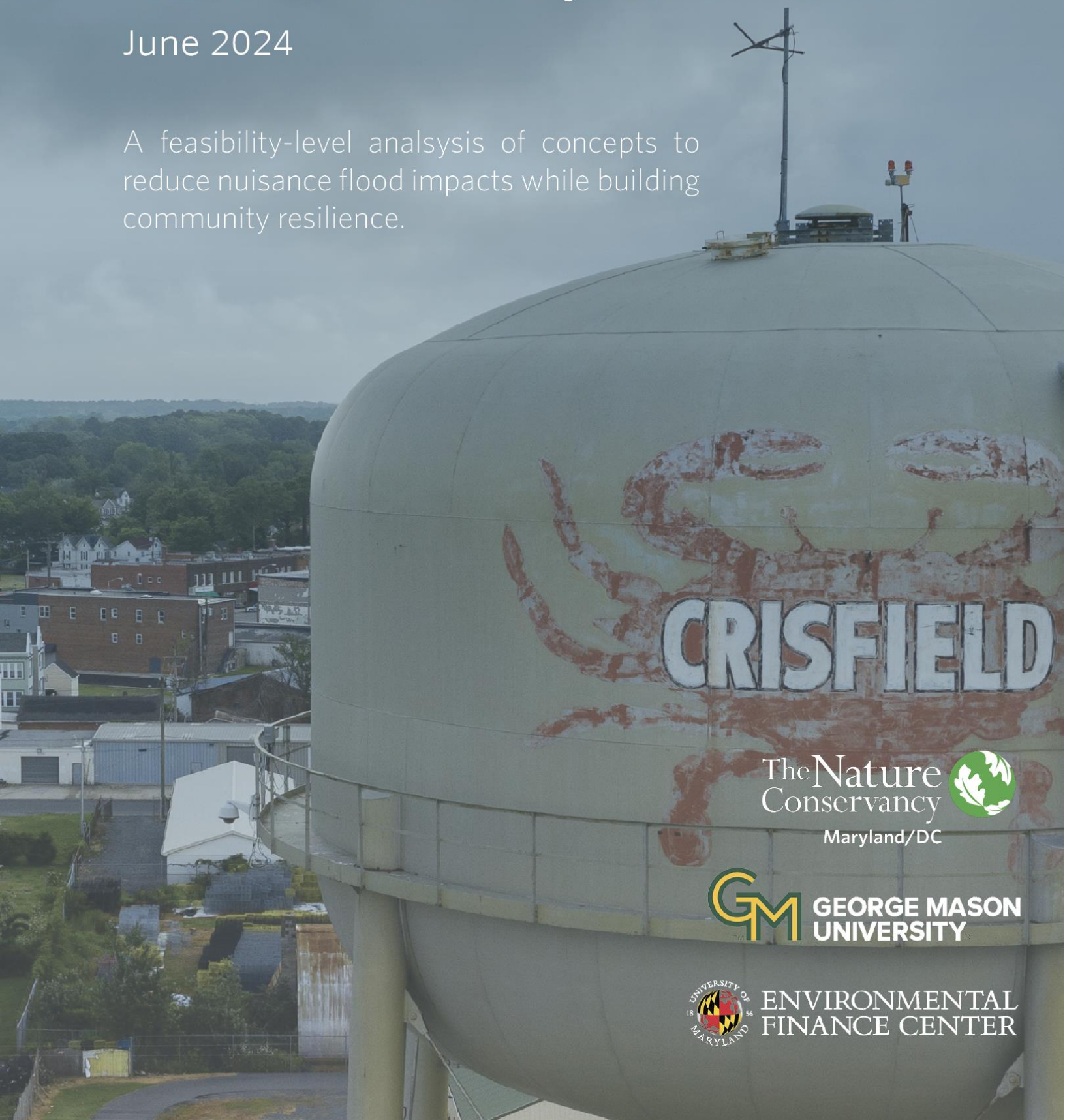
NOAA AdSci Report

Flood Adaptation Assessment for Enhanced Community Resilience

June 2024

A feasibility-level analsysis of concepts to reduce nuisance flood impacts while building community resilience.



The Nature Conservancy
Maryland/DC

GEORGE MASON UNIVERSITY

UNIVERSITY OF MARYLAND
ENVIRONMENTAL FINANCE CENTER

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This work was produced collaboratively by project team members.

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Executive Summary

This project aims to provide adaptation planning and community resilience support to Crisfield, Maryland through a community-guided scientific assessment of coastal flooding and potential adaptation strategies. The assessment evaluates Crisfield's vulnerabilities to coastal flooding challenges and examines the potential results of various adaptation strategies, including taking "no action." This project has been carried out in collaboration with the City of Crisfield and a Crisfield Community Advisory Committee, who ensured the assessment supported shared community objectives for advancing flood resilience in Crisfield.

The assessment builds upon existing NOAA guidance for adaptation decision-making by integrating a community-based participatory research approach to collaboratively evaluate a suite of adaptation options. The resulting Community Resilience Adaptation Decision Framework and accompanying Adaptation Decision Matrix provide Crisfield with customized decision support tools for considering adaptation costs alongside broader co-benefits for community resilience, feasibility, and effectiveness under future sea level rise. Findings from this assessment have been summarized in an Adaptation Decision Matrix to help Crisfield weigh important considerations for short- and long-term planning horizons.

The assessment process is centers around a six locally defined community resilience goals, which include: 1) Resilient infrastructure, 2) Safe and Affordable Housing, 3) Business and Job Opportunities, 4) Recreation and Tourism Investments, 5) Youth Development, and 6) Enhanced Community Spaces. These goals were identified through foundational qualitative research conducted by The Nature Conservancy (TNC) and refined by the project's Community Advisory Committee (CAC). The CAC, a thirteen-member committee of community advocates and leaders, was recruited to participate in a series of collaborative workshops convened to guide the research team's integration of the community's flooding concerns and resilience goals into the assessment process. The CAC's guidance throughout the assessment critically helped the research team align the project's outputs with local lived experiences, capacities, and envisioned futures. The creation of a CAC as part of this project also helped support local capacity building by providing non-governmental community leaders an opportunity to expand their environmental knowledge and directly contribute to local adaptation planning discussions.

The assessment evaluates how well various adaptation strategies could potentially reduce the impacts of nuisance flooding resulting from extreme tides and low-intensity storm events, two types of events identified by the CAC as their hazards of most concern. It examines adaptation benefits and costs in the context of both today's nuisance flooding challenges, as well as projected future nuisance flooding, which is anticipated to become more frequent and severe with sea level rise. To guide the assessment's modeling activities, research team members from George Mason University (GMU) worked with the CAC to identify water levels that best represent their nuisance flooding concerns, identified as 1.5 feet and 2.5 feet above NAVD88. These water levels were used to model baseline flood scenarios of nuisance flooding in Crisfield, to illustrate how deep the flood waters may be in different areas throughout Crisfield with no adaptation interventions in place. As part of this modeling, GMU also developed a geographic database to characterize the current state of the existing stormwater infrastructure in the city, as these features influence the effectiveness of any other

chosen adaptation strategies. Associated maps were published on a web application and were made publicly available.

Using adaptation strategies suggested by the CAC and City of Crisfield, the project team developed four *flood adaptation scenarios*. The first two adaptation scenarios modeled the 1.5-foot and 2.5-foot baseline water levels with 43 functional tide gates to prevent influx of water through ditches and culverts. The second pair of scenarios modeled these water levels with 43 functional tide gates *plus* three strategic flood mitigating structures in place: 1) 9,700 feet of elevated roadway, 2) 4,200 feet of berm, and 3) a seawall measuring 3,500 feet long. In total, this report examines six scenarios, referred to as the *Baseline Scenarios* (at 1.5-foot or 2.5-foot water levels)*, Tide Gates Scenarios* (at 1.5-foot or 2.5-foot water levels), and *Tide Gates + Three Structures Scenarios* (at 1.5-foot or 2.5-foot water levels).

Assessments of the six scenarios were led by research team members from the University of Maryland Environmental Finance Center (UMD EFC), who first estimated the flood damage costs associated with each scenario and then compared the *Baseline Scenarios* against the *Tide Gate Scenarios* and *Tide Gates + Three Structures Scenarios* to calculate the flood damage cost reductions that may be achieved by these adaptation strategies. Damage cost estimates were derived using national damage cost data and information on key community assets that were identified by the CAC as critical for supporting their resilience goals. Working with the CAC, the UMD EFC also qualitatively assessed how well the different adaptation scenarios support the community resilience goals, using CAC-informed evaluation criteria and qualitative input on flood reduction impacts. Their evaluation of strategy feasibility took into account funding and policy mechanisms, as well as the longevity of scenario effectiveness given sea level rise projections.

In addition, The Nature Conservancy evaluated a range of additional non-structural adaptation avenues that could be pursued in support of Crisfield's longer-term resilience. These include early flood warning systems, stormwater maintenance, annexation, planning within the Critical Area Zone, and resilience authorities, each of which were selected with guidance from the City of Crisfield. Research was carried out through interviews with policy experts as well as a case study analysis of existing applications of these strategies to understand limitations and opportunities for Crisfield.

Summary of Key Take Aways:

Assessment Results

- **Flood depth and extent in and around several community assets were reduced** under the Tide Gate Scenarios and Tide Gates + Three Structures Scenarios compared to the two Baseline Scenarios.
- Modeling showed that the strategies with the **Tide Gates + Three Structures Scenario were not able to reduce the impacts of floods higher than a 2.5-foot water level**, which may become daily occurrences between 2050 and 2080.
- A Baseline Scenario **1.5-foot flood event resulted in potential total damage costs of $383,000**, while a **2.5-foot baseline event resulted in up to $2.7 million in potential total damage costs** based on the estimated number of damaged structures in each scenario.

- All adaptation scenarios demonstrated damage cost reduction potential in the short-term (between now and 2050), with the **Tide Gates + Three Structures Scenario providing the greatest damage cost reduction**.
- **Employing a diverse mix of funding and financing mechanisms** to support initiatives will yield more implementation success in addressing the City's flooding concerns, especially over time.
- **Continued coordination with partners, especially regulatory partners**, will be essential moving forward given that much of the City sits within the FEMA floodplain and intersects with Maryland's Critical Area Zone.
- The **feasibility** of implementing any of the proposed options **depends on the City's capacity** to develop competitive proposals, coordinate fiscal and political requirements, and sustain operations and maintenance of infrastructure, programs, and services.
- **Education, outreach, political will, and public support** are also important considerations that can enhance the feasibility of implementing adaptation strategies.

Long-Term Policy Pathways

- With guidance from the City, **five potential long-term adaptation pathways** were identified, including 1) early flood warning systems, 2) stormwater maintenance, 3) annexation, 4) planning within the Critical Area Zone, and 5) resilience authorities.
- The City of Crisfield should **include climate change considerations and future projections in their long-term planning** to develop competitive grant proposals and to anticipate regional landscape changes that will impact future flooding conditions and socioeconomic opportunities.
- **An adaptation pathways approach, including consideration of both short-term and long-term options,** will serve Crisfield as it adapts to changing flooding conditions driven by climate change, land subsidence, and landscape transition.

1. Introduction

The City of Crisfield, located in Somerset County, Maryland, is at the forefront of coastal flooding challenges. With increasing regularity, flooding disrupts daily life, blocking travel to hospitals, schools, and businesses or causing property damage. Of the 41 municipal roads that experience flooding within the City, 27 experience repetitive flooding[1] and nine roads experience evacuation issues (Somerset County Nuisance Flood Plan, 2019). These impacts are compounded by Crisfield's status as a rural, underserved municipality with limited capacity to proactively adapt to changing conditions situation is especially concerning given Crisfield's location along Maryland's coastlines, which are experiencing the third-highest rate of sea level rise among the lower 48 states (Sallenger and Doran, 2012).

To address the increasing amount of damage to infrastructure associated with sea level rise, Somerset County collaborated with the Maryland Department of Natural Resources (DNR) and the National Oceanic and Atmospheric Administration (NOAA) to draft a sea level rise adaptation plan (Somerset County MD, 2008). The County's nuisance flood plan, sea level rise adaptation plan, 2021 Flood Mitigation Plan, and the recently revised Hazard Mitigation Plan serve as guides for the County to address hazards associated with flooding and major storms that will occur in the future. This project builds upon these planning efforts to support local decision-making capacity through a community-guided scientific assessment of potential adaptation strategies to address flood risks of greatest concern to Crisfield. The project goals were to: *1) collaboratively scope adaptation strategies to flooding with potential to support Crisfield's social and economic health; 2) assess the efficacy, cost-benefits, and feasibility of adaptation options; 3) provide innovative funding and policy recommendations; 4) co-develop an Adaptation Decision Framework to assess community-backed adaptation strategies;* and *5) recommend adaptation pathways to support Crisfield's community resilience and goals*.

The assessment builds upon NOAA 2013 decision guidance (Eastern Research Group) by integrating a collaborative process that centers local lived experiences, concerns, and goals through a community-based participatory research approach. The addition of a local collaborative process allowed for scientific data to be positioned alongside local environmental knowledge to support a more holistic, inclusive, and meaningful assessment of adaptation costs and benefits. The research team worked with representatives from the City of Crisfield and a recruited Community Advisory Committee (CAC) of thirteen non-governmental community leaders from key sectors across Crisfield. These individuals convened through a series of collaborative workshops hosted between June 2022 – May 2023 to guide the research team's identification and representation of 1) locally-defined community resilience goals and associated community assets; 2) key flood hazards of local concern; 3) community-backed adaptation scenarios; and 4) relevant criteria for evaluating adaptation costs and benefits. Not only did their guidance help the research team deliver more

[1] Repetitively flooded roads are defined as roads that flood on a daily basis at MHW (Mean High Water) or on a monthly basis during weather events or moon phases, or in general water is on the road bed more days than not throughout the month/year (Somerset County Nuisance Flood Plan, 2019).

meaningful results, but the integration of a non-governmental CAC also helped expand local knowledge and, in turn, local decision-making support in this underserved community.

The research team focused the assessment on smaller, more frequent nuisance flooding associated with extreme tides and low-intensity storm events. These types of nuisance floods were identified as the CAC's primary hazard of concern due to how regularly disruptive they are to the community's daily operations, which in turn, stymies socio-economic development opportunity for Crisfield. Major storms, while impactful, were characterized as much rarer and more difficult to protect against. In contrast, nuisance floods offer more mitigation and adaptation potential that could generate socio-economic benefits. The project's focus on smaller flood events offers an opportunity to assess adaptation strategies to address these community concerns, while also providing insights on their longer-term effectiveness as future flooding becomes more frequent and severe with projected sea level rise.

The study area encompasses all structures within the Crisfield municipal boundary and areas just outside this boundary (see Figure 1). Its geographic scope intentionally captures the full extent of the Crisfield community (within and outside of the city limits) as characterized by the CAC. The study area was co-defined with the CAC through a collaborative mapping exercise that was guided by community-defined resilience goals and corresponding assets identified through preliminary interviews and validated by the CAC. The community resilience goals included: 1) More resilient infrastructure (especially drainage), 2) Improved flood-safe and affordable housing opportunities, 3) Business and job growth opportunities, 4) Recreational and tourism opportunities, 5) Youth development opportunities, and 6) Enhanced public spaces to grow and support community.

To collaboratively guide the development of modeled scenarios to evaluate in this assessment, research team members from George Mason University (GMU) developed numerous baseline flood scenario maps representing recent past flood events with which the CAC was familiar. These events included hurricanes, nor'easters, as well as smaller storm events and sunny-day floods from 2021. The flood maps represented these flood events along a spectrum of incremental water levels between 1 foot to 4 feet above NAVD88 (see Figure 2). The research team reviewed these maps with the CAC to determine the scenarios most representative of their key flooding concerns. Two flood hazard scenarios were selected to represent lower-intensity nuisance flooding events, as water levels of 1.5 feet and 2.5 feet above NAVD88 respectively. These scenarios formed the assessment's *Baseline Scenarios*, which estimate how deep the water may be in different areas throughout Crisfield with no adaptation interventions in place. UMD EFC used these scenarios to analyzed baseline risks and vulnerabilities. This was conducted by comparing property and elevation data against baseline water levels to determine if a property or structure was impacted by flooding and, if so, the estimated damage costs those structures would likely occur as a result.

