersville Road is the only source of vehicular ingress/egress to the island. Areas where the shoreline is beginning to encroach on the road have had shoreline protection measures such as revetments or rubble slope protection added. Some of these measures may be reaching the end of their useful life and require improvement. The road is also very susceptible to flooding given its low elevations. Some stretches of road are so low, they may become impassible during storm surge or even high tide flooding. Inadequate drainage may also result in flooding on the road. The road has little to no adaptive capacity and will require major construction to address the risks posed by coastal stressors.

With SLR, the existing shoreline protection measures may not adequately protect against erosion. Also, with coastal marshes decreasing in size or disappearing altogether, they will no longer provide protection to the road. The frequency of flooding and the flood depths will increase, causing severe impacts to usability of the road. Reduced drainage capacity of the ditches along the road will result in stormwater runoff inundating the ditches for longer durations.

3.7. Summary of Vulnerability

A summary of the Vulnerability Assessment of the areas is presented in Table 10. How the vulnerability will be impacted due to SLR is also included in Table 10.

Table 10 - Summary of Vulnerability Assessment

Coastal Resiliency Stressors	Assessment Areas					
	Northeast Marsh	Northwest Marsh	Rural Residential	Village District	Southern Marsh	Road
Coastal Erosion	Very High	Very High	-	Very High	Very High	Very High
Coastal Erosion w/ SLR	Very High	Very High	Medium	Very High	Very High	Very High
High Tide Flooding	Low	Low	Very High	Very High	Low	Very High
High Tide Flooding w/ SLR	Very High	Very High	Very High	Very High	High	Very High
Storm Surge Flooding	High	High	Very High	Very High	High	Very High
Storm Surge Flooding w/ SLR	Very High	Very High	Very High	Very High	Very High	Very High
Saltwater Intrusion	Low	High	Very High	Very High	Low	-
Saltwater Intrusion w/ SLR	High	Very High	Very High	Very High	High	-
Drainage	-	-	High	High	-	High
Drainage w/ SLR	-	-	Very High	Very High	-	Very High

4. Risk Assessment

Once the vulnerability of each area to the coastal stressors is determined, understanding the probability of the stressors impacting the asset will define the associated risk. A high likelihood of occurrence for vulnerable areas results in a high risk whereas a lower likelihood of occurrence lessens the risk associated with the stressors. How all these components influence the risk is shown in Figure 27.

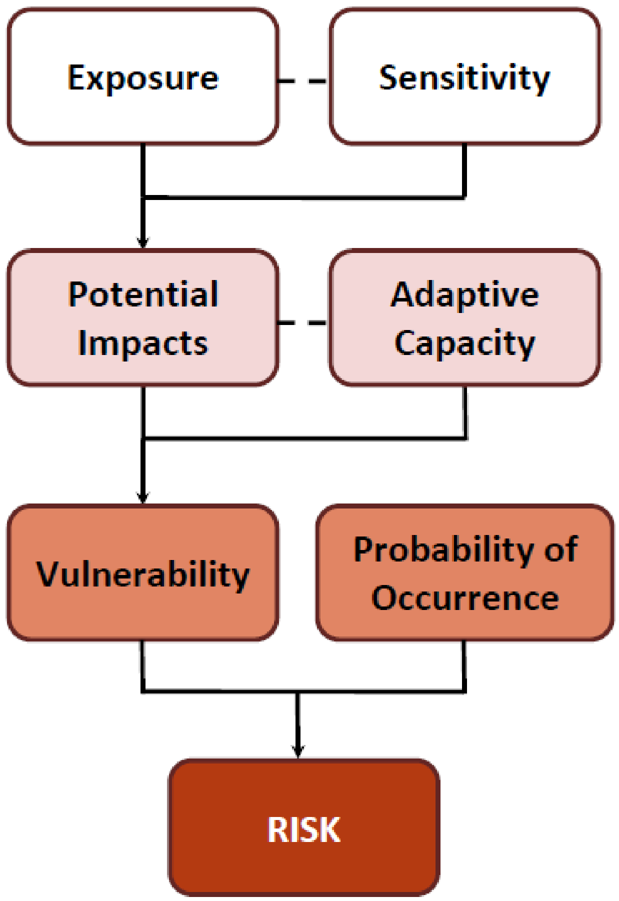

Figure 27 - Components of Risk

As mentioned previously, SLR will increase the probabilities of the stressors described in Section 112.2. For Hoopersville, impacts caused by SLR on each stressor include:

- Coastal Erosion likely to increase due to more frequent larger waves;
- High Tide Flooding will inundate areas more frequently and reach areas that were not previously flooded regularly;
- Storm Surge Flooding is anticipated to occur more frequently and will have higher flood elevations;
- Saltwater intrusion will continue as brackish Bay water will reach further inland;

❖ Drainage will be impacted as high tailwater conditions will not allow flow to pass out into the Bay and backwatering within the ditches will become more common.

To establish the impact of SLR on coastal stressors, a baseline for future conditions was established. The baseline is established by choosing the appropriate sea level rise projection to characterize future water level conditions. Using the guidance provided by the Maryland DNR and Maryland Sea Grant Extension presented in Table 2 and considering the current frequency of flooding and the overall low elevation of the island, the 'High Tolerance for Flood Risk' elevation of 1.7 feet by 2050 was chosen to determine the future impacts of SLR. This projection will result in the tide elevations shown in Table 11.

Table 11 - Tidal Datums with SLR at 8571421 Bishops Head, MD

Datum	Year 2000 - Water Elevation (ft NAVD88)	Year 2030 - Water Elevation (ft NAVD88)	Year 2050 - Water Elevation (ft NAVD88)
Mean Higher High Water (MHHW)	+0.85	+1.75	+2.55
Mean High Water (MHW)	+0.69	+1.59	+2.39
North American Datum of 1988	0.00	+0.90	+1.70
Mean Sea Level (MSL)	-0.19	+0.71	+1.51
Mean Low Water (MLW)	-1.07	-0.17	+0.63
Mean Lower Low Water (MLLW)	-1.21	-0.31	+0.49

Assuming the flooding thresholds discussed in Section 2.2.2, Figure 28 shows the increase in flood days expected in comparison to flood days experienced.

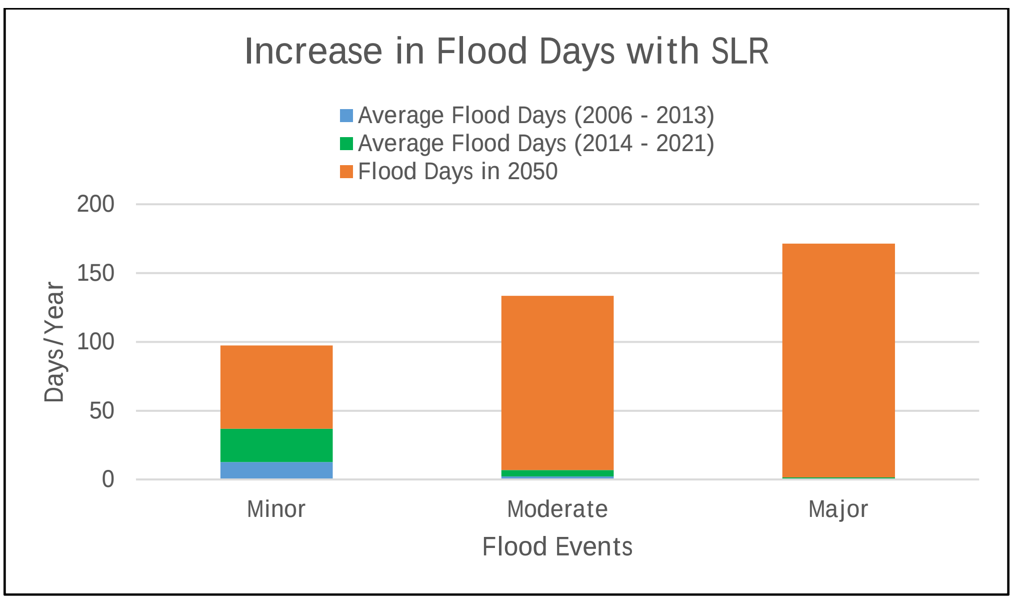

Figure 28 - Days with Flood Events

The graph compares the average number of days in which flooding was experienced between 2006 -2013 and 2014 - 2021 with the probable number of days in which the flooding thresholds will be exceeded in 2050. Additionally, it shows that, in 2050, Hoopersville may be experience a flood event every day.

Developing a prioritization table for risk management of the highest priority areas is the final product of the Vulnerability Assessment. This table will act as a framework for taking action to increase the coastal resiliency of the island. Table 12 shows the prioritization of areas as well as the risk identified for each area.

Table 12 - Prioritization Table

Priority	Assessment Area	Cumulative Vulnerability to Stressors	Cumulative Vulnerability to Stressors w/ SLR	Risk
1	Hoopersville Rd	Very High	Very High	Very High
2	Village District	Very High	Very High	Very High
3	Rural Residential	Very High	Very High	Very High
4	Northwest Marsh	High	Very High	Very High
5	Northeast Marsh	Medium	Very High	High
6	Southern Marsh	Medium	High	High

5. Phase 3 – Adaptation Plan

The third and final phase of the Hoopersville Resiliency Study focuses on development of an Adaptation Plan for managing the risk associated with the coastal resiliency stressors. The Adaptation Plan involves identified the risk management strategies that can be implemented and compares them based on criteria such as feasibility, effectiveness (how well they meet the objectives of the interested groups), socio-economic and environmental impacts and cost of implementation.

Risk management strategies refer to concepts or ideas for handling the risk determined during the vulnerability assessment. Options should follow the four T's of risk management, shown in Figure 29.

Figure 29 - The 4 T's of Risk Management

The four types of Risk Management Strategies (RMS) are defined as follows:

- Tolerate – also referred to as Risk Acceptance where the risk is either ignored or accepted.
- Terminate – also referred to as Risk Avoidance where the risk is avoided altogether.
- Transfer – Risk Transfer occurs when a separate entity is given the responsibility for managing the risk, such as the purchase of insurance.
- Treat – also referred to as Risk Mitigation or Risk Reduction. This option will aim at lessening the risk or the impacts should the risk be realized.

Considering the four T's can help a community assess the options available to them for risk management. The following sections detail the strategies that were evaluate for managing the risk posed by the coastal resiliency stressors.

5.1. Risk Management Strategy 1 – Tolerate the Risk

Tolerating the risk, or Risk Acceptance, is often defined as the 'Do Nothing' alternative. This option will examine in detail the results of not taking any action to protect the land, people, or infrastructure from the coastal resiliency stressors. The following paragraphs will detail the impacts of implementing this risk management technique for each of the Assessment Areas.

5.1.1. Northeast Marsh

The following analysis describes the anticipated impacts experienced by 2050 to the Northeast Marsh if no action is taken.

- Coastal Erosion

Assuming the average erosion rate of 2 feet/year experienced between 1994 and 2016 continues, the Northeast Marsh is anticipated to lose 49 additional acres. Coastal erosion will continue to split the peninsula into smaller islands. Figure 30 shows the additional area eroded projected in 2050.

- Forested Area Lost to Saltwater Intrusion

The existing forested areas within Hoopersville are at or above elevation 1.8 feet NAVD88, which indicates that elevations supporting forested area are between 1 to 1.5 feet above MHW. With 1.7 feet of SLR above existing water elevations, it is anticipated that an additional 1.6 acres of forested area within the Northeast Marsh will be lost by 2050. This will leave an approximate area of 0.06 acres at an elevation high enough to support forest habitat within the Northeast Marsh Assessment Area.

- High Tide and Storm Surge Flooding

The ability of coastal marshes to tolerate regular inundation has been discussed in previous sections of this report. However, once a marsh experiences too much inundation, the marsh habitat converts to underwater grasses. Vegetation seaward of the mean low water (MLW) line are typically classified as underwater grasses. Therefore, once the MLW elevations is higher than the marsh elevation, the marsh is considered ‘drowned’ and no longer functions as a coastal marsh.

Applying the ‘high tolerance for risk’ projection of 1.7 feet of SLR by 2050, the MLW elevation will increase to approximately +0.63 feet NAVD88. Existing marsh grasses at lower elevations will be ‘drowned’ or converted to open water. This area is shown in Figure 31. The figure shows that the marsh shall be breached along the northeast arm, further dividing the marsh and creating an additional island north of Bentley Cove. Marsh species will also be impacted by the increased inundation and natural ‘high’ marsh areas that cannot withstand daily inundation will be converted to ‘low’ marsh areas with a higher tolerance for daily flooding.

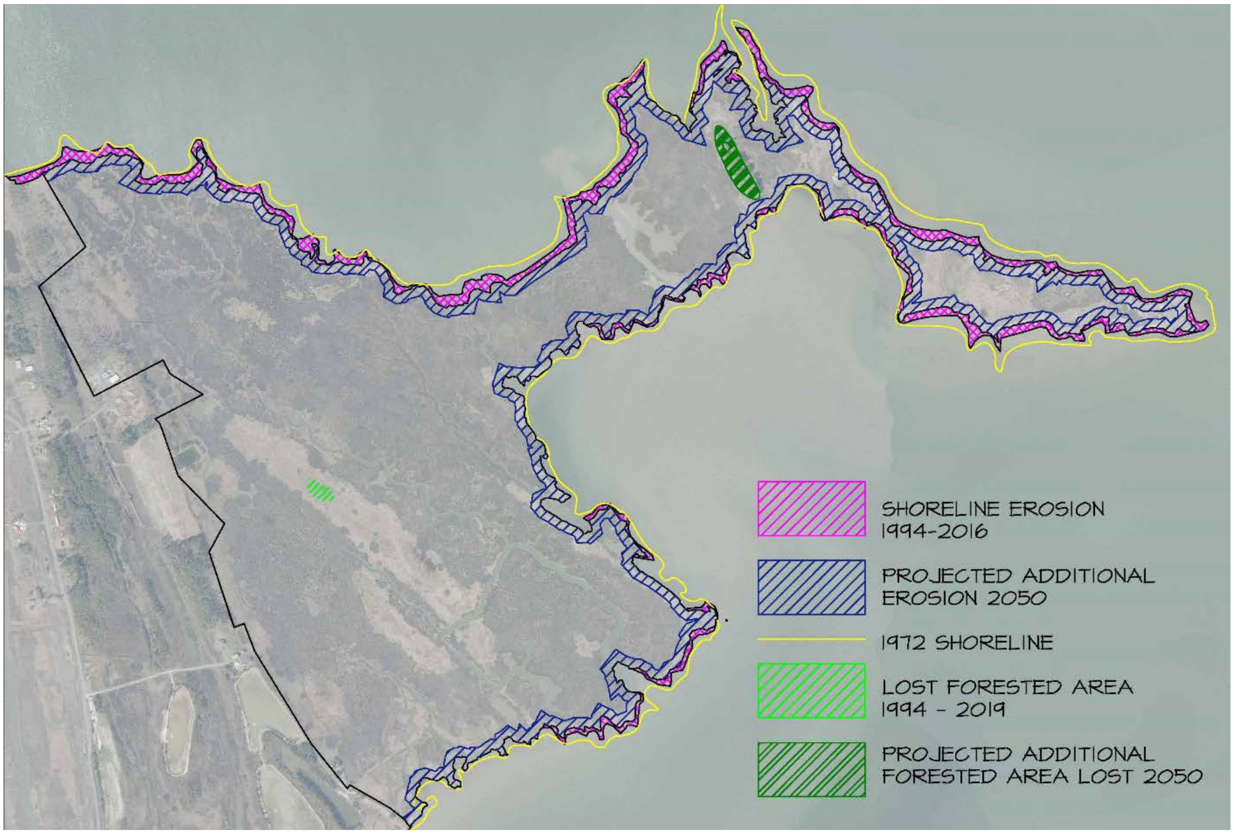

Figure 30 - Northeast Marsh Additional Erosion and Forest Lost in 2050

- Drainage

Because of the lack of development in this area, drainage as a coastal resiliency stressor does not apply to this area.

