DEALE-SHADY SIDE PENINSULA FLOOD RISK REDUCTION FEASIBILITY STUDY

AUGUST 2025

Prepared by:

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"Integrating Engineering and Environment"

In Partnership With:

Anne Arundel County Bureau of Watershed Protection & Restoration

RESILIENCE AUTHORITY
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ACKNOWLEDGEMENTS

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BayLand would like to thank all community members, stakeholder groups, and local leaders who participated in this planning effort, particularly residents of Deale, Shady Side, Churchton, and West River who contributed critical local knowledge through focus groups, site visits, and public meetings.

Their input, along with technical guidance from agency partners, shaped the study's findings and helped identify feasible, community-driven mitigation strategies for the Deale–Shady Side Peninsula.

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ACRONYMS

AACo	Anne Arundel County
BFE	Base Flood Elevation
BMP	Best Management Practice
BEACON	Business Economic and Community Outreach Network
CYC	Chesapeake Yacht Club
CSRM	Coastal Storm Risk Management
CBCIA	Columbia Beach Citizens Improvement Association
CDBG	Community Development Block Grant
CRS	Community Rating System
DOEE	Department of Energy and Environment
DNR	Department of Natural Resources
DPW	Department of Public Works
DEM	Digital Elevation Model
EMS	Emergency Medical Services
EPA	Environmental Protection Agency
EVA	Extreme Value Analysis
FEMA	Federal Emergency Management Agency
FMA	Flood Mitigation Assistance
GDB	Geodatabase
GIS	Geographic Information System
HMGP	Hazard Mitigation Grant Program
HMP	Hazard Mitigation Plan
HSG	Hydrologic Soil Group
ICC	Increased Cost of Compliance
LIDAR	Light Detection and Ranging
MDEM	Maryland Department of Emergency Management
MDE	Maryland Department of the Environment
MHW	Mean High Water
MHHW	Mean Higher High Water
MLW	Mean Low Water
MLLW	Mean Lower Low Water
MSL	Mean Sea Level
MCDA	Multi-Criteria Decision Analysis
NFWF	National Fish and Wildlife Foundation
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NAVD88	North American Vertical Datum of 1988
OEM	Office of Emergency Management
RCN	Runoff Curve Number
RVA	Roadway Vulnerability Assessment
SLR	Sea Level Rise
SCS	Soil Conservation Service

SCBD	Special Community Benefit District
SHA	State Highway Administration
SWMM	Storm Water Management Model
TR	Technical Release
Tc	Time of Concentration
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture

EXECUTIVE SUMMARY

The Deale-Shady Side Peninsula, located in southern Anne Arundel County (AACo), Maryland, is a low-lying coastal region facing escalating flood risks from sea level rise (SLR), storm surge, and more frequent and intense rainfall. Comprising over a dozen distinct communities, the Peninsula is bordered by the Chesapeake Bay to the east and south, and several tidal tributaries including Rockhold Creek and West River. These natural features, combined with extensive low-elevation development and limited egress, make the area particularly vulnerable to both chronic and acute flooding impacts.

This report provides a detailed analysis of flood exposure across the Peninsula, incorporating stormwater modeling, SLR projections, erosion vulnerability, and community-scale infrastructure assessments. The study includes in-depth field assessments, GIS-based flood modeling, and community engagement to ground the findings in local conditions. Vulnerability was evaluated across five major contributors to flood resiliency: SLR, storm surge, stormwater runoff, erosion, and road access disruption. The results indicate that many neighborhoods, such as Columbia Beach, Cedarhurst, Owings Beach, and others, are already experiencing regular flooding that is projected to worsen significantly by mid-century without intervention.

Based on this vulnerability analysis, a suite of flood mitigation strategies was developed. These strategies include nature-based solutions such as living shorelines, infrastructure upgrades like stormwater system retrofits and road raising, as well as land acquisition and community engagement frameworks. Case studies from across the Chesapeake Bay and beyond were reviewed to support locally appropriate, scalable solutions.

The recommended mitigation strategies were translated into an actionable implementation plan, categorized by scale and timeframe. This plan considers not only technical feasibility and flood reduction potential but also community priorities and the potential for co-benefits, such as ecological uplift and recreational value.

The following table presents the list of proposed projects for the Deale–Shady Side Peninsula, along with planning-level cost estimates to guide future funding, phasing, and implementation. This cost framework supports the County and its partners in advancing resilience investments that target the most vulnerable areas first while laying the foundation for long-term adaptation across the entire peninsula. These proposed projects are not guaranteed commitments by AACo, but represent potential strategies to inform planning discussions, identify actionable solutions, and support future funding opportunities in partnership with local, state, and federal entities.

PROPOSED PROJECTS		
Priority	**Project**	**Estimated Cost**
1	West Shady Side Road Raising and SWM Improvements	$763,900
2	Columbia Beach Road Raising and SWM Improvements	$2,700,000
3	Cedarhurst/Snug Harbor Resiliency Project	$11,852,200
4	Franklin Manor Resiliency Project	$10,560,920
5	Ongoing Resilience Improvement Fund	$550,000 – $1,000,000*
6	Owings Beach Flood Mitigation	$1,162,000
7	Chalk Point Road Raising and Shoreline Protection	$1,951,200
8	Avalon Shores Road Raising and Compound Flood Improvements	$1,177,840
9	Home Raising Assistance Program	$250,000 – $450,000*

*Costs reflect estimated annual cost in 2025 dollars.

1 INTRODUCTION

1. INTRODUCTION

Anne Arundel County, located along the western shore of the Chesapeake Bay just south of Baltimore, Maryland, features over 530 miles of coastline, making it highly susceptible to SLR, storm surge, and tidal flooding. The County's extensive shoreline, combined with its network of tributaries, supports a thriving culture of water-based activities such as commercial and recreational fishing, boating, and kayaking. Additionally, the region hosts vital coastal habitats, including wetlands and critical spawning grounds for marine species, all of which depend on a healthy bay and resilient shorelines.

However, the realities of rising sea levels and a changing climate have begun to reshape the daily lives of the County's inhabitants, threatening not only their homes and infrastructure but also the natural landscapes and activities that define the region. Recent studies highlight the need for robust flood mitigation strategies to protect both the community and its environment.

Figure 1 – Project Area of Interest

In January of 2024, the Anne Arundel County Department of Public Works (DPW) tasked BayLand Consultants & Designers, Inc. (BayLand) with assessing the vulnerability of the Deale-Shady Side Peninsula and determining cost-effective, feasible mitigation strategies to enhance its resilience challenges against flooding and coastal impacts associated with SLR and increased storm frequency and intensity. The study area covers approximately 13 square miles in the southeastern portion of the County along the Chesapeake Bay and West River, encompassing all of Shady Side and Churchton and parts of West River and Deale (Figure 1).

1.1. Integration with County Planning Initiatives

This study builds upon prior County efforts, including the AACo Hazard Mitigation Plan (HMP)[1] and the Sea Level Rise Strategic Plan[2], integrating key findings into actionable solutions for the Deale-Shady Side Peninsula.

AACo has prioritized resilience planning through multiple initiatives. Plan2040[3], the County's General Development Plan, explicitly calls for integrating climate resilience into water infrastructure, roads, zoning, and land use decisions. This study directly supports Goal BE16.1 of Plan2040[3], which mandates incorporating SLR considerations across all County functions, including transportation and capital improvement projects.

Additionally, the County has committed to developing Region Plans, including Region 9, which covers Deale, Shady Side, Churchton, and West River (Figure 2). The findings of this study will inform land use and infrastructure planning efforts by identifying the high-risk flood areas, evaluating mitigation options, and proposing cost-effective resilience strategies.

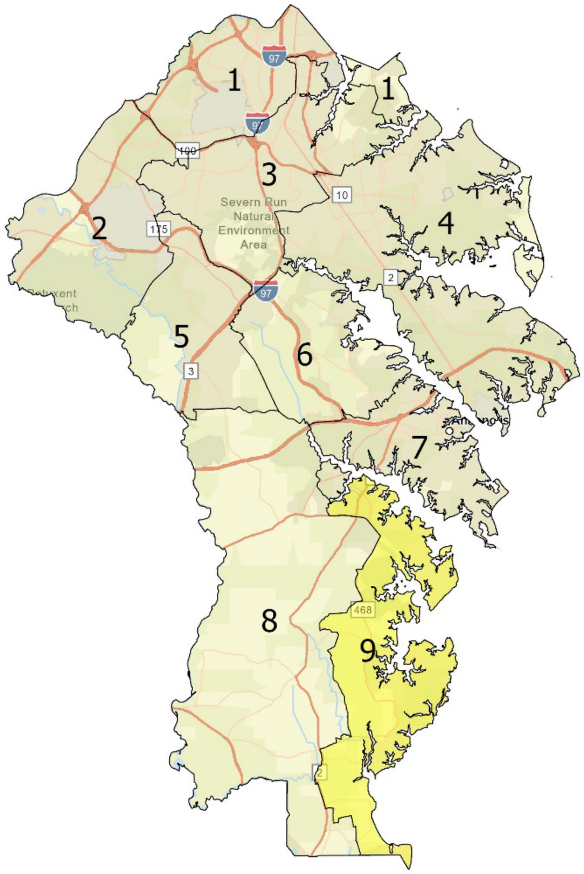

Figure 2 – Anne Arundel County Region Planning Area Map Highlighting Region 9

This study also complements the 2025 AACo Roadway Vulnerability Assessment (RVA)[4], a concurrent County effort which evaluated climate risks to County-maintained roadways from SLR, storm surge, and precipitation-based flooding. While developed through distinct methodologies, each effort contributes to a shared understanding of flood risk and reinforces consistent vulnerability patterns across the Deale–Shady Side Peninsula. Both studies emphasize the risk to critical access routes and highlight the need for proactive adaptation. Findings from this study can help inform the application of the County's adaptation prioritization framework in Region 9 and beyond. Coordination between these efforts will support consistent, scalable strategies for improving infrastructure resilience county-wide.

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[1] Anne Arundel County Office of Emergency Management. 2018 Hazard Mitigation Plan Update. Anne Arundel County, Maryland, June 15, 2020.

[2] Anne Arundel County. Sea Level Rise Strategic Plan Update. Revised August 2023. Prepared by Maryland Environmental Services, Michael Baker International, and Smith Planning & Design under award number NA21NOS4190153 from NOAA.

[3] Anne Arundel County. Plan2040: Anne Arundel County General Development Plan. Adopted May 3, 2021.

[4] Anne Arundel County Department of Public Works. "Roadway Vulnerability Assessment." Anne Arundel County Government, https://www.aacounty.org/public-works/highways/roadway-vulnerability-assessment.

1.2. Vulnerability and Flood Risk

The Deale-Shady Side Peninsula is a low-lying coastal area with an average elevation of less than eight feet above sea level. It contains approximately 4,700 residential units, with 550 properties located within the FEMA-designated 100-year floodplain. Additionally, from 1977 to 2017, 557 National Flood Insurance Program (NFIP) flood claims were filed in the area, with 13 properties experiencing repetitive losses. In addition to immediate threats to life and property, future projections suggest worsening conditions as flood durations are expected to increase, disrupting community access to critical services and transportation networks.

A Maryland State Highway Administration & Salisbury University Climate Change Vulnerability Assessment[5] found that in a storm surge event similar to Hurricane Florence (2018), nearly 100% of the study area would be inundated. Furthermore, by 2050, a significant portion of the Peninsula is expected to experience annual flooding, impacting not only the floodplain properties but also critical roads, emergency services, and transportation networks.

Drawing from other key plans like the 2023 Maryland Sea-Level Rise Projections[6], the County's updated Sea Level Rise Strategic Plan[2], and the Maryland Historical Trust's Flood Mitigation Guide[7], this effort seeks to craft strategies that protect critical infrastructure, homes, and the natural environment. Subsequent sections discuss the HMP and Sea Level Rise Strategic Plan in more detail.

1.2.1. AACo Hazard Mitigation Plan (HMP) (2018)

In 2018, in compliance with the Disaster Mitigation Act of 2000, AACo released an updated HMP, developed by a Hazard Mitigation Planning Committee composed of key County officials from emergency management, planning and zoning, public works, and other departments. Stakeholders from various sectors were also engaged due to their vested interest in potential mitigation projects and strategies. This plan builds upon the 2012 HMP, incorporating more refined risk assessments, prioritization of hazards, and actionable mitigation goals.

The HMP provides a comprehensive evaluation of AACo's vulnerabilities across multiple hazard types, including riverine and coastal flooding, hurricanes, tornadoes, winter storms, drought, and erosion. Flooding was identified as the highest-priority hazard, largely due to the County's extensive shoreline and the frequency and severity of its historical impacts. The plan emphasizes the increasing frequency and intensity of

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[5] Maryland State Highway Administration & Salisbury University. Maryland State Highway Administration Climate Change Vulnerability Assessment. June 2019.
[6] University of Maryland Center for Environmental Science (UMCES), Sea-Level Rise Projections for Maryland: 2023 Update, Cambridge, MD: Maryland Commission on Climate Change, 2023.
[7] Maryland Historical Trust. Flood Mitigation Guide: Maryland's Historic Buildings. June 2018. Prepared by Dominique M. Hawkins, Preservation Design Partnership, LLC.

flood events, highlighting that both riverine and coastal flooding will likely continue to pose a growing threat in the coming years.

The HMP outlines a series of mitigation strategies aimed at protecting human life, property, and critical infrastructure. These strategies include elevating repeatedly flooded structures, promoting public awareness and education, assessing the hazard resistance of existing structures, and developing comprehensive response plans for multi-hazard emergencies. The plan also delves into the County's participation in the NFIP, details flood claims history, and identifies repetitive loss properties, laying the groundwork for more targeted assessments and actions.

The findings and strategies from the HMP initiated more focused efforts, such as the current detailed assessment of the Deale-Shady Side Peninsula. By prioritizing flood risks in highly vulnerable areas, the HMP helped direct resources and attention to communities like the Peninsula, where rising sea levels and frequent flooding demand targeted mitigation measures to enhance resilience.

1.2.2. AACo Sea Level Rise Strategic Plan Update (2023)

In 2023, AACo developed the Sea Level Rise Strategic Plan to address the growing impacts of SLR using the latest projections from the Maryland Commission on Climate Change, the University of Maryland Center for Environmental Science, and NOAA studies. The Plan is divided into three phases: Phase 1 focuses on a Vulnerability and Risk Assessment, Phase 2 explores the feasibility of potential actions, and Phase 3 focuses on implementing priority actions. The current work on the Deale-Shady Side Peninsula falls under Phase 2 as part of a broader feasibility study on adaptive strategies.

Phase 1 of the Plan provided updated spatial models and a comprehensive assessment of the County's vulnerability to relative SLR, integrating these insights with current planning efforts. A detailed case study was conducted for Region 9 (Figure 2), which includes the southern part of the county and vulnerable communities such as Edgewater, Mayo, West River, Shady Side, and Deale.

The Plan also emphasized that the critical infrastructure within this region, including roads, utilities, and emergency services, is at heightened risk. These vulnerabilities threaten not only the safety of residents but also the continuity of essential services. Furthermore, the Plan highlighted the rapid erosion of the shoreline and the loss of wetlands, both of which jeopardize the local ecosystem and critical habitats. The degradation of natural buffers further compounds the flood risks, accelerating habitat loss and undermining the resilience of the entire region.

Given these projections and vulnerabilities, the Sea Level Rise Strategic Plan identified the Deale-Shady Side Peninsula as a critical zone for focused intervention. The study of this area is driven by the need for adaptive strategies tailored to its specific geographic and environmental conditions, ensuring that both the community and its infrastructure can withstand future SLR and storm events.

An overview of the risk assessment and access to the full report is available via the Office of Planning & Zoning's Sea Level Rise webpage.

1.3. Study Approach

The study approach for this project involves several key tasks aimed at assessing and mitigating flood risks on the Deale-Shady Side Peninsula (Figure 3). Representatives from the County and BayLand coordinated efforts to share data, engage the community, and collaborate on potential solutions. The project team attended community events such as AACo's River Days events and hosted community engagement meetings to provide residents with opportunities to express their concerns and discuss favorable improvements for the Peninsula. Geospatial data, including topography, SLR, and flood inundation patterns were used to inform a comprehensive conditions assessment of the current and future flood risks, supplemented by site visits and community input.

A review of case studies from other coastal communities was conducted to highlight successful mitigation strategies such as green infrastructure, natural dunes and berms, raised structures, and property buyout programs. These case studies were analyzed for their relevance to the Peninsula's specific conditions.

The study identified priority areas on the Deale-Shady Side Peninsula through incorporating both local concerns and technical data. Once priority areas were established, the project assessed the best strategies for enhancing resilience. This analysis evaluated options based on feasibility, urgency, and benefits to determine the most effective mitigation approaches.

Finally, this comprehensive report develops an Implementation Plan that outlines cost-effective, feasible, concept-level projects from grouped mitigation strategies.

Figure 3 – Six Key Project Phases

2

DATA COLLECTION & EXISTING CONDITIONS

2. DATA COLLECTION & EXISTING CONDITIONS ASSESSMENT

The existing conditions assessment serves as a critical foundation for identifying vulnerabilities and assessing potential flood mitigation strategies on the Deale-Shady Side Peninsula. This chapter details the data collection process, including geospatial and environmental datasets, field assessments, and community engagement, which informed the study's analysis. These efforts ensured a comprehensive understanding of current risks and challenges while integrating local knowledge and technical data.

2.1. Data Collection Approach

A combination of desktop analysis, field assessments, and community engagement was utilized to evaluate current and projected flood conditions. The study leveraged key datasets and methodologies to establish a data-driven basis for identifying high-risk areas and formulating mitigation strategies.

2.1.1. Desktop Analysis

The following infographic summarizes the key datasets and findings from the desktop analysis. It visually presents topographic data, flood risks assessments, critical infrastructure vulnerabilities, shoreline erosion features, stormwater infrastructure assessments, and insights gathered from community engagement. This provides a clear and accessible overview of the existing data that informed the study's approach.

For additional details on individual data layers, sources, and metadata, refer to Appendix A, which provides an expanded table of GIS data attributes, sources, and application in this assessment.

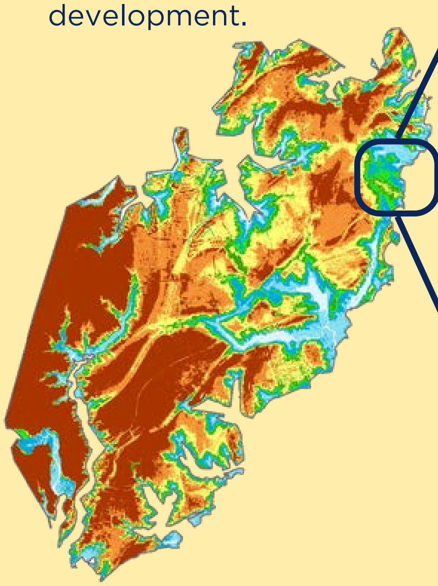
2.1.1 DESKTOP ANALYSIS

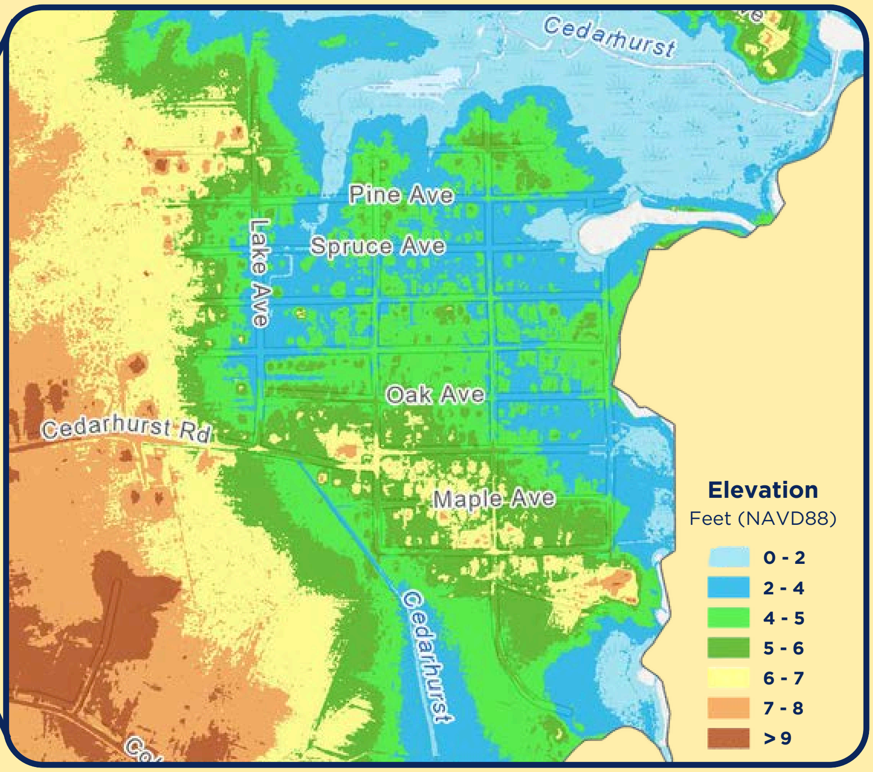
The desktop analysis involved reviewing and processing geospatial data from multiple sources. These layers were sourced from County GIS data and other relevant studies to inform the assessment of current and projected conditions.

TOPOGRAPHY & ELEVATION DATA

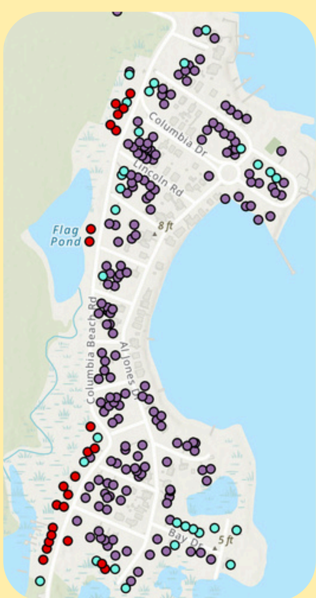
Source: Anne Arundel County GIS & 2020 LiDAR

Purpose: Identified low-lying areas to assess flood risks and guide concept development.





FLOOD RISK & INUNDATION LAYERS



Source: Anne Arundel County Vulnerability Analysis & Region 9 Data

Purpose: Showed increasing floodplain expansion, affecting critical infrastructure & roadways.

Buildings Inundated
- 2050
- 2065
- 2100

CRITICAL INFRASTRUCTURE & COMMUNITY ASSETS

Source: Region 9 Vulnerability Analysis

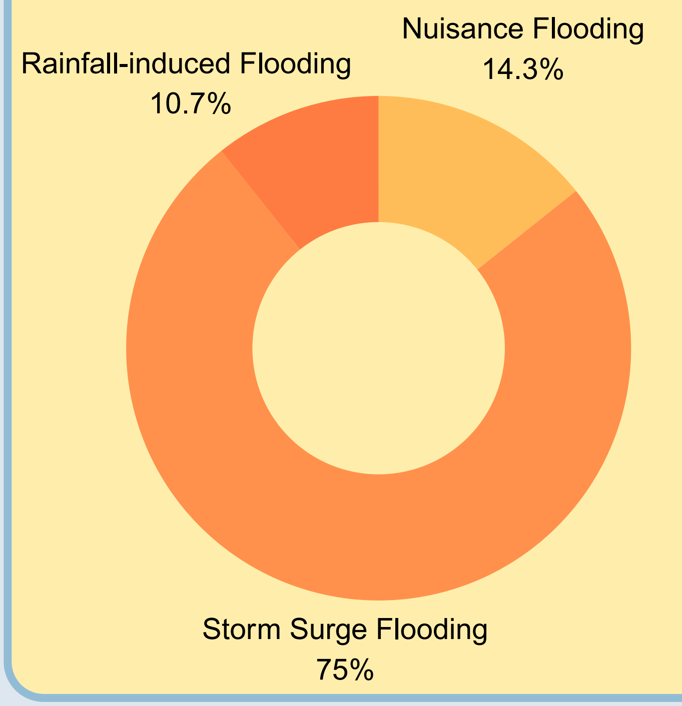
Purpose: Highlighted risks to hospitals, schools, roads, & emergency response stations due to flooding.

COMMUNITY ENGAGEMENT & SURVEY RESULTS

Source: Community meetings, MyCoast Maryland App, Resident Surveys (63 responses)

Purpose: Capture on-the-ground flood experiences & local priorities.

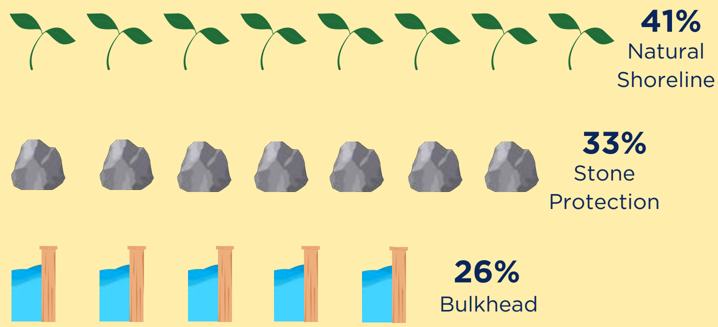
Flooding Concerns on the Peninsula



SHORELINE EROSION & PROTECTION FEATURES

Source: Region 9 Shoreline Erosion Analysis

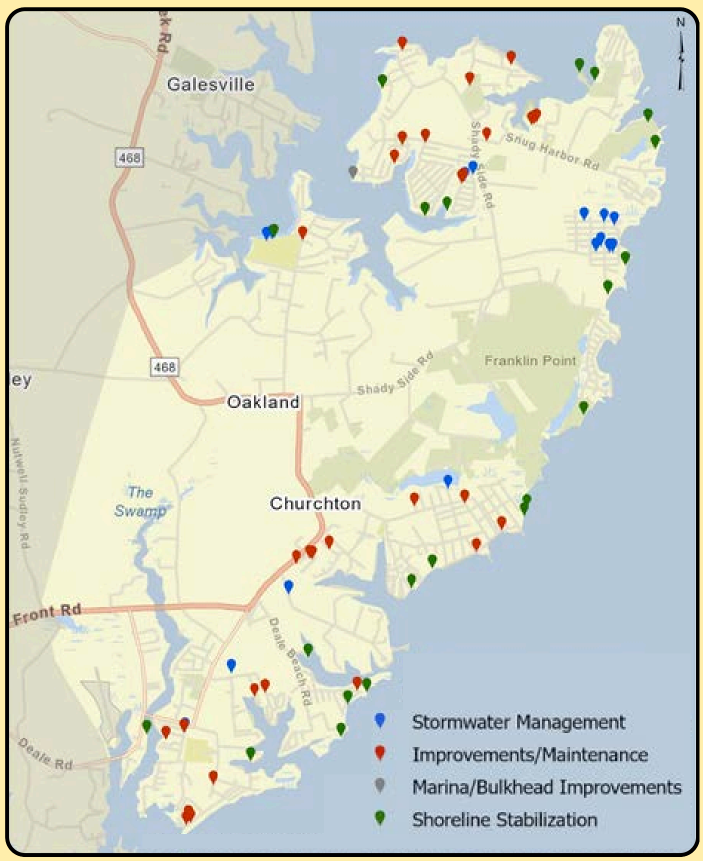
Purpose: Utilize mapped shoreline features and their condition to better understand compounding vulnerability.



RESTORATION PROJECTS

Source: Anne Arundel County

Purpose: Understand previous and ongoing restoration efforts on the Peninsula.



STORMWATER & INFRASTRUCTURE ANALYSIS

Source: Stormwater As-Built Records, Anne Arundel County GIS, Field Survey

Purpose: Evaluated drainage system capacity & pinpointed deficiencies contributing to flooding.

2.2. Community Engagement

The community engagement efforts on the Peninsula played a vital role in shaping the direction of the project. A dedicated landing page was created to inform residents about the study, provide updates, and distribute important resources, such as a flyer and community survey (Figure 4). The flyer encouraged residents to participate by documenting local flooding and storm damage using the MyCoast Maryland app, allowing the community to share valuable on-the-ground data. Additionally, the survey aimed to gather input on residents' concerns about flooding, identify priority areas, and solicit suggestions for potential solutions.

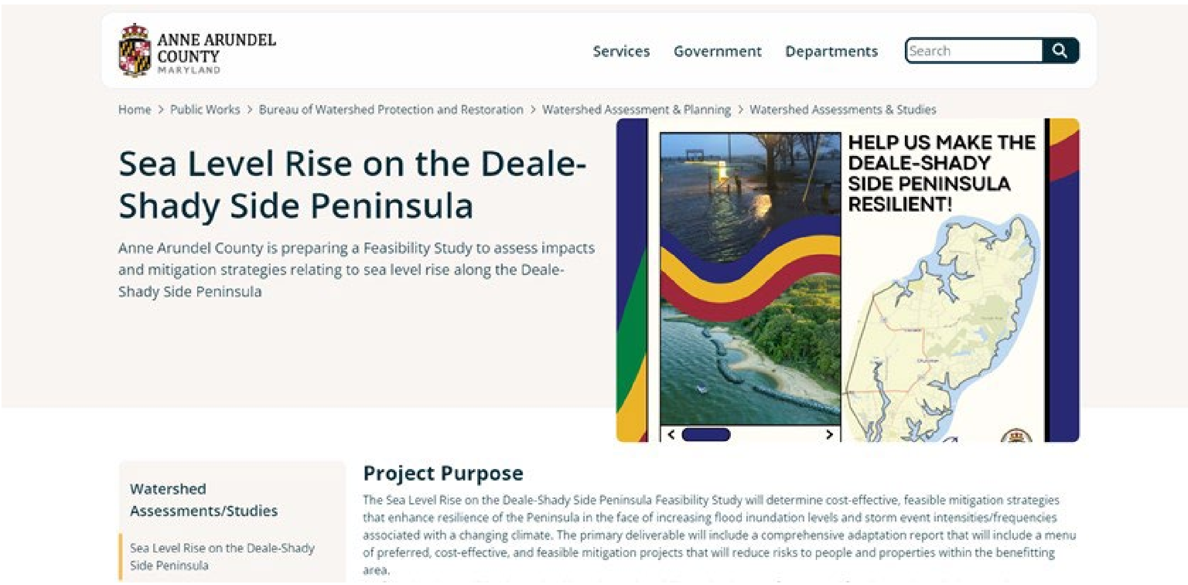


Figure 4 – Landing Page for Sea Level Rise on the Deale-Shady Side Peninsula Website

2.2.1. Community Meetings

The project team organized community meetings and attended local events, such as River Days, to engage directly with the public (Table 1). These events provided a platform for residents to voice their concerns, offer insights into the local impacts of rising water levels, and discuss possible mitigation measures. Focus groups were also held by request with some communities, ensuring that local knowledge was integrated into the study's technical analysis. The final public meeting was held to present the draft study findings, walk through the report's key results and recommended actions, and provide residents with an opportunity to ask questions and offer feedback before the report's finalization.

Table 1 – Community Outreach Events

Event	Date	Location
Open House Public Meeting #1	Wednesday, July 17, 2024	Deale Community Library
AACo River Days	Sunday, August 11, 2024	West River Center
Open House Public Meeting #2	Tuesday, August 13, 2024	Captain Avery Museum
Public Meeting #3	Tuesday, July 22, 2025	Deale Community Library

Photo 1

Photo 2

Photo 3

Photo 4

Photos 1 - 4 – County and BayLand representatives meeting with concerned residents during Open House Public Meeting #1 at the Deale Library on Wednesday, July 17, 2024.

2.2.2. Community Input Survey

The community input survey gathered community input on the local impacts of flooding and solicit input on potential mitigation strategies. The flyer encourages residents to document flooding using the Maryland MyCoast App and outlines ways to participate in the project via community survey. The survey asks respondents about their concerns regarding different types of flooding (nuisance flooding, storm surge, or rainfall-induced flooding) and provides space for them to identify specific areas of concern and suggest potential solutions the community would like to see implemented.

Surveys were collected from approximately 63 individuals via email, Google Forms, and written responses. The responses from the community survey indicate that residents across the Peninsula are primarily concerned with areas that experience frequent nuisance flooding or extreme damage during storm surge.

Figure 5 – Project infographic and community survey

Key areas mentioned include:

- Cedarhurst: Numerous respondents highlighted flooding at the marina and residential areas near Chesapeake Avenue, where high tides and storm surges frequently cause inundation. Residents note that some properties regularly flood under current conditions and maintenance issues, such as blocked drainage ditches, exacerbate the problem.

- Snug Harbor: Residents reported flooding during high tide events, particularly in community property fronted by the Bay.

- Avalon Shores: Concerns were raised regarding the low road elevations which make key travel routes impassable during high tides. Key areas include West Shady Side Road and other residential streets where high tides block access to and from the area.

- Franklin Manor: Flooding along Chesapeake Drive, particularly near the pier, was noted as a concern. Areas near Gloucester and Chesapeake Drive are low-lying and experience persistent flooding with some homes inundated more than three feet during storms.

- Broadwater Creek: Residents requested improvements to stormwater drainage systems and backwatering issues during high tides and emphasized extreme erosion along unprotected stretches of shoreline.

- Deale Beach: Residents are concerned about worsening flooding on Deale Beach Road that occasionally leaves residents stranded.

- Owings Beach: Alterations to flood protections along the Bay shoreline have exaggerated backwatering issues at the southern tip of the Peninsula.

Several recurring themes and suggestions arose from the surveys for solutions to mitigate flooding on the Peninsula:

- Living Shorelines and Natural Barriers: Many surveys expressed interest in living shorelines, which combine natural elements like native plants and oyster reefs with hard structures to control erosion and absorb wave energy. Several people also suggested planting native grasses and removing invasive species such as phragmites to improve marsh drainage and protect wildlife habitats.

- Flood Protection and Erosion Control: A popular mitigation solution from survey responses suggested building berms, breakwaters, or revetments to protect against coastal erosion and storm surges.

- Drainage System Improvements: Another prominent concern was improving the drainage systems throughout the Peninsula. Many residents reported standing water in roadside ditches, which contributes to flooding during storms and high tides. Several residents mentioned that ditches and culverts are often clogged due to overgrowth or debris, and the suggested solutions included better and more regular maintenance practices.

- Storm Surge and Tidal Flooding Solutions: Residents recommended a variety of flood control measures, such as tide gates to prevent tide water from backwatering through the drainage system.

- Community Engagement and Private Homeowner Support: Several residents expressed a desire for greater flexibility in allowing homeowners to implement their own flood protection measures, such as small-scale riprap or other landscaping solutions. They also advocated for incentive programs, such as tax incentives for installing flood mitigation features like living shorelines or raising homes. Additionally, residents requested community education and better access to information on flood preparedness and available resources.

- Road Elevation and Access: The need for raising roads in area where flooding regularly blocks access and emergency services, such as West Shady Side Road near St. Matthews Church, was also highlighted as a critical infrastructure need. Many responses noted that roads become impassable during storm surges, isolating residents and preventing emergency services from accessing certain areas. Road improvements are seen as essential to maintaining safe and reliable access to the broader community during flood events.

These survey responses provide crucial insight into the community’s priorities and concerns, offering a valuable perspective that complements coastal modeling and other vulnerability assessment efforts. The strong community interest in combining nature-based solutions, such as living shorelines and habitat restoration, with structural improvements like berms, drainage system upgrades, and road-raising projects underscores the need for a comprehensive approach to flood mitigation. Additionally, there is a clear need for better maintenance of existing infrastructure and increased community involvement through flexible policies and incentive programs for individual homeowners. By merging community-driven data with technical assessments, the concern areas and preferred flood mitigation strategies identified in the survey helped shape the existing conditions assessment, formulate solutions for the most vulnerable areas on the Peninsula, and develop programs to maintain infrastructure and ensure continued resiliency efforts.

2.2.3. MyCoast Maryland

The study encouraged residents to upload photos of flooding and storm damage to the MyCoast App, which uses these images to help identify problem areas in the community. The app allows users to document flooding, storms, and coastal storm damage, linking the photos to precipitation and tidal data to provide detailed reports. These reports assist government agencies and residents in understanding the impacts of flooding on their community. While the app provides valuable information, its main limitation is that it has only been in use since 2020 and is not yet widely adopted among Deale-Shady Side Peninsula residents.

2.3. Field Assessment

The field assessment phase of the project served to validate desktop analyses, assess on-the-ground vulnerabilities, and inform targeted flood mitigation strategies. By layering SLR inundation maps, elevation data, and critical infrastructure overlays with local knowledge, the team focused on the most at-risk areas. This iterative process enabled real-time integration of new vulnerabilities either identified through community input or observed flood impacts into the broader assessment and project development framework. Field evaluations included documenting indicators of flood impacts (e.g., road damage and standing water), inspecting stormwater and shoreline infrastructure conditions, and mapping critical elevations and flow patterns to support modeling efforts (Photo 5 and Photo 6).

Community engagement was essential in shaping the scope and priorities of the fieldwork. Local input highlighted areas not initially slated for assessment, allowing the team to identify specific problem points and understand how they influenced systemwide flood behavior. While the scale of the Peninsula posed a logistical challenge, efforts were made to ensure balanced coverage across the region without sacrificing detail. This study builds upon prior county-wide assessments by narrowing focus on the Peninsula's most critical vulnerabilities and infrastructure gaps, supporting refined strategies for flood protection and resilience.

Photo 5 – Surveying inlet elevation and location

Photo 6 – Surveying outfall invert and nearby marsh elevations

3

COASTAL FLOODING AND STORMWATER ANALYSIS

3. COASTAL AND STORMWATER ANALYSIS

Understanding the drivers of flooding on the Deale-Shady Side Peninsula is essential for evaluating existing vulnerabilities and determining appropriate flood mitigation strategies. This chapter presents an analysis of coastal flooding and stormwater-driven flooding, highlighting how SLR and storm surge exacerbate existing challenges.

While this study did not conduct original coastal flood modeling, it builds upon the analysis conducted in the Sea Level Rise Strategic Plan Update[2]. This foundational work provides critical insights into anticipated water levels under future climate scenarios and serves as the basis for identifying areas of concern and formulating targeted adaptation strategies.

3.1. Sources of Flooding

Flooding on the Peninsula occurs due to two primary mechanisms:

1. **Coastal Flooding Due to High Water Levels:** This occurs when coastal water levels rise above the adjacent land, leading to inundation. Two contributing factors were evaluated:

    - Sea Level Rise (SLR): Flooding caused by an increase in still water levels (excluding wave effects) due to climate change. As still water levels rise, areas that previously did not flood or only flooded during extreme high tides will experience inundation more frequently.

    - Storm Surge: Flooding caused by elevated water levels during storm events. Hurricanes and other intense storms generate low atmospheric pressure and high winds, which drive water toward the shoreline, raising water levels and resulting in coastal flooding.

2. **Flooding Due to Heavy Rainfall and Stormwater Limitations:** This occurs when intense or prolonged rainfall overwhelms the local drainage system. Unlike coastal flooding, this type of flooding is caused by precipitation rather than rising water levels. Contributing factors include:

    - High-Intensity Rainfall: Sudden, heavy rainstorms or “flash floods” can deliver large volumes of precipitation in a short time, exceeding the capacity of natural or built drainage systems.

    - Prolonged Rainfall: Extended periods of rain can saturate the ground and overwhelm stormwater infrastructure, resulting in localized flooding.

    - Combined Effects with SLR: Rising coastal water levels due to SLR may impair proper stormwater discharge, causing backwater effects in the drainage system. Additionally, climate change is expected to increase the intensity and frequency of rainfall events, further straining existing storm drain systems and increasing runoff volumes.

3.2. Coastal Water Levels and Flood Risk Projections

3.2.1. 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:** The 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:** The increase in the local sea level along a specific coast based on global SLR and land subsidence (sinking of land), tectonic plate movements and other local factors.

Based on water level measurements taken between 1928 and 2023 at the NOAA Tide Station 8575512 in Annapolis, Maryland, sea levels are approximated to have risen 1.25 feet in 100 years.

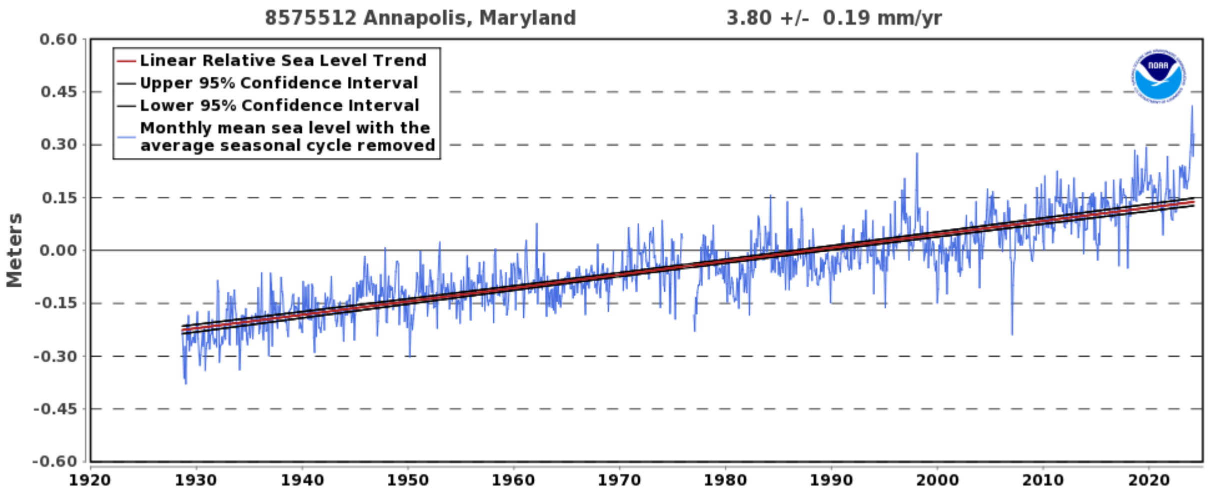


Figure 6 – SLR at Annapolis between 1928 and 2023[8]

The coastal water elevations are based on the tidal datums available from the NOAA-operated Tide Station 8575512 in Annapolis, MD (Table 2). The tidal datums presented in Table 2 are based on the 19-year tidal epoch occurring between 1983 and 2001 and are used to demonstrate typical water levels occurring at the project site during normal conditions.

[8] NOAA Tides and Currents Sea Level Trends citation

Table 2 – Tidal Datums at Station 8575512 Annapolis, MD	
Datum	**Water Elevation (ft NAVD88)**
Mean Higher High Water (MHHW)	+0.66
Mean High Water (MHW)	+0.42
North American Datum of 1988 (NAVD88)	**0.00**
Mean Sea Level (MSL)	-0.05
Mean Low Water (MLW)	-0.55
Mean Lower Low Water (MLLW)	-0.77

Flood mapping results from AACo's Sea Level Rise Strategic Plan Update[2] were used in this study. The full report documenting the methodology used can be found at the Office of Planning & Zoning's Sea Level Rise webpage. The three SLR scenarios are listed in Table 3, and maps showing flood depth and extents can be found in the SLR Strategic Plan Update.

Table 3 – SLR Estimates*	
Year	**SLR Projection (ft)**
2050	1.6
2065	2.54
2100	5.35

* Data provided by AACo (2023 Sea Level Rise Strategic Plan Update[2])

3.2.2. Storm Surge

Storm Surge is the abnormal rise of water, over and above the astronomical tides, generated by a low-pressure weather system. These occurrences can result in increases of water levels by several feet during the duration of a storm. High winds and waves as well as rainfall will often accompany these elevated water levels and cause significant flooding of coastal areas. The largest storm surge recorded by the tide gauge at Annapolis exceed five feet during Hurricane Isabel in 2003.

Though storm surge is often associated with extreme storm events, everyday meteorological occurrences such as wind and pressure will influence water levels. In general, tides are made up of an astronomical component and meteorological component. The astronomical component is highly regular and very predictable. Therefore, the meteorological component can be separated from the astronomical component by subtracting the predicted (astronomical) water levels from the measured water levels. This is referred to as the tidal residual. The tidal residual is the component of the tides that incorporates SLR and storm surge.

To determine the likelihood of large storm surge events occurring, an Extreme Value Analysis (EVA) was performed on the tidal residuals for the hourly water level measurement at the NOAA tide station in Annapolis. The estimated return period storm surge levels are presented in Table 4.

Table 4 – Return Period Storm Surge	
Return Period (yr)	**Storm Surge (ft)**
2	1.87
5	2.29
10	2.67
50	3.88
100	4.60

The total storm water level is determined by adding the storm surge to the appropriate tidal datum to determine the water level elevation during a storm event. Table 5 presents storm elevations for each return period under normal high tide conditions (MHW), comparing current conditions with projections for sea level rise in 2050 and 2065.

Table 5 – Return Period Storm Elevations			
Return Period (year)	**2000 MHW + Storm Surge (ft NAVD88)**	**2050 MHW + Storm Surge (ft NAVD88)**	**2065 MHW + Storm Surge (ft NAVD88)**
2	2.29	3.89	4.83
5	2.71	4.31	5.25
10	3.09	4.69	5.63
50	4.30	5.90	6.84
100	5.02	6.62	7.56

To contextualize, events like Hurricane Isabel (2003), which produce a storm surge exceeding five feet in Annapolis, Maryland, demonstrate the devastating potential of these occurrences. The statistical analysis shows that a 100-year storm surge could reach over five feet today and nearly 7.6 feet by 2065 when combined with SLR projections. Figure 7 illustrates storm water levels compared to tidal datums. For example, peak water elevations during Tropical Depression Debby (2024) were nearly 3.8 feet above NAVD88, or 3.35 feet above MHW.

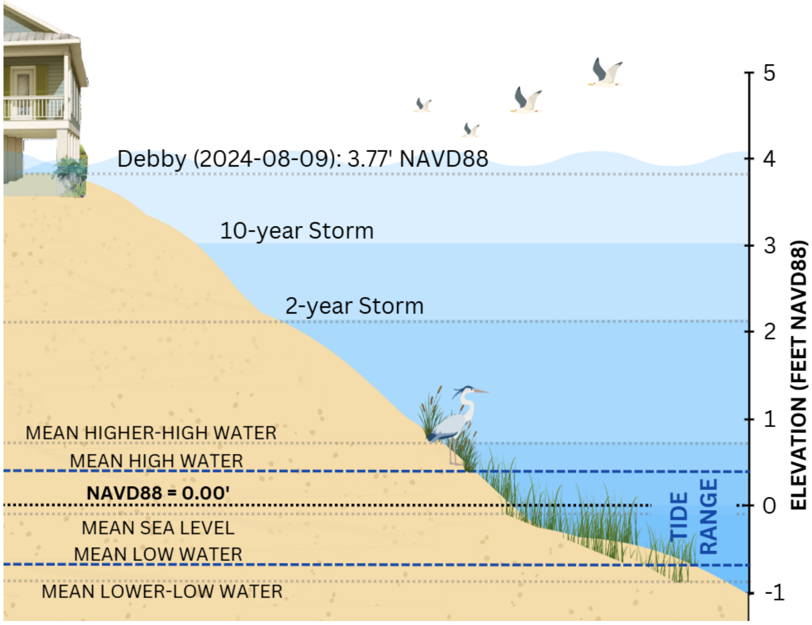


Figure 7 – Storm event water levels compared to datums at Station 8575512 Annapolis, MD

3.3. Stormwater Flooding Assessment

Coastal water levels along the Deale-Shady Side Peninsula during various future storm conditions listed in Table 5 were used to estimate the tailwater conditions occurring during peak discharges.

3.3.1. Hydrologic Analysis

Existing hydrologic parameters were determined using Natural Resources Conservation Service's (NRCS) Urban Hydrology for Small Watersheds methodology. Hydrologic parameters, such as time of concentration, were determined using the most recent AACo GIS topographic and planimetric data. Soils were determined using the United States Department of Agriculture (USDA) Web Soil Survey data. The land use matrix was broken down into the basic components of Open Space, Woods, and Impervious area.

Hydrologic Soil Classifications for the existing soils found in the drainage areas were obtained from a combination of AACo GIS and the USDA online soil survey website. Soils can be classified according to their run-off potential using NRCS Hydrologic Soil Classification, which characterizes the soils and their potential to generate runoff.

These categories range from Hydrologic Soil Group (HSG) A (low runoff, high infiltration) to HSG D (high runoff, low infiltration). The soils in the Peninsula are primarily HSG D soils, resulting in high amounts of runoff and low infiltration (Table 6). The soils within the modeled drainage areas all had a hydraulic soil grade rating of D. The corresponding runoff curve number (RCN) values were applied to the drainage areas of each study point. The full hydrologic analysis is located in Appendix B.

Table 6 – Soil Summary

HSG	Runoff Rate	Infiltration Rate	Percent of Drainage Area
A	Very Low	Very High	0.0
B	Low	High	0.0
C	High	Low	0.0
D	Very High	Very Low	100.0

The USDA Soil Conservation Service (SCS) Technical Release 55 (TR-55) computer program was used to compute the RCN and time of concentration (Tc) for the hydrologic runoff conditions. The RCN and Tc were developed from the land use, soils, and physiographic properties.

3.3.2. Hydraulic Modeling

A hydraulic analysis of the storm drain system was performed using the Storm Water Management Model (SWMM) version 5.2, developed by the Environmental Protection Agency (EPA) and PCSWMM, a 2-dimentional modeling tool that utilizes EPA SWMM 5 to model 1-dimentional drainage systems and 2-dimentional drainage areas. Data on the storm drain structures including size and elevation was obtained during field investigations. Where additional data was necessary for the model, interpolations were assumed based on nearby topographic and survey data.

To assess stormwater-related risk, this analysis utilized hydrologic and hydraulic modeling of 2-year, 10-year, and 100-year storm events to represent a range of flooding conditions from nuisance-level rainfall to extreme storm intensities. The 2-year event reflects routine, lower-intensity storms that frequently stress the existing drainage network, while the 10- and 100-year events provide insight into areas vulnerable to more severe and prolonged inundation. These models were enhanced by incorporating community-reported flooding hotspots, ensuring local knowledge informed both risk identification and model calibration.

Flood extents and durations were determined using 24-hour precipitation frequency estimates (Table 7) and 2050 SLR projections. Tidal cycles from the SLR analysis were used to establish tailwater conditions at system outfalls to the Chesapeake Bay, allowing for realistic interaction between rainfall-driven runoff and coastal backwatering during storm surge conditions.

Table 7 – Projected Storm Scenarios

Average Recurrence Period	Precipitation Estimate (IN)	MARISA Change Factor	Projected Precipitation (IN)
2-yr	3.22	1.08	3.48
10-yr	4.99	1.07	5.34
100-yr	8.62	1.11	9.57

The PCSWMM program is designed to analyze the depth and extent of flooding in an area using data collected about the existing topography and storm drain networks. The analysis calculates precipitation, stormwater runoff, flow paths over terrain, and the capacity of structures. The model results are important in evaluating how well storm drain systems function and identifying portions of the system with insufficient capacity.

Models were developed for existing and projected conditions for all storm scenarios. Storm scenarios were modeled with existing conditions to identify areas with poor drainage and high potential for flooding. This analysis was used along with field observations to identify areas of higher priority and propose the most effective stormwater practices. The stormwater systems within the surveyed drainage area were included in the model to measure their current ability to convey flow. Stormwater inlets, outfalls, and other conveyance systems were all included in the model. Data for the existing stormwater system including elevations, size, and location of features was used to develop the model, but several assumptions about underground system geometry and roof drainage were assumed. Complete model parameters can be found in Appendix C.

Table 8 – Hydraulic Analysis: Analyzed Storm Scenarios	
Storm Event	**Tailwater Elevation (ft NAVD88)**
2-yr	2050 Tidal Cycle
2-yr	2050 Tidal Cycle + Storm Surge
10-yr	2050 Tidal Cycle
10-yr	2050 Tidal Cycle + Storm Surge
100-yr	2050 Tidal Cycle
100-yr	2050 Tidal Cycle + Storm Surge

3.3.3. High Priority Assessment Areas

The results from model analysis were used to identify areas of particular concern regarding storm water runoff and conveyance. These areas currently experience flooding or are believed to be most susceptible to flooding caused primarily by storm water runoff given projected future conditions. The areas examined in detail in this assessment are presented in Table 9.

Table 9 – Hydraulic Analysis Assessment Areas	
ID	**Street Intersection**
Idlewilde Shores	
1	Neale Ave
2	Idlewilde Rd between Winters Ave and Bayview Rd
3	Winters Ave between Girton Ave and Idlewilde Rd
4	Frederick Ave south of Winters Ave
Snug Harbor	
5	West End Rd between Maryland Ave and Lake Ave
Cedarhurst	
6	Lake Ave between Spruce Ave and Cedarhurst Rd
7	Spruce Ave between Lake Ave and Spring Ave
8	Oak Ave between Park Ave and Chesapeake Ave
9	Holly Ave between Lake Ave and Spring Ave
10	Spruce Ave between Spring Ave and Park Ave
11	Spring Ave between Holly Ave and Oak Ave
12	Pine Ave West of Lake Ave
13	Grove Ave between Spring Ave and Park Ave
14	Park Ave between Pine Ave and Spruce Ave
15	Holly Ave between Park Ave and Chesapeake Ave
16	Park Ave between Oak Ave and Bayview Ave
17	Maple Ave between Park Ave and Chesapeake Ave
Avalon Shores	
18	Bonniewood Dr between Washington Cir and Holly St
19	Hawthorne St between Lerch Dr and Shady Side Rd
20	Avalon Blvd between Washington Cir and Shady Side Rd

Table 9 – Hydraulic Analysis Assessment Areas	
21	Beech St between Lerch Dr and Avalon Blvd
22	Steamboat Rd between Lerch Dr and Shady Side Rd
23	Chestnut St between Lerch Dr and Oak St
24	Jordan Dr between Spruce St and Azaelia St
25	Dogwood Rd between Lerch Dr and Oak St
26	Oak St between Aspen St and Beech St
27	Oak St between Elm St and Lerch Dr
Franklin Manor	
28	Carvel St between Gwynne Ave and Delaware Ave
29	Delaware Ave between Carvel St and Exeter St
30	Exeter St between Fairfax Ave and Delaware Ave
31	Franklin Blvd between Fairfax Ave and Chesapeake Dr
32	Fairfax Ave between Carvel St and Dartmouth St
33	Baskin St north of Gwynne Ave
34	Ellicott Ave between Carvel St and Dartmouth St
35	Fairfax Ave between Exeter St and Franklin Blvd
36	Garret Ave between Carvel St and Dartmouth St
37	Berkley Manor Ln north of Gwynne Ave
38	Dartmouth St north of Gwynne Ave
39	Fairfax Ave between Gloucester St and Harford St
40	Carvel St north of Gwynne Ave
41	Ellicott Ave between Franklin Blvd and Gloucester St
Owings Beach	
42	Melbourne Ave between Irvin Ave and Marshall Ave
43	Frazier Ave between Masons Beach Rd and Allwine Ave
44	Mason Ave between Masons Beach Rd and Allwine Ave
45	Melbourne Ave between Clarke Ave and Frazier Ave
46	Irvin Ave between Welch Ave and Melbourne Ave
47	Melbourne Ave between Frazier Ave and Mason Ave
48	Mason Ave east of 1st Ave
49	Charles Ave between Knopp Ave and Melbourne Ave
50	1st Ave between Frazier Ave and Mason Ave

3.4. Coastal Erosion Assessment

Erosion is a compounding factor that intensifies flood vulnerability by weakening natural coastal defenses and increasing exposure of inland areas. Regions experiencing high rates of shoreline recession face an accelerated loss of protective landforms, leading to higher flood risks over time. Erosion-driven shoreline retreat can reduce the effectiveness of both natural and engineered coastal protection features, exacerbating inundation risks and limiting long-term resilience strategies.

Shoreline erosion rates were mapped and classified based on the Region 9 Shoreline Erosion Analysis[2].

Erosion Rate Ranges:

- Extreme Erosion (> 8.0 feet/year)
  - Areas with erosion rates exceeding 8 feet per year are experiencing rapid shoreline retreat, often leading to permanent land loss and direct exposure of inland areas to flooding.
  - These locations are highly vulnerable to coastal inundation and infrastructure failure, requiring urgent intervention, such as shoreline stabilization.

- Severe Erosion (4.0 feet/year to 8.0 feet/year)
  - Erosion rates between 4 and 8 feet per year indicate areas of significant shoreline retreat where protective marshes and vegetated buffers are rapidly disappearing.
  - These areas face high vulnerability, increasing susceptibility to storm surge, tidal flooding, and loss of natural coastal defenses.

- Moderate Erosion (2.0 to 4.0 feet/year)
  - Shoreline erosion in this range suggests ongoing coastal retreat, though at a more gradual rate.
  - Vulnerability in these areas is classified as moderate, as the effects of erosion may not be immediately destructive but will contribute to long-term coastal change.

- Low-Moderate Erosion (0.01 feet/year to 2.0 feet/year)
  - While these locations may not be at immediate risk, sustained erosion over time could lead to future instability and increased flood exposure.

- Minimal Erosion or Accretion (Negligible)
  - These areas generally benefit from stable coastal processes, though they may still be affected by storm-induced erosion events.

- Protected Shorelines
  - Shorelines with engineered protections (e.g., bulkheads, revetments, or other stone protection features) are assigned a low vulnerability score to reflect their reduced susceptibility to erosion.
  - While protection structures help mitigate erosion, they may still degrade over time, requiring maintenance to sustain their effectiveness.

- Unknown or Unclassified Shorelines
  - Locations with insufficient data are classified with a moderate vulnerability score to reflect potential risk where erosion rates are unverified.

4 ASSESSMENT AREAS

4. ASSESSMENT AREAS

This chapter provides a detailed analysis of existing conditions and flood vulnerabilities across communities within the Deale-Shady Side Peninsula (Figure 8). Building upon the data collection and preliminary analyses outlined thus far, this section examines specific challenges each community faces, including coastal flooding, stormwater management deficiencies, and infrastructure limitations.

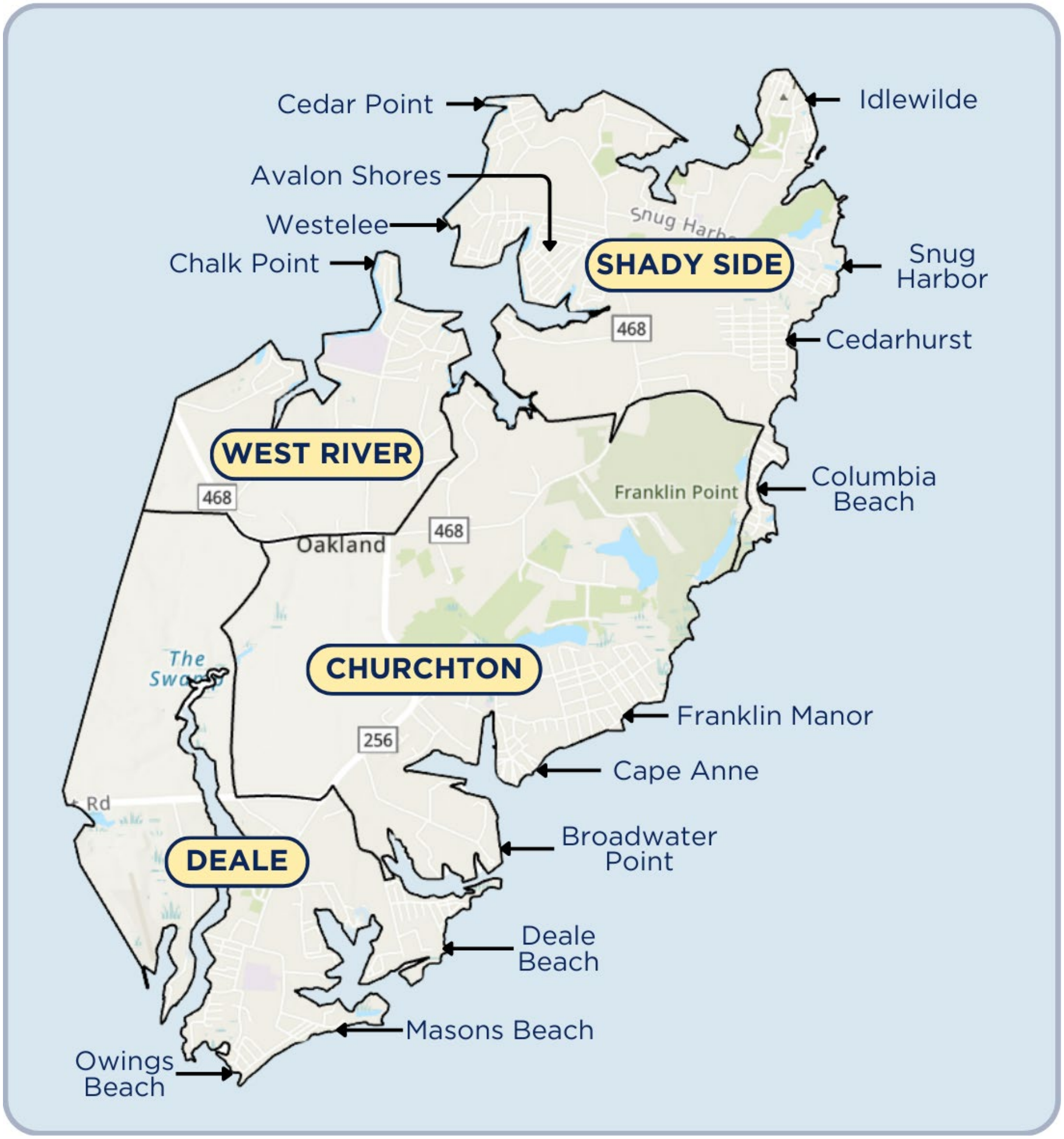


Figure 8 – Neighborhood Map for Deale-Shady Side Peninsula.

The assessment incorporates hydrologic and hydraulic modeling, flood maps, field investigations, and community input to identify and characterize flood risks. Each area is evaluated based on the following factors:

- SLR Exposure: Projected inundation extents under different SLR scenarios.
- Storm Surge and Coastal Flooding: Pathways for tidal flooding and potential impact areas.
- Stormwater Drainage Limitations: Condition and functionality of existing stormwater infrastructure.
- Erosion and Shoreline Stability: Analysis of natural and hardened shoreline features.
- Community and Infrastructure Impact: Implications for road access, property damage, and emergency response.

To provide a clear summary of each community's vulnerabilities, flooding report cards were developed. These reports highlight key flood risk factors in an easily comparable format. Categories assessed in each report card are detailed in Table 10.

Table 10 – Flooding Report Card Criteria

Category	Low	Moderate	High
Flood Pathways	Minimal exposure, few pathways	Increasing exposure, some roads/properties affected	Significant exposure, widespread road/property inundation
Stormwater Drainage	Well-functioning system, limited blockages	Some culverts/swale inefficiencies, periodic flooding	Severe drainage issues, frequent blockages, standing water
Infrastructure Vulnerability	Most roads/properties remain accessible	Some roadways or driveways are impassable during storms	Critical access routes cut off, major flooding impacts
Erosion & Shoreline Stability	Stable shoreline, limited erosion	Moderate erosion, some shoreline protection failing	High erosion, major loss of shoreline, structural failures
Overall Flood Threat	**Minor impacts, infrequent flooding**	**Regular flooding issues, moderate infrastructure impacts**	**Severe, persistent flooding, requiring urgent mitigation**

These report cards serve as a resource for residents to quickly identify the major contributing factors to flooding in their neighborhoods and help decision-makers prioritize mitigation efforts. A more detailed examination of vulnerability is presented in subsequent sections, where these risks are integrated to generate a comprehensive vulnerability rating for the entire Peninsula and ultimately used to guide flood mitigation efforts.

4.1. Shady Side

Shady Side, Maryland, is a small, unincorporated community that makes up the northern portion of the Peninsula (Figure 8). With a population of approximately 5,500 residents, Shady Side is predominantly residential but also features several small businesses, marinas, and critical facilities. These include Shady Side Elementary School and local fire and Emergency Medical Services (EMS). The Captain Salem Avery Museum is also located in Shady Side, which preserves the area's rich maritime history (Photo 7 and Photo 8). The local economy is heavily influenced by its waterfront location, with many residents engaged in boating, fishing, and tourism. The marinas and boatyards play a crucial role in supporting both commercial watermen and recreational boating activities, while local businesses serve both year-round residents and seasonal visitors. However, the community is particularly vulnerable to SLR, storm surges, and increased rainfall.

Photo 7 - Avalon Fire Department

Photo 8 - Captain Avery Museum

Shady Side's significance extends beyond its economic and cultural contributions. The community is home to valuable natural resources, including wetlands, marshes, and forested areas that provide essential ecosystem services such as flood mitigation, water filtration, and wildlife habitat. However, with average elevations between three and ten feet above sea level, Shady Side is especially susceptible to flooding.

As part of field assessment activities in Shady Side, neighborhoods were surveyed to assess the condition of shoreline and stormwater infrastructure.

4.1.1. Avalon Shores

Avalon Shores, established in the 1940s, contains primarily midsized homes situated at or near sea level. With an average elevation of just three feet above mean sea level, the community is highly vulnerable to tidal flooding and storm surge. Access is limited, as the neighborhood's primary entry point along Shady Side Roa is prone to flooding. This route also serves as a critical connection for all communities north of Avalon Shores, underscoring its importance for daily mobility and emergency response.

The majority of Avalon Shores' shoreline consists of private bulkheads and stone revetments (Figure 9). While these structures help prevent erosion, at their current elevations they are not sufficient to protect against flooding, especially during high tides and storm surges. Many of the bulkheads are frequently overtopped (Photo 9) with top elevations only between +2 feet and +2.5 feet NAVD88.

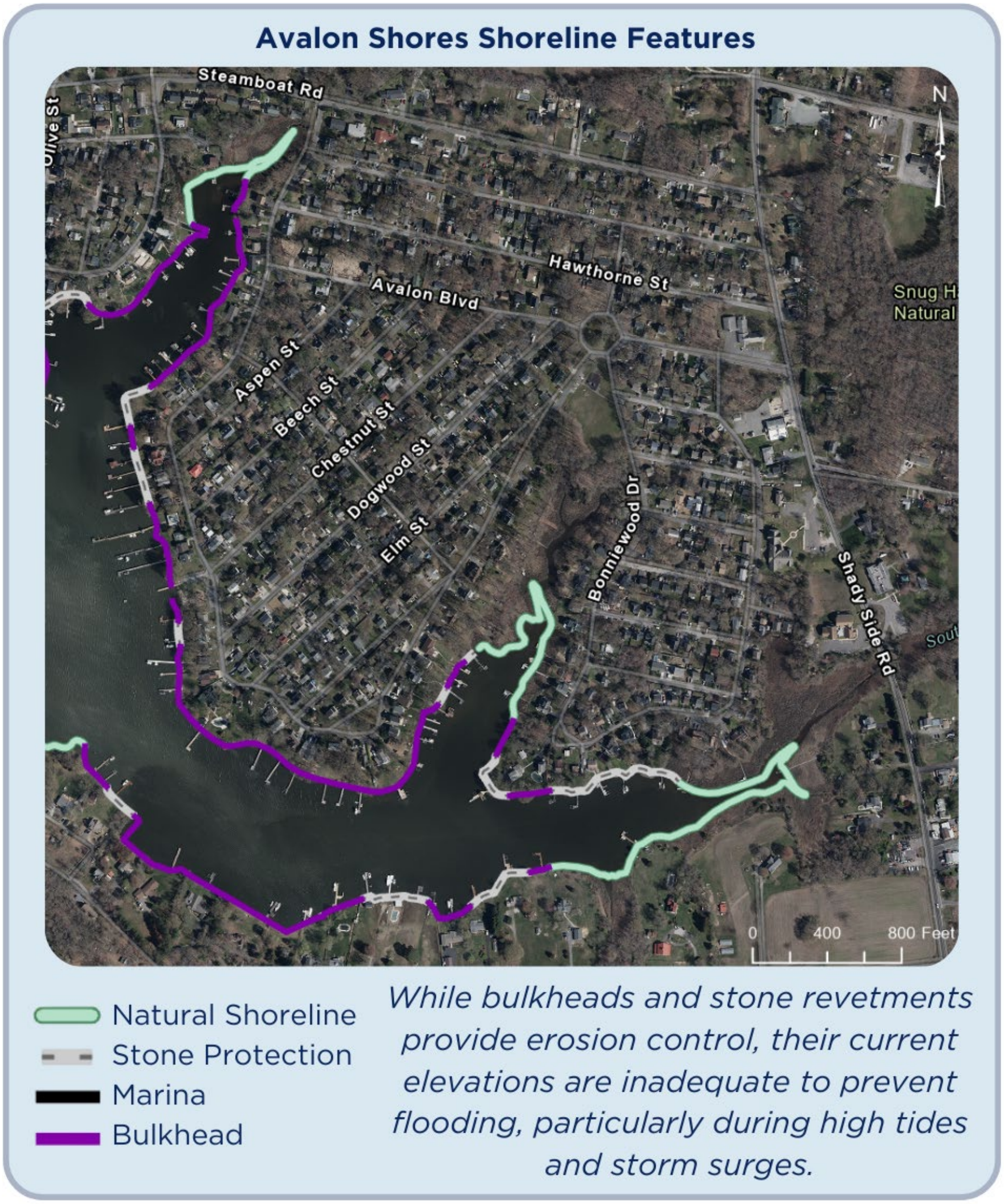


Figure 9 – Shoreline Features in Avalon Shores

Private property along the natural shoreline and marsh in the headlands is increasingly vulnerable to daily nuisance flooding. Photo 10 shows tidal waters encroaching further into private property with average lawn elevations of +3.0 feet NAVD88.

Photo 9 – Bulkhead submerged at high tide (Top of Bulkhead between +2’ and +2.5’ NAVD88)

Photo 10 - Tidal flooding of yard backed by natural marsh area. (Average yard elevation +3.0’ NAVD88)

In Avalon Shores, which is more densely populated and developed than some of the other communities on the Peninsula, the field team focused on mapping the stormwater conveyance system to better understand its capacity. The stormwater infrastructure, primarily consisting of driveway culverts and swales, is vulnerable to backwatering through open-ended tidal outfalls (Figure 10).

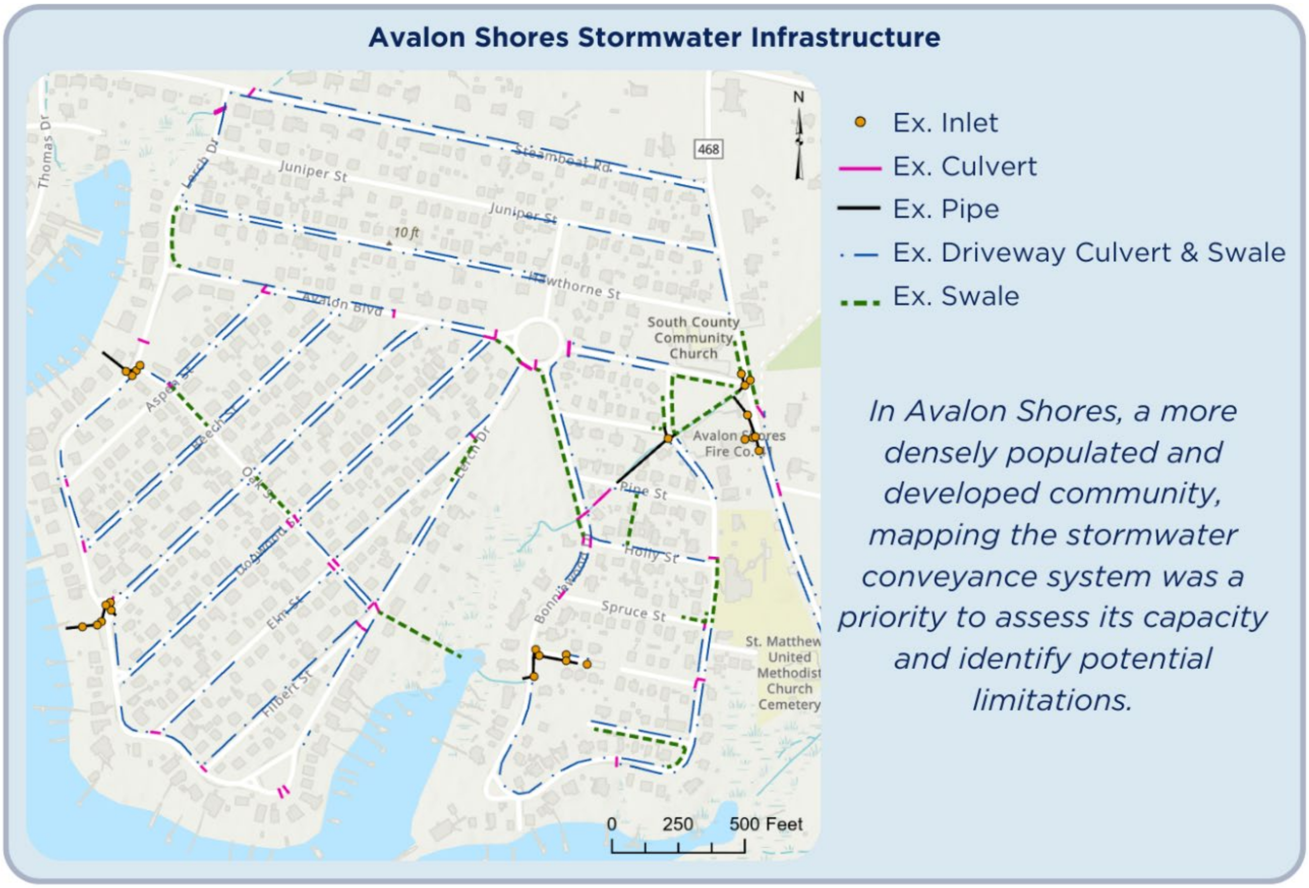


Figure 10 – Stormwater Infrastructure mapped during field assessment

During high tide events, tidal waters backflow into the stormwater system preventing rainfall from properly draining into tidal waters (Photo 11 - Photo 13). Extensive backwatering and pooling of water were observed in swales throughout the neighborhood. Indicators of stormwater-related erosion, such as damaged pavement, were also noted throughout the area (Photo 14). Maintenance issues were evident, with overgrown swales and damaged driveway culverts blocking the conveyance of stormwater, exacerbating flooding issues.