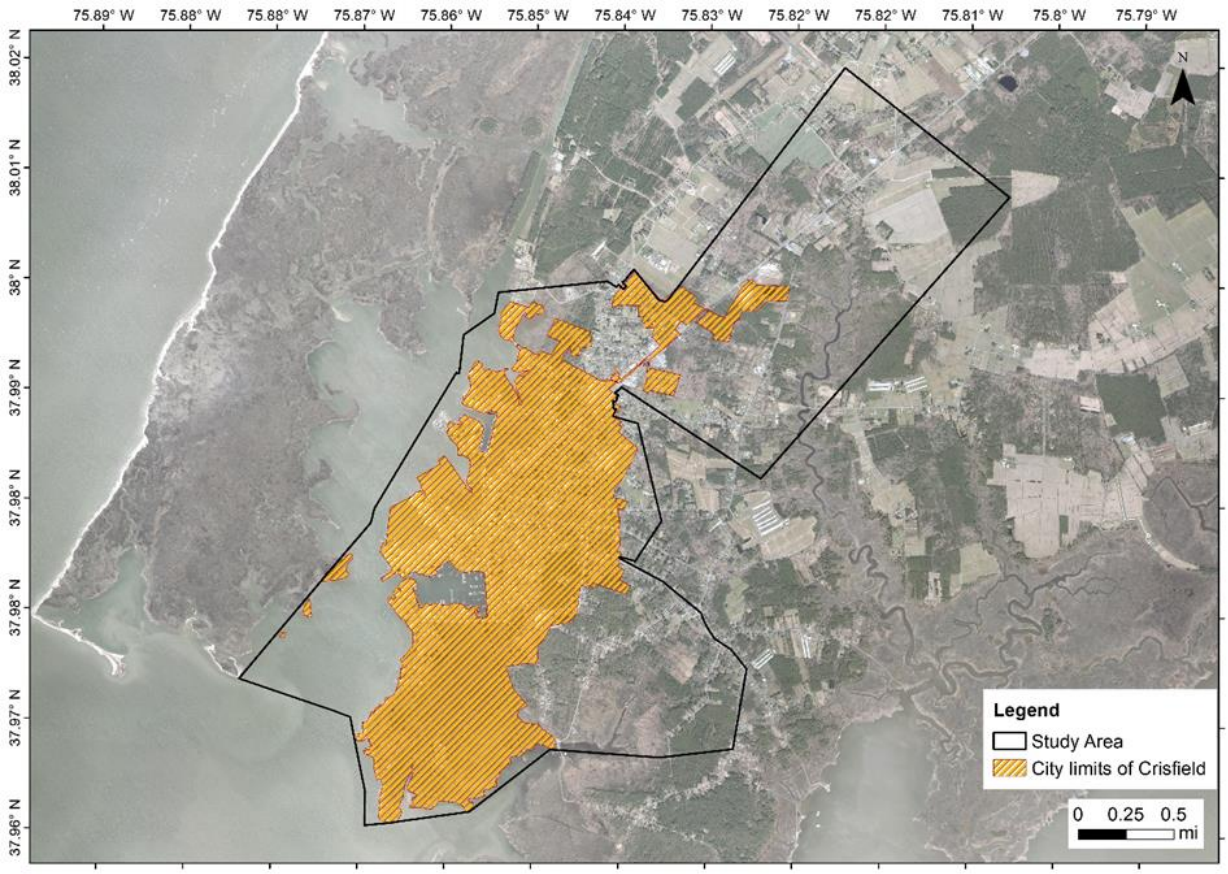


Figure 1. Map of Crisfield municipal boundary and study area.

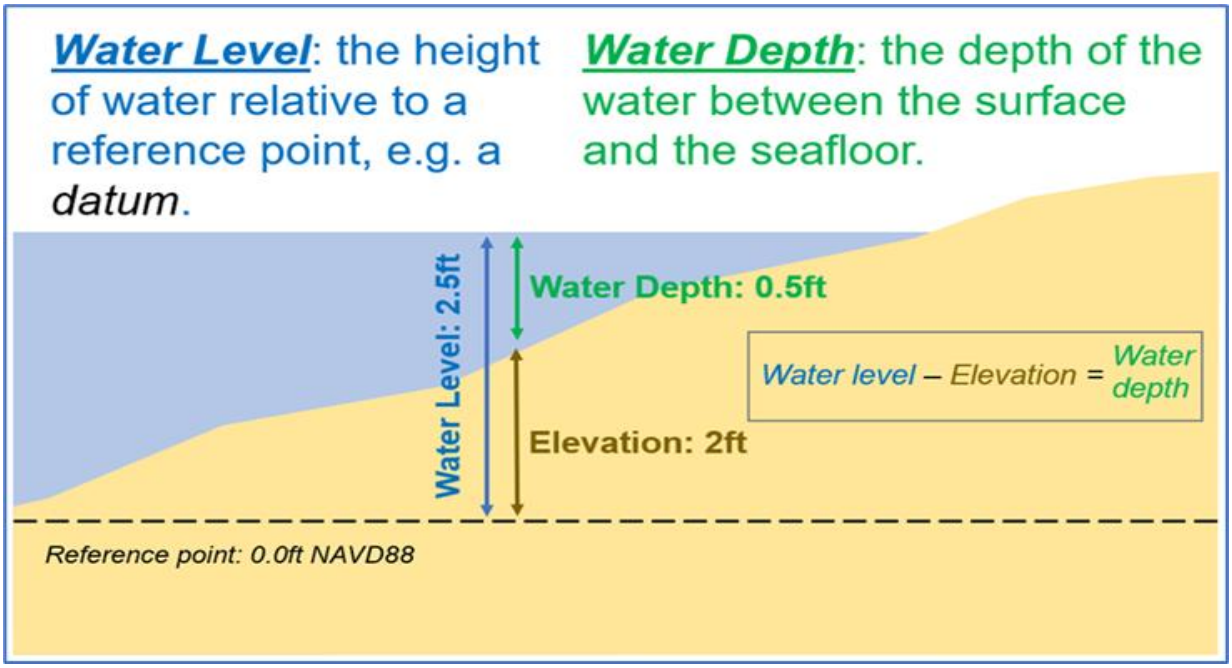


Figure 2. Water level and water depth difference. Water depth is different in different areas because it depends on the elevation of the land surface.

Outputs from UMD EFC's baseline risk and vulnerability assessment helped the research team collaboratively develop four adaptation scenarios with guidance from the CAC, the City of Crisfield, and the City of Crisfield's Drainage Report (2023).[2] The first two adaptation scenarios modeled the 1.5-foot and 2.5-foot water levels with 43 functional tide gates to prevent influx of water through ditches and culverts. The second pair of scenarios modeled these water levels with 43 functional tide gates plus three strategic flood mitigating structures in place: 1) 9,700 feet of elevated roadway, 2) 4,200 feet of berm, and 3) a seawall measuring 3,500 feet long. In this report, these adaptation scenarios are referred to as the *Tide Gates Scenarios* and *Tide Gates + Three Structures Scenarios*.

Working with the CAC, the UMD EFC team then compared the four adaptation scenarios against the *Baseline Scenarios* (at 1.5-foot and 2.5-foot water levels) to quantitatively estimate their flood cost damage reductions and qualitatively assess corresponding community resilience co-benefits. UMD EFC also assessed the long-term effectiveness of the scenarios under future sea level rise projections. UMD EFC and TNC also evaluating the political and financial feasibility of these strategies, as well as additional non-structural strategies that could be considered alongside them in developing long-term adaptation pathways. Outputs from this assessment were integrated into an Adaptation Decision Matrix to help City of Crisfield holistically conceptualize the value of different adaptation strategies as part of their ongoing and future flood mitigation and adaptation planning decisions.

The following report details the assessment process conducted by the project team in collaboration with the CAC and the City of Crisfield government. *Section 2: Project Foundations in Community-Engaged Research* delves into the importance of participatory approaches in research and reviews the ethnographic research employed to better understand Crisfield's experiences of flooding and community resilience goals. *Section 3: Selecting Hazards and Assessing Baseline Vulnerability and Risk* explains how flood hazards were selected, baseline scenarios built, and damages to properties and structures estimated for the selected flooding scenarios. *Section 4: Developing Adaptation Strategies and Scenarios* reviews the adaptation options that this project explored to mitigate selected flood hazards. *Section 5: Developing an Adaptation Decision Matrix for Crisfield* describes how the research team, CAC, and City of Crisfield collaboratively developed the Adaptation Decision Matrix based on a number of criteria that arose through the assessment process for evaluating how well adaptation scenarios help reduce flood exposure and vulnerability, benefit community resilience, and their feasibility. *Section 6: Assessment Results* explores how the selected adaptation strategies performed based on criteria included in the Adaptation Decision Framework. *Section 7: Future Horizons: Adaptation Pathways for Crisfield's Longer Term Community Resilience* highlights implementation considerations as well as a number of additional adaptation trajectories for Crisfield to consider as flooding conditions are predicted to worsen in the future.

[2] Drainage Assessment Report prepared by Bayland Consultants and Designers (November 2021, Revised February 2023).

2. Project Foundations in Community-Engaged Research

This assessment was designed to integrate local input on flooding and adaptation needs through collaborations with a small grassroots Community Advisory Committee (CAC). The consistent involvement of the CAC throughout the research process is aligned with the principles of community science and modeled on the tenets of community-based participatory research (CBPR), which aims to equitably develop a partnership between researchers and community members to facilitate knowledge exchange and power-sharing (Israel et al. 2010). Participatory approaches in the context of adaptation planning have led to a more comprehensive understanding of climate change processes, activated local interest in climate preparedness, and created social networks towards anticipating and planning for climate change (Ross et al. 2015). Ross and colleagues note that these participatory processes importantly build "local empathy, a local knowledge base, and empower... participants to join towards future climate adaptation action" (p. 28). Yet, participatory approaches have traditionally been under-utilized in infrastructure projects and hazard mitigation planning, which tend to be dominated by technical experts (Hendricks et al. 2018). This project brought local perspectives into these processes through the CAC toward developing a more comprehensive assessment of how Crisfield can effectively mitigate their flood vulnerabilities through various adaptation strategies.

The CAC was composed of thirteen non-elected community leaders representing a range of interests and community demographics across Crisfield. The Committee played an essential role in the development and implementation of the *Community Resilience Adaptation Decision Framework*, a stepwise collaborative process that uses CBPR to integrate local knowledge and goals with coastal modeling and a benefit-cost analysis to comparatively evaluate coastal adaptation strategies (see Figure 3). The process results in a community-specific decision matrix of co-defined criteria and community-vetted outputs that local decision-makers can use to select strategies that best meet their community's resilience goals under changing coastal environmental conditions. The Community Resilience Adaptation Decision Framework ('Framework') builds upon the National Oceanic and Atmospheric Administration's (NOAA) 2013 Economic Framework for Coastal Community Infrastructure (Eastern Research Group), offering new guidance to support a more inclusive, participatory process that considers quantitative metrics of success alongside equally important qualitative considerations that help contextualize and deepen the significance of model outputs. Most importantly, the Framework is underpinned by locally defined community resilience goals, which help focus the assessment on key community dimensions affected by adaptation decisions, allowing decision-makers to comprehensively consider a broader range of benefits and costs for their community. The result is a more holistic, locally grounded, and meaningful decision-support tool for adaptation planning.

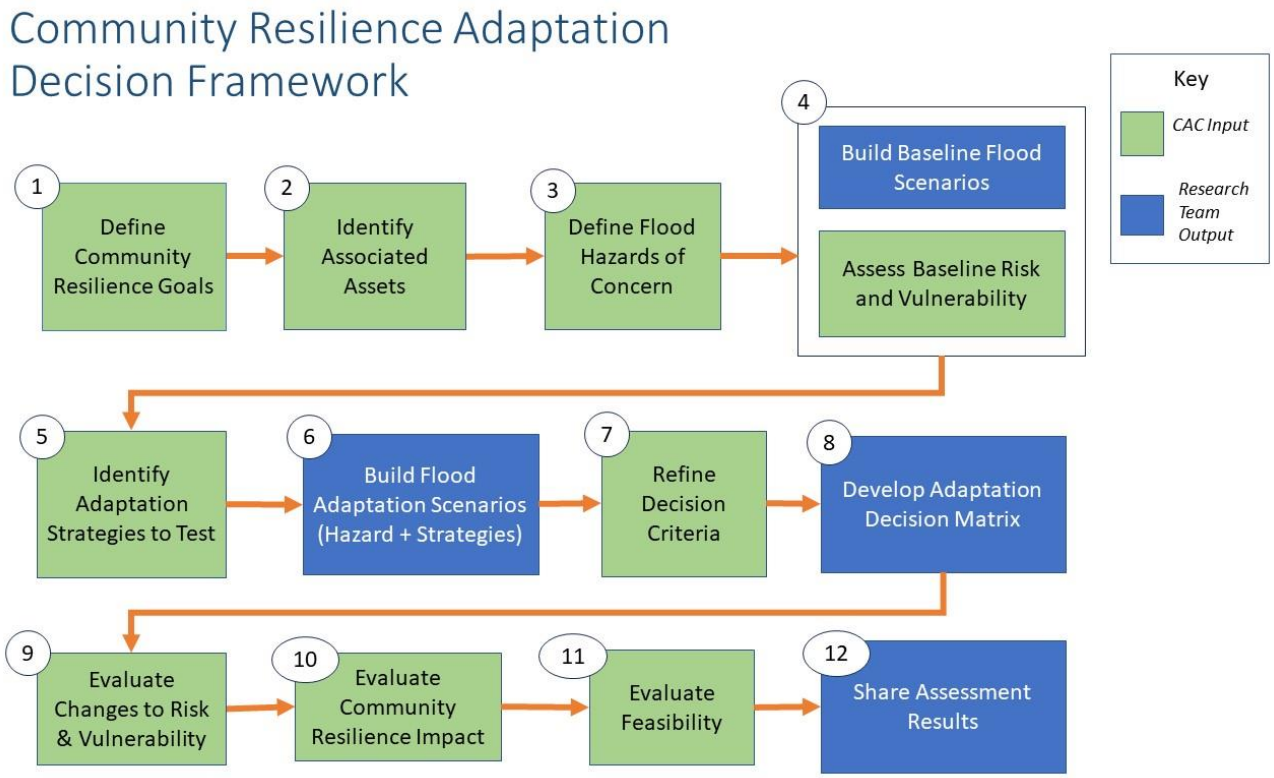


Figure 3. The collaborative process used to develop and implement the Community Resilience Adaptation Decision Framework.

The Framework includes twelve evaluative steps, as illustrated in Figure 3. During **Step 1**, the CAC defines target community resilience goals for the research team. Identified resilience goals are then used in **Step 2** to collaboratively develop a list of community assets that support or could potentially support the advancement of the community resilience goals. Community assets are integrated into mapping layers that the team will use to model flood adaptation scenarios later in the process. During **Step 3**, the research team works with the CAC to appropriately represent their flood hazards of concern in the models, which are used to produce baseline flood scenarios. During **Step 4**, researchers use the flood scenarios to assess the community's baseline flood risk (i.e., flood exposure) and vulnerability (i.e., estimated flood damage costs), using the community resilience assets to frame their assessment. In **Step 5,** researchers and the CAC use the baseline assessment results to co-select strategies with potential to address flooding hotspots and areas of concern. The selected strategies are then used in **Step 6** by the research team to develop Flood Adaptation Scenarios, which include different combinations of the selected strategies added to the baseline flood scenarios. The resulting outputs can then be used to evaluate how well strategies improve flood conditions compared to the baseline scenario.