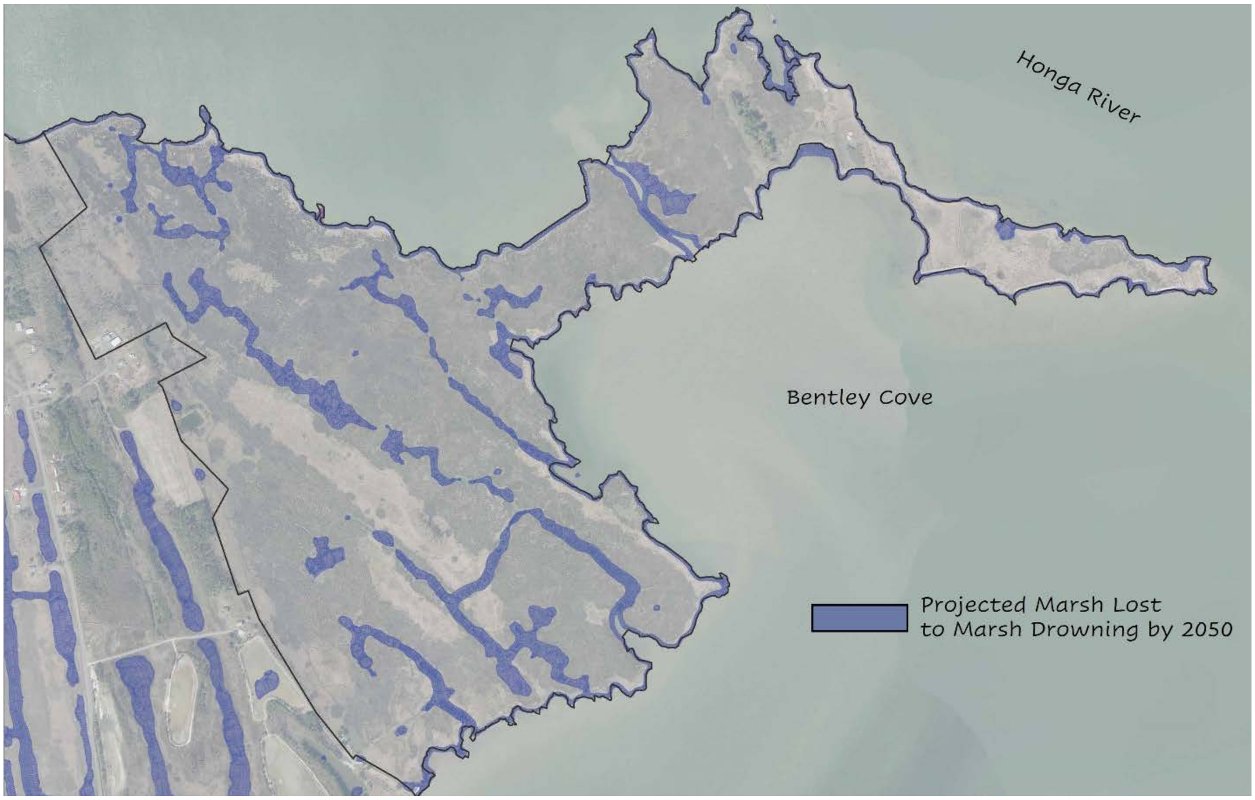

Figure 31 - Northeast Marsh Projected Marsh Lost by 2050

5.1.2. Northwest Marsh

❖ Coastal Erosion

The Northwest Marsh experienced an erosion rate of 3.4 feet/year between 1994 and 2016. Assuming this rate continues, an additional 68 acres of marsh is anticipated to erode by 2050. The additional eroded area is shown in Figure 32. For shoreline with existing shoreline protection, such as the shoreline along Hoopersville Road and Cat Cove, erosion was assumed to have been halted. Since the condition of the existing shoreline protection was not assessed as part of this study, the protection was assumed to be effective in current and future conditions at protecting against coastal erosion. Therefore, erosion is not shown in this area.

❖ Forested Area Lost to Saltwater Intrusion

Using the same threshold value of necessary forest elevations between 1 – 1.5 feet above MHW, it is anticipated that approximately 13 acres of remaining forested area will be lost due to saltwater intrusion by 2050. This additional lost forested area is shown in Figure 32.

Figure 32 - Northwest Marsh Projected Erosion and Forest Lost by 2050

- High Tide and Storm Surge Flooding

Given the low elevations of the area, the majority of the Northwest Marsh will be inundated every day during daily high tides. However, because coastal marshes tolerate daily inundation, only marsh at elevations below the 2050 MLW (0.63 feet NAVD88) will convert to open water. This area is shown in Figure 33. This area accounts for approximately 23 percent of the existing marsh.

- Drainage

Because of the lack of development in this area, drainage as a coastal resiliency stressor does not apply to this area.

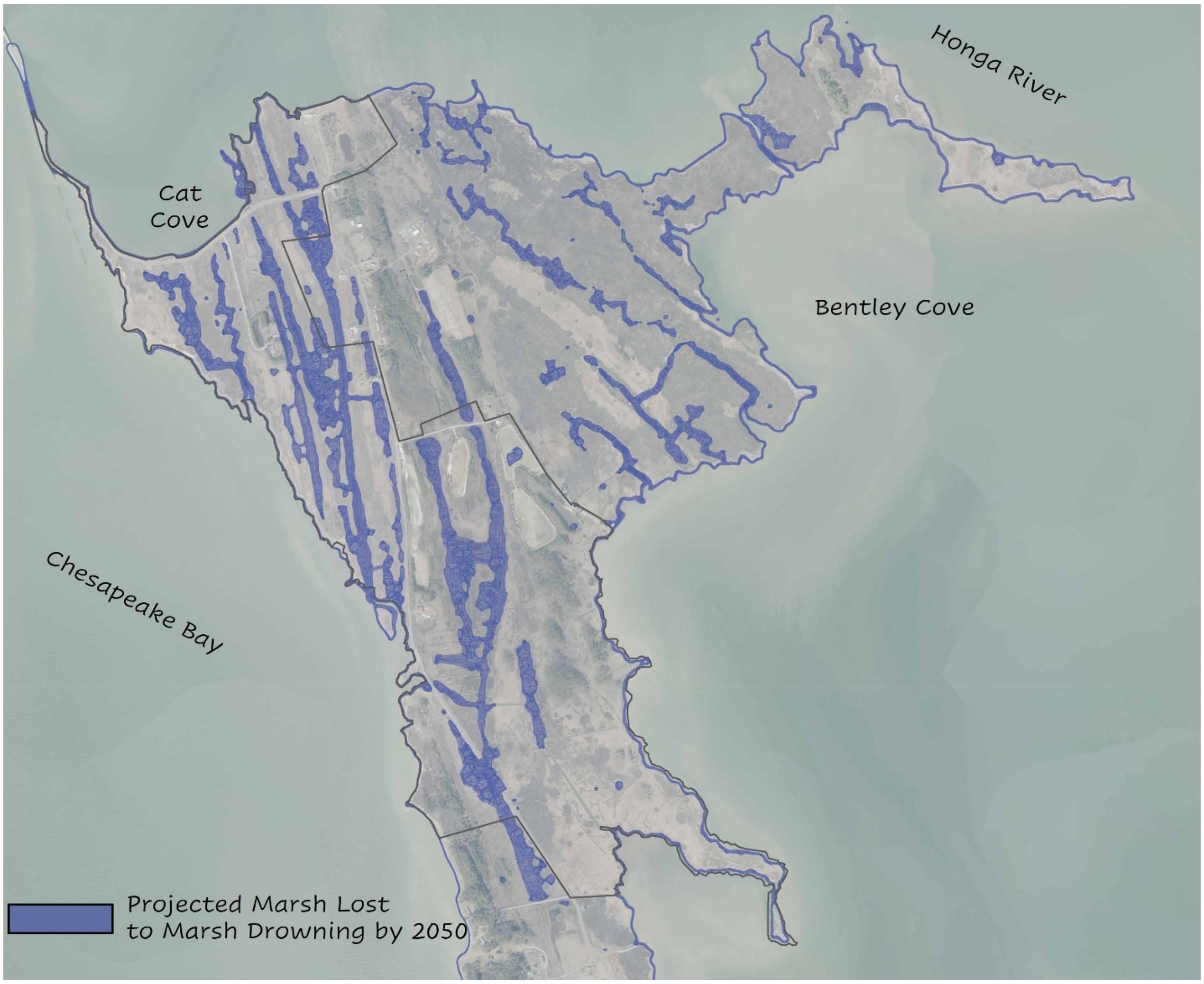

Figure 33 - Northwest Marsh Projected Marsh Lost by 2050

5.1.3. Rural Residential Area

The following analysis describes the anticipated impacts to the Rural Residential Area experienced by 2050.

- Coastal Erosion

Because of the lack of shoreline in this area, coastal erosion as a coastal resiliency stressor does not apply to this area.

- Forested Area Lost to Saltwater Intrusion

The majority of forested area within the Rural Residential area are at elevations between 2 and 2.5 feet NAVD88. With 1.7 feet of SLR, the MHW is anticipated to be approximately 2.4 feet NAVD88. This MHW elevation will likely result in all forested areas below elevation 3.5 feet NAVD88 experiencing too much saltwater intrusion for survival. Approximately 17.3 acres of existing forested area are anticipated to be lost due to saltwater intrusion by 2050 in the Rural Residential area, as shown in Figure 34.

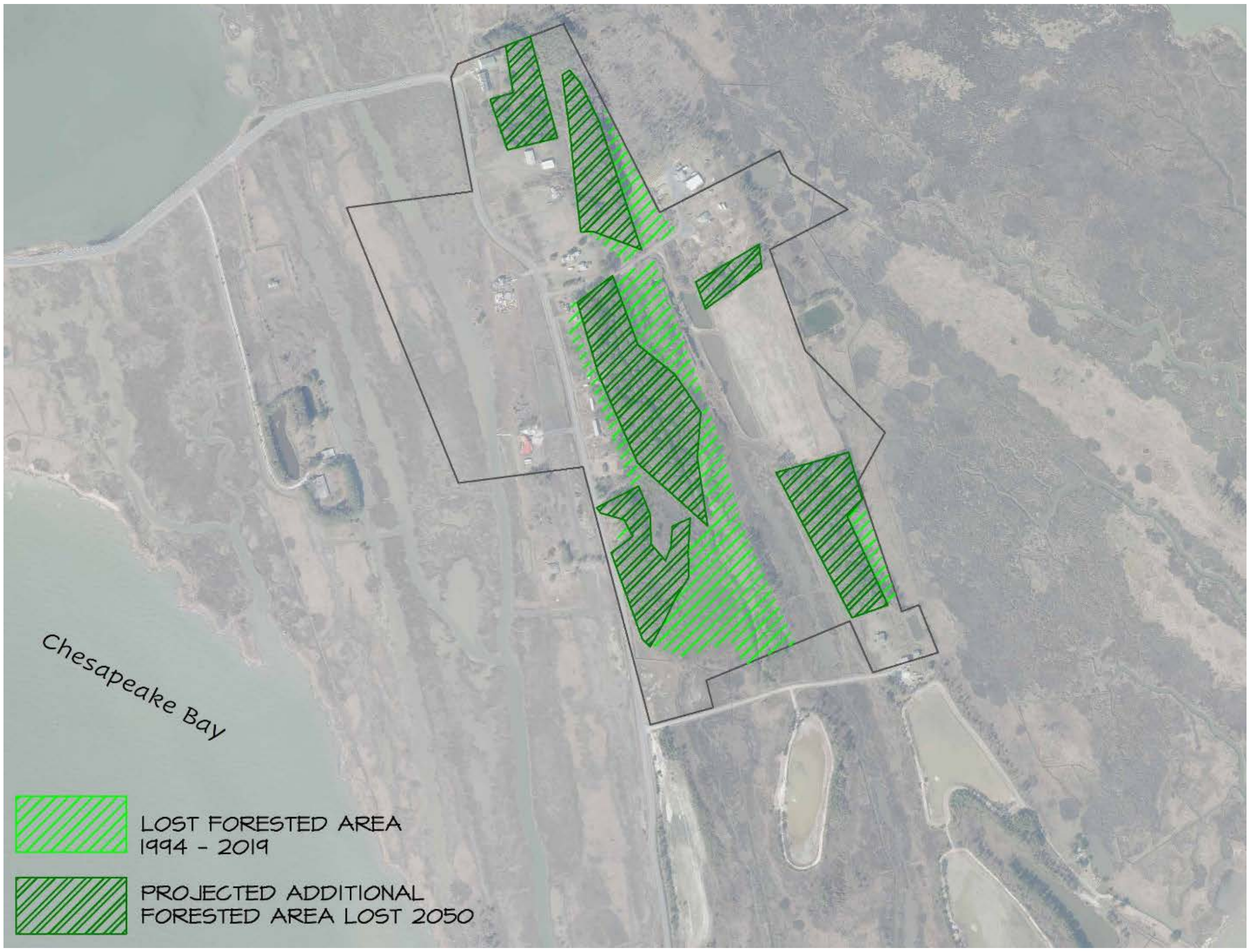

Figure 34 - Projected Forest Lost by 2050 in the Rural Residential Area

❖ High Tide and Storm Surge Flooding

As shown in Figure 35, which depicts the inundation extents of MHW projected in 2050, over 89% of the Rural Residential area is at an elevation that will be inundated daily. The daily inundation area includes approximately 5 of the 10 homes/buildings as well as the entirety of Hoopersville Road within the Rural Residential Area.

❖ Drainage

Drainage within the Rural Residential Area is conveyed through ditches along Hoopersville Road. For the majority of its length within the Rural Residential Area, the ditches run on both sides of the road. The low elevation of the ditch along the southbound lane is at an elevation below the future MLW elevation of 0.63 feet NAVD88 and will likely be permanently inundated by 2050. This will lead to an additional flood risk during rainfall events as the storage capacity of the ditch will be decreased. The ditch along the northbound lane is at a higher elevation, however, it too will be inundated during mid-to-high tide.

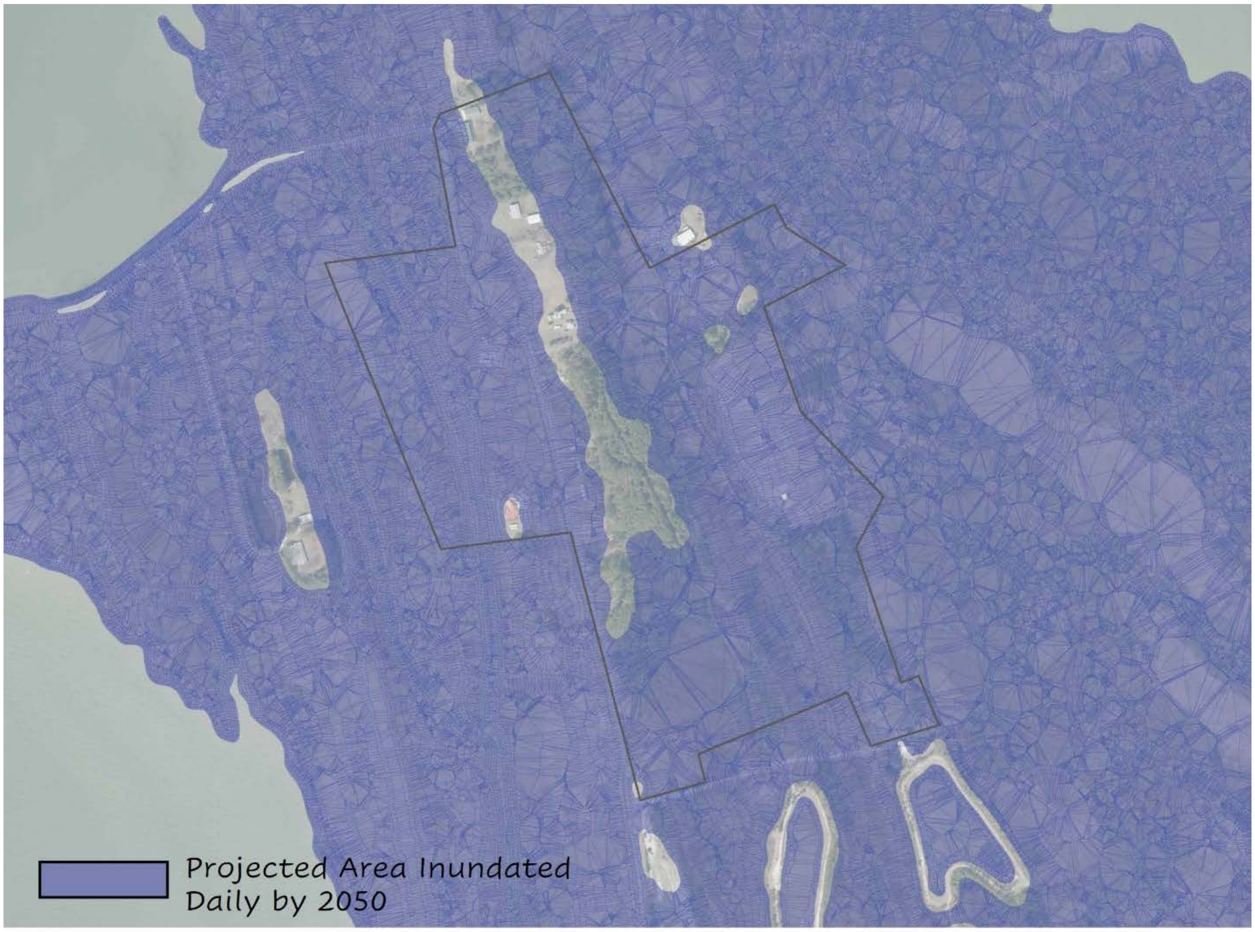

Figure 35 - Projected 2050 MHW Inundation Limits in Rural Residential Area

5.1.4. Village District

The Village District is the center of the housing and commerce of Hoopersville. Elevations within the Village District are some of the highest on the island and approximately 5,100 linear feet of shoreline has been armored along the Chesapeake Bay shoreline. If no further protective action is taken, the following impacts are projected to occur due to coastal resiliency stressors by 2050.

- ❖ Coastal Erosion

Though some erosion was observed between 1972 and the current shoreline along the Honga River side of the Village District, the shoreline was classified as stable based on the 1994 to 2016 ESRGC data. For this reason, it was assumed that erosion along this area is minimal and was not included in the future projections.

For the Chesapeake Bay shoreline within the Village District, a significant portion has been armored with rock revetment. The areas with shoreline protection were also considered stable and additional erosion by 2050 was not added to this area.