Photo 11 - Outfall almost completely submerged at high tide
Water level: +1.73' NAVD88 (or 1.07' above MHW)

Photo 12 - Outfall at Community Park
Water level: +2.09' NAVD88 (or 1.43' above MHW)

Photo 13 - Driveway culvert and swale backwatered at high tide
Water level: +2.16' NAVD88 (or 1.5' above MHW)

Photo 14 - Swale and culvert with standing water and road damage

In addition to existing drainage limitations, future rainfall conditions are projected to significantly worsen stormwater flooding across Avalon Shores. Figure 11 presents modeled flooding depths for the 2-year, 10-year, and 100-year rainfall events projected for the year 2050, under conditions without tidal surge. These simulations isolate the effects of rainfall intensity on the neighborhood's capacity to manage runoff.

Across all scenarios, widespread flooding is evident, with depth increasing and inundation expanding as return intervals lengthen. Even under the 2-year event, substantial portions of low-lying inland streets, such as Beech Street, Hawthorne Street, and Lerch Drive, are inundated. Under the 100-year rainfall projection, flood depths in some areas exceed two feet, with broad inundation extending to interior lots and critical infrastructure. Ponding becomes more connected across the neighborhood, forming larger, contiguous flood zones. These projections reinforce that Avalon Shores faces vulnerabilities from intense rainfall events alone.

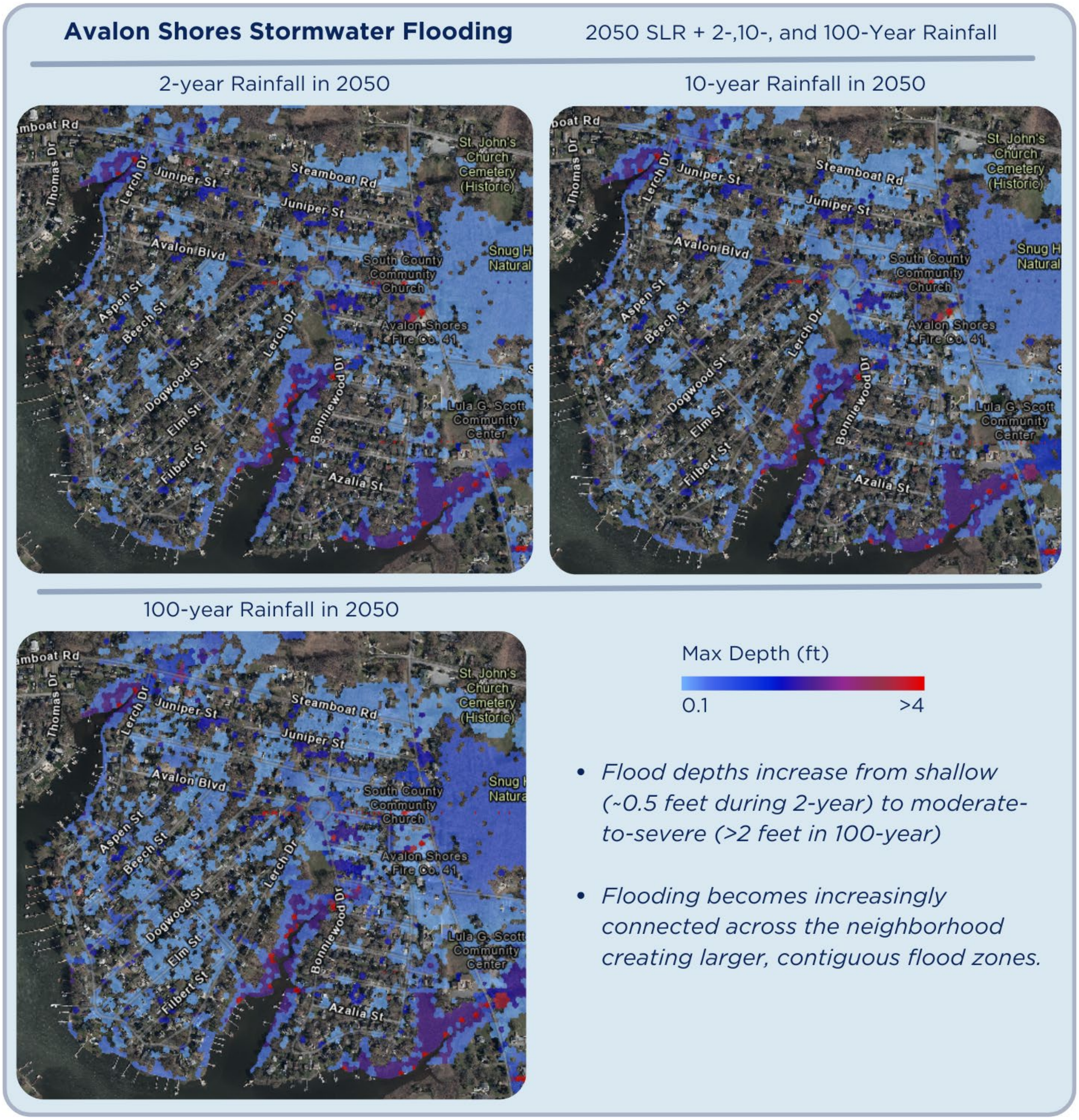


Figure 11 – Projected Stormwater Flooding Depths for Avalon Shores in 2050 under 2-, 10-, and 100-Year Rainfall Events with sea level rise

This figure supports and expands on field observations of undersized infrastructure and inadequate conveyance in many parts of the community. It also highlights that rainfall-driven flooding is expected to become a dominant driver of localized inundation, compounding the effects of tidal and surge flooding already observed.

Figure 12 further illustrates how stormwater flooding is exacerbated along the edges of the community, where low elevations allow for a combination of storm runoff accumulation and coastal flooding, particularly in waterfront properties and areas with compromised drainage systems.

Areas along Beech Street and Chestnut Street experience frequent stormwater flooding due to undersized culverts and swales, which are further impacted by tidal backwater at outfalls. This results in prolonged inundation, particularly during high tide and storm events. The central portions of Shady Side Road and Avalon Boulevard, key transportation routes for the community, face significant flooding due to inadequate stormwater infrastructure and direct exposure to tidal waters. As shown in the 2050 2-year storm surge and rainfall projection, flood depths in this area exceed 1.5 feet in some locations, making these roads impassable during heavy rainfall or minor storm events.

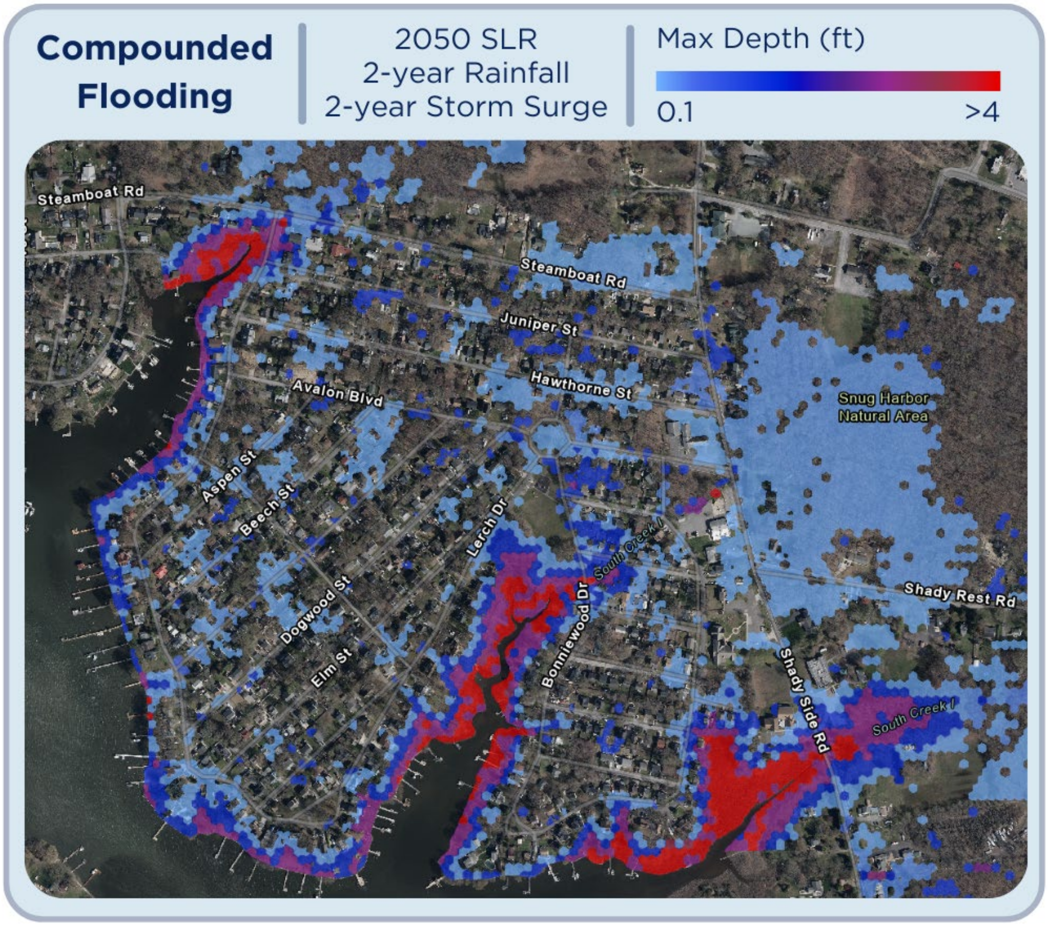


Figure 12 – Projected Stormwater Flooding Depths for the 2050 2-Year Rainfall and 2-Year Storm Surge Scenario in Avalon Shores

Localized stormwater flooding in the residential areas of Steamboat Drive and Hawthorne Street is attributed to limited stormwater infrastructure that is not adequately sized to convey expected runoff. The northeast portion of the community, adjacent to the Snug Harbor Natural Area, exhibits extensive flooding. This area is primarily served by undersized stormwater conveyance infrastructure that is significantly affected by tidal influences. Flood depths in these low-lying sections reach up to four feet, indicating severe stormwater management deficiencies compounded by rising sea levels and storm surge impacts.

During Tropical Depression Debby, tidal levels surged to over four feet above mean low water (MLW), creating significant flooding impacts. Due to Debby's slow movement, which prolonged rainfall and storm surge, stormwater was unable to drain effectively, exacerbating flooding in residential areas. The MyCoast report in Figure 13 – Maryland MyCoast Report During Debby captures the extent of flooding in a residential yard, where flood waters overtopped the bulkheaded shoreline and pooled around homes.

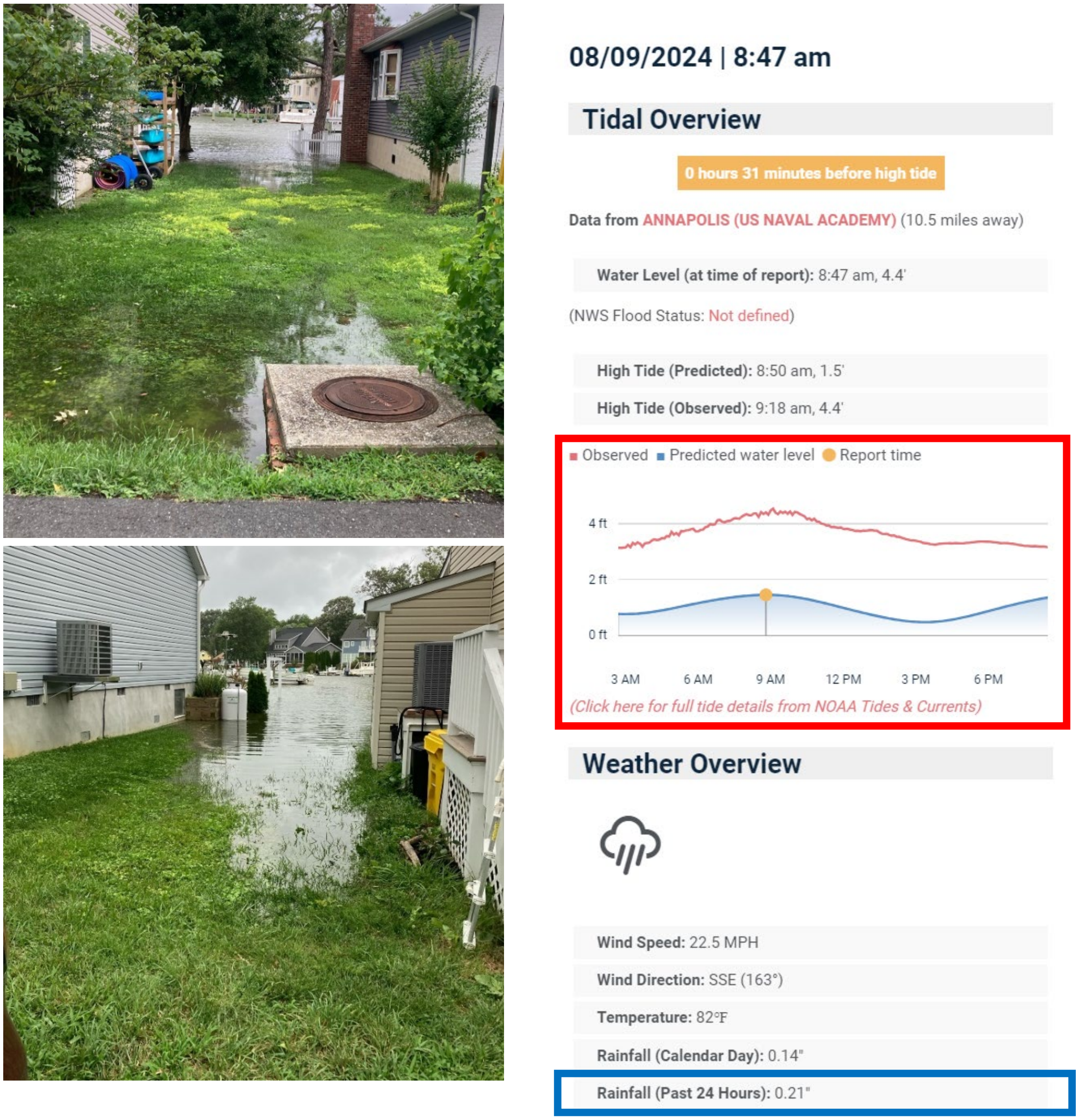


Figure 13 – Maryland MyCoast Report During Debby
*Note: Red Box showing flooding to residential property and associated observed water levels; and Blue Box showing rainfall at the time of the photo

Additional areas of concern highlighted by flooding during Tropical Depression Debby include Shady Side Road near St. Matthews United Methodist Church, a critical access route for the entire Shady Side community. Stormwater swales along this road drain towards a low point with road crown elevations of only about 2.5 feet NAVD88, making it susceptible to frequent flooding (Photo 15). Properties along Lerch Drive, especially between Juniper Street and Steamboat Road, are similarly vulnerable due to their low-lying elevations (Crest Elevation: +2 feet NAVD88) and proximity to the shoreline (Photo 16 and Photo 17). Elevated tidal waters and stormwater runoff converge at this intersection, resulting in frequent overtopping.

Photo 15 - Overtopping of Shady Side Road near St. Matthews United Methodist Church
Water level: +3.53' NAVD88 (or 2.87' above MHW)

Photo 16 - Floodwaters encroaching into residential property and infrastructure
Water level: +3.6' NAVD88 (or 2.94' above MHW)

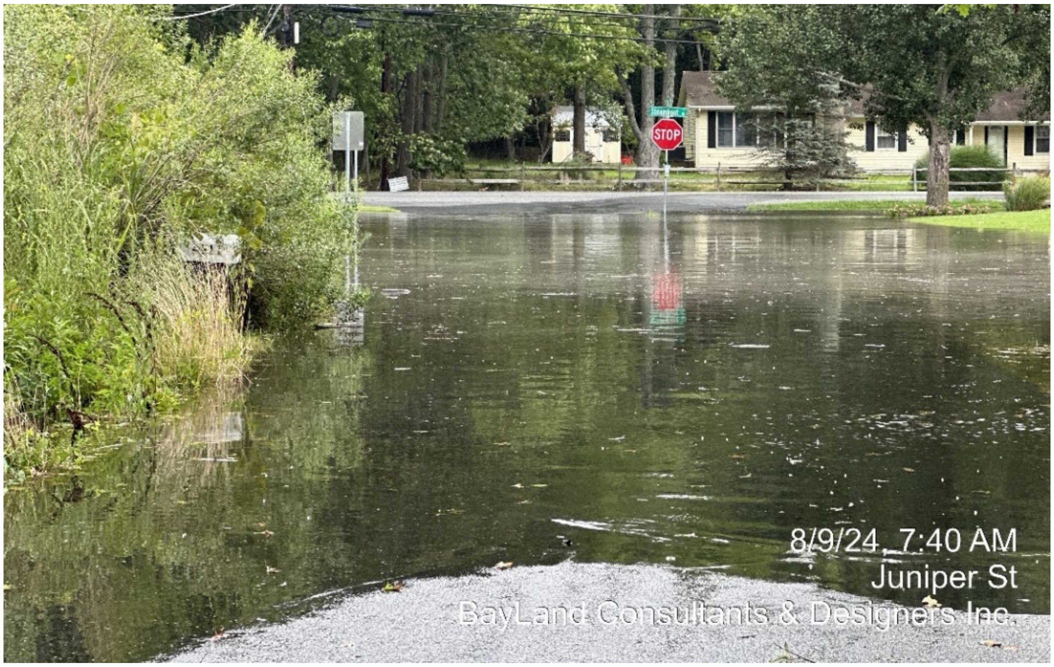


Photo 17 – Lerch Drive flooded at the connection of stormwater conveyance systems to tidal waters
Water level: +3.65' NAVD88 (or 2.99' above MHW)

SLR projections for Avalon Shores indicate increasing flood exposure along the community's waterfront and low-lying inland areas (Figure 14). By 2050, tidal inundation is expected to extend further inland, impacting roads, properties, and stormwater infrastructure. By 2065 and 2100, significant portions of the neighborhood, including roadways critical for emergency access and daily transportation, will experience chronic flooding. By 2050, low-lying waterfront areas will experience daily tidal inundation. By 2065, daily baseline flood depths on Lerch Drive between Juniper Street and Steamboat Road will reach 1.5 feet, while Shady Side Road will experience eight inches of flooding. By 2100, tidal waters will extend further into the community, submerging critical infrastructure and worsening drainage issues. Properties channelward of Lerch Drive and Bonniewood Drive will be permanently submerged with three-foot flood depths in some areas. The entire northern portion of the Peninsula will become inaccessible, with more than three feet of water blocking key access routes.

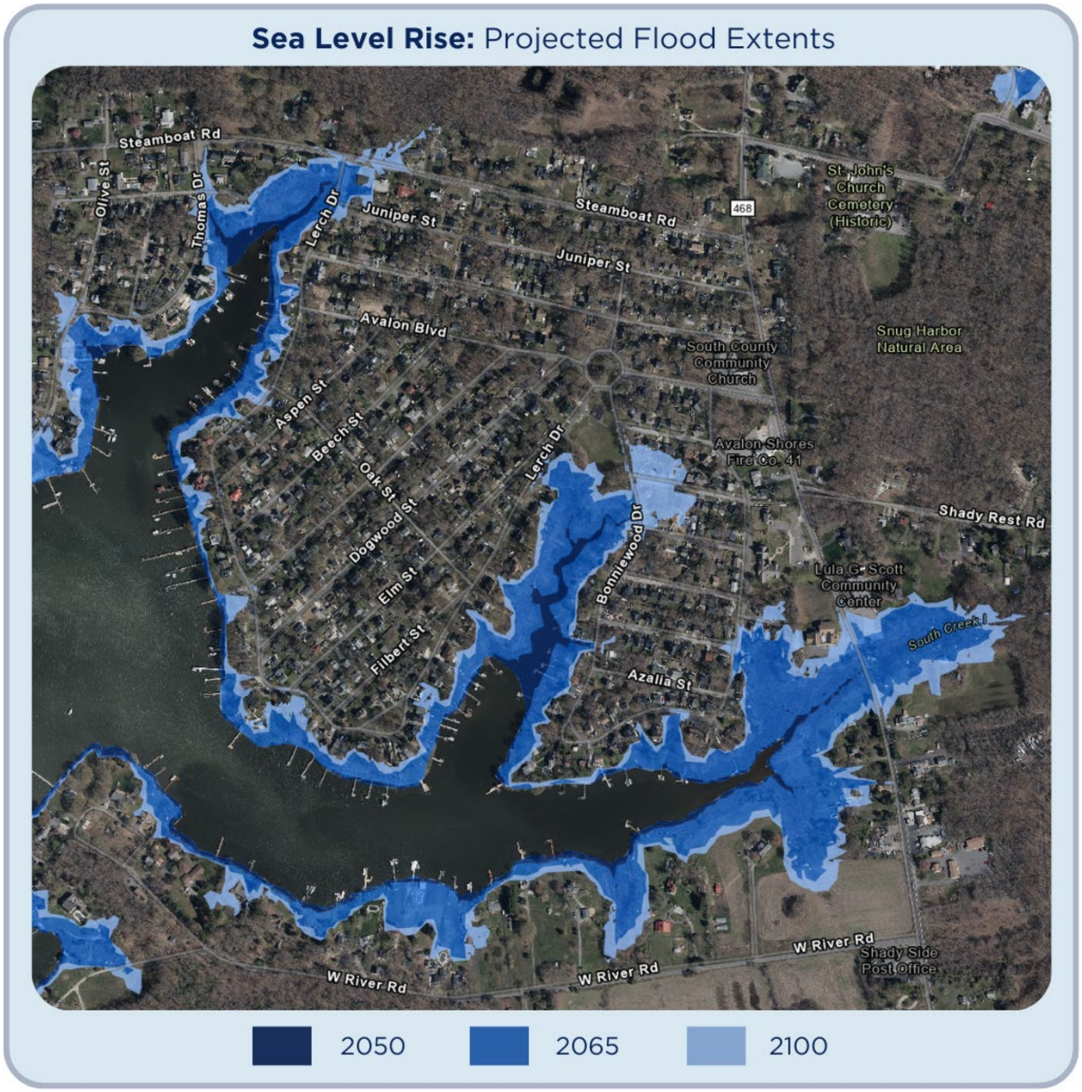


Figure 14 – Projected SLR extents for Avalon Shores illustrate increasing tidal inundation and impacts to access.

As SLR projections indicate increasing flood risks across Avalon Shores, it is important to consider how multiple factors contribute to overall flood vulnerability. While tidal inundation is a significant concern, stormwater drainage, infrastructure resilience, and shoreline stability all influence the severity and frequency of flooding events. The following flooding report card provides an evaluation of these factors to aid in identifying priority areas for mitigation efforts and adaptation planning (Table 11).

Table 11 – Avalon Shores Flooding Report Card		
Category	**Rating**	**Justification**
Flood Pathways	High	Low-lying streets such as Lerch Drive and areas near South Creek are frequently overtopped, especially during high tides and storm events.
Stormwater Drainage	Moderate	The stormwater system is constrained by capacity limitations and blockages, exacerbating runoff issues during storms.
Infrastructure Vulnerability	High	Critical access routes such as Steamboat Road and portions of Avalon Boulevard experience frequent flooding, restricting emergency access.
Erosion & Shoreline Stability	Moderate	Existing bulkheads and stone revetments provide some protection but are undersized and insufficient against storm surges.
Overall Flood Threat	**High**	**Avalon Shores faces recurring flooding from both stormwater and tidal influences, necessitating a comprehensive mitigation strategy.**

4.1.2. Westelee

The Westelee community is a waterfront neighborhood located along the West River and South Creek shoreline. Westelee is home to the Chesapeake Yacht Club (CYC), a gated marina and club, and John Marshall Park, a private beach for members of the Westelee Civic Association. The Westelee Civic Association provides ongoing support for the neighborhood by advocating for community interests and coordinating efforts to address infrastructure maintenance and resilience improvements.

The shoreline of Westelee primarily consists of privately owned properties protected by bulkheads supplemented in limited areas by stone protection measures (Figure 15). Sections of natural shoreline and limited stone revetment are found along the community's less developed shoreline, particularly in the headwaters of South Creek between Avalon Shores and Westelee.

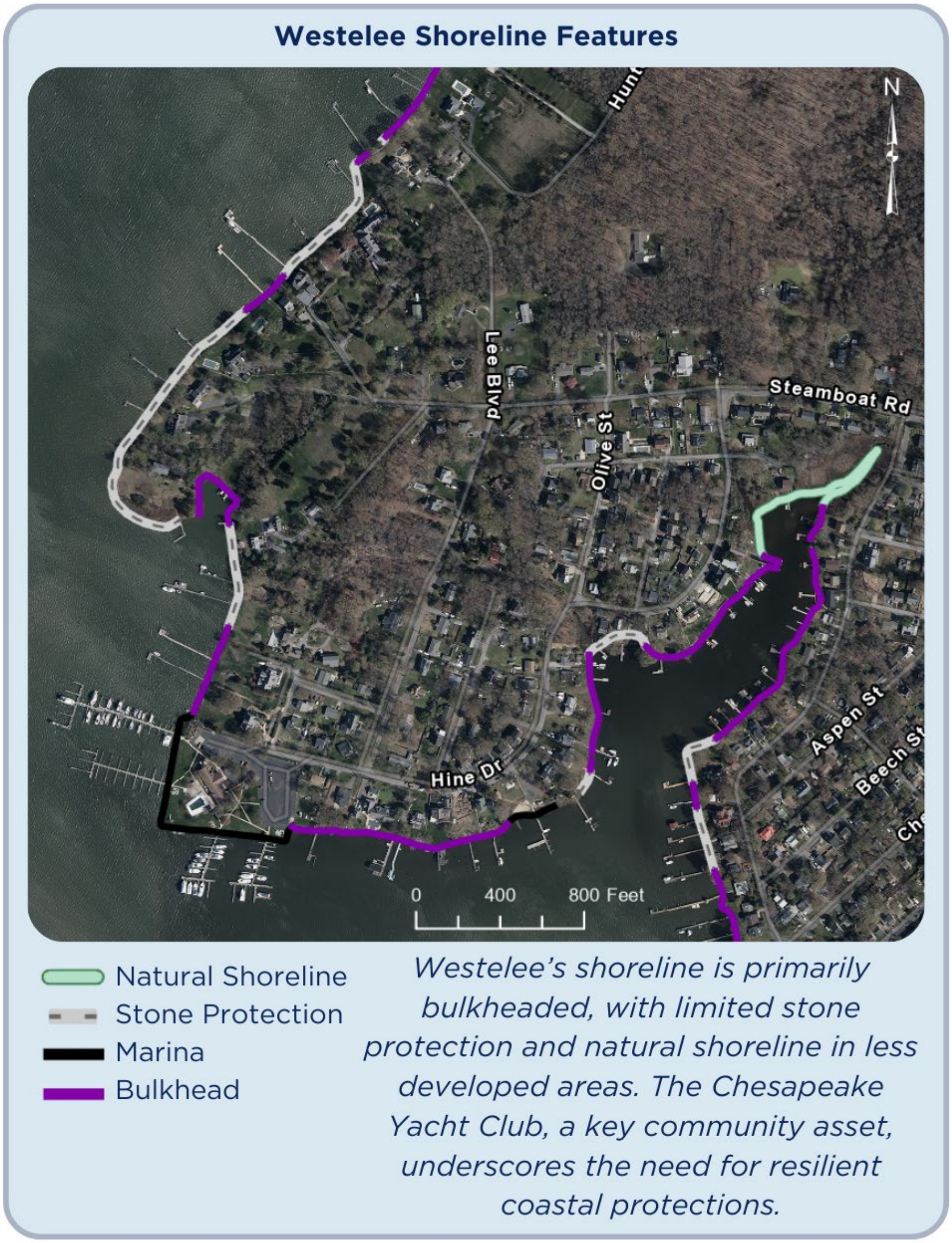


Figure 15 ─ Shoreline Features in Westelee Community

Westelee is largely sheltered from direct Chesapeake Bay exposure, reducing vulnerability to extreme wave conditions; however, the community remains highly susceptible to still-water flooding caused by storm surges and SLR. Many bulkheads in the community are older, privately maintained, and may require upgrades to address increasing water levels caused by SLR. Similar to Avalon Shores, private bulkhead top elevations average +2.5 feet NAVD88.

At the CYC, the bulkhead elevation of approximately +3.45 feet NAVD88 frequently floods during storm events (Photo 18). In response to this challenge, the Yacht Club has incorporated resiliency measures into its infrastructure design, including the installation of a floating dock system. This improvement accommodates rising water levels while maintaining functionality for marina users.

Photo 18 - CYC flooding during storm (October 29,2021)
Water level: +3.45’ NAVD88 (or 2.79’ above MHW)

Stormwater conveyance withing the community relies on a network of grassy swales and driveway culverts designed to channel runoff to tidal outfalls. Blocked or crushed culverts impede the flow of runoff, contributing to localized flooding (Photo 19 and Photo 20). A consistent theme across the Peninsula, grassy swales are overgrown, stagnant, or eroded, reducing their capacity to convey stormwater effectively (Photo 21 and Photo 22). At intersections along Jonhson Drive, pooling stormwater has led to pavement erosion and visible cracking, indicating prolonged runoff stagnation and inadequate drainage (Photo 23 and Photo 24).

Photo 19 - Sedimentation blocking proper conveyance through road culvert

Photo 20 - Overgrown storm grate

Photo 21 - Pooling in roadside swale along Lee Boulevard

Photo 22 - Overgrown swale

Photo 23 – Road damage due to standing water on pavement at Johnson Drive and Olive Street intersection

Photo 24 – Standing water and road damage at Johnson Drive and Magnolia Ridge Road intersection

Westelee’s waterfront location along West River and South Creek makes it susceptible to SLR-induced flooding, despite its reduced exposure to direct wave action from the

Chesapeake Bay (Figure 16). As projected SLR increases over time, low-lying properties and bulkheaded shorelines will experience greater frequency and severity of flooding. Many bulkheads in the community are older and privately maintained, and without upgrades, they may not provide adequate protection as water levels continue to rise. By 2100, property channelward of both Hine Drive and Thomas Drive are permanently inundated by more than three feet of water.

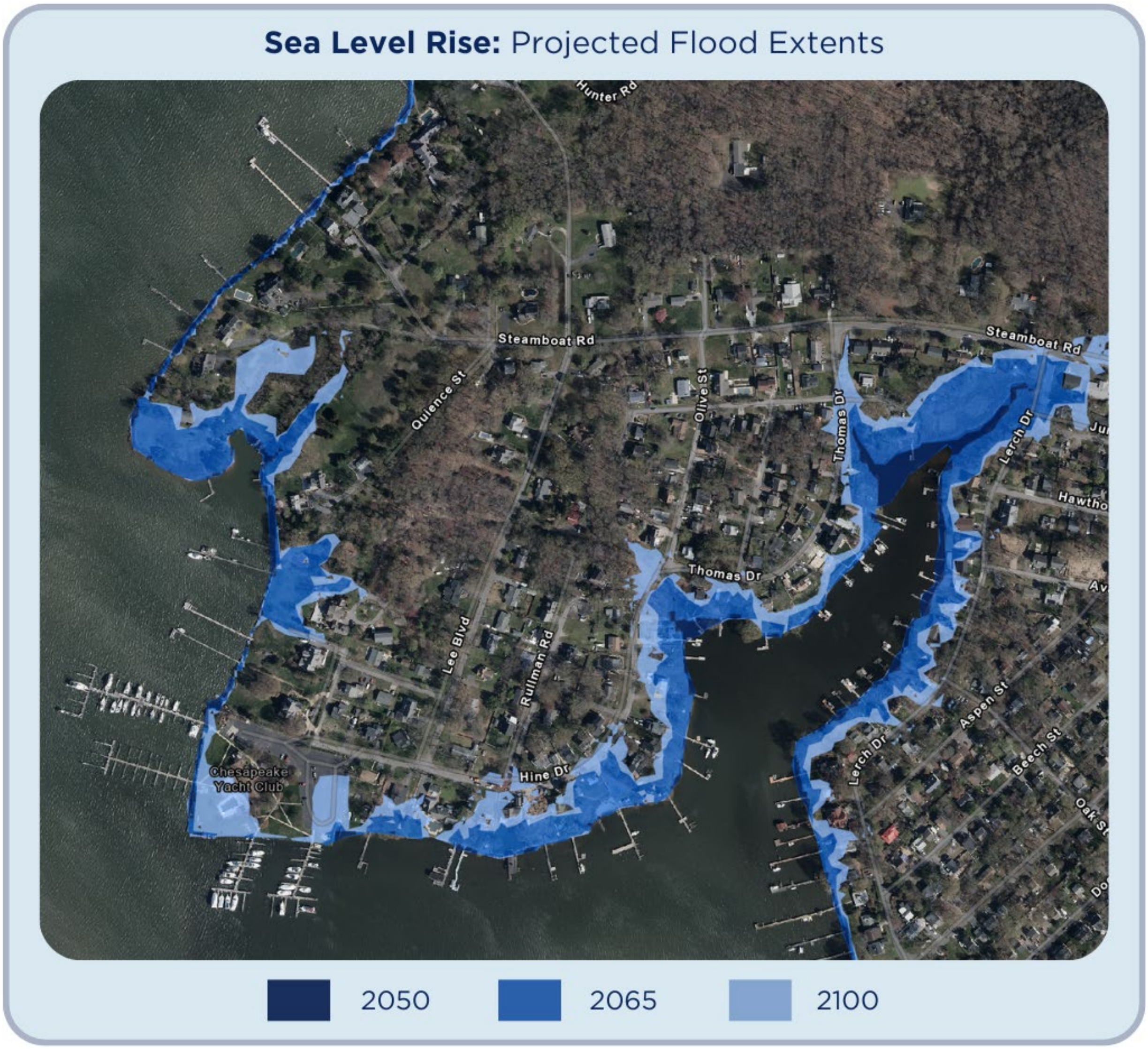


Figure 16 – Projected SLR Flood Extents for Westelee indicate increasing tidal inundation, with low-lying areas and bulkheaded shorelines facing heightened flood risk.

SLR, combined with the existing stormwater drainage challenges in Westelee, exacerbates flood risk. The community's reliance on driveway culverts and grassy swales for stormwater conveyance has resulted in drainage inefficiencies due to sedimentation, overgrowth, and aging infrastructure. These deficiencies not only contribute to localized flooding but also impact the long-term resilience of the community's road network and private properties.

The Westelee flooding report card summarizes these vulnerabilities by evaluating key flooding factors, including flood pathways, stormwater drainage, infrastructure vulnerability, and shoreline stability (Table 12).

Table 12 – Westelee Flooding Report Card		
Category	**Rating**	**Justification**
Flood Pathways	Moderate	The community faces moderate flood exposure due to rising water levels, frequent bulkhead overtopping, and storm-driven flooding. SLR projections indicate increasing risk for both waterfront and inland properties.
Stormwater Drainage	Moderate	The stormwater system primarily consists of driveway culverts and swales, many of which are blocked or undersized. Poor maintenance, sediment buildup, and overgrown vegetation reduce drainage capacity, leading to localized flooding.
Infrastructure Vulnerability	Moderate	Roadways experience flooding during storm events, with standing water causing pavement damage at key intersections. While the primary access routes remain mostly functional, continued exposure to flooding may necessitate upgrades.
Erosion & Shoreline Stability	Moderate	The shoreline is largely bulkheaded, but many structures are aging and privately maintained. Gaps in protection, undersized bulkheads, and limited natural shoreline leave portions of the community vulnerable to erosion and future sea level rise.
Overall Flood Threat	**Moderate**	**A combination of tidal flooding, stormwater drainage limitations, and aging bulkheads contributes to persistent flood risks. Without proactive infrastructure improvements, the community will face increasing vulnerability over time.**

4.1.3. Idlewilde

Idlewilde is a historic waterfront community located on the northern tip of the Deale-Shady Side Peninsula in Shady Side. Established in the early 20th century, Idlewilde has evolved from a seasonal retreat into a year-round residential neighborhood.

Idlewilde's direct Bay exposure along its eastern shoreline yields it vulnerable to erosive wave energy. Most of this exposed shoreline is hardened by bulkheads or seawalls and stone protection barring some stretches of natural shoreline (Figure 17 and Photo 25 and Photo 26).

Figure 17 — Shoreline Features in Idlewilde

Photo 25 - Seawall with stone protection (Top of Wall +5' NAVD88)

Photo 26 - Timber bulkhead and seawall with stone protection (Top of Wall and Stone +5' NAVD88)

Various indicators of erosion and overtopping, such as scour behind stone protection and washout areas behind seawalls, signal that existing infrastructure along stretched of the eastern shoreline fail to protect against the current wave climate in some areas (Photo 27 and Photo 28). However, the area is not as comparatively vulnerable to rising water as some other areas on the Peninsula as elevations are approximately +8 feet NAVD88.

Photo 27 - Stone placed in washout areas

Photo 28 - Washout behind seawall

The more sheltered western shoreline features the Shady Cove Natural Area, a scenic natural preserve with waterfront views, fishing areas, and walking trails that weave through wooded and marsh areas. As a protected space, Shady Cove Natural Area serves as both a recreational resource and a vital ecological buffer for the local community. The wetlands and tidal marshes found within the natural area play an essential role in flood mitigation by absorbing excess runoff during heavy rainfall and storm surge events, thereby reducing the impact on the surrounding residential areas.

The stormwater conveyance system in Idlewilde primarily relies on a network of driveway culverts and grassy roadside swales to direct runoff toward the Bay or into the marshes within the Shady Cove Natural Area. These culverts and swale systems lead to inlets and storm pipes, which discharge at tidal outfalls located at the intersection of Winters Avenue and Idlewilde Road, the end of Girton Avenue, and the end of Chesapeake Avenue (Figure 18).

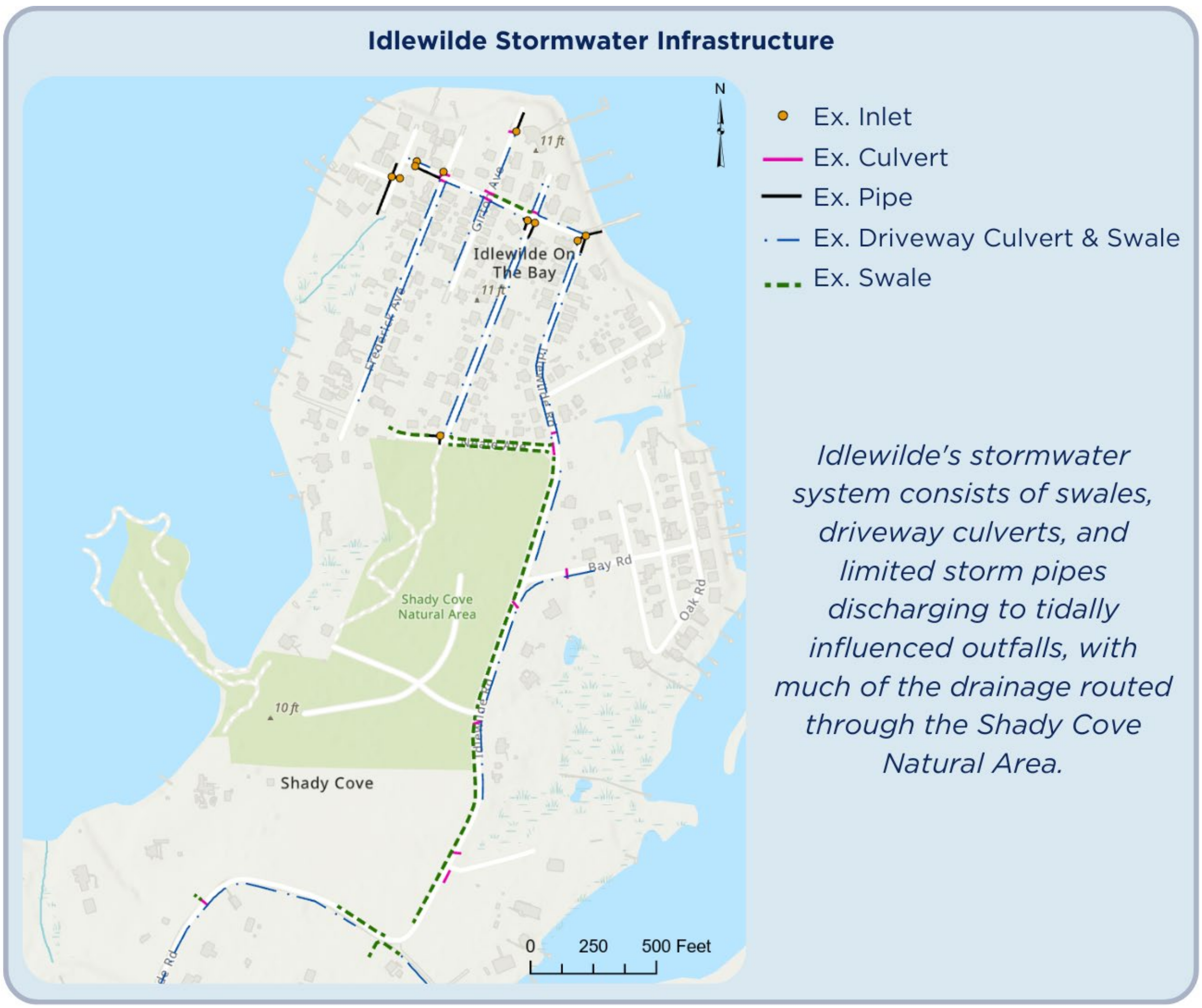


Figure 18 – Stormwater Infrastructure Mapped During Field Assessment

Field observations revealed that many driveway and road culverts were damaged or obstructed by sediment and debris, impeding water flow and causing localized flooding Photo 29). Additionally, roadside swales frequently exhibited pooling water, a sign of insufficient drainage capacity or maintenance (Photo 30). In some areas, the edge of pavement showed damage caused by erosion during flood events. The lack of backflow prevention mechanisms at tidal outfalls leaves the system prone to backwatering during high tides, preventing efficient drainage and increasing the likelihood of flooding during surge events (Photo 31).

Photo 29 - Sedimentation blocking driveway culvert

Photo 30 - Pooling water in roadside swale with damage to edge of pavement

Photo 31 - Tidal outfall without backflow prevention
Water level: +0.38' NAVD88 (or .28' below MHW)

Stormwater flooding in Idlewilde is projected to worsen under future rainfall scenarios. Figure 19 illustrates modeled stormwater flood depths for the 2050 2-year, 10-year, and 100-year rainfall events. Even under the 2-year event, flood extents are substantial in the lower-elevation zones along Idlewilde Road and near the tidal outfalls at Bay Road and Winters Avenue. As rainfall severity increases, both the depth and geographic extent of flooding expand, with some areas transitioning from shallow ponding to depths exceeding two or three feet.

Flooding along Idlewilde Road poses a risk to ingress and egress during storm events. By the 100-year rainfall event, roadside drainage systems are overwhelmed. The Shady Cove Natural Area continues to act as a buffer by absorbing runoff; however, stormwater overtops adjacent roadways and infiltrates residential streets as rainfall intensity increases.

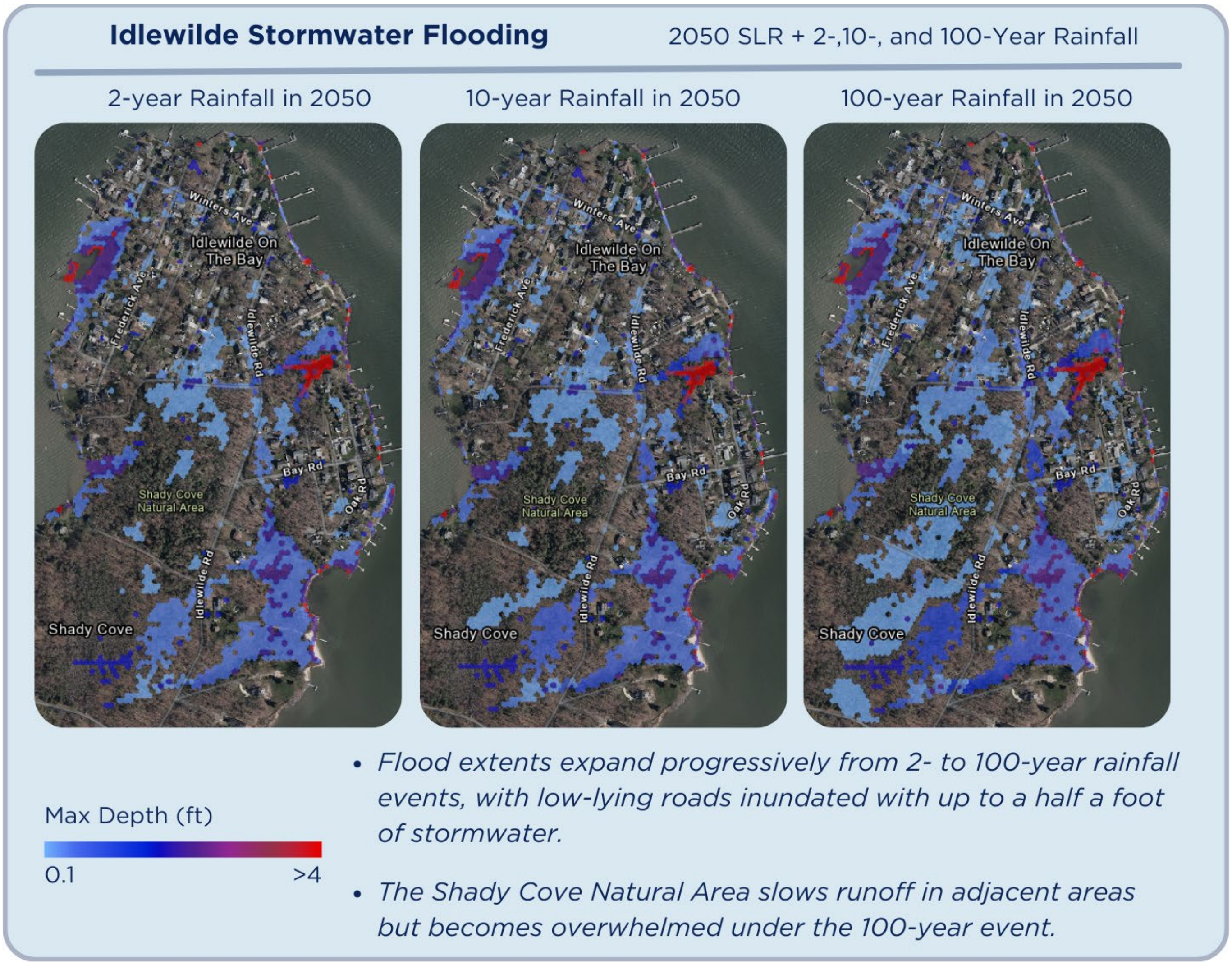


Figure 19 – Projected Stormwater Flooding Depths in Idlewilde during 2-, 10-, and 100-Year Rainfall Events in 2050, assuming sea level rise conditions.

While rainfall-driven flooding presents clear risks to transportation and property access in Idlewilde, these hazards are further intensified when storm surge coincides with heavy precipitation. The interaction of high tide and stormwater runoff significantly reduces the capacity of outfalls and swales to drain effectively, leading to deeper and more persistent flooding. Figure 20 illustrates the compounded effects of the 2050 2-year rainfall event combined with 2-year storm surge, highlighting an even broader extent of inundation, particularly in areas with limited drainage infrastructure and tidal backflow vulnerability.

The existing system of swales and culverts in Idlewilde is insufficient to manage stormwater flow during large storm events, with tidal influences further restricting drainage capacity. As seen in Figure 20, significant portions of the community experience inundation due to stormwater flooding, with areas of deeper flooding concentrated along the western shoreline, portions of Idlewilde Road, and Bay Road.

Winters Avenue, a primary road through the community, is impacted when stormwater flooding is compounded with coastal flooding, with depths reaching up to two feet in some sections. However, the most critical vulnerability is along Idlewilde Road, which serves as the only ingress/egress for the community. Flood depths along Idlewilde Road exceed three feet in low-lying areas, making safe passage impossible during storm events. The intersection of Bay Road and Oak Road is also heavily affected, with widespread pooling due to limited stormwater conveyance capacity.

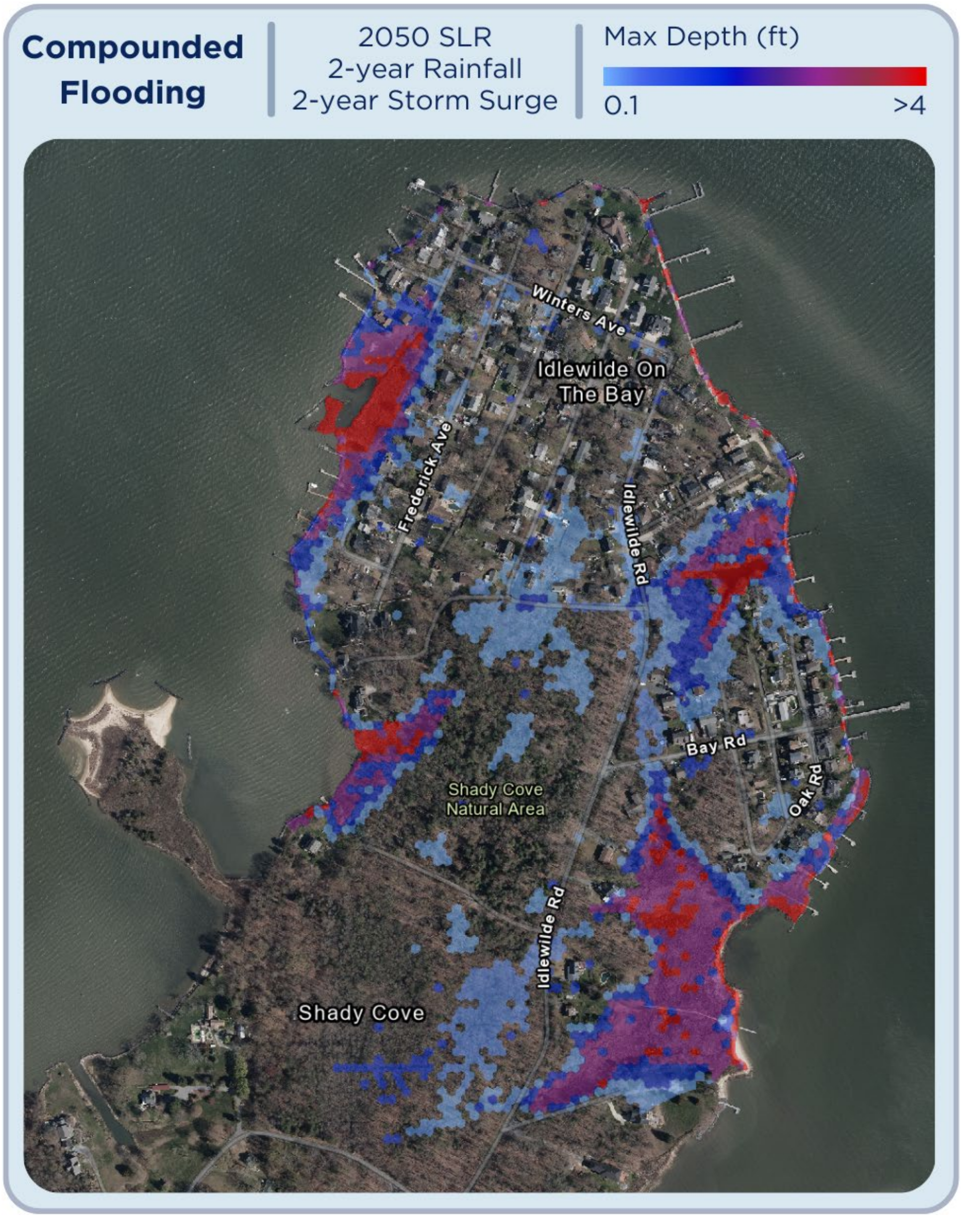


Figure 20 – Projected Stormwater Flooding Depths for the 2050 2-Year Rainfall and 2-Year Storm Surge Scenario in Idlewilde

The stormwater system's limitations, combined with rising sea levels and storm surge, indicate that flooding will become increasingly severe, further isolating the community and threatening critical infrastructure.

Projected SLR flood extents indicate increasing inundation along the waterfront and marsh-adjacent properties (Figure 21). By 2065, nuisance flooding may become more frequent, affecting roadways and properties near tidal outfalls. By 2100, the expansion of inundation into inland areas poses greater risks to infrastructure and stormwater management. The wetland south of Bay Road helps buffer flooding and dissipate offshore wave energy before reaching Idlewilde Road. With an average elevation of +1.7 feet NAVD88, the area is projected to experience 1.5 feet of water by 2065 and 4.5 feet by 2100, leading to increased inland wave propagation and eventual marsh submergence.

Figure 21 – Projected SLR flood extents for Idlewilde indicate increasing inundation along the shoreline and low-lying areas over time.

As SLR amplifies tidal flooding and stormwater drainage inefficiencies, the vulnerability of Idlewilde must be assessed comprehensively. The following report card evaluates primary factors contributing to flood risk (Table 13).

Table 13 – Idlewilde Flooding Report Card		
Category	**Rating**	**Justification**
Flood Pathways	Moderate	Tidal outfalls and low-lying areas are susceptible to rising water levels, leading to periodic nuisance flooding. Storm surge events exacerbate risks along the Bay-facing shoreline.
Stormwater Drainage	Moderate	The system primarily consists of driveway culverts and swales, which are prone to sedimentation and blockages. The lack of backflow prevention at tidal outfalls increases flooding potential.
Infrastructure Vulnerability	Moderate	Some roads and properties experience localized flooding, particularly near tidal outfalls and where stormwater drainage is ineffective. While much of the community sits at higher elevations, key access points remain at risk.
Erosion & Shoreline Stability	Moderate	Bulkheads and seawalls provide protection along the eastern shoreline, but signs of overtopping and washout indicate limitations. The natural shoreline along the Shady Cove Natural Area remains stable but vulnerable to long-term water level changes.
Overall Flood Threat	**Moderate**	**A combination of tidal flooding, stormwater drainage limitations, and infrastructure vulnerabilities contribute to flood risks in Idlewilde, requiring proactive mitigation strategies.**

4.1.4. Snug Harbor

Snug Harbor is a small residential community located on the northeastern tip of the Deale-Shady Side Peninsula. Similar to other Shady Side communities, access to Snug Harbor is limited with the key entry points being Shady Side Road and Snug Harbor Road, both of which are prone to flooding. The area is characterized by a network of residential roads and properties that are particularly vulnerable to rising water levels. High tide events frequently encroach on community spaces, and storm-driven flooding can persist for extended periods due to poor drainage conveyance.

Snug Harbor's eastern shoreline faces direct exposure to the Chesapeake Bay, making it highly susceptible to extreme wave conditions and storm surge. The community's shoreline is predominantly hardened, with bulkheads and stone revetments providing varying levels of flood protection, while other areas remain natural (Figure 22). The entrance to the Snug Harbor basin is sheltered by two stone jetties with crest elevations ranging between +2.0 and +3.0 feet NAVD88 (Photo 32), while bulkheads within the basin protect to flood elevations of +2.5 feet NAVD88. Immediately behind these bulkheads, residential properties maintain similar elevations, and many homes along the waterfront are elevated on piles for additional flood protection (Photo 33).

The wetland area south of Snug Harbor's main tidal connection routes through the Snug Harbor basin (Photo 34). Further, this connection has necessitated regular dredging to maintain navigability due to sedimentation.

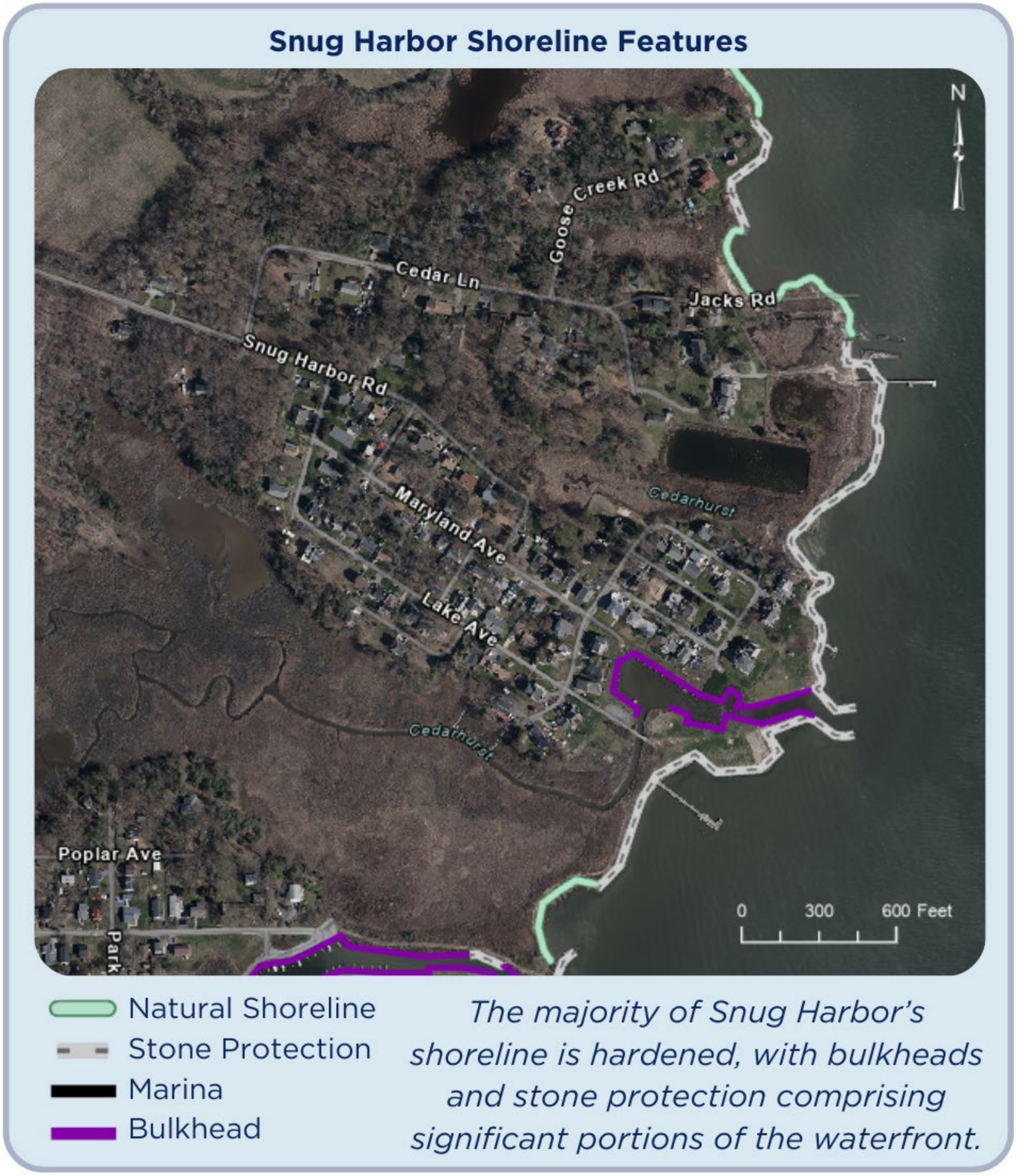


Figure 22 – Shoreline Features in Snug Harbor

Photo 32 - Stone jetties at Snug Harbor basin entrance (Top of Stone +2.0' to +3. 0' NAVD88)

Photo 33 - Elevated home behind marina bulkhead

Photo 34 - Marsh channel connection through Snug Harbor basin

The stone revetments along the bay-facing shoreline vary in height and effectiveness. In some areas, the revetments are undersized, leading to overtopping and landward washout, which undermines the stability of the shoreline (Photo 35). Average top of stone elevations near the marina and extending south past the community pier are +4.5 feet NAVD88 and +2.5 feet NAVD88, respectively. These lower elevations increase susceptibility to overtopping during high tides and storm events. In locations where gaps exist in the stone protection, natural shorelines are directly exposed to the Bay's wave energy, leading to erosion and marsh edge degradation (Photo 36). The impacts of wave action, coupled with rising sea levels, contribute to the progressive submergence of marsh vegetation, reducing its effectiveness as a natural flood buffer (Photo 37).

Photo 35 – Undermining of stone protection along Snug Harbor's shoreline with direct bay exposure

Photo 36 – Erosion of natural marsh edge south of Snug Harbor

Photo 37 – Submergence of marsh

The community's stormwater conveyance network utilizes grassy swales and driveway culverts in most areas, while east of Mariners Drive is primarily sheet flow to tide waters

(Figure 23). Field assessments indicate that Snug Harbor lacks sufficient stormwater infrastructure to manage extreme rainfall events, leading to standing water and backwater flooding from the Chesapeake Bay.

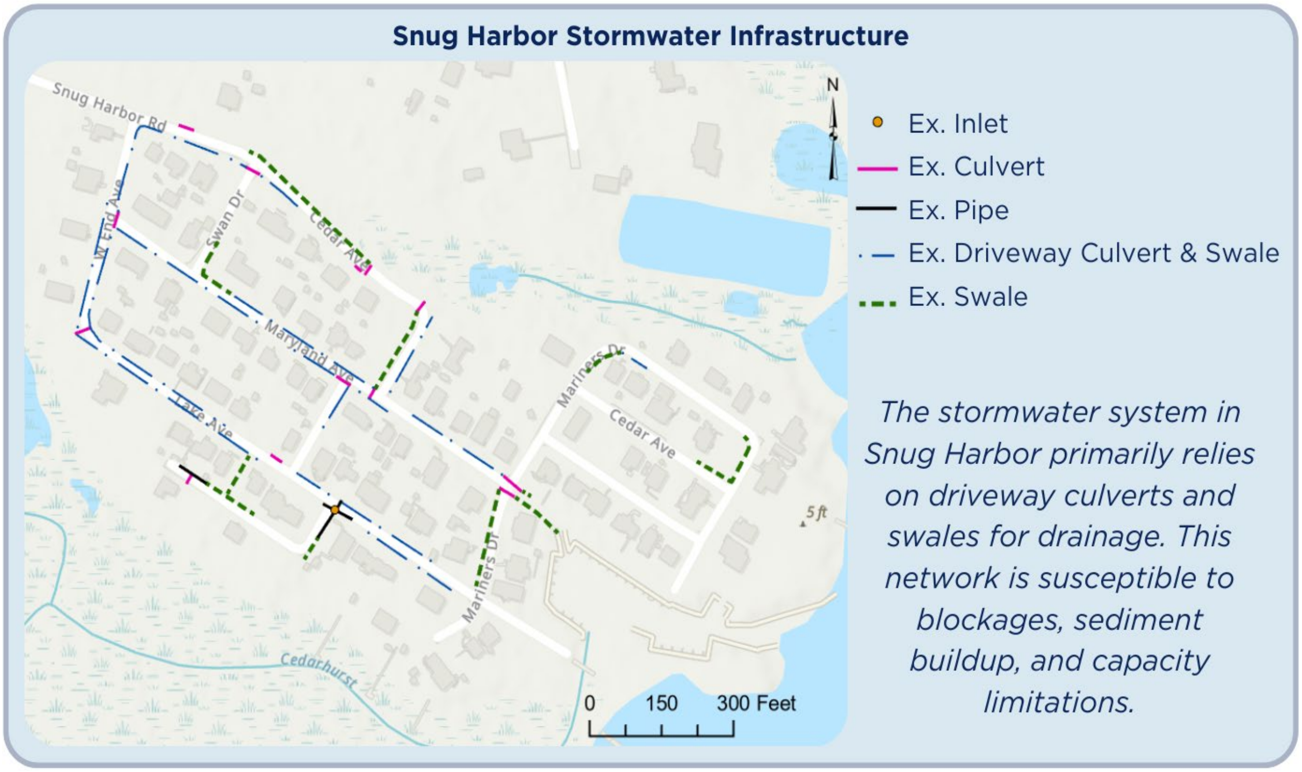


Figure 23 – Snug Harbor Mapped Stormwater Infrastructure

Field assessments identified widespread issues within Snug Harbor's stormwater infrastructure, with many driveway and road culverts either damaged or obstructed by sediment and debris, exacerbating localized flooding (Photo 38 and Photo 39). Inlets were frequently blocked by accumulated sediment, restricting drainage capacity and prolonging standing water (Photo 40). Repeated flood events have also led to erosion at pavement edges, compromising road integrity and accelerating infrastructure deterioration (Photo 41).

Photo 38 – Blocked culvert

Photo 39 – Crushed culvert

Photo 40 - Inlet blocked by sediment and debris

Photo 41 – Eroding edge of pavement

Stormwater flooding in Snug Harbor presents severe and widespread risks due to the community's extremely low-lying topography. As shown in Figure 24, even a 2-year rainfall event in 2050 results in significant inundation, particularly throughout the residential core of the community. Flooding depths reach more than four feet along Maryland Avenue, Cedarhurst Road, and Lake Avenue, with nearly all residential blocks experiencing some degree of inundation. These impacts intensify with increasing rainfall severity, resulting in nearly continuous deep flooding across the majority of the neighborhood during the modeled 100-year event.

These projections reinforce field assessments of localized drainage failures and indicate that Snug Harbor's minimal stormwater conveyance network is unlikely to accommodate even minor rainfall events in future conditions. The combination of low elevations, limited outfall capacity, and backflow from nearby tidal waters compounds the issue, creating conditions where routine rain events can yield widespread and prolonged standing water.

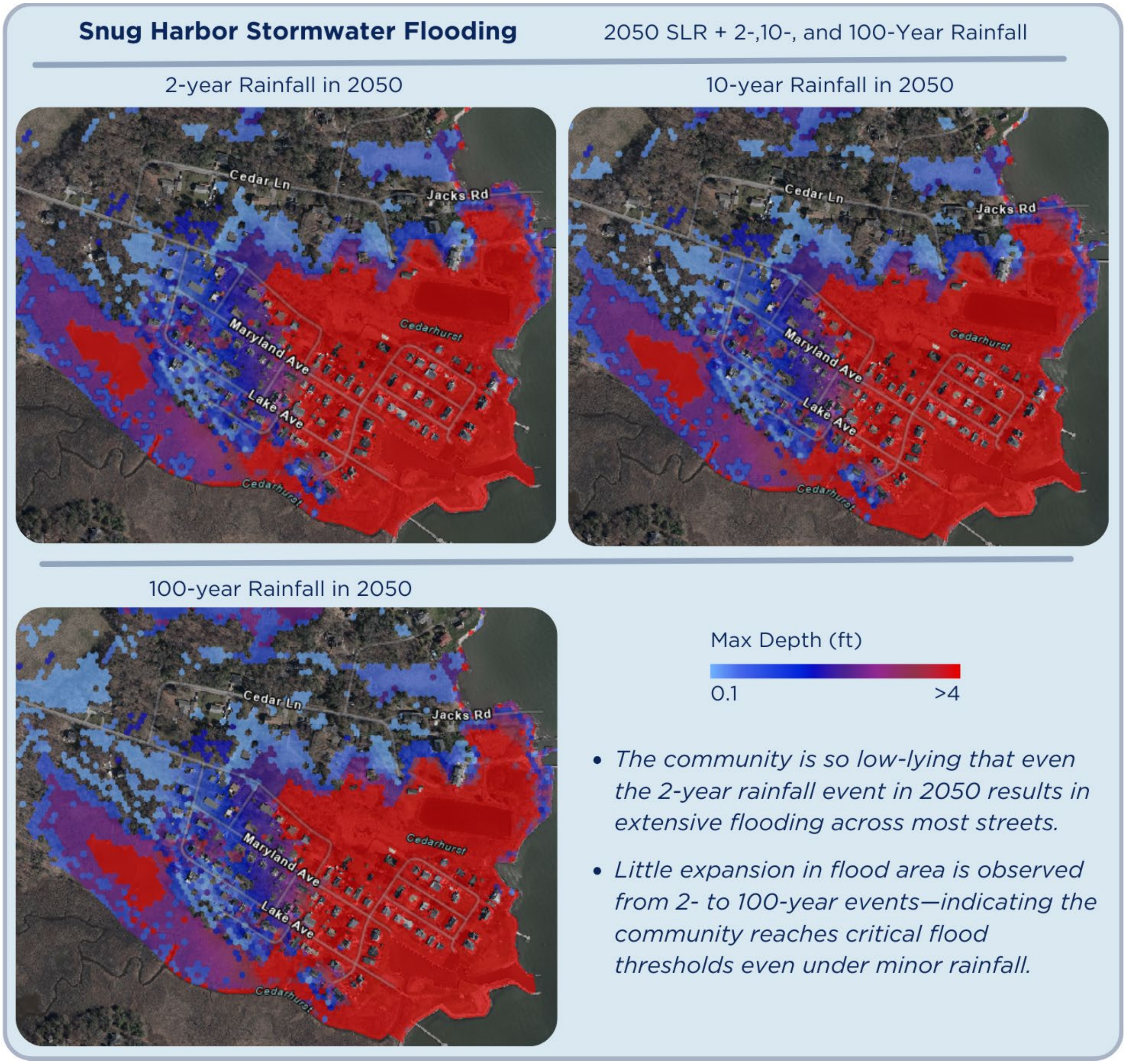


Figure 24 – Projected Stormwater Flooding Depths for the 2050 2-, 10-, and 100-Year Rainfall Events in Snug Harbor, assuming sea level rise conditions.

When storm surge is imposed onto these rainfall events, the flood footprint expands considerably. As seen in Figure 25, the combination of SLR, rainfall, and surge dramatically elevates flood depths and increases inland inundation, with minimal effective drainage during peak conditions. The added influence of tidal backwater eliminates any opportunity for stormwater outflows, causing floodwaters to spread well beyond existing ponding areas and further isolate the neighborhood.

Stormwater infrastructure in the northern portion of Snug Harbor, including Cedar Lane, Jacks Road, and Goose Creek Road, is also highly vulnerable to inundation, with flood depths exceeding 2 feet in some areas. The combination of storm surge, rising sea levels, and insufficient drainage capacity will increasingly isolate sections of the community, making long-term resilience strategies essential to mitigating flood risks.

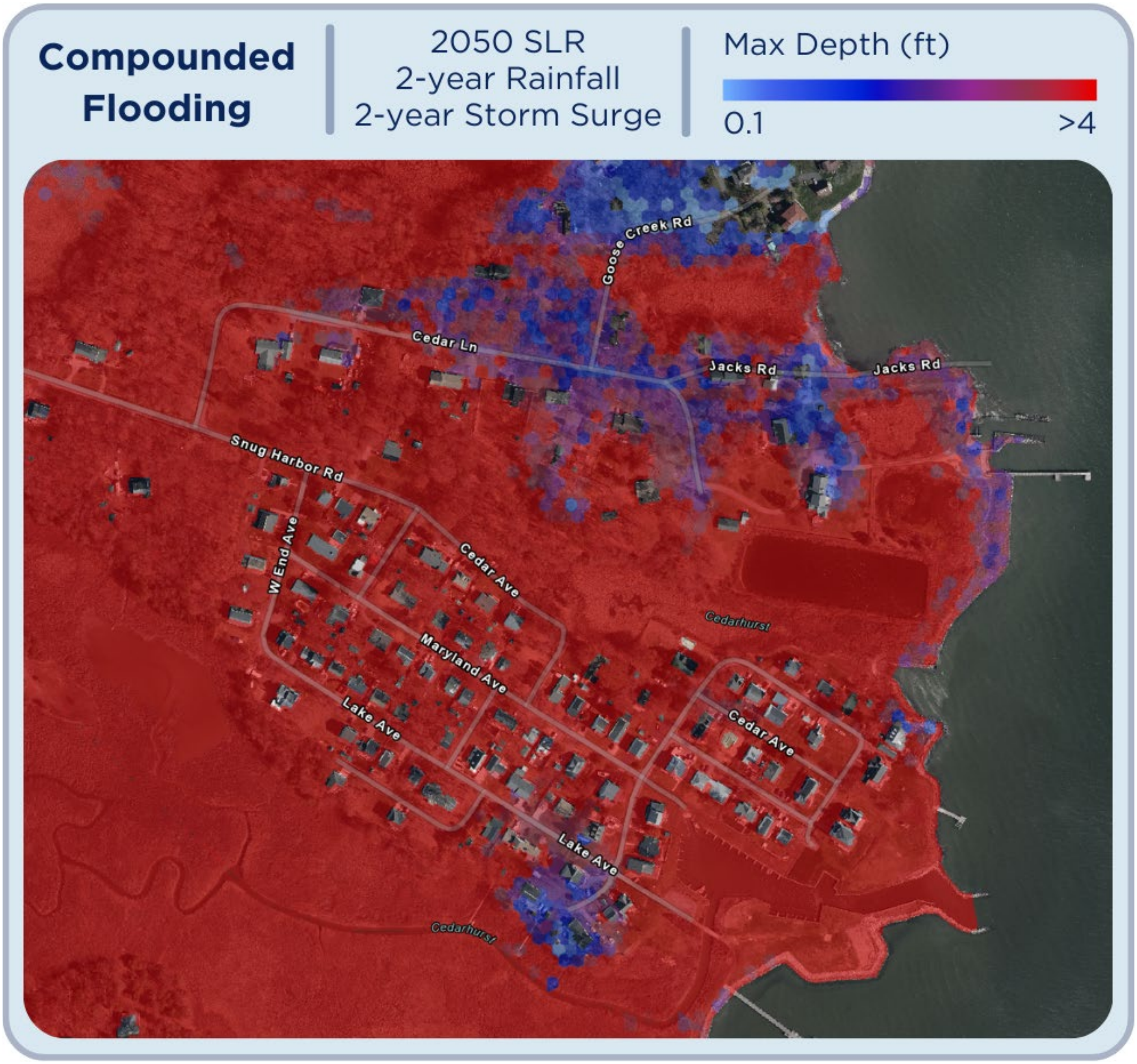


Figure 25 – Projected Stormwater Flooding Depths for the 2050 2-Year Rainfall and 2-Year Storm Surge Scenario in Snug Harbor

During Tropical Depression Debby, floodwaters reached significant depths, blocking access to key roadways within Cedarhurst. More than 1.5 feet of water inundated Chesapeake Avenue and Bay Avenue, making travel impassable (Figure 26).