Before strategies can be evaluated, it is necessary for the research team to collaboratively refine the decision criteria that will be used to explore community benefits and costs of each adaptation scenario **(Step 7)**. This allows the research team to account for other locally relevant factors that affect decision-making, while also making the evaluation process more meaningful for the community participants. The NOAA 2013 Economic Framework offers a number of starting criteria, such as damage costs, implementation costs, and feasibility that can be refined and built upon by the CAC and project team to produce a locally relevant adaptation decision matrix in **Step 8**. The next three steps are used to co-produce the evaluation outputs. **Step 9** quantitatively examines how well adaptation scenarios reduce risk and vulnerability across the community through damage cost assessments, while **Step 10** qualitatively evaluates how well the adaptation scenarios enhance community resilience, using community-identified resilience goals as proxies. **Step 11** assesses the feasibility of the adaptation strategies, taking into consideration the multiple dimensions of feasibility co-defined with the CAC. The resulting assessment results are then shared with local decision-makers in the final **Step 12**.

In this project, the research team and the CAC developed a Crisfield-specific framework through four workshops from Summer 2022 to Fall 2023. Workshops were typically three to four hours long, included a meal, and provided a stipend as compensation for CAC members' time and expertise[3]. These workshops utilized community-engaged methods (primarily via participatory mapping exercises, surveys, and community charrettes) that importantly facilitated iterative modeling and analyses that allowed for mutual sharing and learning. Additional information on the workshop activities is imbedded in the following sections, which describe the assessment steps and results in detail.

The CAC was not the only source of local data expertise that the project team utilized in the guidance of this assessment. The project team also collaborated with representatives of local government on refining research questions, developing criteria to inform the Framework, and ground truthing flood infrastructure and local conditions for the assessment. Increased local government collaborations came on the heels of an influx of other resilience-related projects that the City of Crisfield began to undertake in late 2022, including direct technical assistance from FEMA's Building Resilient Infrastructure and Communities program (BRIC DTA) and engagement with EPA's Creating Resilient Water Utilities (CRWU) program via their Climate Resilience Evaluation and Awareness Tool (CREAT), among others. This led to the project team creating parallel engagement processes with the CAC and the City of Crisfield government and to the appointment of the City Grants Administrator to the CAC for the remainder of the project beginning in January 2023. These touchpoints with the City of Crisfield government allowed the project team to lend additional capacity and support towards the coordination of the various resilience efforts in Crisfield, most notably with FEMA BRIC DTA, and ensured that ongoing resilience planning efforts were synergistic and not duplicative. Ultimately, this coordination resulted in the FEMA BRIC DTA team utilizing various modeling components, adaptation scenarios, and maps that were developed through this project's assessment in the development of a grant

[3] The Nature Conservancy paid each CAC member a consultant fee of $50/hour using supplementary private funds made available during this project.

application for the FEMA BRIC program. The projects in the proposed FEMA BRIC grant applications include stormwater pumps, improvements to the stormwater drainage system, tide gates, reconstructed and constructed wetlands, elevated roads, raised bulkheads, and berms.

In an effort to broaden inclusion from the Crisfield community beyond engagement with the CAC and the City of Crisfield government, the project team hosted two public meetings to allow for residents of Crisfield and nearby communities to offer feedback on the direction of the project and next steps for the City's adaptation planning. These events took place following the fourth CAC meeting on May 6, 2023 and on October 21, 2023 and included panel discussions and Q&A sessions to better communicate project details with the general public. The October 21st meeting also placed this project in conversation with several concurrent adaptation and resilience efforts in Crisfield including the aforementioned FEMA BRIC DTA and EPA CRWU efforts, as well as projects led by the Eastern Shore Long Term Recovery Committee, the EPA ORD, Interfaith Partners for the Chesapeake, and the City of Crisfield local government. It was important for Crisfield officials to present these projects alongside one another in order to communicate to the public that Crisfield's numerous resilience efforts were working together and towards a unified vision for Crisfielders and those living in surrounding areas.

Convening a Project Community Advisory Committee

As a research team with no prior experience working in Crisfield, convening a CAC for the project necessitated additional time investments prior to the project's kick-off toward building relationships on the ground and improving our own baseline understandings of Crisfield's flooding challenges. To facilitate this critical first step, a social scientist team member with ethnographic research expertise from The Nature Conservancy (TNC) conducted preliminary outreach and qualitative research to better understand local knowledge, perceptions, and attitudes about flooding and adaptation[4]. In addition to enabling the research team to connect with and recruit trusted community leaders and advocates for the CAC, this research also importantly provided wide ranging locally-grounded insights that the research team used to facilitate the initial collaborative processes of the Framework.

Initial desktop research and informal outreach to municipal leaders and planning partners was first conducted to identify key community sectors and individuals who represent these key sectors. These sectors included the faith community, business and economic development sector, youth development sector, public services/emergency services, and the community development sector. In-depth qualitative interviews with 29 individuals were then conducted using a semi-structured interview guide to 1) document community knowledge and attitudes about Crisfield's flooding challenges and adaptation needs and 2) generate an initial list of key community assets. Interviewees were recruited with help from municipal leaders and planning partners who facilitated introductions to sector representatives. Additional individuals were recruited

[4] This research was supported with supplementary funding from Lockheed Martin through a donation to The Nature Conservancy. Human Subjects Research Approval was secured on September 21, 2021 following The Nature Conservancy's research protocol, in alignment with Intuitional Review Board approvals.

through a snowball sampling approach (Parker et al. 2019). Interviews were recorded with permission from participants and transcribed. Identifiable information was redacted to protect personal information. Textual data was then qualitatively analyzed in MaxQDA 2022 text analysis software (VERBI Software 2021) using content analysis methodologies to elicit generalizable themes and patterns across the interview.

Interview Results

Interviews revealed three primary themes characterizing how locals conceptualize problematic flooding, characterize flooding costs on the community, and define their community resilience goals.

Key Flooding Concerns

Tidal flooding was identified as a key concern across interviews. As put by one individual, *"Nine out of ten times, the flooding in Crisfield is tidal. … You're at the mercy of the tides."* Tidal flooding tended to be discussed in the context of less frequent storm-driven tidal events, when winds and storm surge push high tides onto roadways and properties***;*** and more frequent astronomically-driven tidal flooding (i.e., "king tides," "high-high tides"), which was noted to be especially problematic during the spring and fall. A number of interviewees estimated that nuisance tidal flooding happens as frequently as several times a month, with several noting that in the most flood-prone sections of the community (e.g., the Down Neck area south of the city limits), nuisance flooding is a daily experience.

While many suggested flooding has always been a "part of living" in Crisfield, most interviewees expressed concerns about the increasing frequency of flooding, which some directly linked to climate-driven sea level rise. Others were more skeptical or even challenged the role of climate change while still acknowledging that flooding has worsened.

Tidal flooding was almost always discussed in tandem with Crisfield's poor drainage infrastructure, specifically non-functional tide gates, pumping stations, and clogged tidal ditches, all which are needed to drain water from low-lying streets where it becomes trapped during and after larger tidal flood events. Interviewees described how these infrastructure challenges are exacerbated by insufficient maintenance and landscape features that create water-trapping "bowls" or "bellies". This is especially problematic in the southern section of the city, which is built on a foundation of oyster shell that is now subsiding.

"I think one of the biggest problems we have with the rise of the tide is that the floodgates around here, which tie into stormwater management system on the streets, many of the floodgates don't work. So, you get a sea level push, and at the drop of a hat, you can get streets around here that may get 8, 10, 12 inches of water."

Community Costs of Flooding

Damage Costs

Flooding is having the most direct impact on Crisfielders in terms of the financial costs of property damage. Descriptions of property damage included structural damage to homes and businesses, damaged or lost material items and appliances (e.g., freezers, furnaces, lawnmowers, clothing, mattresses), damaged or lost

merchandise, and vehicle damage and replacement costs. Structural damage to homes and businesses was most often discussed in the context of storm-driven tidal flooding. While damage costs were less of a concern with tidally-driven nuisance flooding, several interviewees described how these events increase maintenance costs (e.g., painting, mold remediation, rust on vehicles) for Crisfielders, especially for property owners in more flood-prone areas. Vehicle damage was especially concerning for emergency service representatives, whose departments must absorb repair costs on limited budgets in order to safely operate emergency vehicles in times of need, including during flood evacuations. Property damage costs are exacerbated by insurance expenses, which several interviewees suggested have become cost prohibitive for many households in Crisfield, resulting in many households "pay[ing] out of pocket." Even for those who carry insurance, reimbursements tend to not cover replacement expenses that households and businesses need for maintaining their quality of life.

Development Costs

Across interviews, there was a shared sentiment that flooding diminishes Crisfield's opportunity to develop into a healthy, thriving community. Many interviewees discussed these development costs in terms of flood impacts to local businesses and future business development potential, both which were identified as necessary for attracting visitors and retaining residents vis-a-vis goods and services and employment opportunities. For existing businesses, tidal floods increasingly force them to temporarily close, absorb damage costs, and/or hinders access for customers, delivery trucks, and employees alike. A number of interviewees described the cumulative impact of these disruptions on the financial health of local businesses, many which are small family-run enterprises that experience these financial burdens in much more acute way. As a result, local businesses have fewer resources available to grow, creating indirect development costs in the form of reduced employment opportunities and community amenities. Some also expressed concerns about the ways that flooding is detracting investors from bringing new business to town.

Across interviews there was also a general concern that flooding is driving disinvestment from Crisfield. A number of individuals reflected on how large events often result in homeowners and businesses leaving town (e.g., after Hurricane Sandy), when rebuilding becomes either cost prohibitive or too traumatic. Others reflected on how declining employment opportunities result in youth moving away rather than investing their futures in Crisfield. A few others extended these disinvestment concerns to government, noting that Crisfield's location in the floodplain results in public disinvestments that further limits development opportunities for the community.

Declining Capacity

The above two themes relate to a third theme on flood costs, which emphasized the ways in which flooding strains multiple dimensions of local capacity. At an individual and household level, interviewees described the physical, mental, and financial toll of flooding -- especially for those experiencing repetitive impacts, which cumulatively reduce individuals' coping capacity.

These physical, mental, and financial stressors reverberate at the community scale as well. Interviewees connected to key community institutions, such as churches, the volunteer fire department, Crisfield Housing Authority, local youth organizations, and schools offered a range of perspectives on how flooding limits their capacity to sustain key community services. Church leaders shared concerns about having to cancel Sunday services due to flooding. Representatives from local youth organizations and schools reflected on the impacts that frequent delays, early dismissals, and closures have on their students and their families, as well as the how flood impacts to youth amenities limit their ability to provide meaningful youth experiences (e.g., loss of usable recreational spaces). Many interviewees expressed concerns about the potential relocation of the Crisfield Housing Authority due to flooding. As the primary source of housing for nearly a third of Crisfield

"Yeah, I think it's really been disheartening, just not having ... the drive to consistently rebuild. It's such a hard thing to do. It's funny because you look at movies where they have like major earthquakes or hurricanes. Oh, what do you do? You rebuild. When you keep doing that every five to ten years, you wash your house out after a flooding, and you go get a new car, it drives you to a point where you can't do it. You know, you sell the house because you know, I'm tired of not being able to go home on certain nights each month, and having to get a hotel, and things like that. You know, it hurts."

Additional Community Ground-Truthing: Nuisance Flood Cost Survey

To supplement and build on interviewee experiences, the project team developed a survey to collect additional data on the types of costs flooding incurs on residents, including damage costs, time costs, wage costs. Costs of smaller flood events are not well documented in the research literature.

The survey was administered electronically and distributed through advertisements in the local newspaper, the City of Crisfield Facebook page, CAC outreach, and through postcards distributed to local businesses. As an incentive, respondents were entered into a raffle to receive one of two $100 gift cards to a local restaurant. Responses were collected between October 2022 and March 2023.

A total of 20 local residents and business owners completed the survey. Survey data suggest that floods cost households and businesses in Crisfield between $200-600 in in property damages per event, and $50-600 in proactive flood protection investments. Additionally, accessibility challenges to businesses and schools during these smaller nuisance floods cost residents time, resulting in lost wages for businesses and employees (See Appendix F. Nuisance Flood Survey Responses Summary).

residents, many suggested that the loss of this asset threatens to disconnect important community networks, as residents would be forced to relocate due to the lack of affordable housing alternatives in Crisfield.

The City government, as another important community institution, also has capacity challenges, which many attributed to a declining tax base resulting from flood-induced outmigration and property value declines. City officials and staff who were interviewed often reflected on how reduced tax revenues decrease budgets and staffing support needed to maintain infrastructure, upkeep coding and enforcement, provide public services, and secure needed resources to address flooding challenges. This results in the City having to choose between, as one individual noted during their interview, replacing dead batteries in one of the City's primary emergency vehicles used during flood evacuations and funding other pressing needs.

Community Resilience Goals

The overarching resilience goal expressed by interviewees is a desire to preserve and grow the community of Crisfield into a healthy, thriving place to live. Many interviewees described their future envisioned Crisfield as small waterfront community transformed into a Chesapeake heritage and eco-tourism destination with opportunities for visitors and residents alike to experience and support working waterfront traditions of the Chesapeake while enjoying the rich environmental and recreational amenities of the area. Interviewees collectively identified five pathways for achieving this:

Improve City Infrastructure

All interviewees suggested that building a more vibrant Crisfield necessitates improving drainage infrastructure to address flooding challenges. Without these improvements, repetitive flooding will remain a hinderance to retaining and growing businesses, jobs, and homeownership in the community. Drainage infrastructure improvements were the most widely discussed infrastructure improvements needs; however, water and sewer infrastructure, emergency service infrastructure (e.g., fire, police), public health and safety infrastructure (e.g., crime reduction, blight removal, healthcare services), and communications infrastructure (e.g., broadband internet) were also identified as needing more investments in order to support a more resilient and vibrant Crisfield.

Grow Business and Job Opportunities

A number of interviewees expressed a desire for business and job growth to enable more residents to stay vested in the local economy while attracting new residents to the area. Many expressed desires to see more eco-heritage tourism industries in Crisfield to capitalize on Crisfield's rich cultural and environmental experiences as a working watermen community. Others suggested opportunities through research and development industries (e.g., aquaculture, marine technology, desalinization, renewable energy), which some identified as pathways to help transition Crisfield's traditional seafood and agricultural industries in the face of future socio-environmental changes.

Build More Safe and Affordable Housing

Interviewees also expressed strong desires for more safe and affordable housing to increase opportunities for Crisfield's low-income families and attract newcomers to the area. Several interviewees pointed to the

disproportionately high reliance on public housing in Crisfield as an indicator of Crisfield's socioeconomic struggles. As described by on interviewees: "More than 1,000 of our residents live in public housing. Now, that's a referendum on who we are, and what we're dealing with. It's generational poverty." Interviewees noted that Crisfield's public housing is not only located in one of the most flood-prone locations in the city, which has triggered discussions about relocation, but is also prone to drug activity and gang violence. Limited rental options and homeownership opportunities for low-income families and the elderly has rendered public housing one of the few affordable options available for many, leaving this especially vulnerable sector of the community at increased social and environmental risk. The need for flood-safe and affordable housing was not only limited to the public housing community but extended across Crisfield, where many families reside in low-elevation homes prone to repetitive impacts. Others described this need in the context of attracting and retaining new residents to rebuild Crisfield's taxbase.

Invest in Youth Development

Youth development was a fourth theme emphasized across interviews, with many interviewees raising concerns about the lack of youth-oriented amenities and limited opportunities for upward mobility in Crisfield. Among those who spoke to this theme, there was general agreement that more investments in youth development is critical for keeping future generations vested in Crisfield. Desires for more youth development opportunities were often discussed in the context of recreation. Interviewees want to see more flood-safe spaces for children to recreate and have meaningful outdoor experiences, often describing the limited number of playgrounds, parks, and sports complexes available to children and adolescents. Of the few that are available, these tend to be prone to flooding (e.g., basketball courts, baseball field, Wellington Beach Park playground). Several interviewees suggested that recreational amenities are especially limiting for minority youth. Others expressed a desire to see more investment in community services to support youth-oriented skills training and mentorship programs, which could better connect youth to local entrepreneurial opportunities and community improvement initiatives, allowing them to play a more active role in shaping the future of their community.