For the shoreline along the Chesapeake Bay without protection, the 1994 to 2016 data shows an average erosion rate of 4.5 feet/year. Extrapolating this estimate to 2050, an additional 13.8 acres of land is approximated to be lost due to coastal erosion. Figure 36 shows the additional erosion projected by 2050.

❖ Forested Area Lost to Saltwater Intrusion

Based on the estimate that forest habitat cannot survive at elevations less than 1 foot above MHW, approximately 15.3 acres of forested area of the remaining 25.8 acres is anticipated to be lost to saltwater intrusion. These areas are shown in Figure 36.

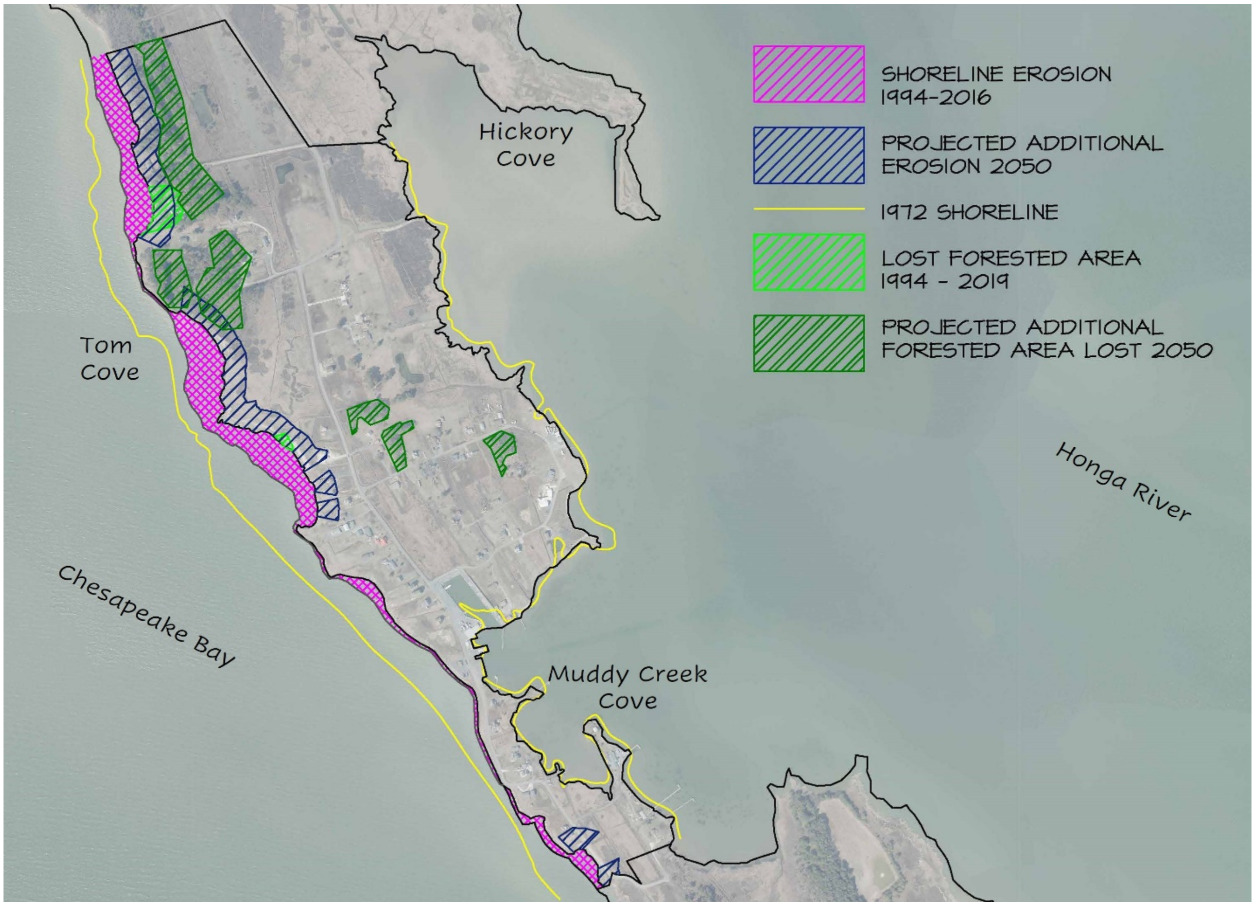

Figure 36 - Projected Additional Erosion and Forest Lost in Village District by 2050

❖ High Tide and Storm Surge Flooding

Of the approximate 35.5 acres that make up the Village District, approximately 70% of the area will be inundated daily during MHW. This area includes approximately 52% of the homes present in this area. Significant portions of the road will also be inundated daily. Figure 37 depicts the flood extents of daily inundation.

❖ Drainage

Similar to the Rural Residential Area, drainage along the Village District is maintained through roadside ditches. These ditches, along with the majority of the road, will be inundated during MHW, significantly decreasing the storage capacity of the ditch and resulting in flooding from rainfall events with deeper flood depths lasting longer.

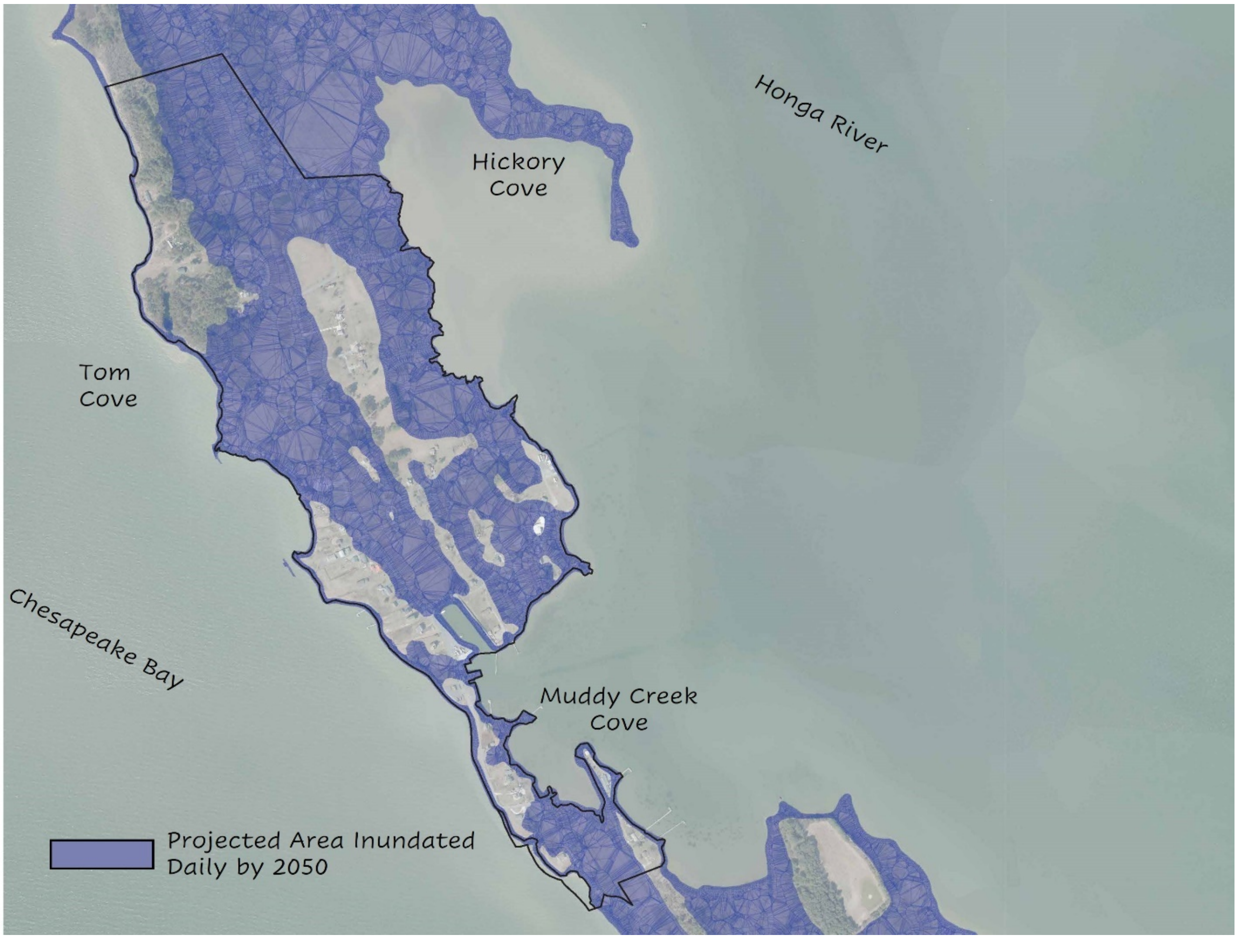

Figure 37 - Projected 2050 MHW Inundation Limits in Village District Area

5.1.5. Southern Marsh

For the Southern Marsh, the following potential impacts due to coastal resiliency stressors by 2050 were identified.

- Coastal Erosion

The average rate of erosion between 1994 and 2016 along the Southern Marsh was estimated to be 3.3 feet/year on the Chesapeake Bay side. The Honga River side experiences an average erosion rate of 2 feet/year. Applying this average erosion rate will result in approximately 68.5 acres of marsh and beach habitat lost by 2050. Figure 38 shows the anticipated erosion along the shoreline of the Southern Marsh area.

- Forested Area Lost to Saltwater Intrusion

Applying the 1.7 feet by 2050 SLR projection, it is anticipated that saltwater intrusion will result in the loss of 4.1 acres of the remaining 9.2 acres of forest area within the Southern Marsh, as shown in Figure 38.

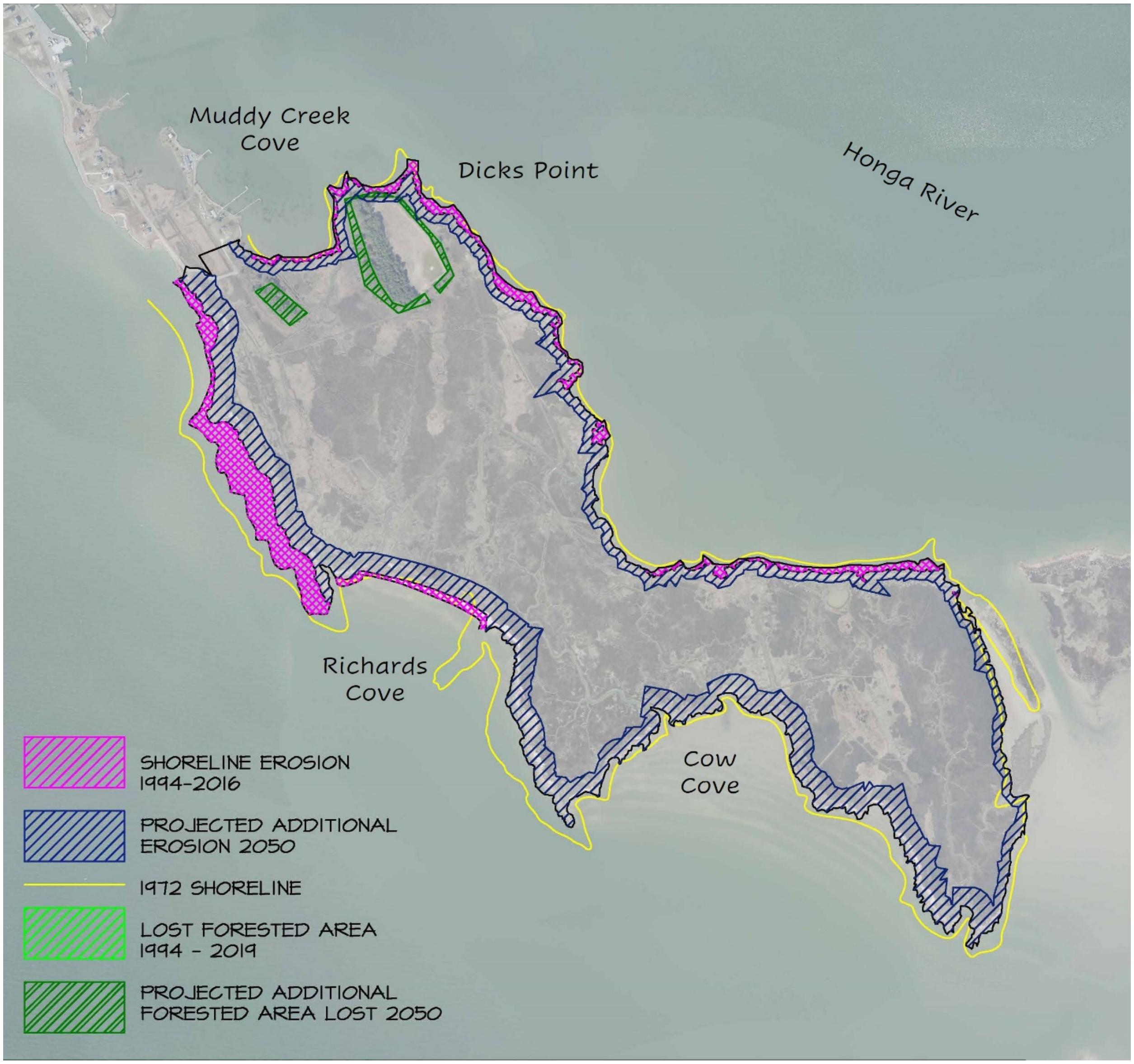

Figure 38 - Projected Erosion and Forested Area Lost by 2050 within the Southern Marsh

- High Tide and Storm Surge Flooding

The higher elevation of the Southern Marsh makes it less susceptible to marsh drowning with projected SLR. Figure 39 shows that less than 5% of the existing marsh will be converted to open water by 2050.

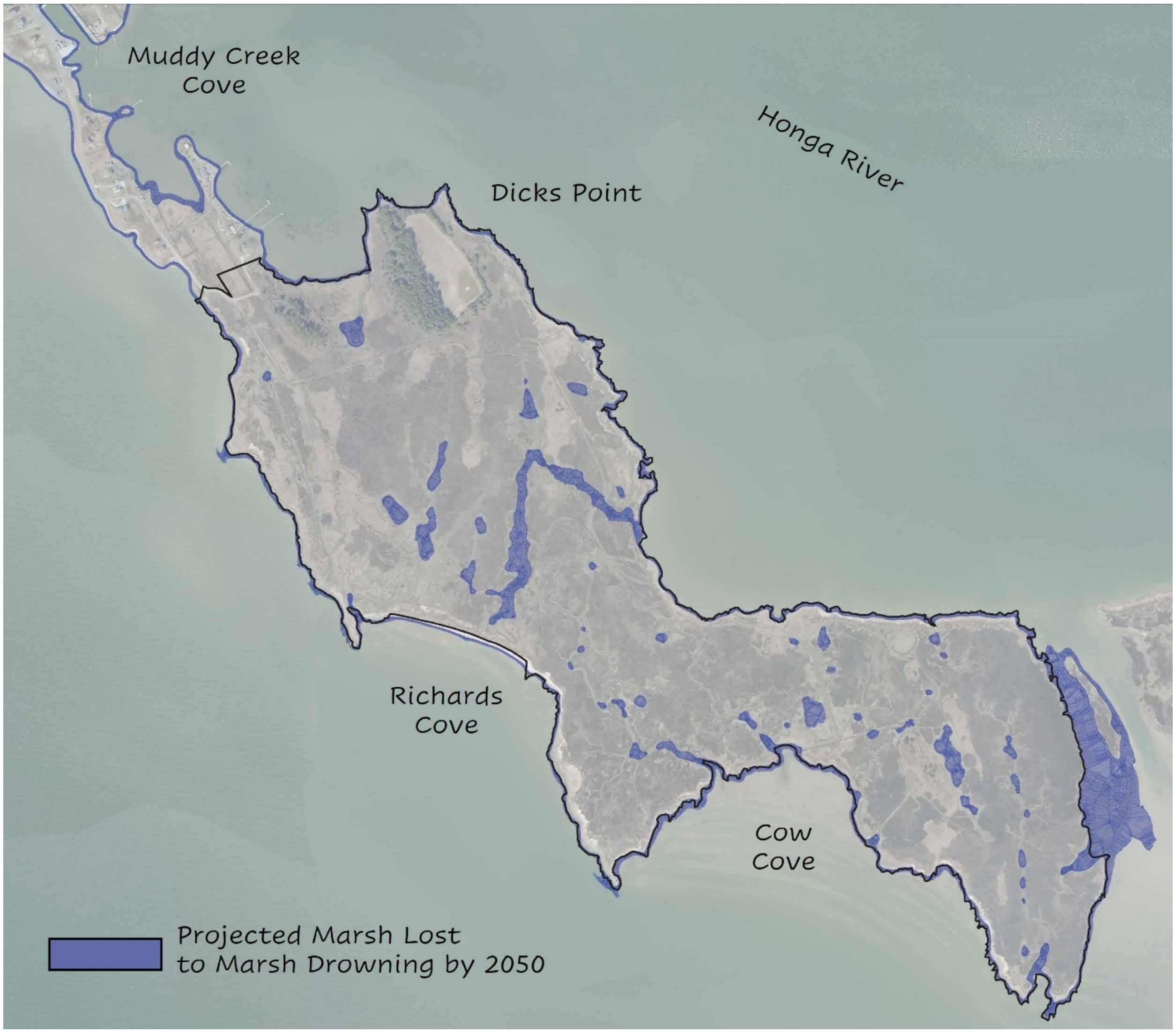

Figure 39 - Projected Marsh Area Lost due to Marsh Drowning by 2050 within the Southern Marsh

5.1.6. Hoopersville Road

The Vulnerability Analysis identified Hoopersville Road as the most vulnerable asset to the community of Hoopersville. The impacts from coastal resiliency stressors by 2050 are discussed in subsequent paragraphs.