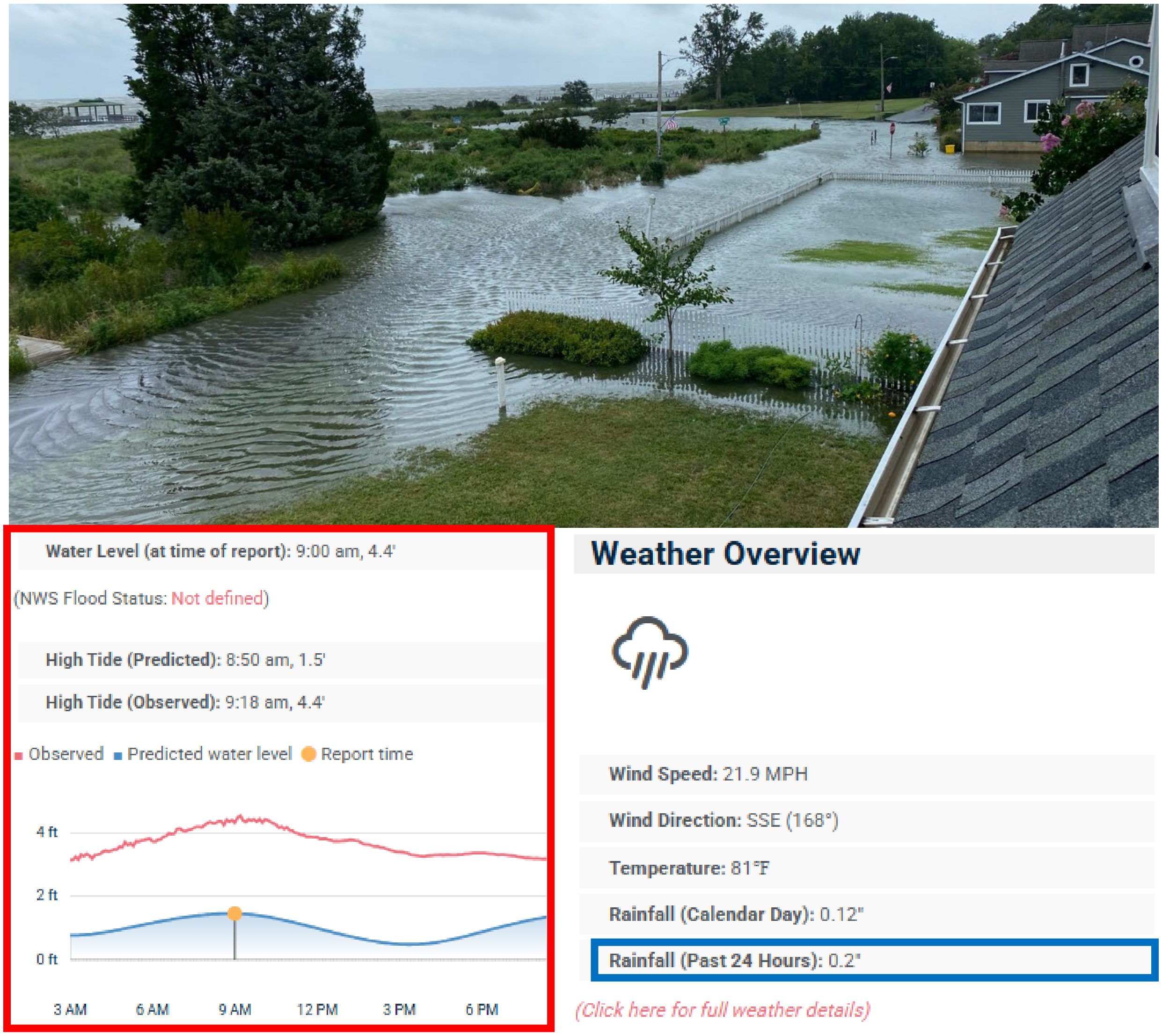


Figure 26 – Maryland MyCoast Report during Debby showing flooding to Chesapeake Avenue and Bayview Avenue
*Note: Red Box showing associated observed water levels; and blue box showing rainfall at the time of the photo.

At the marina, the bulkhead was entirely overtopped, with water depths exceeding two feet in some areas (Photo 45). Along Bay Avenue, floodwaters reached +3.64 feet NAVD88, rendering the roadway impassable with flood depths of approximately one foot (Photo 46).

Photo 42 - Marina bulkhead completely overtopped, and some areas flooded more than two feet
Water level: +3.77' NAVD88 (or 3.11' above MHW)

Photo 43 - Bay Avenue flooded during Tropical Depression Debby
Water level: +3.64' NAVD88 (or 2.98' above MHW)

SLR projections indicate that by 2050, routine tidal flooding will affect large portions of Snug Harbor, with inundation worsening by 2065 and 2100 (Figure 27). By 2065, daily flood depths in residential yards and properties near the basin will reach approximately one foot. The open community space along the Chesapeake Bay will transition to tidal marsh as flood depths at mean higher high water (MHHW) exceed one foot in some areas. Homes adjacent to wetlands at the southern end of Mariners Drive and south of Bay View Drive will face increasingly frequent flooding, with water depths of up to 1.5 feet encroaching on residential properties. The intersection of Goose Drive and Cedar Avenue will experience daily tidal flooding, with water depths reaching four inches. Additionally, non-tidal marsh buffers that currently help mitigate flooding will degrade, remaining saturated and unable to provide effective flood protection.

By 2100, key roadways (Cedar Avenue, Goose Drive, the intersection of West End Avenue and Lake Avenue, and sections of Mariners Drive) will be permanently submerged, with flood depths exceeding three feet. This level of inundation will make safe transportation and emergency access impossible, isolating residents and severely limiting connectivity to essential services.

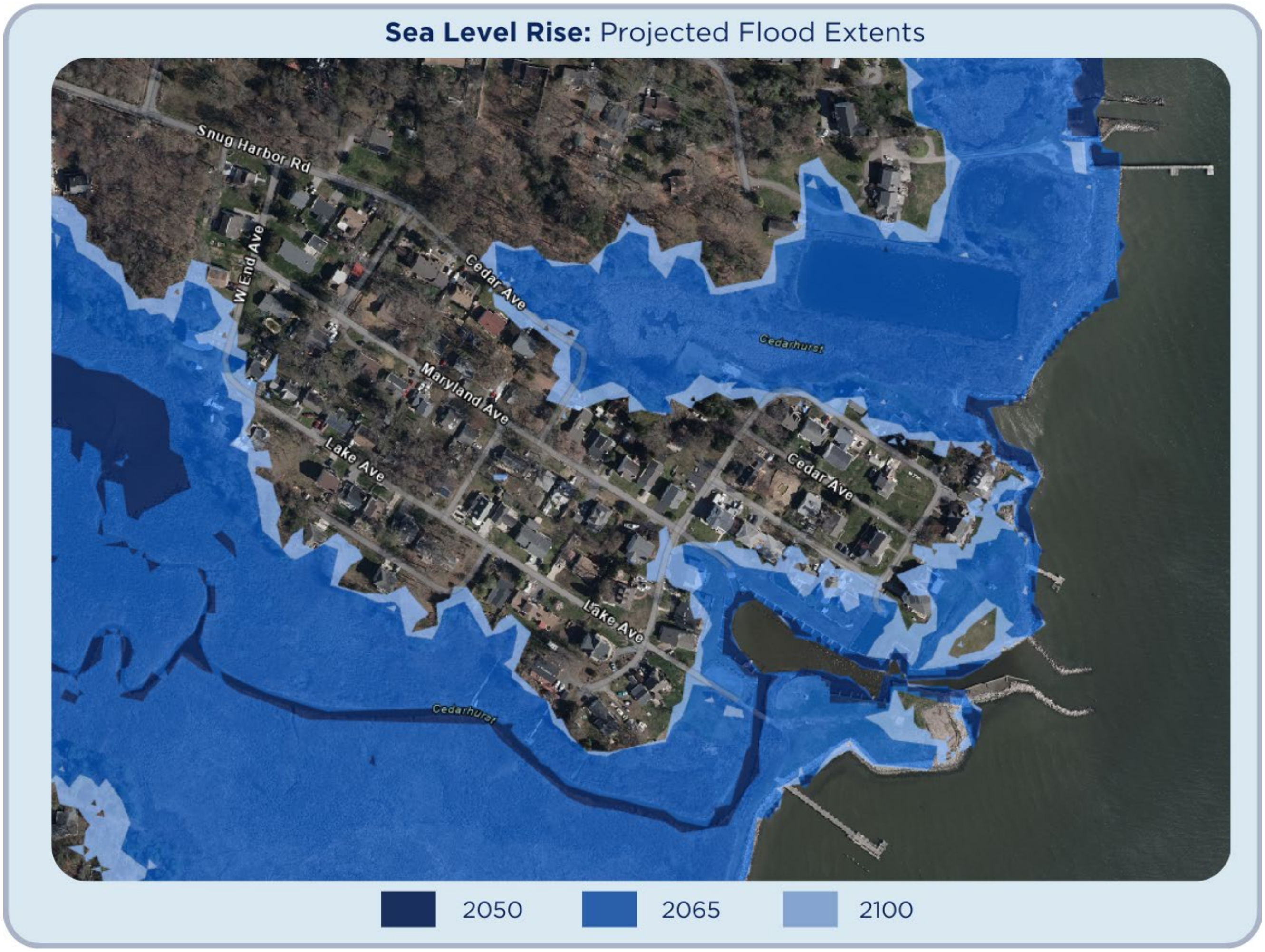


Figure 27 – Map of Anticipated Flood Extents of 2050, 2065, and 2100 SLR Scenarios. Increasing inundation threatens roadways, properties, and drainage infrastructure, highlighting the need for long-term flood mitigation strategies.

As SLR projections indicate increasing flood exposure in Snug Harbor, the vulnerability of the community extends beyond periodic coastal flooding to include deficiencies in stormwater drainage infrastructure and shoreline stability. With roadways, properties, and drainage systems at risk of inundation, a comprehensive understanding of the contributing flood factors is critical for identifying targeted mitigation strategies. The following flooding report card synthesizes key vulnerabilities to provide a holistic view of Snug Harbor's flood risk profile (Table 14).

Table 14 – Snug Harbor Flooding Report Card		
Category	**Rating**	**Justification**
Flood Pathways	High	The community experiences significant flood exposure, with widespread road and property inundation during coastal storm events and high tides. SLR projections indicate increasing risk.
Stormwater Drainage	Moderate	The stormwater system consists mainly of driveway culverts and swales, many of which are blocked, undersized, or failing. Some areas experience standing water and periodic flooding.
Infrastructure Vulnerability	Moderate	Some roads and properties are impacted during storm events, though primary access remains mostly functional except during extreme conditions.
Erosion & Shoreline Stability	Moderate	The shoreline is primarily bulkheaded and protected by stone, but gaps and undersized structures leave sections vulnerable to wave energy and erosion. Rising sea levels threaten natural marsh buffers.
Overall Flood Threat	**Moderate**	**The combination of coastal flood pathways, stormwater drainage deficiencies, and shoreline vulnerability contribute to frequent flooding risks.**

4.1.5. Cedarhurst

Cedarhurst is a waterfront community on the eastern shore of Shady Side, located just south of Snug Harbor. A key landmark in the community is the Cedarhurst Marina, offering over 60 boat slips and providing direct access to the Chesapeake Bay. The neighborhood's low-lying elevation, ranging from +3.0 feet NAVD88 to +3.5 feet NAVD88, makes it particularly vulnerable to rising water levels. The northern extent of the neighborhood is bordered by a natural wetland, and low elevations connecting the wetland to central parts of the neighborhood (+2.25 feet NAVD88) further expose the area to tidal inundation and storm-driven flooding.

Photo 44 - Bay-facing revetment along community property near the marina entrance

The Cedarhurst shoreline is primarily characterized by stone revetments, with the marina area protected by bulkhead (Figure 28 and Photo 42). Bay-facing stone protection features crest elevations of +6.0 feet NAVD88 (Photo 42), while the marina bulkhead averages +2.7 feet NAVD88. South of Oak Avenue, a non-tidal marsh serves as a buffer, helping to mitigate direct wave energy and flooding impacts from the low-lying intersection of Bayview Avenue and Chesapeake Avenue (Road Crest Elevation: +2.5 feet NAVD88) (Photo 43).

At their current elevations these structures are not sufficient to protect against flooding, especially during high tides and storm surges given the direct exposure to the Chesapeake Bay (Photo 44). The marina bulkhead, in particular, is frequently overtopped, leaving adjacent properties increasingly vulnerable.

Photo 45 - Non-tidal marsh protected by stone revetment between Chesapeake Avenue and the bay (Top of Stone +4.5' NAVD88; Marsh Elevation +1.5' to +3.0' NAVD88)

Photo 46 - Cedarhurst Marina bulkhead overtopped during high tide event (April 12, 2024)
Water level: +2.71' NAVD88 (or 2.05' above MHW)

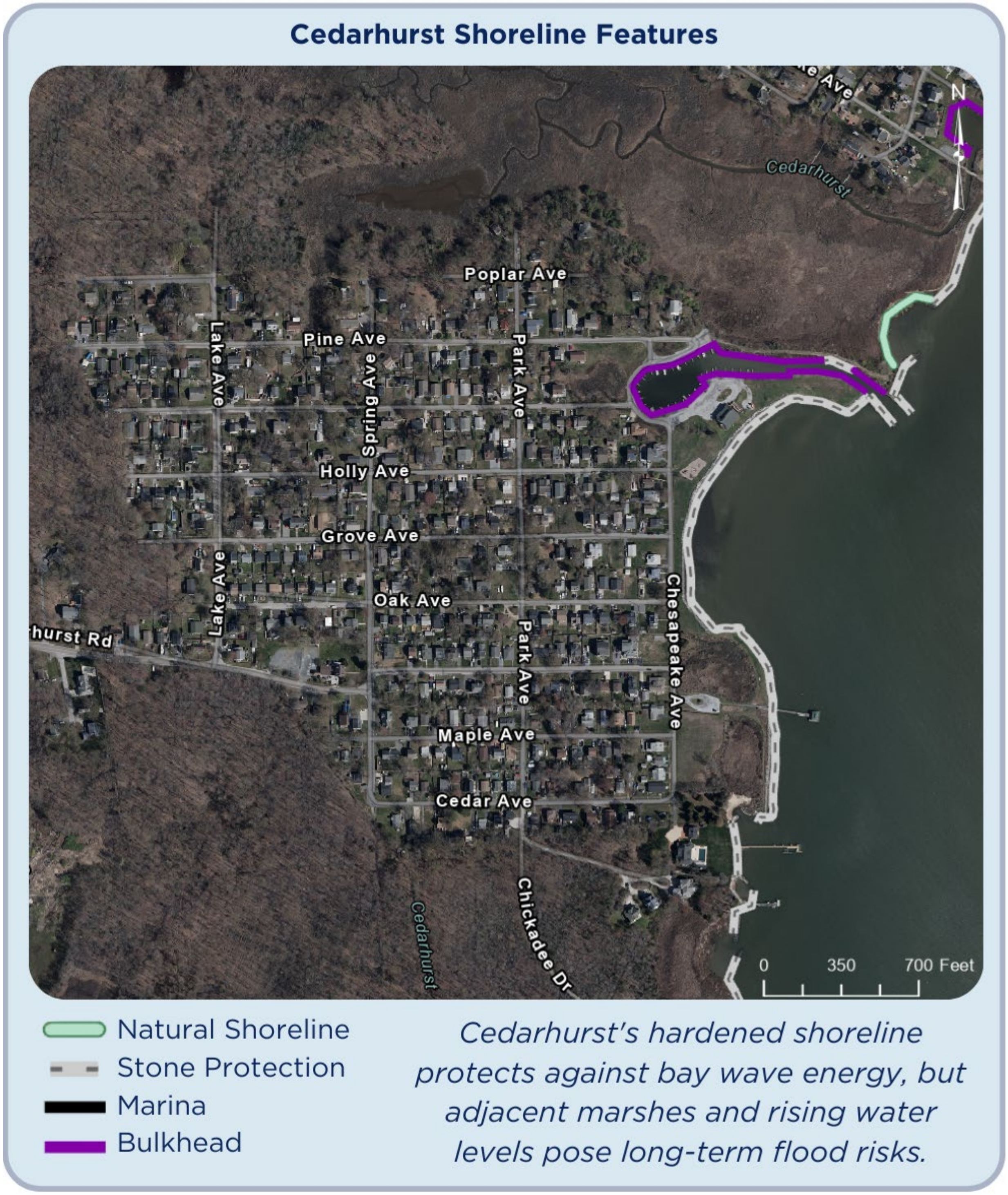


Figure 28 – Shoreline Features in Cedarhurst

Similar to the other Shady Side communities, stormwater infrastructure throughout Cedarhurst consists mainly of grassy and concrete swales and driveway culverts (Photo 47). These culverts and swale systems lead to inlets and storm pipes, which discharge at tidal outfalls located at the end of Oak Avenue, Bay View Avenue, Maple Avenue, and Cedar Avenue (Figure 29).

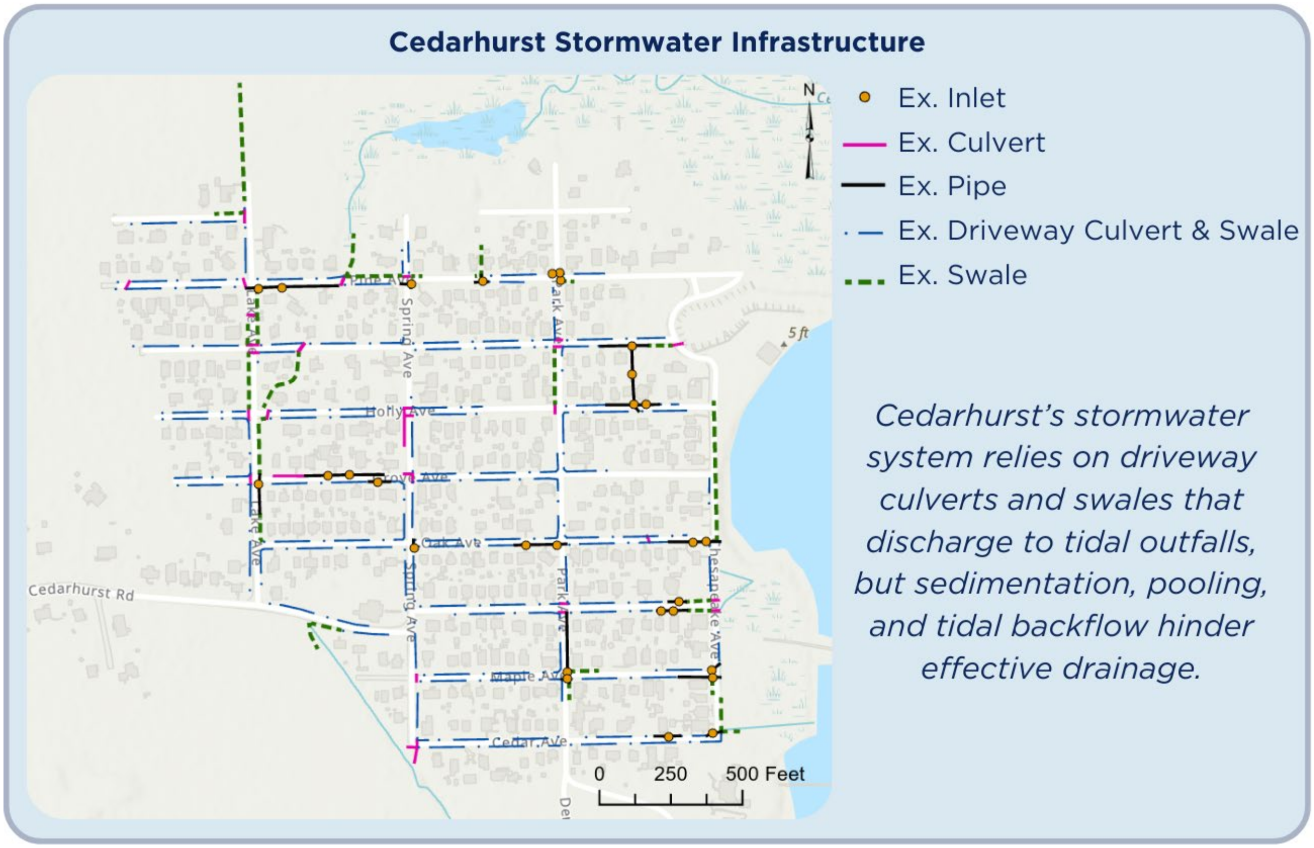


Figure 29 – Cedarhurst Stormwater Infrastructure Mapped During Field Assessment

One of the common issues observed during field investigations was sedimentation in the driveway culverts, blocking proper conveyance (Photo 48). Some roadside swales in the community exhibited pooling water, indicating inadequate drainage capacity or a lack of maintenance (Photo 49). During high tide, tidal waters backflow into the outfalls, hindering rainfall from draining effectively into the tidal waters (Photo 50 and Photo 51).

Photo 47 - Concrete swale

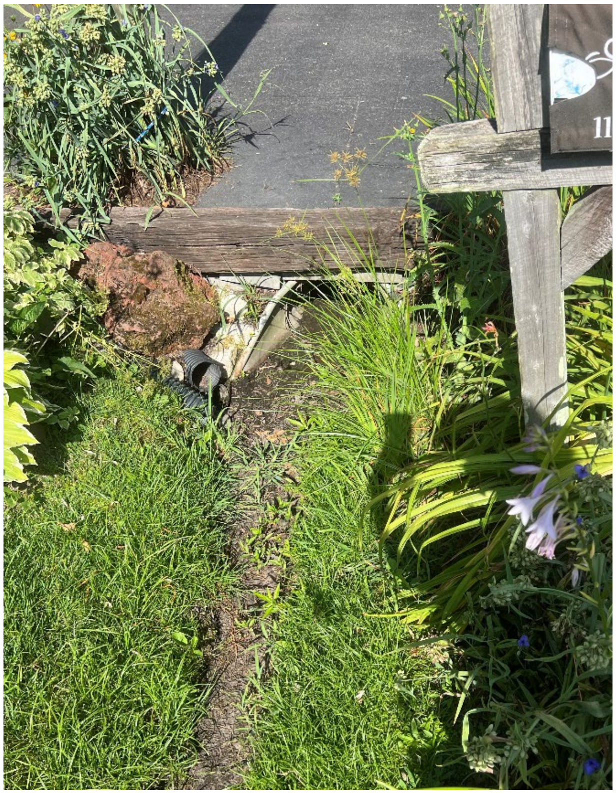


Photo 48 - Sedimentation in driveway culvert

Photo 49 - Standing water in driveway culvert/swale system

Photo 50 - Partially submerged tidal outfall at the Cedarhurst Marina

Photo 51 - Flooded inlet approaching low tide
Water level: +0.03' NAVD88 (or 0.63 below MHW)

Stormwater flooding in Cedarhurst is widespread due to the community's low-lying topography, inadequate drainage infrastructure, and increasing tidal influences. As shown in Figure 30, model results for the 2050 2-, 10-, and 100-year rainfall events reveal consistent flooding across the neighborhood, with shallow to moderate flood depths affecting both roadways and residential lots.

Flooding is especially prevalent along the western portion of Cedarhurst, with streets such as Spruce Avenue, Maple Avenue, and Grove Avenue repeatedly inundated across all rainfall scenarios. The intersection of Pine Avenue and Cedar Lane, as well as the northern portion of Cedar Avenue, show noticeable escalation in flood depth from the 2-year to 100-year events and ultimately reaching depths over four feet. While many flood-prone areas are concentrated in depressions or near drainage outfalls, the pattern of flooding indicates widespread runoff retention due to limited stormwater conveyance and tidal backwater interference.

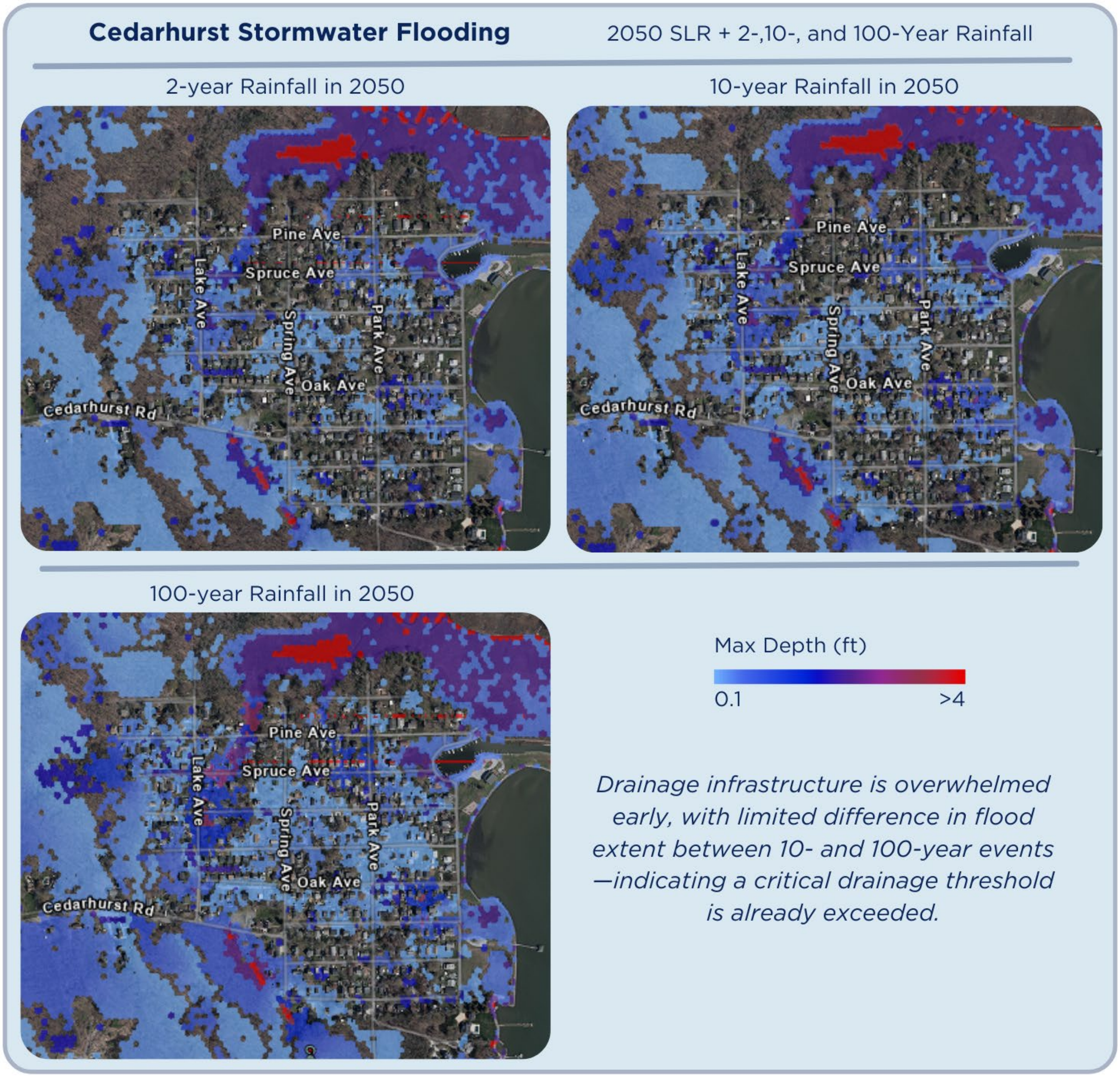


Figure 30 – Projected Stormwater Flooding Depths for the 2050 2-, 10-, and 100-Year Rainfall Events in Cedarhurst, assuming sea level rise conditions.

The already extensive flood extents under rainfall-only conditions become even more severe when storm surge is considered. Figure 31 highlights the combined effects of the 2050 2-year rainfall and a concurrent 2-year storm surge event, demonstrating how tidal backflow prevents stormwater drainage and exacerbates flood depth and coverage throughout the community.

Along Spruce Avenue, Oak Avenue, and Bayview Avenue, existing stormwater swales and culverts fail to effectively convey runoff to the bay, resulting in prolonged flooding of upland residential properties. These areas see extensive inundation, particularly where roadway depressions and undersized culverts contribute to water pooling. As shown in the model results, these areas experience significant stormwater retention, exacerbating flood risks for homes and roadways.

By 2050, the combined effects of SLR, tidal backwater, and insufficient drainage infrastructure will make stormwater flooding a persistent issue throughout Cedarhurst. Without substantial improvements to drainage capacity, road elevations, and outfall efficiency, floodwaters will continue to encroach into residential areas and compromise transportation access.

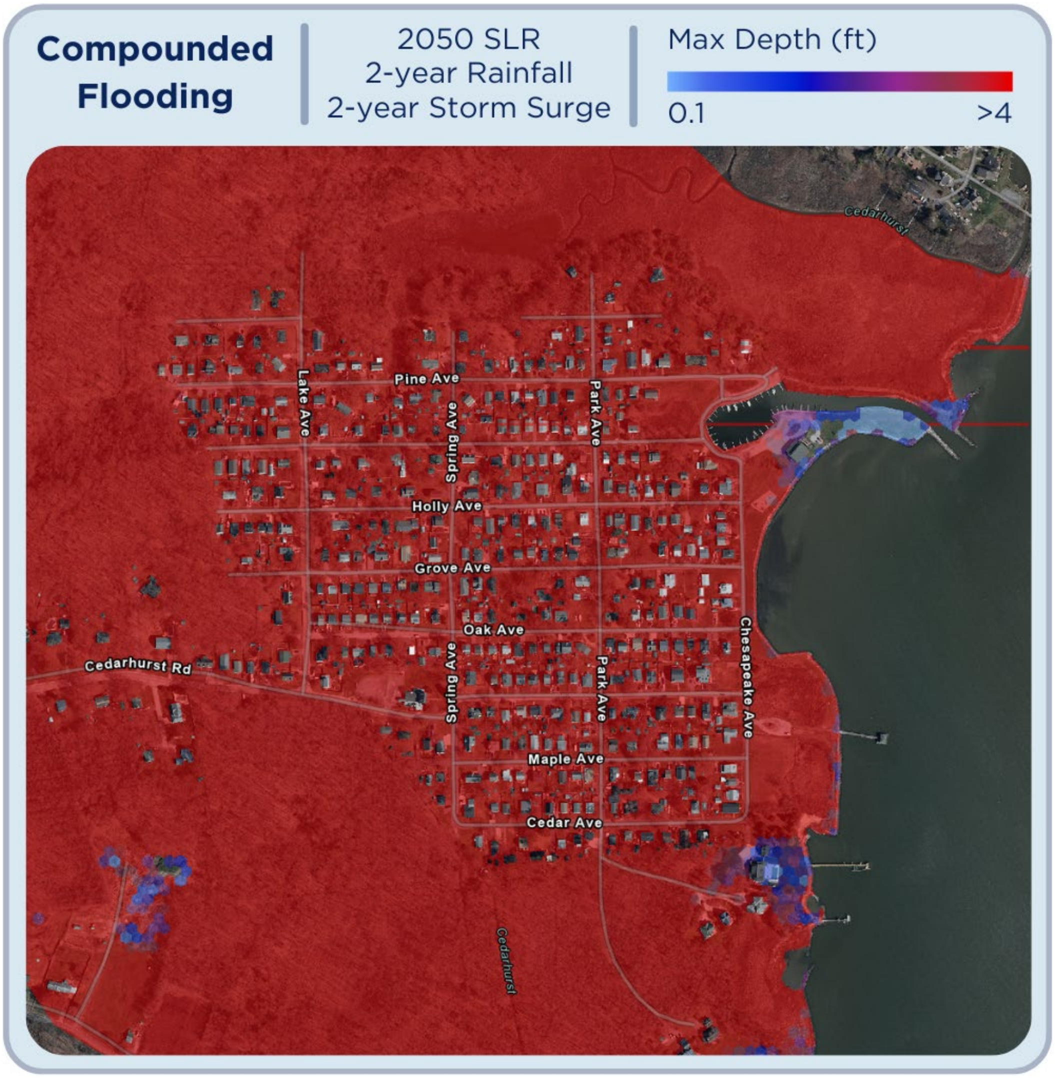


Figure 31 – Projected Stormwater Flooding Depths for the 2050 2-Year Rainfall and 2-Year Storm Surge Scenario in Cedarhurst

Existing shoreline protection infrastructure protects the shoreline from extreme erosion but are insufficient to mitigate flooding. As sea levels rise, the extent of regular inundation will increase, leading to more frequent and severe nuisance flooding as well as greater storm-related flood impacts (Figure 32). By 2065, properties along the eastern and northern edges of the neighborhood will experience daily tidal inundation, and by 2100, regular flooding will extend further into central parts of the community.

By 2050, the marina's bulkhead will be overtopped daily. By 2065, the area behind the marina, between Pine and Spruce Avenues, will be permanently inundated. Daily tidal flooding will also encroach deeper into the developed residential area, reaching up to half a foot of water at the street level along Holly Avenue. At the northern boundary of the neighborhood, flood pathways from the adjacent wetlands will extend into central areas between Pine Avenue and Grove Place, with flood depths reaching two feet near Pine Avenue and approximately 0.5 feet near Grove Place. Along the bayfront shoreline, the intersection of Bayview Avenue and Chesapeake Avenue will see regular flooding, with water levels reaching up to 0.5 feet on Chesapeake Avenue and one foot in the lower-lying sections of Bayview Avenue. The transition of the non-tidal marsh into a fully tidal system will allow flooding and wave energy to propagate further inland, increasing the risk to nearby properties. By 2100, flooding in these areas will continue to expand, affecting adjacent properties and increasing flood depths significantly. Large portions of the neighborhood will be subject to permanent inundation, with some areas experiencing flood depths exceeding five feet.

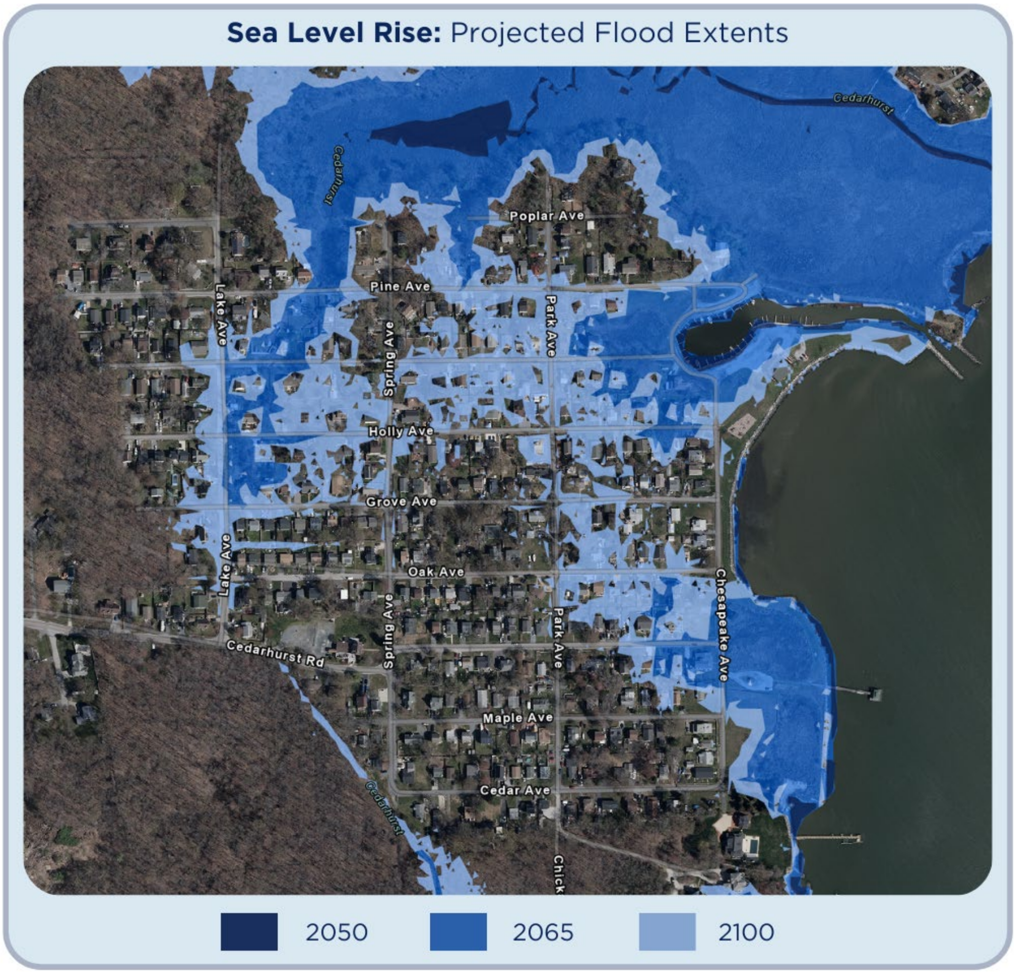


Figure 32 – Projected SLR Flood Extents in Cedarhurst indicate increasing exposure over time, particularly along Chesapeake Avenue and the northern extent of the neighborhood bordered by marsh area.

As SLR worsens existing drainage issues and shoreline vulnerabilities in Cedarhurst, a comprehensive assessment of flood pathways, stormwater infrastructure, and shoreline stability is necessary to guide mitigation efforts. The following flooding report card summarizes key factors contributing to flood risk in the community highlighting areas requiring urgent intervention (Table 15).

Table 15 – Cedarhurst Flooding Report Card		
Category	**Rating**	**Justification**
Flood Pathways	High	Cedarhurst experiences significant tidal flooding along its shoreline, with projected SLR further increasing exposure. Tidal backflow through stormwater outfalls exacerbates flood risks. Additionally, as water levels rise in the wetland bordering the community to the north, homes in this area will flood more regularly.
Stormwater Drainage	Moderate	The system consists of driveway culverts, swales, and outfalls, but sediment buildup and tidal backflow hinder effective drainage, leading to standing water and localized flooding.
Infrastructure Vulnerability	High	While roads generally remain accessible, flooding along Chesapeake Avenue and low-lying streets affects properties and access routes in the densely populated area, particularly during high tides and storm events.
Erosion & Shoreline Stability	Moderate	Bulkheads and revetments provide erosion protection but are insufficient to prevent overtopping and long-term shoreline retreat due to rising sea levels.
Overall Flood Threat	**High**	**The combination of coastal flood exposure, stormwater drainage limitations, and shoreline vulnerability contributes to frequent flooding risks that will worsen drastically with SLR and increased storm frequency and intensity.**

4.1.6. Columbia Beach

Columbia Beach, located on the eastern edge of the Deale-Shady Side Peninsula, was founded in 1940 as a summer retreat for African Americans and remains one of only five historically Black beaches on the western shore of the Chesapeake Bay. Today, Columbia Beach is a diverse neighborhood, comprising 188 homes spread across 67 acres. Managed by the Columbia Beach Citizens Improvement Association (CBCIA), this unincorporated community operates as a Special Community Benefit District (SCBD), with public works and community property maintenance funded and governed by an all-volunteer association.

Photo 52 - Early Columbia Beach summer celebration. (source: CBCIA)

Photo 53 - Early Columbia Beach summer celebration. (source: CBCIA)

Photo 54 - Sign marking Columbia Beach, MD as a historic community

The topography is very flat with its highest elevation at +/- 8 feet NAVD88. This low-lying nature, coupled with Deale-Shady Oak soils, characterized by poor drainage and high water table, presents significant challenges in managing stormwater and mitigating flood risks.

The community's shoreline has undergone significant changes due to natural processes and human interventions. Erosion and storm impacts have necessitated the construction of protective structures. A stone revetment was installed along the eastern shoreline to combat erosion from the wave climate of the direct Bay exposure (Figure 33).

The main entrance to the neighborhood is overtopped during elevated water levels with crown elevations between three and four feet above NAVD88, or only two to three feet above MHW. The road is regularly flooded due to nuisance flooding (Photo 55). During Tropical Depression Debby, water levels to almost four feet above NAVD88 inundating Columbia Beach Road and inhibiting safe ingress/egress to the community (Photo 56).

Photo 55 - Columbia Beach Road during high tide flooding in April
Water level: +3.22' NAVD88 (or 2.6' above MHW)

Photo 56 - Columbia Beach Road flooding during Tropical Depression Debby
Water level: +3.77' NAVD88 (or 3.1' above MHW)

Columbia Beach Shoreline Features

Columbia Beach has a hardened Bay-facing shoreline, but is surrounded by natural marsh along the south and west, leaving it vulnerable to rising water levels from multiple directions.

Figure 33 – Shoreline Features in Columbia Beach

Columbia Beach faces a unique flooding challenge due to its exposure to tidal waters from multiple directions. The community is bordered to the north and east by the Chesapeake Bay, to the south by Franklin Point State Park, and to the west by Flagg Pond. This positioning exposes the community to tidal waters from multiple directions, particularly from the southeast where fetch over the Chesapeake extends over 100 miles, allowing for significant wave action during storms. The existing stone revetment offers erosion control but does little to alleviate storm surge or flooding from extreme storm events (Photo 56 and Photo 57).

Photo 57 - Flooding and wave overtopping during Tropical Depression Debby

On the southern and around the western shorelines, the community faces a different but equally significant flooding dynamic. Here, Columbia Beach is bordered by low-lying wetlands, tidal creeks, and marshes. While these natural systems provide critical flood storage and ecosystem services, they also act as conduits for water to encroach into the community during periods of high tides or extreme precipitation. Unlike the easter shoreline, where wave energy and overtopping are a dominant factor, the flooding on the southwest and west is more gradual, driven by slow backwater effects from tidal inundation and stormwater overflow. The regular ebb and flood of tidal waters in these wetlands create "creeping" flood effect, as water slowly rises and moves inland, inundating properties from the opposite direction of the Bay (Photo 58).

Photo 58 - Western shoreline property inundated during high tide flooding
Water level: +3.22' NAVD88 (or 2.6' above MHW)

The interaction of these two distinct coastal flooding mechanisms—direct wave impact and storm surge on the east and slow tidal encroachment from the wetlands on the west—creates a complex hydrodynamic environment.

As the Columbia Beach community developed and residential improvements were made, stormwater runoff increased, largely as a result of impervious coverage. Drainage system infrastructure was installed to convey this additional runoff away from residential areas but updates to the system over time occurred in a piecemeal fashion. The existing drainage system comprises open swales connected by roadway and driveway culverts with some rain gardens and infiltration systems. However, these systems are undersized for current rainfall patterns, which are becoming more intense and frequent due to climate change. This has led to widespread ponding on residential properties and degradation of roadways where standing water persists (Photo 59 - Photo 61). Sedimentation, organic matter accumulation, and crushed or buried culverts further impair the system's functionality, exacerbating the community's flooding challenges. The stormwater conveyance system in Columbia Beach was not modeled in this assessment as a separate drainage assessment and conveyance improvement plan was completed for the community in June 2023, by BayLand and summarized in the Columbia Beach Community Stormwater Conveyance Approach & Recommendations report[9].

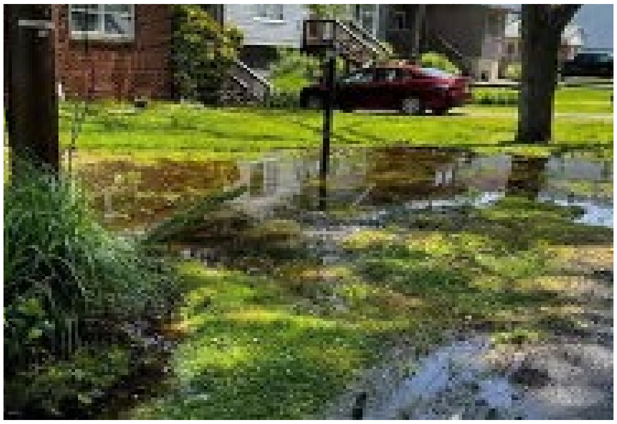


Photo 59 - Flooding of residential areas (Bay Drive)

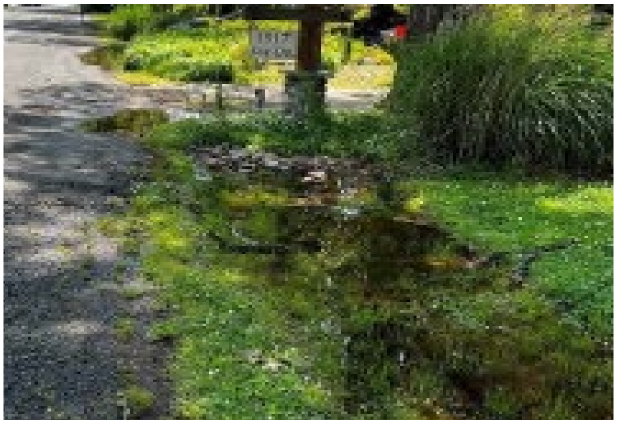


Photo 60 - Existing swale ponding due to removed culvert

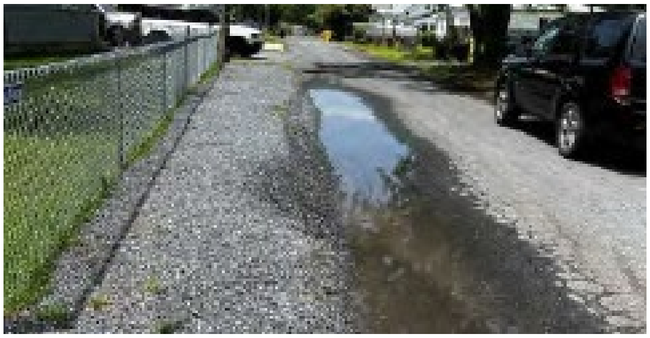


Photo 61 - Water ponding due to swale removal

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[9] BayLand Consultants & Designers, Inc. *Columbia Beach Community Stormwater Conveyance Approach & Recommendations*. Prepared for the Columbia Beach Citizens Improvement Association, June 2023.

Columbia Beach faces a dual threat from SLR, with exposure to both direct wave action from the Chesapeake Bay and tidal encroachment from the surrounding wetlands (Figure 34). The bay-facing shoreline, hardened with stone revetments, mitigates erosion but does not prevent water from overtopping during storms and extreme high tides. Meanwhile, Flagg Pond and the adjacent marshes create a secondary flood pathway, allowing gradual inundation of the community from the south and west.

By 2065, the projected SLR threatens the integrity of the marsh that buffers the southern tip of Columbia Beach. As daily high tide flooding increases, marsh vegetation becomes increasingly vulnerable, leading to erosion, habitat loss, and eventual collapse. Without the marsh acting as a natural barrier, wave energy and floodwaters will more easily encroach on upland areas. This process accelerates the loss of natural flood protection. Furthermore, as water levels continue to rise, additional sections of the community will experience frequent tidal flooding, leading to the progressive isolation of homes and infrastructure. By 2100, the frequency and depth of flooding will create significant access challenges, affecting both emergency response and daily mobility residents.

The interplay between storm-driven flooding, tidal backflow, and interaction of bay side and wetland flood pathways highlights the complexity of flood risk in Columbia Beach. Any proposed flood mitigation efforts must consider how changes to one system may influence the other. For example, installing a flood barrier on the eastern shoreline alone would have limited impact. Similarly,

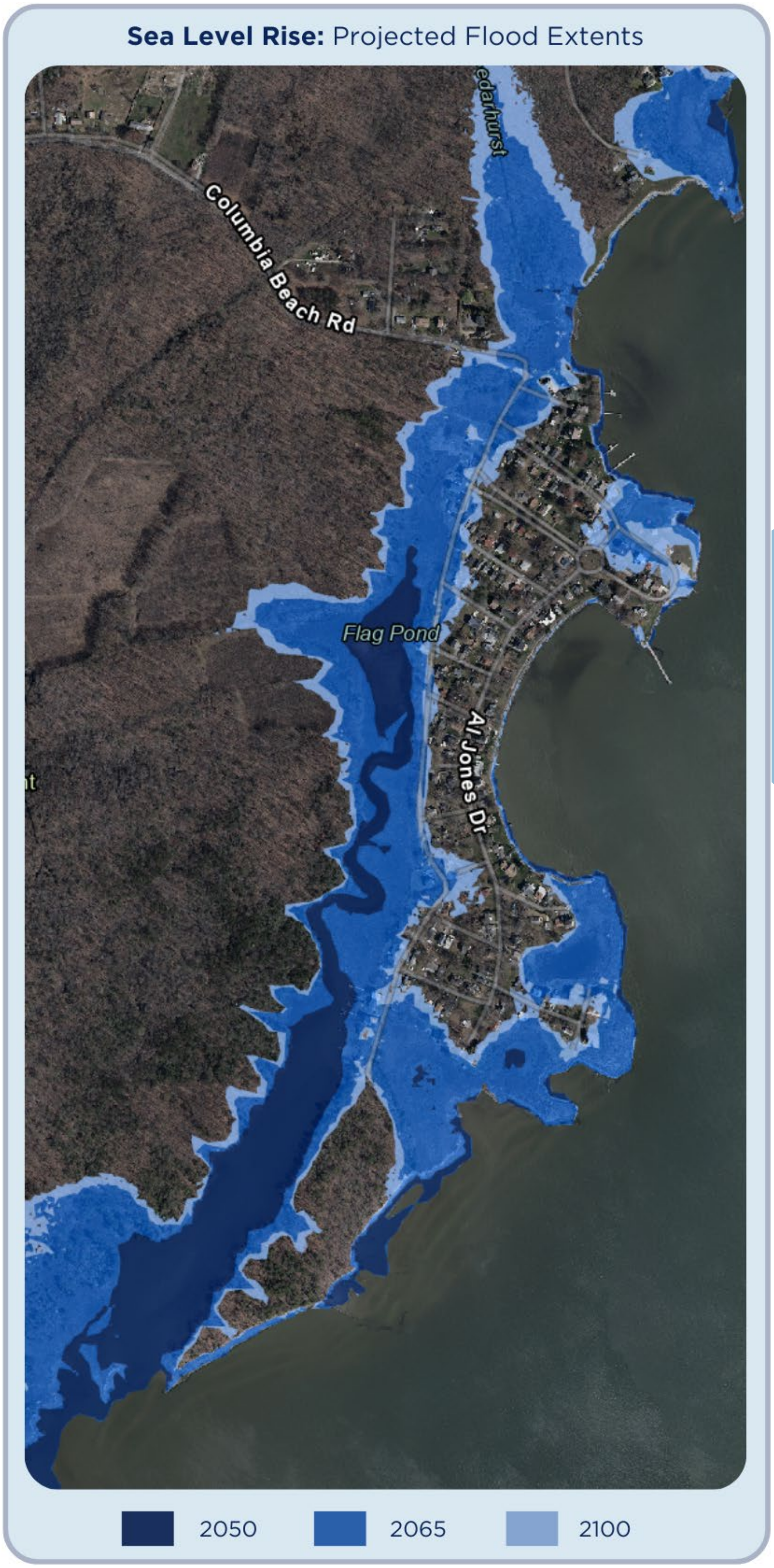


Figure 34 – Projected SLR Impacts for Columbia Beach, illustrating increasing inundation from the Chesapeake Bay and the surrounding marsh.

modifications to the natural flow of water through the marsh and wetland systems could impact their ability to buffer storm surges and filter water. A holistic systems-based approach is essential for designing solutions that balance flood protection with ecological integrity. Innovative stormwater management strategies, such as submerged gravel wetlands and tide gates, can support this balance, reducing flooding while maintaining the functionality of natural wetland systems.

The following flooding report card assesses the primary drivers of flooding in Columbia Beach, categorizing risk levels to help guide mitigation efforts (Table 16).

Table 16 – Columbia Beach Flooding Report Card

Category	Rating	Justification
Flood Pathways	High	Flooding occurs from both the eastern bay-facing and western Flagg Pond shorelines. Storm surge overtopping the revetment and high tides inundating low-lying areas create persistent flood risks even today.
Stormwater Drainage	Moderate	The system consists of driveway culverts, swales, and outfalls, but sediment buildup and tidal backflow hinder effective drainage, leading to standing water and localized flooding.
Infrastructure Vulnerability	High	While roads generally remain accessible, flooding along Chesapeake Avenue and low-lying streets affects properties and access routes in the densely populated area, particularly during high tides and storm events.
Erosion & Shoreline Stability	High	Bulkheads and revetments provide erosion protection but are insufficient to prevent overtopping and long-term shoreline retreat due to rising sea levels.
Overall Flood Threat	**High**	**The combination of coastal flood exposure, stormwater drainage limitations, and shoreline vulnerability contributes to frequent flooding risks that will worsen drastically with SLR and increased storm frequency and intensity.**

In a May 2023 assessment, BayLand inspected runoff patterns and drainage infrastructure in Columbia Beach to develop recommendations for the repair of existing systems and to propose new systems. In 2024, Columbia Beach was awarded the National Fish and Wildlife Foundation’s (NFWF) Chesapeake Small Watershed Grant. This funding supports the Columbia Beach Community Stormwater Improvement Project, aiming to enhance the community’s resilience against flooding and improve water quality through innovative stormwater management solutions.

4.2. West River

West River is a historic community located on the northern portion of the Deale-Shady Side Peninsula, bordered by West River and extending into the Chesapeake Bay. This area is characterized by a blend of rural landscapes, waterfront homes, and small agricultural plots, which are interspersed with wetlands and tidal marshes. The study area for West River focuses on the vulnerable coastal region on the Peninsula, which frequently experiences nuisance flooding and erosion. Important roadways and community facilities and their ongoing exposure to rising tides and more frequent and intense storms necessitate thoughtful planning and investment in flood mitigation.

Photo 62 – Aerial view of West River, MD with Chalk Point in the forefront

4.2.1. Chalk Point

Chalk Point is the northernmost community in the West River study area and is bordered by West River. The West Chalk Point Road provides the only road access to the neighborhood. Located in this community is the Chalk Point Marina which offers over 40 slips and easy access to West River and the Chesapeake Bay.

Photo 63 – Minimal stone protection along Chalk Point Road (Top of Stone +2.0' NAVD88)

The shoreline of Chalk Point is predominately hardened, with bulkheads and stone protection armoring the extents of the neighborhood against erosive coastal processes (Figure 35 and Photo 64 and Photo 63). The community also includes stretches of natural shoreline within protected coves, which contribute to the area's ecological diversity (Photo 65).

Photo 64 - Private properties armored with revetments along Chalk Point's shoreline

Chalk Point Shoreline Features

Chalk Point's shoreline is largely stable due to bulkheads and natural coves, but rising water levels pose a significant risk of isolation as low-lying access routes become increasingly vulnerable

Figure 35 – Shoreline Features in Chalk Point

Photo 65 - Natural shoreline along narrowest stretch of West Chalk Point Road, the only ingress/egress route for the community

While hardened structures provide some erosion control, they are insufficient to prevent flooding at current elevations. Low-lying areas and natural shorelines remain vulnerable to rising water levels and storm-induced flooding, while residual standing water from tidal inundation frequently accumulates along the narrowest sections of West Chalk Point Road (Road Crown Elevation: +2.5 feet NAVD88), highlighting its susceptibility to recurrent flooding (Photo 66).

Photo 66 - Standing water on road edges

Chalk Point has minimal stormwater infrastructure, consisting mainly of driveway culverts, a few inlets, and some swales for drainage. While some infrastructure requires routine maintenance to restore conveyance, standing water from stormwater alone was not observed as a significant issue in the community (Photo 67 and Photo 68).

Photo 67 - Sedimentation blocking stormwater conveyance through driveway culvert and swale system

Photo 68 - Inlet filled with leaf litter

Figure 36 – Projected SLR Impact on Chalk Point Road, illustrating increasing inundation risks, particularly along the community's only access road.

Due to its low-lying topography at its access point (+2.5 feet NAVD88) and peninsular geography, Chalk Point is highly vulnerable to the impacts of SLR (Figure 36). Even under moderate projections, the access road to the community faces frequent inundation, which could isolate residents during daily flood conditions and limit emergency response capabilities. By 2065, West Chalk Point Road and Henry Avenue will flood daily with six to ten inches of standing water, and by 2100 the area is completely detached from the Peninsula. Rising water levels will also challenge the effectiveness of existing shoreline protections, particularly as these structures become increasingly overtopped during extreme tide events.

Chalk Point's flooding vulnerabilities stem primarily from its low-lying topography, shoreline exposure, and limited access routes. The Peninsula's single point of access, West Chalk Point Road, is especially vulnerable, making emergency response and resident evacuation challenging during severe weather conditions. The following flooding report card evaluates the major flood risks affecting Chalk Point (Table 17).

Table 17 – Chalk Point Flooding Report Card		
Category	**Rating**	**Justification**
Flood Pathways	High	The community is vulnerable to tidal flooding and storm surge, with its single access road at risk of frequent inundation.
Stormwater Drainage	Low	Stormwater infrastructure is minimal, consisting of a few inlets and swales. While some culverts require maintenance, stormwater ponding from rainfall alone is not currently a major concern. However, as sea levels rise and tidal flooding becomes more frequent, enhanced stormwater management—such as extended retention areas—may be necessary to improve drainage capacity and mitigate compounding flood risks.
Infrastructure Vulnerability	High	Chalk Point's single access road is a major vulnerability, as it sits at a lower elevation and is prone to flooding, risking community isolation.
Erosion & Shoreline Stability	Moderate	Shoreline protections are in place, but natural shoreline sections remain vulnerable to erosion and rising water levels. Bulkheads may become less effective as sea levels rise.
Overall Flood Threat	**High**	**With increasing SLR, storm surge exposure, and limited access, Chalk Point faces a significant flood risk that may require long-term adaptation strategies**

4.3. Churchton

Churchton, Maryland, is a small, unincorporated community that occupies the central portion of the Deale-Shady Side Peninsula. The community is bordered by the Chesapeake Bay to the east, while Deep Cove Creek and Deep Creek define its northeastern boundary. Compared to neighboring areas, Churchton retains a relatively high percentage of undeveloped woodland, which serves as an important buffer against stormwater runoff and provides habitat for wildlife.

Photo 70 - Churchton shoreline (source: WaterfrontHomes.org

Although predominately residential, Churchton also features several local businesses, including small shops, restaurants, and service providers that support both the local community and visitors. The community's proximity to the water plays a significant role in shaping its identity, with waterfront properties, private docks, and marinas contributing to the local economy. However, like much of the Peninsula, Churchton faces increasing challenges due to SLR, storm surge, and inadequate stormwater management infrastructure.

Photo 70 - Deep Cove in Churchton, MD (source: Chesapeake Legal Alliance)

Average elevations in Churchton vary, with some areas exhibiting low-lying topography that is vulnerable to tidal flooding. While the community benefits from the presence of natural shoreline and wetlands, portions of its waterfront are hardened with bulkheads and revetments to mitigate erosion. Despite these efforts, rising water levels and extreme weather events continue to pose risks to infrastructure and accessibility.

As part of the field assessment activities in Churchton, several neighborhoods were surveyed to evaluate the condition of the shoreline and stormwater infrastructure. The following sections provide a detailed examination of the vulnerabilities and challenges faced by individual communities within Churchton, incorporating observations from field visits and modeling analyses.

4.3.1. Franklin Manor

Franklin Manor is a private waterfront community in Churchton, Maryland, established in 1940. This mid-sized residential area features a mix of homes and community amenities, including a private beach and Franklin Manor Park (Photo 71 and Photo 72). The neighborhood's location between the Chesapeake Bay and extensive tidal wetlands to the north makes it particularly susceptible to coastal flooding.

Photo 71 - Franklin Manor Community Private Park

Photo 72 - Franklin Manor aerial showing intersection of Chesapeake Drive and Franklin boulevard, community open space area, and the community pier.

Franklin Manor's southern shoreline is reinforced by a combination of stone revetments and bulkheads/seawalls particularly along Chesapeake Drive (Figure 37 and Photo 73). While these structures protect against direct wave impact, they do not fully protect against storm surges or high tide flooding. The seawall along Chesapeake Drive (+6.5 feet NAVD88), for example, experiences periodic overtopping during storms (Photo 74), highlighting the limitations of hardened shorelines when faced with rising water levels.

To the north and west, Franklin Manor is surrounded by low-lying marsh and Deep Creek Cove, which provide some natural flood storage but also serve as pathways for water to infiltrate the community (Photo 75 and Photo 76). This dual exposure—direct wave impact from the Bay and gradual tidal encroachment from the marsh—creates compounding flood risks similar to those observed in Cedarhurst and Columbia Beach.

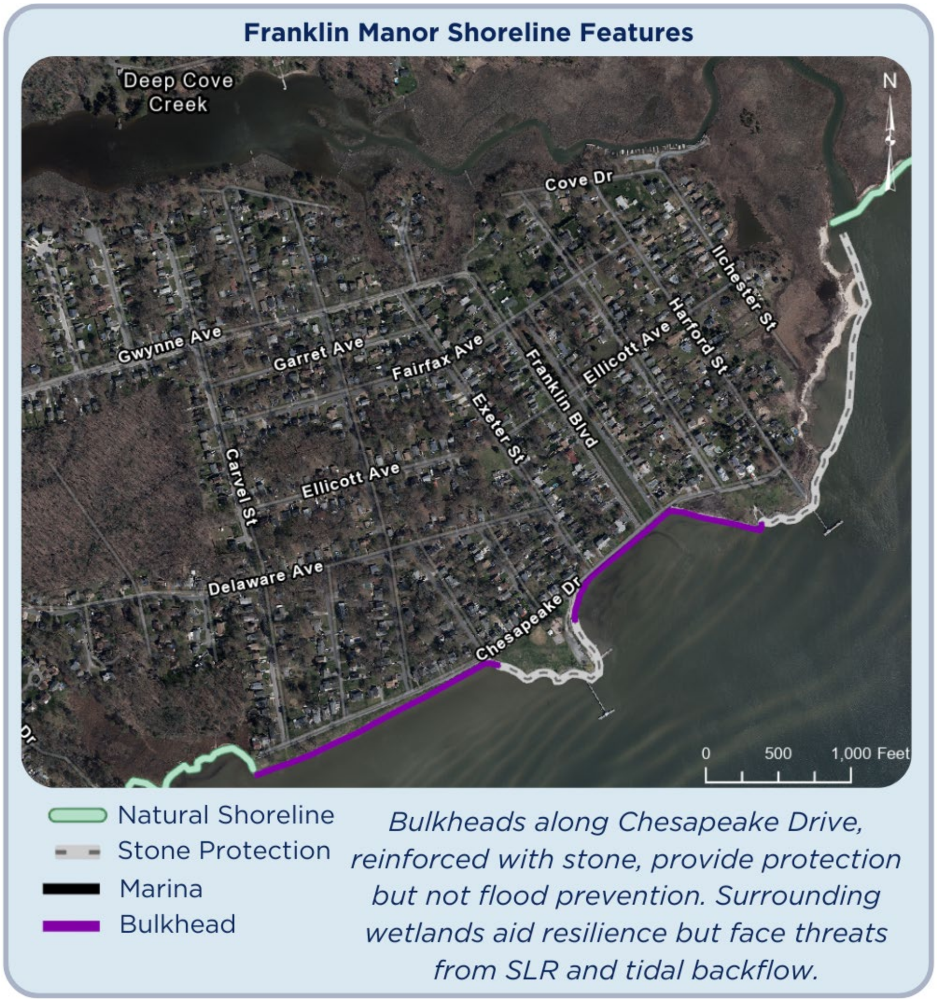


Figure 37 – Shoreline Features in Franklin Manor

Photo 73 - Seawall fronted by revetment along Chesapeake Drive (Top of Bulkhead +6.5' NAVD88; Top of Stone +6.0' NAVD88)

Photo 74 - Wave overtopping along Chesapeake Drive during Tropical Depression Debby Water level: +3.66' NAVD88 (or 3' above MHW)

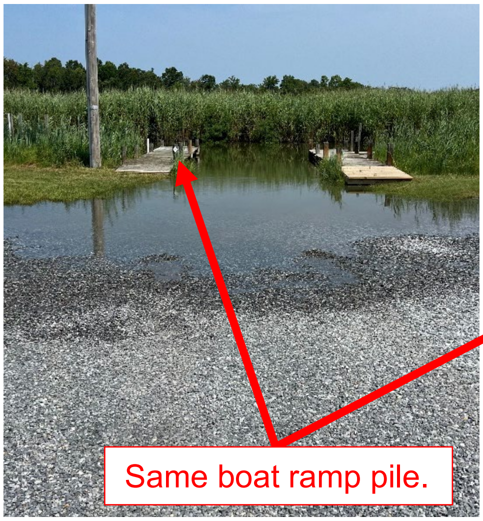


Photo 75 - Franklin Manor Boat Club boat ramp and parking area during "sunny day" flooding (July 29, 2024)
Water level: +1.5' NAVD88 (or 0.8' above MHW)

Photo 76 - Franklin Manor Boat Club boat ramp and parking area during Tropical Depression Debby (August 9,2024)
Water level: +3.66 NAVD88 (or 3' above MHW)

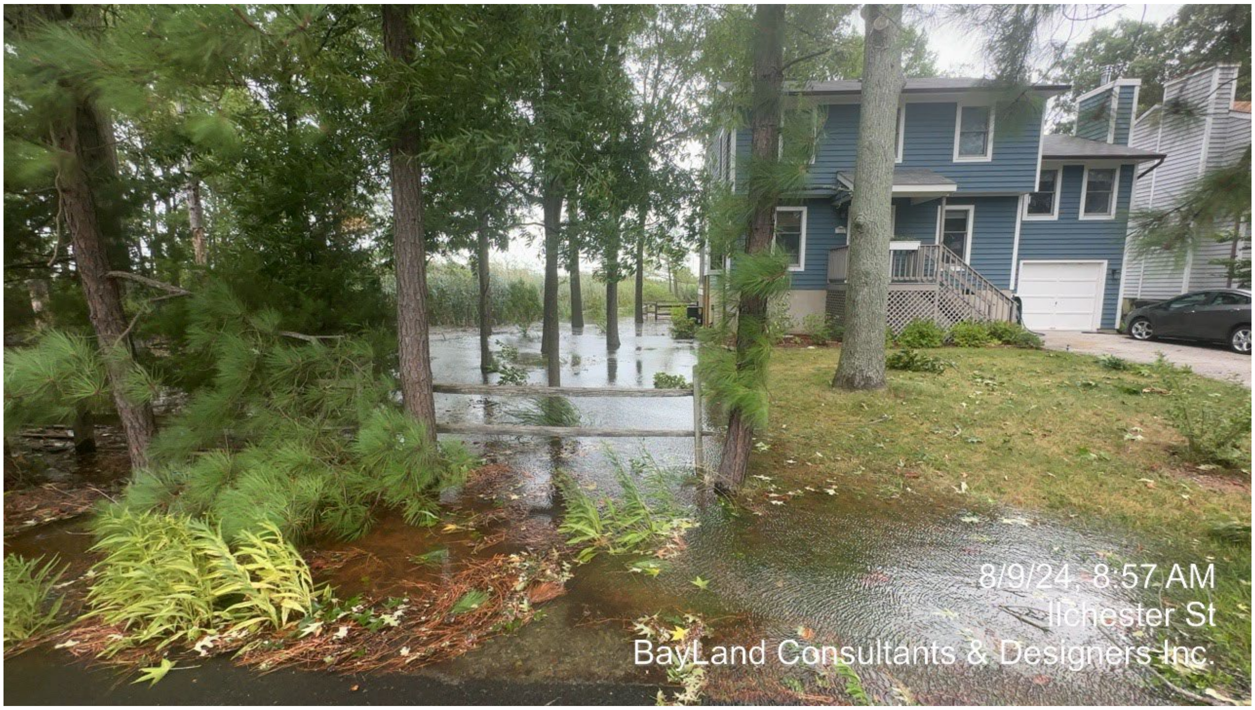


Photo 77 - Stormwater and coastal flooding compounding in residential yard on Ilchester Street during Tropical Depression Debby

The community's stormwater conveyance relies on a well-established system of driveway swales and culverts to manage runoff (Figure 38). Field assessments identified widespread sedimentation, overgrown vegetation, and blocked culverts (Photo 78 and Photo 79), all of which reduce drainage efficiency. A significant issue is that all stormwater outfalls discharge directly into tidal waters without backflow prevention (Photo 80 - Photo 82).

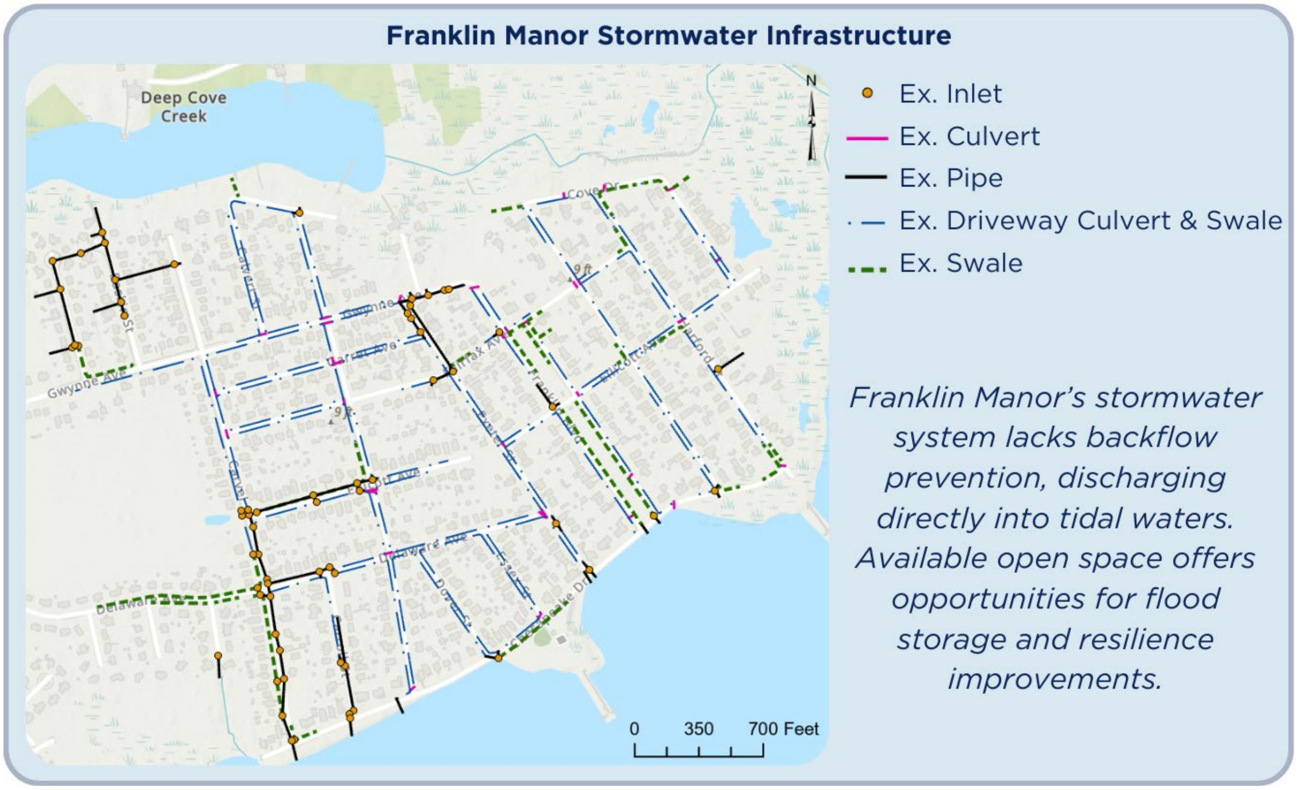


Figure 38 – Franklin Manor Stormwater Infrastructure Mapped During Field Assessment

Photo 78 - Standing water in roadside swale due to crushed driveway culvert

Photo 79 - Culvert blocked by sedimentation and overgrowth; road edge erosion

Photo 80 - Roadway culvert at Gwynne Avenue and Exeter Street backwatered during "Sunny Day" flooding
Water level: +1.5' NAVD88 (or 0.8' above MHW)

Photo 81 - Backwatering of roadway culverts at the intersection of Gwynne Avenue and Dartmouth Street; road repairs along Gwynne Avenue indicating damage due to frequent flooding.