Enhance Community Spaces

Interviewees also expressed desires to enhance community spaces to better support the social fabric of Crisfield. Some of the existing community spaces highlighted as important include the churches, schools, the library, civic organizations (American Legions, Elks Club, Lions Club), the Housing Authority and adjoining recreation center and basketball courts, many which are at risk to flooding. Others expressed a desire to have new community centers that could offer a broader suite of community and visitor services, including indoor recreational space, meeting and event spaces, classrooms to support youth and professional development programming, and tourism information and experiences. Some spoke of even grander community spaces in the form of a hotel-conference center, which advocates described as critical for transitioning Crisfield into a thriving tourism economy.

Using Interview Results to Guide the Assessment

The above-described community resilience goals provided the research team with a locally relevant framework through which to assess adaptation strategies for community benefits and costs. Throughout the

interviews, at least 50 associated community assets were discussed in relation to these community resilience goals (Appendix H. CAC-Identified Community Assets Supporting Resilience). These assets were collected into a list, which the CAC helped refine for the assessment process. As described in the following sections, these community assets in combination with the qualitative insights on flood vulnerabilities and flood costs were used to collaboratively refine modeling parameters, develop appropriate adaptation scenarios, and contextualize the team's evaluation of flooding costs and benefits to reflect Crisfield's lived realities.

CAC Workshop 1: Refining Community Resilience Goals and Associated Assets

The first collaborative CAC workshop took place on June 4, 2022, with the aim of verifying and refining community resilience goals and associated asset list identified through community interview research. Through a facilitated discussion, the CAC validated the community's desire to focus on more nuisance tidal flooding and smaller-storm events that more frequently impact daily operations in Crisfield. It also resulted in an expanded list of six community resilience goals: resilient infrastructure, flood-safe and affordable housing, business and job creation, enhanced recreational opportunities, youth development, and enhanced community spaces. CAC members also reviewed the associated community assets (see Appendix H. CAC-Identified Community Assets Supporting Resilience) to ensure they appropriately reflect the identified resilience goals. Through a participatory mapping exercise using the key assets and goals, the CAC identified seven geographic focus areas, which were used to guide the development of the models used in this assessment.

3. Selecting Hazards & Assessing Baseline Risk and Vulnerability

The following section outlines Steps 3 & 4 of the assessment process, which include identifying hazards of concern and estimating exposure and vulnerability to those hazards. While initial interviews and CAC discussions illustrated that sea level rise is a new and at times contentious topic, it remains a relevant hazard in light of how rising sea levels contribute to Crisfield's concerns about increasing frequencies of tidal flooding. The State of Maryland has conducted extensive research regarding how sea level rise is and will impact coastal communities like Crisfield. While the exact amount of sea level rise is uncertain, especially further into the future, sea level rise will affect coastal communities by increasing baseline water levels. **Error! Reference source not found.** is from the publication Sea-level Rise: Projections for Maryland

Year	Emissions Pathway	Central Estimate 50% probability SLR meets or exceeds:	Likely Range 67% probability SLR is between:
2030		0.6 ft	0.4 – 0.9 ft
2050		1.2 ft	0.8 – 1.6 ft
2080	Growing	2.3 ft	1.6 – 3.1 ft
	Stabilized	1.9 ft	1.3 – 2.6 ft
	Paris Agreement	1.7 ft	1.1 – 2.4 ft
2100	Growing	3.0 ft	2.0 – 4.2 ft
	Stabilized	2.4 ft	1.6 – 3.4 ft
	Paris Agreement	2.0 ft	1.2 – 3.0 ft

Table 1- Sea level rise estimates for Maryland.

2018.[5] The study's projections suggest a strong probability that sea levels across Maryland will rise between 0.8 and 1.6 feet by 2050 (NAVD 88, Mean Sea Level). Beyond 2050, the amount of sea level rise depends on many factors, so the table shows a wider range in future sea level estimates.

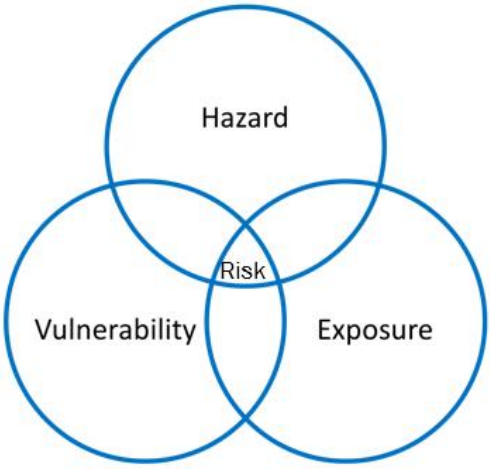


Figure 4. The combination of hazards, exposure, and vulnerability translates to the risk of damage.

Hazard Selection

For this analysis, we focused on the two water levels that the CAC and research team collectively identified to represent Crisfield's primary concerns about frequent and increasingly problematic tidal flooding, i.e., 1.5ft and 2.5ft above NAVD88. These water levels were modeled to assess baseline scenario flood hazards. The flood extents of these two scenarios are depicted below (Figure 6 and 7), as well as in Table 2, which summarizes the impacts of each water level on structures.

OBJ OBJ1.5ft water level will be close to projected sea levels slightly after 2040, and the 2.5ft water level may be sea level in 2060 (see OBJ

[5] Boesch, D.F., W.C. Boicourt, R.I. Cullather, T. Ezer, G.E. Galloway, Jr., Z.P. Johnson, K.H. Kilbourne, M.L. Kirwan, R.E. Kopp, S. Land, M. Li, W. Nardin, C.K. Sommerfield, W.V. Sweet. 2018. Sea-level Rise: Projections for Maryland 2018, 27 pp. University of Maryland Center for Environmental Science, Cambridge, MD. https://ntrs.nasa.gov/api/citations/20190000403/downloads/20190000403.pdf

Appendix B. NOAA Projections of Daily Inundation Depths

The baseline scenarios do not take into account any new flood-mitigating or adaptation strategies; rather, they depict the impacts of flooding under 1.5ft water levels and 2.5ft water levels given the state of Crisfield's existing infrastructure. In both baseline scenarios, all tide gates are considered non-functioning. This reflects not only observations made by this research team during field visits and through interviews but also by City staff and the CAC, who noted that observable tide gates were often clogged and/or had limited functionality while some could not be seen at all.

GMU developed a GIS database to characterize the current state of the existing stormwater infrastructure in the city, as these features influence the effectiveness of any other chosen adaptation strategies. Spatial information was gathered from the City of Crisfield Drainage Assessment Report, Maryland iMAP, aerial imagery, and field visits, and refined in collaboration with the project's CAC and City staff. The drainage system maps were published on a web application publicly available at https://arcg.is/1THzmG.

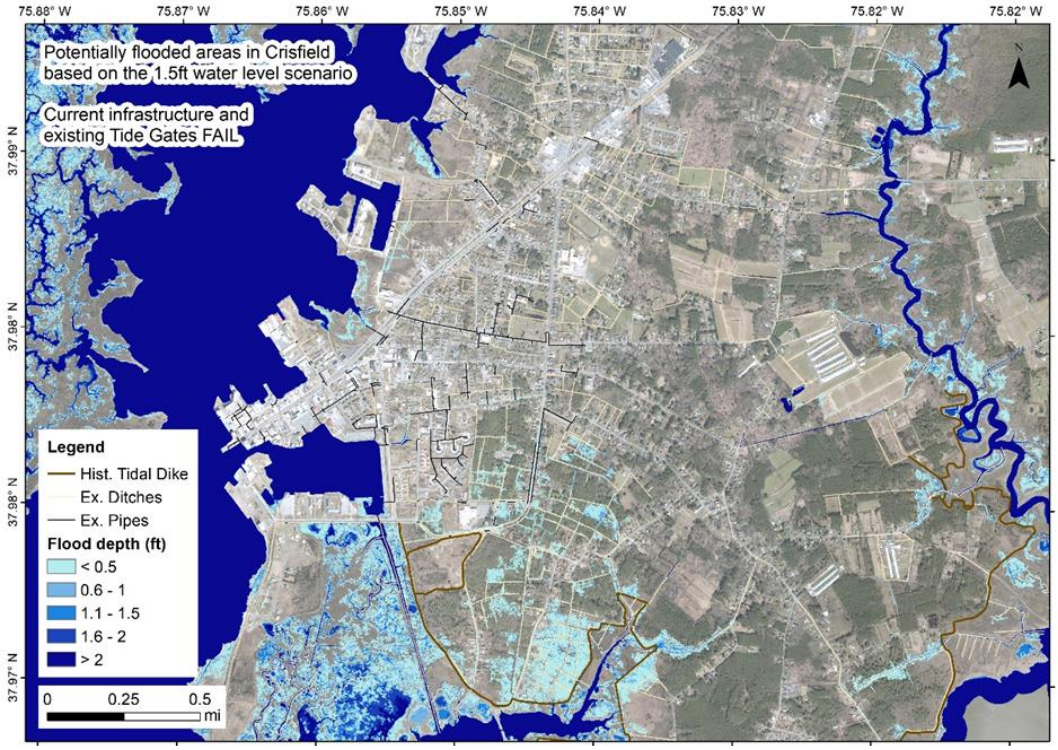


Figure 5. Baseline Scenario 1.5 feet of flooding (NAVD88).

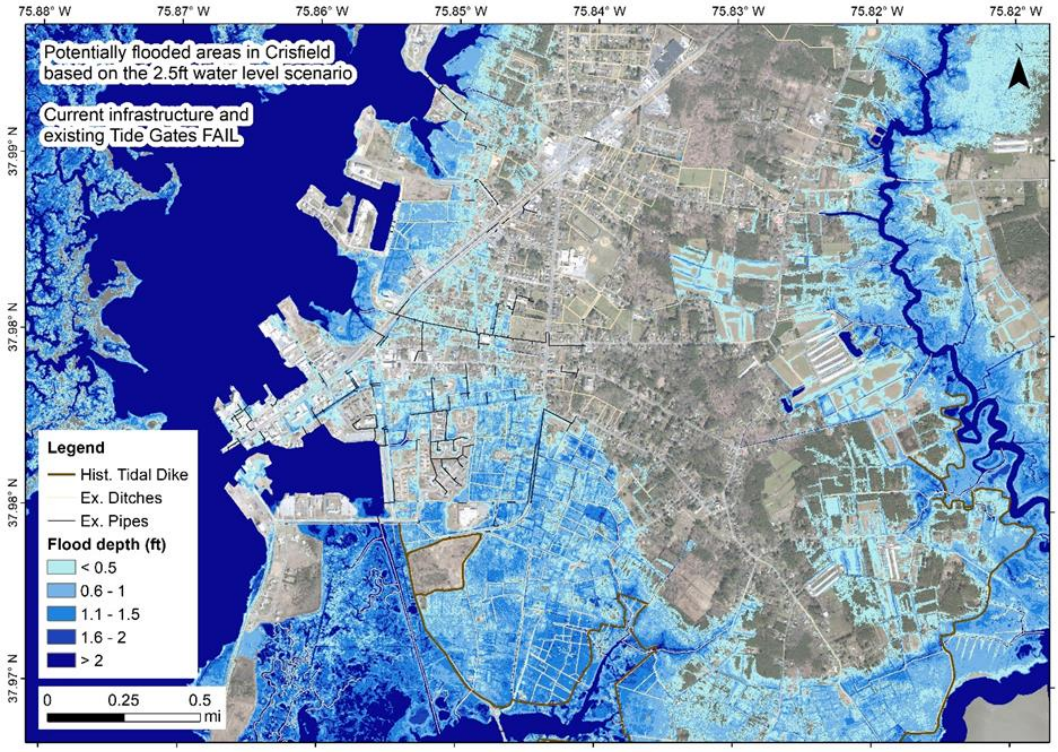


Figure 6. Baseline scenario 2.5 feet of flooding (NAVD88).

CAC Workshop 2: Defining Flood Hazards of Concern

The second collaborative workshop held on October 3, 2022 was used to refine how the CAC's prioritized tidal flooding hazards and drainage infrastructure were represented in the project's coastal hazard model. GMU research team members presented four modeled scenarios of recent flood events including a 2021 Nor'easter, Hurricane Isabel (2003), a 2021 high-tide storm event, and a 2021 sunny-day flooding event. The research team guided the CAC through a participatory mapping exercise to review maps for their accuracy, based on their lived experiences of these events, highlight missing drainage infrastructure, and select the maps that best represented their hazard of most concern. The CAC feedback helped the team refine their baseline flood scenario outputs. This workshop further validated CAC's desire to focus the assessment on adaptation strategies that can address smaller, more frequent and disruptive flooding hazards, which most often disrupt daily life and impact Crisfield's development potentials. The team and CAC collectively chose to represent these flood hazards of most concern as 1.5 - 2.5-foot flooding (above NAVD88).

Evaluating Exposure and Vulnerability

The next step of the assessment was to evaluate the exposure and vulnerability of Crisfield's structures to the selected flood hazards. Exposure is assessed by determining how many and which structures come into contact with flood waters and the depth of the water surrounding impacted structures. The vulnerability of exposed structures is then determined by estimating the amount of damage caused by the corresponding water levels. This damage is expressed as costs and is referred to throughout this report as "damage costs." Depending on a structure's location in the City or its building height, the exposure to flooding and vulnerability to damage will be different.

Both exposure and vulnerability for each baseline scenario were estimated using GMU's modeled water levels and flood extents. First, the water level raster was combined with data on all structures and parcels within the project focus area. This provided a list of how many and which parcels and structures may be inundated at different water levels. An additional classification was assigned to any structures and parcels that had been identified as community assets associated with the CAC's community resilience goals to enable analysis of impacts on community assets specifically. Parcel data from county databases for market values, structure footprint, zoning type, and Federal Emergency Management Agency (FEMA) HAZUS[6] depth damage data were used to estimate property damage. The depth of flooding, which is dependent on the elevation of the land, was used to determine the number of properties impacted by flood water in each scenario. For properties with corresponding structure data, it was assumed that a structure was present. Properties with no available structure data were assumed to be vacant. Vacant properties impacted by flood waters were not included in damage cost estimates but were counted as exposed properties. For parcels with structures

[6] HAZUS is a tool that uses data gathered nationally to estimate potential damages from natural disasters.

present, the year each structure was built was used to estimate the structure's vulnerability to damage costs. After 1981 (when FEMA floodplain maps were adopted—also known as post-FIRM (flood insurance rate map) construction), all new structures in floodplains were required to be built above the 100-year (1% annual chance) flood elevation. If the parcel database showed the structure was built in 1981 or later, then no damage was calculated given that the structure would assumedly have been built above the scenario's water levels given building code requirements. If a structure was built before 1981 and the building footprint was impacted by water levels in a flood scenario, the percentage of damage and corresponding damage costs were estimated based on the water levels within the structure footprint. Damage cost estimates were determined by matching the structures' zoning classification from the parcel database with national HAZUS depth-damage functions, further explained in Appendix E.

Results

The estimated number of structures exposed to damage in the baseline scenarios indicates that a 1.5ft water level causes damage to 34 structures and a 2.5ft water level causes damage to 405 structures. This estimate excludes impacted properties where flooding does not affect structures (e.g., where structures are elevated above potential water levels).

Under the baseline scenarios, the total flood damage cost estimates for the study area are $383,000 for the 1.5ft baseline scenario and $2,700,000 for the 2.5ft baseline scenario (

Table 2). Sixty properties are vulnerable to 1.5 feet of flooding compared to 607 properties in the 2.5ft flood baseline scenario.

Even if a parcel's structure is not impacted, access to and from properties with flooded areas may be impeded by flood water on roads, especially at the 2.5ft water level. The analysis shows that the 2.5ft water level impacts residential structures significantly more than the 1.5ft baseline scenario. It is particularly worth noting that the Housing Authority, one of the key community assets identified by the CAC, does not experience flooding with a 1.5ft water level but is likely to have structural damage with 2.5 feet of flooding. In both scenarios, however, the model shows flooding in the area surrounding the Housing Authority, indicating potential roadway and pedestrian access concerns.

The 1.5ft and 2.5ft baseline scenarios correspond to depths within today's 100-year flood depths (base flood elevations), which are approximately 3-4 feet above NAVD 88 or flood elevations of 6-7 feet. Modeling showed that above 2.5ft water levels, the adaptation scenarios assessed in this project were not able to reduce flooding. This indicates that 2.5 feet is the threshold of effectiveness for structural measures considered in these scenarios to protect Crisfield, an important consideration given future sea level rise projections.