- Coastal Erosion

Many areas of the road that are susceptible to erosion have been protected with shoreline protection. However, continued erosion will result in future portions of road becoming vulnerable. Areas where continued coastal erosion may impact the road if no action is taken are shown in Figure 40 through Figure 42. All areas identified as vulnerable to coastal erosion are directly adjacent to areas where shoreline protection has already been added. It should also be noted that, since the condition of the existing shoreline protection was not assessed as part of this study, areas of road that may have inadequate protection may also be susceptible to impacts from continued coastal erosion.

Figure 41 shows the northern portion of Hoopersville Road. This section of road has been protected along the Cat Cove shoreline and is fronted by marsh on the Chesapeake Bay side. Continued erosion on the Bay side will compromise the road, even with the protection along Cat Cove.

Figure 42 shows the section of road near Tom Point where rubble rip rap has been added to protect the road. However, recent road wash outs have shown this protection to be ineffective at protecting the road. Additional areas where only marsh fronts the road will also become exposed with continued coastal erosion.

Figure 43 shows the very southern end of road exposed to coastal erosion. Though a large rock revetment protects the majority of this area, short portions have been left unprotected and could result in encroachment of the road.

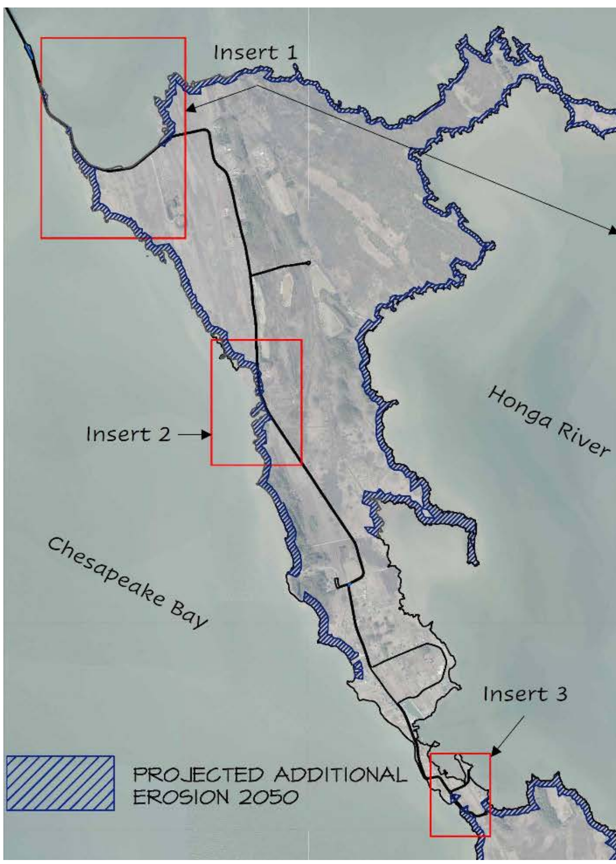

Figure 40 - Projected 2050 Erosion

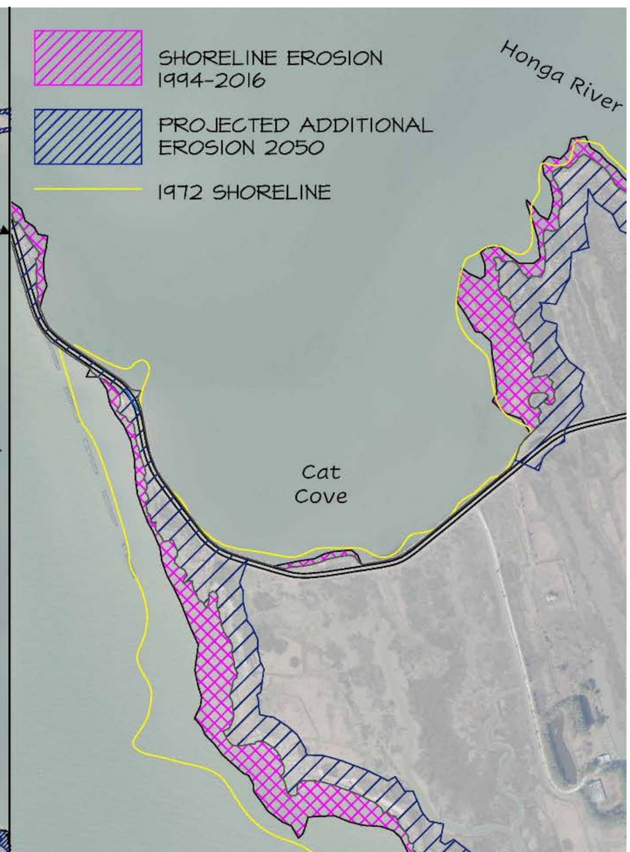

Figure 41 - Insert 1 Projected 2050 Erosion

- ❖ Forested Area Lost to Saltwater Intrusion

For Hoopersville Road, saltwater intrusion does not apply as a coastal resiliency stressor.

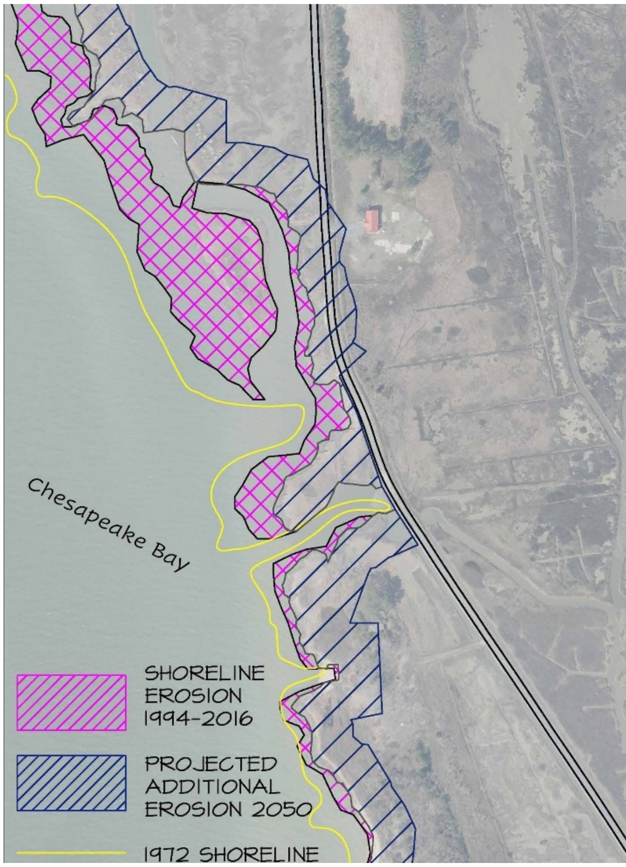

Figure 42 - Insert 2 Project 2050 Erosion

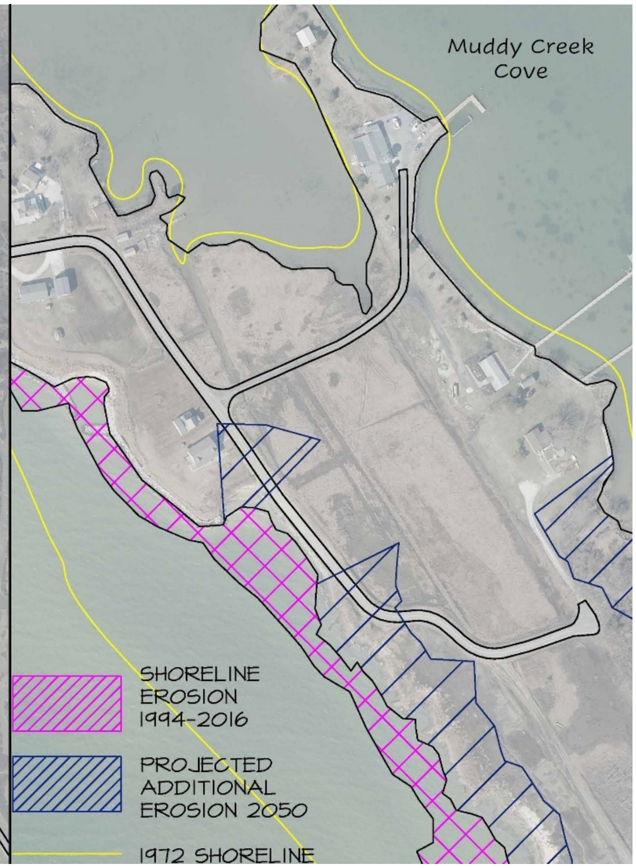

Figure 43 - Insert 3 Projected 2050 Erosion

- High Tide and Storm Surge Flooding

Figure 44 shows that approximately 95% of the road will be inundated daily during MHW in 2050. Only portions of the road within the Village District will not experience daily flooding.

- Drainage

As discussed for the Assessment Areas, drainage along the road is conveyed through drainage ditches. The majority of these ditches will become permanently inundated by 2050 if no ditch maintenance is performed. This will reduce the storage capacity within the ditches and lead to longer periods of ponding on the roadway.

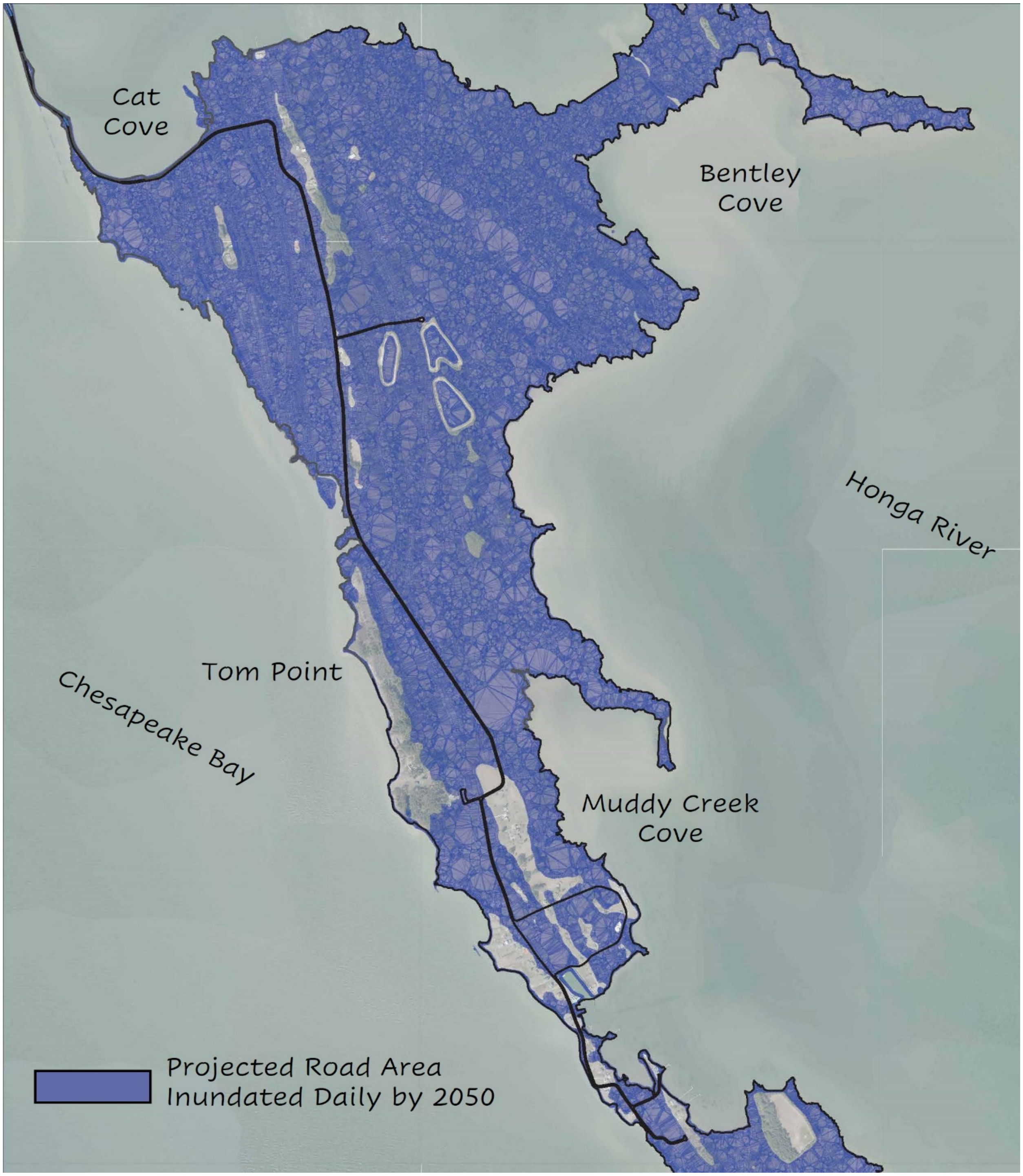

Figure 44 - Projected MHW in 2050 Inundation Limits on Hoopersville Road

5.1.7. Benefits and Impacts of Implementation - Tolerate

The benefits and impacts of implementing the RMS 1 of 'Tolerate' for each rating criteria is as follows:

- Feasibility – Implementation of this strategy requires no action and is, therefore, fully feasible.

- Effectiveness – The strategy provides no improvement on lessening the impacts of the coastal resiliency stressors. Conversely, implementation will have the following impacts:
  - Coastal erosion will cause the loss of approximately 202 acres of land (14% of existing island);
  - Saltwater Intrusion will claim an additional 51 acres of forested area (74% of existing forested area);
  - Approximately 235 acres of marsh (16% of existing land) will be converted to open water and 1355 acres of land (93% of existing island) will be inundated daily.
  - The daily high tide will reach the ground level of 52% of the homes on Hoopersville.
  - Drainage ditches will be permanently inundated which will decrease storage capacity and result in more frequent and longer duration of standing water after rainfall events.
  - Approximately 95% of Hoopersville Road will be inundated during MHW with areas having flood depths as high as 1.5 feet.
- Socio-economic Benefits – Implementation of this strategy would have low socio-economic benefits because conditions on the island in 2050 will likely result in the island becoming uninhabitable. Based on 2018 Dorchester County tax records, property taxes collected for the parcels in Hoopersville amount to approximately $180,000 per year.
- Environmental Impacts – Land loss due to coastal erosion, saltwater intrusion and flooding will have significant impacts on the existing habitats of the island. Most of the areas identified by the Maryland DNR as TEAs (discussed in Section 2.1.2) are in jeopardy of significant adverse impacts by 2050.

The largest habitat at risk due to coastal resiliency stressors are coastal marshes. Erosion and drowning of these marshes will result in loss of habitat for waterfowl, plants, mammals, invertebrates, and reptiles. Because coastal marshes serve to trap and store pollutants such as phosphorous and nitrogen from entering the Bay, the erosion and drowning of these marshes will result in significant release of pollutant loads that will negatively impact Bay water quality. To quantify this impact, the Annual Total Pollutant Loading and the Impervious Acre Credits presented in the *2019 Recommendations of the Expert Panel to Define Removal Rates for Shoreline Management*[1] was applied to determine the estimated average pollutant loading due to loss of this marsh acreage. Based on the default values presented in the Expert Panel Recommendations, the Table 13 below shows the annual pollutant load into the Bay.

Table 13 - Annual Pollutant Loading due to Lost Marsh

Pollutant	Annual Total Pollutant Loading (lbs/year)
Total Nitrogen	18,513
Total Phosphorous	1,127
Total Suspended Solids	1,402,934

[1] 2019 Recommendations of the Expert Panel to Define Removal Rates for Shoreline Management

To monetize the benefits of coastal marshes and other island habitats, recent marsh restoration projects were researched to see the cost per acre of marsh creation and/or rehabilitation. Specifically, the restoration of Poplar Island, which began in 1998 and is anticipated to be constructed in multiple phases was examined to estimate the cost. Cost projections for restoration of this island totaled $ 1.4 billion for the construction of 1,715 acres. Estimated for James and Barren Island construction are approximated to be $ 1.9 billion for construction of approximately 2,200 acres. Based on this estimated lost habitat acreage of 435 acres by 2050, the estimate cost of lost habitat is $ 365 million. If the entire island is to be lost and rebuilt, the cost would be approximately $1.2 billion.

Additionally, forested areas act as a carbon sink, meaning they absorb more carbon dioxide than they release[2]. The amount of carbon sequestered by a forest is dependent on a number for factors, including but not limited to, age of forested area and type of trees. In lieu of data specific to the forested areas in Hoopersville, the approximate annual carbon capture of a young forest is approximately 5 tons per acre[3]. Therefore, the loss of 51 acres equates to approximately the loss of approximately 255 tons of carbon sequestration annually. To estimate the monetary value of one acre of forested area, a recent large scale reforestation project in China cost approximately $1000/acres. With Hoopersville poised to lose 51 acres of forested area by 2050, the loss of this forested area would result in approximately $51,000.