Photo 82 - Tidal outfall partially inundated along Chesapeake Drive
Water level: +1.52' NAVD88 (or 0.8' above MHW)

Stormwater flooding in Franklin Manor is a persistent challenge due to undersized drainage infrastructure, limited outfall capacity, and tidal proximity to Deep Cove Creek and the Chesapeake Bay. Figure 39 shows modeled stormwater flooding under 2050 sea level rise conditions for 2-, 10-, and 100-year rainfall events. Even during a 2-year rainfall event, much of the neighborhood experiences shallow inundation. As rainfall intensity increases, flood extents expand, and depths escalate, particularly in low-lying areas along Gwynne Avenue, Franklin Boulevard, and the intersection of Essex Street and Ellicott Avenue.

By the 100-year event, flooding depths exceed two feet in multiple locations, with some depressions along Garrett Avenue and Chesapeake Drive reaching depths over four feet. The street grid layout traps runoff in bowl-shaped depressions, particularly along Essex Street and Ilchester Avenue, where stormwater cannot effectively exit the system. Flooding persists near key intersections and along large sections of roadway, highlighting insufficient capacity and the limited effectiveness of the existing drainage infrastructure.

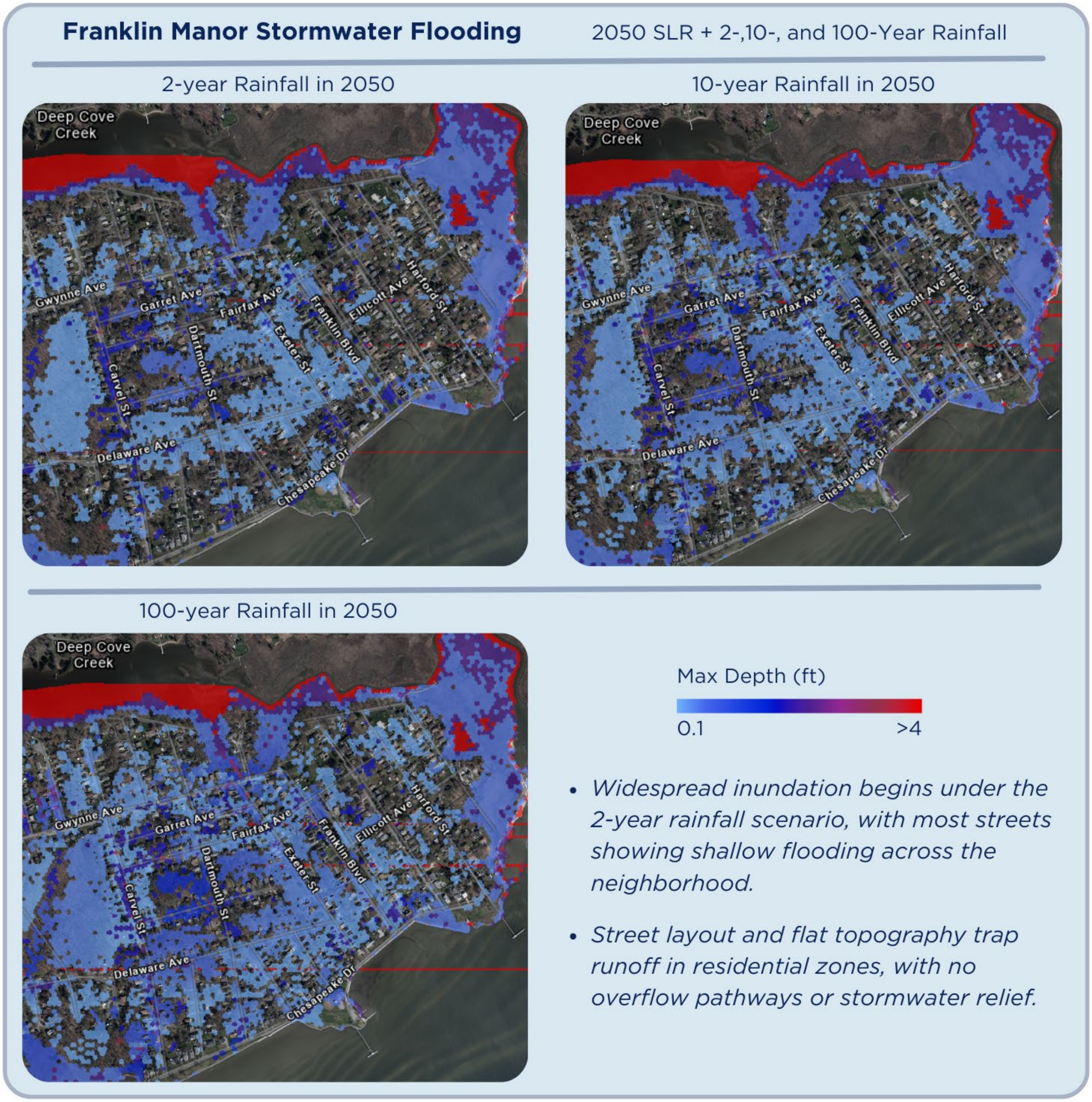


Figure 39 – Projected Stormwater Flooding Depths for the 2050 2-, 10-, and 100-Year Rainfall Events in Franklin Manor under sea level rise conditions.

When stormwater flooding is compounded with storm surge from tidal backflow, conditions in Franklin Manor deteriorate significantly. Tidal influences further inhibit drainage as they backwater stormwater systems flooding streets and yards and significantly deepening flood depths even under modest rainfall events. The model results for the 2050 2-year rainfall and storm surge scenario show extensive inundation across the community, particularly in low-lying areas where drainage is insufficient (Figure 40).

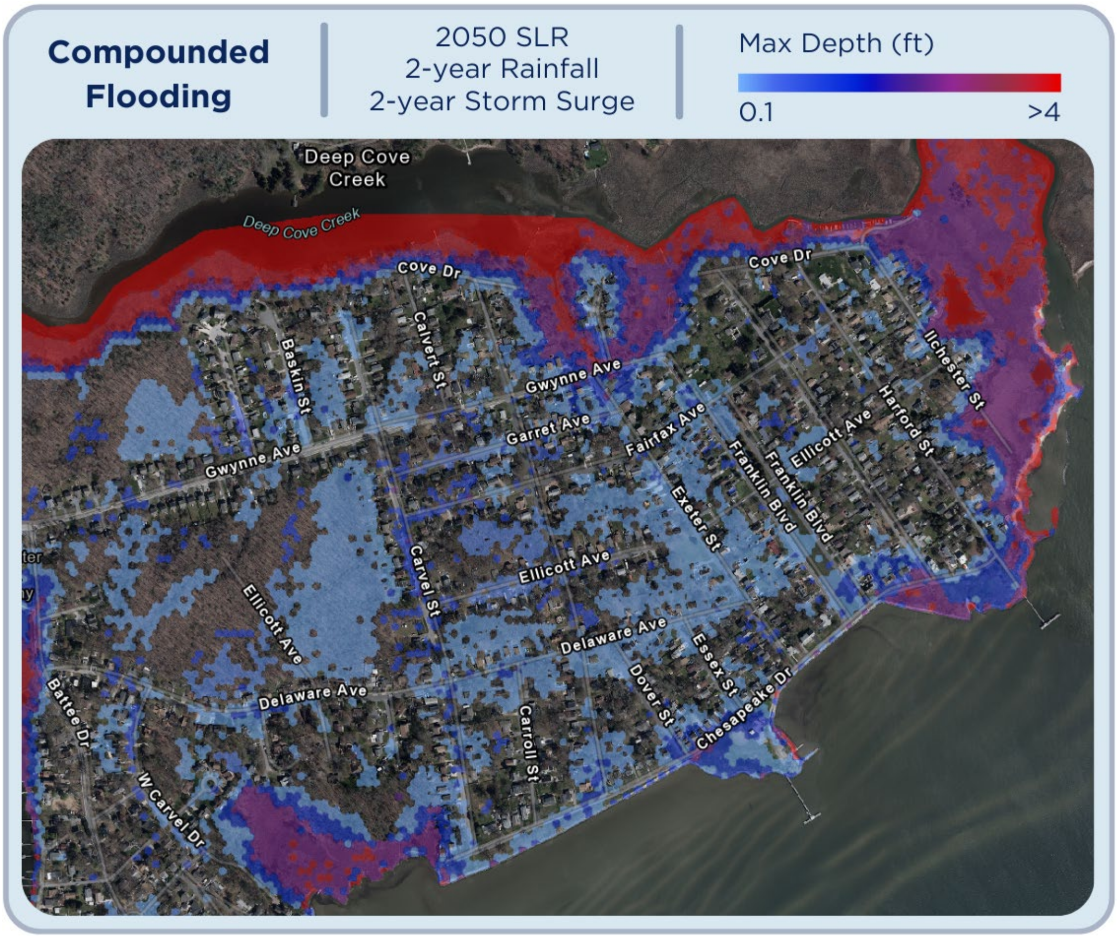


Figure 40 – Projected Stormwater Flooding Depths for the 2050 2-Year Rainfall and 2-Year Storm Surge Scenario in Franklin Manor

Areas to the north of the community, adjacent to Deep Cove Creek, are relatively well elevated above the creek but still experience significant flooding. The stormwater system in this area lacks sufficient outfalls, leading to prolonged ponding and slow drainage. Additionally, the backwatering effects from the adjacent marsh and creek further restrict stormwater conveyance, causing water to accumulate in residential streets and properties.

Much of the community's stormwater infrastructure, spanning from Franklin Boulevard to Carvel Street, drains southward to outfalls located in areas with relatively lower flood impacts. However, as shown in the model, these areas still experience significant and widespread inundation from stormwater runoff. Undersized conveyance infrastructure prevents effective drainage, while tidal backwater at outfalls reduces capacity, leaving stormwater trapped in the system. This results in prolonged periods of flooding across major roadways and residential properties.

The stormwater flooding model also highlights significant inundation along Gwynne Avenue, Garrett Avenue, and Essex Street, where flood depths exceed one foot in some areas. Intersections along Ellicott Avenue and Delaware Avenue also exhibit localized flooding, indicating that stormwater runoff is not effectively conveyed. The model results emphasize that areas near Deep Cove Creek and Chesapeake Drive are particularly vulnerable to deep stormwater flooding, with depths exceeding two to four feet during storm events.

Franklin Manor faces significant vulnerabilities to SLR, with projected flood extents indicating widespread inundation by 2065 and severe impacts by 2100 (Figure 41). Low-lying roads, adjacent wetlands, and shoreline properties will experience increasingly frequent tidal flooding, which will worsen over time as natural flood buffers become submerged.

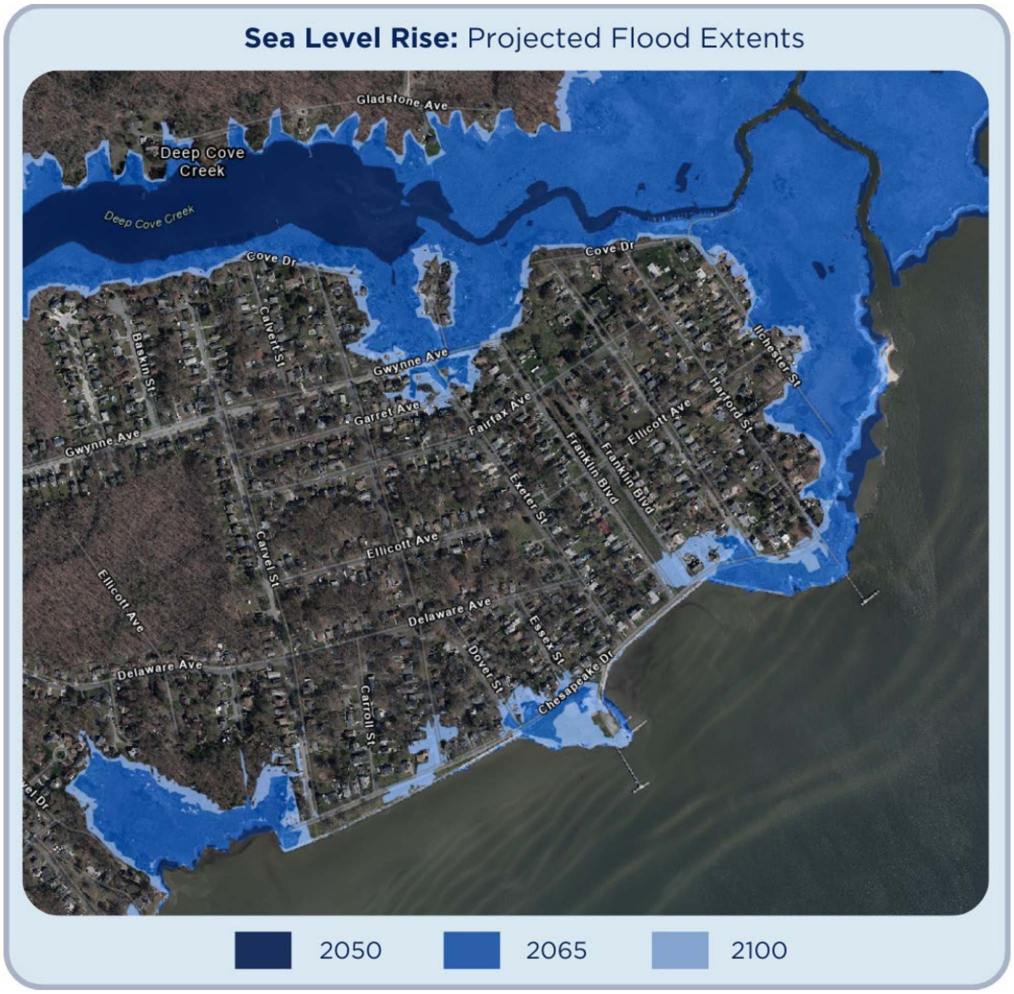


Figure 41 – Projected SLR Impacts in Franklin Manor highlight increasing flood exposure from both the Chesapeake Bay and Deep Cove Creek.

By 2065, Chesapeake Drive between Dover Street and Essex Street will flood daily, with flood depths reaching eight to ten inches. Depressions along Chesapeake Drive, as well as at the intersections of Gloucester and Gwynne Avenue with Exeter Street, are projected to flood with at least a foot of water. The wetlands bordering the neighborhood to the north will be permanently inundated, reducing their ability to absorb floodwaters and increasing exposure to wave-driven flooding along Deep Cove Creek and the Chesapeake Bay.

By 2100, floodwaters will encroach further into the residential core of Franklin Manor. Ilchester Street and adjacent shoreline areas will be permanently submerged, cutting off access to homes and community spaces. The encroachment of adjacent wetlands into residential properties will further compromise drainage, leading to prolonged periods of flooding even outside of storm events. The tidal creeks and marshes surrounding the northern portion of the neighborhood will be fully submerged, allowing high tides and storm surges to propagate deeper into the community, threatening infrastructure and property.

The following flooding report card summarizes Franklin Manor's vulnerabilities across key flood risks categories, highlighting areas for mitigation efforts (Table 18).

Table 18 – Franklin Manor Flooding Report Card

Category	Rating	Justification
Flood Pathways	High	Community faces flooding from both direct Chesapeake Bay exposure and tidal backflow from Deep Cove Creek. Rising sea levels will make both pathways worse.
Stormwater Drainage	Moderate	Drainage infrastructure lacks backflow prevention, leading to water backing up into swales and private properties. Some maintenance issues (sediment, vegetation) reduce efficiency.
Infrastructure Vulnerability	High	Major roads (Chesapeake Drive and Gwynne Avenue) are at risk of frequent flooding, potentially cutting off emergency access.
Erosion & Shoreline Stability	Moderate	Rising water levels will increasingly overtop shoreline protections, such as revetements and seawalls.
Overall Flood Threat	**High**	**The combination of coastal flooding, stormwater backflow, and infrastructure vulnerability makes Franklin Manor one of the most flood-prone areas on the peninsula, requiring urgent attention.**

4.3.2. Cape Anne

Cape Anne is a small, waterfront community located along the Chesapeake Bay and Broadwater Creek in Churchton. The community's shoreline features a combination of natural marshes, bulkheads, and stone revetments, offering varying levels of protection against erosion and flooding (Figure 42).

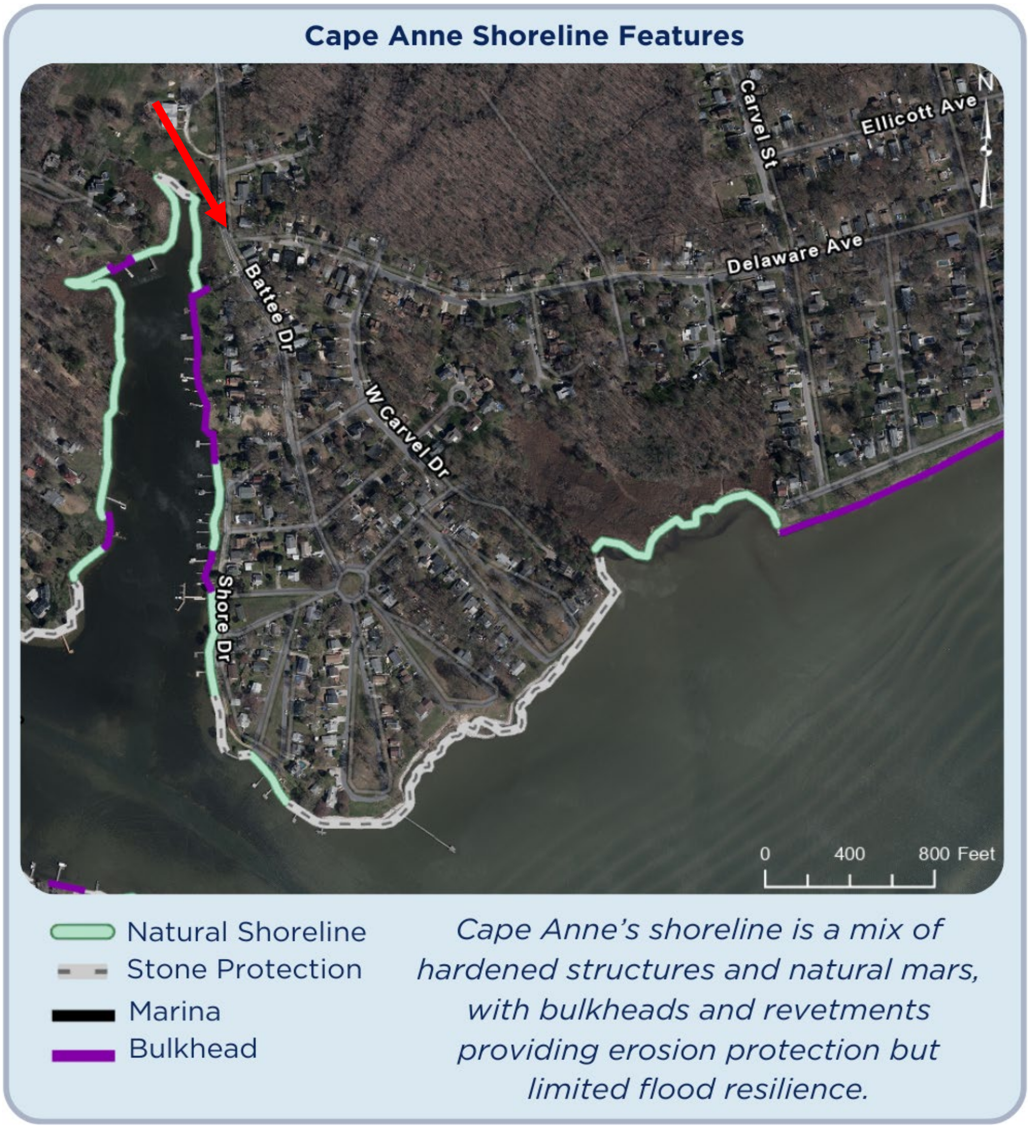


Figure 42 – Shoreline Features in Cape Anne with fallout at intersection of Wildwood Lane and Battee Drive

The western extent of the community is protected from direct wave energy due to its sheltered location within Broadwater Creek, reducing its vulnerability to extreme wave action. However, the area remains highly susceptible to still-water flooding in the headwaters of Broadwater Creek. Battee Drive at the intersection of Wildwood Lane (red arrow) is particularly vulnerable to flooding with roadway crest elevations only about two feet above sea level (approximately +2 feet NAVD88). Additionally, many of the bulkheads along the Broadwater Creek shoreline are aging and privately maintained, and at their current elevations, they do not provide adequate protection against increased water levels.

The marsh area adjacent to the eastern extent of the community is currently under design for beneficial use enhancement as part of a larger coastal resiliency effort. This project, a component of the South County Coastal Resiliency Initiative, aims to strengthen the marsh and improve its ability to withstand rising sea levels. If successful, this effort could serve as a model for future nature-based solutions in the region.

Stormwater management in Cape Anne relies heavily on grassy roadside swales and driveway culverts for drainage. However, many driveway culverts are partially or completely blocked by sedimentation, restricting water conveyance (*Photo* 82 and Photo 84). Additionally, sections of roadside swales exhibit pooling water, suggesting either a lack of maintenance or insufficient drainage capacity (Photo 85).

Photo 83 - Partially blocked driveway culvert on Battee Drive

Photo 84 – Roadway culvert blocked by stone and overgrown vegetation

Photo 85 - Standing water in grassy swale along Bay View Parkway

The projected impacts of SLR in Cape Anne indicate increasing vulnerability, particularly in low-lying, marsh-adjacent areas that will be inundated on a daily basis by 2065 (Figure 43). The wetlands that currently buffer developed areas from offshore wave energy will be permanently submerged, reducing their ability to dissipate storm surge and tidal flooding. As these wetlands deteriorate, Cape Anne's flood risk will intensify, leaving residential areas more exposed to wave action and extreme high tides.

By 2065, the sole access route to the community along Battee Drive will experience daily tidal flooding, with water depths reaching 10 inches in some locations. This poses a significant threat to transportation, emergency response, and evacuation capabilities. Although the flood extents between 2065 and 2100 do not expand drastically, flood depths on Battee Drive are projected to more than double, making it increasingly impassable. Without intervention, Cape Anne's isolation during flood events will become a severe concern, as residents may be cut off from critical services.

Additionally, increasing flood depths will encroach into residential properties along Shore Drive, with water levels inundating roads and driveways even outside of major storm events. The degradation of the adjacent marshland will further exacerbate flooding, as the loss of this natural buffer will allow floodwaters to propagate further inland with greater intensity.

Given these projections, planned marsh restoration efforts are a critical step toward preserving natural flood buffers and mitigating the worst impacts of SLR. Enhancing wetland resilience through restoration and elevation measures, alongside roadway adaptation strategies, will be necessary to maintain accessibility and protect Cape Anne from worsening flood conditions.

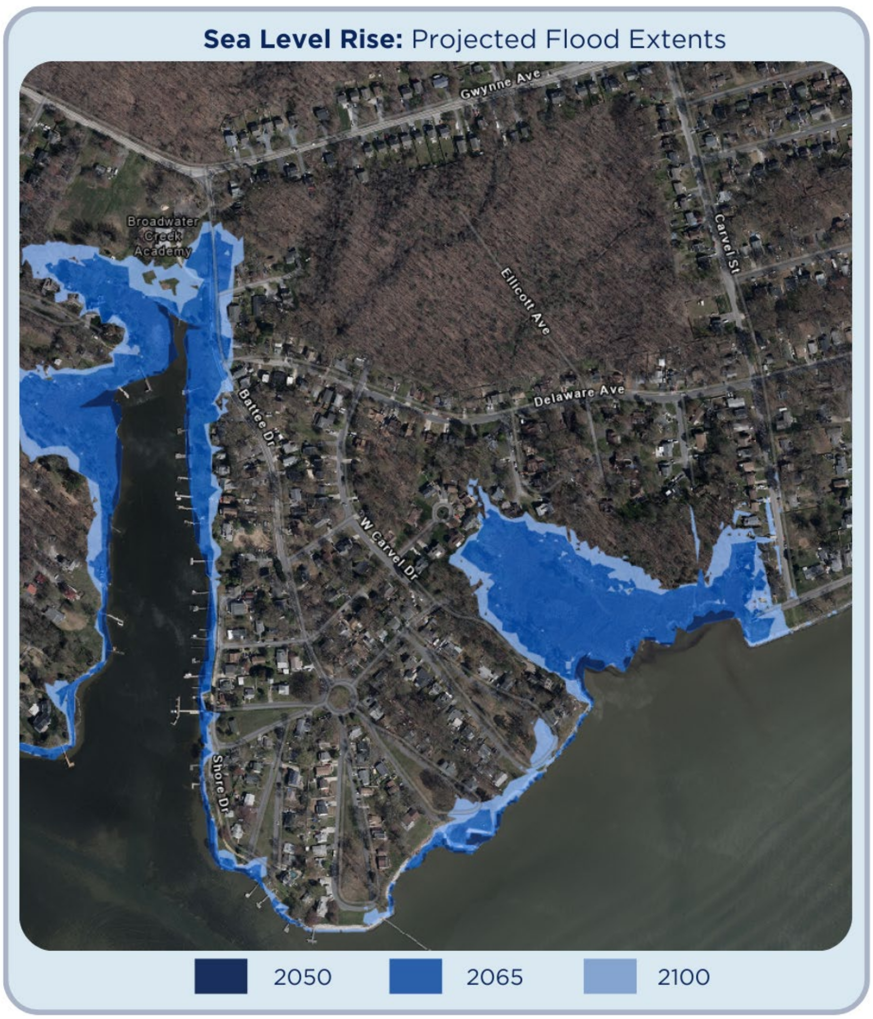


Figure 43 – Projected SLR Impacts in Cape Anne show increased flooding on key access routes.

While the planned marsh restoration project offers a proactive measure for improving resilience, additional mitigation strategies will be necessary to address flood risks in the long term. The following report card evaluates Cape Anne's flood risk factors (Table 19).

Table 19 – Cape Anne Flooding Report Card		
Category	**Rating**	**Justification**
Flood Pathways	Moderate	The community is vulnerable to flooding from both Broadwater Creek and the Chesapeake Bay. SLR projections show increasing exposure, with Battee Drive at risk of daily inundation by 2065.
Stormwater Drainage	Moderate	Swales and driveway culverts require maintenance, and pooling water in swales indicate drainage inefficiencies.
Infrastructure Vulnerability	Moderate	The road network is at risk of flooding during storm events and SLR projections indicate future access challenges. Privately maintained bulkheads provide limited flood protection.
Erosion & Shoreline Stability	Moderate	Stone revetments and bulkheads offer erosion protection, but aging infrastructure and the loss of natural marshes may lead to increased shoreline instability over time.
Overall Flood Threat	**Moderate**	**Future access concerns compound other infrastructure vulnerabilities. Planned marsh enhancements may improve resilience but require continued monitoring and adaptation.**

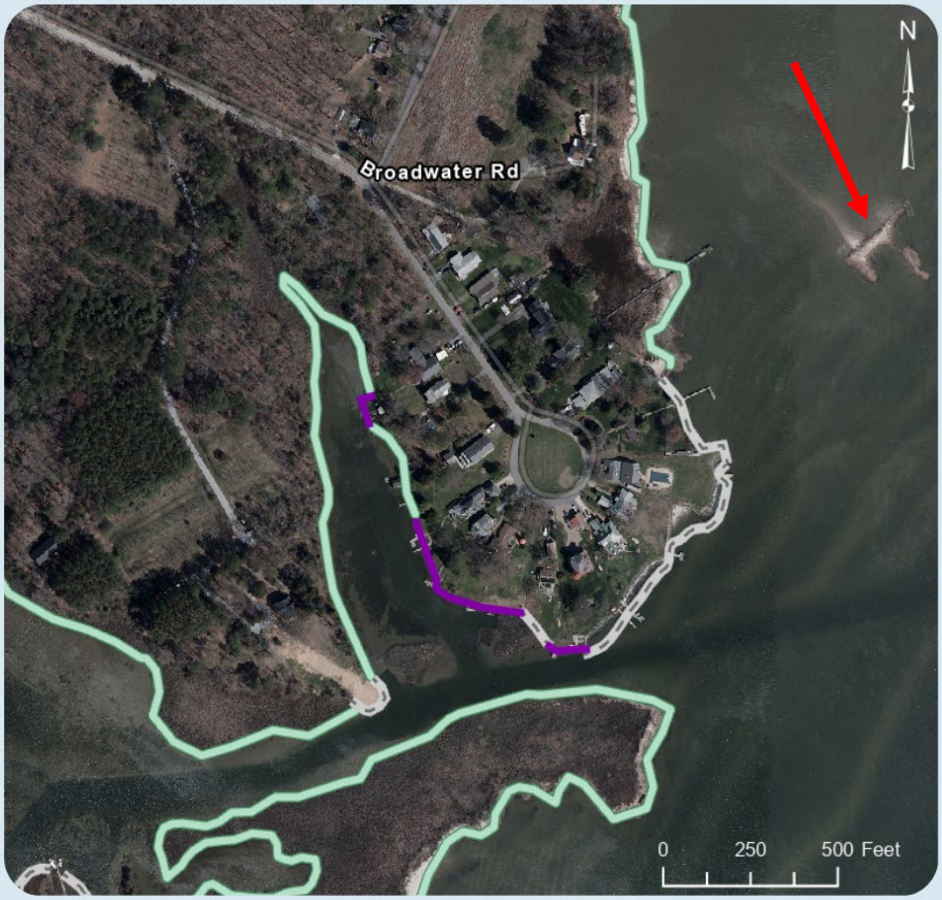
4.3.3. Broadwater Point

Broadwater Point is located along the headwaters of Carrs Creek, south of Cape Anne and Broadwater Creek. This small, relatively undeveloped community consists of homes primarily along Broadwater Point Road. The area is divided between properties facing the Chesapeake Bay and those along the more sheltered Carrs Creek shoreline. The natural marsh areas play a vital role in buffering the community from wave energy.

Many private residences are protected with bulkhead or revetments (Top of Stone: 4.0 to 4.5 feet NAVD88), particularly those facing the Bay, while more natural shoreline persists along the Carrs Creek frontage. However, the northeast portion of the community was once protected by the remnant island (Figure 44), which previously contributed to wave attenuation and flood protection.

Like other areas on the Peninsula, inadequate maintenance of culverts and swales causes frequent pooling and standing water, leading to road and driveway damage. (Photo 86 and Photo 87).The wetlands, tidal marshes, and forests in the community assist in flood mitigation by absorbing excess runoff during heavy rainfall and storm surge events, thereby reducing the impact on surrounding residential areas (Photo 88 and Photo 89).

Broadwater Point Shoreline Features



Natural Shoreline
Stone Protection
Marina
Bulkhead

The natural shoreline and tidal marshes provide critical flood protection for Broadwater Point, but ongoing marsh loss, including the submergence of the island to the northeast, threatens long-term resilience.

Figure 44 – Shoreline Features in Broadwater Point *(Callout showing remnant marsh island)*

Photo 86 - Standing water leads to roadway degradation.

Photo 87 - Overgrown roadway culvert

Photo 88 - Degrading natural shoreline due to increased exposure at remnant island is submerged.

Photo 89 - Open space serves as a natural retention area for stormwater runoff and coastal inundation.

Figure 45 highlights flooding at a residential property along the sheltered shoreline of Carrs Creek, where stormwater runoff exits the conveyance system between two residential properties. While historically protected, this section of shoreline is gradually transitioning into a regularly flooded marsh area due to rising water levels. Bulkheads along this stretch of shoreline are frequently inundated and, in some areas, have deteriorated due to prolonged exposure.

The MyCoast report captures observed conditions at the time of the photo, highlighting how predicted tide levels do not account for water level surges that can significantly impact flooding. While the forecasted tide was expected to reach just 0.5 feet, actual conditions resulted in a 5.1-foot tide due to additional influences such as wind-driven surge and regional hydrodynamics.

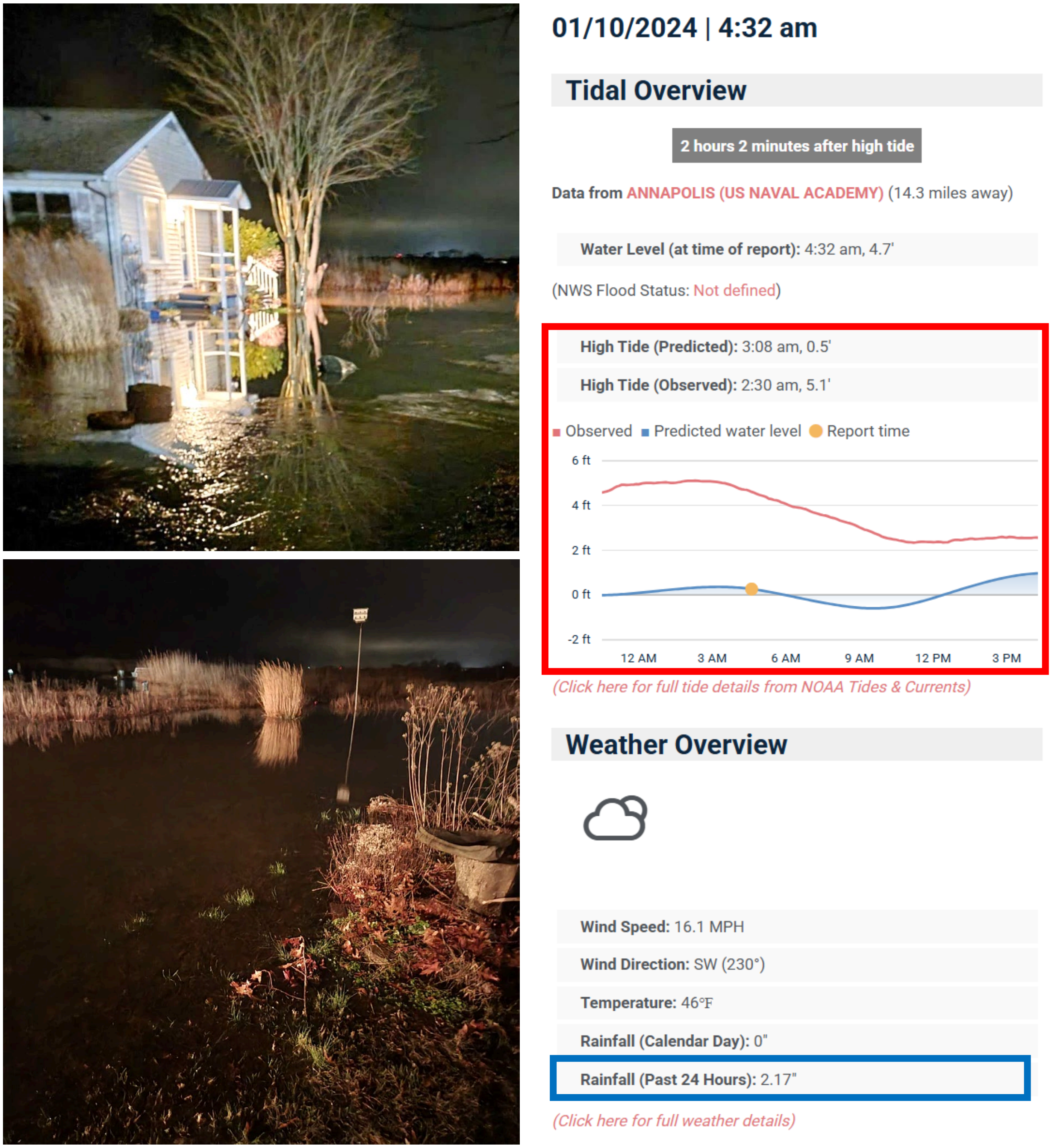


Figure 45 ─ Maryland MyCoast Report Showing Flooding to a Residential Property
*Note: Red Box showing associated observed water levels; and Blue Box showing rainfall at the time of the photo

While projected SLR models provide insight into future daily flood levels, storm surge events can significantly amplify these projections, temporarily expanding flood extents and increasing flood depths far beyond what is anticipated under normal tidal conditions. These temporary flood events will exacerbate chronic flooding and accelerate marsh degradation, further reducing natural flood protection for Broadwater Point.

By 2065, many low-lying areas along Broadwater Point Road and the surrounding marsh will experience more frequent and prolonged inundation (Figure 46 and Photo 90). Daily tidal flooding will reach depths of six to seven inches along Broadwater Point Road, restricting access to and from the community. The increased tidal influence will also slow the drainage of floodwaters, extending the duration of flooding in the area. Marsh buffers along natural shoreline segments will be permanently inundated, leading to a loss of habitat, reduced storm surge protection, and increased shoreline erosion.

The vulnerability of Broadwater Point Road, the only ingress/egress route for the community, will continue to increase. By 2100, persistent flooding and marsh submergence will result in the community becoming completely isolated from the mainland, with flood depths exceeding two feet along critical roadways. The loss of marsh elevation will not only reduce the community's ability to recover from storm events but will also increase the likelihood of permanent roadway failures due to erosion and repeated flood damage.

Photo 90 - Broadwater Road flooding during high tide event (April 12, 2024)
Water level: +2.88' NAVD88 (or 2.2' above MHW)

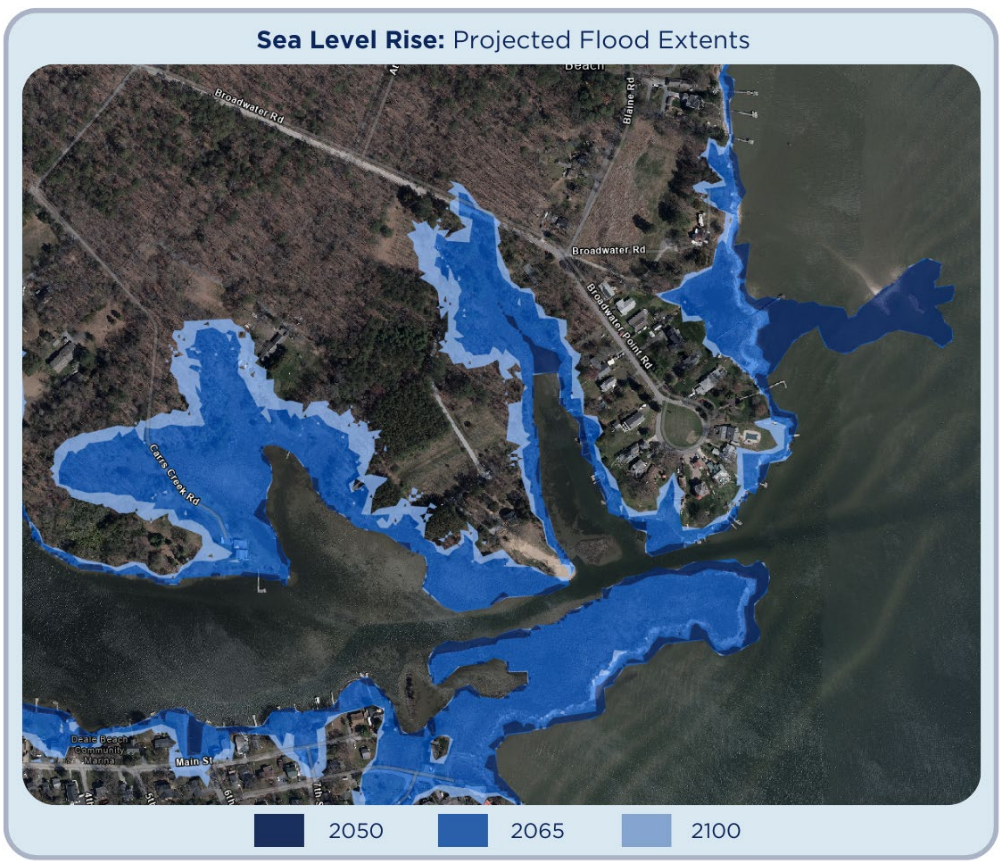


Figure 46 – Projected SLR Along Carrs Creek shows increasing inundation in marsh areas protecting the community, threatening marsh stability and community access.

Broadwater Point's flood risks stem from a combination of coastal exposure, loss of protective marsh, and single point access. The flooding report card assesses the impact of major contributors to risk, including pathways for flooding to enter the community, stormwater conveyance, infrastructure challenges, and shoreline stability (Table 20).

Table 20 – Broadwater Point Flooding Report Card

Category	Rating	Justification
Flood Pathways	Moderate	Rising water levels will overtop low-lying areas, particularly near Carrs Creek and surrounding marsh.
Stormwater Drainage	Moderate	The existing stormwater system consists of some driveway culverts and swales, some of which require maintenance. Standing water and pooling are common in areas where stormwater drains to tidal waters.
Infrastructure Vulnerability	Moderate	Roadway conditions are deteriorating in areas with frequent standing water. Access along Broadwater Road could be compromised by future flooding events.
Erosion & Shoreline Stability	Moderate	Natural shorelines provide protection, but marsh loss and erosion are ongoing concerns. The disappearance of a marsh island to the northeast has already reduced storm surge buffering capacity.
Overall Flood Threat	**Moderate**	**The community's reliance on natural flood mitigation, combined with rising water levels and marsh loss, increases future flood risk. Long-term resilience will depend on shoreline adaptation and infrastructure improvements.**

4.4. Deale

Deale, Maryland is a quaint, coastal community that makes up the southern portion of the Peninsula. With a population of approximately 4,700 residents, Deale has evolved from its agricultural roots into a vibrant residential area renowned for its rich maritime heritage.

The community's location along the Chesapeake Bay has fostered a thriving boating culture (Photo 91). Deale is home to numerous marinas and boatyards, serving both recreational boaters and commercial watermen. Notably, Rockhold Creek, one of Deale's five tidal creeks, is a central hub for maritime activities, housing several marinas and the majority of the area's fishing vessels. Deale's natural landscapes, including wetlands, marshes, and forested areas, play a crucial role in environmental sustainability. These ecosystems provide essential services such as flood mitigation, water filtration, and habitats for diverse wildlife species. As part of the field assessment activities in Deale, neighborhood shoreline features, stormwater infrastructure, and flooding patterns were evaluated based on field survey and various analyses.

Photo 91 - Aerial imagery of Rockhold Creek (source: Marinas.com)

4.4.1. Deale Beach Area

The Deale Beach Area is a residential area between Parker and Carrs Creeks. Central parts of the neighborhood are approximately 8.5 feet above NAVD88 while the lowest lying areas along Flood Avenue, 2nd Street and Bay Drive are less than two feet above NAVD88.

Deale Beach is bordered by both natural and hardened shorelines (Figure 47). The Chesapeake Bay-facing shorelines are protected along some stretches by marsh buffers that provide critical flood resilience (Photo 92). The combination of natural and hardened shoreline elements influences how floodwaters interact with the community, with natural wetlands helping to absorb wave energy while again bulkheads struggle against rising water levels. While these structures provide localized shoreline stability, their frequent overtopping at current elevations during high tides and storm events highlights their limitations in mitigating flood risks.

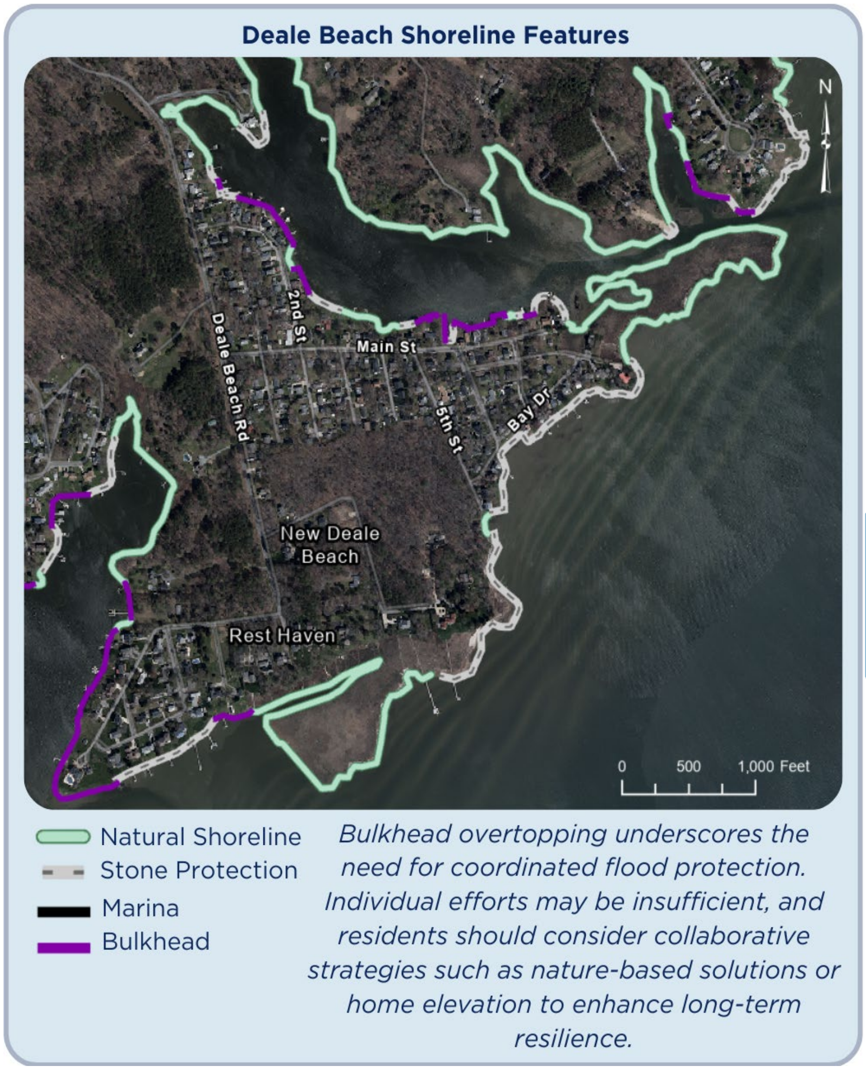


Figure 47 – Shoreline Features in Deale Beach

Photo 92 - Bay-facing shoreline protected by stone revetments and natural wetlands.

Stormwater management in Deale beach follows patterns similar to other communities on the Peninsula, with an informal network of driveway swales, and outfalls directing runoff into tidal waters. Maintenance of these systems is required to ensure proper conveyance, as sedimentation and blockages reduce efficiency (*Photo* 93 and *Photo* 94). Expanding retention areas in naturalized spaces could allow floodwaters more time to recede before re-entering the drainage system, improving resilience to concurrent rainfall and tidal flooding.

Photo 93 - Pooling water and sedimentation in grassy swale at the intersection of 1st Street and Main Street.

Photo 94 - Series of driveway culverts connected by overgrown grassy swale.

Deale Beach faces significant flood risks due to both storm-driven coastal flooding and daily high tides (Photo 95). The primary concern is Deale Beach Road, which serves as the only ingress/egress route for the community. The road is regularly inundated, rendering it impassable during certain conditions and isolating residents. This persistent flooding disrupts transportation, emergency response, and property access, necessitating mitigation strategies to maintain safe connectivity.

Photo 95 - Flooding of Deale Beach Road during Tropical Depression Debby
Water level: +2.88' NAVD88 (or 2.2' above MHW)

SLR projections indicate that low-lying areas within Deale Beach, particularly waterfront properties along Carrs Creek and adjacent shorelines, will experience increasingly severe and persistent flooding by 2050 (Figure 48). The marshes that currently serve as natural flood buffers will become more vulnerable to excessive inundation, leading to accelerated marsh degradation. As these natural defenses weaken, Deale Beach will face higher exposure to wave energy and storm surge impacts, further compounding flood risks.

By 2065, daily tidal flooding will significantly affect Deale Beach Road, with flood depths reaching 1.5 feet in the lowest-lying areas. The loss of marsh elevation and increasing tidal influence will reduce drainage efficiency, leading to prolonged flood conditions after storms. Bulkheads along the waterfront will become increasingly ineffective, frequently overtopped by rising water levels and further contributing to shoreline erosion. Properties along the shoreline will begin experiencing daily flooding, placing ground-level structures at risk for chronic inundation.

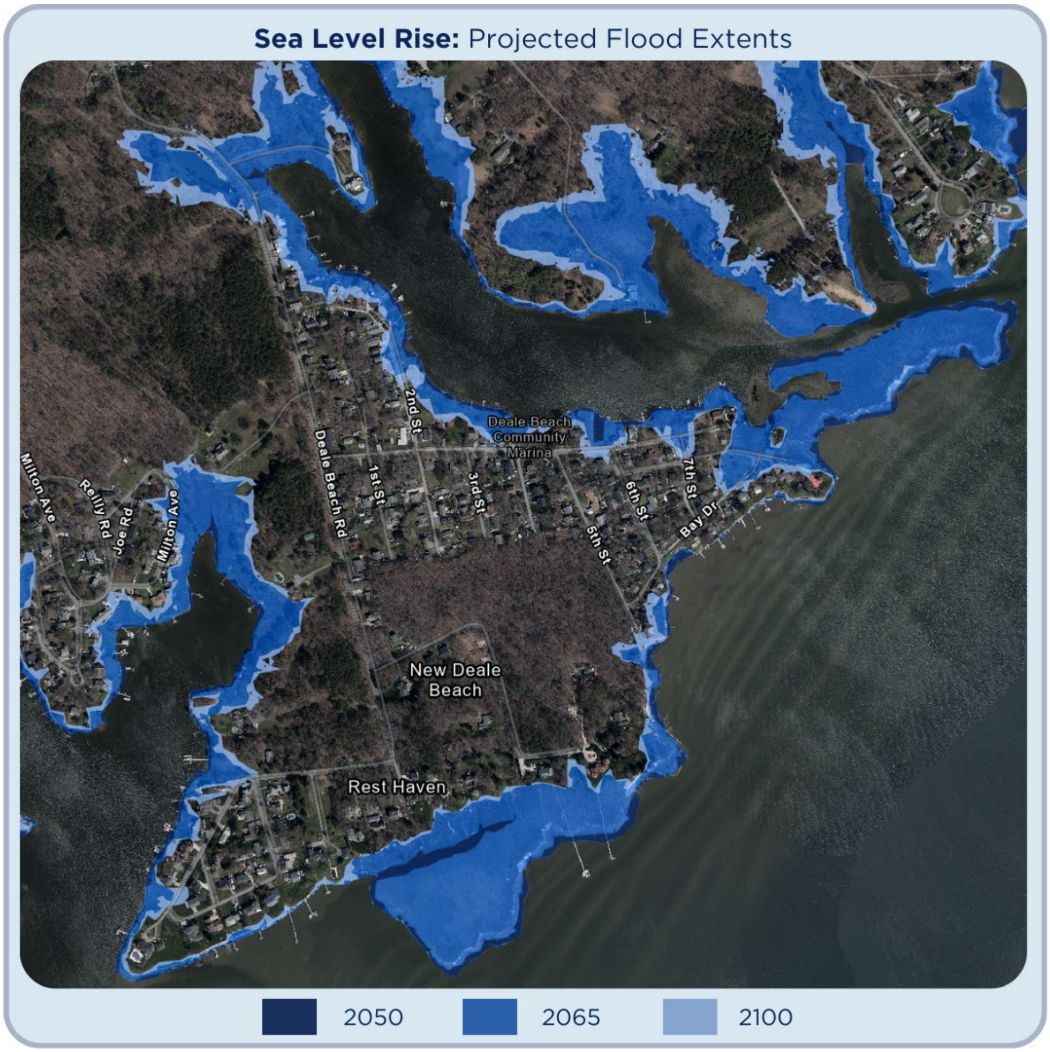


Figure 48 – Projected Flood Extents for Deale Beach indicate worsening conditions along Deale Beach Road and waterfront properties along the shorelines of the community, with increasing daily tidal inundation and storm-related flooding by 2065.

By 2100, projected SLR impacts will expand inland by approximately 100 feet, with some areas in this flood zone becoming permanently inundated. Marsh buffers will be completely submerged, eliminating a critical line of flood defense for Deale Beach. Deale Beach Road, the primary access route to the community, will be permanently underwater, cutting off access for residents and emergency responders. Extreme flooding events will become more frequent and severe, requiring significant adaptation efforts, such as road elevation, marsh restoration, and alternative flood protection measures, to sustain long-term community resilience.

Deale Beach faces significant flood challenges due to its low-lying elevations and reliance on a single access road that is frequently inundated. The following flooding report card for the community evaluates the risk posed by multiple flood factors Table 21).

Table 21 – Deale Beach Flooding Report Card		
Category	**Rating**	**Justification**
Flood Pathways	High	The community is highly vulnerable to coastal flooding, particularly along Deale Beach Road and low-lying residential areas near tidal waterways.
Stormwater Drainage	Moderate	The stormwater system consists of informal swales and culverts that require regular maintenance.
Infrastructure Vulnerability	High	Deale Beach Road serves as the only access point and is frequently flooded, creating a significant risk for emergency access and daily transportation.
Erosion & Shoreline Stability	Moderate	Natural marshes and wetlands provide stability, but bulkheads along Carrs and Parker Creeks are overtopped, increasing the risk of property damage. The loss of marshland further accelerates vulnerability.
Overall Flood Threat	**High**	**The combination of daily tidal inundation, storm-driven flooding, marsh degradation, and vulnerable infrastructure poses persistent risks to residents and access routes.**

4.4.2. Masons Beach

Masons Beach is a small waterfront community bordered by Parkers Creek to the north and the Chesapeake Bay to the east. Historically a fishing and recreational area, Masons Beach remains a coastal neighborhood with a mix of seasonal and year-round residents. The area is defined by a combination of bulkheads, stone protection structures, and natural marshes that provide varying degrees of flood protection (Figure 49).

Along the bay-facing shoreline, natural marshes help absorb wave energy, playing a critical role in flood protection. However, repeated inundation and gradual degradation threaten their long-term stability. Marsh elevations range one to three feet above sea level. Sections of the marsh’s shoreline are protected by stone or bulkhead while some remain natural (Photo 97). In more developed areas, bulkheads fronted by stone offer additional protection. Along this stretch of residential shoreline, protection elevations are relatively continuous and less frequently overtopped with top of bulkhead elevations at +7.0 feet NAVD88 (Photo 98).

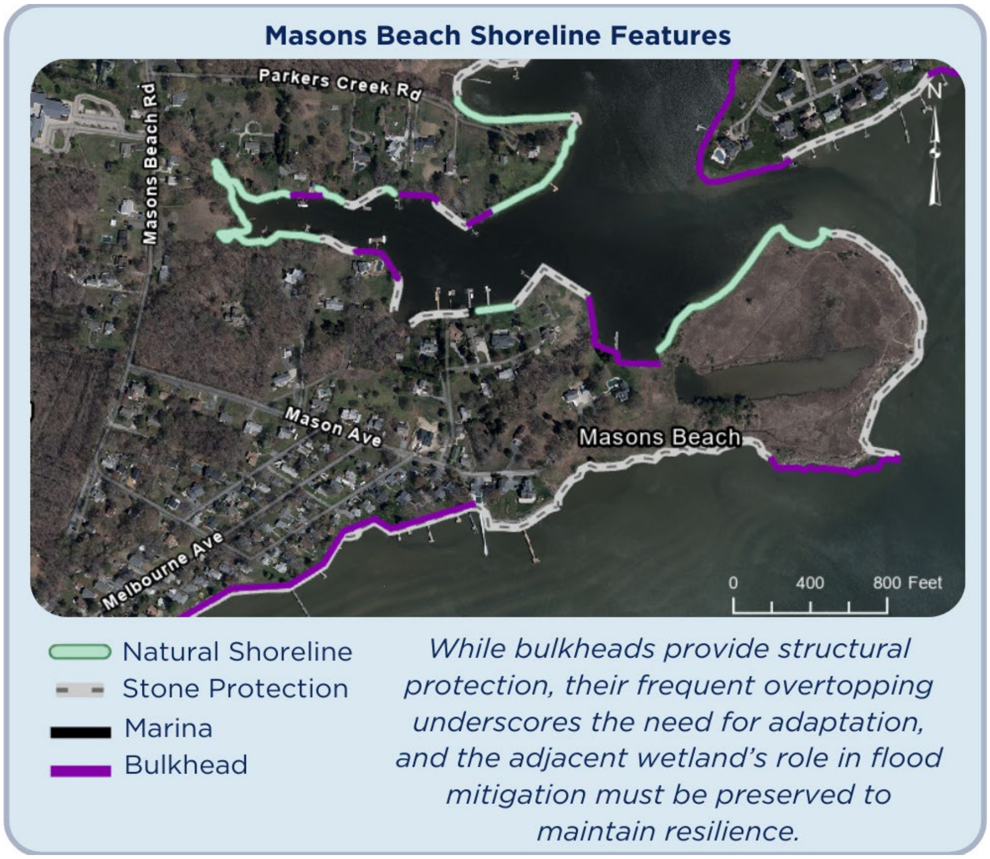


Figure 49 – Shoreline Features in Masons Beach

Photo 96 - Aerial imagery of Masons Beach with callouts showing the vantage points of Photo 97 and Photo 98.

Photo 97 - Stone protection at edge of marsh along bay-facing shoreline (Marsh interior +1.0 - +3.0 feet NaVD88; Top of Stone +1.5 feet NAVD88)

Photo 98 - Standard residential shoreline protection along bay-facing shoreline in Masons Beach (Top of Bulkhead +7.0 feet NAVD88)

Photo 99 - Parker Creek marsh shoreline

On the Parker Creek shoreline, bulkheads and stone protection structures with top elevations between +2.5 and +4.0 feet NAVD88 provide stability but are frequently overtopped during elevated water levels, limiting their effectiveness. Flood protection in the area remains fragmented, as individual property owners have varying levels of shoreline defenses.

Stormwater management in Masons Beach follows patterns observed in other coastal communities on the Peninsula. The system consists of a series of culverts, swales, and inlets that convey stormwater to outfall into tidal waters (Figure 50). However, maintenance is a persistent challenge, with sediment buildup and blockages reducing drainage efficiency. Additionally, the area is particularly vulnerable to tidal backflow, which occurs when high water levels prevent stormwater from properly draining, leading to prolonged periods of standing water (Photo 100).

Photo 100 - Roadway culvert that outfalls to tidally influenced marsh area is backwatered into connecting swale system

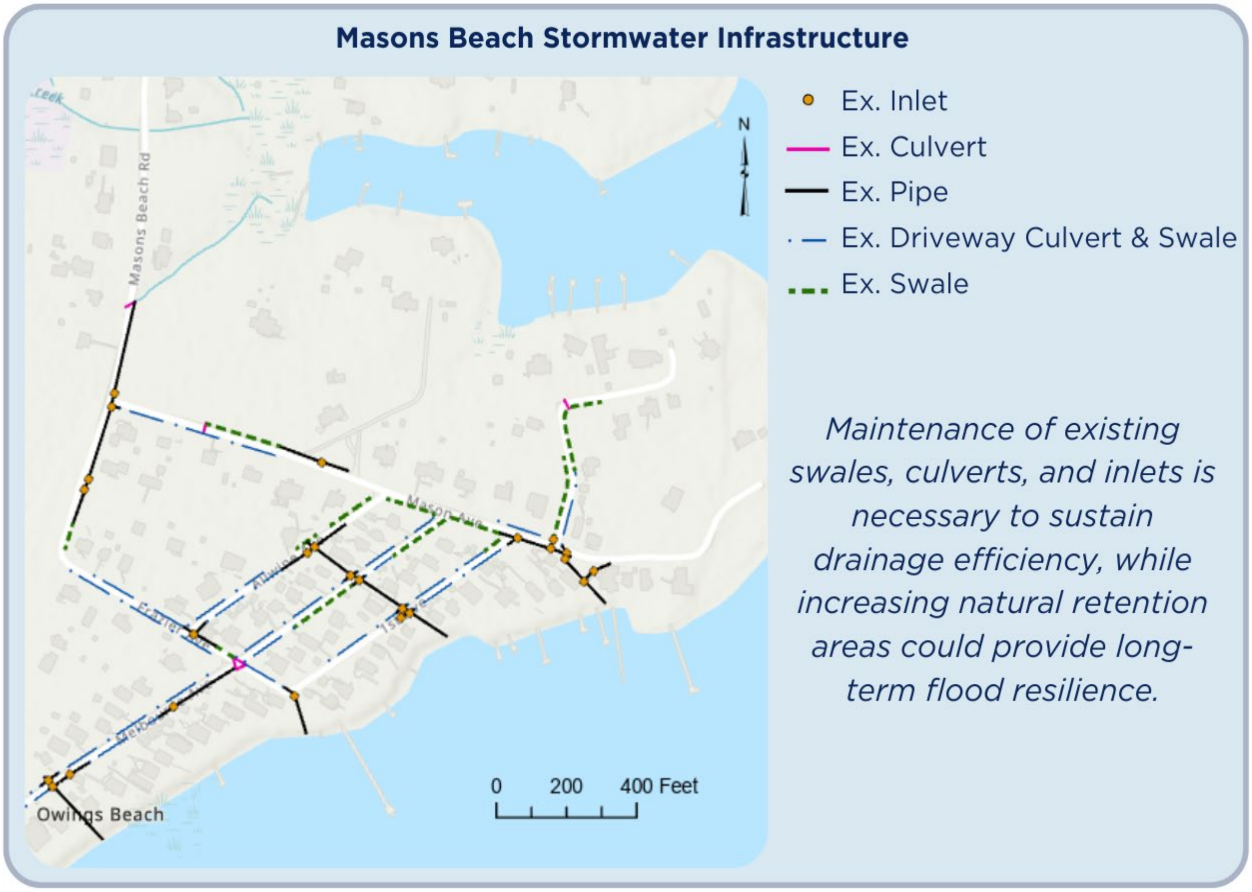


Figure 50 – Mapped Stormwater Infrastructure for Masons Beach

By 2050, stormwater infrastructure in Masons Beach will struggle to handle increased rainfall intensity and tidal surge impacts, leading to more frequent and severe flood conditions. Stormwater flooding in Masons Beach is influenced by the community's low elevations, tidal backwater effects, and limited stormwater infrastructure.

In Masons Beach, stormwater flooding under the 2050 rainfall-only scenario is relatively limited in depth but widespread in coverage (Figure 51). The area's eastern shoreline marsh is already overwhelmed by tidal inundation, making it difficult to distinguish additional flooding caused solely by rainfall. Within the residential core of the neighborhood, shallow nuisance flooding emerges during the 2-year rainfall event, with depths around 3 inches in low-lying areas along Mason Avenue, Masons Beach Road, and Allwine Avenue.

As rainfall severity increases from the 2- to 10-year event, flood extents expand slightly inland, though overall flood depths rise only marginally reaching approximately 5 inches during the 100-year storm. While these depths may appear minor in isolation, the broader saturation of streets and yards presents challenges for safe travel and drainage. By the 100-year rainfall event, nearly all residential streets in Masons Beach exhibit some level of temporary stormwater inundation, particularly in low-lying lots and road depressions. The flooding remains largely shallow, but its widespread presence and persistence after storms indicate vulnerabilities in both elevation and drainage infrastructure.

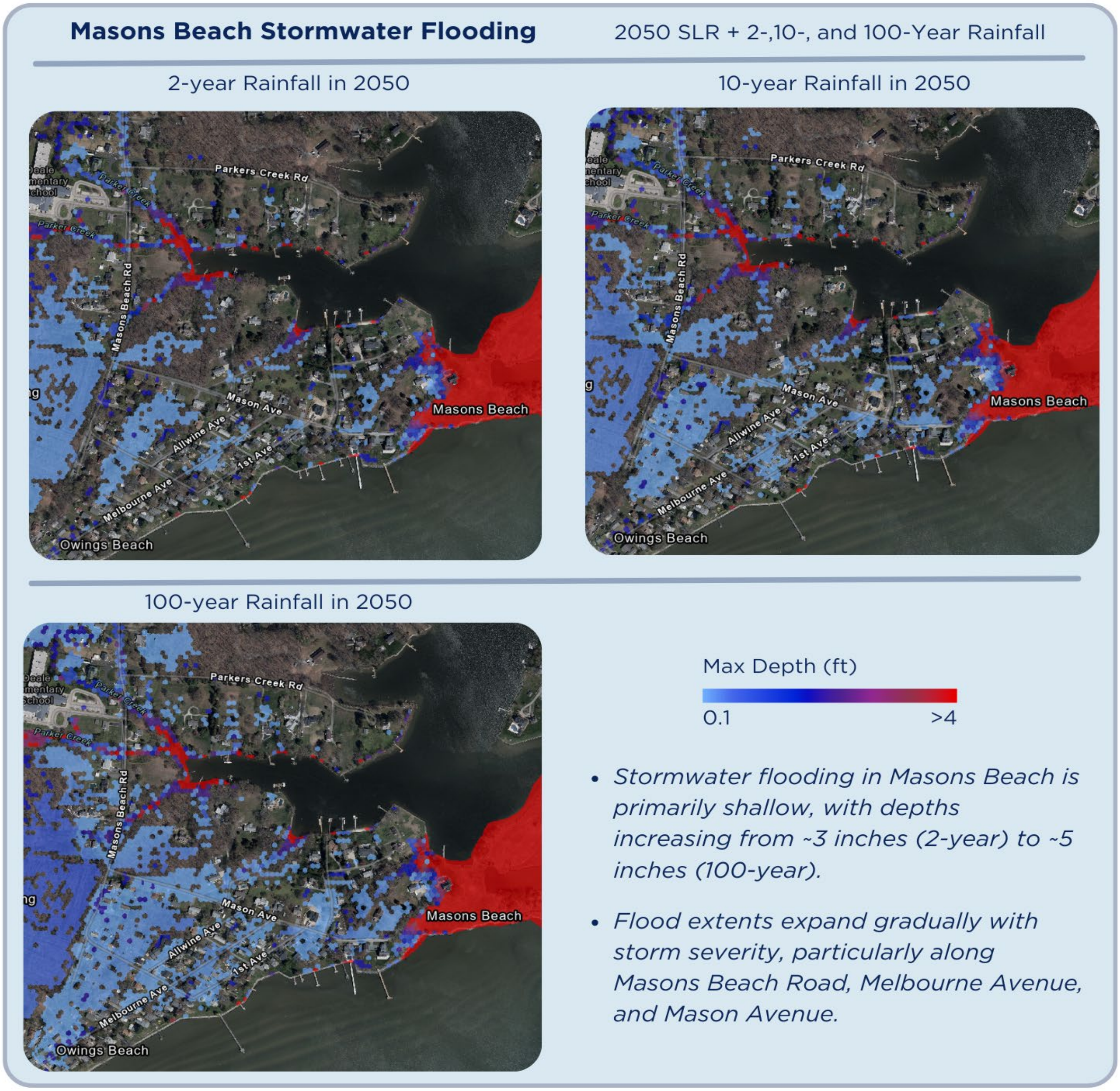


Figure 51 – Projected Stormwater Flooding Depths for 2050 2-, 10-, and 100-Year Rainfall Events in Masons Beach

While stormwater-only flooding results in relatively shallow, short-term inundation across Masons Beach, the impacts are significantly magnified when storm surge is introduced. As shown in the following section, compounded flooding from rainfall and elevated tides leads to much deeper and more hazardous conditions, particularly along the eastern shoreline and adjacent residential streets where backflow and runoff converge.

The 2050 2-year rainfall and 2-year storm surge scenario (Figure 52) projects widespread inundation across the area, particularly along Mason Avenue, Masons Beach Road, and Allwine Avenue. The presence of marshes and low-lying shorelines around Masons Beach allows storm surge to propagate inland, overwhelming the drainage system. As a result, tidal backflow through stormwater outfalls exacerbates flooding, preventing effective drainage during high tides and storm events. The eastern portion of the community is particularly vulnerable, with projected flood depths exceeding four feet in some areas. This region is heavily impacted due to low-lying landforms and insufficient structural flood protection. Masons Beach Road and Mason Avenue serve as primary access routes for the community but are projected to experience persistent flooding under future storm conditions. Flood depths along these roads are expected to reach over one foot, making them impassable and limiting emergency response access.

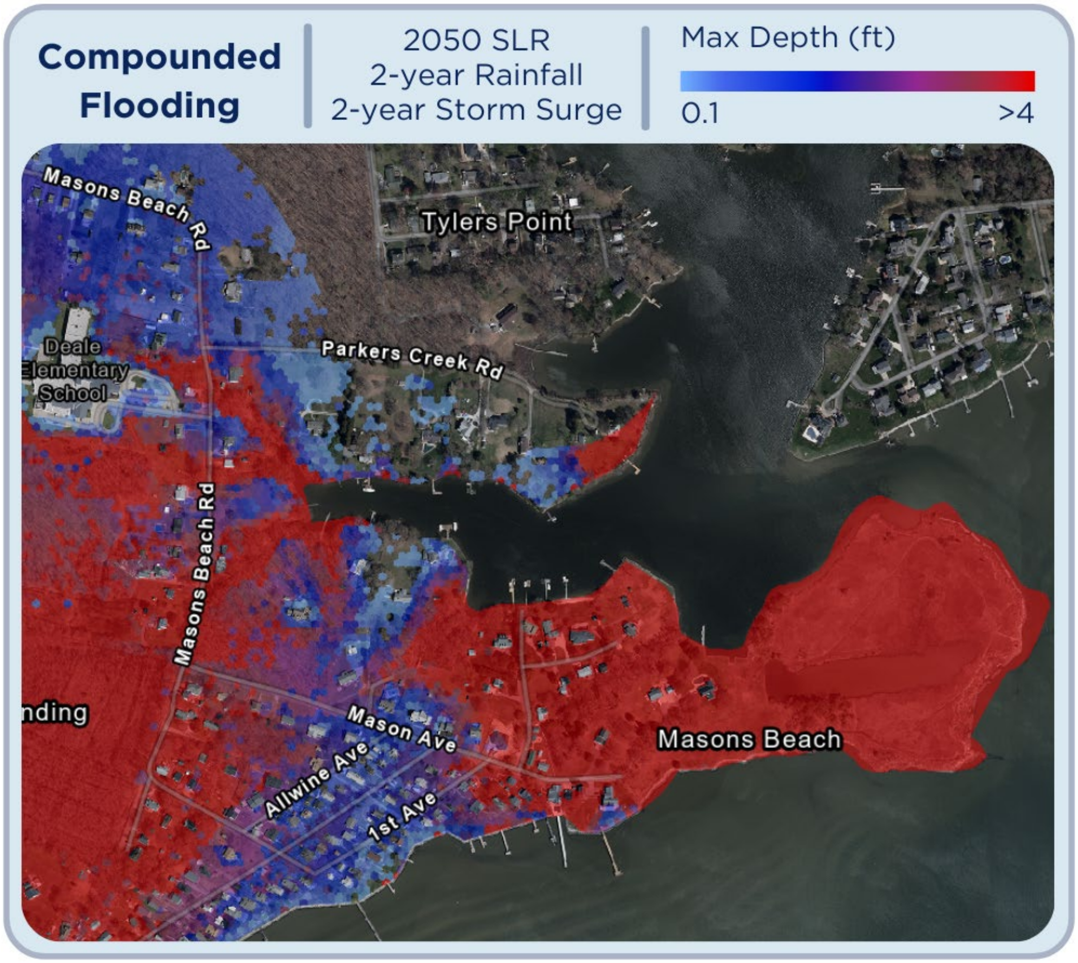


Figure 52 – Projected Stormwater Flooding Depths for the 2050 2-Year Rainfall and 2-Year Storm Surge Scenario in Masons Beach

Masons Beach faces increasing flood risks. The combination of rising sea levels, marsh degradation, and storm surge contributes to frequent inundation along roadways and private properties. The low-lying nature of Parker Creek's shoreline and its adjacent wetlands, while beneficial for absorbing stormwater, also makes the area more prone to standing water, particularly during high tides.

SLR projections indicate that by 2065, tidal inundation will significantly increase in low-lying areas, particularly along Parkers Creek and the surrounding wetlands (Figure 53). The frequency and duration of flooding events will accelerate marsh degradation, reducing the natural flood protection that currently benefits the community. Additionally, more frequent high water levels will further compromise bulkhead integrity, exacerbating erosion and increasing the drainage difficulties.