Table 2- Estimated baseline condition flood impacts.

Baseline Flood Exposure & Vulnerability of Crisfield Parcels and Structures					
Baseline Scenario (NAVD88)	**Total Damage Cost Potential (per event)**	**Estimated Number of Parcels Impacted**	**Estimated Number of Structures with Damage**	**Description of Damage Cost to Structures**	**Impact on Housing Authority Structures**
Water level 1.5 feet	$383,000	60	34	The majority (77%) of total damage cost is to industrial and commercial structures, with 23% damage to residential structures. The City Dock is one of the assets with estimated damage costs.	Structures not flooded. Roads may have minor flooding.
Water level 2.5 feet	$2,700,000	607	405	The majority (80%) of total damage cost is to residential structures, with approximately 10% of damage costs each to commercial and industrial properties.	The area around the Housing Authority is flooded. Estimated structural damage to the Housing Authority totals $146,000.

4. Developing Adaptation Strategies and Scenarios

Once risk and vulnerability were determined, the assessment process then identified adaptation strategies with potential to protect Crisfield from the risks and vulnerabilities created by their flood hazards of concern, i.e., low-level tidally influenced flooding, represented in this project as 1.5ft and 2.5ft water levels above NAVD 88. This represents Step 5 in the Community Resilience Adaptation Framework. Many adaptation

strategies exist to protect property and reduce flood damage, each with varying levels of effectiveness, cost, and maintenance considerations. Adaptation strategies should be selected with specific goals in mind, including what to protect and under what circumstances the protection should function.

Selected strategies can then be combined with the selected flood hazards of concern to produce *adaptation scenarios,* Step 6 of the Community Resilience Adaptation Framework*.* Adaptation scenarios allow the research team to evaluate how well various combinations of strategies reduce flood impacts in comparison to the baseline flood scenario. The adaptation strategies evaluated in this project were selected to not only to evaluate how effectively they reduce flood exposure levels and damage costs, but also their potential for increasing opportunities for supporting the CAC's community resilience goals. Appendix G. NOAA Adaptation Strategy Options for Coastal Communities contains the full list of strategies that were considered in

Figure 7. Concept-level structural strategies and tide gate locations.

developing adaptation scenarios for this project.

The strategies incorporated into this project's adaptation scenarios are considered engineered barriers and infrastructure modification, and were co-selected with the CAC and local government partners. They include combinations of tide gates, berms, seawalls, and elevated roadways (Figure 7). While nature-based solutions were considered, it became clear to the research team that natural infrastructure would be less effective in addressing the community's flood concerns due to the city's extensive hardened shorelines, high water tables, and lack of infiltration for natural drainage within the project's defined focus areas.

The GMU team members modeled *four* adaptation scenarios to test how well the selected infrastructure modification strategies reduce flood vulnerabilities in the baseline scenarios for 1.5ft and 2.5ft water levels above NAVD 88 (Table 2). The scenarios, which build upon the City of Crisfield Drainage Assessment Report, include two combinations of strategies: 1) 43 functioning tide gates within (19) and outside (24) of Crisfield jurisdictional limits to prevent backflow into the stormwater system, referred to as the *Tide Gate Scenario*; and 2) those same 43 functional tide gates plus three flood-mitigating structures: 1) road elevations totaling 9,700 feet in length, 2) a berm of 4,200 feet in length, and 3) an elevated seawall of 3,500 feet in length (referred to as the *Tide Gate + Three Structures Scenario)*. These strategy packages were combined with the 1.5ft and 2.5ft water levels to form the following four scenarios (see Figure 8 and Figure 9):

- Tide Gate Scenario at 1.5ft water level
- Tide Gate + Three Structures Scenario at 1.5ft water level
- Tide Gate Scenario at 2.5ft water level
- Tide Gate + Three Structures Scenario at 2.5ft water level

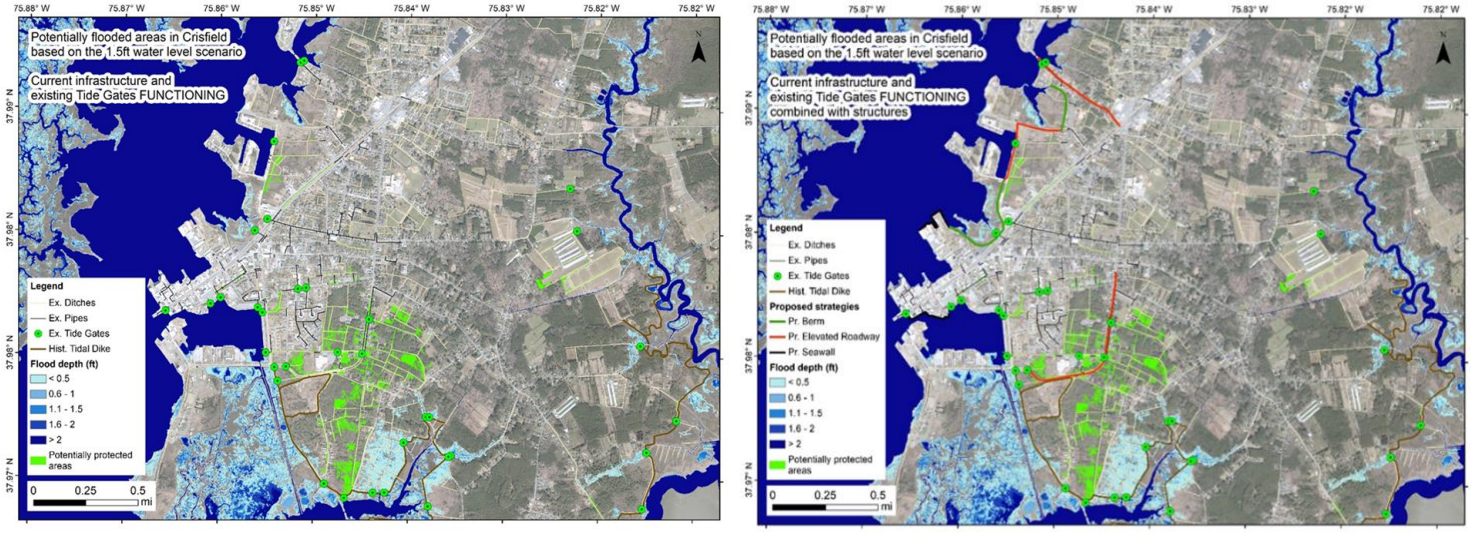
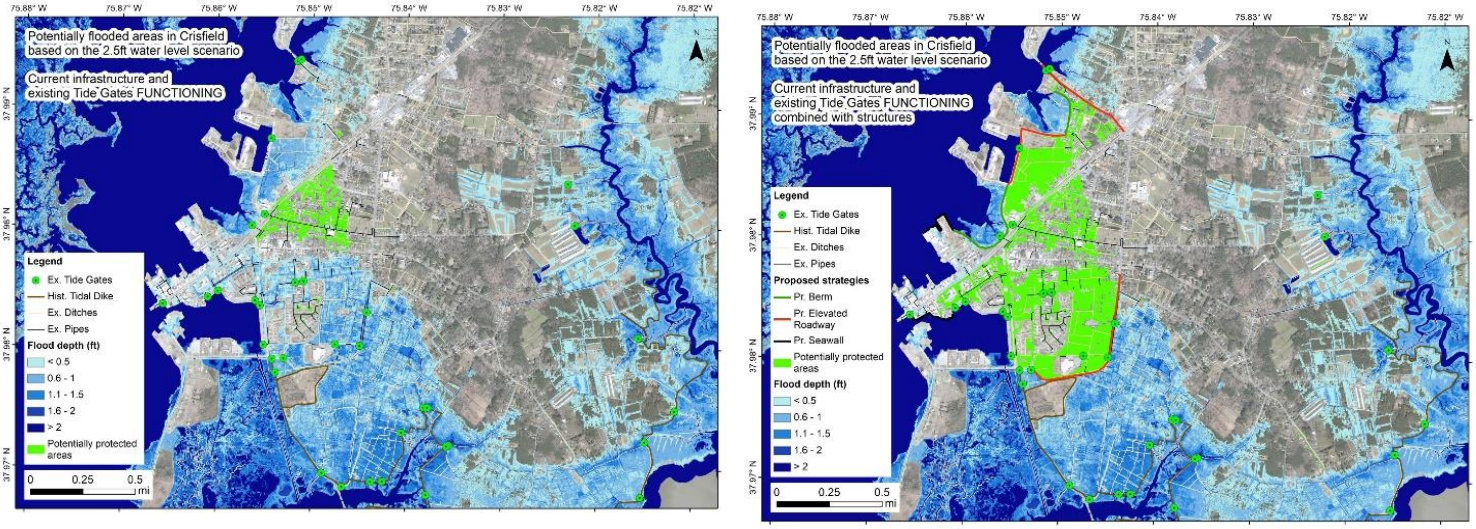


Figure 8. Left: Tide gates, 19 in the city and 24 in the county to prevent backflow into the stormwater system with a 1.5 foot water level. Right: Tide



gates and road elevation length of 9,700 ft, berm length of 4,200 ft, and 3,500 ft length of an elevated seawall with a 1.5 foot water level.

Figure 9. Left: Tide gates, 19 in the city and 24 in the county to prevent backflow into the stormwater system with a 2.5 foot water level. Right: Tide gates and road elevation length of 9,700 ft, berm length of 4,200 ft, and 3,500 ft length of an elevated seawall with a 2.5 foot water level.

5. Developing an Adaptation Decision Matrix for Crisfield

Figure 10. CAC prioritization of community assets for resilience during Workshop 3.

Step 7 of the Community Resilience Adaptation Decision Framework focuses on refining the decision criteria used to evaluate the selected adaptation scenarios. This step seeks to integrate descriptive, qualitative community criteria with the more quantitative criteria of conventional benefit-cost analyses to evaluate risk and vulnerability, benefits, and feasibility. The goal of integration is to guide the research team and community towards holistic, community resilient adaptation planning decisions for Crisfield. In this project, the collaborative process employed through the Framework was critical for collecting input from the CAC toward identifying and refining key decision criteria, which the research team used to develop a discrete yet locally relevant decision-making tool called the *Adaptation Decision Matrix*.

The Adaptation Decision Matrix identifies a range of evaluation criteria and organizes them into three primary domains to allow decision-makers to comprehensively compare the baseline and adaptation scenarios for their costs to benefits. The matrix serves as an "adaptation checklist" of sorts for identifying the scenarios that most effectively reduce exposure and vulnerability, support the community's resilience goals, and are most feasible (see Figure 11. The Adaptation Decision Matrix with co-refined criteria.). The first domain includes quantitative criteria for evaluating *Exposure and Vulnerability*. These include standard evaluation criteria for estimating flood exposure and damage costs to parcels and structures, but adds to these community-informed criteria for examining how exposure and vulnerability changes for key community resilience assets, including damage costs, exposure, and accessibility to these assets.

The second domain focuses on *Benefits for Community Resilience.* This domain builds upon the quantitative evaluation outputs from the first domain and captures qualitative descriptions of how reductions to flood exposure and vulnerability contribute to advancing the community's resilience goals. This domain helps bring

into focus considerations of the broader social and economic benefits of adaptation, which tend to be more indirect and difficult to quantify. In the Adaptation Decision Matrix developed for Crisfield, the criteria listed under this domain are the resilience goals identified through initial interviews and validated and refined by the CAC (see Section 2).

The third and final domain contains criteria related to *Feasibility*, which include considerations of implementation and maintenance costs, permitting and regulation requirements, local capacity to support the implementation and maintenance of the strategy, political will and public support, financing. It also includes considerations of how long benefits can be sustained given future sea level rise projections.

The utilization of the criteria contained in these three domains expands upon the 2013 NOAA Economic Framework by allowing for considerations beyond the largely quantitative benefit-costs analysis paradigm, to include evaluations of more qualitative dimensions related to community health, well-being, and project feasibility. This attends to the risks that others have noted regarding benefit-cost analysis, where a focus on "the economic value of property protected, result[s] in an inequitable distribution of funds to those people whose property is of greatest value" (NOAA 2022, p. 93). This is particularly important in the case of Crisfield, where property values are low and therefore evaluating the monetary value of property damage reductions alone fails to capture the magnitude of need and potential.

CAC Workshop 3: Refining Scenarios and Developing an Adaptation Decision Matrix

On December 10, 2022, the research team shared four proposed adaptation scenarios, which included a combination of recommended tide gates, berms, and elevated roadways from the 2021 City of Crisfield Drainage Assessment Report (CCDAR) under the two selected water levels (1.5 feet and 2.5 feet above NAVD88). Through workshop discussions, the CAC refined these interventions, expanding berms and adding additional tide gates and a seawall with boardwalk – an idea proposed by one CAC member to enhance tourism and community amenities. This workshop was a critical for step for defining key community criteria for the Adaptation Decision Matrix. To facilitate this process, CAC helped the research team prioritize a shortened list of community assets to focus their analysis of the adaptation scenarios. Fourteen prioritized assets were selected based on their importance to the community resilience goals. Working in small breakout groups, the CAC and research team used these priority assets as proxies to qualify the broader community impacts of flood reductions – or lack thereof – in each scenario. The resulting discussions identified the importance of considering improvements to accessibility, changing flood frequencies, and the community's capacity to support strategy implementation and maintenance. These discussions also helped the team to begin to qualitatively evaluate how scenarios contribute to advancing the community resilience goals.

The Adaptation Decision Framework Matrix			
Scenario	Criteria		
	Exposure & Vulnerability	Impacts to Community Resilience	Feasibility
	Sub-Criteria	*Sub-Criteria*	*Sub-Criteria*
Baseline Flood Scenario (No Interventions)			
Adaptation Scenario 1			
Adaptation Scenario 2			

Decision Criteria	*Sub-Criteria*
Exposure and Vulnerability	1) Estimated Number of Exposed Parcels
	2) Estimated Number of Exposed Structures
	3) Estimated Damage Costs to Exposed Structures
	4) Estimated Number of Community Assets Exposed to Flooding
	5) Estimated Damage Costs to Exposed Community Assets
	6) Accessibility
Benefits and Costs for Community Resilience	1) Resilient Infrastructure
	2) Flood Safe and Affordable Housing
	3) Job Creation and Business Development
	4) Enhanced Recreation and Tourism Opportunities
	5) Youth Development
	6) Enhanced Community Spaces
Feasibility	1) Implementation and Maintenance Costs
	2) Regulatory and Permitting Requirements
	3) Capacity
	4) Political Will and Public Support
	5) Financing Pathways
	6) Time Horizon of Benefits

Figure 11. The Adaptation Decision Matrix with co-refined criteria.

6. Assessment Results

Exposure and Vulnerability

Following the Adaptation Decision Matrix, we first evaluated how the adaptation scenarios reduce exposure and vulnerabilities throughout Crisfield. Looking across all Crisfield parcels and structures,

Table 3 shows how each adaptation scenario changes flood exposure and vulnerability (i.e., damage costs) compared to the baseline scenarios at the two water levels. The estimated damage reduction to structures increases with deeper flood levels from $49,000 per event at a 1.5ft water level to $1,519,000 per event at a 2.5ft water level. The protection of community-identified assets is summarized in

Table 4.[7]

The assessment reveals that the *Tide Gate Scenario* does not protect assets, but the *Tide Gate + Three Structures Scenario* reduces damage to one asset and removes flood waters from around six others.[8] The number of properties and structures that are protected is highest with the *Tide Gates + Three Structures Scenario* at 2.5ft water levels. Properties are considered protected by strategies if the flood water is no longer on the parcel, and structures are considered protected if flood waters do not enter the structure footprint. Of note, the Housing Authority -- a key community asset where roughly one-third of Crisfielders live -- is best protected (structurally and access-wise through reduced road flooding) by the *Tide Gate + Three Structures* scenario.