- Cost – Because this alternative corresponds to the ‘Do Nothing’ alternative, there is no cost associated with implementation of this strategy.

5.2. Risk Management Strategy 2 – Terminate the Risk

Risk Management Technique 2 refers to implementing solutions that will terminate the risk posed by coastal resiliency stressors by 2050. The following solutions were identified for each stressor:

5.2.1. Coastal Erosion

Construction of an engineered structure, or ‘hardening’ of the shoreline, will prevent future erosion. Two different structures could be applied at Hoopersville. For areas at higher elevations or areas where the road is directly adjacent to the shoreline, a stone revetment similar to the structure constructed by FEMA along the Village District could be implemented. For coastal marsh areas, low-profile stone sills with small portals used for flushing can be applied in front of the existing marsh to continue to allow some flow into the marshes. Some adjustments to the existing grades will be required to properly tie-in the structures. A schematic of a stone revetment and stone sill is presented in Figure 45 and Figure 46.

[2] USDA, Forest Carbon & Climate Change, 2016.
[3] https://www.terraformation.com/blog/the-carbon-removal-xprize-winner-will-have-to-beat-7-per-ton

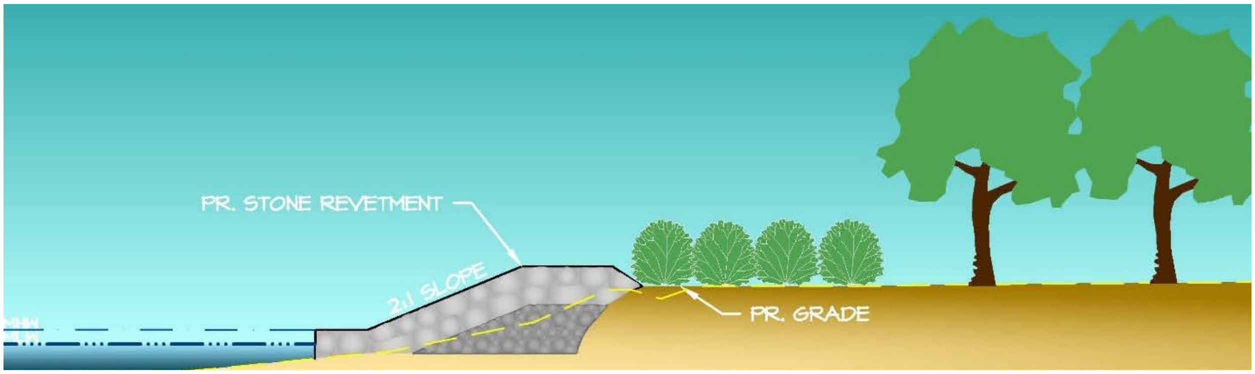

Figure 45 - Proposed Revetment to 'Terminate' Coastal Erosion

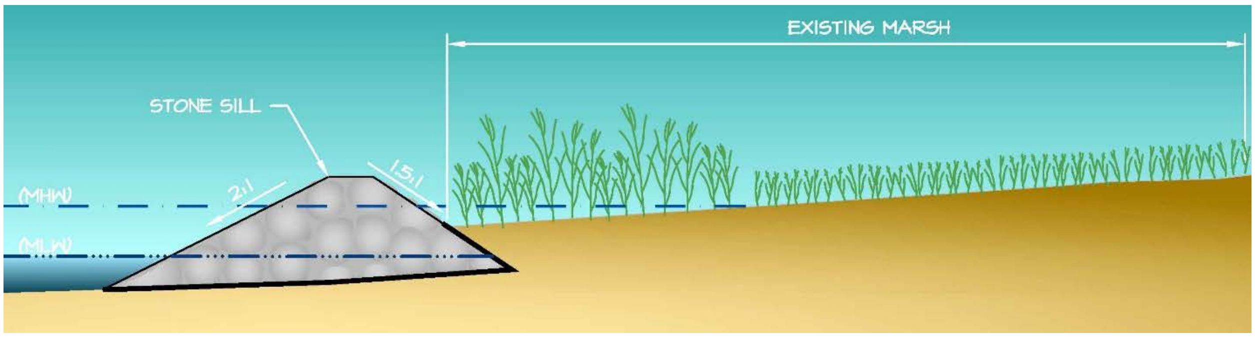

Figure 46 - Stone Sill to 'Terminate' Coastal Erosion

The total estimate for implementing this alternative is present in Table 14.

Table 14 - Cost to 'Terminate' Coastal Erosion				
Item	**Unit Quantity**	**Unit Size**	**Cost/Unit**	**Total Cost**
Stone Revetment	970	LF	$680	$659,600
Stone Sill	80,550	LF	$400	$32,220,000
Earthwork for Proper Tie-In	81,520	LF	$20	$1,630,400
			Construction Subtotal	$34,510,000
			25% Continency	$8,627,500
			20% Design, Permitting & Construction Management	$6,902,000
			Total	**$50,039,500.00**

**Cost per 2022 dollars*

5.2.2. Saltwater Intrusion

Preventing saltwater intrusion from impacting the existing forests would require hardening the shoreline and raising the elevation of the surrounding area. To adequately protect the existing forested area, it is anticipated that the surrounding areas will need to be at an elevation of +4 feet NAVD88 or higher. The estimated cost for constructing stone sills near the existing forested areas and raising the elevation of the surrounding area is presented in Table 15.

Table 15 - Cost to 'Terminate' Saltwater Intrusion				
Item	**Unit Quantity**	**Unit Size**	**Cost/Unit**	**Total Cost**
Stone Sill	17,350	LF	$400	$6,940,000
Earthwork for Proper Tie-In	17,350	LF	$20	$347,000
Fill to +4' NAVD88	250	Acres	$140,000	$35,000,000
			Construction Subtotal	$42,287,000
			25% Continency	$10,571,750
20% Design, Permitting & Construction Management				$8,457,400
			Total	**$61,316,150.00**

**Cost per 2022 dollars*

5.2.3. High Tide and Storm Surge Flooding

In order to terminate the risk of high tide and storm surge flooding, the assessment areas were categorized based on their function. The coastal marsh area consists of the Northeast Marsh, the Northwest Marsh, Southern Marsh. The Developed Area will include the Rural Residential area and the Village District. Finally, the risk termination measure for Hoopersville Road is discussed.

❖ Coastal Marshes

In order to prevent the drowning and degradation of the existing marshes due to frequent inundation by 2050, the proposed strategy is to raise the existing elevation of the marsh to keep up with SLR. Applying the assumption that SLR will increase by 1.7 feet by 2050, the estimate to raise the marsh area by the same amount is presented in Table 16.

Table 16 - Raise Marsh by 2050 SLR Projection of 1.7 feet				
Item	**Unit Quantity**	**Unit Size**	**Cost/Unit**	**Total Cost**
Raise Marsh Area	1,042	AC	$175,000	$182,350,000
			Construction Subtotal	$182,350,000
			25% Continency	$45,587,500
20% Design, Permitting & Construction Management				$36,470,000
			Total	**$264,407,500.00**

**Cost per 2022 dollars*

❖ Developed Area

The Rural Residential and Village District consist primarily of homes at low elevations. Termination of the risk to impacts from high tide and storm surge flooding would require relocation of the homes and businesses. Property acquisition or buyouts are available through FEMA's Hazard Mitigation Grant Program (HMGP) which provides grants to state and local governments after a major disaster declaration in which FEMA provides 75% funding while the state or local government covers the remaining 25%. This program is based on the principle fair value of the home being acquired and the land must then be restricted to open space, recreational or wetland management use in perpetuity.

Another option for the developed areas is to aid each resident and business in adjusting their home and property. Options available to each individual property owners to prevent flood damage include, but are not limited to:

- Elevating home and surrounding property to higher elevations;
- Wet or dry flood proofing homes;
- Install flood damage-resistant materials;
- Temporary or permanent barriers (subject to regulatory approval).

FEMA provides funding for such activities through the Flood Mitigation Assistance (FMA) program as well as the Building Resilient Infrastructure and Communities (BRIC), which also have a 75% federal and 25% non-federal cost share that increases to 90% federal 10% non-federal for impoverished communities.

To estimate the total cost to acquire the private property located on Hoopersville, the 2021 assessed total fair value of all property parcels on the island was divided amongst the number of property parcels. Additionally, for the purpose of this exercise, it was assumed likely that, should home and business owners choose to retrofit their properties to prevent flood damage instead of relocating, the cost would be similar to the cost of property acquisition. The cost estimate for the acquisition or improvement of all properties to prevent flooding in Hoopersville is presented in Table 17.

Table 17 - Property Acquisition				
Item	**Unit Quantity**	**Unit Size**	**Cost/Unit**	**Total Cost**
Property Acquisition/ Improvement	147	1	$110,000	$16,170,000
			25% Continency	$4,042,500
			Total	**$20,212,500.00**

**Cost per 2022 dollars*

- Hoopersville Road

The risk termination measure that would prevent flooding of Hoopersville Road is to raise the road to an approximate elevation of +4 feet NAVD88. A schematic of this option is shown in Figure 47. This would prevent the road from flooding under all but the most extreme storm surge conditions.

To reach elevation +4 feet NAVD88, Hoopersville Road would need to be raised an average of 2.3 feet. This would require compacted fill to be placed along the current road, shoulder and existing ditch. Graded Aggregate Base (GAB) and bituminous pavement would be placed along the roadway. The shoulder would be extended into the existing ditch so as to provide stability to the newly raised road. The ditch would have to be relocated to the outside of the new shoulder. The cost to raise the road to approximately +4 feet NAVD is provided in Table 18.

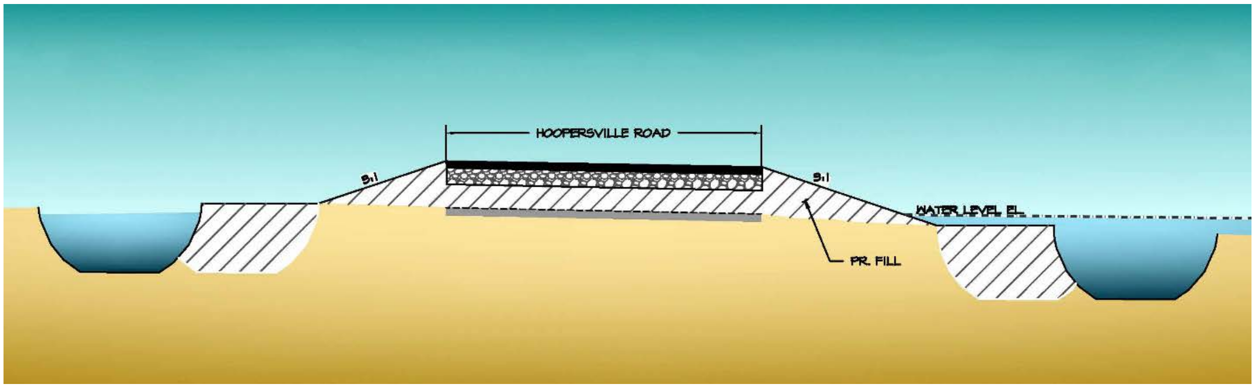

Figure 47 - Schematic of Raising Road

Table 18 - Elevate Road to +4' NAVD88				
Item	**Unit Quantity**	**Unit Size**	**Cost/Unit**	**Total Cost**
Elevate Road	18,000	LF	$220	$3,960,000
			Construction Subtotal	$3,960,000
			25% Continency	$990,000
			20% Design, Permitting & Construction Management	$792,000
			Total	**$5,742,000.00**

**Cost per 2022 dollars*

5.2.4. Drainage

In order to avoid flooding impacts due to drainage inadequacies, the preferred alternative is to perform regular maintenance on the roadside ditches. The anticipated cost to implement this strategy up to three times before 2050 is provided in Table 19.

Table 19 - Perform Drainage Ditch Maintenance				
Item	**Unit Quantity**	**Unit Size**	**Cost/Unit**	**Total Cost**
Ditch Maintenance Event 1	15,500	LF	$15	$232,500
Ditch Maintenance Event 2	15,500	LF	$15	$232,500
Ditch Maintenance Event 3	15,500	LF	$15	$232,500
			Construction Subtotal	$697,500
			25% Continency	$174,375
			Total	**$871,875.00**

**Cost per 2022 dollars*

5.2.5. Cost of Strategy Implementation

The cost to implement these alternatives and terminate the risk posed by the coastal resiliency stressors is presented in Table 20.

Table 20 - Total Cost to 'Terminate' the Risk	
Risk Management Strategy to Terminate the Risk	**Total Cost**
Stop Coastal Erosion	$50,039,500
Prevent Loss of Forested Area from Saltwater Intrusion	$61,316,150
Prevent Flooding Damage	$290,362,000
Maintain Adequate Drainage	$871,875
Total	**$402,589,525.00**

**Cost per 2022 dollars*

5.2.6. Benefits and Impacts of Strategy Implementation

The benefits of implementing the RMS 2 for the analysis criteria are as follows:

- Feasibility – Project implementation will depend on multiple factors such as community consensus on relocation, significant regulatory implications, large volumes of construction material and significant funding, which result in low feasibility of implementation of this alternative.
- Effectiveness – The strategy will prevent impacts from coastal resiliency stressors;
- Socio-economic Benefits – Implementation of this strategy would have low socio-economic benefits as residents and businesses would be required to relocate or make significant improvements.
- Environmental Impacts – Though environmental impacts associated with implementation of this strategy will be significant, they are in line with initiatives currently being undertaken within the Chesapeake Bay.
- Cost – Implementation of this risk management alternative has a significant associated cost.

5.3. Risk Management Strategy 3 – Transfer the Risk

The Risk Management Strategy 3 is referred to as Risk Transfer. This strategy entails giving the responsibility of risk management to a third party. RMS 3 is typically implemented through purchase of an insurance policy where the policy holder pays premiums to transfer the risk to the insurer.

Though this option for risk management does not exist for coastal resiliency stressors such as coastal erosion or saltwater intrusion, it is currently the most popular strategy for risk management against flooding. Home or business owners are either required to or can choose to purchase insurance to protect against damages incurred during flood events. The US Department of Homeland Security (DHS) and the Federal Emergency Management Agency (FEMA) administers the National Flood Insurance Program (NFIP) which provides affordable flood insurance for communities located with flood prone areas. The risk of flooding is established through the use of Federal Insurance Rate Maps (FIRMs), which show the flood extents of various flooding scenarios. A limitation of the FIRMs is that, currently, they do not take into account future conditions.

Given the exposure and low elevations of Hoopersville, SLR may render NFIP inadequate in protecting the homes and businesses from impacts. Without implementation of preventive or mitigative actions, impacts will be so frequent and severe that insurance will no longer be a cost-effective method for managing risk. Additionally, environmental impacts and some socio-economic impacts cannot be managed through the transfer of risk.

For these reasons, RMS 3 – Transfer of Risk is not a viable alternative for managing the risk of the coastal resiliency stressors for 2050 conditions at Hoopersville and will not be applied in this study.

5.4. Risk Management Strategy 4 – Treat the Risk

The final strategy for managing risk is to ‘treat’ the risk. This strategy examines options for risk mitigation where solutions are implemented with the intention of reducing the risk without eliminating it. The following solutions were identified for risk reduction for each coastal resiliency stressor.

5.4.1. Coastal Erosion

Unlike the revetment and stone sills proposed for the RMS 2 for risk termination, a living shoreline is proposed to reduce the risk of coastal erosion. The proposed living shoreline will have breakwaters built offshore from the shoreline with gaps that allow some flow and wave energy to pass through. This allows for the continued dynamic behavior of shorelines where sediment is allowed to move along the shoreline. However, movement is greatly reduced as breakwaters will dissipate much of the wave energy that would typically transport the sediment away from the shoreline. In this way, shoreline erosion is mitigated with the addition of breakwaters without being eliminated. A schematic of this alternative is provided in Figure 48.

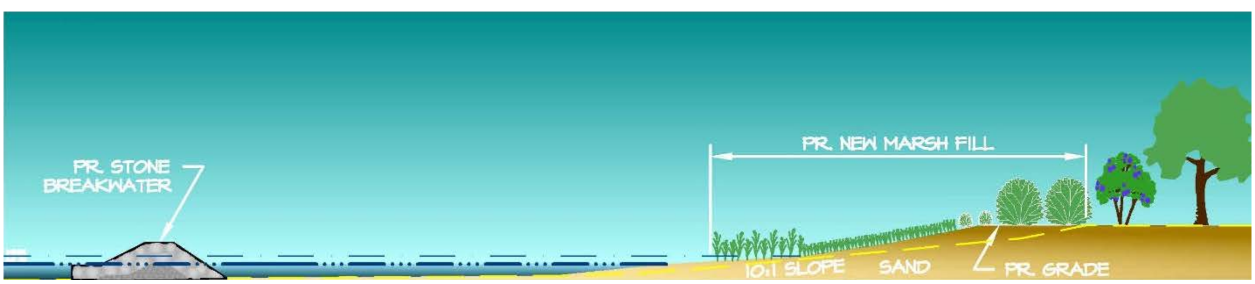

Figure 48 - Stone Breakwaters and Marsh against Coastal Erosion

Where needed, sand fill is added behind the breakwaters to lessen the distance between the structure and the shoreline. This helps ensure that waves do not have the proper distance to rebuild after passing the breakwater structures. For the concept design developed, an approximate breakwater length to gap ratio of 2:1 (structure length: gap length) was utilized. This ratio has been applied in other parts of the Chesapeake Bay and has shown to be effective in reducing erosion. The sand placed behind the structures will be planted with marsh grasses. The root system of the grasses helps to stabilize the sand and further reduce its movement.