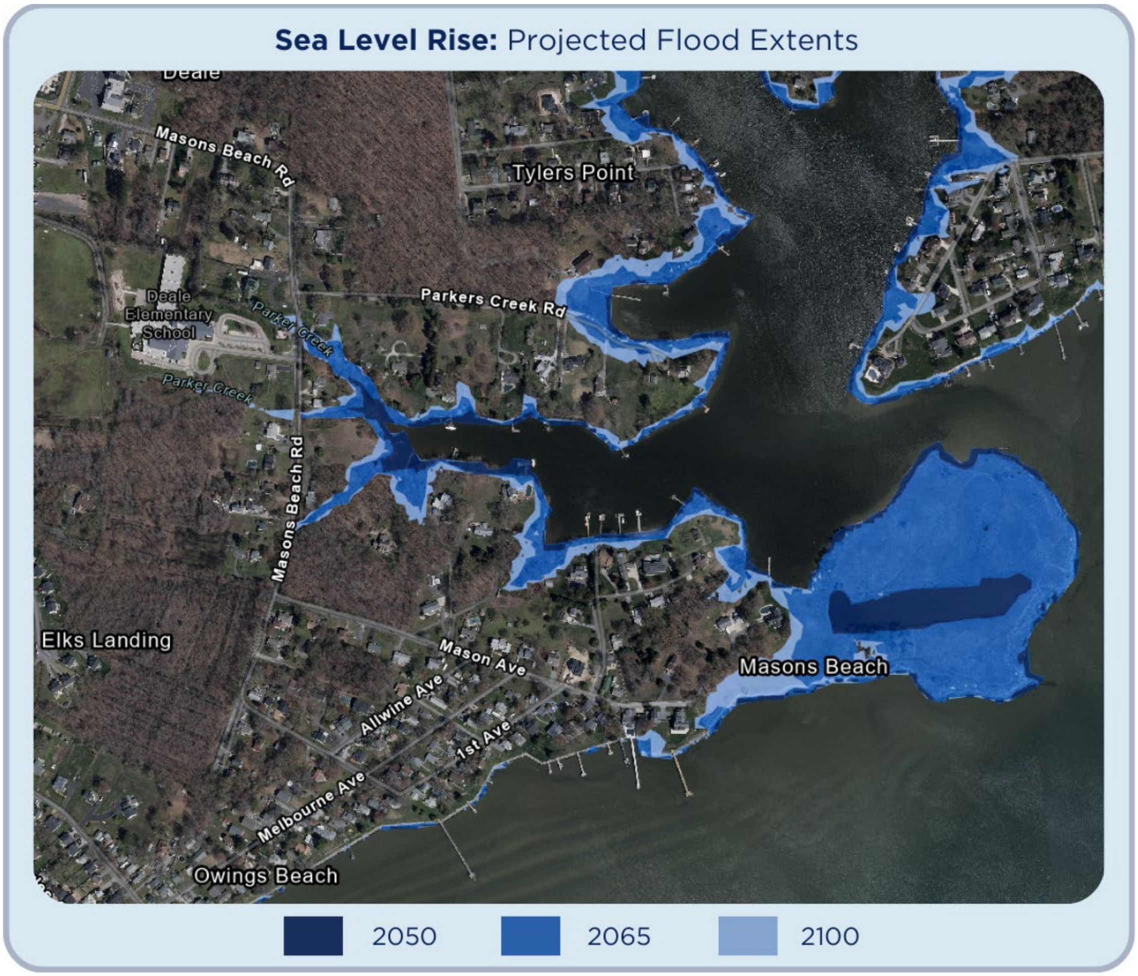


Figure 53 – SLR Projections for Masons Beach illustrate the increasing vulnerability of Parker Creek's shoreline and adjacent wetlands.

Masons Beach faces moderate flood risks due to a combination of shoreline characteristics, infrastructure limitations, and ongoing marsh degradation. While the bay-fronting shoreline benefits from more continuous flood protection, areas along Parker Creek are more vulnerable to rising water levels. The effectiveness of existing flood defenses depends on the long-term stability of natural flood buffers and the maintenance of bulkheads and stone revetments. The following flooding report card details the vulnerabilities of various criteria contributing to flood resilience (Table 22).

Table 22 – Masons Beach Flooding Report Card		
Category	**Rating**	**Justification**
Flood Pathways	Moderate	The bay-facing shoreline has relatively continuous protection, reducing flood risks, but Parker Creek's lower elevations and marsh loss increase vulnerability.
Stormwater Drainage	Moderate	The community's stormwater system requires maintenance to ensure proper conveyance and prevent localized pooling.
Infrastructure Vulnerability	Moderate	Roads are not regularly flooded, but the degradation of natural flood buffers and aging shoreline defenses could increase future exposure.
Erosion & Shoreline Stability	Moderate	Bulkheads along the bay-facing shoreline offer structural protection, but Parker Creek's marshes are gradually degrading, weakening natural flood defenses.
Overall Flood Threat	**Moderate**	**While the community benefits from some protective infrastructure, ongoing marsh loss and aging shoreline defenses present challenges that must be addressed to maintain resilience.**

4.4.3. Owings Beach

Owings Beach is situated at the southern tip of the peninsula, between Drum Point and Masons Beach. Elevations in the neighborhood vary, with higher ground reaching approximately +7.5 feet NAVD88 along the outer edges, while a central depression features elevations as low as +3.0 feet NAVD88.

Photo 101 - NNW facing aerial view of Owings Beach and Rockhold Creek.

The bay-facing shoreline is protected by seawalls with stone protection, and more protected shorelines along Rockhold Creek feature a combination of less robust hardened structures and natural shorelines (Figure 54).

Figure 54 – Shoreline Features in Owings Beach

The seawall spanning the residential properties on the Chesapeake Bay protects the area to an elevation of approximately +6.5 feet NAVD88. The seawall is fronted by a formalized revetment with crest elevations level with the seawall behind it (Photo 102). The southernmost property in the community breaks this continuous protection and protects the gap in the seawall with less formalized stone protection (Photo 103). At the transition from bay-facing shoreline to the more sheltered Rockhold Creek shoreline, a jetty (Top Elevation +6.0 feet NAVD88) extends out from the southern tip of the Peninsula (Photo 104).

Photo 102 - Seawall with revetment along bay-fronting shoreline (Top of Seawall +6.5 feet NAVD88)

Photo 103 - Gap in seawall at southernmost property in Owings Beach

Photo 104 - SSW aerial view of southern tip of the community and stone jetties at the entrance to Rockhold Creek (Top of Stone +6.0 feet NAVD88)

The northwestern edge of the community is bordered by a wetland area (Photo 105), with marsh elevations ranging from +1.0 to +2.5 feet NAVD88. This marsh buffer extends to Owings Beach Road, where low road crest elevations (+2.6 feet NAVD88) are frequently overtopped by rising water levels in the marsh. During Tropical Depression Debby, elevated water levels caused approximately 10 inches of flooding on the roadway (Photo 106). While this road is not the only access to the community, it serves as the primary ingress/egress, with the only alternative route passing through Masons Beach.

Photo 105 - Rockhold Creek shoreline in Owings Beach

Photo 106 - Standing water on Owings Beach Road due to Tropical Depression Debby
Water level: +3.49' NAVD88 (or 2.83' above MHW)

While Owings Beach has a network of inlets, pipes, swales, and culverts that could function as a well-established drainage system, its effectiveness is limited by vulnerable low-lying areas and maintenance issues (Figure 55). Typical of other areas on the Peninsula, driveway culverts and swales require repairs and maintenance to prevent blockages and ensure proper conveyance (*Photo* 107 and *Photo* 108).

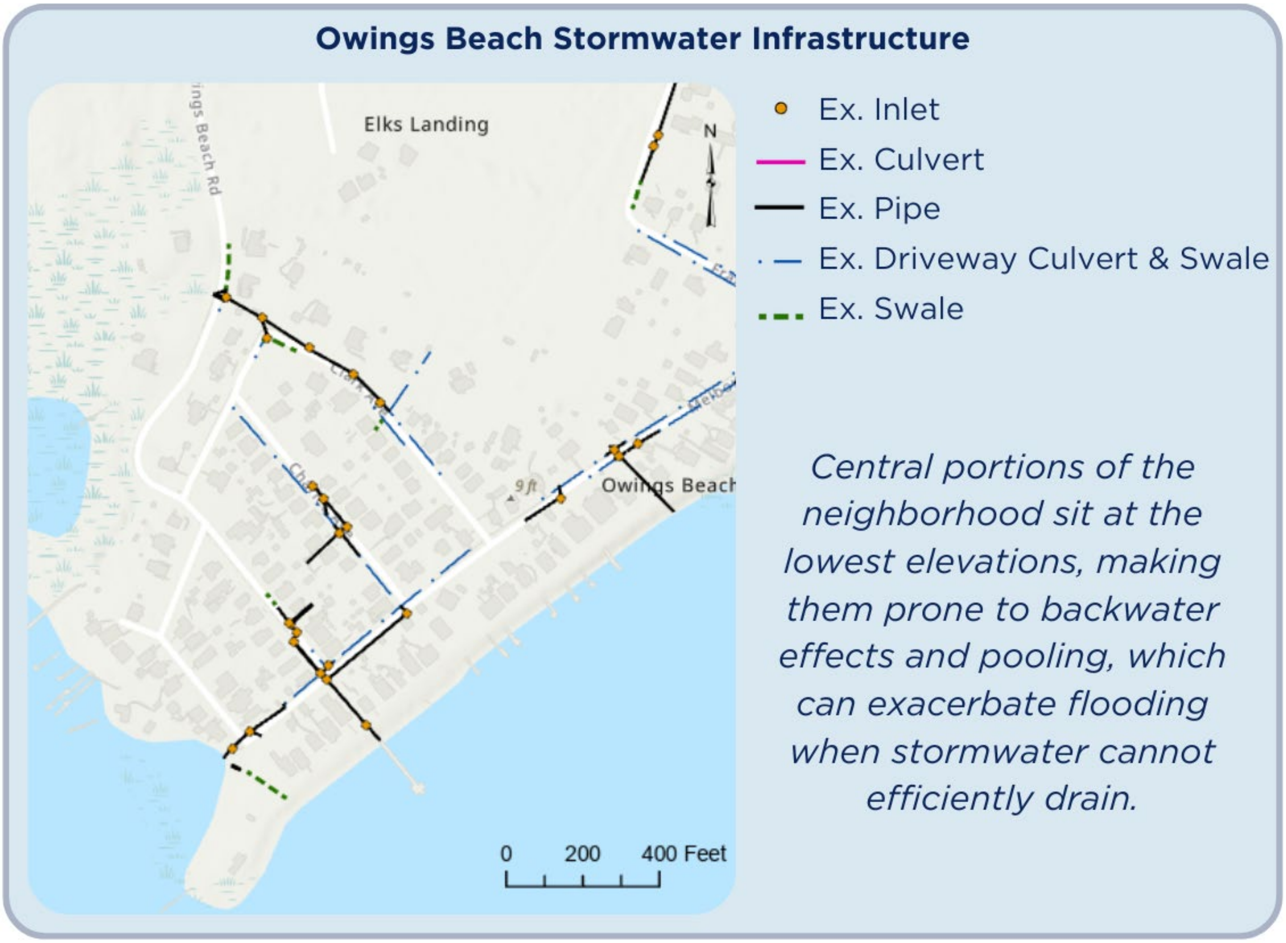


Figure 55 – Mapped Stormwater Infrastructure for Owings Beach

Photo 107 - Crushed driveway culvert

Photo 108 - Overgrowth and sedimentation in roadside swale

Photo 109, taken during the field assessment, shows one such outfall at the community pier partially inundated under normal conditions, highlighting its vulnerability to rising water levels. Many stormwater outfalls in Owings Beach experience similar challenges, particularly those with low invert elevations that limit drainage capacity and allow tidal backflow into the system. Roadway culverts along Owings Beach Road, which connect stormwater conveyance systems to adjacent wetlands (Photo 110). However, with invert elevations between +1.0 and +1.4 feet NAVD88, these culverts operate near existing water levels, making them prone to backwatering during high tides. Crossing over Owings Beach Road, outfalls are fully submerged and overgrown (Photo 111). These conditions contribute to poor drainage and prolonged standing water, particularly when coupled with rising water levels. The accumulation of sediment and vegetation reduces efficiency, requiring ongoing maintenance to maintain flow capacity. Additionally, Photo 112 shows backwatering effects at a gap in the seawall at the community's southernmost property. This demonstrates how low points in flood protection infrastructure create weak links that allow water intrusion into areas that might otherwise remain dry.

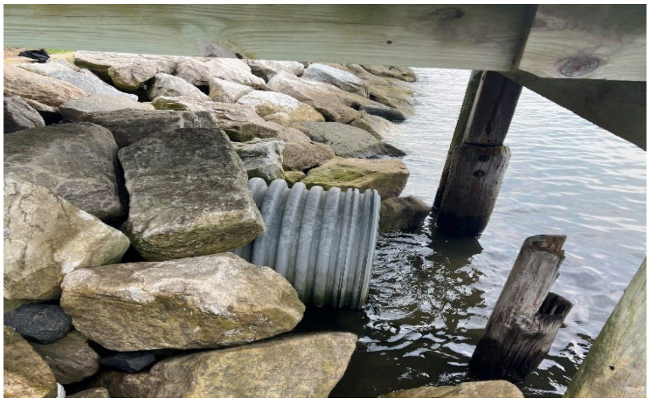


Photo 109 - Tidal outfall at the community pier (Invert Elevation +0.67' NAVD88) along the bay-facing shoreline Water level: +1.15' NAVD88 (or 0.49' above MHW)

Photo 110 – Roadway culverts connecting conveyance systems across Owings Beach Road to outfall into adjacent wetland (Invert Elevations +1' to +1.4' NAVD88) Water level: +0.72' NAVD88 (or 0.06' above MHW)

Photo 111 – Submerged and overgrown outfalls (Invert Elevations +0.36' to +0.58' NAVD88) at Owings Beach Road Water level: +0.74' NAVD88 (or 0.08' above MHW)

Photo 112 – Backwatering at gap in seawall at 6089 Melbourne Avenue. Water level: +1.14' NAVD88 (or 0.48' above MHW)

Stormwater flooding in Owings Beach is primarily concentrated in the central, low-lying portions of the neighborhood, which sit at elevations as low as +3.0 feet NAVD88 (Figure 56). In contrast to other nearby areas like Masons Beach, where flood extents expand significantly with increasing rainfall severity, Owings Beach experiences a more pronounced deepening of flooding within consistently affected areas.

Even during a 2-year rainfall event, stormwater depths reach approximately 0.5 feet in the central depression. As rainfall severity escalates to 10-year and 100-year return periods, those same low-lying areas reach depths of 0.75 feet and nearly two feet, respectively. While flood coverage grows modestly across the 2050 rainfall scenarios, it is the accumulation of water in these topographic depressions that most dramatically escalates flood risk to infrastructure and residential parcels.

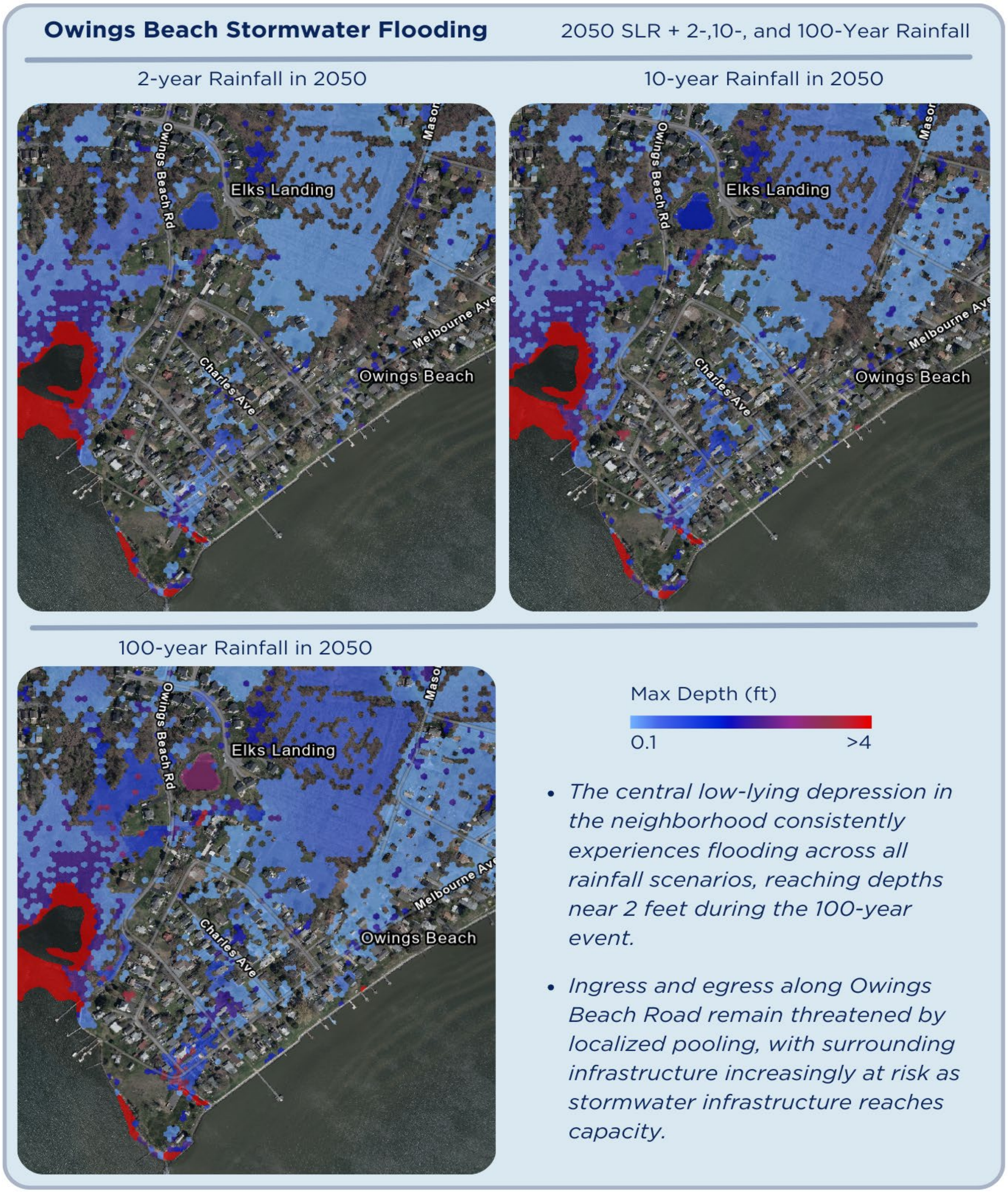


Figure 56 – Projected Stormwater Flood Depths in Owings Beach for 2-, 10-, and 100-Year Rainfall Events under 2050 SLR Conditions

Low outfall invert elevations and tidal backwater effects already limit the neighborhood's drainage capacity, and under future conditions, these challenges are amplified. With rainfall events projected to deliver more intense precipitation over short durations, the neighborhood's undersized and partially blocked stormwater network will struggle to manage runoff, especially in zones like Charles Avenue and Elks Landing, where runoff converges.

While rainfall-only flooding presents a clear and growing threat to the central neighborhood depression, the inclusion of tidal surge further strains drainage systems and raises flood depths across Owings Beach. Compounded flood scenarios introduce widespread inundation from Rockhold Creek and the Bay shoreline, overtopping defenses at known weak points and expanding the depth and duration of flooding. The following section evaluates these compounded impacts and their implications for access, infrastructure, and long-term resilience.

Owings Beach experiences significant stormwater flooding due to a combination of inadequate drainage infrastructure, tidal backwater effects, and naturally low elevations, creating widespread flood vulnerabilities during storm events. As shown in Figure 57, large portions of the community are expected to experience widespread and significant stormwater flooding under a 2050 2-year rainfall and 2-year storm surge scenario.

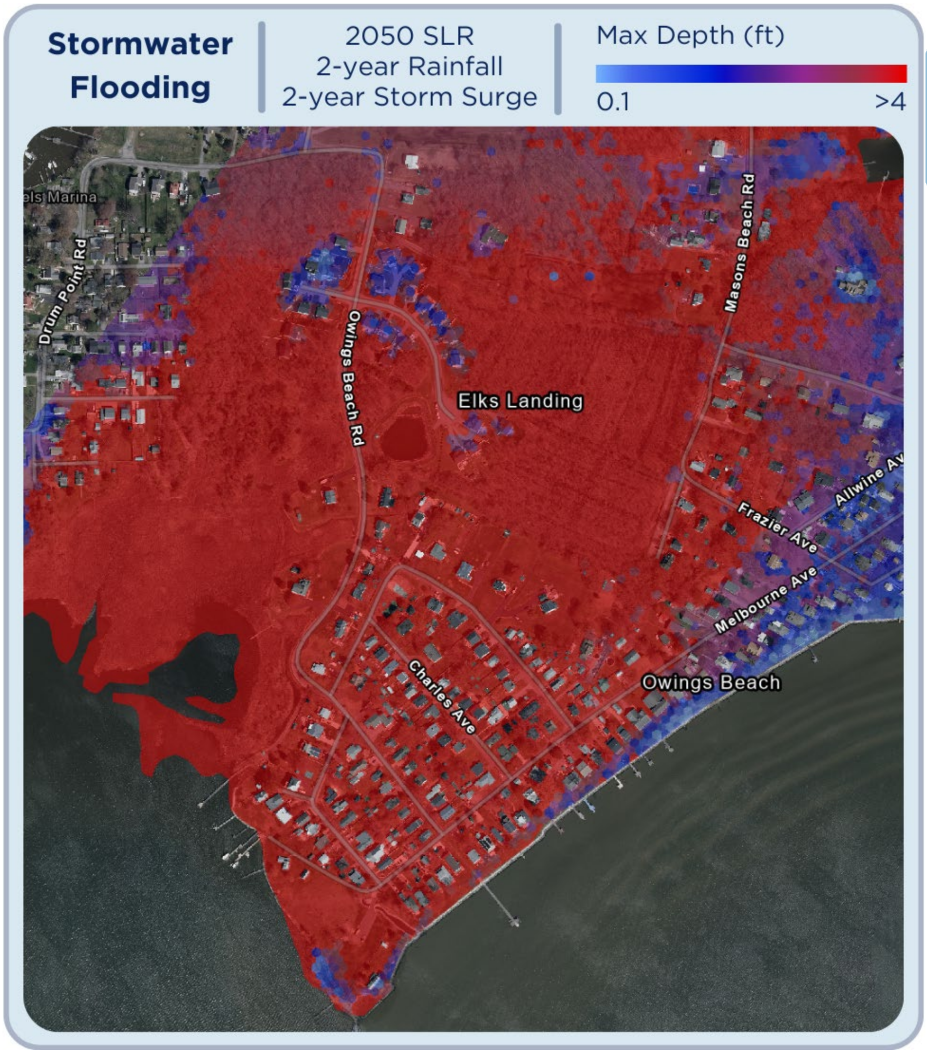


Figure 57 – Projected Stormwater Flooding Depths for the 2050 2-Year Rainfall and 2-Year Storm Surge Scenario in Owings Beach

The western portions of the community, particularly around Elks Landing and Owings Beach Road, are projected to experience extensive flooding exceeding four feet in some areas. These areas are low-lying and adjacent to tidal marshlands, making them highly susceptible to backwater effects from rising water levels and tidal surges. Owings Beach Road, the main access route into and out of the community, is heavily impacted by flooding. This poses a significant risk for emergency response and evacuation during storm events, as floodwaters could block transportation routes and isolate residents. Stormwater infrastructure along Melbourne Avenue, East Marshall Avenue, and Charles Avenue is undersized and inadequate, leading to frequent localized flooding in residential areas. Isolated stormwater runoff pooling is also seen near the north end of Melbourne Avenue and Frazier Avenue, where existing swales and culverts fail to effectively drain stormwater.

Tropical Depression Debby provided a real-time example of how extreme water levels impact Owings Beach, illustrating the community's susceptibility to coastal flooding. As captured in Maryland MyCoast reports (Figure 58 and Figure 59), observed water levels during the event exceeded predictions, demonstrating the role of storm surge in compounding flood risks. Low-lying properties along Rockhold Creek experience significant inundation, demonstrating that even small storm systems can create localized flooding issues that threaten access and property safety.

One of the most severely impacted areas was the intersection of Melbourne Avenue and Irvin Avenue, where floodwaters reached over a foot in depth, making roadways impassable (Figure 59). Flooding in this area is exacerbated by a gap in the previously continuous flood protection system, which had safeguarded the neighborhood up to +6.5 feet NAVD88. This break in the system now allows floodwaters to backwater into the stormwater conveyance system, regularly inundating the area. As water encroaches through this vulnerable pathway, it accumulates in the neighborhood's central low-lying depression, making flooding a persistent issue.

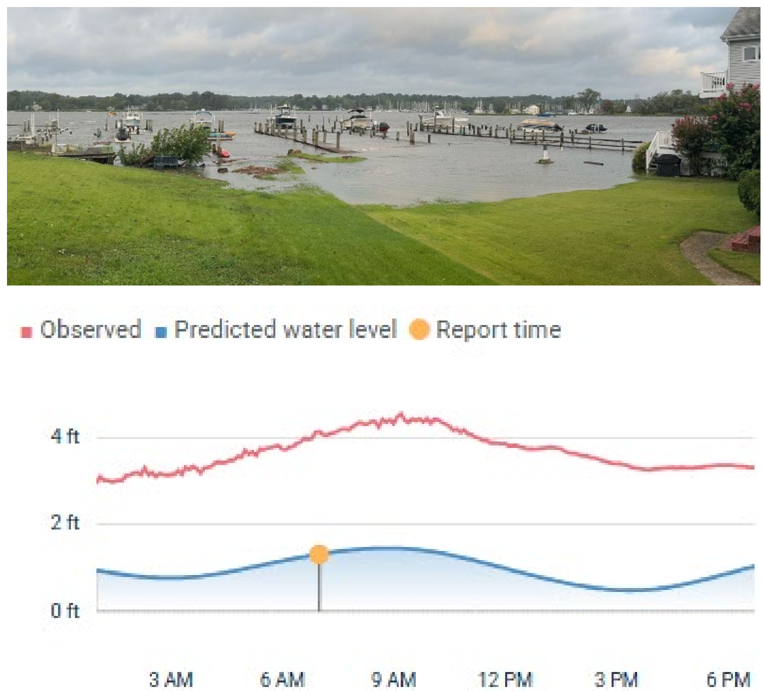
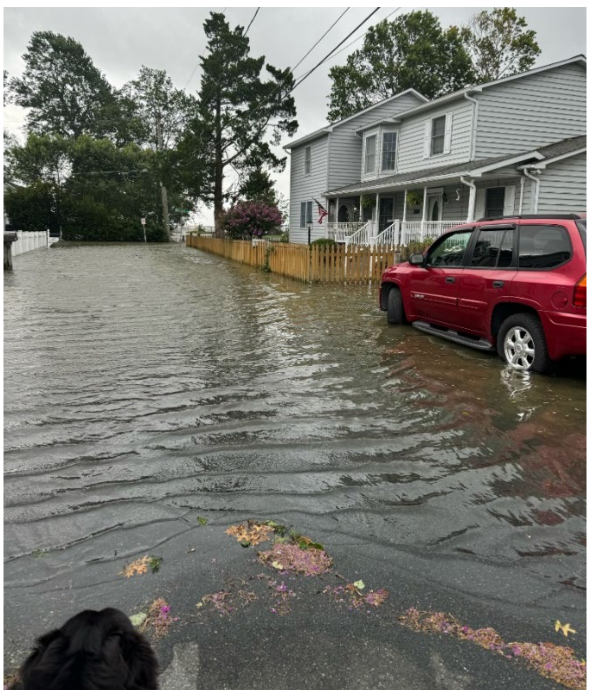


Figure 58 – Maryland MyCoast Report Documenting Property Flooding along Rockhold Creek Shoreline in Owings Beach during Tropical Depression Debby (August, 9, 2024)
Water level: +4.1' NAVD88 (or 3.44' above MHW)



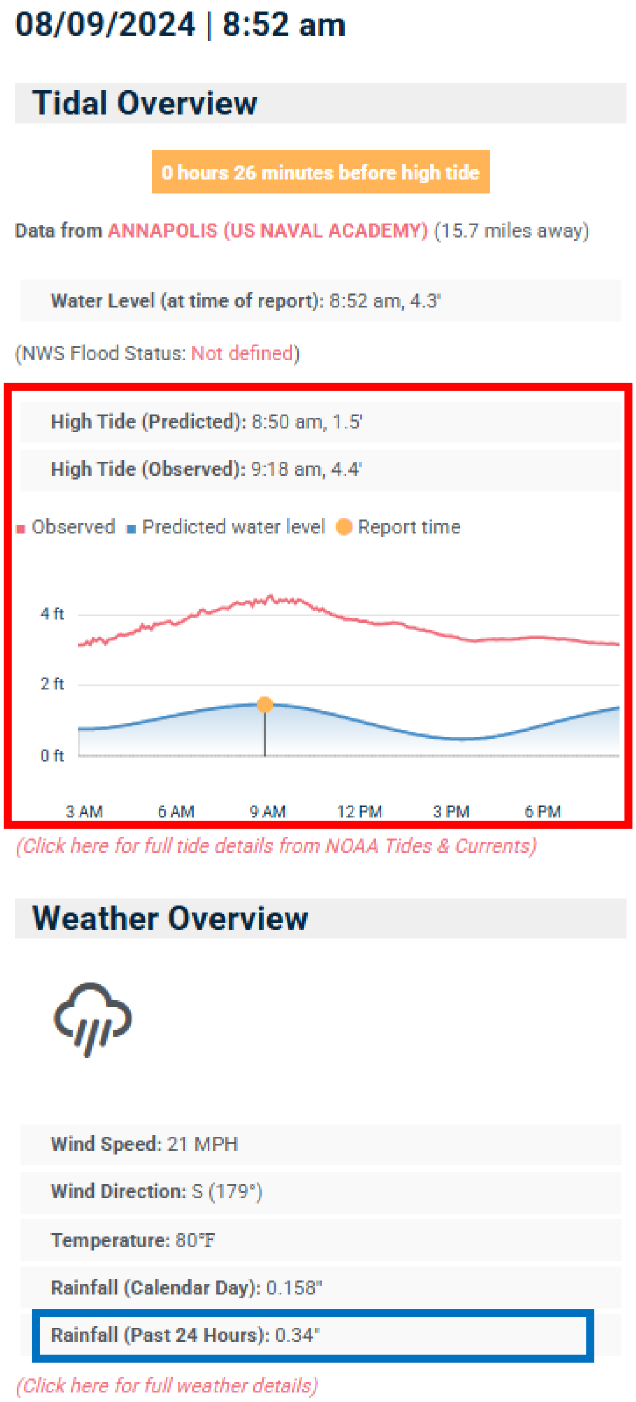


Figure 59 – Maryland MyCoast Report Showing Flooding at Corner of Melbourne Avenue and Irvin Avenue during Tropical Depression Debby
*Note: Red Box showing associated observed water levels; and Blue Box showing rainfall at the time of the photo.

SLR projections indicate that Owings Beach's vulnerability will increase significantly by 2065 (Figure 60). Daily flood depths on sections of Owings Beach Road, the main access route, are expected to reach at least 0.5 feet by 2065 and as high as four feet in some areas by 2100. Additionally, without restoration efforts, the existing marsh buffers will degrade, allowing worsening flood conditions and making traditional drainage infrastructure increasingly ineffective. By 2100, chronic tidal flooding is expected to extend beyond the current flood-prone areas, placing additional properties at risk.

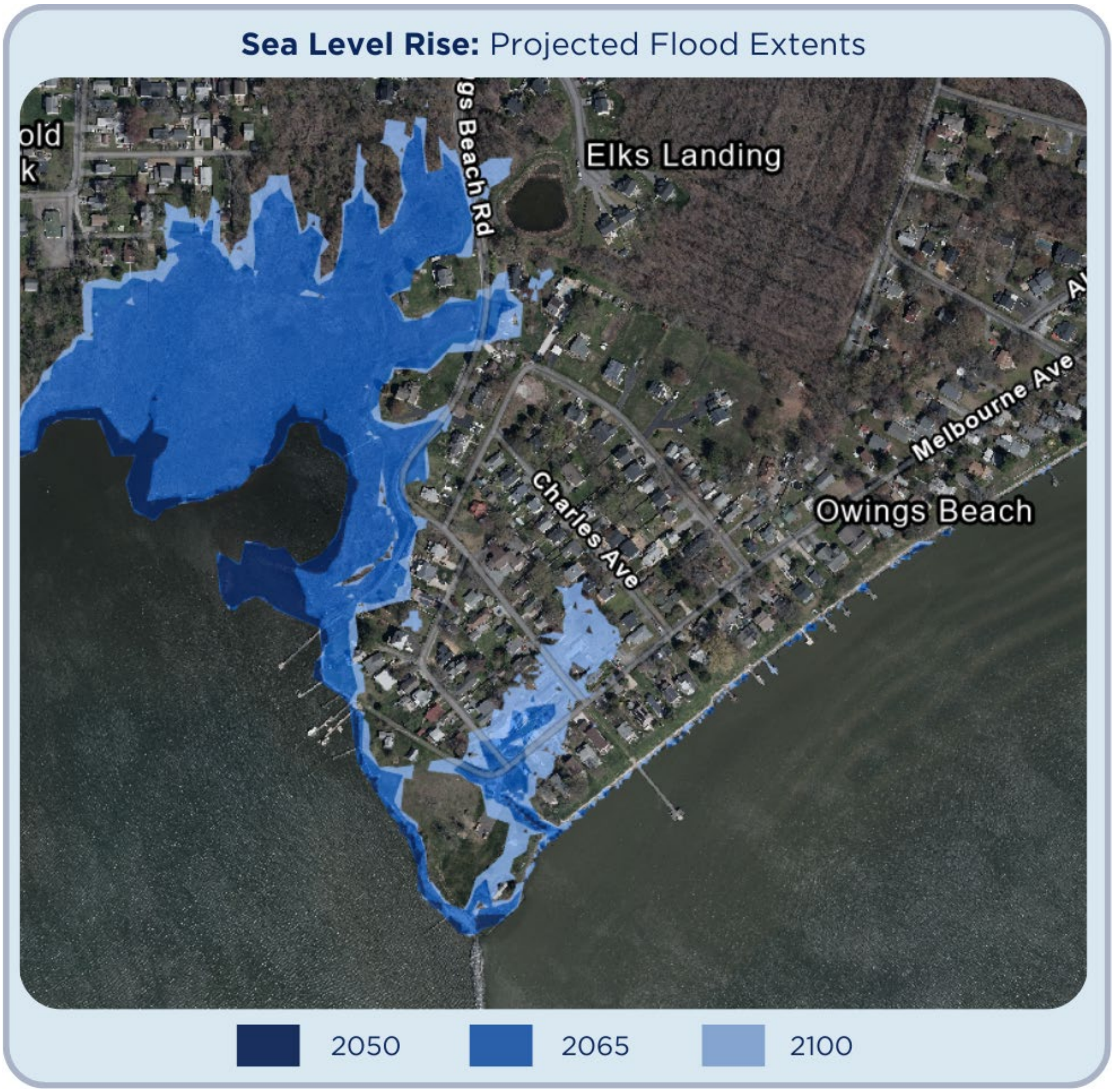


Figure 60 – Projected SLR Flood Extents for Owings Beach indicate increasing vulnerability in low-lying areas, where inundation is expected to worsen by 2065.

The impacts of flooding observed during recent storm events will only intensify as baseline water levels continue to rise. The following flooding report card evaluates key criteria impacting flood resilience in Owings Beach (Table 23).

Table 23 – Owings Beach Flooding Report Card		
Category	**Rating**	**Justification**
Flood Pathways	Moderate	Flooding primarily occurs in low-lying areas due to gaps in the flood protection system and backwater effects from the stormwater conveyance network. The presence of a continuous seawall along the bay-facing shoreline reduces direct flood encroachment.
Stormwater Drainage	Moderate	While Owings Beach has a network of inlets, pipes, swales, and culverts, its effectiveness is limited by vulnerable low-lying areas and maintenance issues, leading to backwatering and frequent pooling.
Infrastructure Vulnerability	Moderate	The community's primary ingress/egress route, Owings Beach Road, experiences periodic inundation, but flooding has not yet rendered it completely impassable during typical high tides. However, continued SLR will increase the frequency and depth of flooding, threatening long-term access.
Erosion & Shoreline Stability	Moderate	The bay-facing seawall and revetment provide structured protection, but gaps in flood protection at the southernmost properties create weak links that allow water intrusion. Marsh buffers along Rockhold Creek are degrading due to frequent inundation, which will exacerbate shoreline erosion.
Overall Flood Threat	**Moderate**	**While current flood protection measures reduce direct exposure to high-energy waves, vulnerabilities in the flood protection system, degrading marsh buffers, and stormwater backwatering effects pose an increasing flood risk to the community.**

5 MITIGATION CASE STUDIES

5. MITIGATION CASE STUDIES

Communities along the Deale-Shady Side Peninsula face persistent flood risks from SLR, storm surge, and inadequate drainage infrastructure. As flooding events become more frequent and severe, small coastal communities must explore innovative and cost-effective flood mitigation strategies tailored to their specific vulnerabilities.

This chapter presents a series of mitigation case studies, highlighting real-world examples of flood resilience projects. This chapter also highlights how community engagement and education can serve as critical tools for empowering residents to understand flood risks and participate in long-term resilience strategies alongside physical infrastructure improvements. Each case study was selected based on relevance to the Peninsula's conditions.

These case studies provide insight into:

- The effectiveness of various mitigation approaches, ranging from green infrastructure to engineered flood protection projects.
- Challenges faced during implementation and lessons learned from past efforts.
- Best practices that could be adapted for the Peninsula's unique communities.

Each case study includes:

- **Background and Flooding Challenges**: Context about the community and its specific flood-related issues.

- **Implemented Solutions**: A breakdown of the mitigation measures used and their effectiveness.

- **Key Takeaways and Lessons for the Deale-Shady Side Peninsula**: Insights on how similar approaches could be applied locally.

To ensure these strategies are accessible and actionable, the case studies focus on scalable solutions that can be applied across the Peninsula. While no single mitigation approach will eliminate flood risks entirely, a layered and adaptive strategy that combines community engagement, policy interventions, and physical flood protections can help improve long-term resilience.

The following case studies of successful mitigation efforts implemented across the Chesapeake Bay region and beyond offer a roadmap for future flood adaptation planning on the Deale-Shady Side Peninsula.

5.1. Case 1: Earthen Berm with Living Shoreline for Flood Protection in North Beach, Maryland

The Town of North Beach, located in Calvert County, Maryland, is a small coastal community with a population of between 2,500 and 3,000 residents. Historically a residential saltwater resort, North Beach remains a waterfront destination featuring a half mile-long boardwalk, public beaches, and several parks. However, its low elevation, primarily below +5 feet NAVD88, makes it highly vulnerable to coastal flooding due to storm surges and rising water levels.

Flooding from storm surges, high tides, and extreme weather events has led to frequent road closures, overwhelmed drainage systems, and erosion along critical infrastructure such as Bay Avenue (Maryland Route 261), which serves as the community's main transportation corridor and emergency evacuation route. Without adequate flood protection, frequent tidal inundation and storm events threaten the Town's mobility and public safety.

Recognizing these risks, The Town of North Beach implemented nature-based flood protection measures. Funded by the National Fish and Wildlife (NFWF) Hurricane Sandy Coastal Resiliency Grant, this project aimed to stabilize the shoreline, mitigate erosion, and improve flood resilience through the construction of a living shoreline and an earthen berm.

5.1.1. Background

The Walton Beach Nature Preserve, located north of 9th Street between Bay Avenue and Atlantic Avenue, was identified as a priority area for flood mitigation due to its susceptibility to coastal flooding and erosion (Photo 113 and Photo 114).

Photo 113 - Flooding at Bay Avenue during Hurricane Sandy (2012) – Photo from northbeachmd.org

Photo 114 - Flooding on 9th St. during Hurricane Sandy (2012) – Photo from northbeachmd.org

The project was implemented in two phases to provide both shoreline stabilization and inland flood protection. Phase 1, completed in 2015, focused on constructing a 670-foot-long living shoreline to reduce erosion and enhance ecological resilience. This included the planting of native marsh grasses and wetland vegetation protected by headland breakwaters, which improved habitat stability and provided a natural buffer against rising water levels (Photo 115 and Photo 116).

Photo 115 - Tricolored Heron at Walton Beach Nature Preserve – Photo from Silverman, 2019

Photo 116 - Walton Beach Nature Preserve's Breakwaters – Photo from BayLand 2022

Phase 2, completed in 2017, introduced and 1,000-foot-long earthen berm designed to act as a dike and provide flood protection. Constructed to an elevation of four feet above mean sea level, the berm serves as a critical barrier against tidal inundation and storm surge. To reinforce the structure, native vegetation was planted along the berm's surface, helping to stabilize the soil and support long-term resilience. The project also incorporated drainage improvements on the landward side of the berm to manage surface water runoff and reduce the risk of pooling in adjacent areas.

With a total project cost of $540,000, funding also supported public education and community outreach initiatives to engage residents in coastal resiliency efforts. Local high school students from Calvert County Public Schools participated in planting efforts, providing hands-on experience with wetland restoration and increasing public awareness of nature-based flood mitigation strategies.

Photo 117

Photo 118

Students participating in Walton Beach Nature Preserve's Outreach and Education Program.

5.1.2. Results & Effectiveness

The Walton Beach Nature Preserve has provided immediate flood protection benefits, with the Town of North Beach reporting significant improvements even before project completion. The newly constructed berm was reported to have successfully prevented flooding in the 9th Street area on at least five separate occasions during high tide events in August 2017 immediately post-construction, reducing disruption to residents and infrastructure. Additionally, the marsh restoration component of the project has contributed to improved coastal resilience by reducing erosion along the shoreline.

5.1.3. Lessons for the Deale-Shady Side Peninsula

The North Beach flood mitigation project provides valuable insights for implementing nature-based flood protection on the Deale-Shady Side Peninsula. Key lessons applicable to the Peninsula include:

1. **Cost Effective Nature-Based Flood Protection:**

   The North Beach berm demonstrated that integrating natural features such as earthen berms and wetland restoration can provide effective flood protection at a lower cost compared to other engineered solutions, such as seawalls and bulkheads.

   Application to the Deale-Shady Side Peninsula:

   - Identify vulnerable areas where natural flood barriers could be implemented instead of or in combination with hard infrastructure.
   - Explore grant opportunities, such as those utilized by the Town of North Beach, to fund nature-based flood mitigation projects, which incorporate wetland restoration and living shoreline techniques into flood resilience planning.

2. **Multi-Functional Infrastructure for Flood Mitigation and Ecological Uplift:**

   The berm and living shoreline not only mitigate flooding but also stabilizes eroding shorelines and provides habitat for wildlife.

   Application to the Deale-Shady Side Peninsula:

   - Design flood mitigation infrastructure that supports multiple benefits, such as habitat creation and shoreline stabilization.
   - Consider marsh migration corridors and wetland expansion to provide long-term flood resilience.
   - Integrate stormwater retention features into flood mitigation designs to reduce runoff and improve water quality.

3. **Scalable Approach for Small Coastal Communities:**

   As a small town with limited resources, North Beach successfully leveraged state and federal funding to implement its earthen berm and living shoreline. This model is replicable for other small coastal communities facing similar flood risks.

   Application to the Deale-Shady Side Peninsula:

   - Develop a roadmap for implementing nature-based flood solutions across multiple neighborhoods, starting with high-risk areas.
   - Engage regional and state agencies to align local flood resilience strategies with broader Chesapeake Bay watershed goals.

By applying these lessons, the Deale-Shady Side Peninsula can develop a comprehensive flood mitigation strategy that leverages nature-based solutions, promotes ecological resilience, and maximizes cost-effectiveness in addressing coastal flood risks.

5.2. Case 2: Crisfield Resilience Academy: A Model for Community-Driven Flood Preparedness

Crisfield, Maryland, located on the Lower Eastern Shore of the Chesapeake Bay, is highly susceptible to tidal flooding, storm surge, and SLR. With a low elevation and history of nuisance flooding, the city has adopted both structural and community-based strategies to address these risks. Among these, the Crisfield Resilience Academy stands out as a model for building local capacity through education and engagement.

Launched in collaboration with the U.S. Environmental Protection Agency (EPA), the City of Crisfield, and regional partners including Salisbury University’s Business Economic and Community Outreach Network (BEACON) and The Nature Conservancy, the Academy is part of a larger resilience effort that includes marsh restoration, tide gate installation, and berm construction.

5.2.1. The Program

The Crisfield Resilience Academy offers a six-session educational series designed to engage residents, business owners, and local officials in long-term flood resilience planning. The program, held at the Crisfield Public Library, is free and open to individuals aged 15 and older in the Crisfield area. Participants who complete all sessions receive a certificate and are eligible for a stipend of up to $300. The Spring 2025 session topics include:

1. ***What is Resilience?*** – Introduction to resilience and its relevance to Crisfield.
2. ***Drainage & Flood Warnings*** – Overview of the ditch system and flood alert technologies.
3. ***Economics & Careers*** – Opportunities in resilience-related careers.

4. ***Nature-Based Solutions*** – Benefits of marsh restoration, living shorelines, and green infrastructure.
5. ***Community Capacity Building*** – Civic engagement and local leadership strategies.
6. ***Celebration*** – Recognition event for participants and networking opportunity.

Sessions include expert presentations, handouts, and hands-on activities. Topics such as ditch maintenance and climate risk assessment are paired with public learning events and educational resources tailored to Crisfield's flood risks. Additionally, the Academy offers public learning sessions that are free and open to all community members. These sessions cover various environmental topics relevant to Crisfield and aim to broaden the reach of resilience education within the community.

The Resilience Academy is included in broader flood protection projects, including the restoration of surrounding marshes, construction of berms, and implementation of tide gates to control water flow through urban flood pathways.

While outcome data is not yet available, the Crisfield Resilience Academy represents a forward-thinking model that combines technical education with community empowerment. Its structure, partnerships, and incentive-driven engagement offer a replicable framework for other flood-prone areas looking to build long-term resilience through local capacity building.

5.2.2. Lessons for the Deale-Shady Side Peninsula

The Crisfield Resilience Academy provides valuable insights into how community-driven initiatives can complement structural flood mitigation efforts. The program demonstrates the importance of integrating education, local engagement, and technical expertise to support long-term resilience. Several key lessons from Crisfield's approach can be applied to the Deale-Shady Side Peninsula:

1. **Community Engagement as a Resilience Strategy:**

   Successful flood mitigation efforts require active public participation. The Academy's hands-on training and educational outreach provide a model for fostering a well-informed and engaged community.

   Application to the Deale-Shady Side Peninsula:

   - Develop structured education programs to increase awareness of flood risks and resilience measures.
   - Provide training on home floodproofing, stormwater management, and the role of nature-based solutions.
   - Offer incentives, such as stipends or certification programs, to encourage participation in resilience-building efforts.

2. **Align Educational Efforts with On-the-Ground Projects:**

   Crisfield's Academy is directly linked to ongoing resilience infrastructure projects.

   Application to the Deale-Shady Side Peninsula:

   - Coordinate education sessions with local flood mitigation project planning or implementation phases.

3. **Collaborative Partnerships for Resilience:**

   The Academy's success is largely due to partnerships with academic institutions, government agencies, and non-profits that provide technical expertise and funding.

   Application to the Deale-Shady Side Peninsula:

   - Partner with universities, environmental organizations, and state agencies to leverage expertise in resilience planning.
   - Explore funding opportunities through federal and state grants for community-based adaptation initiatives.
   - Encourage inter-agency coordination to ensure consistency in flood mitigation efforts across jurisdictions.

While hard flood protection is essential, Crisfield demonstrates that long-term resilience also depends on educating communities who live with flood risk. By adapting the Resilience Academy model to the Deale–Shady Side Peninsula, local leaders can foster community-driven adaptation, deepen public understanding of flood risk, and support equitable participation in mitigation planning.

This approach can complement structural investments by ensuring that residents are equipped to act both individually and collectively as the climate continues to change.

5.3. Case 3: Voluntary Buy-out in Staten Island, NY

Staten Island faced catastrophic loss when Superstorm Sandy struck in 2012. The southern shore communities, including Oakwood Beach, were particularly devastated. In the aftermath, residents faced the daunting challenge of rebuilding or relocating. The Oakwood Beach community successfully advocated for a state-run voluntary buyout program. This case study examines the program's development, implementation, and outcomes, providing insights for similar initiatives in other flood-prone areas, such as the Deale Shady Side Peninsula.

5.3.1. Background

Oakwood Beach, located along Staten Island's South Shore, is a close-knit neighborhood primarily composed of single-family homes. Most homes "are older wooden bungalows reminiscent of its past as a seasonal beach community"[10] having been built in the 1950s and 60s. The community is characterized by its working and middle-class residents, many of whom have lived there for over 25 years. Situated on former wetlands, Oakwood Beach is highly susceptible to flooding.

Following Sandy, Joe Tirone, a local property owner, initiated efforts to explore a buyout program through connecting with FEMA representatives and other communities with similar experiences and coordinating the formation of the Oakwood Beach Buyout Committee.

Photo 119 - Post-Superstorm-Sandy damage in Oakwood Beach (source: Curbed NY)

Photo 120 - Advocation for Buyout program in Oakwood Beach post-Sandy (source: Urban Omnibus)

The committee, comprised mainly of long-term residents, aimed to secure a buyout at pre-storm market value with a 10% incentive and to ensure the land was not redeveloped but returned to nature as a flood buffer. The committee faced significant challenges, particularly the need to navigate bureaucratic processes and secure support from local and state officials. The committee involved Governor Cuomo, who leveraged the Community Development Block Grant (CDBG) program to expedite the buyouts. Unlike the Hazard Mitigation Grant Program (HMGP), CDBG funds were not contingent on a presidential disaster declaration, allowing for quicker disbursement.

By 2022, over 300 households in Oakwood Beach had participated in the buyout program, with residents receiving an additional 10% of their pre-storm property value and a 5% bonus for relocating within the borough. The vacant properties are being transformed into a natural flood buffer, with plans for a waterfront park to protect remaining communities. Other communities along Staten Island's south shore (Figure

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[10] Koslov, Liz. "Fighting for Retreat after Sandy: The Ocean Breeze Buyout Tent on Staten Island." Metropolitics, April 23, 2014.

61) have since followed suit and organized their own buyout committees modeled by the Oakwood Beach Buyout Committee. The total program cost was over $130 million funded largely through federal disaster recovery allocations.

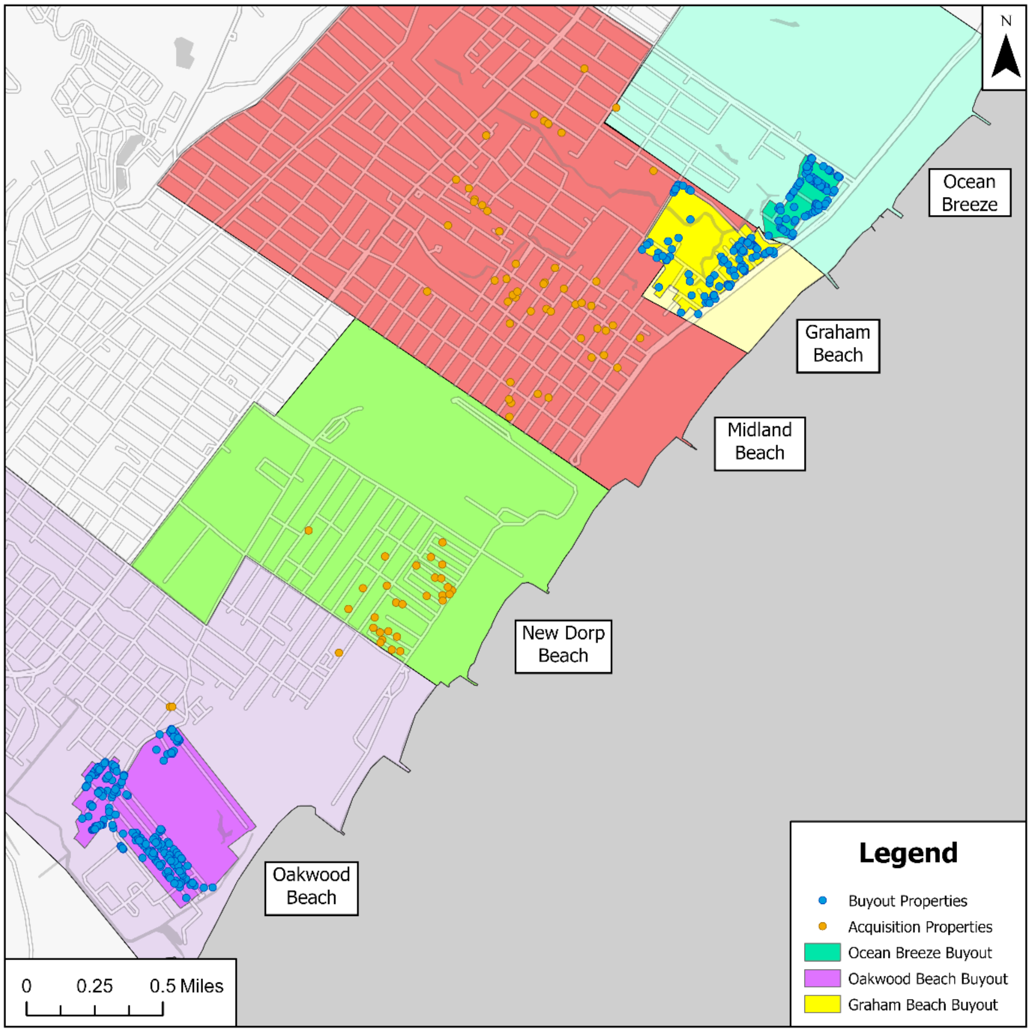

Figure 61 – Neighborhoods with Buyout Committees and Buyout and Acquisition Properties

5.3.2. Local Application: Maryland and AACo Buyout Program

The Maryland Department of Emergency Management (MDEM) administers a statewide buyout program that provides opportunities for property owners in high-risk flood zones to voluntarily sell their homes. The program, supported by FEMA's Hazard Mitigation Assistance (HMA) funds, aims to prevent repetitive loss by acquiring properties and converting them into flood buffers, parks, or other public green spaces.

Additionally, AACo launched a pilot buyout program in 2020. In collaboration with the City of Annapolis and the Chesapeake Bay Trust, the County allocated $1.3 million to purchase flood-prone properties experiencing frequent non-tidal or stormwater flooding. This initiative focuses on mitigating long-term flood risks before disaster occurs, reducing the need for emergency response funding.

This local effort aligns with broader national strategies where voluntary buyouts have been used to restore natural floodplains and absorb stormwater. By converting bought-out properties into green spaces, AACo can create natural buffers that reduce flood risks and protect nearby communities.

For residents of the Deale-Shady Side Peninsula, understanding the framework and leveraging both county and state-level buyout programs is essential. While voluntary buyouts may not be a widespread solution, they can serve as a last-resort measure for property owners facing repeated flooding. Establishing a buyout program before disaster strikes provides a structured and community-focused approach to relocation and land use planning.

5.3.3. Lessons for the Deale-Shady Side Peninsula

The Deale-Shady Side Peninsula shares many similarities with Oakwood Beach: small, rural coastal communities prone to flooding and situated on or near wetlands. The potential for severe storms and rising sea levels poses significant risks to these areas. The following lessons from Staten Island's buyout program can inform future discussions on managed retreat and flood resilience in AACo.

1. **Community Engagement and Education:**

   A critical strategy gleaned from the Oakwood Beach Buyout case study is the importance of community engagement and education. Residents in the Deale-Shady Side Peninsula, many of whom are long-term inhabitants with deep emotional attachments to their properties and way of life, may view buyouts as an extreme measure.

   This approach establishes a baseline understanding of how a successful buyout program works and determines its feasibility for application to the Deale-Shady Side peninsula.

   Application to the Deale-Shady Side Peninsula:

   - Develop interactive workshops and creative outreach mechanisms to educate the community about the long-term implications of compound flood threats on resilience in their communities.
   - Establish a framework for implementing a structured buyout program before a disaster occurs.
   - Ensure emergency preparedness and hazard mitigation strategies are communicated clearly to affected homeowners.

2. **Localized Buyout Committees:**

   Oakwood Beach's success was driven by a strong, organized community committee that engaged directly with government officials, funding agencies, and community members. A similar approach could be beneficial for the Peninsula, ensuring that decisions reflect local needs and priorities.

Application to the Deale-Shady Side Peninsula:

- Establish a buyout committee composed of trusted residents, local officials, and subject-matter experts.
- Foster collaboration between the County and community leaders to advocate for funding and streamline program implementation.

3. **Incentives to Improve Participation:**

The Staten Island model shows that monetary incentives—such as a 10% bonus on appraised value and a 5% relocation stipend—can significantly increase willingness to participate.

Application to the Deale-Shady Side Peninsula:

- AACo and MDEM should consider integrating similar incentives into their pilot buyout programs.

A notable difference between Oakwood Beach's voluntary buyout program and potential applications for the Deale-Shady Side peninsula is the context in which these programs are implemented. The Oakwood Beach buyout was a reactive measure in response to the immediate devastation caused by Superstorm Sandy. Establishing the framework for a buyout program would be a proactive measure, aimed at mitigating future risks from potential severe storms and SLR. However, this program can also be implemented in the event of a significant hazard, offering a structured and community-focused approach to relocation and land use planning. Establishing the program prior to a natural disaster could capitalize on immediate post-disaster sentiment for relocation.

5.4. Case 4: Green Stormwater Infrastructure in D.C.

The District of Columbia has a combined sewer system prone to flooding and overflow into nearby waterways, creating environmental, health, and transportation concerns. To reduce stormwater entering the system and promote natural infiltration, the Department of Energy and Environment (DOEE) created the Get RiverSmart programs. These programs provide grants, rebates, and incentives for residents, communities, and schools to install green stormwater systems on their property. As a result, over 20,000 green features have been installed residentially, and numerous community environmental projects have been constructed.

5.4.1. Background

Built in 1810, the District of Columbia's sewer system is one of the oldest in the United States. Initially, it began as a series of sewers and culverts before becoming a unified system[11]. Today, over two-thirds of D.C.'s sewer system is a separate sewer system keeping stormwater and sewage in dedicated pipes. However, a third of D.C.'s sewer systems are combined sewer systems, with stormwater and sewage using the same pipes. Combined sewer and stormwater systems have a known issue during rainy conditions where the system is overloaded, resulting in overflow (Figure 62).

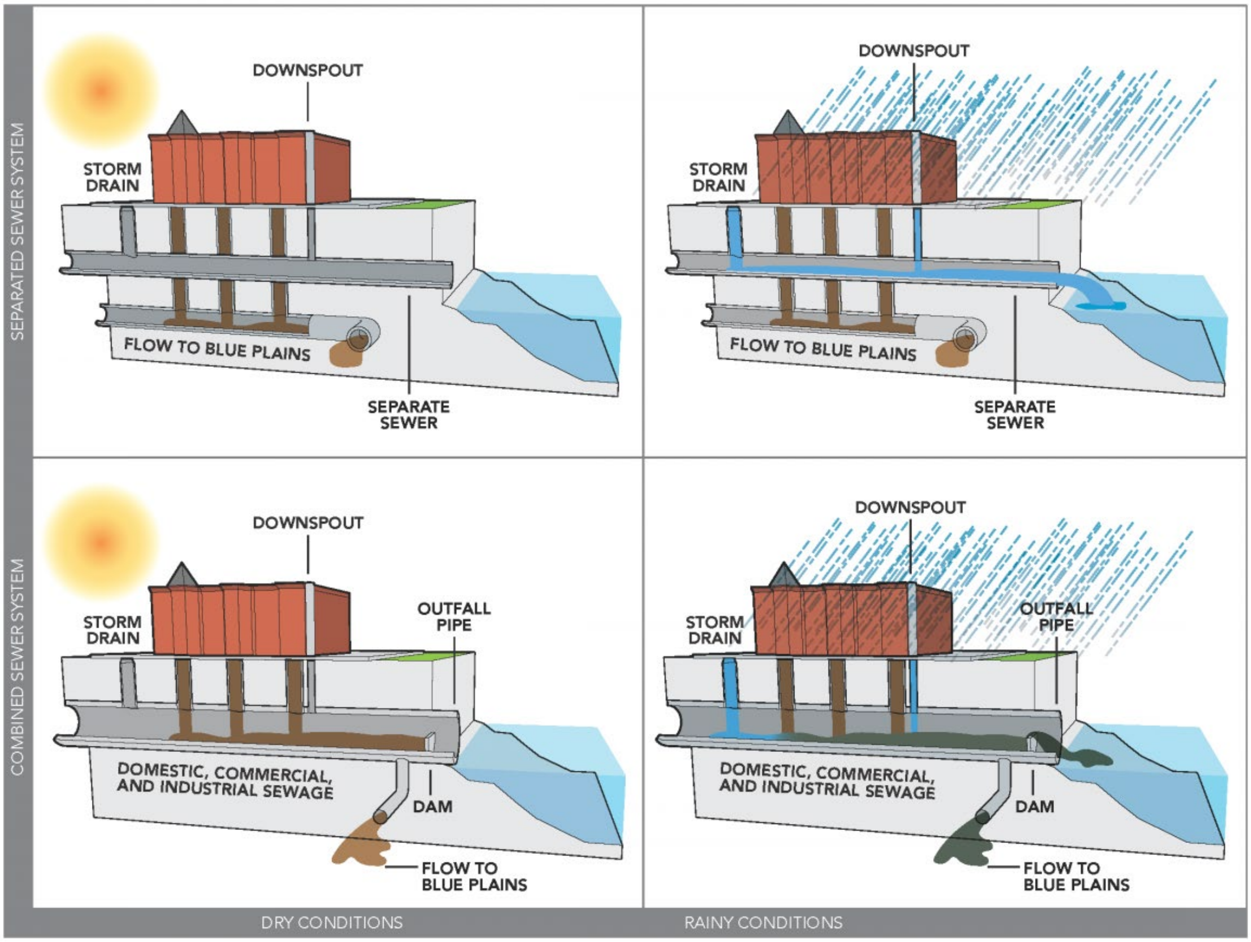

Figure 62 – Combined Sewer and Stormwater System in Wet and Dry Conditions

To prevent flooding, regulators open to allow the mixture of rainwater and sewage to discharge into nearby rivers and creeks. In D.C., the mixture is discharged into the Anacostia River, Rock Creek, Potomac River, and other tributary waters during most moderate rain events (Photo 121 and Photo 122). This has resulted in high levels of bacteria in the water and low dissolved oxygen levels, which can cause increased water pollution and stress on impacted ecosystems.

[11] DC Water. *Combined Sewer System*. https://www.dcwater.com/about-dc-water/what-we-do/wastewater-collection/css.

Photo 121 - Combined sewer system backs up into residential streets in Washington D.C.

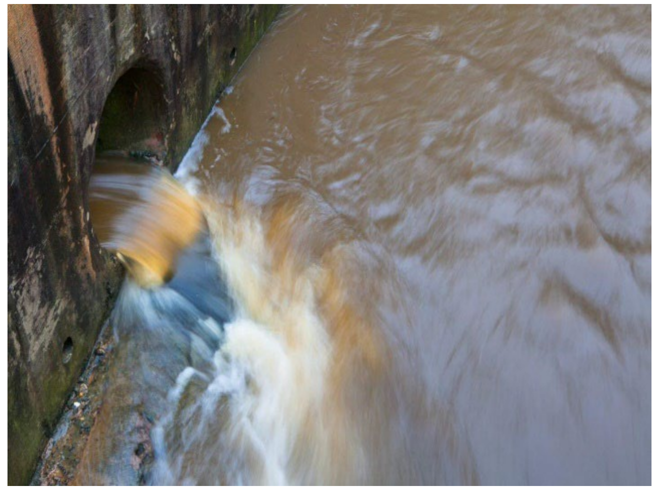

Photo 122 - Combined sewer systems discharge into waterbody

5.4.2. The Program

To lower the stormwater load on the combined sewer systems, the RiverSmart programs were developed. These programs offer incentives and rebates throughout D.C. through RiverSmart Homes, Communities, and Schools.

Funded through the U.S. EPA's Chesapeake Bay Implementation Grant, the RiverSmart Homes program is tailored to small, single-family residential properties. The DOEE helps install, provide copayments, and rebates for green stormwater systems. RiverSmart features include rain barrels, shade trees, rain gardens, native plant gardens, permeable pavers, and re-vegetation (Photo 123 - Photo 127). Photo 128 and Photo 129 show before and after photos of a RiverSmart Home project to replace impermeable pavement with a vegetated area to improve infiltration and reduce runoff.

Photo 123 - Rain Garden

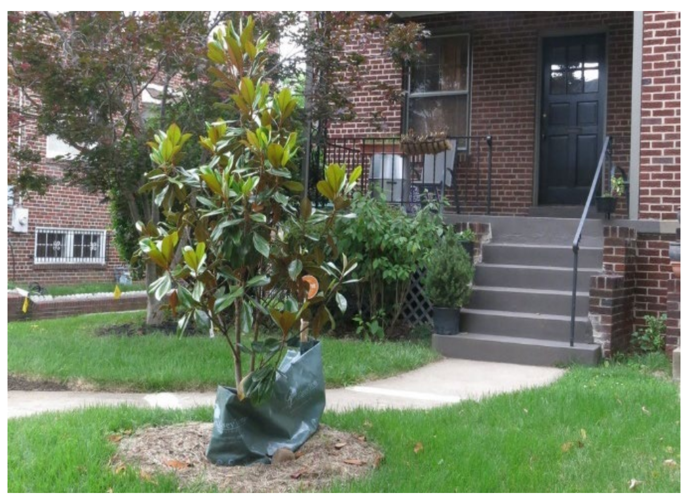

Photo 124 - Shade Trees

Photo 125 - BayScaping

Photo 126 - Rain Barrel install supported by RiverSmart

Photo 127 - Permeable Pavers

Photo 128 - Before RiverSmart Homes Project

Photo 129 - After RiverSmart Homes Project

The initiative also established an Ambassador Program focused on outreach and engagement in prioritized neighborhoods for assessment and project implementation. RiverSmart Communities is a collaboration between the DOEE and the Anacostia Watershed Society. It focuses on providing RiverSmart Communities Grants to non-profit organizations to assist with the cost and installation of green stormwater features while beneficiaries provide continued outreach and a long-term maintenance plan[12].

Photo 130 - Volunteers installing green infrastructure project sponsored by RiverSmart Communities Program

Photo 131 - Community-Built Bioswale at First Rock Baptist Church

The RiverSmart Schools Program, provided by the DOEE's Watershed Protection Division, includes funding and training to assist schools in installing projects focused on creating habitats for local wildlife, planting native plants, and filtering stormwater runoff. The program provides teachers with accredited resources and training to use the site as a teaching tool based on D.C. Public School Standards.

Photo 132 – *RiverSmart Schools functional and education installment at Two Rivers Public Charter School*

In addition to the three RiverSmart programs, there are numerous rebates available to property owners who wish to implement projects independently. Funding is provided through multiple sources, including the District's Stormwater Enterprise Fund. The rebate programs cover rain gardens, permeable surface installation, and green roofs, with rebate amounts varying by project type. Direct reimbursements are provided to homeowners once the project is installed, inspected, and approved by the Alliance for the Chesapeake on behalf of the DOEE.

The most relevant to the Deale–Shady Side Peninsula is RiverSmart Homes, which targets residential properties.

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[12] District of Columbia Department of Energy & Environment. RiverSmart Homes. https://doee.dc.gov/service/riversmart-homes.

How to be a RiverSmart Home:

1. **Initial Contact:** Homeowners interested in participating call a dedicated DOEE hotline or fill out an online interest form.

2. **Site Evaluation:** A trained environmental engineer or partner organization staff visits the property to assess drainage issues and suitability for green infrastructure features.

3. **Project Proposal:** Based on the assessment, a set of eligible green infrastructure features (e.g., rain gardens, native plantings, permeable surfaces) is proposed, along with a cost estimate.

4. **Agreement & Cost-Share:** Homeowners sign an agreement outlining a 25% cost-share requirement and a long-term maintenance commitment. DOEE covers the remaining 75% through program funding.

5. **Contractor Engagement:** The program maintains a pool of pre-qualified contractors. The engineer selects a contractor to complete the installation.

6. **Installation & Final Inspection:** Once the project is complete, DOEE or its partners conduct a final inspection to ensure compliance with program standards.

7. **Reimbursement or Direct Payment:** For some features, DOEE directly pays the contractor. For eligible self-installed features, homeowners can be reimbursed after inspection.

Schools and Communities follow a grant-based model, where applicants (nonprofits, schools, churches) submit proposals for projects that will manage stormwater while also providing educational or outreach benefits. Selected projects receive funding, technical support, and educational materials from DOEE.

5.4.3. Results

Through the Get RiverSmart Program, over 20,000 green features have been installed on residential properties since 2008, with an estimate 2.7 million gallons of stormwater treated by RiverSmart Homes's green features[10] (Figure 63). These numbers do not include the schools, churches, community centers, and commercial buildings that have participated through the school and community programs. Benefits of green infrastructure include reduced stormwater runoff pollution, beautified properties, potential energy savings, and increased habitats for local wildlife. Additionally, by providing resources for residents to take action, they feel more empowered to address the threat of climate change. Community projects also foster a sense of community through public participation in their maintenance.

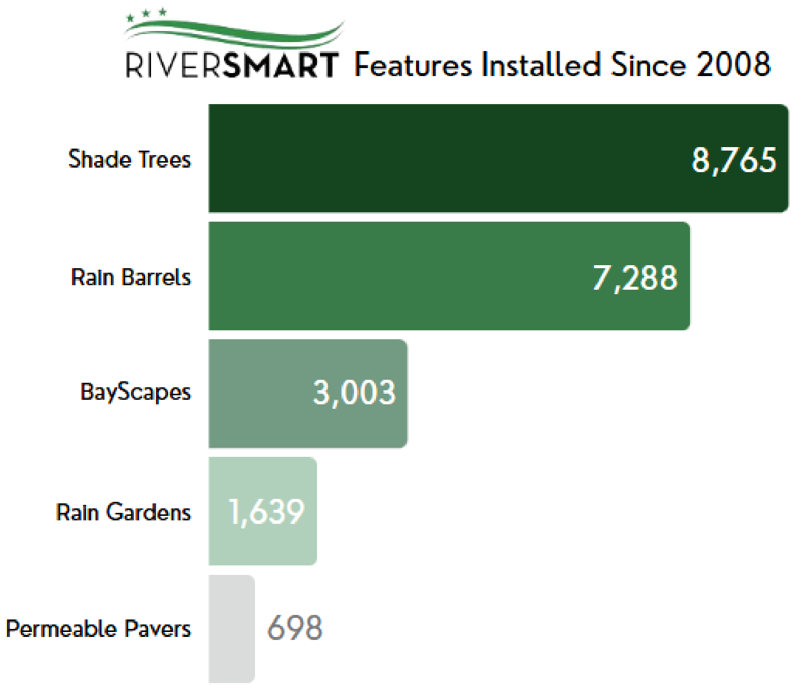

Figure 63 – RiverSmart Features Installed Since 2008

5.4.4. Lessons for the Deale-Shady Side Peninsula

The RiverSmart program is scalable and could be beneficial for the Deale-Shady Side Peninsula. This program empowers concerned residents and homeowners by providing the necessary resources for community action for a shared interest. Lessons learned and applicable to the Peninsula include:

1. **Formalize a Resident-Facing Participation Model:**

   The RiverSmart program offers a clear, step-by-step implementation process, guided by accessible tools such as community hotlines and online forms. Participants receive hands-on support throughout the process from initial inquiry to completed installation ensuring successful project delivery and community-wide participation.

   Application to the Deale-Shady Side Peninsula:

   - Create a hotline or online application portal for homeowners to express interest.
   - Conduct site visits with trained staff to assess opportunities for nature-based stormwater solutions.
   - Require a signed agreement outlining maintenance responsibilities and financial contributions.

2. **Engage the Public Through Structured Outreach Programs:**

   The success of the RiverSmart program in D.C. at implementing more than 20,000 green infrastructure projects in residential, communal, and commercial properties underscores the importance of structured and targeted public engagement. By actively involving residents and providing them with the necessary resources and education, the program achieved significant participation and support. This approach not only empowers residents to take control of their environment while fostering community cohesion and collective responsibility.

   Application to the Deale-Shady Side Peninsula:

   - Develop comprehensive outreach and education programs to inform residents about green infrastructure benefits and opportunities.
   - Conduct workshops, seminars, and community events to demonstrate the installation and maintenance of green stormwater systems.
   - Utilize local media, social platforms, and community networks to spread awareness and encourage participation.

4. **Utilize Diverse Funding Mechanisms:**

   The RiverSmart Program is funded through multiple sources, including the U.S. EPA's Chesapeake Bay Implementation Grant and the District's Stormwater Enterprise Fund. This diversified funding model ensures sustainability and scalability, allowing for continuous support and expansion of the program.

   Application to the Deale-Shady Side Peninsula:

   - Explore federal and state grants similar to the Chesapeake Bay Implementation Grant for initial funding.
   - Establish a dedicated flood mitigation fund within the County to finance small-scale green infrastructure and coastal resiliency projects.
   - Implement a stormwater utility fee or tax incentives for property owners who install green stormwater solutions, ensuring a steady revenue stream for ongoing support and maintenance.
   - Partner with non-profit organizations an private enterprises to secure additional funding and resources.

5. **Leverage Community Involvement for Maintenance and Sustainability:**

   Community involvement is vital for the long-term success and maintenance of green infrastructure projects. The RiverSmart program encourages residents and local organizations to participate in the upkeep of installed features, fostering a sense of ownership and responsibility.

Application to the Deale-Shady Side Peninsula:

- Establish volunteer programs and community groups to assist with the maintenance of communal flood mitigation installations.
- Provide training and resources to ensure residents and local organizations are equipped to maintain and monitor these systems effectively.
- Create a recognition program to acknowledge and reward active community participants, enhancing motivation and sustained engagement.

By applying these lessons from the RiverSmart Program, the Deale-Shady Side Peninsula can develop a robust and effective flood mitigation strategy that leverages community involvement, sustainable funding, and integrated flood mitigation strategies.

5.5. Case 5: Raising Roads & Upgrading Stormwater Infrastructure in Norfolk, VA

Norfolk, Virginia faces significant challenges due to SLR and recurrent flooding, conditions that threaten its infrastructure and essential services (Photo 133 and Photo 134). As a low-lying coastal city along the Chesapeake Bay, Norfolk has implemented a series of infrastructure projects aimed at mitigating the impacts of rising water levels and increasing storm surges. This case study examines the city's coordinated efforts, focusing on raising roads and enhancing grey infrastructure, offering insights for similar resilience initiatives in AACo.