Given the social and economic costs of frequent flooding in the Crisfield community today (see Section 2), it is also worth considering how the frequency of 1.5ft and 2.5ft flood events may change in the future with sea level rise. Data from a nearby tide gauge (Solomons Island) indicates that in 2021, 1.5ft water level occurred 88 times, and a 2.5ft water level occurred six times[9]. Based on NOAA's sea level rise projections for this area, it is likely that Crisfield will experience 1.5ft water levels as a daily event by 2030 and the 2.5ft water level may occur daily between 2050 and 2080 (see Appendices A and B).

We also evaluated reduced vulnerability and exposure of community assets critical for advancing community resilience goals.

[7] the *Tide Gates Scenario* and *Tide Gates + Three Structures Scenario* produce the same results at the 1.5ft water level; only one of these scenarios is utilized in the table for this reason.

[8] The EPA is conducting analyses that model connectivity and road access, preliminary outputs from which are viewable in Figures 12 and 13. The tide gate strategies may improve connectivity and road flooding.

[9] https://tidesandcurrents.noaa.gov/inventory.html?id=8577330

Table 4 lists four community assets that were identified during the baseline assessments as exposed to flood waters during an event with 1.5ft water levels, and one community asset (City Dock) as vulnerable to flood damage costs. The table describes how their exposure (flood water around structure) and vulnerability (damage costs) change under the *Tide Gate + Three Structures Scenario* at 1.5 feet above NAVD 88. At 1.5 feet of flooding, the *Tide Gate + Three Structures Scenario* does not change flood impacts to the four assets listed, nor does it reduce the estimated flood damage cost to the City Dock. The other three assets, Fisherman's Grille, MeTompkin Bay Oyster Company, and Captain's Quarters Condos are not likely to sustain damage because they were either built after 1981 and therefore the first floor is above water levels, or they only experience minor water levels that are not associated with damages estimated by HAZUS.

In contrast, the baseline scenario assessments show that fourteen community assets and their corresponding propoerties were exposed by 2.5ft water levels (see Appendix I). However, ten of the structures on these properties were built after 1981 or would only experience minor water levels, suggesting that these structures are not likely to sustain flood damage in this type of event. There are, however, four assets that may sustain damage when 2.5ft water levels occur. These include the City Dock / "The Depot," MeTompkin Bay Oyster Company, Blancia Rose Faith and Healing Chapel, and Charity Holiness Deliverance Center. Under the scenario with functioning tide gates alone (*Tide Gates Scenario*), the damage risk is not reduced. However, with the addition of elevated roadways, berms, and a seawall in the *Tide Gates + Three Structures Scenario*, seven flood-prone assets would no longer experience flooding within the property boundary (i.e., "impact removed"). Furthermore, two of the assets likely to sustain damage in the *Tide Gates Scenario* (Blancia Rose Faith and Healing Chapel and Charity Holiness Deliverance Center) have these vulnerabilities removed in the *Tide Gates + Three Structures Scenario*.

The CAC identified accessibility to and from community assets as another important criterium to evaluate as part of assessing vulnerability. Project partners from the EPA Office of Research and Development (EPA ORD) developed modeling outputs to enable to the team and CAC to collaboratively consider how accessibility improves under the adaptation scenarios (see Figures 12 and 13). EPA ORD developed these by first estimating the average drive times for residents to travel the most direct route to all asset parcels in greater Crisfield under normal water levels (i.e., non-flood conditions). Using GMU's baseline and flood-adaptation scenarios at 2.5 water levels, EPA ORD then estimated water depths on roadways to identify sections of road that would be inaccessible under the baseline and adaptation scenarios. These data were then used to calculate additional average drive times for residents to safely navigate around flooded roadways to reach all asset parcels. The differences between travel times under normal water levels and travel times under flooded conditions were calculated to estimate access changes for each scenario. For parcels with no accessible roadways under flood conditions, these parcels were identified as inaccessible. Figures 12 shows access change for the Baseline Scenario at 2.5 feet water levels compared to non-flood conditions, while Figure 13 shows access change for the *Tide Gates + Three Structures Scenario* at 2.5ft water levels compared to non-flood conditions. Examined together, they demonstrate that accessibility within the City Limits improves under the *Tide Gates + Three Structures Scenario* at 2.5 ft. water levels, with drive times reduced and access to previously disconnected parcels and priority community assets restored. However, they also suggest that accessibility remains a challenge for those south of the city limits (e.g., in the Down Neck area), even under

this best-case adaption scenario. These accessibility maps were used to collect qualitatively input from the CAC on how accessibility changes directly or indirectly affect Crisfield's ability to advance its community resilience goals. These insights are summarized in the following section as well as in Appendix J.

Table 3- Adaptation Scenario Impacts compared to 1.5ft and 2.5ft Baseline Scenarios.

Adaptation Scenario Benefits: Reduced Exposure and Vulnerability for Crisfield Parcels & Structures				
Scenario (NAVD 88)	**Damage Cost Reduction Potential (per event)**	**Number of Assets Protected**	**Estimated Number of Properties and Structures that Benefit from Reduced Damages**	**Impact on Housing Authority Structures**
Tide Gate + Three Structures Scenario at 1.5ft water level	$49,000	0	18 properties and 14 residential structures	Structures not flooded. Roads may have minor flooding.
Tide Gate Scenario at 2.5ft water level	$503,000	0	155 properties and 126 structures	No change from the baseline for structures' flood damage. Roads may have minor flooding.
Tide Gate + Three Structures Scenario at 2.5ft water level	$1,519,000	7	378 properties and 267 structures	Structural damage removed. Reduced road flooding. Access to other areas in Crisfield improved.

Table 4- Asset protection from the 1.5ft flood with adaptation scenarios.

Adaptation Benefits: Reduced Exposure and Vulnerability for Community Resilience Assets at 1.5ft Water Levels			
Scenario (NAVD 88)	**Assets Impacted**	**Damage Cost**	**Description of impact**
Tide Gate + Three Structures Scenario at 1.5ft water level	Fisherman's Grille	0	Built after 1981; estimated structural damage of $0. The asset may experience access challenges.
	MeTompkin Bay Oyster Company	0	Flood levels do not reach the depth to cause damage based on damage functions used. The asset may experience access challenges.
	Captain's Quarters Condos	0	Built after 1981; estimated structural damage of $0. The asset may experience access challenges.
	City Dock / "The Depot"	$129,000	No change in flood damage estimates.

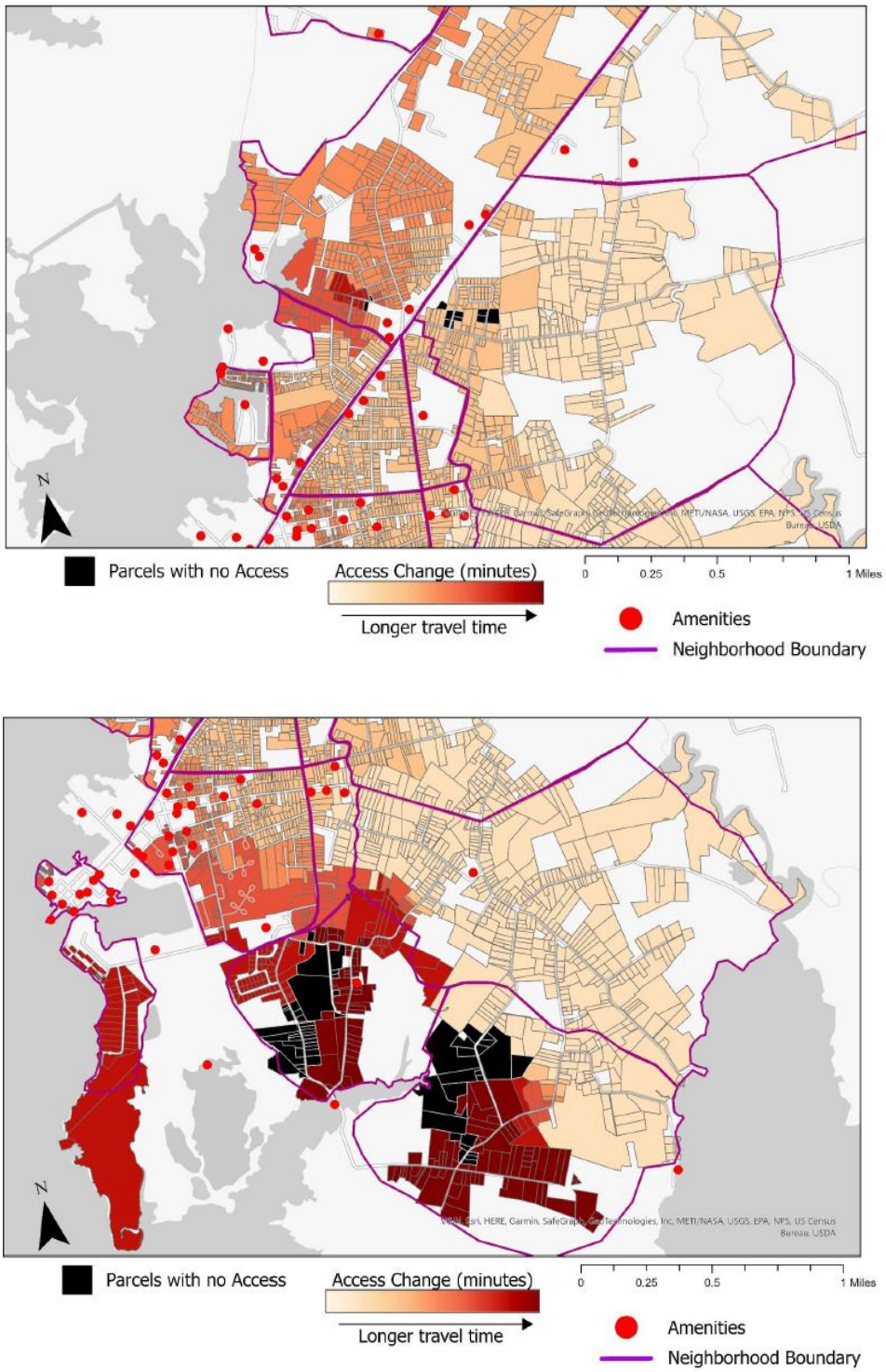


Figure 12. Access to Community Assets (red dots) in northern Crisfield (top) and southern Crisfield (bottom) under Baseline Scenario at 2.5ft Water Level (NAVD88). Maps display change in drive time from normal water levels per residential property.

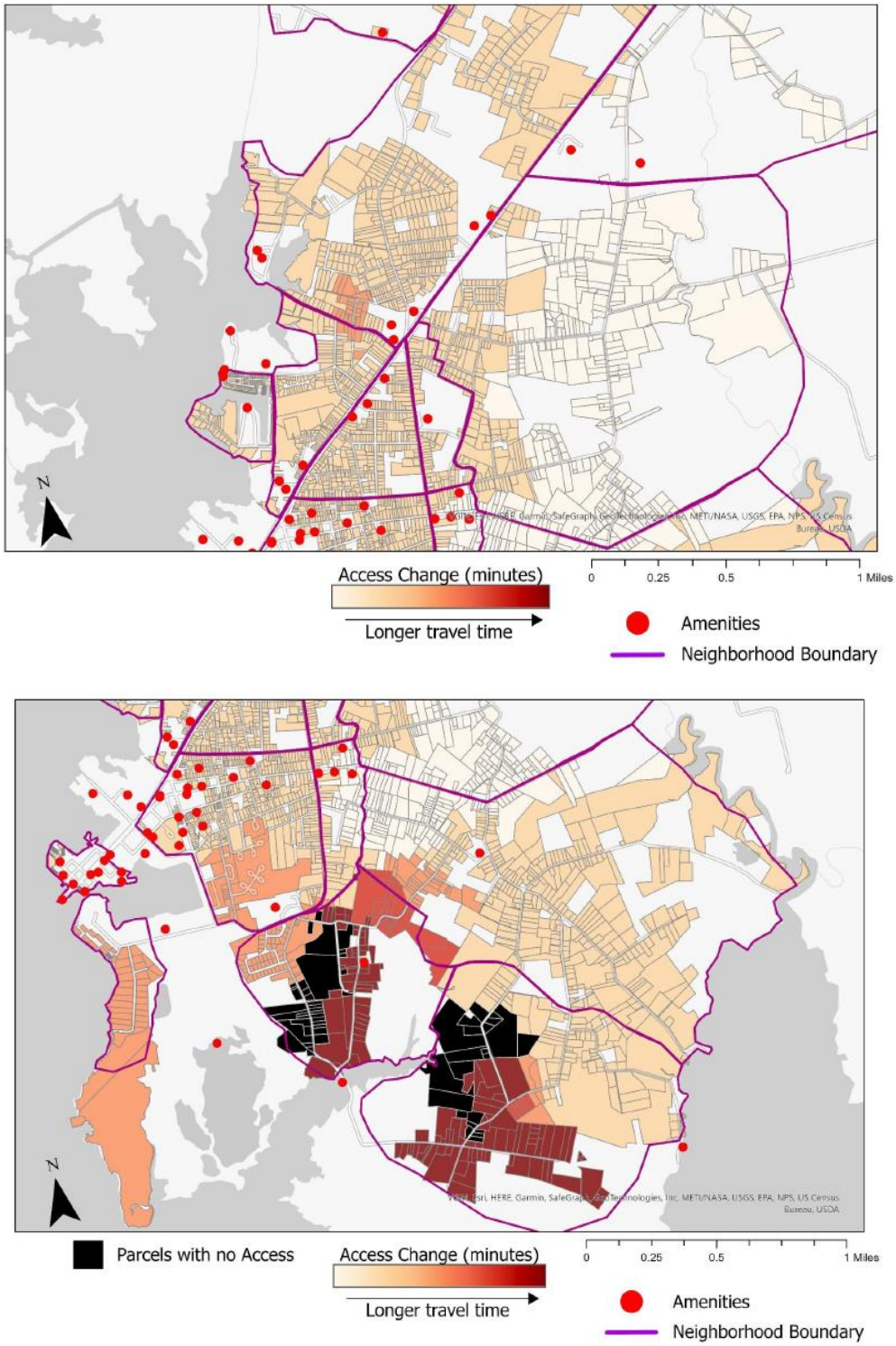


Figure 13. Access to Community Assets (red dots) in northern Crisfield (top) and southern Crisfield (bottom) under *Tide Gates + Three Structures Scenario* at 2.5ft Water Level (NAVD88). Maps display change in drive time from normal water levels per residential property.

Benefits & Costs to Community Resilience

This project modeled very high to high-frequency flood events that will become even more frequent in the future (see Table 5). These events cause less structural damage than lower-frequency storms and hurricanes, so the damage costs associated with an individual smaller flood event may be relatively low. However, the cumulative impacts of these events in a community are significant. The cost-effectiveness challenge, which applies to all flood mitigation projects, is to select and design adaptation measures that reduce flood damage and other impacts while keeping costs lower than the benefits of the projects. The damage reduction estimates from the analysis presented in this report are conservative and include reduced damage costs for structures based on flood events that may occur up to six times a year.

Table 5- Quick screening for cost effectiveness.