This shoreline stabilization method was only applied to the Chesapeake Bay side of the shoreline. The Honga River side did not have breakwaters added as the shoreline erosion is significantly less than the Bay side. Some areas along the Honga River side were identified as not eroding while others may have experienced some shoreline recession due to sea level rise over the last few decades. Therefore, for the Honga River side, reduced shoreline recession is proposed by increasing the elevation of the marsh to keep up with sea level rise. Because this correlates with the solution for Saltwater Intrusion and High Tide and Storm Surge Flooding, more information on this solution will be provided in section 5.4.2 and 5.4.3.

The cost to implement this alternative to mitigate the risk for coastal erosion for the entire island is presented in Table 21.

Table 21 - Cost to Mitigate Coastal Erosion				
Item	**Unit Quantity**	**Unit Size**	**Cost/Unit**	**Total Cost**
Stone Breakwaters	26,000	LF	$400	$10,400,000
Sand Fill	47.5	AC**	$315,000	$14,962,500
Vegetation	47.5	AC	$75,000	$3,562,500
			Construction Subtotal	$28,925,000
			25% Continency	$7,231,250
			20% Design, Permitting & Construction Management	$5,785,000
			Total	**$41,941,250.00**

**Cost per 2022 dollars*
***Assume average fill depth of 3 feet*

5.4.2. Saltwater Intrusion

The proposed solution for protecting the inland area from saltwater intrusion is to raise the elevation of the surrounding area. However, unlike the RMS 2 which proposes terminating the risk by raising the areas directly around the forested area to +4 feet NAVD88, RMS 4 proposes just raising the coastal marshes on the fringes of the island. This will act to reduce the frequency at which saltwater approaches the forested areas, which will reduce the risk from saltwater intrusion. Since this is the same solution as proposed for RMS 4 for High Tide and Storm Surge Flooding, more information on this alternative is provided in Section 5.4.3.

5.4.3. High Tide and Storm Surge Flooding

To examine the different options for decreasing the risk of impacts from high tide and storm surge flooding, the assessment areas were categorized based on their function. The coastal marsh area consists of the Northeast Marsh, the Northwest Marsh, the Southern Marsh and the marsh area in the Rural Residential and Village District. The

Developed Area will include the uplands in the Rural Residential area and the Village District. Hoopersville Road is discussed separately.

❖ Coastal Marshes

For the coastal marshes, the risk of flooding can be decreased by raising the marsh elevation to keep up with SLR. To implement this strategy, sediment would have to be brought to the site and placed on the existing marsh. Figure 49 shows a schematic of this preferred alternative paired with the breakwaters and sand fill proposed to protect against coastal erosion.

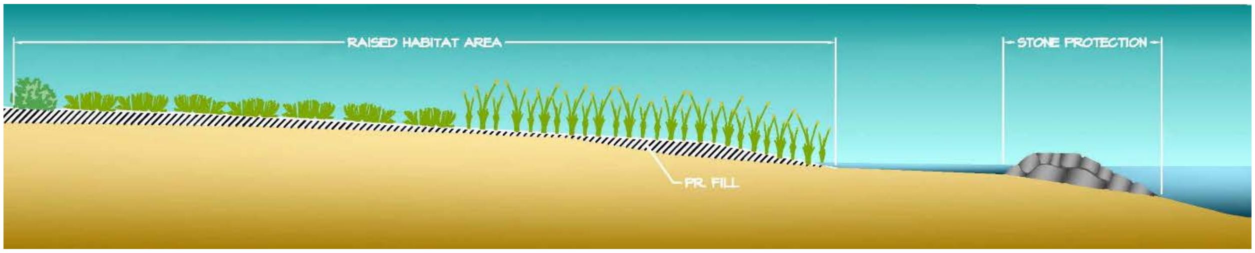

Figure 49 - Raised Habitat Area

For the purposes of this study, it was assumed that the marsh would be raised to an elevation of 3 feet above MLW, which corresponds to +1.9 feet NAVD88. This elevation was chosen as it is not too high to function as a marsh in current conditions and not too low that it will be drowned or degraded by 2050. To reach this elevation, the existing marshes would need to be raised an average of eight inches. Temporary containment structures such as hay bales and geotubes filled with sediment would act as containment for the marsh fill. The total cost to raise the marsh area to this elevation is presented in Table 23.

Table 22 - Cost to Raise Marsh Area to +1.9 feet NAVD88				
Item	**Unit Quantity**	**Unit Size**	**Cost/Unit**	**Total Cost**
Temporary Containment	80,000	LF	$20	$1,600,000
Marsh Elevation	1250	AC*	$80,000	$100,000,000
Construction Subtotal				$101,600,000
25% Continency				$25,400,000
20% Design, Permitting & Construction Management				$20,320,000
Total				**$147,320,000.00**

**Cost per 2022 dollars*
**Assume average elevation increase of 8 inches*

❖ Developed Area

The majority of the developed area on the island is privately owned residential properties or businesses. Therefore, the level or risk reduction is significantly dependent on the risk tolerance each property owner is willing to accept. RMS 2 assumed that all property owners are either willing to relocate or provide such improvements to eliminate the risk of flooding. RMS 4 assumes each property owner continues to reside in

Hoopersville but implements risk reduction measures. These measures will reduce impacts from flooding without removing the risk completely.

Table 22 - Property Improvements				
Item	**Unit Quantity**	**Unit Size**	**Cost/Unit**	**Total Cost**
Property Improvements	147	1	$75,000	$11,025,000
			25% Continency	$2,756,250
			Total	**$13,781,250.00**

**Cost per 2022 dollars*

- Hoopersville Road

Similar to RMS 2, raising Hoopersville Road will reduce the frequency and depth of flooding for current and future conditions. However, RMS 4 proposes to raise the road only to the elevation of the 2050 projected MHW line, approximately +2.4 feet NAVD88. This will prevent daily tides from flooding the road, however, flooding will still be experienced during unusually high-water events. However, the depth of flooding along the road during these higher water events will be in the magnitude of inches instead of feet. Furthermore, because the objective of RMS 4 is risk reduction, the raising of the road can be done in phases as funding becomes available.

Raising the road in phases will consists of multiple construction events where the road will be raised an average of 4 inches during each cycle. On average, approximately 12 inches of road raising is required to bring the entire road to +2.4 feet NAVD88, which, if done with a phased approach, will require three cycles. Each cycle will include 4 inches of bituminous pavement overlain on the existing road. At either cycle two or three, a shoulder modification will need to be conducted to adjust the shoulder and areas of roadside ditch. A schematic of this proposed alternative is provided in Figure 50.

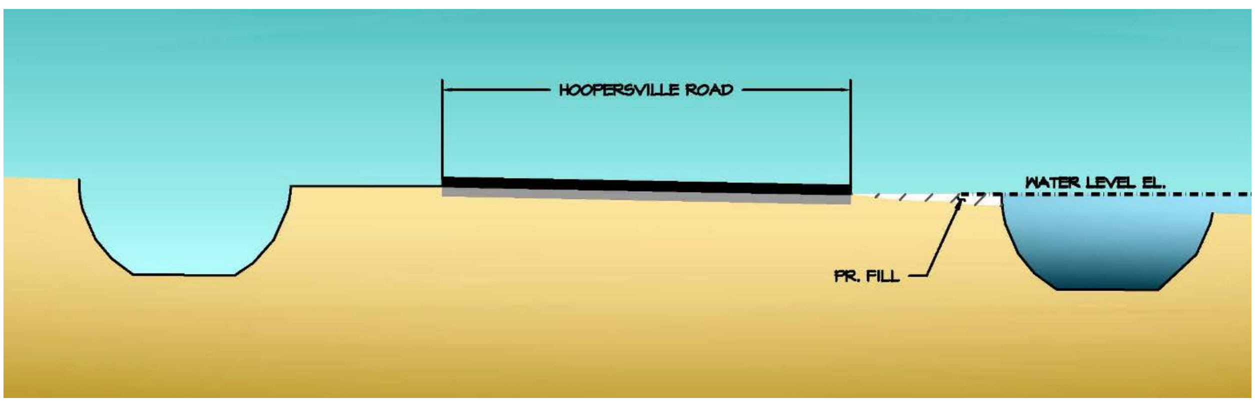

Figure 50 - Proposed Road Raising in Phases

Given that portions of the road already meet the +2.4 feet NAVD88 criteria, not all of the road will require raising to meet this threshold. Of the area of road below this threshold elevation, the average elevation increase is 12 to 15 inches. The approximate cost to perform this work is presented in Table 23.

Table 23 - Elevate Road to +2.4' NAVD88				
Item	**Unit Quantity**	**Unit Size**	**Cost/Unit**	**Total Cost**
Elevate Road	12,300	LF	$200	$2,460,000
			Construction Subtotal	$2,460,000
			25% Continency	$615,000
			20% Design, Permitting & Construction Management	$492,000
			Total	**$3,567,000.00**

**Cost per 2022 dollars*

5.4.4. Drainage

Maintaining the drainage ditches through regular maintenance, as proposed in RMS 2, is proposed as the alternative to reduce flood risk due to drainage inadequacy. The number of maintenance events to be performed was reduced from three to two events as the objective of this alternative is to reduce the risk instead of eliminating it. The cost estimate for this alternative is provided in Table 24.

Table 24 - Drainage Ditch Maintenance to Reduce Flood Risk				
Item	**Unit Quantity**	**Unit Size**	**Cost/Unit**	**Total Cost**
Ditch Maintenance Event 1	15,500	LF	$15	$232,500
Ditch Maintenance Event 2	15,500	LF	$15	$232,500
			Construction Subtotal	$465,000
			25% Continency	$116,250
			Total	**$581,250.00**

**Cost per 2022 dollars*

5.4.5. Cost of RMS 4 Strategy Implementation

The cost to implement these alternatives and terminate the risk posed by the coastal resiliency stressors is presented in Table 25.

Table 25 - Total Cost to 'Reduce' the Risk	
Risk Management Strategy to Terminate the Risk	**Total Cost**
Reduce Coastal Erosion	$41,941,250
Reduce Loss of Forested Area from Saltwater Intrusion**	
Reduce Flooding Damage	$164,668,250
Reduce Flooding from Drainage Deficiency	$581,250
Total	**$207,190,750.00**

**Cost per 2022 dollars*
***Cost to reduce risk of forest area lost from saltwater intrusion accounted for in ‘Reduce Flooding Damage’ estimate.*

5.4.6. Benefits of RMS 4 Strategy Implementation

The benefits of implementing the Risk Reduction strategy for the analysis criteria area as follows:

- Feasibility – All proposed projects part of RMS 4 can feasibly be implemented with community participation and significant funding support.
- Effectiveness – Though impacts will not be prevented, the RMS 4 strategies will achieve the project objective of reducing impacts from coastal resiliency stressors;
- Socio-economic Benefits – Implementation of this strategy would have socio-economic benefits as residents and businesses could continue to reside in Hoopersville under similar conditions that are experienced today;
- Environmental Impacts – Though environmental impacts associated with implementation of this strategy will be significant, they are in line with initiatives currently being undertaken within the Chesapeake Bay.
- Cost – Though implementation of the RMS 4 strategies has a significant associated cost, the cost is approximately 48% lower than RMS 2.

6. Preferred Alternatives

In order to evaluate each alternative against each other, a decision matrix was utilized with a ranking system applied toward each criterion. The criteria were ranked between from 0 to 5 depending on how well the alternative met the criteria. The ranking of the criteria utilized is as follows:

- Feasibility – How easily can the alternative be implemented (0 – not at all; 5 – very easy);
- Effectiveness – How well does the alternative reduce the risk from coastal resiliency stressors (0 – not at all; 5 – very well);
- Socio-economic Impacts – How beneficial to the community is the implementation of the alternatives against protecting against the coastal resiliency stressors (0 – not beneficial; 5 – very beneficial);
- Environmental Impacts – How significant are the environmental impacts of the alternative (0 – significant impacts; 5 – few impacts);
- Cost – How expensive will constructing the alternative be (0 – expensive relative to other alternatives; 5 – not expensive relative to other alternatives).

The following discussion presents the preferred alternatives based on a decision matrix conducted for each coastal resiliency stressor.

6.1. Coastal Erosion

The decision matrix for evaluation of coastal erosion is presented in Table 26. The options for protection against this coastal resiliency stressor are:

- RMS 1 – Tolerate the Risk – Do Nothing

- ❖ RMS 2 – Terminate the Risk – Installation of Revetments and Stone Sills
- ❖ RMS 4 – Treat the Risk – Installation of Living Shoreline on Chesapeake Bay shoreline only

Table 26 - Decision Matrix for Coastal Erosion

Options	Feasibility	Effectiveness	Socio-economic Impacts	Environmental Impacts	Cost	Total
RMS 1 – Do Nothing	5	0	0	1	5	11
RMS 2 – Terminate Risk	2	5	5	1	1	14
RMS 4 – Treat Risk	4	4	4	3	2	17

The result of the decision matrix shows that installation of the living shoreline on the Chesapeake Bay side of the island only has a slight advantage over installation of revetment and stone sills to prevent coastal erosion. The preferred alternative does not completely prevent coastal erosion, however, it has lower environmental impacts and would face less regulatory hurdles during the permitting process. However, given the small discrepancy between the coastal erosion protection proposed in RMS 2 and 4, both alternatives can be applied to protecting against coastal erosion.

6.2. Saltwater Intrusion

The decision matrix for evaluation of protection of forested areas against saltwater intrusion is presented in Table 27. The options for protection are:

- ❖ RMS 1 – Tolerate the Risk – Do Nothing
- ❖ RMS 2 – Terminate the Risk – Raise Area around Forests to +4 feet NAVD88
- ❖ RMS 4 – Treat the Risk – Raise Marshes around the Forested Area

Table 27 - Decision Matrix for Saltwater Intrusion

Options	Feasibility	Effectiveness	Socio-economic Impacts	Environmental Impacts	Cost	Total
RMS 1 – Do Nothing	5	0	0	1	5	11
RMS 2 – Terminate Risk	1	5	3	1	1	11
RMS 4 – Treat Risk	3	3	4	3	3	16

The preferred alternative for protecting the forested areas from saltwater intrusion is to raise the marsh areas around the forested areas. This is the same preferred alternative as for High Tide and Storm Surge Flooding. Implementation of this strategy is discussed in the next section.

6.3. High Tide and Storm Surge Flooding

Strategies for risk management of high tide and storm surge flooding were evaluated for the coastal marshes, upland area, and Hoopersville Road, as described in the subsequent paragraphs.

6.3.1. Coastal Marshes

The decision matrix for protection of the coastal marshes is provided in Table 28. The options presented are:

- RMS 1 – Tolerate the Risk – Do Nothing
- RMS 2 – Terminate the Risk – Raise Marsh Area +4 feet NAVD88
- RMS 4 – Treat the Risk – Raise Marsh to +1.9 feet NAVD88

Table 28 - Decision Matrix for High Tide and Storm Surge Flooding for Coastal Marshes

Options	Feasibility	Effectiveness	Socio-economic Impacts	Environmental Impacts	Cost	Total
RMS 1 – Do Nothing	5	0	0	1	5	11
RMS 2 – Terminate Risk	1	5	3	1	1	11
RMS 4 – Treat Risk	3	3	4	3	3	16

The preferred alternative for the marsh area within the Northeast Marsh, Northwest Marsh, Southern Marsh and marsh area within the Rural Residential and Village District is to nourish the marshes in order to raise their elevation to +1.9 feet NAVD88. The preferred method of nourishing the marsh is to beneficially use dredged material from neighboring dredging channels. The material is dredged and pumped onto the marsh in a method called Thin Layer Placement, which has been used to raise marsh elevations in other parts of Maryland. In 2019, the US Army Corps of Engineers (USACE) placed 60,000 CY of material (65% silt and 35% fine sand) from neighboring federal channels to restore acres of degraded marsh on Swan Island. In 2002 and 2016, Thin Layer Placement of fine-grained dredged material was used to restore 40 acres of marsh in the Blackwater National Wildlife Refuge.

The material used to raise the elevation of the marsh could be obtained from the multiple federal channels near Hoopersville. Currently, the USACE is responsible for maintaining four dredging channels within 5 miles of Hoopersville. These channels include the Honga River and Tar Bay, Back Creek Channel, Muddy Hook Cove Channel, and Duck Point Cove Channel. The location of these channels in relation to Hoopersville is shown in Figure 51. Dredging last occurred within the channels in the 2000s and each has experienced sedimentation past its maintenance depth. Because these channels are shallow draft channels that primarily serve the boating communities of Dorchester County and not deep draft shipping channels serving the multiple ports along the Chesapeake Bay, dredging of the channels is performed less often due to funding restraints.