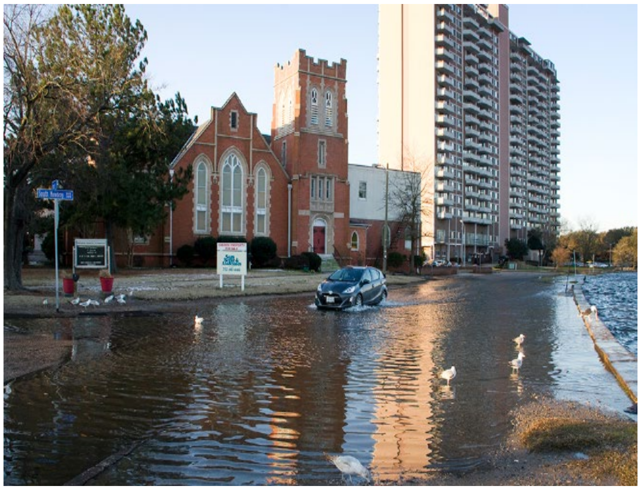
Photo 133 - Flooded streets of Norfolk neighborhood during high tides - Photo by Nicholas Kusnetz/ICN


Photo 134 - Flooding at Norfolk Naval Base - Photo from Inside Climate News

5.5.1. Background

Norfolk is particularly vulnerable to the effects of SLR, with the highest rate of SLR along the U.S. East Coast—nearly 4.5 millimeters per year[13,14]. Since the 1920s,

[13] World Resources Institute (2014). *Sea-Level Rise and its Impact on Virginia.*
[14] RTI International (2019). *Rising sea levels could impact economy in Hampton Roads, VA*.

relative sea levels in Norfolk have risen by over 14 inches. This rapid increase. Combined with land subsidence, has led to significant economic and social impacts. Tidal flooding events have tripled since the 1970s, now occurring about once a month, and projections indicate these could quadruple by 2030 without further intervention[13,15].

The economic and social consequences of failing to address SLR in Norfolk are severe, with over $1 billion in local assets currently at risk. Additionally, frequent flooding disrupts essential services, reduces property values, and burdens residents with escalating flood insurance premiums, exacerbating socio-economic dipartites in affected neighborhoods[13].

One of the most affected areas is Brambleton Avenue, a key artery serving Norfolk's medical district and nearby communities. Frequent flooding of this road has disrupted access to essential services, making it a priority for infrastructure upgrades.

5.5.2. Project Overview

In 2014, the City of Norfolk completed a $2.4 million project to raise and reconstruct a critical stretch of Brambleton Avenue, a major east-west arterial that serves Norfolk's Fort Norfolk area and Medical District. The project was designed to address both flood vulnerability and traffic congestion in an area frequently inundated during high tide and storm events, particularly where Brambleton intersects Colley Avenue.

To reduce the impacts of flooding, 1,800 linear feet of westbound Brambleton Avenue between Colley Avenue and the Brambleton Bridge was widened and elevated, raising the roadbed above the projected 2040 flood levels. This elevation effort was paired with stormwater drainage upgrades designed to handle more intense rainfall and improve runoff conveyance, helping to reduce the duration and extent of ponding water during high tide events. The project's key objectives included:

- **Reducing flooding frequency** on Brambleton Avenue during moderate to severe weather events.
- **Improve access to essential services** like medical centers during flood conditions.
- **Enhancing pedestrian and vehicle safety** by adding a walking path, improved lighting, and landscaping.
- **Future-proofing transportation infrastructure** by raising roads above projected flood thresholds.

[15] Union of Concerned Scientists (2016). *Sea Level Rise and Tidal Flooding in Norfolk, Virginia*.

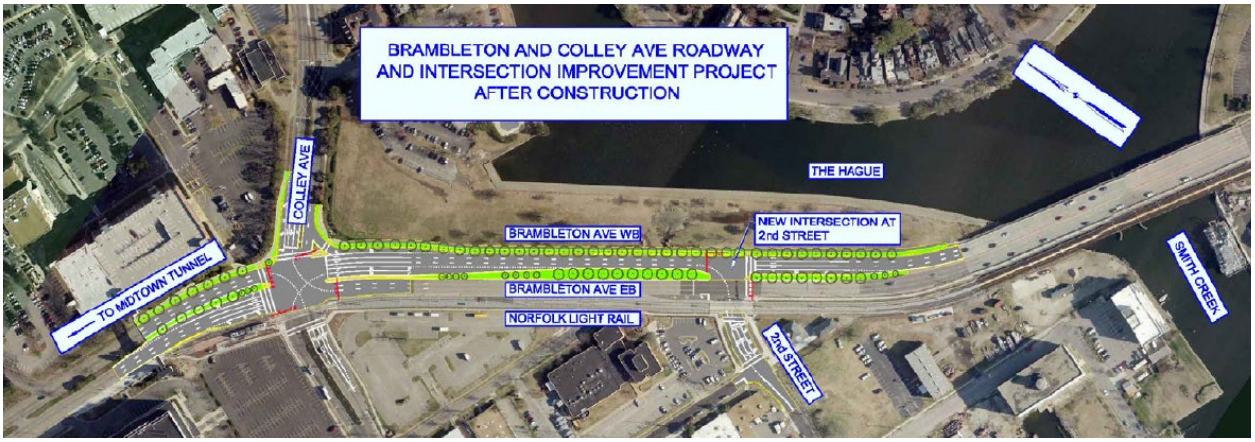

Figure 64 – Brambleton and Colley Avenues Roadway and Intersection Improvement Project Post-Construction

5.5.3. Results

Since its completion, the Brambleton Avenue Resilience Project has demonstrated substantial success in reducing flood-related disruptions and improving infrastructure resilience. The elevated stretch of 1,800 linear feet roadway has remained passable during over 95% of flood events that previously caused closures, including recurring nuisance tidal flooding. This improvement has ensured uninterrupted access to critical services in the Fort Norfolk and Medical District areas, including hospitals and emergency routes. Post-project hydrologic modeling also revealed a greater than 15% improvement in stormwater drainage efficiency, indicating that the combined roadway elevation and drainage enhancements have had a measurable impact on flood mitigation performance.

To date, $2.4 million has been invested in the project, which now serves as a model for arterial upgrades being planned throughout the city. Brambleton Avenue's success has informed the broader Coastal Storm Risk Management (CSRM) Project, a $2.6 billion joint effort between the City of Norfolk and the U.S. Army Corps of Engineers. The CSRM strategy includes a comprehensive suite of resilience measures, such as nearly nine miles of floodwalls and levees, 11 tide gates, 10 pump stations, and nature-based interventions like oyster reefs, living shorelines, and wetland restoration[16] (Figure 65). Together, these efforts reflect Norfolk's shift toward integrated, scalable approaches to managing chronic and acute flood risks.

[16] City of Norfolk. Resilient Norfolk. https://www.resilientnorfolk.com/. Accessed 19 Feb. 2025.

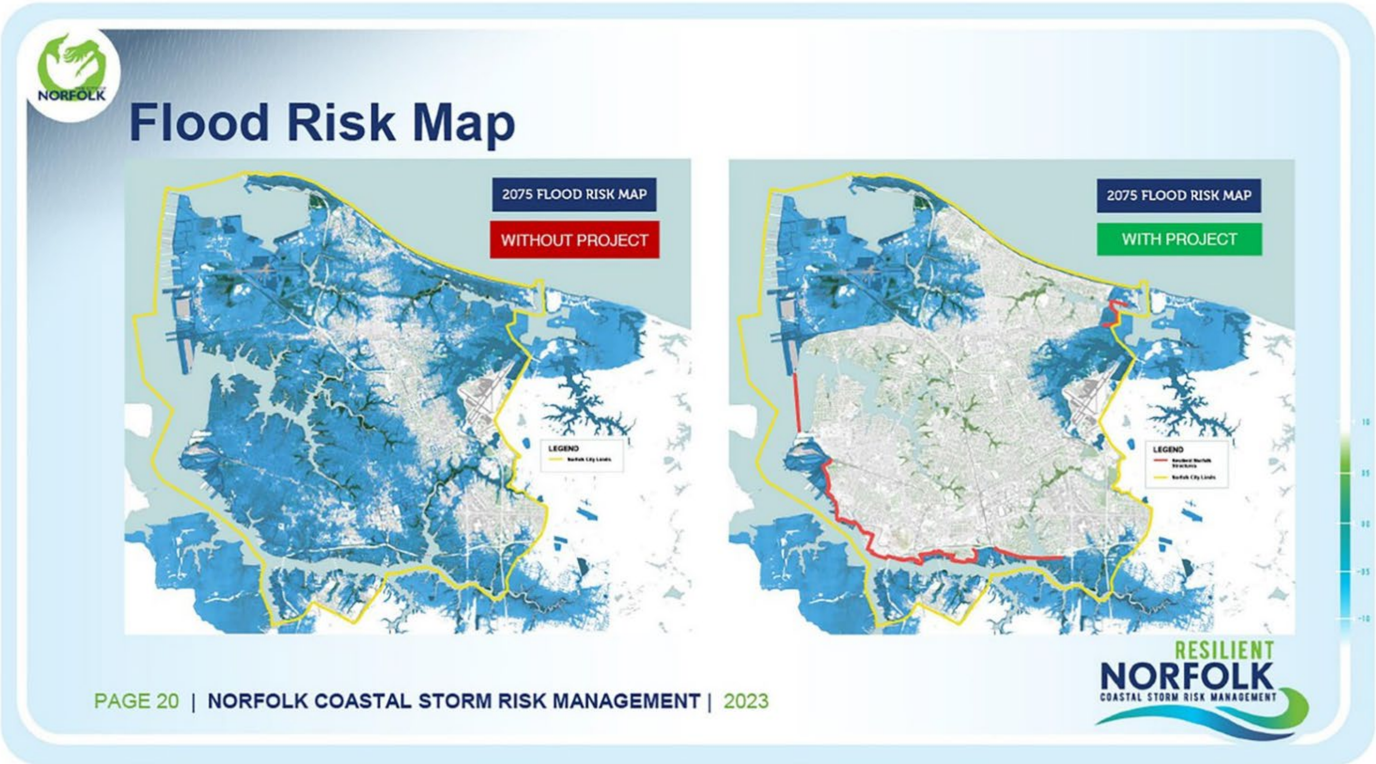

Figure 65 – General Path of Proposed Floodwall Map (source: City of Norfolk)

5.5.4. Lessons for the Deale-Shady Side Peninsula

Norfolk's implementation of road-raising and stormwater system upgrades along Brambleton Avenue offers valuable insights for improving flood resilience in vulnerable coastal communities like the Deale–Shady Side Peninsula. The project provides a replicable example of integrated infrastructure improvements that address both access and drainage.

1. **Prioritize Multi-Benefit Corridors:**

   Norfolk elevated Brambleton Avenue, a critical connector to the Fort Norfolk Medical District, not only to reduce chronic flooding but also to improve access, traffic flow, and safety.

   Application to the Deale-Shady Side Peninsula:

   - Target roadways on the Peninsula that are low-lying and serve as emergency routes.
   - Prioritize designs that enhance both flood protection and community function.

2. **Design for Projected Water Levels:**

   The project raised 1,800 feet of Brambleton Avenue and improved stormwater infrastructure based on recurring nuisance flooding and sea level rise trends.

   Application to the Deale-Shady Side Peninsula:

   - Integrate 2050 and 2100 sea level rise scenarios into design criteria for all road raising projects to ensure long-term functionality.
   - Use recent nuisance flooding and high tide data to identify priority elevations for road segments.

3. **Coordinated System Solutions:**

   The key objective of this project was to raise the road. However, the project also improved drainage, installed dual-turn lanes, upgraded sidewalks, and restored flood-prone outfalls to ensure a complete system response.

   Application to the Deale-Shady Side Peninsula:

   - Couple road elevation efforts with comprehensive drainage upgrades such as outfall retrofits, new culverts, or swale improvements to avoid backwatering and isolated failures.
   - Evaluate whether existing stormwater systems can accommodate rerouted flow due to raised roads.

4. **Provide Long-Term Vision with Immediate Value:**

   Though Brambleton Avenue was a relatively small project, its visible success has informed Norfolk's larger $2.6 billion Coastal Storm Risk Management Plan (CSRM).

   Application to the Deale-Shady Side Peninsula:

   - Leverage smaller-scale implementation projects as pilot efforts within broader flood resilience strategies to demonstrate effectiveness, build community trust, and inform scalable solutions for long-term planning.
   - Use clear performance metrics (e.g., passability during tides, drainage time improvements) to communicate success and build momentum for additional projects.
   - Engage community stakeholders early to highlight co-benefits like safer roads, beautification, and public access.

While Norfolk's Coastal Storm Risk Management efforts are being implemented at a much larger urban scale, the Brambleton Avenue project offers directly transferable strategies for smaller coastal communities like those on the Deale–Shady Side

Peninsula. Norfolk's phased, multi-benefit infrastructure approach—raising critical roads, improving stormwater drainage, and integrating long-term resilience planning—demonstrates how even modest-sized projects can deliver meaningful flood protection and serve as models for future adaptation. For the Peninsula, applying these lessons means investing in locally scaled upgrades that not only address immediate vulnerabilities but also align with broader, long-term resilience goals.

5.6. Case 6: Elevating Homes in Snoqualmie, WA

The City of Snoqualmie, located in King County, Washington, sits within the Snoqualmie River Valley, an area highly susceptible to flooding due to heavy annual precipitation and seasonal snowmelt runoff. These repeated flood events have had widespread impacts on residents, businesses, and essential infrastructure, prompting the city to adopt a proactive, long-term flood mitigation strategy. This case study examines the implementation, funding mechanisms, and outcomes of Snoqualmie's home elevation program, providing insights that can inform similar efforts in flood-prone communities such as the Deale-Shady Side Peninsula.

5.6.1. Background

Today, Snoqualmie is a small city known for its suburban yet rural small-town charm and is considered a sought-after area to live in Washington. With a population of 13,750 residents, the city has a total area of 5,628 acres and 4,762 residential units[17]. Of these homes, around 8% (400 units) are located within the 100-year floodplain compared to the 12% of homes in the Deale-Shady Side Peninsula that face similar risks.

During a typical year, King County experiences minor flooding in the fall and winter, with major flood events occurring after prolonged heavy rainfall in western Washington. The valley's topography and hydrological conditions contribute to recurrent flood events, with the city experiencing at least 15 presidentially declared flood disasters between 1964 and 2006. Since 1990, the region has experienced eight major floods, with flood levels exceeding six feet in some areas. Seasonal Snowmelt also contributes to expected minor flooding during the winter, but the patterns and magnitude of these hazards within the river basin are influenced by varying environmental conditions.

[17] Snoqualmie, WA. (n.d.). Niche. Retrieved January 20, 2025, from https://www.niche.com/places-to-live/snoqualmie-king-wa/#about

Photo 135 - Snoqualmie Falls flooding in February 2012 – Photo by Living Snoqualmie

Photo 136 - Lower Snoqualmie Basin Levee Breach in 2009 – Photo by King County

Given the high costs associated with property buyouts and the strong community attachment to existing neighborhoods, elevating homes above base flood elevations (BFE) was identified as a feasible and cost-effective alternative.

5.6.2. The Program

The first structured initiative to elevate homes in Snoqualmie began in 1987 following a major flood event that led to a federal disaster declaration. Between 1987 and 2002, approximately 60 homes were elevated, with additional properties retrofitted through various grant-funded programs. The 2006 King County Flood Hazard Mitigation Plan provided a strategic framework for flood-risk reduction, including the establishment of the King County Flood Control District, a special-purpose government entity tasked with funding and overseeing flood protection efforts throughout the County[18].

Under the Flood Control District, numerous flood mitigation programs were developed, including the Home Elevations & Buyouts Program, which assists property owners in elevating their homes, or alternatively, offers voluntary buyout options. This program prioritizes structures covered by flood insurance with a documented history of repetitive flooding. The average cost of elevating a home as of 2020 was estimated at approximately $250,000, with funding sourced primarily from federal and state grants. Additional financial support is often made available following a presidential disaster declaration.

Property owners seeking financial assistance for elevation projects are encouraged to explore additional funding mechanisms such as Increased Cost of Compliance (ICC) insurance coverage, included in all flood insurance policies. ICC coverage provides up to $30,000 for compliance with local floodplain management ordinances when a structure sustains substantial damage exceeding 50% of its value die to flooding. In the event of a presidentially declared disaster, Small Business Administration (SBA) loans

[18] *King County Flood Control District. (2024, May 1). About King County Flood Control District. Retrieved January 27, 2025, from https://kingcountyfloodcontrol.org/about-us/.*

may also be available. These loans offer property owners financial assistance for hazard mitigation projects, with eligibility for an additional 20% of the loan amount to fund home improvements such as home elevation.

Snoqualmie's home elevation program has been implemented in phases, targeting the most vulnerable residential properties. The process follows a structured approach:

1. **Identification and Prioritization of Eligible Homes:**

    - The city, in collaboration with state and federal agencies, conducted flood risk assessments to identify homes most susceptible to repetitive flood damage.
    - Priority was given to properties with a history of repeated flood claims under the National Flood Insurance Program (NFIP).

2. **Funding and Cost-Sharing Mechanisms:**

    - The home elevation program has been primarily funded through a combination of Federal Emergency Management (FEMA) Hazard Mitigation Assistance (HMA) grants and state flood mitigation funds.
    - Homeowners were responsible for a cost-sharing portion, with financial assistance available through low-interest loan programs.
    - The city's participation in FEMA's Community Rating System (CRS) has provided additional financial relief by reducing flood insurance premiums for residents.

3. **Technical and Construction Considerations:**

    - Homes were elevated to at least three feet above BFE, as per FEMA recommendations and local floodplain management regulations.
    - The process involved lifting the structure onto a temporary framework while new, reinforced foundations designed to withstand future flood conditions were constructed.
    - Critical utilities, such as electrical panels, HVAC systems, and plumbing, were elevated above flood levels to enhance resilience.

4. **Community Outreach and Support:**

    - The city conducted extensive outreach efforts, educating homeowners about the elevation process, expected costs, and available funding opportunities.
    - Technical workshops and public meetings provided step-by-step guidance on the application process, contractor selection, and long-term benefits of home elevation.

Based on a 2003 case study, *Market Impacts on Elevated Homes in a Known Floodplain*[19], conducted by a collaboration between Mundy Associates, the University of

[19] *Market Impacts on Elevated Homes in a Known Floodplain – A Case Study* (2003) Throupe et al.

Washington, and the City of Snoqualmie, it was found that homes elevated through the FEMA's HMGP and Flood Mitigation Assistance Programs were not only positively perceived in the housing market but often equated to increased property value. Additionally, the financial feasibility of home elevations was affirmed, as surveyed property owners viewed the project as economically sound, particularly with HMGP covering up to 87% of the elevation costs.

An additional study performed by FEMA focused on 28 homes in Snoqualmie that were elevated prior to a major flood event in November 2006[20]. The study determined that the total cost of elevating these homes in Snoqualmie was justified by the flood damage avoided, yielding a return on investment of 1.24. This return is expected to improve as elevated homes continue to withstand future flood events.

Photo 137 - Home Elevated 3 Feet in Snoqualmie, WA - Before (left) and After (right)[21]

According to King County's Flood Control District, since 2008, more than 66 homes have been elevated, with up to 90% of the total elevation cost covered by the Flood District.

5.6.3. Lessons for the Deale-Shady Side Peninsula

The home elevation program in Snoqualmie, Washington, offers valuable insights into how flood-prone communities can implement long-term mitigation strategies while maintaining neighborhood integrity. Elevating homes has proven to be a cost-effective alternative to property buyouts, particularly in areas where relocation is not feasible due to economic or community attachment factors. The following lessons from Snoqualmie's approach can inform home elevation efforts on the Deale-Shady Side Peninsula.

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[20] *Loss Avoidance Study: City of Snoqualmie, WA* (n.d.) Federal Emergency Management Agency
[21] *Elevating Structures to Reduce Flood Damages: Guidelines for Property Owners* (2024) King County Flood Control District.

1. **Community Engagement as a Resilience Strategy:**

   Snoqualmie's success in implementing home elevation projects has largely been driven by robust community engagement, ensuring that residents are informed, supported, and actively involved in the mitigation process.

   Application to the Deale-Shady Side Peninsula:

   - Establish structured education programs and public workshops to increase awareness of flood risks and mitigation strategies.
   - Provide guidance on navigating home elevation funding programs, including eligibility requirements and the application process.
   - Engage local officials and community organizations in outreach efforts to build trust and encourage participation.

2. **Sustainable Funding Mechanisms:**

   Long-term home elevation programs require reliable funding sources to assist homeowners in mitigating flood risks. Snoqualmie leveraged a combination of FEMA grants, state mitigation funds, and local resources to finance projects while reducing the financial burden on individual property owners.

   Application to the Deale-Shady Side Peninsula:

   - Explore federal and state funding opportunities, such as FEMA's HMGP and Increased Cost of Compliance (ICC) coverage.
   - Implement cost-sharing programs to ensure equitable financial support for homeowners in flood-prone areas.
   - Encourage participation in FEMA's Community Rating System (CRS) to lower flood insurance premiums and incentivize flood mitigation efforts.

3. **Integrating Home Elevation with Broader Mitigation Efforts:**

   While home elevation effectively reduces structural flood damage, Snoqualmie's approach highlights the importance of integrating elevation efforts with complimentary flood mitigation strategies.

   Application to the Deale-Shady Side Peninsula:

   - Combine home elevation programs with stormwater infrastructure improvements to enhance overall flood resilience.
   - Prioritize elevation projects in areas where complementary nature-based solutions, such as wetland restoration or living shorelines, can provide additional flood protection benefits.
   - Ensure alignment between home elevation policies and local floodplain management regulations to maintain consistency across mitigation efforts.

Snoqualmie's home elevation program demonstrates how strategic flood mitigation efforts can protect at-risk properties while preserving community character and reducing long-term disaster costs. By prioritizing resident engagement, securing sustainable funding, and integrating elevation projects with broader resilience planning, the city has successfully strengthened its flood resilience.

When considering the positive lessons learned from Snoqualmie's home elevation program, it is also important to consider its challenges. Even with grant assistance, the cost of elevating homes remained a barrier for some residents. To address this, the city explored additional funding sources, including low-interest loans and state resilience grants. Additionally, homeowners were required to temporarily relocate while elevation work was completed. The city coordinated with local agencies to provide relocation assistance as necessary. Construction limitations also influenced feasibility. Home elevation methods vary depending on foundation types, structural integrity, and lot constraints. In cases where elevation was not viable, alternative flood mitigation measures, such as wet floodproofing, were recommended.

The Deale-Shady Side Peninsula can adopt approaches inspired by Snoqualmie's program, tailoring mitigation strategies to its unique flood risks and community priorities. Implementing a structured home elevation program, supported by funding and community outreach, will provide long-term protection for flood-prone properties while ensuring the Peninsula's continued viability in the face of increasing flood risks.

6 VULNERABILITY ANALYSIS

6. VULNERABILITY ANALYSIS

The Vulnerability Analysis for the Deale-Shady Side Peninsula employs a Multi-Criteria Decision Analysis (MCDA) approach to assess flood exposure, infrastructure resilience, and emergency accessibility across the study area. This methodology integrates geospatial datasets to create a composite vulnerability layer, offering a data-driven foundation for identifying high-risk areas and prioritizing flood mitigation efforts.

A combination of geospatial analysis, cost-distance modeling, and flood impact assessments was utilized to generate a comprehensive understanding of where flood hazards intersect with vulnerable infrastructure and communities. The key analytical steps involved in this process included data reclassification, which transformed individual datasets into standardized risk categories, distance-based accessibility analysis, which evaluated challenges in emergency response, and a weighted overlay analysis, which integrated multiple risk layers into a final composite vulnerability map. By employing this multi-faceted approach, this study provides an evidence-based framework for prioritizing mitigation strategies and infrastructure investments.

The mapped flood extents and layers derived from their mapped flood scenarios used in this analysis reflect only the increase in MHHW in the projected SLR year and do not account for additional factors such as storm surge or extreme weather events. While these data provide valuable insight into future flood vulnerability, they do not capture the influence of surges in daily water levels, which can further intensify flooding impacts. While this section highlights example areas to discuss the vulnerabilities considered in the MCDA, additional high-resolution vulnerability maps covering the entire study area can be found in Appendix D.

6.1. Key Vulnerability Criteria

6.1.1. Flood Depth Projections Under SLR Scenarios

The projected depth of flooding under different SLR scenarios is one of the most critical factors influencing flood vulnerability. As sea levels continue to rise, previously dry areas will experience recurrent tidal inundation, and low-lying regions will see a substantial increase in flooding severity.

Flood depth projections were generated for the years 2050, 2065, and 2100, based on bathtub-model flood depth rasters[2]. These data were classified into a standardized vulnerability scale, where lower flood depths correspond to lower risk values, and areas expected to experience three feet or more of inundation were classified as high-risk zone.

For visualization purposes, the flood depth vulnerability classifications used in Figure 66 are based on a generalized vulnerability scale, derived from grouped vulnerability score ranges of 1–3, 4–7, and 8-10 for low, medium, and high-risk groups, respectively. While this figure highlights Cedarhurst and Franklin Manor, these patterns are indicative of broader trends across the Peninsula.

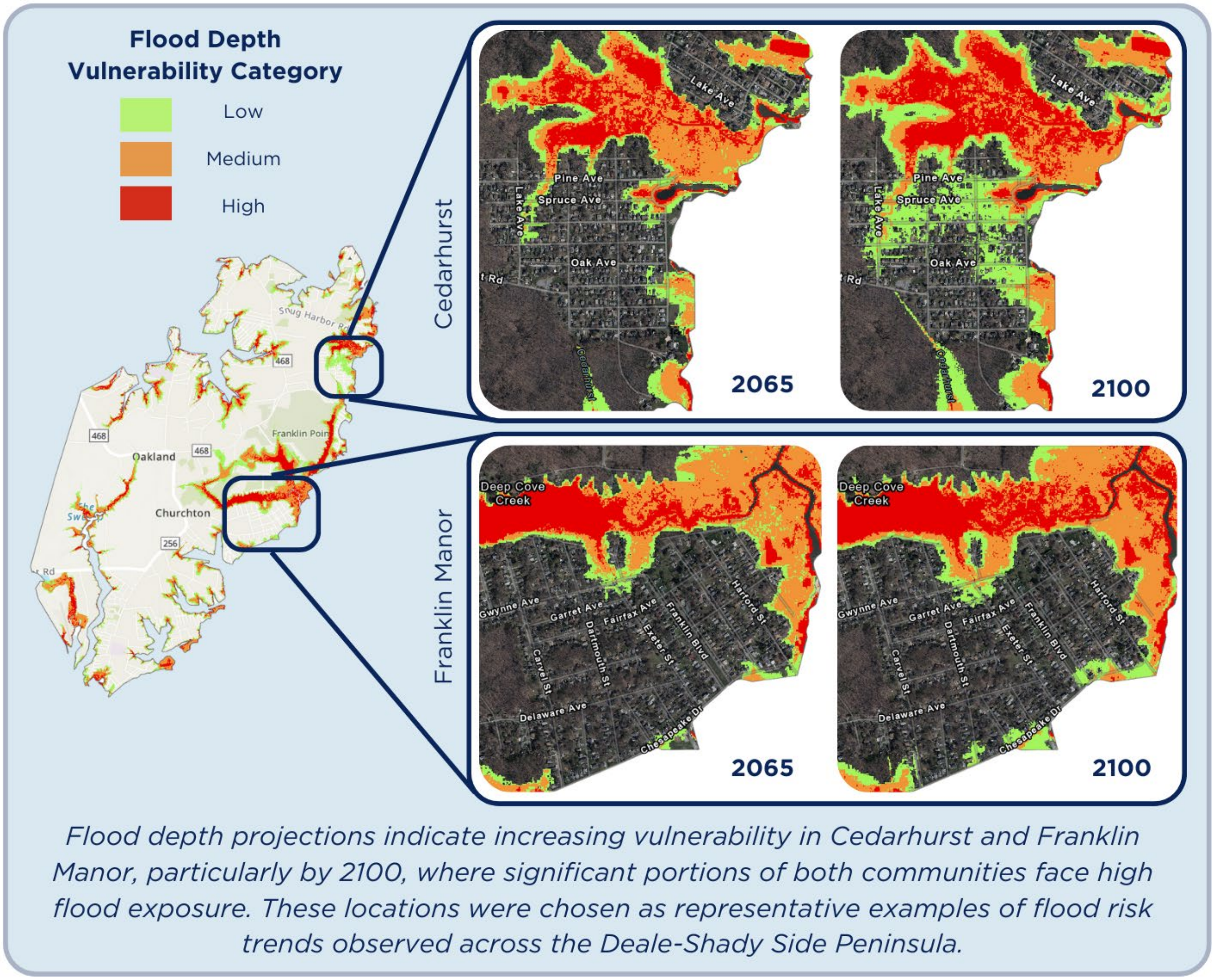


Figure 66 – Generalized Flood Vulnerability Projections for Cedarhurst and Franklin Manor. By 2100, significant portions of both communites are projected to experience high flood exposure. These locations were selected as representative examples of broader flood risk trends observed across the Peninsula.

6.1.2. Density of Buildings Inundated

The density of inundated buildings across the Deale-Shady Side Peninsula highlights the relationship between flooding and developed areas, demonstrating how flood exposure is not uniform across the region. As sea levels rise, buildings in low-lying areas become increasingly vulnerable, with some communities experiencing gradual increase in risk, while others face rapid flood expansion once critical elevation thresholds are exceeded.

The density of buildings exposed to flooding is another key determinant of vulnerability. Areas with high concentrations of inundated buildings are particularly at-risk due to the potential for large- scale damage to homes, businesses, and community infrastructure.

To assess this factor, a density analysis was applied to identify clusters of structures that would be inundated by the years 2050, 2065, and 2100. Neighborhoods with a high density of flood-exposed buildings were assigned higher vulnerability scores (Figure 67). This analysis highlighted that communities such as Avalon Shores, Columbia Beach, Cedarhurst, and Franklin Manor are among the most flood-prone areas, requiring proactive flood mitigation measures to protect residents and properties.

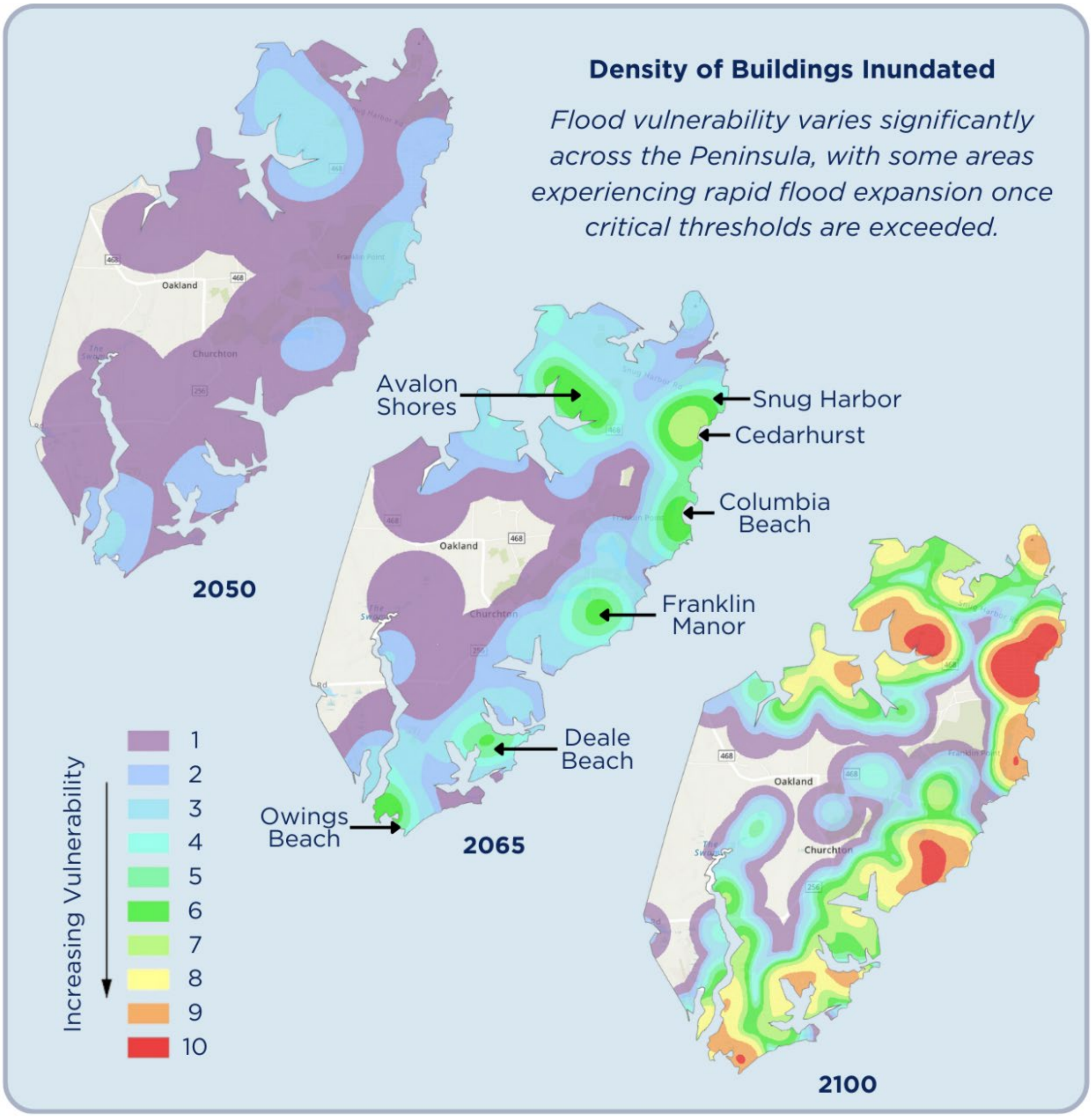
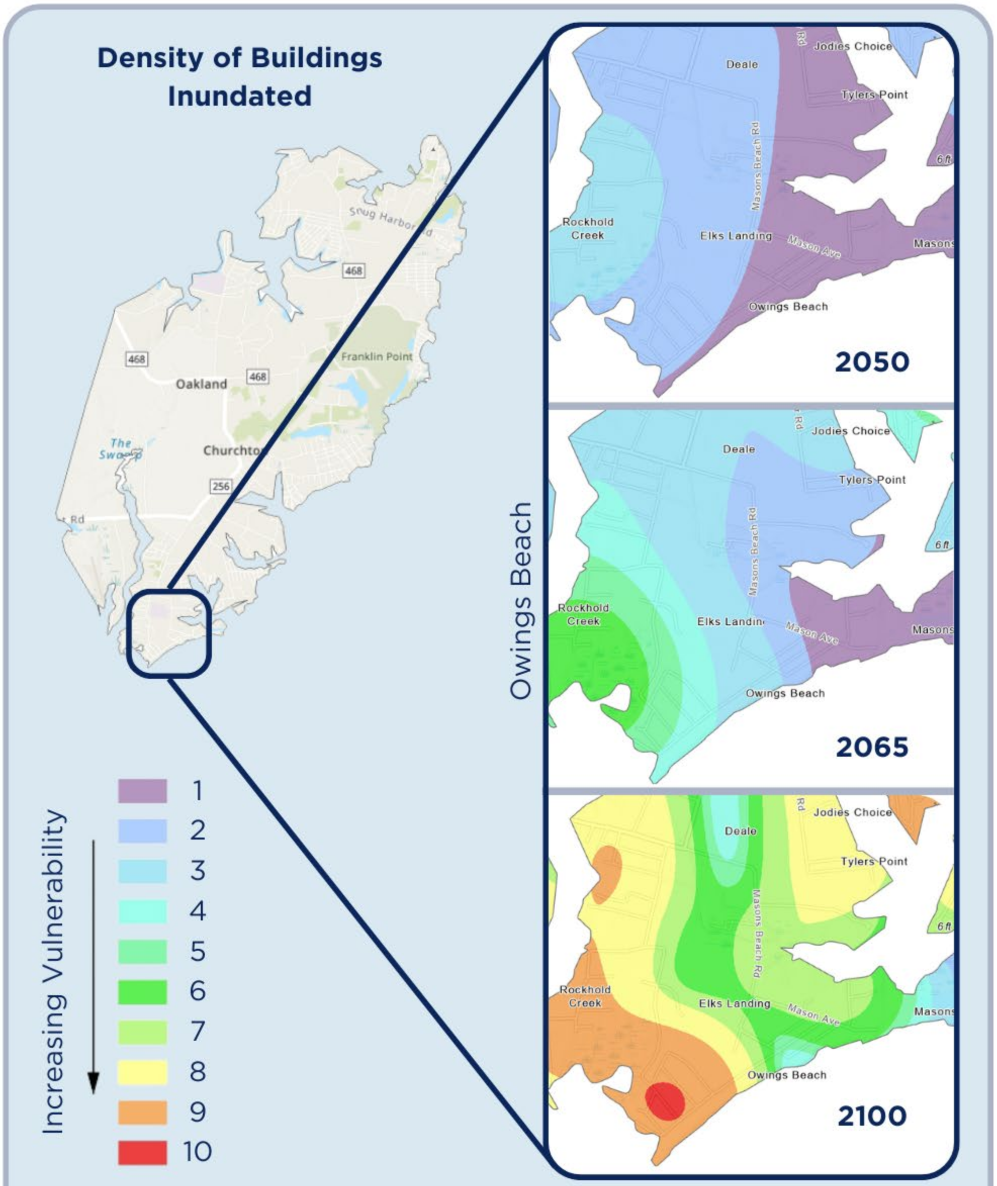


Figure 67 – Projected Inundation of Buildings for Each SLR Scenario. Vulnerability icreases significantly between 2050 and 2100, with certain areas experiencing rapid flood expansion once critical thresholds are exceeded. These changes highlight the growing risk to developed areas as natural buffers become increasingly inundated.

The Deale Beach area illustrates this threshold effect, where between 2050 and 2065, minor increases in flood levels lead to a disproportionate increase in the number of buildings exposed to flooding. By 2100, nearly all low-lying structures in high-risk zones experience daily inundation, emphasizing the compounding nature of SLR and the growing risks to developed areas on the Peninsula.



Projected vulnerability due to inundated building density in Owings beach increases significantly between 2050 and 2100. This pattern is representative of other flood-prone communities across the Deale-Shady Side Peninsula, where increasing flood vulnerability correlates with greater building exposure.

Figure 68 – Projected Inundated Building Density in Owings Beach under Future SLR Scenarios. The inset series illustrates the increasing exposure of buildings to flooding from 2050 to 2100, highlighting areas of concentrated risks.

6.1.3. Land Cover Vulnerability

Land cover type plays a critical role in flood vulnerability, influencing both floodwater absorption and damage potential. Natural land cover, such as forested wetlands and marshes, provides valuable flood storage capacity, helping to buffer adjacent developed areas from rising water levels. Conversely, residential, commercial, and industrial areas are comprised of impervious surfaces that exacerbate flood impacts by inhibiting natural infiltration and increasing runoff.

For this analysis, land cover classifications were reclassified based on their flood susceptibility. Areas with high impervious surface coverage, including dense residential developments, received high vulnerability scores, while wetlands and vegetated floodplains were categorized as low-risk zones due to their ability to adapt and attenuate floodwaters.

Figure 69 illustrates how projected SLR and storm-driven flooding will gradually shift the balance between natural infiltration and increasing runoff. By 2050, inundation is primarily confined to existing wetlands and open spaces in the Franklin Manor neighborhood, reinforcing their role as protective buffers. By 2065, flooding expands inland, beginning to impact developed areas along the waterfront. By 2100, much of the residential and commercial land use in flood-prone areas experiences regular or permanent inundation, increasing risk to critical infrastructure and property.

This transition highlights the importance of land use planning strategies that prioritize coastal resilience, such as:

- Preserving and expanding wetlands to maintain natural flood buffers.
- Restricting new development in natural flood buffers.
- Incorporating nature-based solutions (e.g., marsh restoration, living shorelines) to slow the loss of protective landscapes.
- Enhancing green stormwater management in developed areas to mitigate increased runoff and backflow flooding.

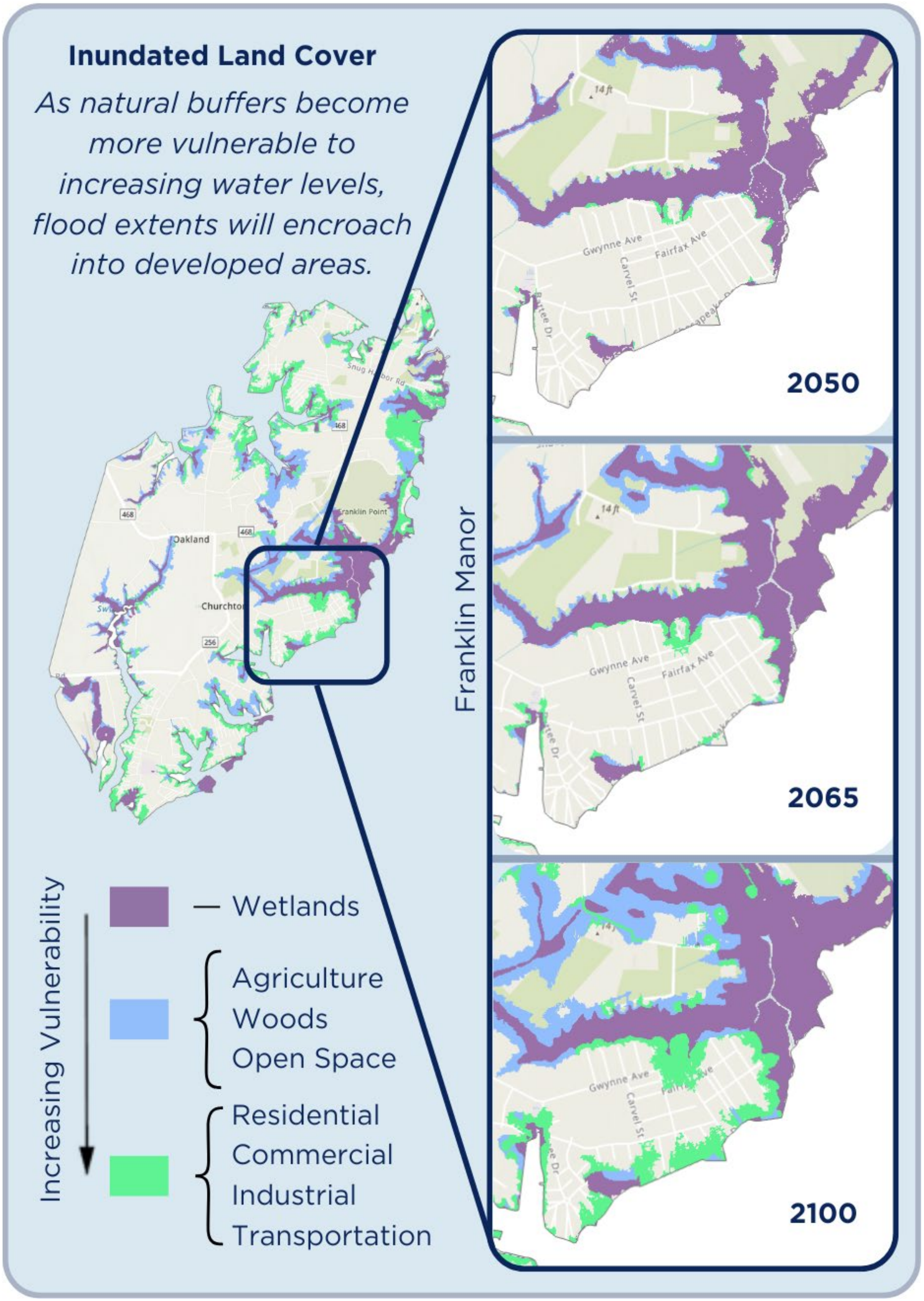


Figure 69 – Projected Land Cover Inundation Under Future SLR Scenarios. The inset series highlights progressive inundation in Franklin Manor from 2050 to 2100, illustrating the growing risk to residential and commercial land uses.

6.1.4. Shoreline Erosion

To quantify shoreline erosion vulnerability across the Peninsula, raw erosion rate data were translated into standardized metrics and spatially interpolated to assess both direct shoreline impacts and inland exposure. Erosion rates were classified into vulnerability categories based on severity, with higher erosion rates indicating greater flood vulnerability due to loss of coastal landforms (Table 24). Protected shorelines, such as those with hardened structures (e.g., bulkheads, revetments, and various stone protection features), were included in the analysis but assigned a low vulnerability score (2) to acknowledge their stabilization effects. Unknown or unassessed areas (e.g., "No transects cast; unprotected or unknown shoreline condition") were assigned a moderate vulnerability score (5) to reflect the uncertainty in their susceptibility. To produce a continuous erosion vulnerability surface, kriging interpolation was used to transform the point-based shoreline erosion data into a raster format.

Table 24 – Erosion Rate Ranges and Vulnerability Scores

Classification	Erosion Rate Range (feet/year)	Vulnerability Score
Extreme	> 8.0	10
Severe	4.0 – 8.0	8
Moderate	2.0 – 4.0	6
Low-Moderate	0.01 - 2.0	4
Minimal Erosion or Accretion	Negligible	3
Protected Shoreline	-	2
Unknown or Unclassified Shorelines	-	5

Erosion-induced vulnerability is not only dependent on shoreline retreat rates but also proximity of inland areas to eroding shorelines. To reflect this, the analysis applied a distance-weighted erosion model that considered inland proximity to eroding areas and weighted erosion impacts, with areas closer to the shoreline receiving higher vulnerability scores. Figure 70 maps vulnerability scores based on erosion rate ranges on the Peninsula.

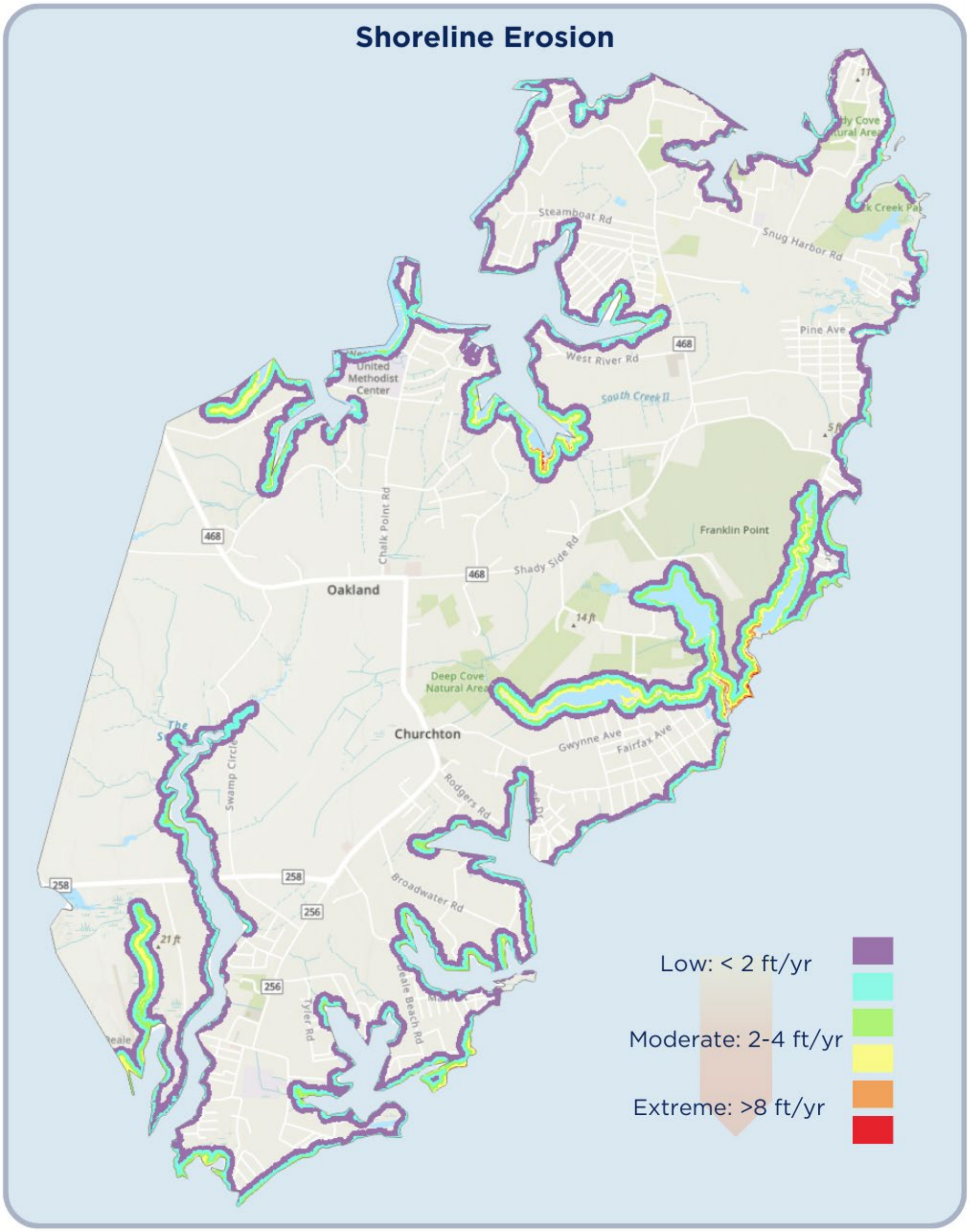


Figure 70 – Vulnerabilities to Shoreline Erosion

6.1.5. Accessibility to Emergency Services

The Peninsula's low elevation and coastal proximity make its roadway network particularly susceptible to disruption from SLR. As high tides rise in response to projected sea level increases, roadways in many communities will begin experiencing daily tidal flooding, significantly limiting access and isolating neighborhoods. Ensuring timely access to emergency services is a critical factor in assessing community vulnerability to flooding. As SLR progresses, low-lying communities across the Deale–Shady Side Peninsula will face increasingly constrained road access. Figure 71 highlights the roads projected to be inundated daily under 2050, 2065, and 2100 SLR scenarios. These inundation extents are based solely on modeled stillwater tidal levels, which account for daily high tides but do not include flooding due to storm surge or extreme rainfall events. The results show that key access points in communities like Cedarhurst, Deale Beach, and Owings Beach are already vulnerable by mid-century, with many local roads projected to be inundated on a daily basis.

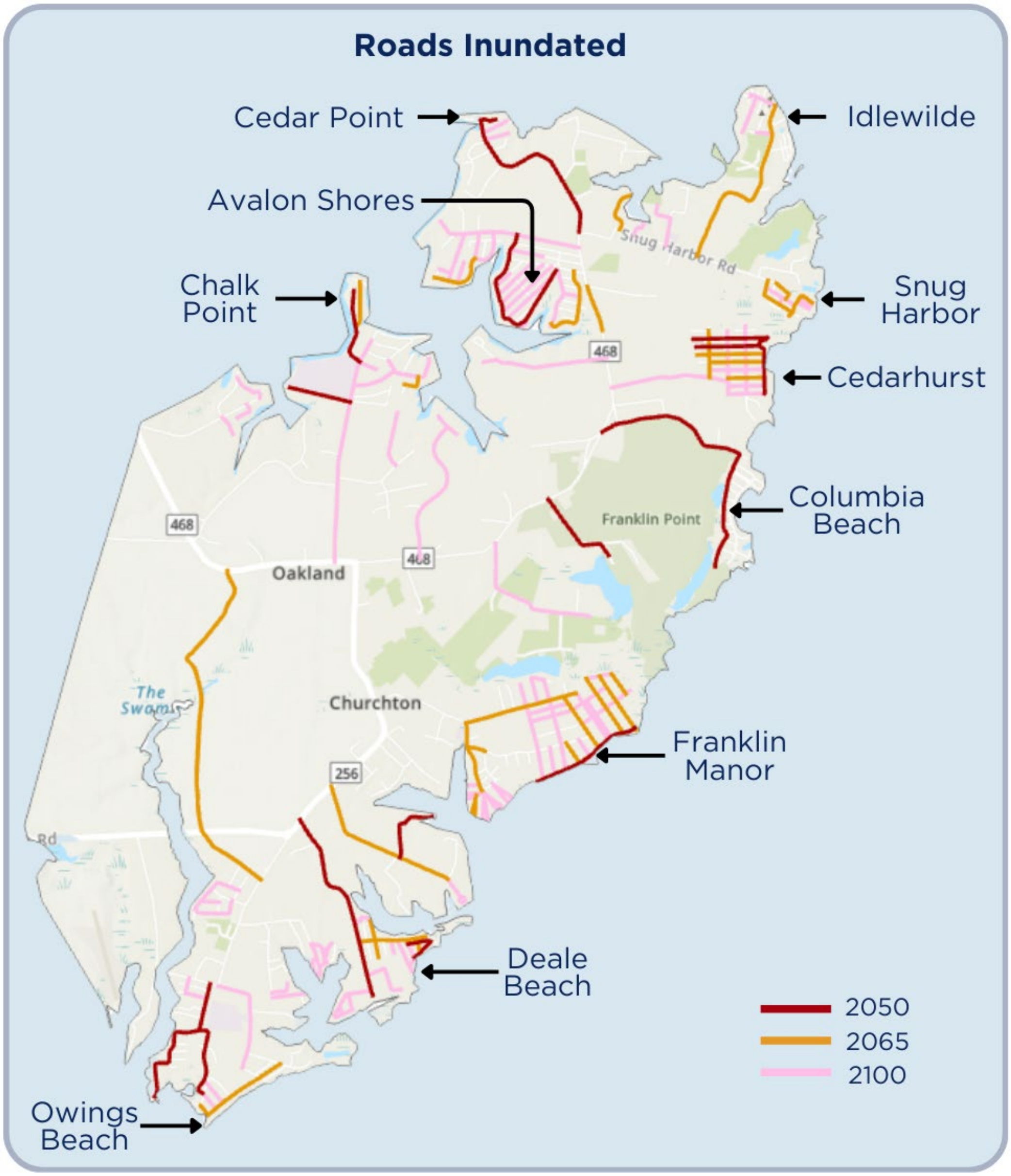
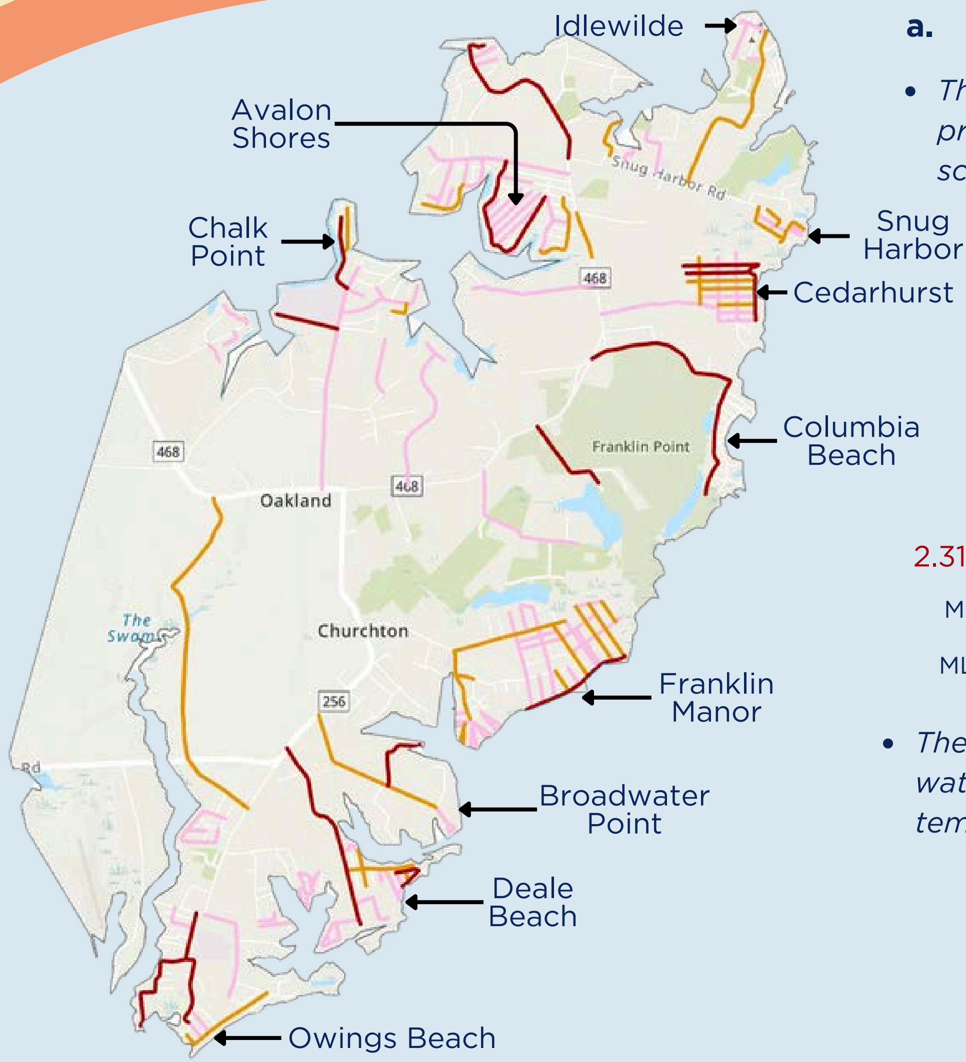


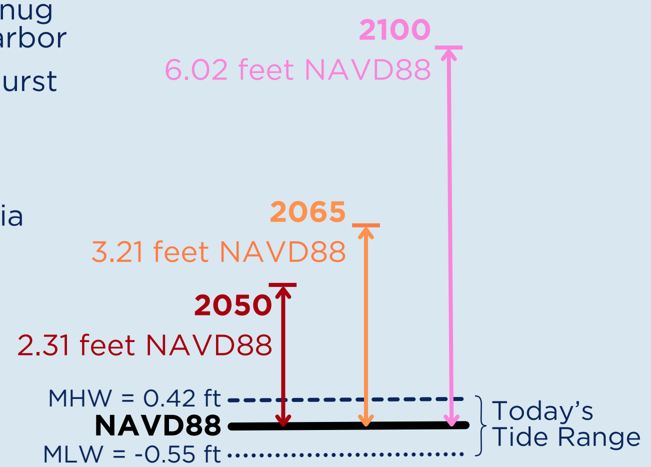
Figure 71 – Roads Inundated by Each SLR Scenario

To further illustrate the accelerating impact of storm surge, threshold-based elevation mapping estimates the potential for temporary flooding caused by storm events under future SLR conditions. Roads below 3.94 feet are considered vulnerable under a typical 2-year storm event by 2050, while roads below 5.26 feet may flood during more extreme (5-year return) events by 2065. These thresholds are critical in capturing episodic accessibility failures that fall outside of daily tidal projections but significantly affect emergency response, evacuation routes, and long-term infrastructure planning.



a. Roads Inundated by SLR

- *This map highlights roads impacted by projected daily high tide levels for the SLR scenarios of 2050, 2065, and 2100.*



- *These projections only account for still water levels and do not reflect the impact of temporary but extreme storm surge events.*

b. The Impact of Surging Water Levels

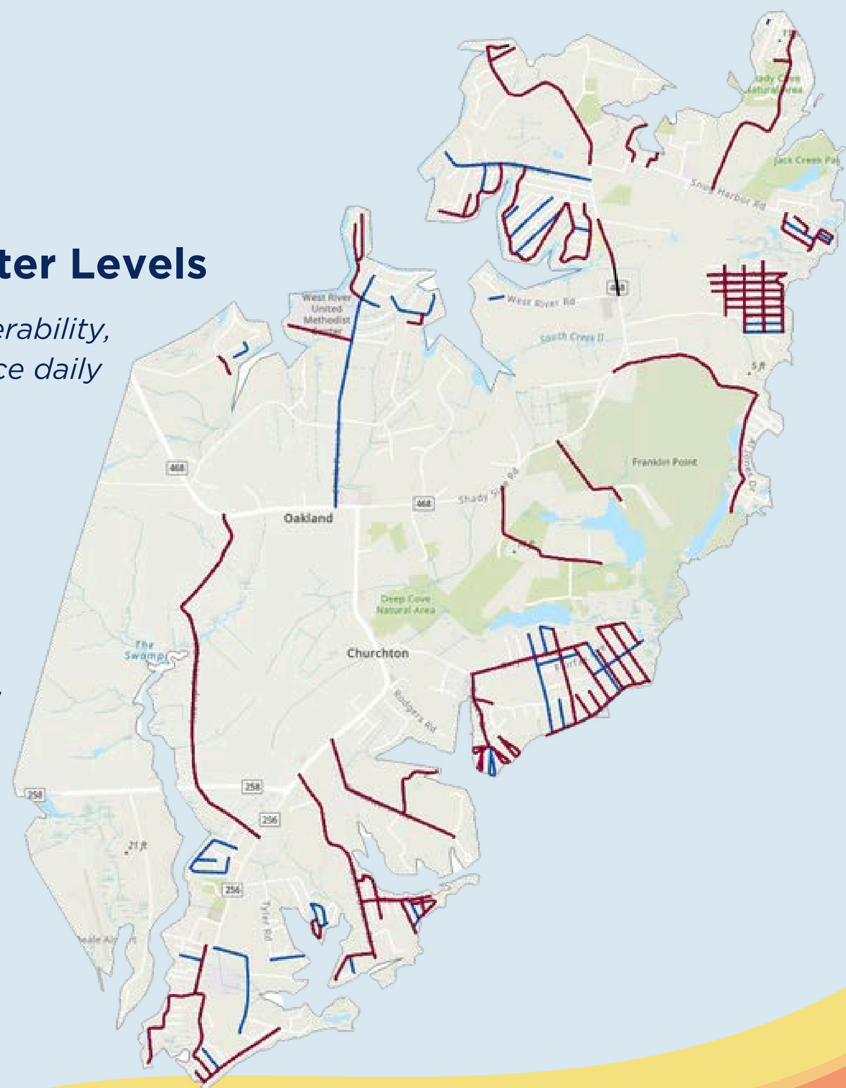
Storm surge accelerates roadway vulnerability, affecting roads that may not experience daily inundation under SLR alone.

< 2050 Threshold Elevation
3.94 feet

- *The 2050 threshold captures roads that would be impacted by a typical 2-year storm event under 2050 SLR conditions.*

< 2065 Threshold Elevation
5.26 feet

- *The 2065 threshold represents roads vulnerable to a more extreme storm event (5-year storm return) by 2065.*



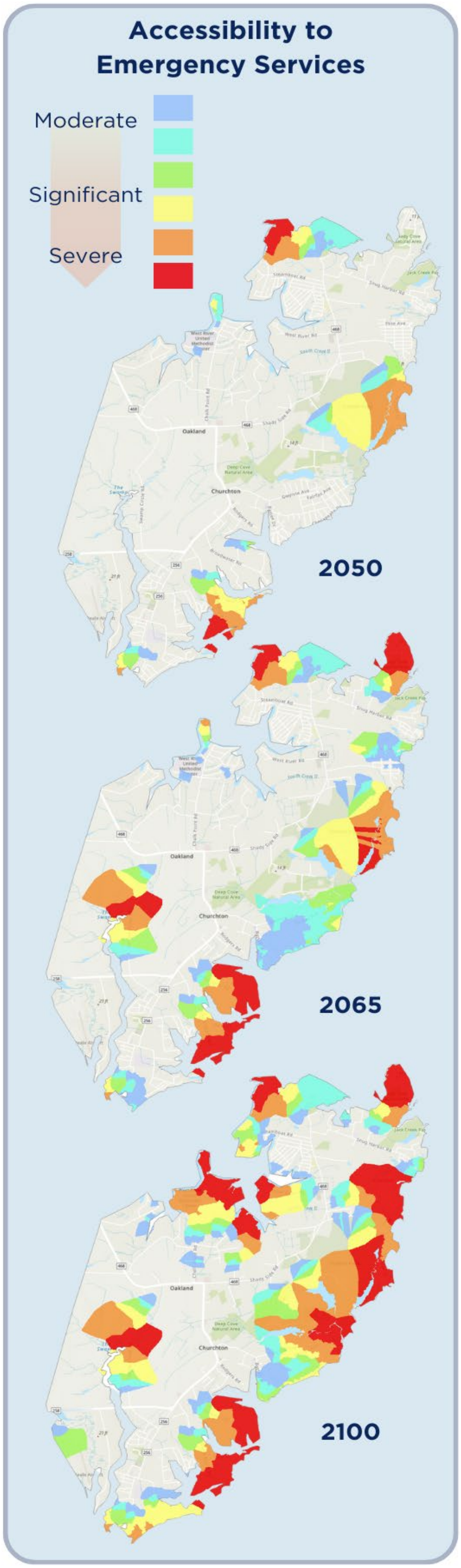


Figure 72 – Accessibility Vulnerability by SLR Scenario

To evaluate accessibility constraints, a cost-distance analysis was performed using the spatial proximity to hospitals, fire stations, and designated evacuation routes. This analysis calculated travel costs from each grid cell across the study area, accounting for impassable road segments due to permanent inundation from SLR in 2050, 2065, and 2100. While episodic stormwater flood events were not factored into the cost-distance algorithm, they were visualized separately to provide insight into near-term disruptions that may precede permanent SLR impacts. For cost-distance and accessibility analyses, this distinction ensures the focus remains on areas likely to experience prolonged or permanent disruptions, which pose the greatest challenge to infrastructure longevity and emergency service delivery.

Figure 72 classifies affected areas based on vulnerability scores, with moderate to severe impacts defined as scores ranging from five to ten on the standardized vulnerability scale.

Moderate Accessibility Impact (5-6 on Standardized Vulnerability Scale):

- Areas within this classification experience accessibility disruptions to local roads due to shallow or intermittent flooding
- Emergency response times may be slightly delayed, but alternative routes generally remain available.
- In 2050, neighborhoods in central Deale and portions of Shady Side fall into this category, indicating that early adaptation measures could prevent future escalation into more severe categories.

Significant Accessibility Constraints (7-8 on Standardized Vulnerability Scale):

- This classification indicates flooding of primary roadways, making emergency response times noticeable longer and requiring detours for service providers.
- By 2065, many coastal neighborhoods, including Deale Beach and Columbia Beach, experience this level of restriction, as rising water levels begin to impact key access roads.

- If left unaddressed, these areas will likely transition into the severe accessibility loss category by 2100.

Severe Accessibility Loss (9-10 on Standardized Vulnerability Scale):

- At this stage, major road networks become impassable, cutting off access for entire communities.
- Emergency response services may be severely delayed or entirely impassable without alternative evacuation measures.
- By 2100, extensive areas along the shoreline face isolation, posing serious safety risks to residents.

The Peninsula's coastal communities, particularly those with single access roads, will face increasing isolation risks over time. Threshold effects become increasingly apparent between 2050 and 2065, as relative minor increases in water levels lead to disproportionate accessibility losses in multiple communities. The expansion of severe accessibility loss zones by 2100 highlights the need for adaptive strategies. In Figure 73, Map A (left) displays areas facing moderate to severe accessibility impacts (scores 5–10), while Map B (right) isolates locations with severe accessibility risks only (scores 9–10). Gray pins indicate single access point communities, where flood-related road closures cut off all ingress and egress. Blue pins represent threshold isolation, or areas where accessibility rapidly deteriorates after a critical flood level is reached. Colored polygons denote the SLR scenario (2050, 2065, or 2100) in which these impacts are projected to occur.

Notably, the entirety of Shady Side relies on a single primary access route along West Shady Side Road which becomes increasingly vulnerable as water levels rise. Areas such as Deale Beach, Columbia Beach, Chalk Point, and Cedar Point begin to experience moderate impacts by 2050 but become severely constrained by 2100. Idlewilde and Broadwater Point are also impacted by floodwaters impeding travel via their single-access points.

While some areas experience gradual increases in emergency access constraints, others reach a critical flood threshold where accessibility rapidly deteriorates. Map B highlights communities where minor flood impacts are initially manageable, but once a certain flood level is exceeded, accessibility shifts from partial, intermittent travel restrictions to complete, regular isolation. Cedar Point, Columbia Beach, and Deale Beach experience severe impact on accessibility immediately, while Cedarhurst, Idlewilde, and Broadwater Point experience minimal access impact in 2050 but by 2065, major access routes are fully inundated, requiring alternative evacuation strategies.

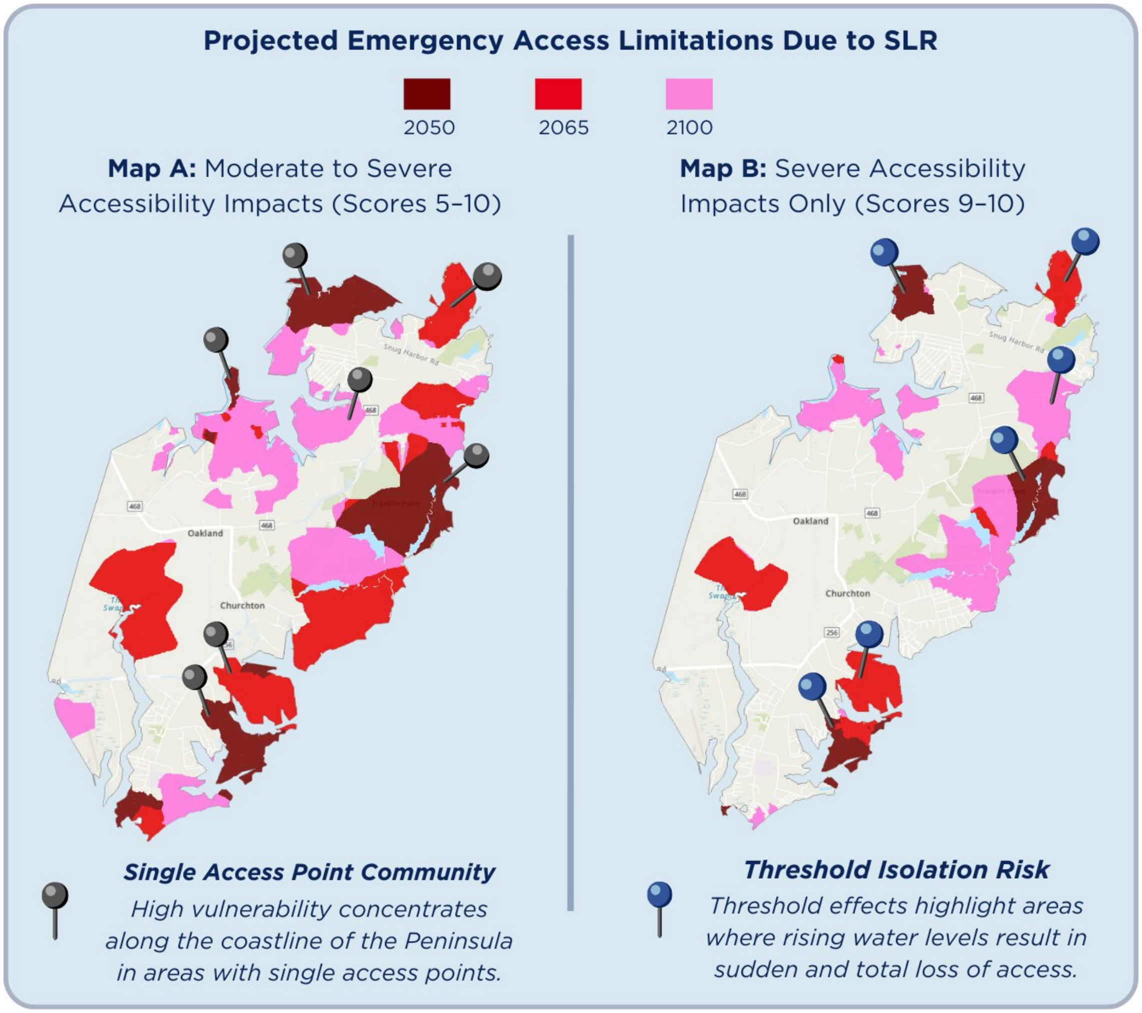


Figure 73 – Projected Emergency Accessibility Risks Due to SLR for 2050, 2065, and 2100. Map A highlights areas facing moderate to severe impacts (scores 5–10), while Map B isolates regions with the most extreme accessibility loss (scores 9–10). Gray pins identify communities with only a single access point; blue pins highlight areas where isolation occurs abruptly due to threshold flooding effects. Colored polygons indicate the SLR scenario when impacts are expected to occur.

These insights indicate that while some areas will require progressive adaptation strategies, others will require early intervention before critical accessibility thresholds are reached. Without preemptive planning, emergency response to these high-risk communities may become impractical or impossible in future flood scenarios.

6.1.6. Stormwater Flooding

Stormwater management plays a crucial role in mitigating flood risks, particularly in developed areas where impervious surfaces prevent natural infiltration and increase runoff volume. Many communities on the Deale Shady Side Peninsula rely on aging or undersized drainage infrastructure, which is becoming increasingly ineffective under higher-intensity rainfall events and rising sea levels. Stormwater outfalls that discharge directly into tidal waters are particularly vulnerable to backflow and reduced drainage capacity, compounding flood risks in low-lying neighborhoods.