	Likelihood of Cost-Effectiveness			
Attribute	**Very High**	**High**	**Moderate**	**Low**
Frequency of Flood	10-year flood	10- to 25-year flood	25- to 50-year flood	50- to 100-year flood
Level of Damage	Very high damage	High damage	Limited damage	Minor damage
Project Cost	Low relative to damages	Moderately-low relative to damages	Close to cost of damages in frequent floods	High relative to damages in frequent floods
Project Benefits	Very high	High	Moderate	Low
Criticality (impact or loss of function)	Very high, broad damages to community	High damages to key facility; community	Moderate loss of certain functions limited impact	Little or no loss of functions; minor impact

(Source: *How to Determine Cost-Effectiveness of Hazard Mitigation Projects*, Chapter 3 from FEMA's Mitigation BCA Toolkit Version 2.0)

Social costs to the community are not quantified here[10] but are important to consider based on the information collected from preliminary interviews and the nuisance survey (Section 2) as well as discussions with City staff and the CAC. If social costs are reduced or avoided, that is a benefit of the project. Social costs include the cost of time (needing to drive out of the way to avoid flooded roads), displacement costs (requiring temporary lodging because your house is flooded), costs of lost business productivity, school closures, loss of wages due to inaccessible roads or business closures, and the costs

[10] Social and environmental costs were not explicitly part of the grant scope but could be part of a future analysis. Additional data to estimate these costs per person may include more surveys and interviews to determine the costs per person and event (e.g. for displacement or loss of school hours).

of mental stress and anxiety associated with these disruptions and other daily routine changes. Some estimates of these social costs range from several hundred to several thousand dollars per day. For example, school closures cost an estimated $179 - $214 per household per day.[11] This is estimated based on lost wages from parents or caregivers. Mental stress and anxiety from flooding are estimated at $2,443 per event with lost productivity at $8,736 per event.[12]

While social costs were not directly accounted for in this assessment, the project's community resilience goals (see Section 2) were utilized within the project's framework to assess how flood adaptation strategies more broadly benefit the social fabric of Crisfield beyond reduction of damages to properties and structures. By evaluating how well strategies support these community resilience goals, additional benefits of these adaptation strategies become more apparent. The *Tide Gates + Three Structures Scenario* proved to best support community resilience goals. With regards to supporting resilient infrastructure and flood-safe affordable housing, this scenario provided the most improvements to the Downtown area and locations surrounding the Housing Authority, both in terms of reduced flood impacts and accessibility. It was noted that this scenario supported enhanced community spaces, as the majority of Crisfield's churches were protected and access to these important community centers was also largely improved. Youth development was also supported by keeping school areas dry and reducing the number of school delays and closures due to access challenges. However, it is worth nothing that It Takes A Village to Teach Our Children – a community-based organization that provides educational services and childcare for at-risk youth -- was on the border of modeled flooding, as a such remains vulnerable to impacts. Economic, business, and tourism opportunities were supported by protecting the Downtown area where many businesses are located. It was also noted that the protection provided in this scenario could provide opportunity for new business development. Despite improvements for much of Crisfield, sections of the community located south of the City, known locally as the Down Neck area, do not see much in the way of benefits from even the best case adaptation scenario examined in this project. This raises environmental justice concerns, as these members of the community would likely increasingly struggle with flood impacts, which in turn would exacerbate this already social vulnerable section of the community. Table 6 displays the community assets that the CAC prioritized, and which of these assets supported the varying community resilience goals scoped via this project. This table put alongside the CAC's qualitative summaries of community resilience (Appendix J) benefits further help illuminate how various adaptation strategies directly or indirectly support community resilience.

[11] Gall, M., Sheldon, T. L., & Collins, L. (2022). The economic impact of school closures during the 2015 flood in Richland County, South Carolina. Risk, Hazards & Crisis in Public Policy, 13(3), 255-276.
[12] FEMA Introduction to Benefit-Cost Analysis, The Benefit-Cost Model Unit 3. (https://www.fema.gov/sites/default/files/2020-04/fema_bca_student-manual_unit-3.pdf)

CAC Workshop 4: Evaluating Adaptation Scenarios

On May 6, 2023, the research team collected evaluation feedback on model outputs of the refined adaptation scenarios, using four CAC-identified decision criteria: accessibility, costs, capacity, and flood frequency. To support these discussions, EPA Office of Research and Development (ORD) shared new model outputs that examined the revised adaptation scenarios through accessibility dimensions. UMD EFC also shared initial damage cost estimates for the revised adaptation scenarios. CAC members reviewed these data alongside model outputs of adapted flood extents to offer additional qualitative evaluations of benefits and costs of adaptation strategies. Project partners from EPA ORD also led charrettes on community capacity, helping to refine the team's grasp of capacity-related challenges and opportunities for actionable adaptation pathways. CAC members and the research team also engaged in a collective examination of changing flooding frequencies in Crisfield as recorded through historical tide gauge data. The group discussed how these patterns might evolve with future sea level rise, and the implications of changing trends for the adaptation strategies examined via the assessment.

Table 6- Prioritized community assets supporting community resilience goals.

	Resilient Infrastructure	Business and Job Opportunities (Including Recreation and Tourism)	Safe and Affordable Housing	Youth Development	Enhanced Community Spaces
City Dock		x			x
Crisfield High School		x		x	
Carter G. Woodson Elementary School		x		x	
It Takes a Village to Help Our Children				x	
Wellington Beach		x			
Little League Park					x
Tidal Health Hospital	x	x			
Crisfield Fire Dept.	x				
Janes Island		x			
Crisfield Housing Authority			x		
Rubberset		x			
Little Boat Harbor		x			
Somers Cove Marina		x			
Churches*					x
Stores*		x			
Community Center**				x	x

* includes all churches and stores in the Crisfield community
** a future community center that has yet to be established

Feasibility

Policy Strategies and Funding Options

Successful implementation of adaptation strategies for communities will require multiple approaches and considerations. These may include programmatic adjustments, education and outreach programs, and the establishment of novel funding mechanisms. It will also be essential to consider capacity building, policy reforms, and regulatory measures alongside physical infrastructure enhancements.

This section explores the feasibility of the structural flood adaptation strategies evaluated in this project (i.e., those strategy packages included in the *Tide Gates Scenario* and *Tide Gates + Three Structures Scenario*s) under Crisfield's current conditions. It identifies potential funding and financing opportunities and introduces other policy and planning avenues for Crisfield decision-makers to consider as part of the City's adaptation planning efforts.

Feasibility of Strategies

The feasibility of the strategies explored in this study is an important consideration when weighing decisions about which strategies to advance. The strategies may be feasible from a flood mitigation effectiveness standpoint (i.e., they would reduce flood impacts), but there may be other factors that could make implementation of the strategies more challenging. Other important feasibility considerations for these strategies include permitting and regulations, capacity and maintenance, public support and political will, and financial needs.

Flood Protection

In terms of flood protection, the *Tide Gates Scenario* does not sufficiently reduce flood impacts within the City. However, it is more financially feasible because it is a less costly option and would likely take less time to implement. On the other hand, The *Tide Gates + Three Structures Scenario* improves and alleviates flood impacts up to a 2.5-foot water level, which would yield near-term benefits for much of the City. However, this scenario will likely be more difficult to implement due to the need for more community engagement, funding, engineering, design, permitting, procurement, construction, and long-term operations and maintenance considerations.

The introduction of FEMA BRIC Direct Technical Assistance (DTA) support improves the feasibility of implementing any effective flood adaptation strategies for Crisfield. The additional capacity of the DTA team, who have experience developing and implementing flood mitigation projects and FEMA applications, will help the City navigate the process, develop the most effective projects possible, and strengthen their applications for funding. The flood adaptation projects that the DTA team has developed aim to reduce flooding during a major storm, so they should yield the most benefit to the community out of all the options explored throughout this project.

It is important to note that the FEMA BRIC designs will not directly benefit the low-lying areas that are part of the wider Crisfield community but outside the municipal boundaries. However, there are efforts underway to pursue more funding that will ensure that the wider Crisfield community is accounted for in the future.

Regulations and Permitting

Any infrastructure project that is proposed for the area will need to comply with applicable local, state, and federal regulations and may be subject to approval from relevant government agencies that either have jurisdiction over a location or are providing funding for the project. Permit review processes can add time and complexity to project development, so this must be factored into planning. Given that the City is within the 100-year (1% annual chance) floodplain and is within the Critical Area, any fill, dredging, and construction would necessitate state, federal, and local permits under the Clean Water Act and state and local laws. For instance, construction in FEMA-designated floodplains has a set of requirements as well, such as consideration of raising the 100-year base flood elevation and no net fill in the floodplain. Some projects require excavation to balance any new fill caused by a project.

The process and permits required in regards to Critical Areas are further discussed in *Section 4. Critical Areas in the Bay Watershed* in the Addendum Report.

Capacity

The capacity of the City, as well as other key partners (particularly Somerset County), is another important consideration to factor for successful implementation of flood adaptation projects. Local governments need staff and/or access to consultants that have the time, knowledge, and support to pursue funding, design, and implementation of projects, as well as ongoing administrative and maintenance needs. Leaders that support and champion an initiative are critical as well. Although Crisfield is small, having staff and capacity dedicated to pursuing grants and funding opportunities allows the City to maintain momentum over time. Support from the FEMA BRIC DTA program will help support the City and provide expertise on flood mitigation practices, while also delivering FEMA application support that will strengthen the City's funding submissions to that agency.

For the longer term, the City will need to manage and maintain its flood mitigation infrastructure to ensure its continued performance. Ongoing maintenance has already been a challenge for the City's stormwater drainage infrastructure, which consists primarily of ditches (see *Section 1. Stormwater Maintenance* in the Addendum Report for more information). Securing funds, staff or consultants, and equipment to conduct regular maintenance of existing and new infrastructure will be important. Cross-jurisdictional partnerships with other entities, especially Somerset County, are a strong option to pursue for operational and maintenance needs in the future.

Non-profits and community-based organizations also serve as additional capacity for the community. One group that is currently active in the City and surrounding community is the Eastern Shore Long Term Recovery Committee (ESLTRC), which is supported by Maryland Voluntary Organizations Active in Disaster (VOAD). This group brings in resources, including funding and labor, to rebuild and lift homes after floods. They have provided support to many residents so they could reoccupy their homes and stay in the community after enduring flood damage. As the City moves forward with flood adaptation projects, they should maintain relationships with ESLTRC and other community organizations to coordinate efforts and maximize the benefits of each other's work.

Political Will and Public Support

Engaging community members meaningfully as early in the process of a project as possible can help ensure that their goals are heard and their concerns are addressed and will increase participation and public support. On the other hand, if community members have major concerns about the proposed projects and feel that they have not been addressed, they may seek to change or delay the projects. As described in the previous sections, this project has been very intentional in fostering a sense of empowerment by listening to community members, focusing on community strengths and goals, and developing a collaborative process to build the adaptation decision framework.

It is also imperative to bring local governments into the process, as they will be the decision-makers to implement the framework. Additionally, being cognizant of the political and policy priorities of the local administration is also key to garnering support.

Financial

Design and construction costs for large structural flood adaptation projects are often exceptionally costly. Communities often combine multiple sources of funding to complete infrastructure projects. For instance, if the City of Crisfield wishes to pursue any of these adaptation strategies (road elevations, a berm, a seawall, and/or functioning tide gates), cost estimates will be necessary to pursue funding for projects. The strategies were selected to maximize flood reduction; further analysis may reveal different configurations of strategies that would be most effective. The structural interventions assessed in this study are not low-cost options. Based on estimates from NOAA factsheets[13], a seawall can cost $150-$4,000 per linear foot, and berms (also called levees or dikes) can cost $100-$1,500 per linear foot. Road elevation costs would be dependent on the support and involvement of the Maryland State Highway Administration or other partners such as Somerset County.

Many places take advantage of federal disaster funding from FEMA and/or HUD as well, if available. Detailed cost estimates were not prepared for the conceptual adaptation strategies proposed in this project. However, the City's FEMA BRIC application, which includes some of the strategies outlined in this project, have projected and estimated costs to reach over $60 million. These costs are significant, making funds one of the biggest barriers to implementation.

Flood mitigation and other infrastructure projects that are located in rural areas sometimes fail to meet federal funding cost effectiveness thresholds simply due to lower population density or lower property values. Consequently, communities seeking federal funding must account for as many benefits as possible to improve the competitiveness of funding requests. Even in the absence of federal funding considerations, a benefit-cost analysis can support local government decision-making to help anticipate future costs and benefits, as well as to better inform decision-making on spending limited tax dollars.

Funds to support ongoing maintenance costs of new projects, combined with the operations and maintenance needs of existing infrastructure, may also be a challenge given the City's budget

[13] NOAA. June 2013. What Will Adaptation Cost? An Economic Framework for Coastal Community Infrastructure. https://coast.noaa.gov/data/digitalcoast/pdf/adaptation-report.pdf

constraints. Designing projects with streamlined maintenance in mind should help, but operations and maintenance will still be necessary and strategies to support these costs should be developed. If regular operations and maintenance needs cannot be met, the risk of costlier repairs, failures, and reduced structural lifetime rises over time.

Funding and financing options

Communities that employ a diverse mix of funding and financing mechanisms to support an initiative tend to have more success, especially over time. Diversifying funding sources helps withstand variability and reduces the risk of failure if individual sources fall through. Securing ongoing funds to support administration and operations (i.e., staff, maintenance) should be part of any successful strategy. Municipal, state, federal, and private opportunities and revenues as well as cost-reducing strategies for adaptation projects and programs are discussed in the following sections.

Municipal Revenue

It is important for the long term to allocate revenue to pay for ongoing costs, especially infrastructure and project operations and maintenance, which are rarely eligible for grant dollars. Revenue is also important because it can provide non-federal matching funds for grants. Stormwater and ditch maintenance financing ideas are suggested in *Section 1. Stormwater Maintenance* in the Addendum Report. An additional revenue stream that may be an option for the region is a Resilience Authority, which is detailed in *Section 5. Resilience Authorities* in the Addendum Report as well. Table 7 provides an overview of typical municipal funding sources and different types of revenue options.

Table 7- Summary of revenue or cash flow management tools.

Source	**Cost Coverage**		**Strengths**	**Weakness**
	Capital	**O&M**		
General Fund	Yes	Yes	Can be used to support all program costs	Competes with other community priorities, changes from year-to-year, less equitably spreads costs across payers
Grants	Yes	No	Good source for “shovel ready” project implementation, demonstration projects, and initial program staff	Not guaranteed, highly competitive, suitable for demonstration projects, not sustainable in the long-term
SRF & Loan Programs	Yes	No	Can offer up-front capital for larger projects	Not guaranteed funding source, highly competitive, must often repay with interest
Bond Financing	Yes	No	Can be used for large, long-term expenditures	Dependent on fiscal capacity, must repay with

				interest, cost of securing bond may be high
Permit, Development & Inspection Fees	Yes	No	Offers nexus to system and program expansion needs	May not sufficiently cover program costs, may deter development
Stormwater Utility Fee	Yes	Yes	Can generate sufficient revenue, sustainable, dependable, equitable depending on design, support all program costs	Requires significant public dialogue, can create administrative challenges
Tax Districts	Yes	Yes	Can generate sufficient revenue, sustainable, dependable	Necessitates enabling statute, can have equity problems due to property value basis

Note: Financial Burdens of Flooding and Sea Level Rise Adaptation

Bringing in as many outside dollars as possible to finance flood mitigation projects in a community helps reduce the financial burden on local government and taxpayers. The proposed projects that are part of the City's FEMA BRIC application(s) would likely be impossible to execute without significant external funding that comes mostly in the form of grants that do not need to be repaid, given the magnitude of the projects' costs compared to the City's typical annual budget.

In this case, the City has to contribute or locate additional non-federal matching funds for the FEMA grant dollars. They are pursuing various additional kinds of financial support ranging from additional state and federal grants and low-interest loans, again to reduce impacts on local taxpayers. Although projects are being designed to simplify future maintenance needs, there will still be ongoing maintenance costs that will likely need to be shouldered by Crisfield.

Without implementation of major flood mitigation projects in or near Crisfield, the financial burden of repetitive and increasingly frequent flooding will continue to be borne largely by community members and local governments, except in the case of more severe events that trigger federal support. Lost municipal revenue is part of the financial burden the community will experience if no action is taken.

State and Federal Level Grants and Loans

Most state and federal funding sources are well-known to the City of Crisfield and supporting partners. As such, they will not be covered in depth. However, relevant funding options are listed below and additional details are provided for certain opportunities that are more relevant or promising for the City's flood adaptation efforts. Below are tables on potential state and federal grant funding opportunities.

Table 8- Notes about state grants and low-interest loans that may support flood mitigation / adaptation and related infrastructure and habitat projects.