Based on the latest surveys performed by the USACE, the following quantity of dredged material is available down to the authorized depth + two feet of allowable overdepth:

- ❖ Honga River and Tar Cove Channel = +/- 260,000 CY
- ❖ Back Creek Channel = +/- 140,000 CY
- ❖ Muddy Hook Cove Channel = +/- 21,000 CY
- ❖ Duck Point Cove Channel = +/- 30,000 CY

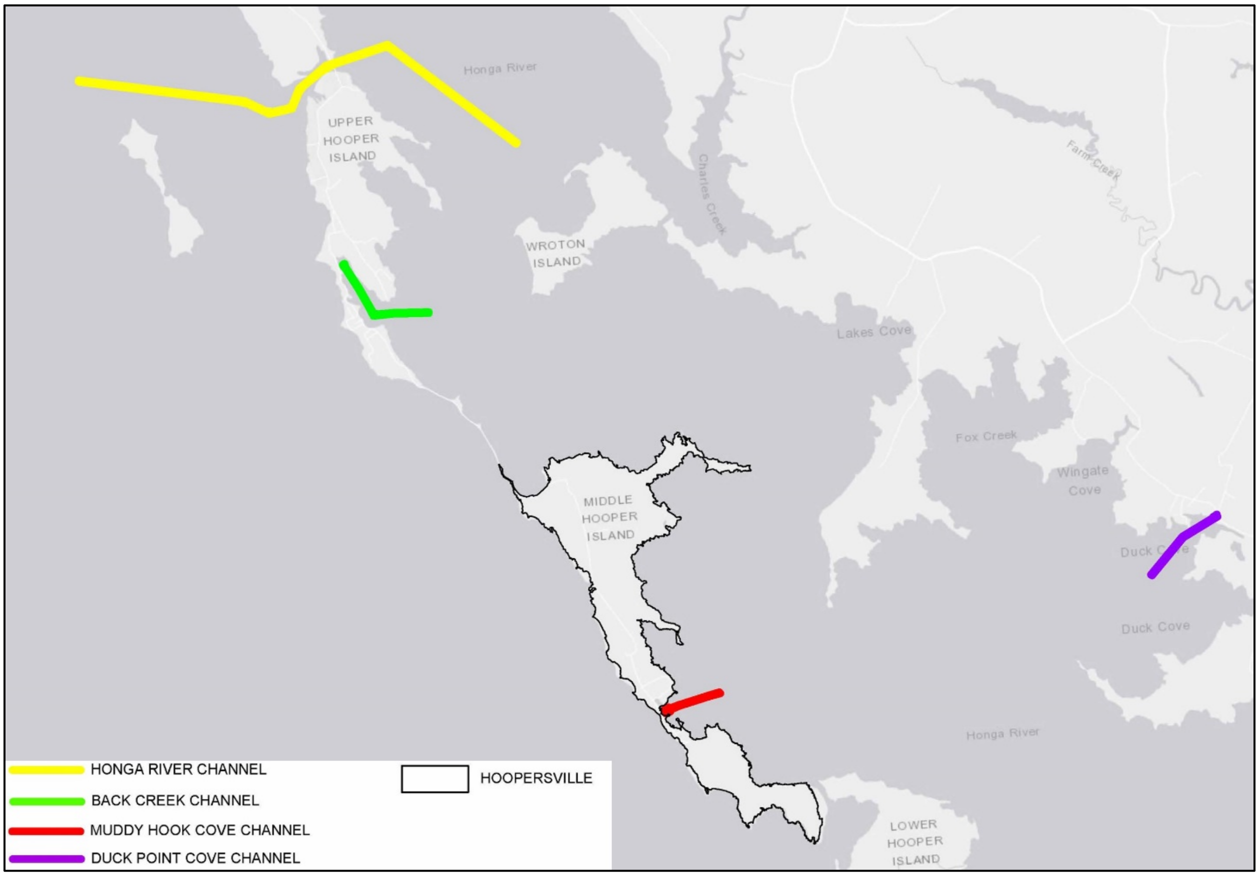

Figure 51 - USACE Dredged Channels within 5 miles of Hoopersville

Therefore, the potential dredged material volume within 5 miles of Hoopersville is +/- 451,000 CY. It should be noted that the USACE, in partnership with the Maryland Department of Transportation Maryland Port Administration (MDOT MPA) has slated the material from these dredged channels to be placed on the newly recreated Barren Island. Construction for Phase 1 of Barren Island is anticipated to begin in September 2022 and the dredged material placement will occur as part of Phase 4. However, because sedimentation passed the authorized channel depth occurs within a few years of dredging, it is anticipated that all channels will need two to three dredging cycles to maintain their authorized depths before 2050. Therefore, beneficial placement from these channels must be coordinated with Barren Island construction.

For project construction, the material would be dredged and hydraulically placed onto the existing marsh. Typically, if the dredged channel is less than five miles from the placement site, the dredged material can be pumped directly through a floating pipeline from the dredging site onto the marsh. For longer pumping distances, either a booster pump must be utilized, or the material is dredged and transported to the site via barge where it is mixed into a slurry (85% water + 15% sediment) and pumped onto the marshes.

Based on recent hydraulic dredging projects with direct pump to the placement site, an estimate of $65 per cubic yard of material was used for the cost of dredging and placement. Temporary containment structures such as hay bales and geotubes filled with sediment are proposed for containment of the dredged material at a unit cost of $20 per linear foot. These are only applied along the shoreline of the placement site as the material will be allowed to run back into the marsh.

6.3.2. Upland Areas

For the upland areas, the decision matrix for protecting against high tide and storm surge flooding is shown in . The proposed alternatives are:

- ❖ RMS 1 – Tolerate the Risk – Do Nothing
- ❖ RMS 2 – Terminate the Risk –Improve Upland Areas to Reduce Risk
- ❖ RMS 4 – Treat the Risk – Improvements to Infrastructure to Reduce Risk

Table 29 - Decision Matrix for High Tide and Storm Surge Flooding for Upland Areas

Options	Feasibility	Effectiveness	Socio-economic Impacts	Environmental Impacts	Cost	Total
RMS 1 – Do Nothing	5	0	0	5	5	15
RMS 2 – Terminate Risk	1	5	3	3	1	13
RMS 4 – Treat Risk	3	3	4	3	3	16

The preferred alternative is to implement improvements to the upland areas that will not prevent risk but will reduce it. These improvements include elevating homes or buildings, elevating surrounding areas or implementing flood proofing techniques. Installation of permanent or temporary flood barriers can also be considered but must be approved by local regulatory authorities.

6.4. Drainage

The options considered for improving drainage within Hoopersville include:

- ❖ RMS 1 – Tolerate the Risk – Do Nothing
- ❖ RMS 2 – Terminate the Risk – Perform 3 Ditch Maintenance Events
- ❖ RMS 4 – Treat the Risk – Perform 2 Ditch Maintenance Events

The decision matrix for managing the flood risk due to inadequate drainage is presented in Table 30.

Table 30 - Decision Matrix for Drainage						
Options	**Feasibility**	**Effectiveness**	**Socio-economic Impacts**	**Environmental Impacts**	**Cost**	**Total**
RMS 1 – Do Nothing	5	0	0	3	5	13
RMS 2 – Terminate Risk	4	4	4	4	3	19
RMS 4 – Treat Risk	5	3	4	4	4	20

RMS 2 and RMS 4 rank very closely when considering all criteria. However, reducing the number of maintenance events from three to two makes the alternative more feasible and less costly and is, therefore, the preferred alternative.

6.5. Hoopersville Road

The alternatives investigated for the raising of Hoopersville Road are:

- RMS 1 – Tolerate the Risk – Do Nothing
- RMS 2 – Terminate the Risk – Raise Road to +4 feet NAVD88 to Prevent Flooding
- RMS 4 – Treat the Risk – Raise Section of Road to +2.4 feet NAVD88 to Reduce Flooding

The decision matrix that compares these alternatives is presented in .

Table 31 - Decision Matrix for Raising of Hoopersville Road						
Options	**Feasibility**	**Effectiveness**	**Socio-economic Impacts**	**Environmental Impacts**	**Cost**	**Total**
RMS 1 – Do Nothing	5	0	0	5	5	15
RMS 2 – Terminate Risk	3	5	5	2	2	17
RMS 4 – Treat Risk	4	4	4	3	3	18

Raising the road to the 2050 MHW elevation of +2.4 feet NAVD88 has the highest rating.

7. Implementation Plan

Once the preferred alternatives for risk management were selected, projects are developed and prioritized in an Implementation Plan. The Implementation Plan is meant to focus efforts on the areas most in need and/or projects that will have the greatest benefits. Projects were developed that could address multiple coastal resiliency stressors or help multiple areas during a single implementation event.

Based on the Vulnerability Assessment and applying the preferred alternatives, the Implementation Plan was divided into three categories, as defined below:

- Immediate Implementation – Action to recognize benefits in 0 – 5 years
- Short Term Implementation – Action to recognize benefits in 5 – 10 years
- Long Term Implementation – Action to recognize benefits in +10 years

The projects developed and prioritized are discussed in subsequent paragraphs.

7.1. Immediate Implementation

Projects defined for ‘Immediate Implementation’ target areas of high priority that currently pose the highest risk to impacts from coastal resiliency stressors. These are the projects where work should begin immediately for securing funding for engineering, permitting and design so that construction can be underway in the near future.

The projects proposed for Immediate Implementation are improvements to Hoopersville Road at the lowest elevations and improvements within the Village District. Not only are these areas ranked highest in the vulnerability assessment, but they also likely have the best chance of receiving funding. Given the designation as a ‘Village District’ with historical and cultural significance as well as the area being categorized as a ‘Priority Funding Area’ and the presence of Targeted Ecological Areas (TEAs), the proposed projects are likely to have the most appeal to funding sources and have the most impact to preservation of the continued inhabitance of the island. The proposed projects and planning level implementation costs are presented in the following sections.

7.1.1. Hoopersville Road Raising

The first project for Immediate Implementation is raising of an approximate 3530-foot portion of Hoopersville Road where elevations average between +0.5 to +1.5 feet. Half of the road length is located within the Northwest Marsh area and the other half in the Village District. Given the low elevations of portions of the road, it is believed that, with SLR, areas will frequently be impassable in the near future.

Though the preferred alternative presents two options for implementing road raising, it is recommended that the road be completely raised to the 2050 MHW elevation of +2.4 feet NAVD88 instead of periodically adding pavement in 4-inch increments. This alternative is recommended because some low-lying areas would require up to six lifts using this technique, which no longer makes it a cost-efficient option.

The proposed solution would include adding compacted fill to raise the road and shoulder elevation that is covered with Graded Aggregate Base (GAB) and pavement. The shoulder would need to be modified and adjustments to the ditches should be done in conjunction with the road raising. Though not included in the cost estimate due to the unknown condition of the shoreline protection along portions of this area, any enhancements needed for the road protection should also be conducted. The estimated cost to implement this project is provided in Table 32.

Table 32 - Project 1.1: Road & Drainage Improvements				
Item	**Unit Quantity**	**Unit Size**	**Cost/Unit**	**Total Cost**
Bituminous Pavement	1,680	Tons	$145	$243,600
Graded Aggregate Base	1,475	CY	$75	$110,625
Compacted Fill	1,950	CY	$50	$97,500
Shoulder Modification	3,540	LF	$50	$177,000
Ditch Maintenance Event 1	4,550	LF	$15	$68,250
Ditch Maintenance Event 1	4,550	LF	$15	$68,250
Construction Subtotal				$765,225.00
25% Continency				$191,306
20% Design, Permitting & Construction Management				$153,045
Total				**$1,109,576.25**

**Cost per 2022 dollars*

The concept plan for this project is provided in Figure 52.

7.1.2. Village District Shoreline Protection

The next project proposed as part of the Implementation Plan is to add shoreline protection along the areas of the Village District that are currently unprotected. The living shoreline technique discussed in Section 5.4.1 is proposed for the majority of the length except in the areas nearest the road where a revetment is proposed. Because this area has experienced some of the highest erosion rates on the island, the proposed solution extends the shoreline out to reclaim some of the recently eroded land to provide a larger buffer from the coastal resiliency stressors as well as provide a larger marsh habitat area. The seaward limit of the breakwaters follows the 1972 shoreline, which is considered by the regulatory agencies to be the maximum permittable encroachment into tidal waters for restoration projects. If available funding does not cover the cost of the concept plan, the size of the living shoreline can be adjusted by moving the breakwaters closer to the shoreline and requiring less and sand fill and marsh plantings. A smaller living shoreline option will decrease the amount of habitat restored by will offer similar performance in shoreline protection.

The planning level cost estimate for implementing this project is provided in Table 33.

Table 33 - Project 1.2: Shoreline Protection				
Item	**Unit Quantity**	**Unit Size**	**Cost/Unit**	**Total Cost**
Breakwaters	7,450	LF	$400	$2,980,000
Sand Fill	110,000	CY	$65	$7,150,000
Vegetation	23	AC	$75,000	$1,725,000
			Construction Subtotal	$12,051,000.00
			25% Continency	$3,012,750
			20% Design, Permitting & Construction Management	$2,410,200
			Total	**$17,473,950.00**

**Cost per 2022 dollars*

The concept plan for this project is provided in Figure 52.

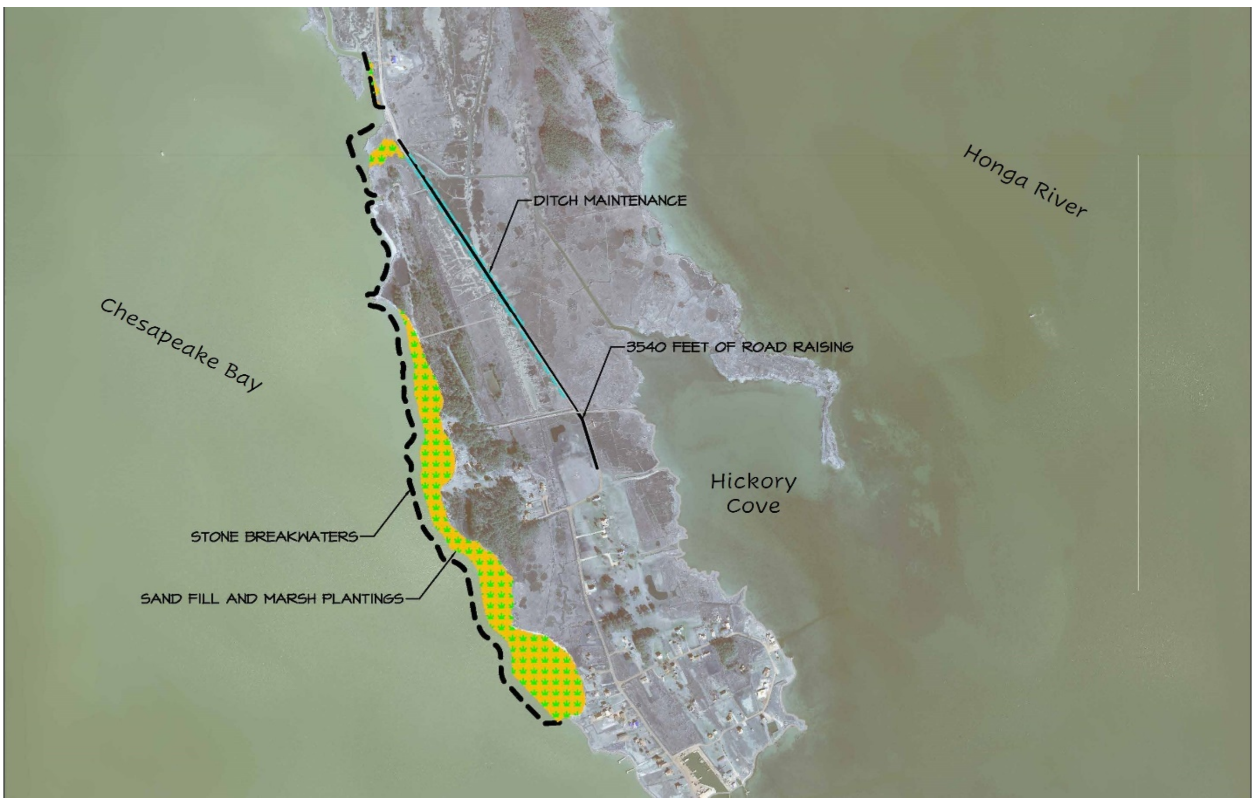

Figure 52 - Immediate Implementation Concept Plan

The proposed project depicts the engineering recommendation for this area. If funding limitations exist, at a minimum, the shoreline protection of stone sill and breakwaters should be implemented to reduce the erosion occurring along this area. The function of the shoreline protection is improved with additional sand fill and marsh. The sand fill and marsh also add habitat and water quality benefits.

7.1.1. Improvements to Infrastructure

With improvements to Hoopersville Road and shoreline protection being constructed along this area, it is also recommended that flood proofing of the homes and businesses, as described in 5.2.3, also be conducted for all properties within Hoopersville. The project improvements will be negotiated with each individual property owner for the approximate 147 parcels. For the purposes of this assessment, it is anticipated that improvements to the property cost approximately two-thirds of the 2021 assessment value of the property. Based on this assumption, the planning level cost for implementing this project is provided in Table 34.