Stormwater flood depths from each model scenario were reclassified into the established standardized vulnerability scale (1-10), allowing for consistent comparison with other flood risks factors. The reclassification framework assigned low vulnerability scores to shallow flooding and high vulnerability scores to deeper, widespread inundation. Figure 75 illustrates stormwater flood vulnerabilities in the communities identified for modeling efforts. Cedarhurst, a low-lying area faces increasing exposure to compounding flood risks. In southern Deale, the combination of stormwater and coastal flooding is impacting neighborhood access by 2050, highlighting critical infrastructure vulnerabilities. Because flood vulnerability in many areas is primarily driven by tidal inundation, low-lying wetland areas were reclassified to a vulnerability score of one in the stormwater analysis to avoid duplicating vulnerability already captured in the SLR flood inundation layers.

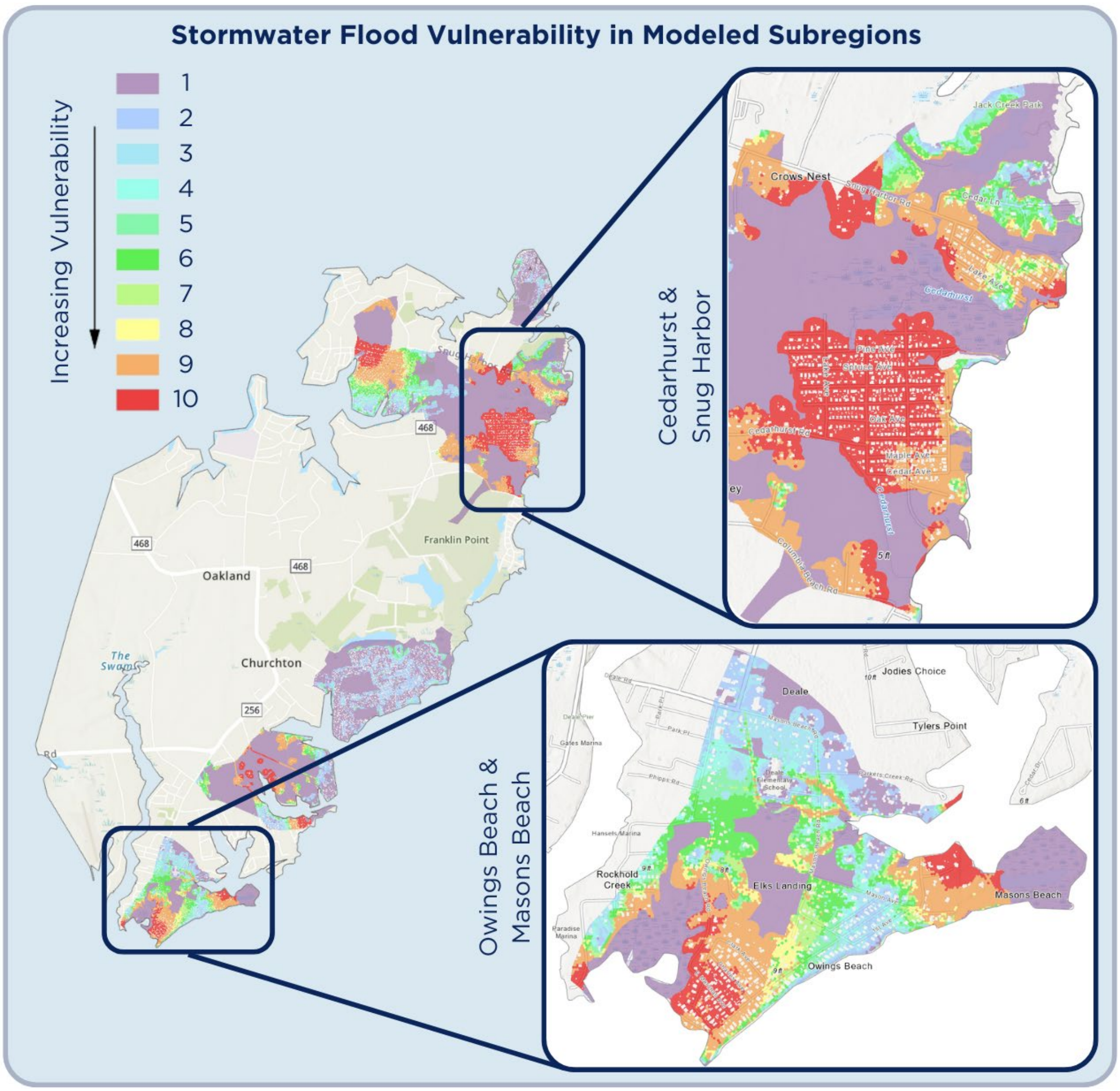


Figure 74 – Vulnerability to Stormwater Flooding Based on Modeled Stormwater Flood Response

To ensure a comprehensive vulnerability assessment across the Peninsula, vulnerability estimates were extended beyond directly modeled areas by integrating land cover-based vulnerability estimates with modeled stormwater flood depths. Land cover data was reclassified based on stormwater runoff potential with higher scores assigned to impervious land types (e.g., commercial, transportation) and lower scores to permeable land covers (e.g., wetlands, forests). The impervious surface dataset (e.g., roads, parking areas) was merged with the reclassified land cover raster to produce a final impervious surface raster allowing vulnerability scores in unmodeled areas to reflect imperviousness-based stormwater flooding susceptibility.

In locations where hydrologic and hydraulic stormwater models were conducted, the modeled flood depths were reclassified and preserved, ensuring interpolated estimates did not override observed vulnerabilities. Figure 75a. illustrates the integration of land cover-based vulnerability assessments with stormwater modeling extents. Figure 75b. presents the final stormwater vulnerability map, which combines modeled flood response with land-use characteristics to provide a comprehensive assessment of stormwater-driven flood risk across the Peninsula.

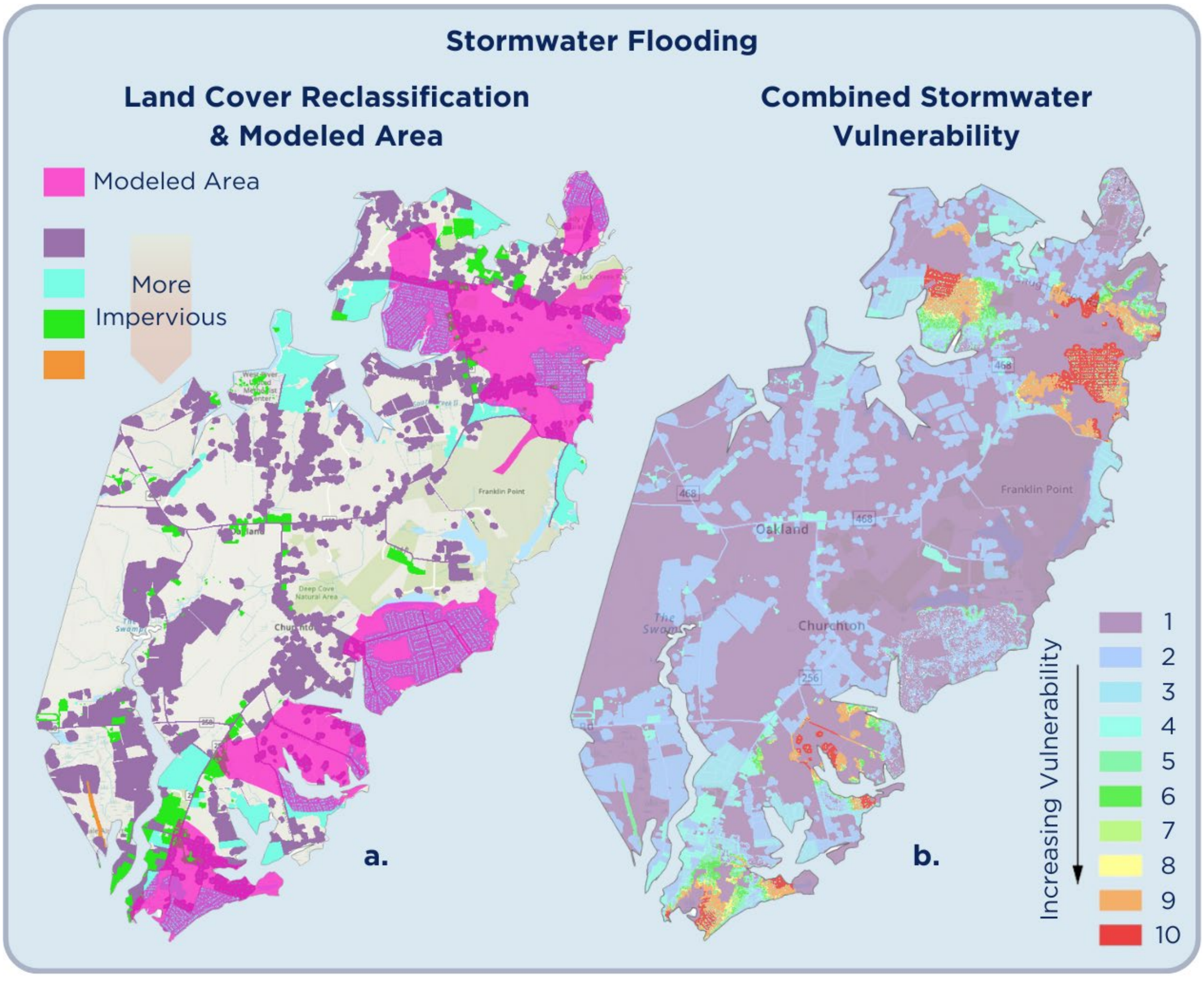


Figure 75 – (a.) Comparison of modeled stormwater extents with land cover-based vulnerability assessments. (b.) Combined land cover and modeled stormwater vulnerability

6.2 WEIGHTED OVERLAY ANALYSIS

The final composite vulnerability map was generated using a weighted overlay analysis, which assigns numerical weights to each contributing factor based on its relative influence on flood vulnerability.

LANDCOVER SUSCEPTIBILITY — 15%

For every SLR scenario, the composite vulnerability score considers impervious surfaces and urban development intensify flood risks.

2050	5%
2065	5%
2100	5%

SHORELINE EROSION — 5%

Loss of natural shoreline protection exacerbates coastal flooding impacts.

EMERGENCY ACCESS CONSTRAINTS — 20%

2050	Initial disruptions to critical routes affecting emergency response.	10%
2065	Increasing flood frequency and depth begins to isolate communities.	8%
2100	Severe long-term accessibility issues necessitating alternative emergency planning an infrastructure redesign.	2%

FLOOD DEPTH — 16%

2050	Accounts for near-term flood risks and adaptation needs.	9%
2065	Reflects mid-century flooding impacts with increasing severity	5%
2100	Represents long-term risks critical for planning major infrastructure.	2%

INUNDATED BUILDINGS DENSITY — 30%

2050	Represents immediate impact on structures requiring near-term considerations.	15%
2065	Expanded flood extents increase damage potential for densely built areas.	10%
2100	Long-term exposure suggests permanent inundation for structures, reducing adaptive capacity and requiring retreat or elevation strategies.	5%

STORMWATER FLOODING — 14%

Reflects challenges in managing stormwater runoff alongside coastal risks.

The vulnerability analysis underscores the critical interplay between physical infrastructure, natural systems, and projected climate impacts. The resulting vulnerability layer provides a robust foundation for targeting flood mitigation strategies on the Deale-Shady Side Peninsula (Figure 76). Low-lying neighborhoods with direct Bay exposure, areas with dense development, and regions with critical access issues were highlighted as priority zones for mitigation efforts.

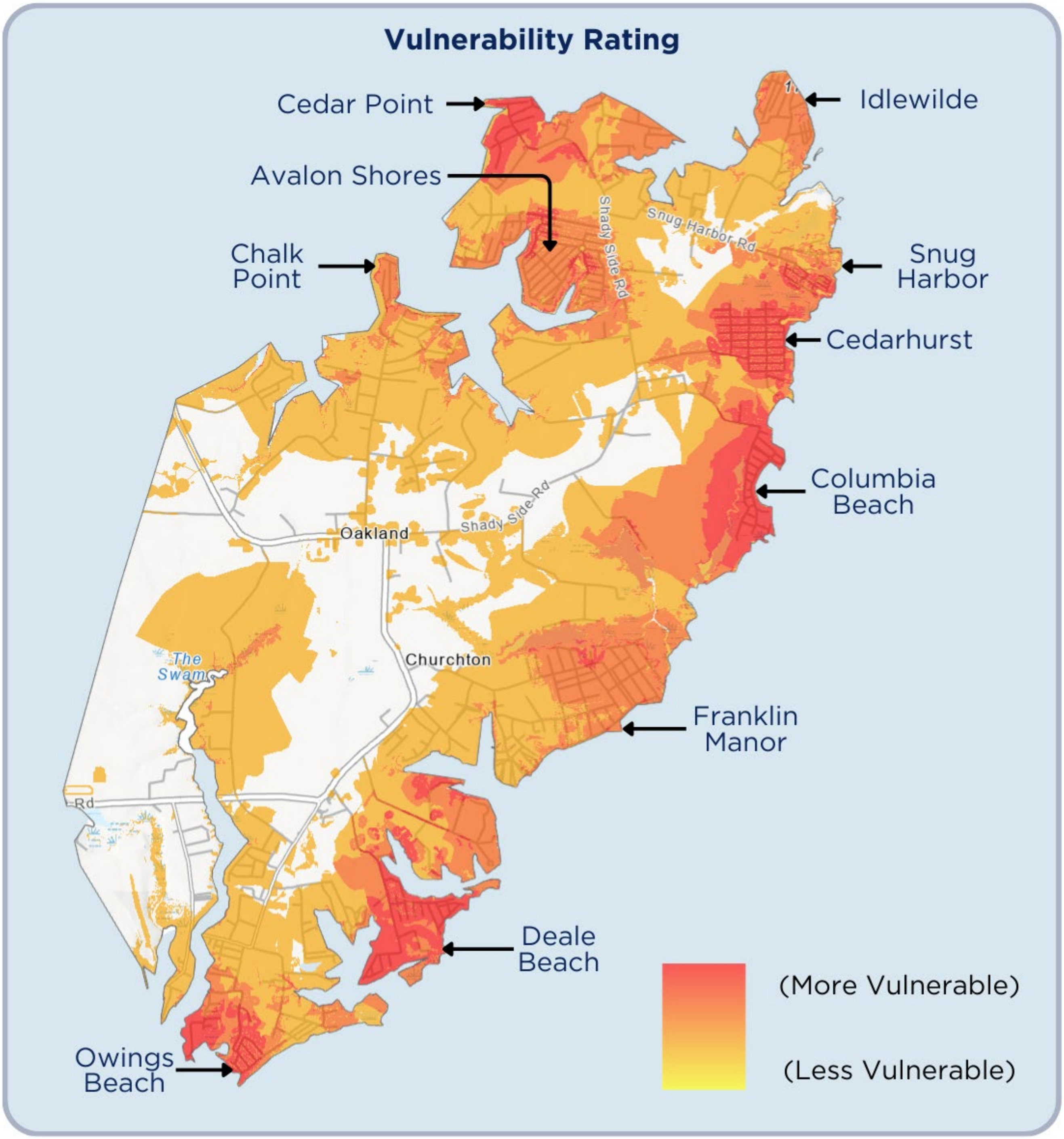


Figure 76 – Peninsula Vulnerability Ratings Derived from Weighted Overlay Analysis

6.3. Area Prioritization

Based on the composite vulnerability analysis presented in Sections 6.1 and 6.2, the following areas are prioritized for mitigation. The rankings are general and intended to guide the geographic focus of mitigation efforts. Subsequent sections refine implementation strategies and target specific interventions within these areas.

Table 25 below outlines community-level priority rankings, supported by observed vulnerabilities derived from mapped analysis layers. These summaries justify each area's placement within the prioritization framework, emphasizing high-risk flood exposure, access limitations, and concentrations of at-risk development.

Table 25 – Implementation Prioritization by Community

Priority	Community/ Neighborhood	Observed Vulnerability
1	Cedarhurst	Among the highest composite vulnerability on the Peninsula; displays extreme flood exposure from both SLR and stormwater, high density of inundated buildings, and severe emergency access constraints by 2065.
2	Columbia Beach	Single access point and multi-directional flood exposure lead to early isolation by 2050; high SLR and stormwater vulnerability intersect with dense shoreline development.
3	Deale Beach	High building density, extreme SLR exposure, and daily roadway inundation by 2065 make this a critical area for flood protection and access maintenance.
4	Owings Beach	Severe vulnerability to both coastal and stormwater flooding; displays rapid flood extent expansion due to threshold effects; road access is limited by 2065.
5	Snug Harbor	Large contiguous area of high SLR vulnerability with limited elevation relief; stormwater modeling shows widespread inundation; access declines sharply by 2100.
6	Cedar Point	Small community with a single access route fully inundated by 2065.
7	Franklin Manor	Moderate SLR and stormwater flood risk with high concentrations of at-risk buildings; displays early exposure to daily tidal flooding.
8	Avalon Shores	Moderate overall vulnerability but shares a low-lying shoreline with high SLR flood depths.
9	Chalk Point	Lower density, but the single access point and exposure to daily isolation by 2065 increases vulnerability.
10	Idlewilde	Displays delayed but accelerating SLR vulnerability; single access road becomes impassable by 2100.
11	Masons Beach	Creek shoreline vulnerable to flooding impacts.
12	Cape Anne	Smaller community with pockets of high stormwater vulnerability; displays localized risks and should be monitored.
13	Broadwater Point	Primarily road access vulnerability due to narrow ingress/egress; low development density reduces relative risk.
14	Westelee	Higher interior elevations with projected flood impact by 2100.

7 MITIGATION STRATEGIES

7. MITIGATION STRATEGIES

To reduce the impacts of SLR, storm surge, and increasingly intense rainfall events, a diverse set of coastal and stormwater flood mitigation strategies is essential. These strategies span both hard infrastructure and nature-based solutions, offering dual benefits such as flood protection and ecological enhancement. The vulnerability analysis emphasized the importance of targeted interventions such as improving road access in high-risk zones can preserve emergency service routes during flood events, while enhancing stormwater conveyance in moderate-risk areas can significantly reduce localized flooding.

The spatial variability of flood risk across the Deale–Shady Side Peninsula highlights the need for localized modeling and community-specific adaptation strategies. These findings reinforce the value of data-driven, adaptive resilience planning that directs resources where they are most needed based on a community's physical layout and exposure profile. The following section presents a comprehensive set of mitigation strategies that can be designed to address the Peninsula's unique flood risks and support long-term resilience.

7.1. Coastal Flooding Mitigation Strategies

Various strategies to inhibit the propagation of coastal floodwaters inland can be used alone or in conjunction with one another to mitigate the risk of flooding during high tide or storm surge events. These strategies are presented in the following sections.

7.1.1. Earthen Berm with Living Shoreline

For areas along the shoreline where additional habitat could be implemented, an earthen berm can be constructed with a living shoreline. The living shoreline would serve as protection to the berm by providing a wider buffer for incoming storm wave energy as well as environmental benefits due to the marsh plantings.

Figure 77 – Earthen Berm with Living Shoreline

Earthen berms, made from compacted soil and reinforced with vegetation, offer both flood protection and ecological benefits. These berms are cost-effective and environmentally friendly but require significant land area for construction. The alternative also requires a significant amount of fill to be bought and transported to the site to construct the berm. Stormwater management through the use of pumps or redirection of flow would also be required for areas when drainage would be blocked by the elevated structure.

If the large seaward encroachment and significant fill are impractical for implementation, an alternative would be to construct the earthen berm and living shoreline by excavating a portion of the uplands and placing the berm and living shoreline in upland areas. This alternative balances the upland footprint and the tidal encroachment. The excavation also provides the material for earthen berm, reducing the need to buy and transport fill from offsite. This alternative is often preferred by regulatory agencies as it converts uplands to tidal marsh, creates additional habitat and balances impacts to both upland and tidal resources. A cross section of this alternative is provided in Figure 78.

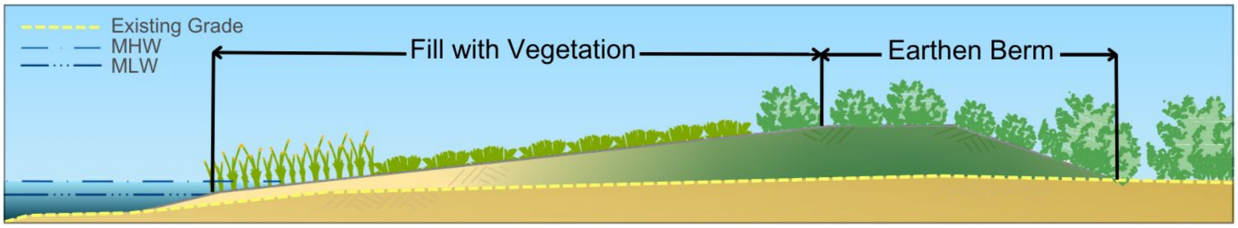


Figure 78 – Replacement of Bulkhead with Berm & Living Shoreline

The advantages of this alternative include utilizing green infrastructure and the replacement of hard structures, which is more appealing to funding and regulatory agencies. Utilizing the excavated material on site will also result in significant cost savings. Challenges include the footprint size, which may still be too large for use on private property or community areas and the implementation of stormwater management measures to prevent blockage of stormwater flow.

7.1.2. Impermeable Rock Berm

An impermeable rock berm, shown in Figure 79, is also a strategy for preventing flooding while reducing the footprint of the protection structure. An impermeable liner is placed along the seaward edge of the rock structure to prevent flooding through the voids. Similarly to the seawall or bulkhead, it utilizes hard infrastructure and does not provide environmental benefits. However, the berm could serve as a walking path or waterfront viewing area with benches for the community. This design can also be adjusted for higher water levels and will likely require less maintenance than the earthen berms or seawalls. Disadvantages of this alternative include difficulty in obtaining grant funding for hard structures and the permitting challenges likely to occur. Stormwater management will also need to be included so as not to block flows after rainfall events.

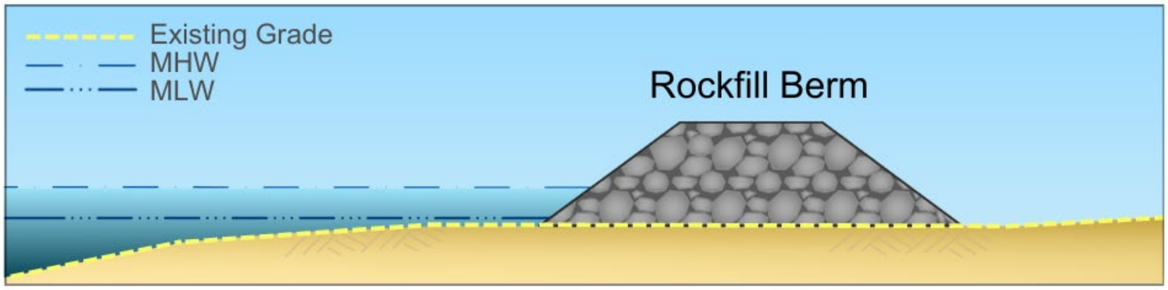


Figure 79 – Impermeable Rock Berm

7.1.3. Seawalls and Bulkheads

For shorelines adjacent to developed areas, marina infrastructure or private properties that require a minimum footprint or encroachment to protect against flooding from SLR and storm surge, a seawall or bulkhead can be implemented. The wall can take multiple forms depending on the site and geotechnical conditions. Options for structural protection include timber or vinyl sheeting bulkheads or concrete seawalls on foundations or piles. This alternative has the advantage of having a minimal footprint and less disturbed area. However, this alternative does not provide any environmental benefits or habitat uplift. Stormwater management for diverting or pumping the stormwater blocked by the structure will also be required.

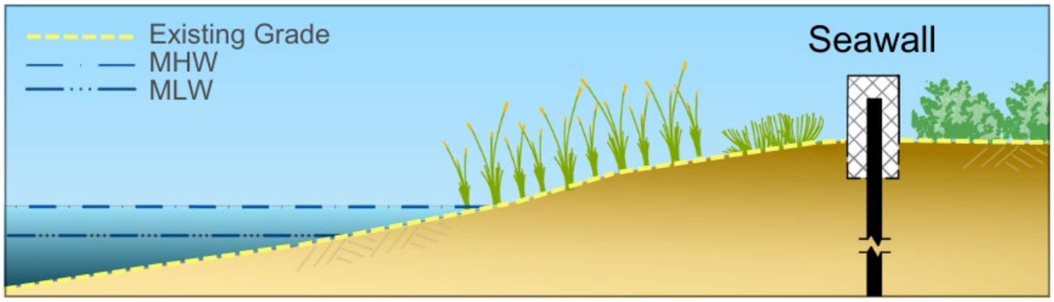


Figure 80 – Seawall Along Existing Marsh Areas

7.1.4. Road Raising

Road elevation is a widely used strategy to reduce flood exposure along critical transportation routes, particularly in low-lying coastal areas. Raising roadways above projected flood levels ensures continued access for residents and emergency services and can help prevent isolation during flood events. In addition to improving connectivity, elevated roads can be designed to serve as linear flood protection features, helping to hold back floodwaters and reduce inland inundation in adjacent areas. When paired with upgraded drainage infrastructure, road elevation projects can provide both transportation resilience and flood mitigation benefits.

7.1.5. Flood-Proofing Buildings

There are multiple methods to flood-proof buildings including: elevating the building, wet flood proofing, and dry flood proofing.

Elevating the building as a form of flood-proofing involves raising the first level of the building above the recommended base flood elevation with some additional freeboard. This can be accomplished through multiple methods as shown in Figure 81.

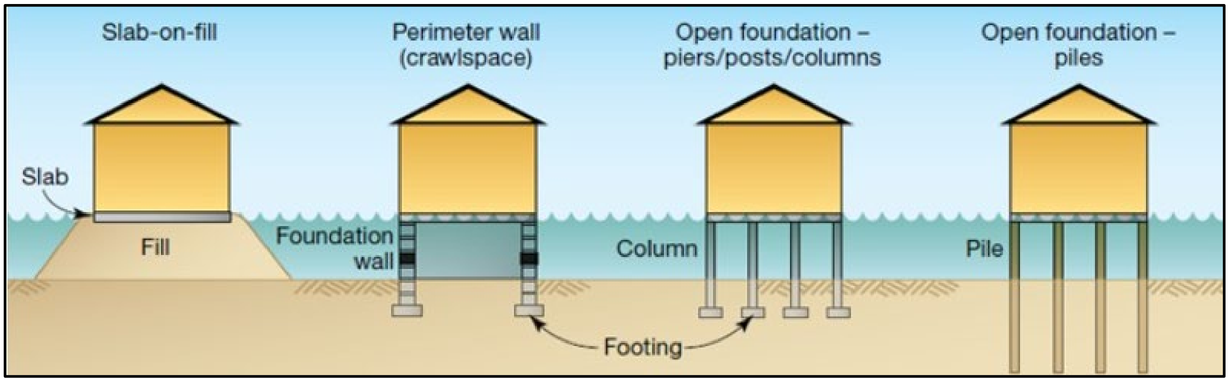


Figure 81 – Examples of Elevation Methods[22].

Wet flood-proofing a building involves allowing water to pass through the structure by elevating valuables and utilities and installing openings for controlled water flow, as shown in Figure 82. This can be accomplished with flood louvers, vents, and openings.

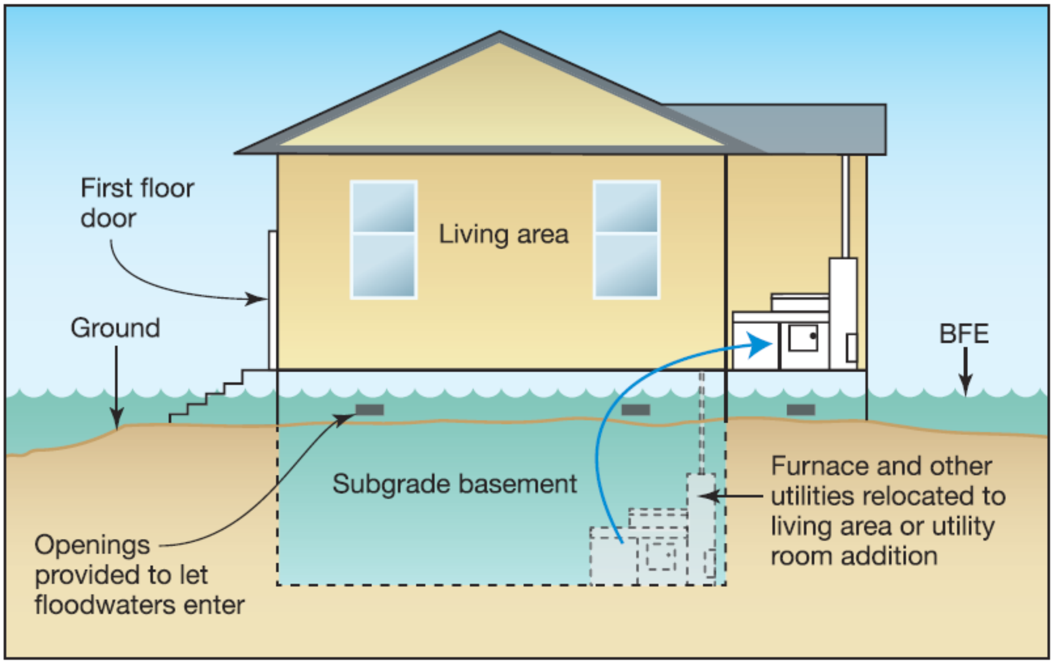


Figure 82 – Example of Wet Flood-Proofing[23].

[22] Federal Emergency Management Agency (FEMA). Quick Reference Guide: Comparison of Select NFIP & Building Code Requirements. Federal Emergency Management Agency, 2020.
[23] Federal Emergency Management Agency (FEMA). Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures (FEMA 259). 2nd ed., Federal Emergency Management Agency, Jan. 2001.

Dry-proofing a building involves installing an outer barrier to prevent water from entering the building. Methods include flood doors, door panels, window panels, and temporary barriers (Figure 83).

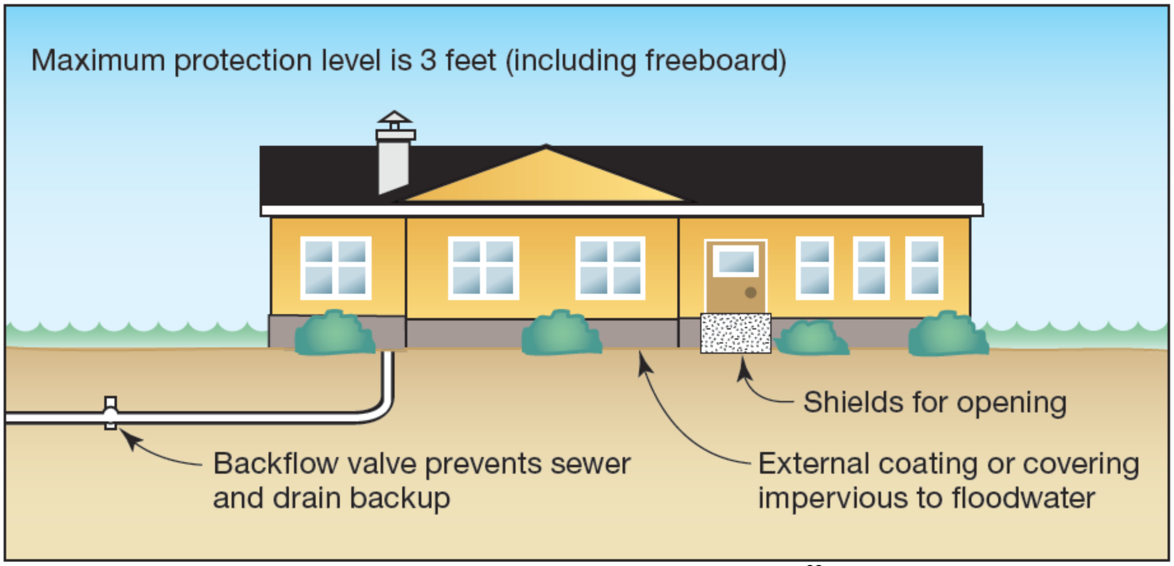


Figure 83 – Example of Dry Flood-Proofing[22]

7.1.6. Tide Gates

Often, flooding occurs from tidal waters backflowing up storm drain pipes and flooding inland areas. Tide gates are another effective strategy for controlling tidal backflow and preventing coastal flooding. Tide gates are designed to be installed within pipes or channels to restrict flow in one direction during storms.

A simple and cost-effective option, duckbill or inline check valves prevent backflow from tidewater into the stormwater system. However, during rainfall events, the hydraulic head will open the check valves and allow stormwater to drain through the outfalls.


Photo 138 - Duckbill backflow prevention valve (source: Red Valve)

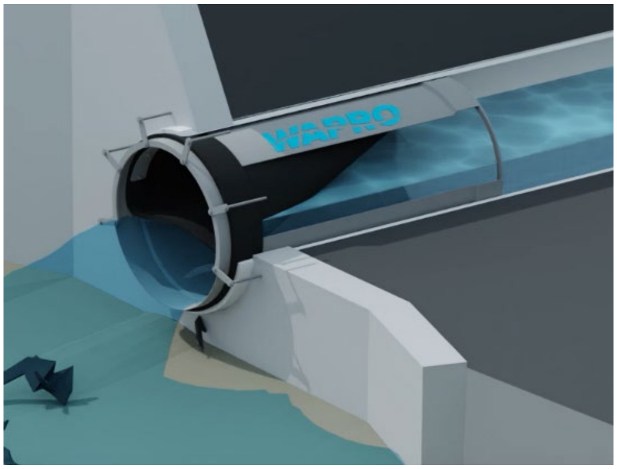


Photo 139 – Inline check valve (source: Wapro Inc.)

7.1.7. Surge Barriers

Self-Regulating or Mechanical Surge Barriers remain open under normal conditions, allowing tidal flow to flow freely, but close during high tides or storm surges. These flood barriers are ideal for tidal ecosystems, such as creeks or wetlands, as flows are not impacted during normal conditions.

Photo 140 - Self-Regulated Surge Barrier (source: Golden Harvest, Inc)

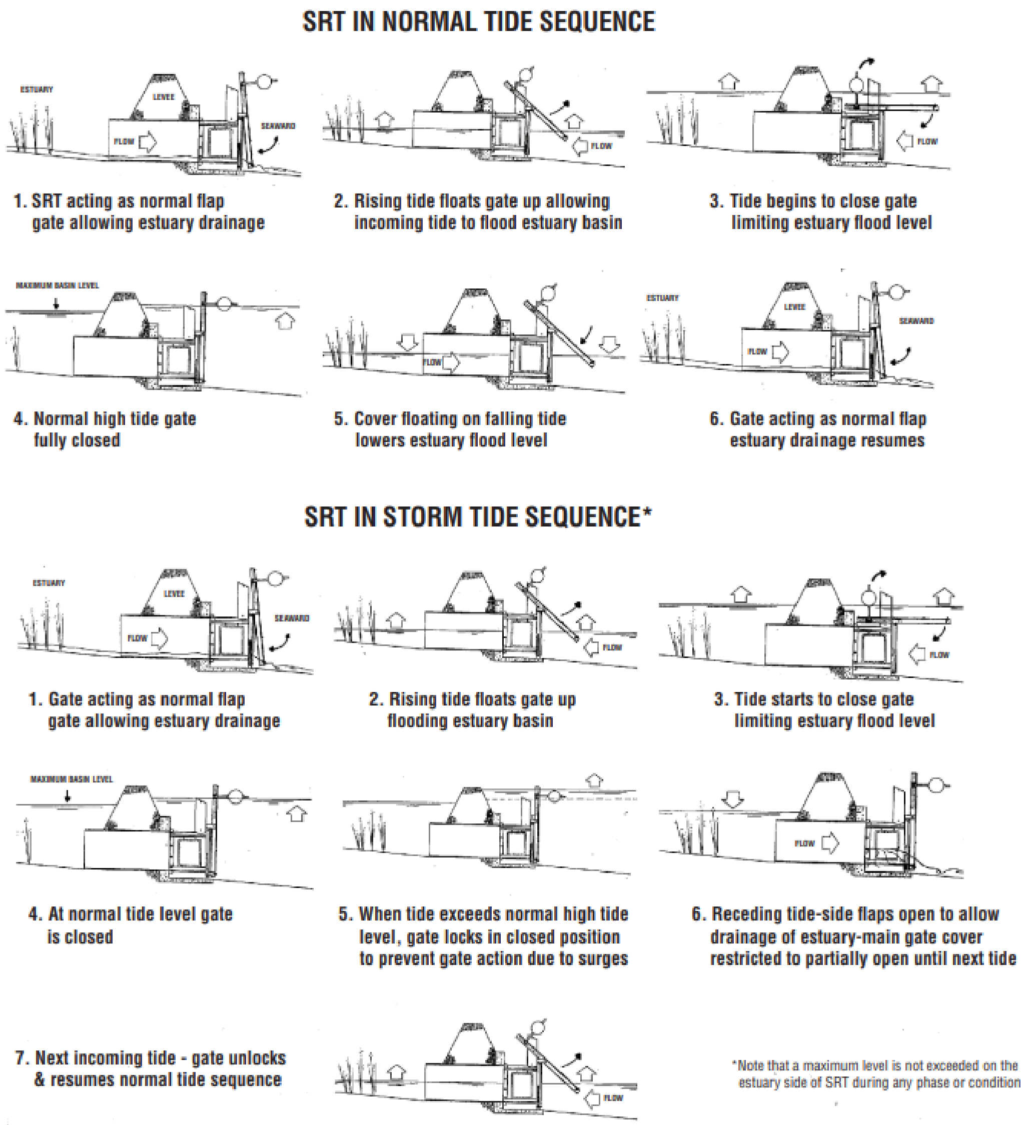


Figure 84 – Diagram of Self-Regulating Tide Gate (source: Waterman Valve[24])

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[24] Waterman Industries. Waterman SRT TideGate Specification Sheet. Waterman Industries, Dec. 2020, https://watermanusa.com/wp-content/uploads/2020/12/Waterman_SRT_TideGate_SpecSheet.pdf.

The advantage of this mitigation strategy is the minimal impact to the existing shoreline. As these structures are typically installed downstream of the area they are protecting, the shoreline, vegetation and areas immediately adjacent to the shoreline are not impacted and require little to no improvements. Additionally, installation of a surge barrier can reduce the flood risk for many areas upstream of the gate location. Finally, little to no adjustments to the existing stormwater drainage system are required as a result of this alternative. Maintenance and operations must also be considered depending on the product chosen.

7.1.8. Land Acquisition and Conversion

Land acquisition is a proactive, non-structural flood mitigation strategy that reduces long-term flood risk by removing development pressure in vulnerable areas and allowing for the restoration of natural floodplain functions. On the Deale–Shady Side Peninsula, targeted acquisition of high-risk parcels offers a path to expand flood storage capacity, restore wetlands, and buffer communities from rising water levels.

In the near term, this strategy can support the preservation or conversion of critical parcels into natural or semi-natural spaces that provide co-benefits, such as stormwater retention, improved ecological health, and public open space. Any acquisition would occur on a voluntary, willing-seller basis and only if feasible funding and programmatic partnerships are identified. Properties with repetitive flooding, proximity to tidal marshes, or those that interfere with natural drainage patterns should be prioritized for acquisition. Integration of land acquisition into a broader coastal resilience strategy will maximize its impact by aligning purchased parcels with stormwater retrofits, marsh migration corridors, or recreational greenways.

Long-term, acquired properties can be transformed into multi-benefit landscapes that enhance flood mitigation, biodiversity, and recreational access. Repurposed parcels could be used for wetland restoration, native habitat corridors, or designed stormwater retention systems. If coordinated effectively, this strategy can help manage flood risk while creating public amenities that reinforce community resilience.

The Coastal Hazards Overlay District Guide[25] developed by the Maryland Department of Planning provides a useful framework for incorporating land acquisition into local zoning and floodplain management. By applying these planning tools, AACo can formalize policies that prevent redevelopment in flood-prone areas and ensure that converted properties contribute to the Peninsula's broader resilience goals.

7.2. Stormwater Flood Mitigation Strategies

Stormwater runoff is collected by branches of the storm drain system and concentrated into several main branches before being discharged. Various strategies to increase the

[25] *Coastal Hazards Overlay District Guide*. Coastal Resilience Center of Excellence/Renaissance Computing Institute, 2025.

capacity of the system can be used in conjunction with one another to attenuate flooding.

7.2.1. Stormwater Drain Infrastructure Improvements

Ensuring the existing stormwater system functions effectively is crucial for managing stormwater flooding. In areas where current infrastructure is undersized or deteriorating, upgrading storm drains by enlarging pipes, adding new inlets, or installing parallel systems can significantly improve the capacity to handle runoff. This approach is particularly effective in more developed areas where space for natural stormwater solutions is limited. However, upgrades can be costly and disruptive.

Increasing pipe sizes is limited by the existing topography, storm drain system elevations and other underground infrastructure but can be used to mitigate flooding at the upper reaches of the system by efficiently conveying the flow to outlets. This approach can be used widely to mitigate flooding in areas where above ground practices are not feasible. The design must consider the increased flow being routed to the central storm drain conduits to ensure they do not become inundated.

Additionally, regular inspection, cleaning, and repair of storm drains ensure systems perform optimally during storms. Maintenance is a relatively low-cost high feasibility solution.

7.2.2. Pump Stations

In areas where gravity-based drainage is insufficient, pump stations are effective at removing water from an area and direct it to nearby water bodies. Though pumping stations will not prevent flooding during the storm event, they help dewater larger flooded areas in a timely manner. While effective, pump stations require significant capital investment and ongoing maintenance, making them suitable for high risk, flood-prone areas.

Photo 141 - Pumping Station

7.2.3. Underground Storage Vaults

Underground storage vaults are used to store excess stormwater during peak rainfall events and release it slowly to prevent overloading the drainage system. For areas with little existing underground infrastructure, underground storage vaults can be used to increase storage capacity within the system and allow the area more time to discharge flow before areas become inundated with flooding. Periods of high intensity rainfall can quickly inundate an area before it has time to discharge through gravity flow or pumping. The additional capacity provided by an underground storage vault attenuates the peak flow and provides more time for the system to discharge flow before flooding occurs at inlets. Although highly effective at reducing peak flows, vaults are expensive and complex to install.

7.2.4. Green Infrastructure

Green infrastructure concepts can be used to restore and mimic natural runoff patterns. These practices include bioretention facilities, vegetated swales, and riffle-pool conveyance. The facilities intercept runoff that would otherwise enter the storm drain system and allow for it to infiltrate. The size and location of the practices impact their effectiveness at mitigating runoff, but they can be used to lower overall inflow to the system and decrease peak flow rates.

Photo 142 - Bioretention Facility

Photo 143 - Riffle-Pool Conveyance System

Photo 144 - Submerged Gravel Wetland

7.3. Policy, Planning, and Community-Based Strategies

In addition to the physical mitigation strategies proposed in Sections 7.1 and 7.2, the County can manage flood risk through a range of policy, planning, and community-based strategies. These include expanding outreach and education, implementing operational improvements, adopting new ordinances and policy updates, and revising design standards to better manage development in flood-prone areas of the Deale-Shady Side Peninsula.

7.3.1. Outreach and Education

A key component of resilience planning involves increasing community understanding of flood risk. Through targeted outreach and education, the County can improve resident participation in mitigation activities and empower individuals to take proactive steps that support neighborhood-wide resilience. Public education campaigns should focus on raising awareness of specific flood hazards and the long-term impacts of sea level rise. Interactive tools, such as web-based flood mapping platforms, can help residents visualize future risks under various sea level rise and storm surge scenarios. These tools should be updated regularly and promoted widely.

The County is encouraged to partner with local civic associations and nonprofits to host outreach events tailored to neighborhood concerns. Workshops, town halls, and homeowner information sessions can focus on floodproofing strategies, stormwater management, and property protection. These engagements should be complemented by a comprehensive floodproofing resource guide for property owners, detailing step-by-step actions such as wet floodproofing, elevating utilities, and installing backflow preventers (Figure 85). The County can further support private property resilience by connecting residents to available grant programs for home elevation, utility protection, and rain garden installation. Affordable do-it-yourself guidance on small-scale projects such as rain gardens to reduce runoff can be delivered through online tutorials or community events.

Figure 85 – Home Raising Infographic (source: Expert House Movers)

To deepen engagement, the County can develop a “Resilience Ambassadors” program consisting of local representatives who serve as liaisons between residents and County staff. These individuals can promote best practices, assist with distributing resources, and support implementation of flood mitigation projects at the neighborhood level. In tandem, hands-on community-based efforts such as rain garden installations, swale and culvert cleanouts, and shoreline restoration activities can be organized to demonstrate tangible progress and promote civic pride in resilience-building work.

7.3.2. Governance and Policy

Improving governance and policy is another cornerstone of effective flood mitigation. Local policies and ordinances must evolve and expand to reduce flood risk while supporting sustainable growth. The County can expand its floodplain management ordinance to prohibit or limit development in areas with high flood risk to adopt a “no net increase” in flood risk approach. Upgrades to utility infrastructure, including wastewater and water supply systems, should also be prioritized in areas at risk of prolonged inundation.

All new County infrastructure, including roadways and stormwater conveyance systems, should comply with the Maryland Coast Smart Council Guidelines. These standards recommend minimum elevation thresholds that incorporate sea level rise projections and require special permitting within the Coast Smart Climate Ready Action Boundary.

Incentivizing green infrastructure can complement regulatory approaches by encouraging the use of rain gardens, permeable pavement, bioswales, and similar practices that manage stormwater and reduce pollutant loads. The County can offer property tax reductions, fee waivers, or expedited permitting for projects that incorporate flood-resilient design. These incentives will help catalyze widespread adoption of low-impact development strategies across the Peninsula.

7.3.3. Operational Improvements

Operational improvements are essential to the long-term performance of stormwater and flood mitigation systems. AACo should pursue participation in FEMA’s Community Rating System (CRS), a program that reduces flood insurance premiums for residents based on the County’s implementation of best practices in floodplain management. Activities that earn CRS points include updating floodplain maps, increasing public access to risk data, and delivering community education. In tandem, the County should implement a maintenance and inspection program for critical stormwater infrastructure such as culverts, swales, and outfalls. Annual inspections and proactive maintenance can prevent failures and ensure systems are functioning as intended.

Together, these policy, operational, and community-based strategies can position AACo to address current and future flood risks comprehensively while empowering local residents to be part of the solution.

7.4. Financial Mechanisms

A sustainable and diversified financial framework is critical for realizing the resilience strategies outlined in this plan. While this document serves primarily as a planning tool, funding will ultimately determine the pace and scale of implementation. Accordingly, this section presents a range of potential financial mechanisms designed to support flood mitigation efforts and infrastructure upgrades across the Peninsula. These tools are not intended as formal commitments, but rather as a suite of options that can be explored and refined through future partnerships. The following financing strategies are presented to guide future collaboration, funding alignment, and multi-source funding efforts.

7.4.1. Property-Level Assistance and Voluntary Buyouts

Property-level interventions are a key component of comprehensive resilience. Voluntary buyout programs can be considered for properties in high-risk areas, particularly repetitive loss properties. Financial assistance for homeowners through grants or low-interest loans can support elevation and floodproofing improvements, while cost-share programs can help offset the expense of installing sump pumps, backflow preventers, and other small-scale mitigation measures. These programs could mirror existing models, such as large-scale homeowner assistance programs in New Jersey and Louisiana that combine FEMA mitigation funding with state-administered buyouts, elevation, and home retrofit support. These programs demonstrate that multi-source financing and proactive state-local coordination can make flood mitigation accessible and equitable, especially in communities facing chronic inundation. A similar framework could be adapted to the Peninsula, potentially led by the Resilience Authority of Annapolis and AACo, herein referred to as the Resilience Authority, in collaboration with county and state partners.

7.4.2. Local Funding Mechanisms and Revolving Capital

Local financial mechanisms can generate revenue and provide direct support for project implementation. To ensure ongoing investment, the County could establish a Resilience Improvement Fund dedicated to addressing small-scale, localized flood issues in less densely populated areas. This fund can be capitalized through annual appropriations or grants to address nuisance flooding in underserved, rural areas that may not qualify for large infrastructure grants.

A revolving loan structure can offer upfront capital to property owners, businesses, or community groups undertaking flood mitigation projects. These funds can be initially seeded with grants, appropriations, or philanthropic contributions and then sustained by repayments from low-interest loans issued to property owners, businesses, or local partners. As loans are repaid, the funds are replenished and reinvested into new projects, allowing capital to circulate and support multiple rounds of adaptation over time. This model supports long-term resilience financing without requiring continuous new investment and can scale over time to meet evolving community needs.

In some cases, it may be appropriate to explore petition-based models for cost-sharing, where a group of property owners formally request and agree to contribute to infrastructure improvements that provide shared community benefits. AACo currently uses this approach for water and sewer extensions. If a majority of property owners within a defined area support the request, the County designs and constructs the proposed project, and costs are repaid through annual property-based assessments. This could be adapted for resilience infrastructure such as stormwater upgrades, flood barriers, or road elevation. Under this model, community members or civic associations would initiate a petition, with County staff providing support to define the project area, develop cost estimates, and guide the process through implementation. If approved by a majority vote, the County would manage construction and assess participating properties over time to recover costs. Establishing a process for community-initiated resilience projects could empower residents to proactively invest in local resilience while leveraging County expertise in planning, coordination, and delivery.

Additionally, a fee based on impervious surface area can generate a consistent, locally controlled revenue stream with revenues directed toward both capital improvements and long-term operations and maintenance. This model is widely used in jurisdictions across the U.S. and can be structured to incorporate tiered rates based on runoff contribution and by providing exemptions or credits for low-income households, nonprofits, or property owners who implement onsite mitigation measures such as rain gardens or permeable surfaces.

7.4.3. Coordinated Financing Through the Resilience Authority

The Resilience Authority, established in 2021, is designed to finance, manage, and implement resilience infrastructure across jurisdictional boundaries. The Resilience Authority does not have taxing power but is authorized to issue revenue bonds, coordinate grant applications, and manage public-private partnerships to fund complex climate adaptation projects[26].

Looking ahead, the Resilience Authority is well-positioned to serve as a coordinating entity for many of the financial strategies outlined in this plan. Its core functions include streamlining access to federal and state funding, structuring flexible financing packages that blend public, private, and philanthropic capital, and aligning implementation timelines across jurisdictions to avoid duplication and accelerate delivery. By administering resilience investments through transparent, performance-based frameworks, the Resilience Authority can help scale resources over time to meet the Peninsula's evolving needs. Leveraging this institutional capacity will be essential to turn the strategies in this plan into tangible, long-term outcomes.

Together, these financial mechanisms provide a scalable and adaptable foundation to support the wide range of mitigation strategies proposed in this plan. From parcel-scale improvements to community-wide infrastructure upgrades, each tool plays a role in

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[26] Resilience Authority of Annapolis and Anne Arundel County. *Our Approach*. https://resilienceauthority.org/our-approach/

ensuring that investments can be targeted, phased, and sustained over time. The ability to combine local revenue streams, revolving capital, and external grant funding will be essential as climate impacts intensify and funding sources evolve. The Resilience Authority's leadership and coordination capacity will be critical to aligning these mechanisms with implementation timelines and community priorities. As such, this framework is not intended as a single solution but as an evolving set of tools that can be refined through future collaboration to accelerate the Peninsula's long-term resilience.

8 IMPLEMENTATION PLAN

8. IMPLEMENTATION PLAN

The Implementation Plan for the Deale-Shady Side Peninsula is structured around six core themes that address the region's most pressing vulnerabilities to flooding. These themes—road raising, tide gates, stormwater conveyance, compound flood mitigation, land acquisition, and home raising—were identified through the vulnerability analysis, incorporating current flood risks and future projections. Each theme represents a targeted strategy to mitigate specific challenges while contributing to the broader resilience of the Peninsula.

Flood risks on the Peninsula are multi-faceted, combining tidal inundation, storm surge, and stormwater-related challenges. To address the complexities, the Implementation Plan prioritizes both immediate actions and long-term planning, ensuring that proposed solutions are adaptive and sustainable. The individual themes provide a framework for understanding the necessary improvements across different aspects of flood resilience, from protecting critical infrastructure to supporting homeowners in at-risk areas.

8.1. Road Raising

Ensuring safe and reliable access is a cornerstone of flood resilience planning, as roadways are essential for emergency response, evacuation, and daily mobility. The road raising strategy prioritizes segments most at risk from future flooding, identified through a multi-step geospatial analysis that incorporates stormwater flooding, SLR projections, and storm surge impacts.

Roads serving as primary access points for high-density residential areas and critical infrastructure were prioritized. In the short term, the focus is on identifying and categorizing the most vulnerable road segments for immediate elevation, focusing on those frequently inundated and serving as primary access or evacuation routes. Long-term actions include initiating studies and designs for road sections projected to face future flood risks, ensuring preparedness for rising water levels. Monitoring efforts will involve tracking areas that may become increasingly at risk, allowing for adaptive planning and phased implementation. See Figure 86 and Table 26 for prioritized actions.

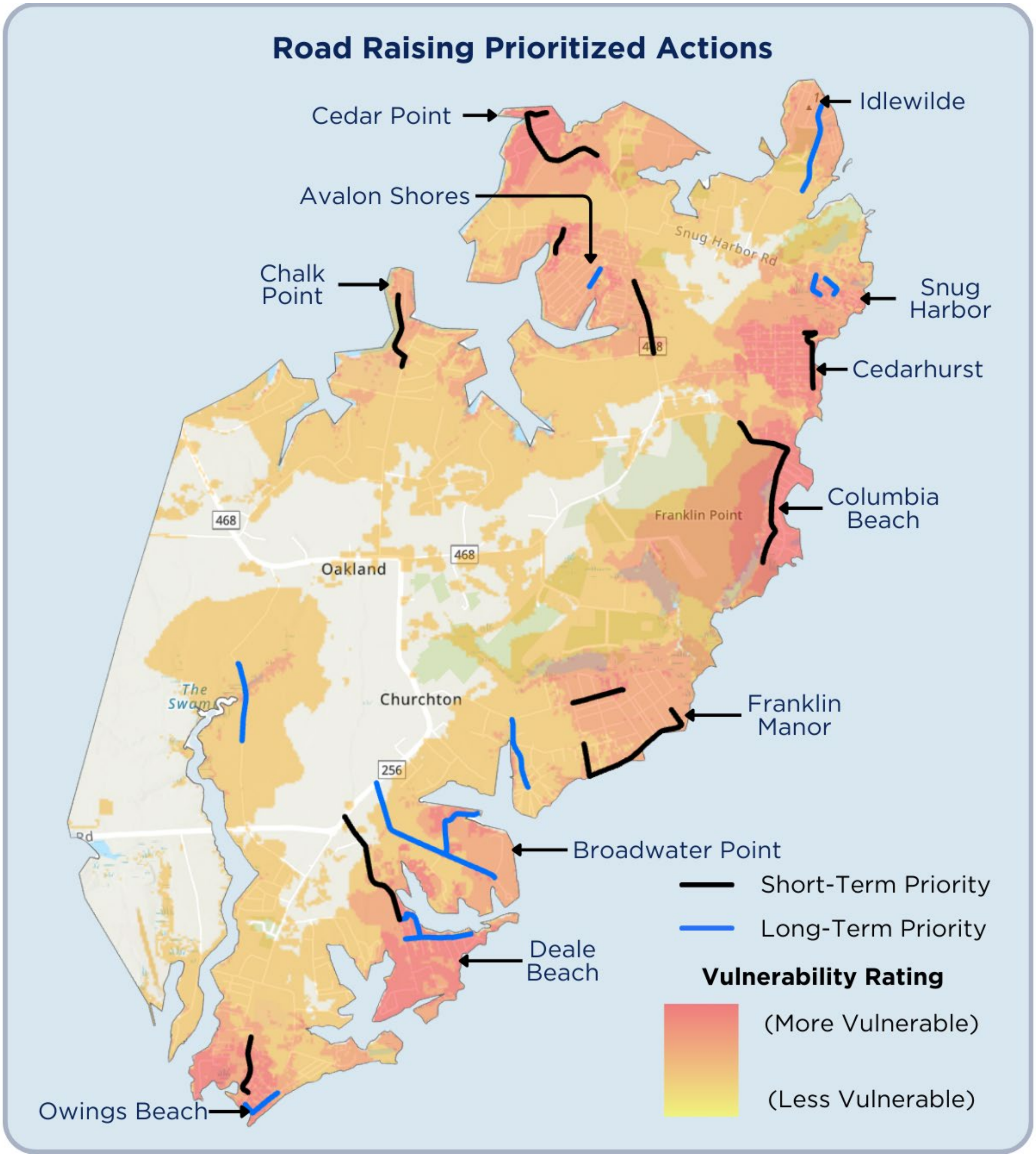


Figure 86 – Road Raising Prioritized Actions Overlain with Vulnerability Rating

Table 26 – Road Raising Prioritized Actions*		
Priority	**Priority Area**	**Linear Feet (LF)**
Short-Term (0 – 10 years)	Carvel Street (between Delaware Avenue & Chesapeake Drive) & Chesapeake Drive	4,600
	Chesapeake Avenue	2,150
	Columbia Beach Road	5,200
	Deale Beach Road (between Deale Churchton Road & Flood Avenue)	3,600
	Gwynne Avenue (between Carvel Street & Franklin Boulevard)	1,500
	Lerch Drive (between Steamboat Road & Avalon Boulevard)	745
	Owings Beach Road (between Drum Point Road & Welch Avenue)	1,800
	Shady Side Road (between Shady Rest Road & West River Road)	2,175
	W Shady Side Road (between Griner Lane & Linton Lane)	3,600
	West Chalk Point Road	2,300
	Sub Total for Short-Term Priority Areas:	**27,670**
Long Term (10 – 20 years)	Battee Drive	2,060
	Broadwater Creek Road	2,010
	Broadwater Road	4,760
	Cedar Avenue and Goose Drive	630
	Flood Avenue & 2nd Street	890
	Idlewilde Road (between Coster Drive & Winters Avenue)	2,590
	Irvin Avenue & Melbourne Avenue (between Irvin Avenue & Clark Avenue)	1,270
	Lerch Drive (between Oak Street & Washington Circle)	610
	Main Street	1,920
	Swamp Circle Road	2,280
	West End Avenue	700
	Sub Total for Long-Term Priority Areas:	**19,720**
Monitor	**Updates to Building Codes to incorporate resiliency considerations (Overall)**	-

* Road lengths within their respective short- and long-term priority groups are listed in alphabetical order and not priority rank.

8.2. Tide Gates

Tide gates are an essential tool for mitigating tidal backflow into stormwater drainage systems and worsening inland flooding. Stormwater modeling efforts and the vulnerability analysis were used to identify key stormwater outfalls where tidal backwater effects compound neighborhood flooding, particularly during high tides and storm events. These outfalls were mapped using documented County stormwater infrastructure and field-verified surveyed outfalls. However, additional outfalls may require intervention, particularly as low-lying areas become more vulnerable to flooding. Figure 87 illustrates the prioritization of tide gate installations based on vulnerability levels and expected flood impacts.

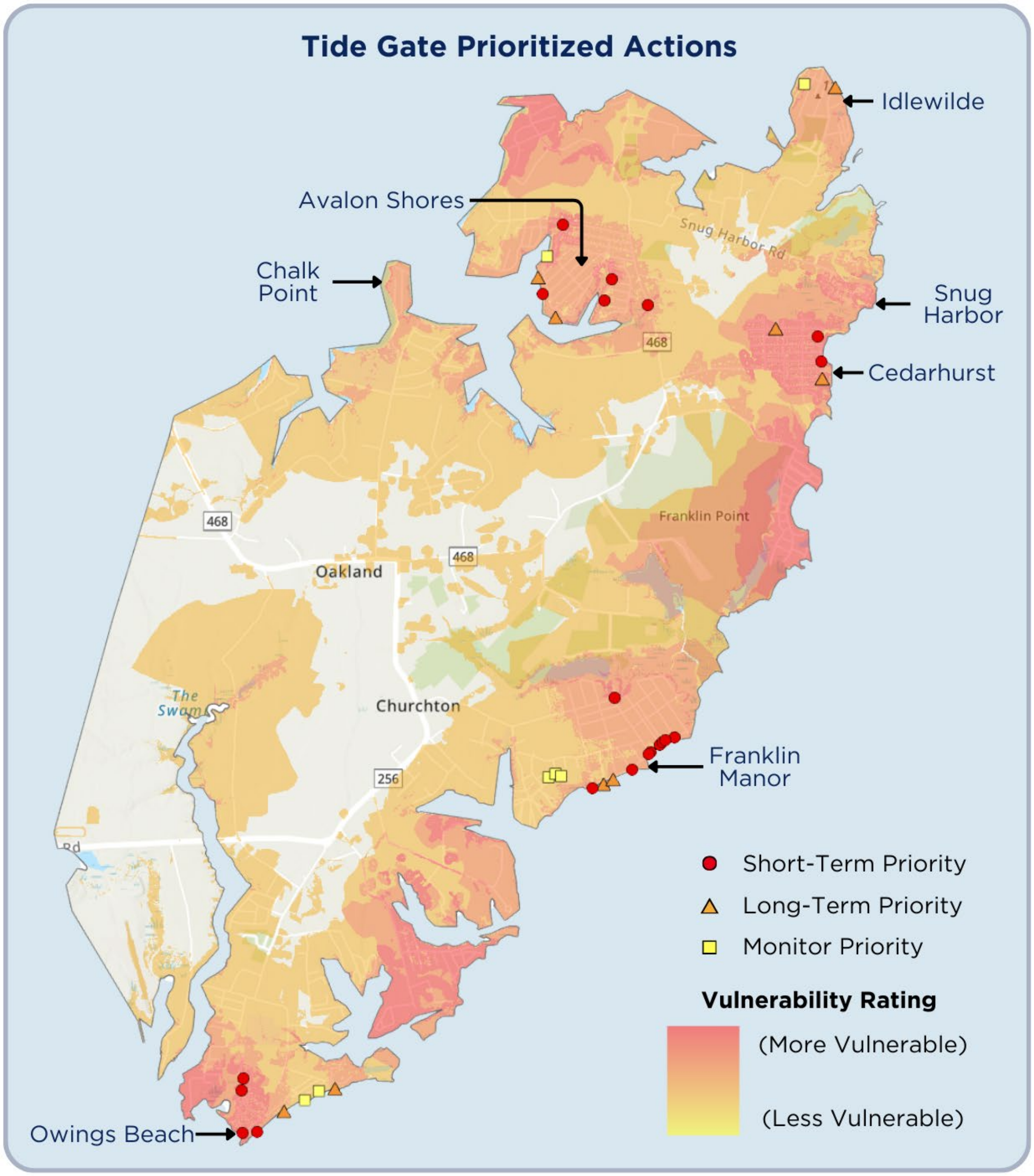


Figure 87 – Prioritized Tide Gate Installation Locations Overlain with Vulnerability Rating

Short-term actions include installing tide gates at the highest-priority outfalls where chronic tidal backflow is already a problem and contributing to neighborhood flooding. Efforts should focus on densely developed communities with limited natural drainage alternatives, particularly where residents report regular stormwater backup issues. Long-term planning focuses on incorporating tide gates into stormwater systems expected to face increased vulnerability due to rising sea levels. Monitoring efforts will ensure that future designs for stormwater infrastructure integrate tide gate features to maintain system functionality under changing conditions.

Residents who experience recurring street flooding from high tides should be encouraged to report problem areas to County representatives so that additional outfalls can be evaluated for potential backflow prevention. Additionally, long-term monitoring of installed tide gates will be necessary to ensure continued functionality as rising sea levels alter drainage conditions.

This tiered approach to improvements ensures that critical infrastructure is protected in the near term, while long-term resilience planning accounts for evolving flood risks. By incorporating modeled stormwater impacts and community-reported problem areas, tide gate installations can be prioritized effectively, ensuring that stormwater infrastructure continues functioning under increasing tidal pressures.

Priority	Table 27 – Tide Gate Prioritized Actions* Priority Area
Short-Term (0 – 10 years)	Avalon Shores - Lerch Drive & Steamboat Road
	Avalon Shores - Bonniewood Drive & Butternut Street
	Avalon Shores - Bonniewood Drive (Pine Street & Holly Street)
	Avalon Shores - Lerch Drive & Chestnut Street
	Cedarhurst - Chesapeake Avenue & Spruce Avenue
	Franklin Manor - Chesapeake Drive & Carvel Street
	Franklin Manor - Chesapeake Drive & Dover Street
	Franklin Manor - Chesapeake Drive & Exeter Street
	Franklin Manor - Chesapeake Drive & Franklin Boulevard
	Franklin Manor - Chesapeake Drive & Franklin Boulevard
	Franklin Manor - Chesapeake Drive & Gloucester Street
	Franklin Manor - Gwynne Avenue & Exeter Street
	Owings Beach - Melbourne Avenue
	Owings Beach - Melbourne Avenue & Irvin Avenue)
	Owings Beach - Owings Beach Road
	Owings Beach - Owings Beach Road
	Shady Side - West Shady Side Road
Long-Term (10 -20 years)	Avalon Shores - Lerch Drive & Aspen Street
	Avalon Shores - Lerch Drive & Filbert Street
	Cedarhurst - Chesapeake Avenue & Maple Avenue
	Cedarhurst - Pine Avenue
	Franklin Manor - Chesapeake Drive & Carroll Street
	Franklin Manor - Chesapeake Drive & Dartmouth Street
	Idlewilde - Winters Avenue & Idlewilde Road
	Masons Beach - Mason Avenue
	Owings Beach - Melbourne Avenue (between Clark Avenue & Frazier Avenue)
Monitor	Avalon Shores - Lerch Drive & Oak Street
	Cape Anne - Bay Breeze Court
	Cape Anne - Bimini Court
	Cape Anne - Sailfish Court
	Idlewilde - Chesapeake Avenue
	Masons Beach - 1st Avenue (between Frazier Avenue & Mason Avenue)
	Owings Beach - Melbourne Avenue & Frazier Avenue

* Tide gate locations within their respective short- and long-term priority groups are listed in alphabetical order and not priority rank.

8.3. Stormwater Conveyance

Over time, the Peninsula's stormwater infrastructure has evolved through incremental additions, creating a network of drainage systems that vary in capacity and effectiveness in managing runoff. Many neighborhoods rely on driveway culverts and roadside swales, which, in their current condition, lack the necessary capacity to handle future stormwater volumes and considerations for tidal flooding. The vulnerability analysis identified key areas where outdated or undersized stormwater infrastructure contributes to frequent flooding, as well as locations where pooling occurs due to inadequate conveyance routes.

A long-term, large-scale approach is needed to incrementally create a more cohesive and efficient stormwater system, ensuring that drainage improvements are not just reactive but integrated into a Peninsula-wide strategy (Figure 88 and Table 28). In the short term, efforts should focus on upgrading and maintaining existing stormwater

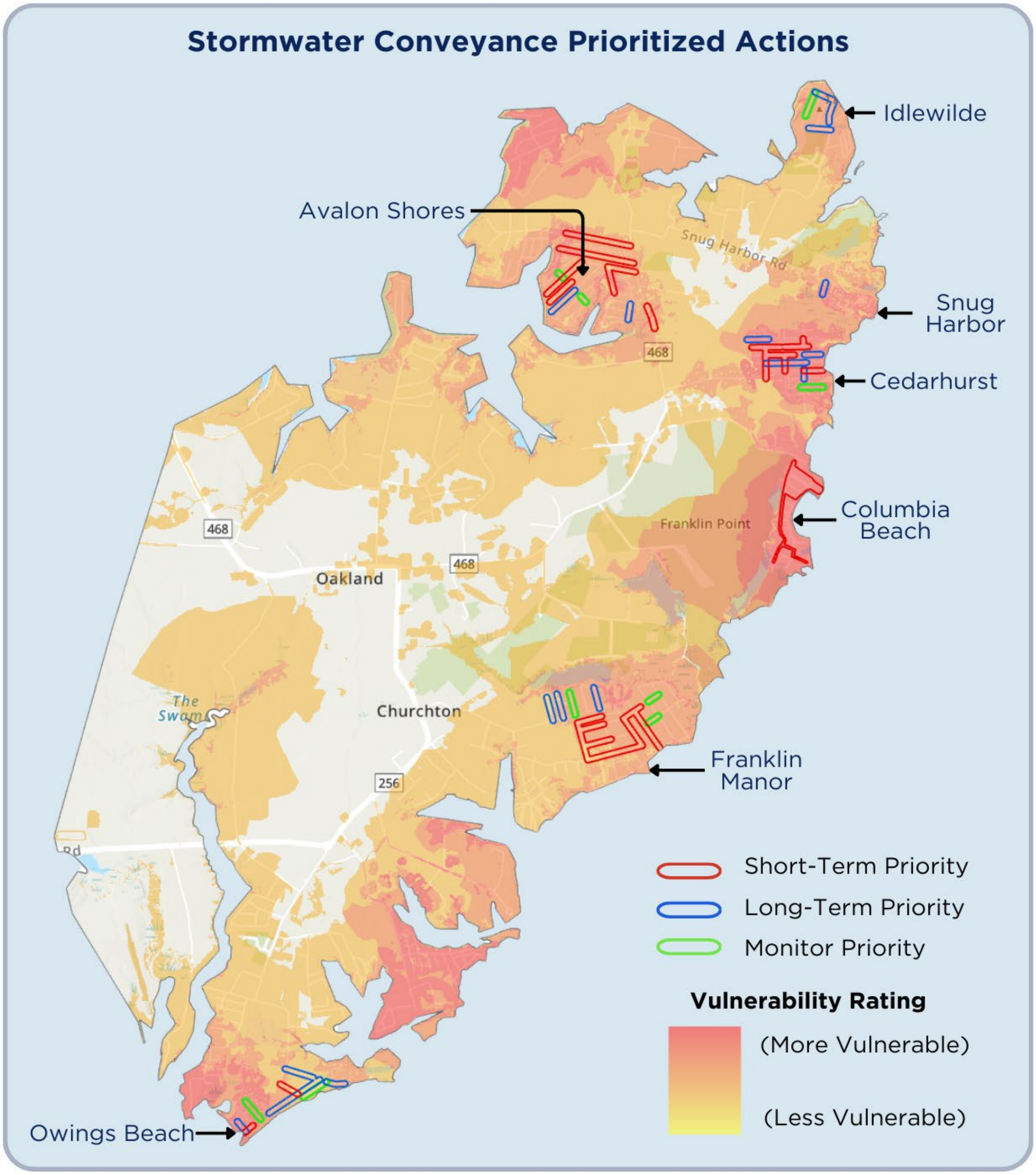


Figure 88 – Prioritized Stormwater Improvements Overlain with Vulnerability Ratings

infrastructure to provide immediate improvements while laying the groundwork for more comprehensive, long-term solutions. This includes clearing, resizing, and realigning driveway culverts and swales, particularly in areas prone to pooling and backwatering. Additionally, a structured maintenance program should be developed to ensure these systems function effectively over time, addressing recurring challenges such as sedimentation, overgrowth, and blockages.

Planning and coordination for larger-scale, long-term stormwater system enhancements should happen in tandem with these foundational improvements. Future strategies focus on phased upgrades that improve connectivity between existing drainage networks and integrated regional stormwater solutions. Continuous monitoring and adaptive management will be key to refining strategies over time, ensuring that stormwater infrastructure evolves to meet the Peninsula's changing environmental conditions and future climate impacts.

Table 28 – Stormwater Conveyance Prioritized Actions*

Priority	Priority Area	Actions	Linear Feet (LF)
Short-Term (0 – 10 years)	Avalon Boulevard (between Washington Circle & Shady Side Road)	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	820
	Beech Street (between Lerch Drive & Avalon Boulevard)	Swale re-establishment, Culvert repair and up-sizing	1,370
	Bonniewood Drive (between Washington Circle & Holly Street)	Swale re-establishment, Culvert repair and up-sizing	700
	Carvel Street (between Garret Avenue & Delaware Avenue)	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	1,100
	Chestnut Street (between Lerch Drive & Oak Street)	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	900
	Columbia Beach	Swale re-establishment, Culvert repair and up-sizing	6,000
	Delaware Avenue (between Carvel Street & Exeter Street)	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	1,600
	Ellicott Avenue (between Carvel Street & Dartmouth Street)	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	830
	Exeter Street (between Fairfax Avenue & Delaware Avenue)	Swale re-establishment, Culvert repair and up-sizing	980
	Fairfax Avenue (between Carvel Street & Dartmouth Street)	Swale re-establishment, Culvert repair and up-sizing	730
	Fairfax Avenue (between Exeter Street & Franklin Boulevard)	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	630
	Franklin Boulevard (between Fairfax Avenue & Chesapeake Drive)	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	1,350

Table 28 – Stormwater Conveyance Prioritized Actions*			
Priority	**Priority Area**	**Actions**	**Linear Feet (LF)**
	Frazier Avenue (between Masons Beach Road & Allwine Avenue)	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	610
	Garret Avenue (between Carvel Street & Dartmouth Street)	Swale re-establishment, Culvert repair and up-sizing	740
	Hawthorne Street (between Lerch Drive & Shady Side Road)	Swale re-establishment, Culvert repair and up-sizing	2,160
	Holly Avenue (between Lake Avenue & Park Avenue)	Swale re-establishment, Culvert repair and up-sizing	840
	Lake Avenue (between Spruce Avenue & Cedarhurst Road)	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	930
	Melbourne Avenue (Between Irvin Avenue & E Marshall Avenue)	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	360
	Oak Avenue (between Park Avenue & Chesapeake Avenue)	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	560
	Park Avenue (between Pine Avenue & Spruce Avenue)	Swale re-establishment, Culvert repair and up-sizing	250
	Shady Side Road (between Shady Rest Road & West River Road)	Swale re-establishment, Culvert repair and up-sizing	450
	Spring Avenue (between Holly Avenue & Oak Avenue)	Swale re-establishment, Culvert repair and up-sizing	470
	Spruce Avenue (between Spring Avenue & Park Avenue)	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	700
	Spruce Avenue west of Spring Avenue	Swale re-establishment, Culvert repair and up-sizing	850
	Steamboat Road (between Lerch Drive & Shady Side Road)	Swale re-establishment, Culvert repair and up-sizing	1,880
	Guidance on Program to Improve Peninsula-wide Stormwater Conveyance	-	-
		Sub Total for Short-Term Priority Areas:	**27,810**
Long-Term (10 – 20 years)	Baskin Street north of Gwynne Avenue	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	730
	Berkley Manor Lane north of Gwynne Avenue	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	730
	Dartmouth Street (between Cove Drive & Gwynne Avenue)	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	660
	Dogwood Street (between Lerch Drive & Oak Street)	Swale re-establishment, Culvert repair and up-sizing	940

Table 28 – Stormwater Conveyance Prioritized Actions*			
Priority	**Priority Area**	**Actions**	**Linear Feet (LF)**
	Grove Avenue (between Lake Avenue & Park Avenue)	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	1,180
	Holly Avenue (between Park Avenue & Chesapeake Avenue)	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	500
	Idlewilde Road (between Winters Avenue & Bayview Road)	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	690
	Irvin Avenue (between Welch Avenue & Melbourne Avenue)	Swale re-establishment, Culvert repair and up-sizing	410
	Jordan Drive (between Spruce Street & Azalia Street)	Swale re-establishment, Culvert repair and up-sizing	500
	Mason Avenue (between Masons Beach Road & Allwine Avenue)	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	860
	Mason Avenue east of 1st Street	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	570
	Melbourne Avenue (between Clark Avenue & Mason Avenue)	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	1,860
	Neale Avenue	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	670
	Park Ave (between Pine Ave and Spruce Ave)	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	260
	Park Avenue (between Oak Avenue & Bay View Avenue)	Swale re-establishment, Culvert repair and up-sizing	330
	Pine Ave west of Lake Ave	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	650
	W End Avenue (between Lake Avenue & Snug Harbor Road)	Swale re-establishment, Culvert repair and up-sizing	430
	Winters Avenue (between Frederick Avenue & Idlewilde Road)	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	630
		Sub Total for Long-Term Priority Areas:	**12,600**
Monitor	1st Avenue (between Frazier Avenue & Mason Avenue)	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	780
	Carvel Street north of Gwynne Avenue	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	660

Table 28 – Stormwater Conveyance Prioritized Actions*			
Priority	**Priority Area**	**Actions**	**Linear Feet (LF)**
	Charles Avenue (between Knopp Avenue & Melbourne Avenue)	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	700
	Ellicott Avenue (between Franklin Boulevard & Gloucester Street)	Swale re-establishment, Culvert repair and up-sizing	360
	Fairfax Avenue (between Gloucester & Harford Street)	Swale re-establishment, Culvert repair and up-sizing	360
	Frederick Avenue south of Winters Avenue	Swale re-establishment, Culvert repair and up-sizing	750
	Maple Avenue (between Park Avenue & Chesapeake Avenue)	Swale re-establishment, Culvert repair and up-sizing, Storm Drain system up-sizing	530
	Oak Street (between Aspen Street & Beech Street)	Swale re-establishment, Culvert repair and up-sizing	240
	Oak Street (between Elm Street and Lerch Drive)	Swale re-establishment, Culvert repair and up-sizing	240
		Sub Total for Monitor Priority Areas:	**4,620**

* Stormwater conveyance prioritized locations within their respective short- and long-term priority groups are listed in alphabetical order and not priority rank.

8.4. Land Acquisition

While land acquisition offers clear flood mitigation and ecological benefits, implementation requires sustained community engagement, transparent policy development, and long-term stewardship planning. Acquisitions would be pursued only on a voluntary, willing-seller basis and contingent upon the availability of dedicated funding. Inclusion of a property acquisition concept in this plan does not indicate an active County effort to acquire any specific parcel at this time.

Short-Term Actions:

- Community Engagement and Willing Seller Outreach: Begin conversations with homeowners in high-risk areas to understand interest in voluntary buyout programs.
- Establish Screening Criteria: Define parcel screening criteria based on vulnerability (e.g., depth of flooding, frequency, repetitive loss), ecological value, and potential for conversion to natural buffers.
- Identify Funding Pathways: Evaluate grant programs (e.g., FEMA's Hazard Mitigation Grant Program or Flood Mitigation Assistance (FMA), state flood mitigation programs, and begin pursuing seed funding to support early acquisitions.

Long-Term Actions:

- Develop a Land Acquisition and Conversion Plan: This plan should prioritize areas for acquisition, describe intended uses for acquired parcels (e.g., green infrastructure, marsh restoration), and outline roles and responsibilities for long-term site management.
- Integrate with County Land Use Policy: Establish overlay districts or zoning provisions that discourage redevelopment in flood-prone areas and direct future growth away from high-risk zones.
- Coordinate with Habitat and Restoration Plans: Ensure acquired land supports ongoing marsh migration and habitat connectivity goals and explore partnerships with conservation organizations to support stewardship.
- Monitor and Reassess: Implement a system to revisit land acquisition priorities periodically as flood risk evolves with sea level rise and infrastructure changes.

By treating land acquisition as both a near-term opportunity and a long-term planning tool, AACo can reduce future exposure while simultaneously creating space for nature-based resilience solutions.

8.5. Home Raising

While flood mitigation strategies such as road raising, tide gates, and stormwater conveyance improvements can significantly reduce risk, they cannot eliminate all flooding risks across the Peninsula. As sea levels rise, some residents will need to adapt to living with flooding rather than relying solely on large-scale structural and nature-based interventions to prevent flooding. Home raising provides a parcel-scale resilience measure that enables property owners to remain in their homes while reducing flood damage and improving safety.

Figure 89 illustrates the growing flood risk over time, highlighting buildings projected to be inundated under the 2050, 2065, and 2100 SLR scenarios.

Avalon Shores faces chronic “sunny day” flooding along the private bulkheaded shoreline along West River, where adaptation will be necessary for long-term habitability. In Columbia Beach, homes along Flag Pond sit within low-lying wetland areas, making it impractical to prevent all flooding. Instead, elevating structures is the most viable strategy to manage future flood exposure.

As with other resiliency themes presented in this Implementation Plan, home raising should be integrated into a broader, multi-layered resilience approach. It is most effective when combined with community-wide measures to ensure elevated homes remain accessible and functional. However, this strategy’s feasibility depends on cost, structural conditions, and homeowner willingness to participate in future programs.
By proactively identifying flood-prone buildings and establishing clear guidance on home-raising options, the County and its partners can help property owners make informed decisions about their long-term flood resilience. While some residents may be

able to rely on protective infrastructure for the foreseeable future, others will need to adapt their homes and daily lives to an increasingly dynamic floodplain.

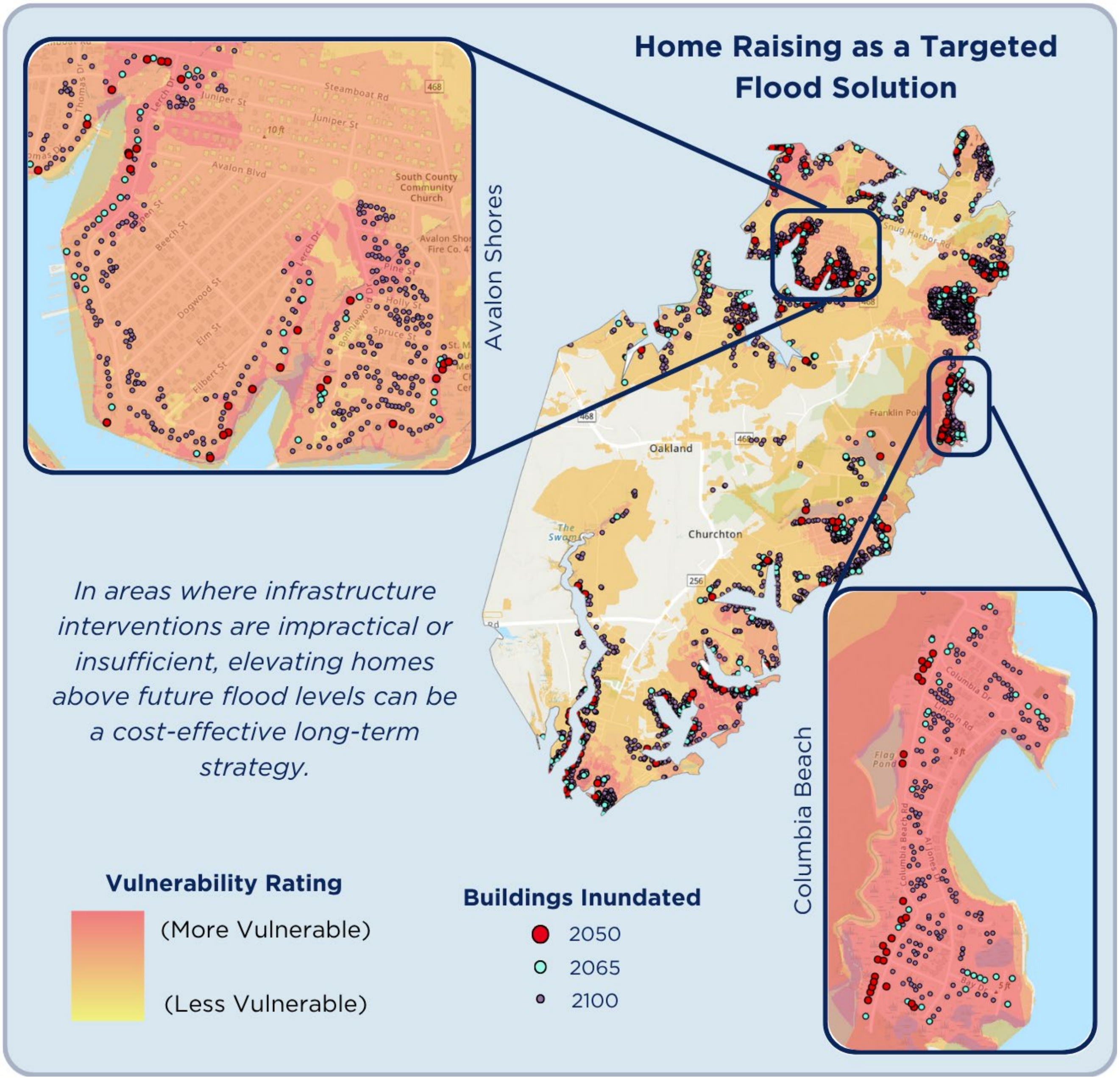


Figure 89 – Buildings Inundated by Each SLR Scenario Overlain with Vulnerability Ratings

8.6. Conclusion

The Deale-Shady Side Peninsula experiences multi-faceted flood risks, including tidal inundation, storm surge, and heavy rainfall. In many locations, these hazards interact to create compound flooding, where multiple flood mechanisms amplify overall impacts. This is particularly problematic in low-lying neighborhoods where stormwater drainage systems are already strained by rising tides. As sea levels continue to rise, floodwaters will expand further inland, increasing the frequency and severity of these challenges.

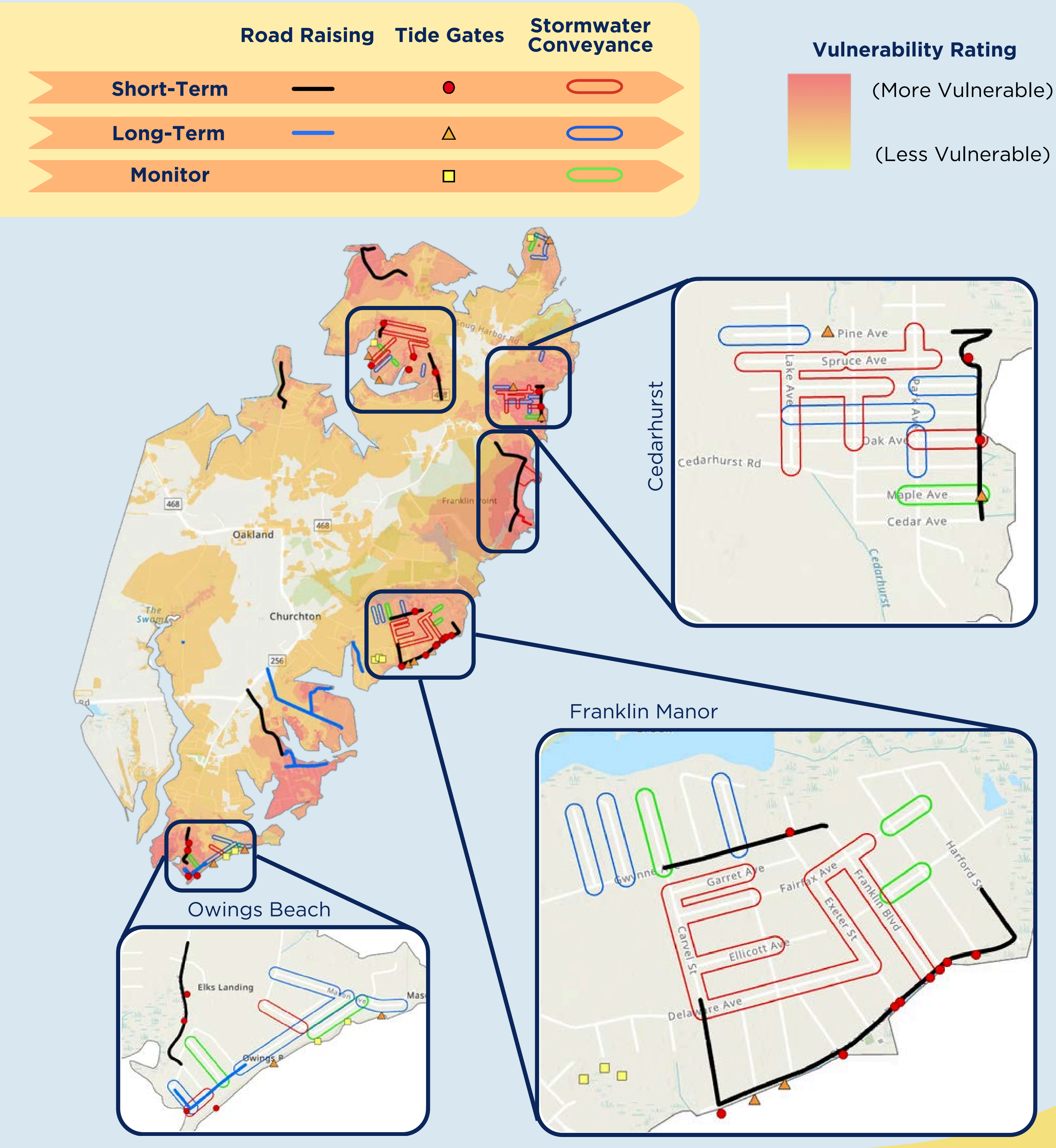
Addressing these risks will require a long-term, adaptive approach that enables communities to incrementally adjust to rising water levels while maintaining livability and accessibility. Rather than relying on a single intervention, a phased strategy will allow for targeted infrastructure improvements that evolve alongside changing flood conditions. This includes prioritizing immediate actions in the most at-risk areas while also planning for future adaptations that will be necessary as the floodplain expands further inland.

When the road raising, tide gates, and stormwater drainage improvements flood mitigation strategies are overlaid on the weighted vulnerability analysis, clear patterns emerge. The most densely developed neighborhoods exhibit significant overlap in required interventions, demonstrating the need for multi-layered solutions in these high-risk areas.

This does not serve as a commitment from the County to fully fund, execute, and maintain all proposed improvements independently. Instead, it provides a framework that identifies where interventions will be most impactful, allowing for informed decision-making and strategic investment. Successful implementation will require shared responsibility between government entities, private landowners, and community organizations to develop cost-effective, feasible solutions that can be phased over time.

Integrated Flood Mitigation Strategies:
Targeting High-Risk Areas

Road raising, tide gates, and stormwater conveyance improvements working together to enhance flood resilience. Locations where these interventions overlap indicate areas facing compound flooding risks that require a coordinated response.



9 PROJECT CONCEPTS

1. West Shady Side Road Raising & SWM Improvements
2. Columbia Beach Road Raising & SWM Improvements
3. Cedarhurst/ Snug Harbor Resiliency Project
4. Franklin Manor Resiliency Project
5. **O**ngoing **R**esilience **I**mprovement **F**und
6. Owings Beach Flood Mitigation
7. Chalk Point Road Raising & Shoreline Protection
8. Avalon Shores Road Raising & Compound Flood Improvements
9. Home Raising Assistance Program

9. PROJECT CONCEPTS

The following section presents a series of targeted project concepts designed to mitigate flood risks and enhance community resilience on the Deale-Shady Side Peninsula. These concepts were developed using a prioritization framework, integrating vulnerability analysis results, stakeholder input, and feasibility considerations. Each project is intended to address specific flood challenges whether through infrastructure improvements, policy interventions, or natural systems enhancement. While many project concepts propose upgrades to traditional (grey) stormwater infrastructure, such as pipes and culverts, these components may be substituted with green infrastructure or BMPs where feasible, based on site-specific conditions and community priorities.

Project concepts were formulated by integrating:

MODELED VULNERABILITIES

Identifying areas subject to stormwater flooding, tidal inundation, and storm surge impacts.

IMPLEMENTATION FEASIBILITY

Assessing project complexity, permitting needs, funding opportunities, and constructability.

COMMUNITY NEEDS & PRIORITIES

Ensuring proposed actions align with local concerns, economic considerations, and practical implementation strategies

ENVIRONMENTAL & SOCIAL BENEFITS

Incorporating nature-based solutions and equitable resilience strategies.

Concepts were assessed based on their ability to address critical flood risks, implementation feasibility, and long-term sustainability using the following key criteria:

Table 29 – Implementation Considerations Scoring Criteria

Criteria	1	2	3
Feasibility	Project requires extensive permitting, coordination, or funding challenges.	Some challenges exist, but phased implementation is feasible.	Straightforward implementation with minimal permitting barriers.
Effectiveness	Provides localized benefits but does not significantly contribute to long-term resilience.	Moderately reduces flood risk but may require additional measures for long-term effectiveness	Significantly improves flood resilience and reduces long-term risks.
Environmental Considerations	Significant environmental considerations; project is located in sensitive areas and faces significant environmental barriers.	Some environmental challenges; requires moderate permitting and impact mitigation.	Low environmental impact or provides ecosystem benefits such as wetland restoration.
Access Impacts	No significant impact on road access or emergency routes.	Improves access on minor roads or alternate routes.	Enhances transportation network or emergency access at critical locations.

Table 29 – Implementation Considerations Scoring Criteria			
Criteria	**1**	**2**	**3**
Social Benefits	Limited direct social benefits; project supports general resilience but does not target vulnerable populations.	Moderate benefits; improves conditions for some community members but not broadly transformative.	Significant benefits; improves public safety, reduces displacement risk, and enhances equity for vulnerable populations.
Urgency	Future risk exists but does not require immediate action; could be addressed in later phases.	Medium-term priority; action needed within the next planning cycle to prevent worsening risks.	Immediate need; delaying action will significantly increase flood risks or economic losses.

Figure 90 – Project Cost Ranges

Projects were also assessed on estimated implementation costs and categorized into cost range categories. The presented cost estimates provide a planning-level perspective on the investment required for flood mitigation and resilience-building efforts across the Deale-Shady Side Peninsula. While some projects require relatively low investments (such as community-based incentive programs or small-scale stormwater improvements), others involve significant infrastructure enhancements that may require multiple funding sources, partnerships, and phased implementation.

The ranges defined above offer a framework for prioritization, allowing decision-makers to weigh feasibility, effectiveness, and long-term resilience benefits against financial constraints. Lower-cost projects tend to focus on non-structural interventions, education, and small-scall drainage improvements, while higher-cost projects involve significant capital investments in infrastructure and flood protection measures.

The categorization also reflects the likelihood that certain projects may be phased over time, with incremental funding supporting progressive implementation. Additionally, funding mechanisms such as federal/state grants, cost-sharing agreements, and local investments will play a key role in determining how and when these projects are executed.

The following project concepts illustrate how these adaptation strategies will be implemented across the Deale-Shady Side Peninsula. The next section presents each project concept in detail, including estimated costs, expected benefits, and key implementation considerations. Each project concept is presented in a standardized format to ensure clarity and ease of comparison.

Figure 91 visually outlines information included in each pamphlet. This structured format ensures that projects can be compared systemically based on their expected benefits, feasibility, and cost. Projects were ranked based on their criteria totals; however, implementation order is highly dependent on factors beyond prioritization scores, including funding availability, partnership opportunities, and construction timelines. While the rankings reflect comparative benefits and feasibility, the actual sequence of implementation will be shaped by when resources become available and how quickly projects can be advanced through design and permitting.

It is also important to note that while individual project timelines may be reasonable in isolation, implementing multiple large-scale efforts will require coordination beyond existing County capacity. To achieve concurrent progress, strategic partnerships and resource sharing among County agencies, the Resilience Authority, state and federal funding agencies, and community stakeholders will be essential. This plan is intended not only to identify priority projects but also to serve as a roadmap for aligning implementation capacity and funding to accelerate resilience building across the Peninsula.

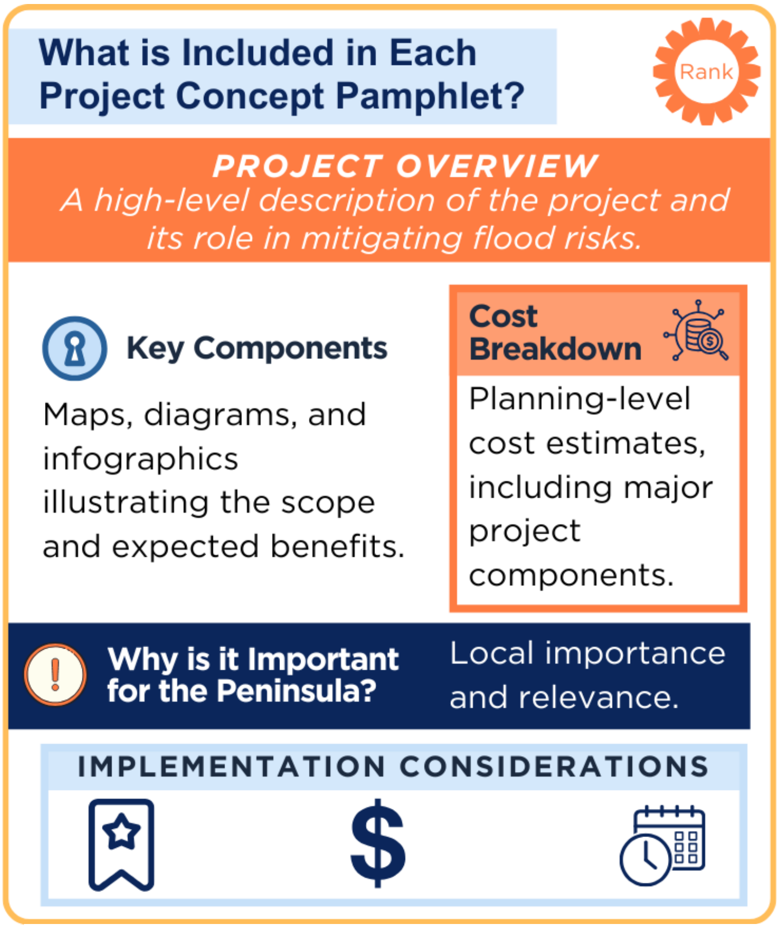


Figure 91 – Summary of Project Concept Components

West Shady Side Road Raising & SWM Improvements

1

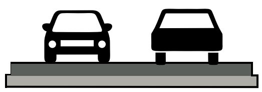
IDENTIFY CRITICAL ACCESS ROUTES AND IMPROVE RESILIENCE TO FLOODING.

Key Components

1 TIDE VALVE INSTALLATION

Installing 21" Wapro Inline Check Valve on culverts crossing West Shady Side Road to prevent backflow of tidal waters from South Creek during high tide events.

2 ROAD RAISING



Elevating approximately 830 LF of West Shady Side Road by ±2 feet to 5.25 feet NAVD88 to ensure access during a Hurricane Isabel-like event.

3 DRAINAGE SYSTEM & SWALE IMPROVEMENTS

Addressing localized flooding through improved stormwater management systems to mitigate adverse effects on nearby properties. Installing 30 LF of watertight box culvert under roadway. Enhancing 650 LF of roadside drainage swales to improve water conveyance and reduce pooling.

Why Is It Important for the Peninsula?

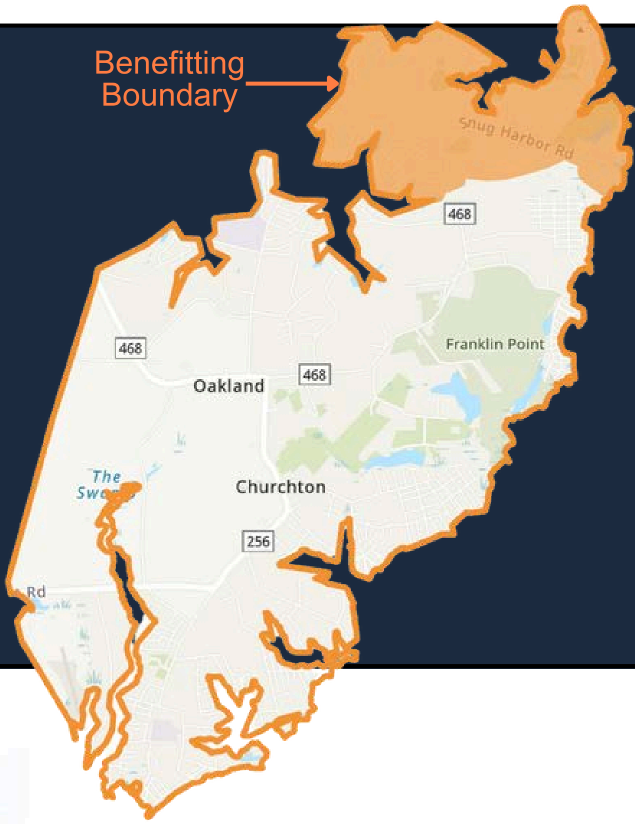
West Shady Side Road is the sole access route for northern communities on the Deale-Shady Side Peninsula. Frequent flooding disrupts safe access for residents and emergency services, impacting the entire Peninsula. This project ensures reliable connectivity, addressing a critical vulnerability that affects regional safety and resilience.

West Shady Side Road Raising & SWM Improvements

1

Benefitting Area

Buildings	Parcels	of Peninsula
2,878	3,308	Buildings: 25%
		Parcels: 34%



COST BREAKDOWN

Description	Capital Cost
Roadway Raising	$332,250
Watertight Box Culvert	$156,000
Furnish & Install 21" Inline Check Valve	$35,000
Swale Improvements/Re-establishment	$5,000
Subtotal	$528,250
20% Contingency	$105,650
Design & Permitting	$130,000
Total Cost	$763,900

IMPLEMENTATION CONSIDERATIONS

FEASIBILITY	●●●	ACCESS IMPACTS	●●●
EFECTIVENESS	●●●	SOCIAL BENEFITS	●●●
ENVIRONMENTAL	●●○	URGENCY	●●●

CRITERIA TOTAL

17 /18

**$**$$

$250K - $1M

<3 years

3 - 6 years

> 6 years

Columbia Beach Road Raising & SWM Improvements

A COMPREHENSIVE FLOOD MITIGATION APPROACH THAT INTEGRATES STORMWATER MANAGEMENT, NATURE-BASED SOLUTIONS, AND ROAD ELEVATION TO ENSURE LONG-TERM RESILIENCE.

Key Components

1 ROAD RAISING

The project proposes raising 5,600 LF of Columbia Beach Road, the primary access route, by ±2 feet to ensure accessibility during high tides and storm events. With roadway crown elevations of only 3-4 feet NAVD88, this route is frequently impassable due to nuisance flooding. Elevation to +6 feet NAVD88 will help maintain emergency ingress and egress while reducing chronic flood-related road degradation.

2 DRAINAGE SYSTEM & SWALE IMPROVEMENTS

Stormwater management improvements are funded through the National Fish and Wildlife Foundation (NFWF) Chesapeake Small Watershed Grant, ensuring cost-effective implementation while enhancing flood resilience and water quality in the community.

Columbia Beach's existing stormwater system is undersized and deteriorating, leading to ponding, sedimentation, and system failures that exacerbate flood risks. Improvements include:

Submerged gravel wetlands to enhance water storage and infiltration, particularly suited to the area's high water table and poorly drained soils.

Expanded vegetated swales to improve stormwater conveyance, filter pollutants, and mitigate standing water.

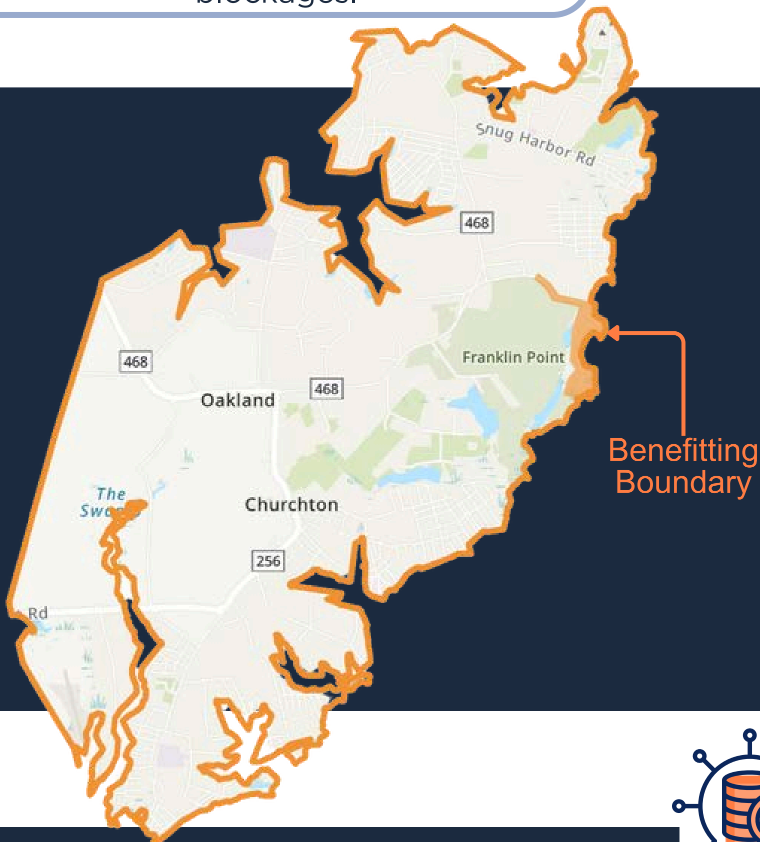
Restoration of tidal pond outfall to prevent backwater flooding and improve discharge into the Bay.

Columbia Beach Road Raising & SWM Improvements

2

Bubbler outfall system to control sedimentation and prevent conveyance blockages.

Culvert rehabilitation and sediment removal to restore system capacity and improve overall drainage efficiency.



Benefitting Area

321 Buildings

689 Parcels

% of Peninsula

3%

7%

Why Is It Important for the Peninsula?

By coupling awarded grant funding for stormwater improvements with additional infrastructure support, this project maximizes funding efficiency while protecting a vulnerable coastal community that serves as an example for equitable climate resilience efforts across the region.

COST BREAKDOWN

Description	Capital Cost
Stormwater Conveyance*	$1,350,000
Roadway Raising	$1,875,000
Subtotal	$1,875,000
20% Contingency	$375,000
Design & Permitting	$450,000
Total Cost	$2,700,000

* Design and implementation of proposed improvements funded by NFWF - Chesapeake Small Watershed Grant

IMPLEMENTATION CONSIDERATIONS

FEASIBILITY	●●●
EFECTIVENESS	●●○
ENVIRONMENTAL	●●○
ACCESS IMPACTS	●●●
SOCIAL BENEFITS	●●●
URGENCY	●●●

CRITERIA TOTAL

16 /18

$$$

$1M - $5M

<3 years

3 - 6 years

> 6 years

Cedarhurst/Snug Harbor Resiliency Project

3

INTEGRATE ROAD RAISING, BERM CONSTRUCTION, TIDE GATES, STORMWATER IMPROVEMENTS, AND WETLAND MANAGEMENT TO MITIGATE FLOODING, PROTECT NATURAL HABITAT, & ENHANCE COMMUNITY RESILIENCE.

Key Components

1 ROAD RAISING

Raise 1,420 LF of Chesapeake Avenue by ± 2.5 feet to create a flood barrier to +6 feet NAVD88. This elevated roadway also facilitates safe access during high water levels in 2065 and ties into the proposed berm along the wetland area.

2 BERM

Construct 2,850 LF of rockfill berm along the shoreline of the wetland area, forming a continuous barrier to +6 feet NAVD88 from the raised Chesapeake Avenue to higher ground at West End Avenue in Snug Harbor. This structure helps prevent flooding from the Bay and directs water through controlled pathways.

3 SELF-REGULATING SURGE BARRIER

Installed along the bay-facing berm, this surge barrier allows water exchange during regular tidal cycles while preventing tidal flooding during high water events. The self-regulating design supports the health of the wetland ecosystem by controlling inundation levels.

4 CONTROLLED FLOODING AREA

The project establishes a controlled flooding area within the existing wetland system. The rockfill berm along the wetland's shoreline, combined with the elevation of adjacent roadways, forms a physical defense against tidal flooding while also guiding water through designated pathways. A self-regulating tide gate allows natural tidal exchange but restricts inflow during elevated water levels.

5 TIDE VALVE INSTALLATION

Three 15" Inline check valves can be installed within Cedarhurst's stormwater system to prevent backflow from tidal waters during elevated water levels.

6 DRAINAGE SYSTEM & SWALE IMPROVEMENTS

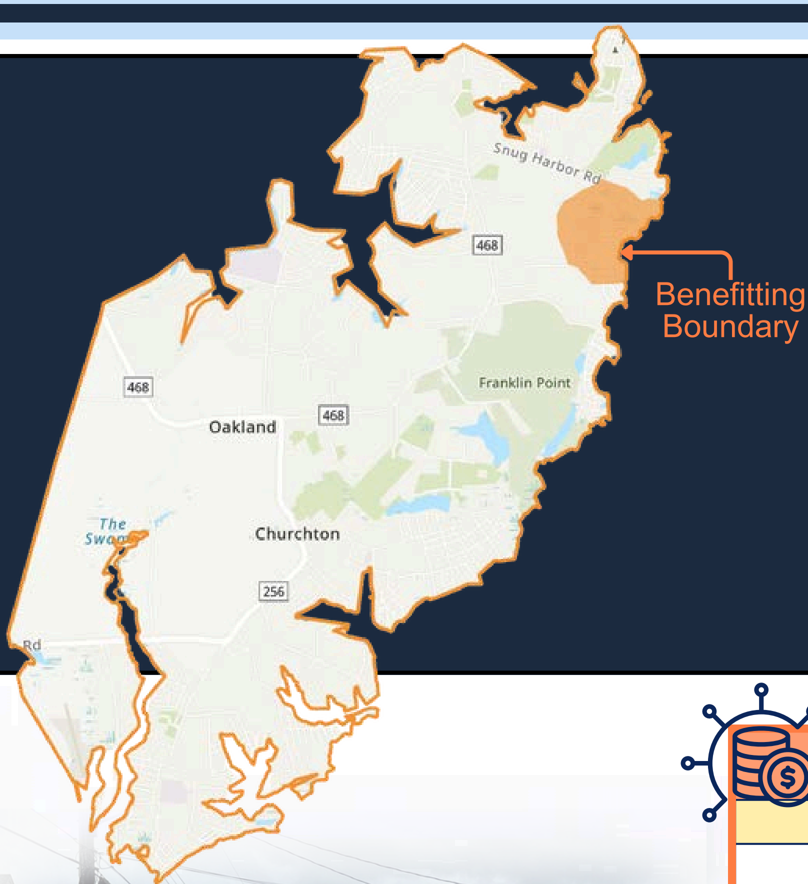
Localized stormwater conveyance and storage improvements throughout Cedarhurst will address drainage challenges and enhance capacity during flood events. These upgrades include improvements or reestablishment of 850 LF of swales, upgrading 800 LF of storm drains, and replacing and upsizing almost 1,800 LF of driveway and roadway culverts.

! Why Is It Important for the Peninsula?

This large-scale compound flood mitigation project addresses multi-faceted flood challenges faced by one of the most vulnerable and densely populated areas on the Deale-Shady Side Peninsula. By integrating solutions for tidal, storm surge, and rainfall-induced flooding, the project provides robust protection for a significant number of residential properties while maximizing ecological benefits through wetland preservation and controlled flooding measures. Projects like this serve as scalable models for similar flood-prone areas, offering valuable insights that can be applied across the Peninsula, Anne Arundel County, and the Chesapeake Bay watershed, reinforcing resilience on a regional scale.

Cedarhurst/Snug Harbor Resiliency Project

3



Benefitting Area

933 Buildings

962 Parcels

% of Peninsula
8%
10%

COST BREAKDOWN

Description	Capital Cost
Roadway Raising	$482,800
Rockfill Berm	$3,536,480
Drainage Improvements Incidental to Berm*	$1,900,000
Waterman Valve Self-Regulating Tide Gate	$2,000,000
Furnish & Install 15" Inline Check Valve	$78,000
Swale Improvements/Re-establishment	$6,720
Storm Drain Upgrades	$135,000
Culvert Upgrades	$92,000
Subtotal	$8,231,000
20% Contingency	$1,646,200
Design & Permitting	$1,975,000
Total Cost	$11,852,200

* Includes a planning-level allowance for drainage improvements incidental to berm construction to manage stormwater effects of the proposed berm.

IMPLEMENTATION CONSIDERATIONS

FEASIBILITY	●○○	ACCESS IMPACTS	●●○
EFECTIVENESS	●●●	SOCIAL BENEFITS	●●●
ENVIRONMENTAL	●●●	URGENCY	●●●

CRITERIA TOTAL

15 /18

$$$

> $5M

<3 years

3 - 6 years

> 6 years

Franklin Manor Resiliency Project

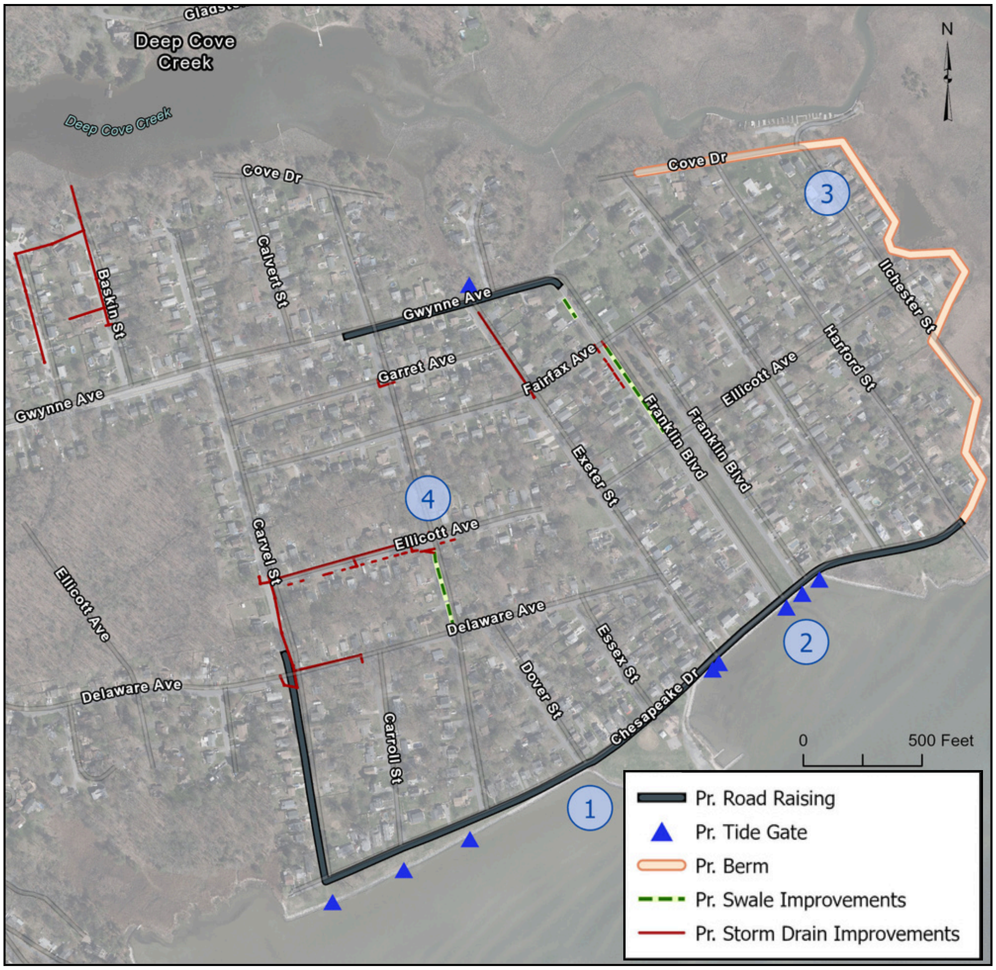
4

LONG-TIME FLOOD RESILIENCE FOR HOMES, INFRASTRUCTURE, & EMERGENCY ACCESS IN ONE OF THE PENINSULA'S MOST DENSELY DEVELOPED COMMUNITIES.

Key Components

1 ROAD RAISING

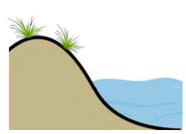
Elevate 4,000 LF of Chesapeake Drive and 930 LF of Gwynne Avenue by ±1.5 feet to maintain safe and reliable access during flood events. The raised roads will also serve as barriers to tidal flooding less than +6 feet NAVD88, directing water away from vulnerable properties and into controlled drainage pathways. Road raising includes grading to ensure proper tie-ins with surrounding infrastructure and minimizing disruption to nearby properties.



2 TIDE VALVE INSTALLATION

Install nine 18″ inline check-valves on tidal outfalls along Chesapeake Drive and Deep Cove Creek to prevent backflow into the stormwater system.

3 BERM



Construct approximately 3,000 LF of earthen berm along the edge of deep Creek marsh, creating a continuous flood barrier along the eastern edge of the neighborhood. The berm will tie into higher ground along Cove Drive (+6 feet NAVD88), minimizing flood pathways into residential areas.

Why Is It Important for the Peninsula?

Franklin Manor faces severe recurring compound flooding, threatening homes, roadways, and other infrastructure. This project integrates multiple flood mitigation measures ensuring long-term accessibility to on of the Peninsula's most densely populated communities.

4 DRAINAGE SYSTEM & SWALE IMPROVEMENTS

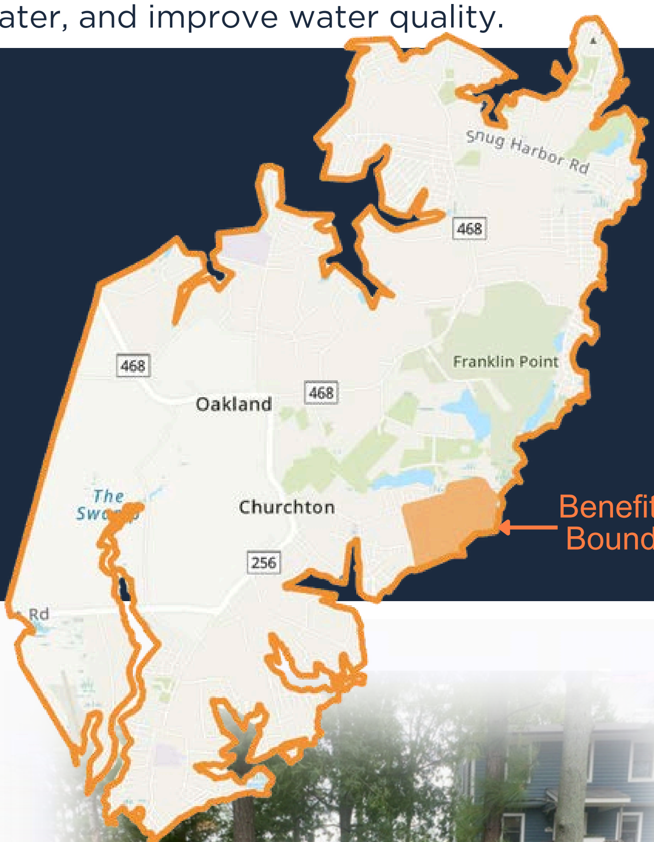
Address localized flooding challenges by upgrading 3,600 LF of storm drains, approximately 30 inlets, and 840 LF of swale improvements. Improvements include regrading swales to restore positive drainage and replacing damaged or undersized storm drains. Other elements like bioswales or rain gardens can also be used to enhance stormwater capacity, reduce standing water, and improve water quality.

Benefitting Area

933 Buildings

596 Parcels

% of Peninsula: 8% (buildings), 6% (parcels)



COST BREAKDOWN

Description	Capital Cost
Roadway Raising	$1,506,600
Earthen Berm	$3,261,500
Drainage Improvements Incidental to Berm*	$1,700,000
Furnish & Install 18" Inline Check Valve	$279,000
Swale Improvements/Re-establishment	$7,000
Storm Drain Upgrades	$580,000
Subtotal	$7,334,100
20% Contingency	$1,466,820
Design & Permitting	$1,760,000
Total Cost	$10,560,920

* Includes a planning-level allowance for drainage improvements incidental to berm construction to manage stormwater effects of the proposed berm.

IMPLEMENTATION CONSIDERATIONS

FEASIBILITY	●●○
EFECTIVENESS	●●●
ENVIRONMENTAL	●●○
ACCESS IMPACTS	●●○
SOCIAL BENEFITS	●●●
URGENCY	●●○

CRITERIA TOTAL **14** /18

$$$ (> $5M)

<3 years
3 - 6 years
> 6 years

Ongoing Resilience Improvement Fund

5

EMPOWERING THE DEALE-SHADY SIDE PENINSULA TO ADDRESS LOCALIZED FLOOD CHALLENGES.

The **Ongoing Resilience Improvement Fund (ORIF)** is a targeted financing mechanism designed to address smaller-scale, isolated flood issues. By prioritizing projects in less densely populated areas, the ORIF ensures that every community benefits from flood mitigation and resilience strategies, fostering equitable and comprehensive resilience throughout the Peninsula. The fund could be administered by the County, the Resilience Authority, or another managing organization, with staffing tailored to the selected structure.

Community

- Enhances flood resilience for isolated communities
- Quick response funding for immediate resilience needs
- Equitable resource allocation for low-density areas

Environmental

- Encourages green infrastructure solutions, such as rain gardens and enhanced natural areas
- Reduces pollutant runoff into the Chesapeake Bay

Economic

- Protects small businesses and residential homeowners from recurring flood losses
- Lowers long-term repair costs for County infrastructure

Why Is ORIF Important for the Peninsula?

The Peninsula faces unique flood risks due to its geographical location and community structure. With many neighborhoods only accessible by single roadways and bordered by tidal waters, localized flooding can cut off essential access, disrupt daily life, and damage critical infrastructure.

Local Focus:

- Addresses standing water in swales, culverts, and low-lying intersections.
- Complements major County and State resilience projects by filling funding gaps for smaller-scale issues.
- Prioritizes solutions tailored to the Peninsula’s mixed residential, fisheries, and small business landscape.

Ongoing Resilience Improvement Fund

5

How It Works

The ORIF operates as a flexible, sustainable funding model designed to adapt to the Peninsula's evolving resilience needs.

1 **Community Identification**
Local residents, civic associations, or small businesses report isolated flood issues.

2 **Project Evaluation**
Staff assess reported issues based on cost, feasibility, and urgency.

3 **Implementation**
Approved projects receive funding for green infrastructure, maintenance, or small-scale engineering solutions.

4 **Monitoring & Maintenance**
Completed projects are regularly evaluated to ensure long-term effectiveness.

MANAGEMENT & ADMINISTRATION

Application Process: Allow residents, neighborhood associations, and County departments to submit flood issue reports and funding requests.

Prioritization Framework: Use a scoring system to rank projects based on urgency, community impact, flood risk, and cost.

Tracking & Accountability: Develop a public-facing dashboard to show which projects have been funded, project cost magnitudes, and its implementation status.

POTENTIAL FUNDING SOURCES

- State and Federal Resiliency Grant Programs
- FEMA's Safeguarding tomorrow Revolving Loan Program
- County Budget Allocation
- Public-private partnerships for co-funding opportunities
- Grants or low-interest loans that may require matching contributions from property owners

ESTIMATED ANNUAL COST

Description	Capital Cost
Administrative/Staffing Costs	$75,000 - $100,000
Community Engagement/Outreach	$25,000 - $50,000
Small-Scale Resiliency Project Fund	$400,000 - $800,000
Monitoring and Maintenance	$50,000 - $100,000
Total Annual Fund Estimate	$550,000 - $1,000,000

IMPLEMENTATION CONSIDERATIONS

FEASIBILITY	●●●
EFECTIVENESS	●●●
ENVIRONMENTAL	●○○
ACCESS IMPACTS	●○○
SOCIAL BENEFITS	●●○
URGENCY	●●●

CRITERIA TOTAL
13 /18

**$**$$
< 1 M ANNUALLY

<3 years
3 - 6 years
> 6 years

Owings Beach Flood Mitigation

PROACTIVELY ADDRESSING RECURRENT FLOODING THROUGH INFRASTRUCTURE IMPROVEMENTS.

Key Components

1 ROAD RAISING

Elevate approximately 1,800 LF of Owings Beach Road at its lowest points (EL. +2.32′ NAVD88) by ±1.5 feet to ensure continued accessibility during elevated water levels. The raised roadway (+5 feet NAVD88) will function as both an access improvement and a flood barrier, redirected flooding away from vulnerable properties.

2 TIDE GATE INSTALLATION

Three 15″ and two 18″ inline check valves will be installed at key outfalls to prevent tidal backflow. Implementation will help reduce street level flooding during high tides, improving overall drainage system performance.

3 DRAINAGE SYSTEM & FLOOD PROTECTION IMPROVEMENTS

Address the gap in the seawall at the southern tip of Owings Beach to reduce backwatering into the community's stormwater conveyance system. Improvements would include stabilizing and reinforcing the shoreline near the gap correcting stormwater pooing issues, and upgrading outfalls in the area to improve drainage performance.

In other coastal communities, similar projects have been paired with the repurposing of high-risk parcels into permanent flood buffers, combining shoreline protection with public access and stormwater management benefits. While this property is privately owned, this location illustrates how such a strategy could be applied to enhance long-term resilience.

Owings Beach Flood Mitigation

6

Why Is It Important for the Peninsula?

Repairing a gap in flood protection infrastructure and upgrading adjacent drainage reduces a known flood pathway in Owings Beach. While acquisition is not directly proposed here, this location illustrates how repurposing high-risk parcels can complement infrastructure upgrades to encourage resilience through protective flood buffers.

Benefitting Area

202 Buildings

116 Parcels

% of Peninsula
- Buildings: 2%
- Parcels: 1%

COST BREAKDOWN

Description	Capital Cost
Seawall & Localized Drainage Repairs*	$150,000
Roadway Raising	$540,000
Furnish & Install 15" Inline Check Valve	$78,000
Furnish & Install 18" Inline Check Valve	$62,000
Subtotal	$830,000
20% Contingency	$166,000
Design & Permitting	$166,000
Total Cost	$1,162,000

*Includes correction of localized stormwater pooling and outfall upgrades adjacent to the seawall gap.

IMPLEMENTATION CONSIDERATIONS

FEASIBILITY	●●●	ACCESS IMPACTS	●●○
EFECTIVENESS	●●○	SOCIAL BENEFITS	●●○
ENVIRONMENTAL	●●○	URGENCY	●●○

CRITERIA TOTAL **13** /18

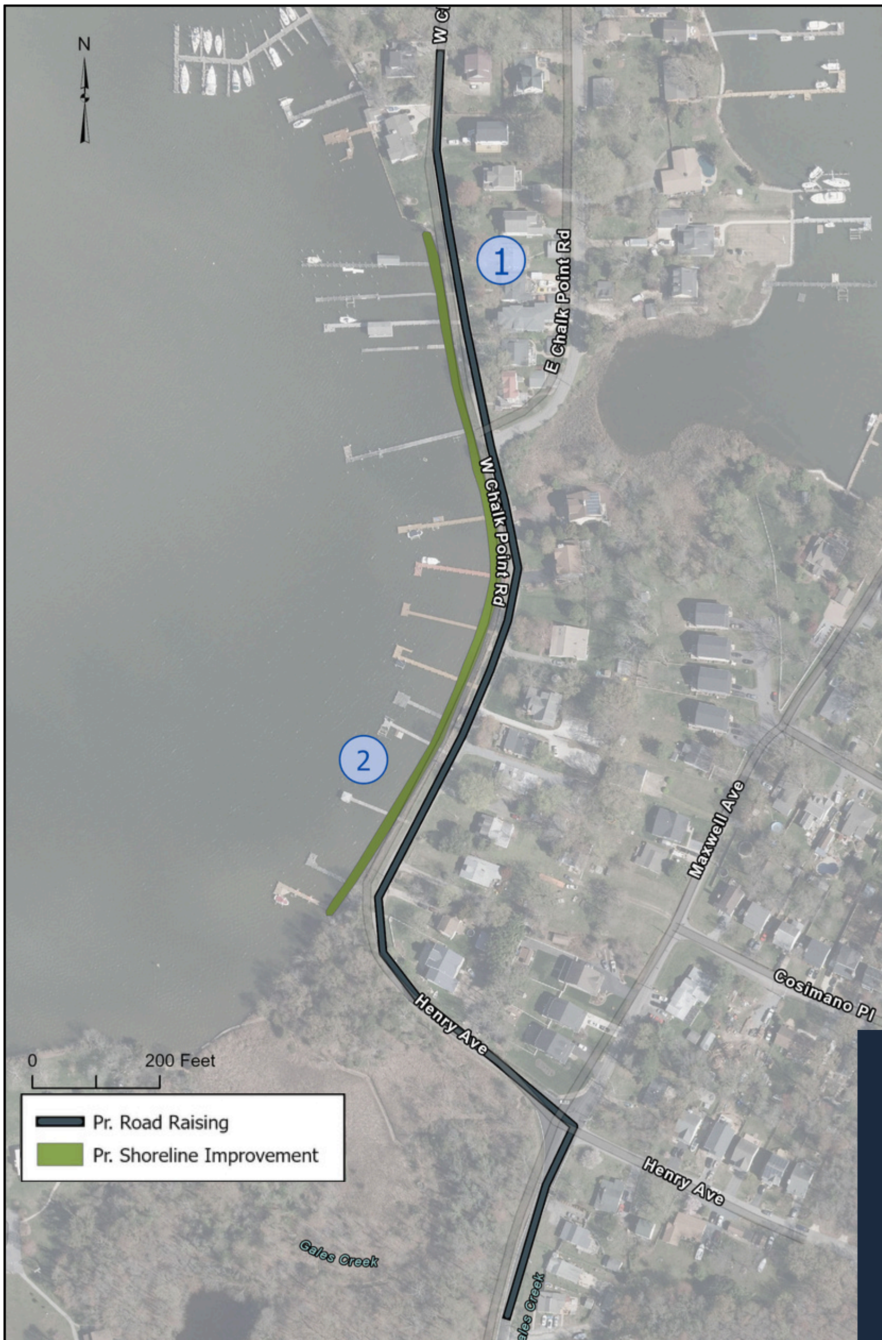
**$$**$ — $1M - $5M

<3 years
3 - 6 years
> 6 years

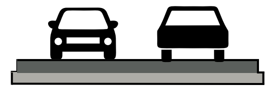
Chalk Point Road Raising & Shoreline Protection

INTEGRATING ROAD ELEVATION WITH SHORELINE PROTECTION ENSURES LONG-TERM ACCESSIBILITY WHILE ENHANCING COASTAL RESILIENCE THROUGH NATURE-BASED SOLUTIONS.

Key Components



1 ROAD RAISING



West Chalk Point Road is the sole access route for the community, making it critical to maintain safe and reliable passage during flood events. This project raises 2,300 LF of roadway by ±2 feet to +6 feet NAVD88, reducing flood risk and ensuring accessibility.

2 SHORELINE IMPROVEMENT

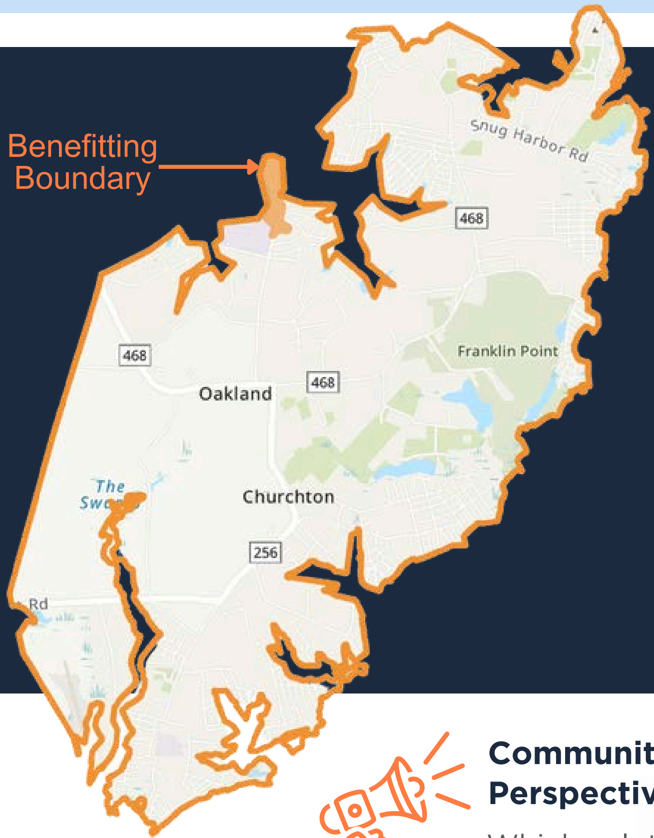
Shoreline improvements are proposed along 1,300 LF of shoreline to provide both environmental uplift and structural protection for the raised road. This nature-based solution dissipates wave energy, reduces erosion, and enhances habitat value along the shoreline.

Why Is It Important for the Peninsula?

By integrating shoreline protection with infrastructure upgrades, this project enhances flood resilience while balancing environmental uplift with environmental solutions.

Chalk Point Road Raising & Shoreline Protection

7



Benefitting Area

153 Buildings

126 Parcels

% of Peninsula
1% (buildings)
1% (parcels)

Community Voices: Perspectives on Flood Resilience

Which solutions would you like to see implemented on the Peninsula?

> "Barriers to protect the shoreline and road elevation in flooded areas."

COST BREAKDOWN

Description	Capital Cost
Roadway Raising	$690,000
Shoreline Protection	$665,000
Subtotal	$1,585,000
20% Contingency	$317,000
Design & Permitting	$380,400
Total Cost	$2,282,400

IMPLEMENTATION CONSIDERATIONS

FEASIBILITY	●●●	ACCESS IMPACTS	●●○
EFECTIVENESS	●●○	SOCIAL BENEFITS	●○○
ENVIRONMENTAL	●●○	URGENCY	●●○

CRITERIA TOTAL

12 /18

**$$**$

$1M - $5M

<3 years

3 - 6 years

> 6 years

Avalon Shores Road Raising & Compound Flood Improvements

8

IMPLEMENT HOLISTIC AND COHESIVE STORMWATER MANAGEMNT SYSTEM IMPROVEMENTS, IMPROVING CONVEYANCE, RETENTION, AND FLOOD RESILIENCE ACROSS THE COMMUNITY.

Key Components

1 ROAD RAISING

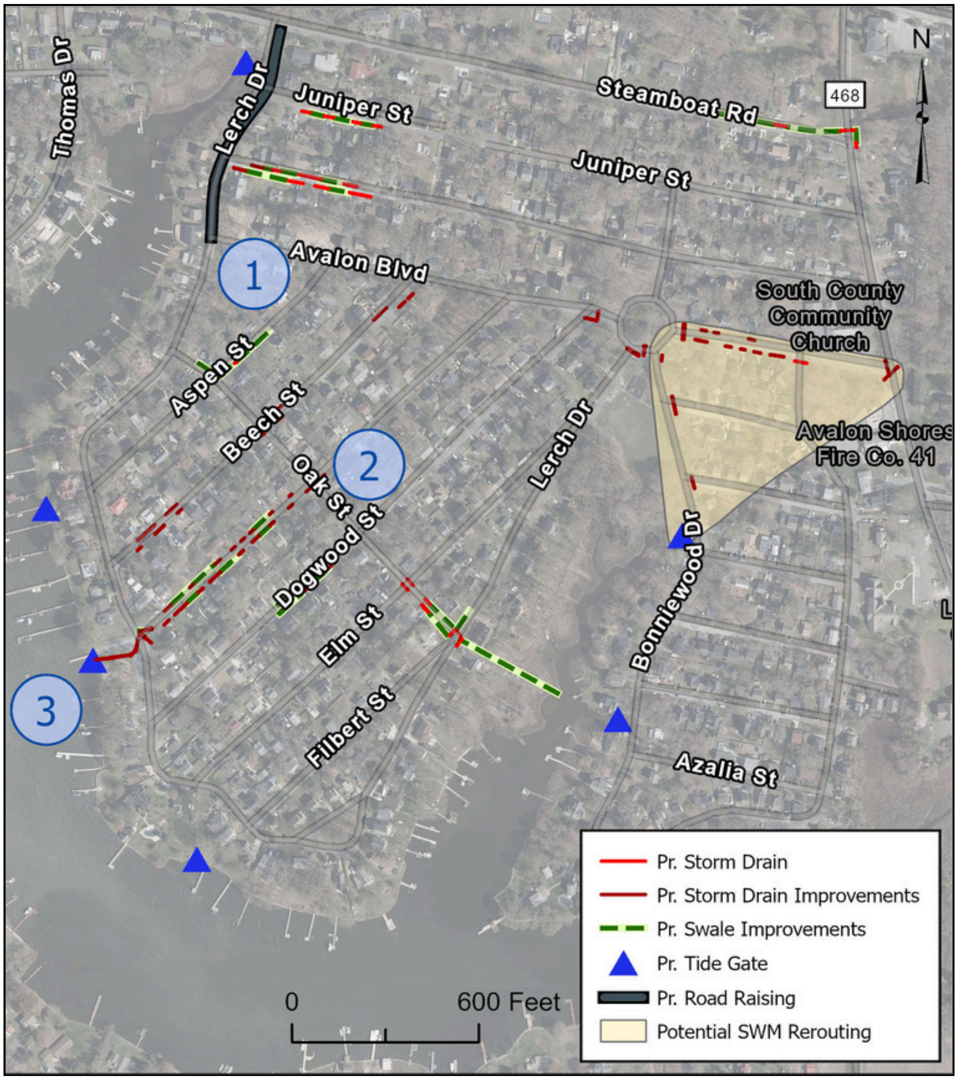
Raise 750 LF of Lerch Drive by ±2 feet to +5 feet NAVD88, mitigating disruption to residents during elevated tides.

2 DRAINAGE SYSTEM & SWALE IMPROVEMENTS

Improvements including reestablishing 2,400 LF of swales to increase stormwater retention capacity, restoring connectivity between drainage features with 2,500 LF of culvert upgrades and 420 LF of pipe, and improving eight stormwater inlets. The project also evaluates the need for conveyance pathways to be rerouted to improve flow. These upgrades will enhance water quality and improve system functionality.

3 TIDE GATE INSTALLATION

Installing eight inline check valves ranging 15 to 36 inches at key outfalls will prevent the backflow of tidal water through stormwater conveyance systems, reducing persistent flooding.

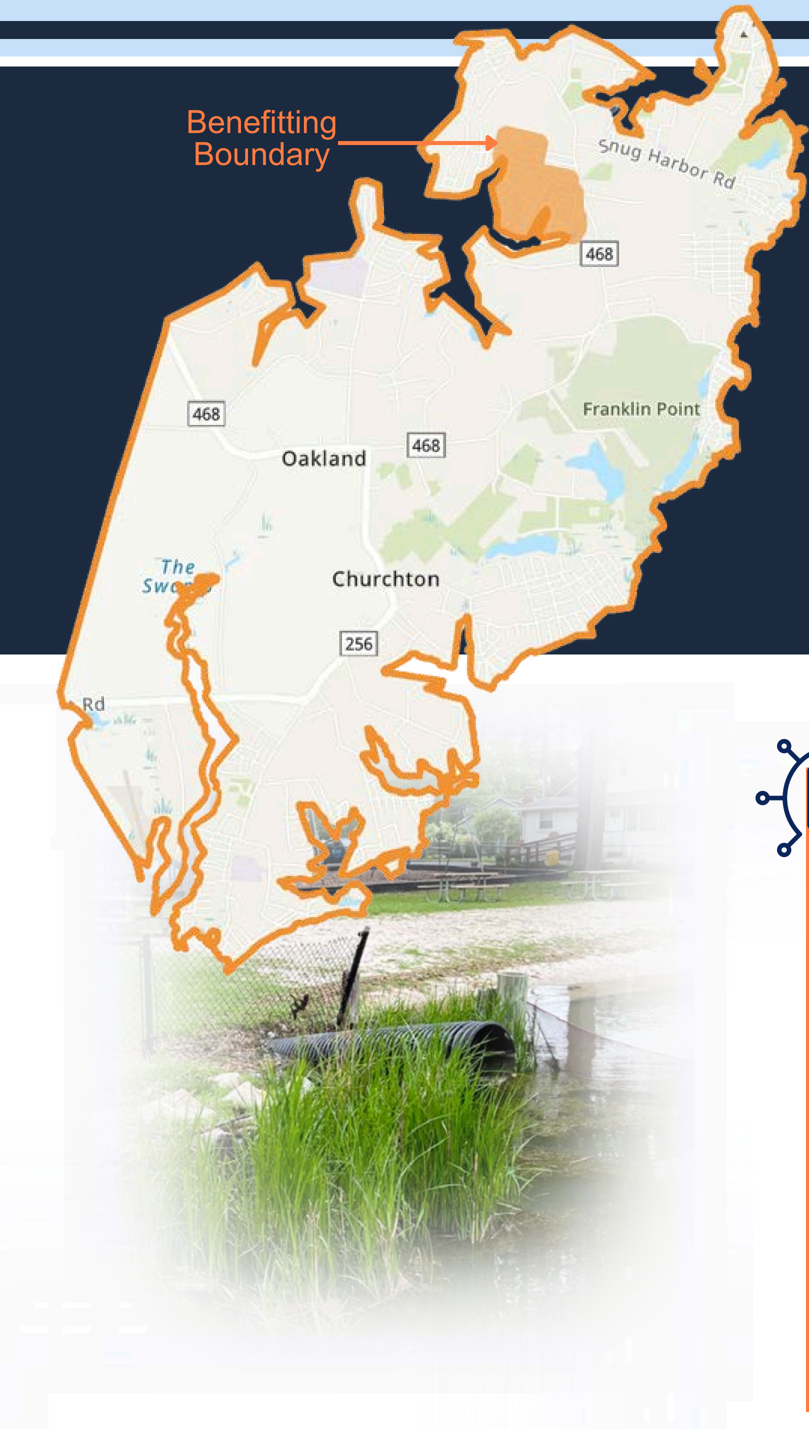


Why Is It Important for the Peninsula?

Avalon Shores faces chronic drainage and flooding issues due to low-lying stormwater outfalls, limiting effective runoff conveyance. This project provides a comprehensive approach to improving stormwater retention and drainage while creating opportunities for nature-based stormwater solutions in open spaces.

Avalon Shores Road Raising & Compound Flood Improvements

8



Benefitting Area

936 Buildings	1,291 Parcels	% of Peninsula
		8% (buildings)
		13% (parcels)

COST BREAKDOWN

Description	Capital Cost
Roadway Raising	$255,000
Furnish & Install 15" Inline Check Valve	$26,000
Furnish & Install 18" Inline Check Valve	$93,000
Furnish & Install 24" Inline Check Valve	$120,000
Furnish & Install 36" Inline Check Valve	$75,000
Swale Improvements/Re-establishment	$19,200
Storm Drain Upgrades	$100,000
Culvert Upgrades	$130,000
Subtotal	$818,200
20% Contingency	$163,640
Design & Permitting	$196,000
Total Cost	$1,177,840

IMPLEMENTATION CONSIDERATIONS

FEASIBILITY	●●●	ACCESS IMPACTS	●○○
EFECTIVENESS	●●○	SOCIAL BENEFITS	●●○
ENVIRONMENTAL	●○○	URGENCY	●●○

CRITERIA TOTAL

11 /18

**$$**$

$1M - $5M

< 3 years

3 - 6 years

> 6 years

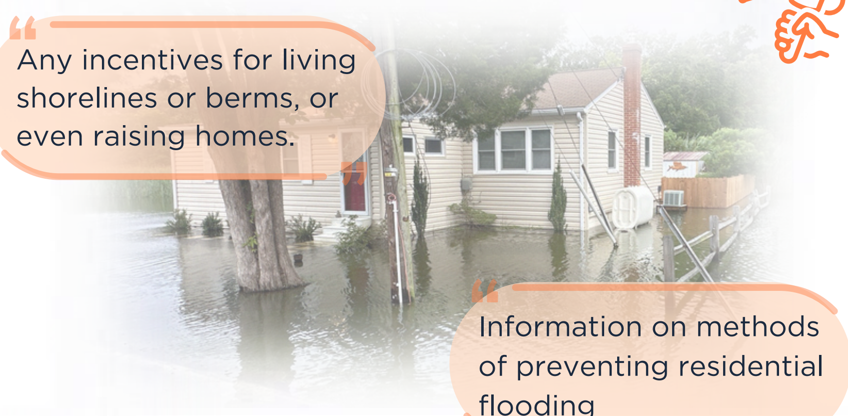
Home Raising Assistance Program

9

EDUCATE & ELEVATE: EMPOWERING RESILIENCE THROUGH HOME RAISING

This program will provide education about home raising as a viable flood mitigation option, along with guidance on potential funding opportunities and incentives. This approach acknowledges that while flooding may not be entirely preventable in some areas, raising homes can help residents adapt to living with flood risks more effectively. The program could be administered by the Resilience Authority, the County, or another appropriate organization depending on capacity and resources.

Community Voices: Perspectives on Flood Resilience



"Any incentives for living shorelines or berms, or even raising homes."

"Information on methods of preventing residential flooding"

Why Is It Important for the Peninsula?

FLOOD INSURANCE SAVINGS FOR VULNERABLE AREAS

Elevating homes in areas prone to repetitive flooding, above the Base Flood Elevation (BFE), as outlined by FEMA guidelines, can significantly reduce flood insurance premiums for property owners in these high-risk zones.

A RESILIENT OPTION WHERE MITIGATION ISN'T FEASIBLE

While engineered flood mitigation measures like road raising and tide gates address larger community needs, some areas of the Peninsula will continue to experience flooding. Home raising provides a viable solution for these residents allowing them to adapt and live safely with regular inundation.

PRESERVING THE CHARACTER & CULTURE OF THE PENINSULA

This strategy keeps existing homes in place while limiting flood risk, minimizing the risk of property abandonment and dilapidation, and supporting the long-term vibrancy of the community.

EMPOWERING INDIVIDUAL PROPERTY OWNERS

Home raising enhances resilience at the property-owner level, reducing personal recovery costs and helping maintain community integrity during flood events.

Key Components of the Home Raising Assistance Program

Create a **Home Raising Assistance Program** that offers financial incentives such as tax credits, direct grants, or low-interest loans to homeowners in flood prone areas.

Establish a **partnership with financial institutions** to offer subsidized or low-interest loans for home elevation projects.

A **Home Raising Assistance Program** would prioritize educating homeowners about the feasibility, costs, and process of elevating their homes. The program would provide clear, accessible materials including brochures and online guides to help residents assess feasibility, understand costs, and navigate the steps to implement home raising.

Leverage state and federal funding, such as FEMA's Hazard Mitigation Grant Program (HMGP), to expand resources available for the program.

Target areas identified in the County's flood risk analysis where engineered mitigation solutions are not feasible or sufficient.

ESTIMATED ANNUAL COST

Description	Capital Cost
Administrative/Staffing Costs	$50,000 - $100,000
Education and Outreach	$50,000
Direct Grants/Incentive Payments	$150,000 - $300,000
Total Annual Program Estimate	$250,000 - $450,000

IMPLEMENTATION CONSIDERATIONS

Criterion	Rating (of 3)
FEASIBILITY	2
EFECTIVENESS	2
ENVIRONMENTAL	1
ACCESS IMPACTS	1
SOCIAL BENEFITS	2
URGENCY	2

CRITERIA TOTAL **10**/18

**$**$$

< 1M (ANNUALLY)

<3 years
3 - 6 years
> 6 years