Table 34 - Project 1.3: Property Improvements

Item	Unit Quantity	Unit Size	Cost/Unit	Total Cost
Property Improvements	147	1	$75,000	$11,025,000
			25% Continency	$2,756,250
			Total	**$13,781,250.00**

**Cost per 2022 dollars*

7.2. Short-Term Implementation

The Short-Term Action Plan includes projects that address areas not of immediate concern but will experience more significant and frequent impact in the near future. Engineering, design and permitting is recommended to begin so as to allow for complete project implementation in 5 to 10 years. The proposed projects are discussed in the following paragraphs.

7.2.1. Hoopersville Road Raising

The northern portion of Hoopersville Road that would require raising is approximately 6060 feet and averages elevations between +1.2 to +1.5 feet NAVD88. Given the higher elevations of this road, the option to raise the road to the 2050 MHW elevation of +2.4 feet NAVD88 can be conducted in one or multiple cycles depending on funding availability. Construction will be conducted for Option 1 – One Cycle and Option 2 – Multiple Cycles as described in Section 5.2.3 and Section 5.4.3, respectively. The planning level cost estimate to implement Option 1 to +2.4 feet NAVD88 and perform two ditch maintenance events is presented in Table 35.

Table 35 - Project 2.1: Northern Hoopersville Road Raising – Option 1				
Item	**Unit Quantity**	**Unit Size**	**Cost/Unit**	**Total Cost**
Bituminous Pavement	2,250	Tons	$145	$326,250
Graded Aggregate Base	2,000	CY	$75	$150,000
Compacted Fill	1,800	CY	$50	$90,000
Shoulder Modification	6,060	LF	$50	$303,000
Ditch Maintenance Event 1	4,560	LF	$15	$68,400
Ditch Maintenance Event 2	4,560	LF	$15	$68,400
Construction Subtotal				$937,650.00
25% Continency				$234,413
20% Design, Permitting & Construction Management				$187,530
Total				**$1,359,592.50**

**Cost per 2022 dollars*

In order to raise the road in phases, it is anticipated that three cycles will be required to reach the design elevation. A shoulder modification will need to be performed to maintain road stability and should be part of either the first or second cycle. The planning level cost estimate to raise the road in three cycles and perform two ditch maintenance events is presented in Table 36.

Table 36 - Project 2.1: Northern Hoopersville Road Raising – Option 2				
Item	**Unit Quantity**	**Unit Size**	**Cost/Unit**	**Total Cost**
Elevation Event 1				
Bituminous Pavement	2,250	Tons	$145	$326,250
Ditch Maintenance Event 1	4,560	LF	$15	$68,400
Elevation Event 2				
Bituminous Pavement	2,250	Tons	$145	$326,250
Shoulder Modification	6,060	LF	$50	$303,000
Elevation Event 3				
Bituminous Pavement	2,250	Tons	$145	$326,250
Ditch Maintenance Event 2	4,560	LF	$15	$68,400
Construction Subtotal				$1,418,550.00
25% Continency				$354,638
20% Design, Permitting & Construction Management				$283,710
Total				**$2,056,898.00**

**Cost per 2022 dollars*

This option will allow for the road and drainage improvements to be conducted in three phases between $500,000 to $1,000,000 dollars each.

7.2.2. Nourishment of Western Shoreline Coastal Marshes

The next proposed project is to provide marsh nourishment to the marshes along western shoreline of the island. The area includes the marshes in the Northwest Marsh and Village District. These areas have experienced the most significant erosion and are at the greatest risk of continued erosion and marsh drowning. The proposed project includes beneficially using dredged material in order to take advantage of an available resource as well as achieve multiple benefits from project construction. This project would allocate dredged material to create, restore and preserve habitat as well as act as a placement site for local dredging projects. An additional benefit for beneficially using dredged material is that construction cost can be shared with local dredging programs. The planning level cost to implement this project is presented in Table 37.

The concept plan for this project is provided in Figure 53.

Table 37 - Project 2.2: Raise Marsh Area along Western Shoreline

Item	Unit Quantity	Unit Size	Cost/Unit	Total Cost
Temporary Containment	8,500	LF	$20	$170,000
Marsh Fill	350,000	CY	$65	$22,750,000
			Construction Subtotal	$22,920,000
			25% Continency	$5,730,000
			20% Design, Permitting & Construction Management	$4,584,000
			Total	**$33,234,000.00**

**Cost per 2022 dollars*

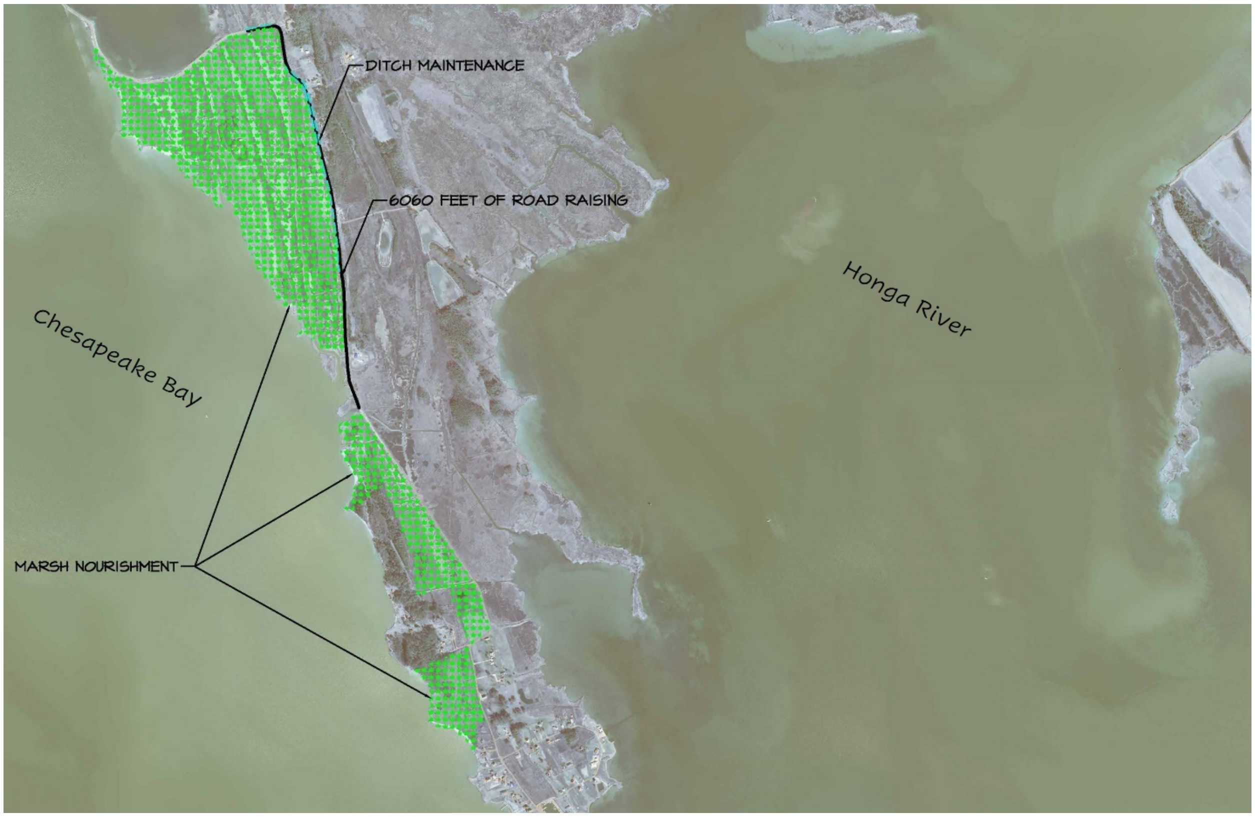

Figure 53 - Short Term Implementation Concept Plan

7.3. Long-Term Implementation

Long-term implementation refers to projects that can be completed in +10 years in order to prepare the community for 2050 conditions.

7.3.1. Hoopersville Road Raising

The final stretch of Hoopersville Road that needs to be raised to +2.4 feet NAVD88 is located along the southern extents of the road. The average elevation of the approximate 2,700 feet of road is +1.5 feet NAVD88, requiring less than one foot to bring it to +2.4 feet NAVD88. Table 38 presents the planning level cost for raising the road in one cycle.

Table 38 - Project 3.1: Southern Hoopersville Road Raising – Option 1				
Item	**Unit Quantity**	**Unit Size**	**Cost/Unit**	**Total Cost**
Bituminous Pavement	1,400	Tons	$145	$203,000
Graded Aggregate Base	1,250	CY	$75	$93,750
Compacted Fill	1,050	CY	$50	$52,500
Shoulder Modification	2,700	LF	$50	$135,000
Ditch Maintenance Event 1	6,260	LF	$15	$93,900
Ditch Maintenance Event 2	6,260	LF	$15	$93,900
			Construction Subtotal	$672,050.00
			25% Continency	$168,013
			20% Design, Permitting & Construction Management	$134,410
			Total	**$974,472.50**

**Cost per 2022 dollars*

Even though the average elevation change is less than one foot, it is anticipated that three cycles will be needed if Option 2 is applied. Ditch maintenance events are included at the first and third cycle while the shoulder modification occurs during the second phase. The planning level cost estimate for this road raising is presented in Table 39.

Table 39 - Project 3.1: Southern Hoopersville Road Raising – Option 2				
Item	**Unit Quantity**	**Unit Size**	**Cost/Unit**	**Total Cost**
Road Raising Event 1				
Bituminous Pavement	1,400	Tons	$145	$203,000
Ditch Maintenance Event 1	6,260	LF	$15	$93,900
Road Raising Event 2				
Bituminous Pavement	1,400	Tons	$145	$203,000
Shoulder Modification	2,700	LF	$50	$135,000
Road Raising Event 3				
Bituminous Pavement	1,100	Tons	$145	$159,500
Ditch Maintenance Event 2	6,260	LF	$15	$93,900
			Construction Subtotal	$888,300.00
			25% Continency	$222,075
			20% Design, Permitting & Construction Management	$177,660
			Total	**$1,288,035.00**

**Cost per 2022 dollars*

It should be noted that the end of the road raising terminates just after the Hoopersville Memorial Church as the last stretch of road is above the 2050 MHW level except for the last 1000 feet. This portion of road does not lead to any additional infrastructure, so it was left out of the Implementation Plan.

7.3.2. Nourishment of Eastern Marshes

The short-term project for raising the elevation of the coastal marshes focuses on the more vulnerable marshes along the western shoreline of Hoopersville. The coastal marshes along the eastern shoreline are not experiencing the same rate of erosion and do not act as a buffer against waves traveling across the Chesapeake Bay. However, the elevation of these marshes puts them at risk of marsh drowning when considering 2050 SLR projections.

To combat the impacts from high tides and storm surge, the marsh area along the eastern shoreline of the island is proposed to be raised to +1.9 feet NAVD88. Similar to the western marshes, the project proposes to use dredged material pumped through Thin Layer Placement. The large area of the marsh to be raised will require a significant quantity of material to elevate the marsh even the few inches required. Therefore, it is anticipated that this nourishment will be done over the course of several decades. The planning level cost estimate is provided in Table 40.

Table 40 - Project 3.2: Raise Eastern Marsh Area

Item	Unit Quantity	Unit Size	Cost/Unit	Total Cost
Temporary Containment	43,500	LF	$20	$870,000
Marsh Fill	730,000	CY	$65	$47,450,000
			Construction Subtotal	$48,320,000
			25% Continency	$12,080,000
			20% Design, Permitting & Construction Management	$9,664,000
			Total	**$70,064,000.00**

**Cost per 2022 dollars*

7.3.3. Northwest Marsh Shoreline Protection

The final component of the long-term implementation plan is to add shoreline protection along the upper Northwest Marsh shoreline. The shoreline protection shall be a living shoreline similar to the project constructed during the Immediate Implementation. Breakwaters shall be constructed offshore with sand fill and marsh plantings placed along the existing shoreline to optimize the effectiveness of the shoreline protection.

For the purposes of this study, the outer edge of the breakwaters follows the 1972 shoreline as this is considered the farthest extent into tidal waters where restoration action is permittable. Once this project advances into the design phase, adjustments can be made to the size of the living shoreline to better fit within budgetary constraints.

The planning level cost for implementation of this shoreline protection project is provided in Table 41.

Table 41 - Project 3.3: Shoreline Protection				
Item	**Unit Quantity**	**Unit Size**	**Cost/Unit**	**Total Cost**
Breakwaters	5,800	LF	$400	$2,320,000
Sand Fill	54,000	CY	$65	$3,510,000
Vegetation	12	AC	$75,000	$900,000
			Construction Subtotal	$6,730,000.00
			25% Continency	$1,682,500
			20% Design, Permitting & Construction Management	$1,346,000
			Total	**$9,758,500.00**

**Cost per 2022 dollars*

A graphical representation of all three Long Term Implementation projects is provided in Figure 54.

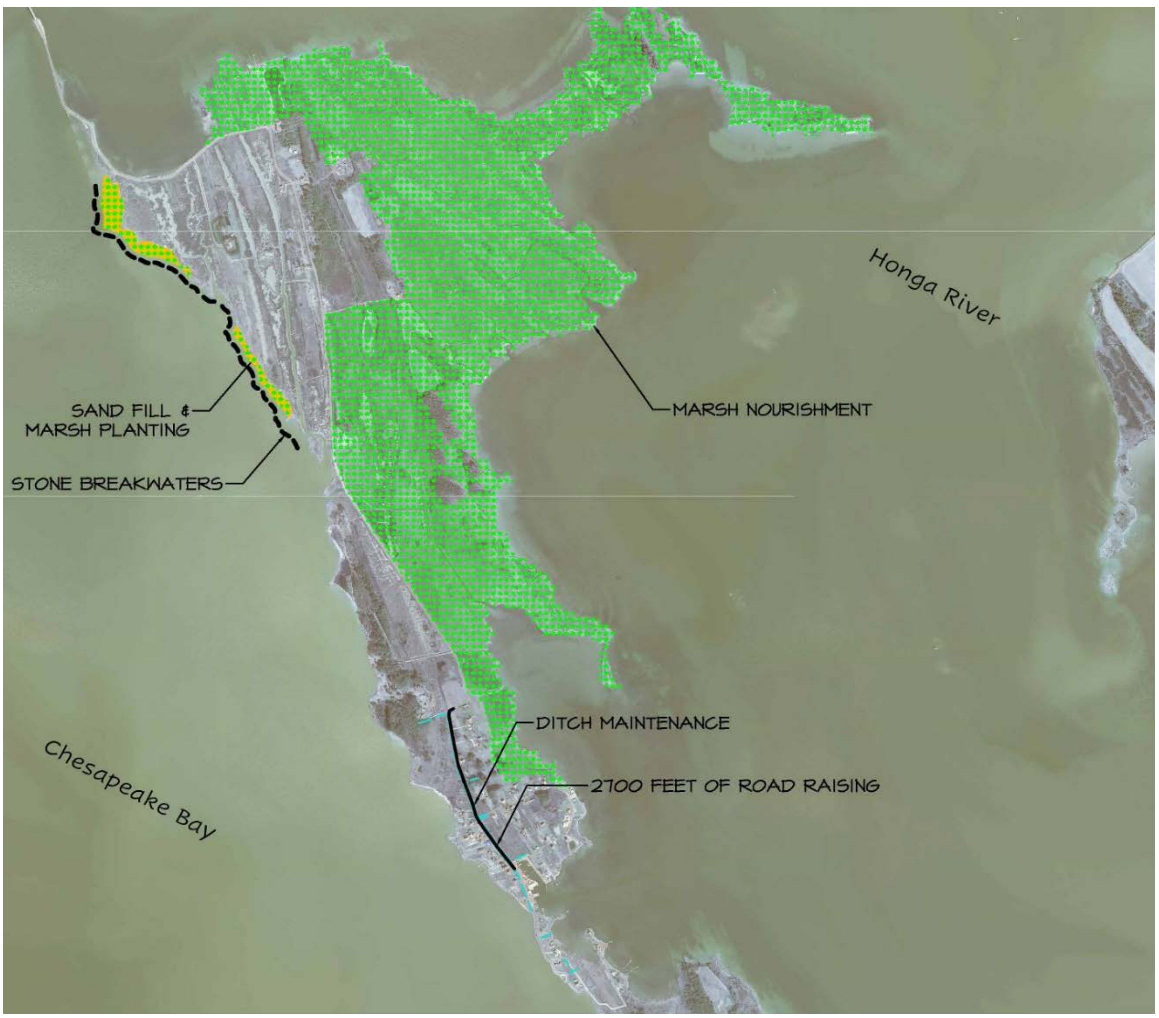

Figure 54 - Long Term Implementation Concept Plan

7.4. Future Action

The Implementation Plan presented in the previous sections is intended to outline action to be taken by 2050. Even though the Southern Marsh was included as an Assessment Area, the analysis showed that it is generally at a higher elevation than the remainder of the coastal marshes. Less than 5% of the existing marsh will be converted to open water by 2050. Erosion rates here are also less than other marshes exposed to the Chesapeake Bay. Additionally, no infrastructure is located in this area, so the marsh is not serving the additional purpose of providing protection against coastal resiliency stressors. The forested area within the marsh is located at the highest elevation on the island. For these reasons, it was decided that efforts should be focused on restoring the protecting the other more vulnerable Assessment Areas prior to 2050. However, the preferred alternative for the coastal marshes of providing shoreline protection through a living shoreline and using dredged material to increase the elevation of the marsh apply to the Southern Marsh as well.