DNR	Chesapeake and Coastal Grants Gateway (Grants Gateway) supports planning and projects that address pollution, flooding, erosion, outdoor education, and waterfront sustainable development. Some grants require match and some do not. https://dnr.maryland.gov/ccs/Pages/funding/grantsgateway.aspx
MDE	The Comprehensive Flood Management Grant Program contributes to the non-federal matching funds for federal grants to implement flood mitigation projects, or contributes a larger portion of funding if a project does not have federal funding support. https://mde.maryland.gov/programs/Water/StormwaterManagementProgram/Pages/floodmgmt.aspx
DHCD	Administers HUD Community Development Block Grants. https://dhcd.maryland.gov/Communities/Pages/programs/CDBG.aspx
SHA	Studies and capital project funding may be requested through the Consolidated Transportation Program (CTP) for state- or locally managed roadways. More information is below.
MHT	Maryland Historical Trust (MHT) provides grants, loans, and tax incentives to support historic preservation-related activities. https://mht.maryland.gov/Pages/funding/funding.aspx
RMC	Rural Maryland Council's Rural Maryland Prosperity Investment Fund provides grants to local government applicants proposing intergovernmental community development projects, including infrastructure improvements. https://rural.maryland.gov/

Additional information about Maryland Department of Transportation (MDOT) State Highway Administration (SHA) Resources

It may be possible to acquire state transportation funding to support the adaptation strategies outlined in this project, should the proposed FEMA BRIC funding be insufficient. The primary process for securing this support involves county letters sent to the state each year. Communities pursuing transportation capital projects, including elevation or other roadway flood mitigation measures, can request state support by working through their county. Through this coordination, the county can suggest that the municipality should

be considered in the state's six-year capital budget under the Consolidated Transportation Program (CTP).[14] Counties submit a letter of transportation priorities to MDOT each year around April 1. Non-competitive funding can also be obtained by working with elected Congress members and representatives at the state level.

It is important to note that roadway improvements that serve rural areas may be less competitive than projects in more densely congested areas or in places that have major development projects planned. However, the state does try to spread funding around geographically so that heavily populated areas are not the only beneficiaries of state investments in transportation. Reviewing past letters can provide context and examples of successful and unsuccessful requests. Submitted letters from counties from the past several years can be obtained at the Maryland Priority Letter Map website.[15] Additionally, demonstrating that federal funding has been allocated to a project can help direct state funding to the project. Highlighting the importance of the project for disaster response and emergency management purposes can also help raise the priority of a project with the state.

Table 9- Notes about federal grants and low-interest loans that may support flood mitigation / adaptation and related infrastructure and habitat projects.

FEMA	In general, ensure City's priorities are reflected in Somerset County's Hazard Mitigation Plan and/or Flood Mitigation Plan, as this alignment helps support applications for FEMA funding. Flood Mitigation Assistance (FMA) supports projects to reduce flood risks for repetitively damaged properties insured through the National Flood Insurance Program (NFIP), as well as other capability and capacity building activities. Hazard Mitigation Grant Program (HMGP) - is available after federally declared disasters. In case of disaster, it is helpful to have ideas ready for using these funds in ways that strengthen resilience, rather than simply rebuilding preexisting conditions. Building Resilient Infrastructure and Communities (BRIC) supports projects to reduce risks from disasters, as well as resilience capability and capacity building activities.
HUD	Community Development Block Grants (CDBG) are passed down through the state can be used as match to federal funds. Funds are usually distributed via the Maryland Department of Housing and Community Development (DHCD).

[14] https://mdot.maryland.gov/tso/pages/Index.aspx?PageId=84
[15] https://mdot.maryland.gov/tso/pages/Index.aspx?PageId=82

FHWA	Promoting Resilient Operations for Transformative, Efficient, and Cost-saving Transportation Program (PROTECT) offers planning grants and Competitive Resilience Improvement Grants for surface transportation resilience projects; local governments can apply directly for this program or collaborate with metropolitan planning organizations (MPO). https://www.transportation.gov/rural/grant-toolkit/promoting-resilient-operations-transformative-efficient-and-cost-saving
USFWS (DOI)	Wildlife habitat grant programs could be used to support projects that also have flood mitigation or other community objectives incorporated into their designs. https://www.fws.gov/service/financial-assistance One example: North American Wetlands Conservation Act (NAWCA) grants support protection, restoration, and/or enhancement of wetlands and associated uplands habitats for the benefit of all wetlands-associated migratory birds. Partnering with conservation organizations is recommended to develop strategies and projects.
NPS (DOI)	The National Park Service (NPS) has grant programs to support historic preservation and heritage projects as well as conservation and recreation initiatives. https://www.nps.gov/subjects/historicpreservationfund/project-grants.htm https://www.nps.gov/getinvolved/community-assistance.htm
NOAA	The Office for Coastal Management (OCM) and the Climate Program Office (CPO) both offer grants that may pertain to climate adaptation and coastal habitat restoration. The specific types of projects supported through these programs vary from year to year. https://coast.noaa.gov/ https://cpo.noaa.gov/Funding-Opportunities/
EPA	Consider funding and technical assistance offered through the new Environmental and Climate Justice Program, particularly the Community Change Grants: https://www.epa.gov/inflation-reduction-act/inflation-reduction-act-environmental-and-climate-justice-program
USDA	Farm Bill cost-share programs can be used on privately owned agricultural lands to manage erosion and runoff, restore freshwater wetlands, improve forest health, etc.

	Low-interest Rural Development (RD) loans support infrastructure projects; two programs that may be applicable include: Water & Waste Disposal Loan & Grant Program in Delaware, Maryland Community Facilities Direct Loan & Grant Program in Delaware, Maryland
EDA	The Economic Development Authority provides Disaster Recovery Grants and Supplemental Funding to areas affected by Presidentially declared disasters. https://www.eda.gov/funding/
DOD	REPI Department of Defense's (DOD) Readiness and Environmental Protection Integration (REPI) Program preserves military missions by supporting cost-sharing agreements between the Military Services, other federal agencies, state and local governments, and private conservation organizations to avoid land use conflicts near military installations, address environmental restrictions that limit military activities, and increase resilience to climate change. https://www.repi.mil/

Private philanthropy

Private (non-governmental) philanthropic sources of funding are important supplements to grants, loans, and municipal revenue. These tend to be smaller than state and federal sources of funding.

Donations from corporations or grants from corporate foundations are another source of funding that some communities are able to use. Typically, the company has a presence in the region or similar relationship with a community, but some companies have purpose-directed grant programs.

Table 10- Summary of private philanthropic funding opportunities.

NFWF	Grants from NFWF are often federal in origin, so they usually require non-federal match and cannot be used to match federal grants. The National Coastal Resilience Fund (NCRF) should be a medium to high priority for future projects. The program supports "natural infrastructure to protect coastal communities while also enhancing habitats for fish and wildlife." This program currently does not have a matching funds requirement, so it is a good option for projects that involve both habitat and coastal flood resilience components. www.nfwf.org/ncrf
CBT	The Chesapeake Bay Trust provides grants to a variety of applicant types around the Chesapeake Bay for projects that improve water quality and address other issues. Programs that are particularly relevant include the Green Streets, Green Jobs, Green Towns grants and the Watershed Assistance Grant Program.

	https://cbtrust.org/grants/
CFES	Community Foundation of the Eastern Shore https://www.cfes.org/

Other Resources and Tools for Identifying Funding Opportunities

1. Maryland Water and Wastewater Funding Sources Compiled by the Environmental Finance Center Network, May 2022. https://efcnetwork.org/wp-content/uploads/2022/06/MD-Water-Wastewater-Funds-2022.pdf
2. Funding And Financing Options and Considerations for Coastal Resilience Projects. https://coast.noaa.gov/data/digitalcoast/pdf/financing-resilience.pdf
3. Navigating Federal Funding for Green Infrastructure and Nature-Based Solutions https://www.epa.gov/system/files/documents/2024-02/navigating-federal-funding-for-gi-and-nbs-master-summary_02_12_2024-508.pdf

Existing funds and cost reducers

There are a number of ways to reduce the overall cost of infrastructure, flood adaptation, and climate resiliency efforts. These include integrated decision-making and planning efforts, asset management, planning and regulatory methods, and collaboration.

Adjusting how funds “in hand” are spent is an important part of any comprehensive flood adaptation strategy. This means taking flooding into account when planning or implementing projects and programs going forward. This can include integration of current and future flood risks into request for proposals, updating the design of infrastructure when it is due to be repaired or replaced, or adjusting maintenance schedules. Asset management plans and capital improvement plans are excellent ways to begin integrating current and future flood risks into decisions and planned spending. Incorporating future flooding and precipitation projections into infrastructure design can also significantly help reduce future repair costs in the long-term.

Planning and land use decisions and regulations are another way to save money by avoiding future damage and repair costs by directing growth away from the most hazardous areas and into areas where future flood impacts are lower and existing infrastructure is more readily available. Similarly, codes and ordinances addressing how growth happens can improve community resilience directly into the development process.

Costs can also be spread across individuals and private entities by requiring or incentivizing resilient design via codes and ordinances. This is more directly applicable in situations where there may be wider community benefits from the adoption of certain practices on private properties. For example, reducing stormwater runoff by incentivizing the installation of green stormwater features across collections of individual properties reduces the cost burden that must be shouldered by the municipality.

Coordination and collaboration with other communities and the County is an approach to flood adaptation that can yield both cost savings and other benefits. Working with neighboring communities on projects and initiatives can create cost efficiencies. These regional approaches take many forms, from informal but routine peer-to-peer exchanges, to shared equipment and personnel, to codified intergovernmental agreements for the implementation of shared flood adaptation projects, infrastructure maintenance programs, or financing mechanisms.

Example: Coordination with Somerset County and the Maryland Department of Transportation (MDOT)

Coordination between Somerset County and MDOT would help with adaptation of roads and bridges maintained by different jurisdictions under different policies and regulations. Several of Crisfield's roads are vulnerable to flooding and are under the jurisdiction of the MDOT. As the city formulates its adaptation agenda, it should ensure ongoing communication with MDOT regarding local adaptation plans that could impact or be impacted by road, bridge culvert, and tide gate design and maintenance decisions. This collaboration is particularly crucial if local strategies would either bolster or be incompatible with MDOT or the County's current approach.

Locally, Crisfield can adopt policies for vulnerable road segments that are cost-effective. Given the escalating costs associated with flooding on road and bridge maintenance, Crisfield must prioritize cost-effectiveness in future infrastructure decisions. This entails integrating cost-effectiveness as a fundamental criterion for road and bridge designs, service level determinations, and maintenance schedules. Initially, this may involve utilizing a budgeting baseline, akin to the aforementioned approach, but should ultimately entail more formal measures. This could include revisions to the comprehensive plan transportation element or the enactment of an ordinance stipulating that the level of service for certain road and bridge segments is contingent upon their costs remaining close to the city-wide average.

Other Considerations and Planning Strategies

Other components to consider that help enable the feasibility of implementing adaptation strategies include public education, outreach, and engagement and priority planning for the short-, mid-, and long-term.

Outreach and Engagement

The City should continue to educate the public and both residential and commercial property owners about what sea level rise impacts and potential policy responses to expect in the foreseeable future. The City should develop a communications plan in conjunction with an advisory group of property owners that includes strategies for regularly engaging various city audiences in an on-going dialogue about the impacts of flooding. A risk communication and education tool that could also be developed is a robust flood early warning system as outlined in detail in *Section 2. Flood Early Warning Systems* in the Addendum Report.

Another public education tactic could include requiring disclosure statements for private parties to give or take notice of known risks, for instance by requiring disclosure in real estate transactions. Disclosures

could include the frequency and height of all types of flooding that affect the property, as well as documented access issues during smaller events.

In the United States, there is no federal mandate for home sellers to disclose details regarding a property's susceptibility to flooding or any past flood-related damage to potential buyers. Consequently, prospective homebuyers often encounter challenges in obtaining information concerning a property's flood history. Despite this, numerous individuals proceed with home purchases without such vital knowledge, potentially jeopardizing the safety and financial stability of their households without realizing it.[16]

Planning

It is also important to consider the amount of time, or lifespan, a proposed adaptation strategy will benefit the City's resilience. Time horizons or estimating the lifespan of strategies can be a tool to help understand the feasibility of these strategies and help prioritize them. Table 11 depicts the potential life span of flood mitigation benefits of each of the scenarios discussed throughout this project.

Table 11- Time horizon of benefits for three scenarios.

Scenarios (NAVD88)	Time Horizon of Benefits (Short-, Med-, Long-term)
Tide Gate + Three Structures Scenario at 1.5ft water level	Medium-term with the length of span influenced by active maintenance.
Tide Gate Scenario at 2.5ft water level	Medium-term with the length of span influenced by active maintenance.
Tide Gate + Three Structures Scenario at 2.5ft water level	Medium- to long-term with the length of span influenced by active maintenance.

As can be seen, most of the strategies outlined in this report benefit Crisfield for the medium term. As climate impacts continue to worsen, it will become more and more critical to account for them. For instance, the City is aware that the Comprehensive Plan is a tool to help guide future development and protection of resources. One option is to adopt "level of service standards." This means taking an

[16] Risk Factor. Learn about flood risk disclosures and which states have them. https://tinyurl.com/34xerbkn, Maryland has a grade of "D" for mandatory disclosure. https://www.nrdc.org/resources/how-states-stack-flood-disclosure

approach that would look at the expected services now and in the future for different assets and resources (including land use) and adopt policies to limit spending where relocation or redesign would be more cost-effective than reconstruction.

> ***Example: Designate Adaptation Action Areas or AAAs***
>
> *An AAA is a highly flexible form of zoning overlay to expressly facilitate local adaptation planning in the face of the impacts of sea level rise. Within the boundary of an AAA, Crisfield could employ one or more policies that are distinct from what governs other parts of the City. This would provide flexibility and the option not only to choose where to draw the AAA's boundary but whether to do so in a way that is expressly subject to change as environmental circumstances change. This approach could send a powerful signal about future conditions and regulatory responses to those conditions. AAAs have been implemented in some municipalities in Florida.*

Given the estimated lifespan of the proposed strategies in this project, it is critical to consider long-term strategies in concurrence to shorter- and mid-term strategies as this will only enhance Crisfield's resilience.

7. Future Horizons: Adaptation Pathways for Crisfield's Longer-Term Resilience

Planning for various and often uncertain impacts of climate change is a highly local and place-based process that is necessary to identify solutions that can meet the unique needs of each community. Cities and states across the country are creating climate adaptation plans and exploring various pathways to find the solutions that work for them. Like Crisfield, municipalities are exploring and developing strategic roadmaps for adapting with these uncertain futures. While long-term planning for climate change can seem like a daunting task, there are actions that can be taken today to protect and help support Crisfield's long-term socio-economic interests and envisioned futures even in the face of climate change.

We envision a climate-ready Crisfield implementing effective policy solutions, ensuring environmental justice for its residents, and serving as a model for state and federal policy change. Our goal is to provide a portfolio of options for city leaders and community members to consider, and a discussion of challenges and opportunities associated with each strategy. Each city, county, and state have its own unique considerations and priorities associated with long-term planning, and Crisfield is no different. Our policy team had conversations with climate change practitioners, local, state, and federal government officials, Crisfield residents, and local leaders from other coastal towns to collect a range of perspectives, experiences, and insights to help inform Crisfield's climate adaptation planning. We synthesized our research and conversations, and we analyzed a few long-term transitional and transformational policy tools can help the City of Crisfield adapt and be resilient to impacts of climate change. The list of strategies we analyzed was created after conversations with City leaders and decisions makers.

For Crisfield, flooding caused by high tides and storm surge are the top priorities to be addressed. The existing strategies outlined in the report before only safeguard against flooding up to 2.5 feet. However, climate projections indicate that by as early as 2050, this level of flooding could become a daily occurrence in Crisfield. Therefore, it is critical to plan for more sustainable, long-term investments for when the currently outlined strategies will fail. Long-term planning must continue to account for increased and more extreme impacts of climate change as rising emissions worldwide, will result in varied regional and local impacts.

This section of the report provides a summary and top recommendations for five near to long-term flood adaptation strategies, including 1) stormwater maintenance, 2) flood early warning systems, 3) land annexation, 4) critical area considerations, and 5) resilience authorities.

Climate Adaptation Recommendations for Crisfield

No one strategy will be able to meet all of Crisfield climate and resilience needs, rather a combination of strategies is needed to deliver the best results. In compiling the strategies below, our goal has been to consistently center the needs and resilience goals that the Crisfield community has shared with us through multiple workshops and conversations with the city leaders and residents. The vibrant community in Crisfield is deeply connected to the waterfront and surrounding nature. We must

continue to center people and planet together as we look towards implementing climate adaptation solutions in Crisfield.

The Nature Conservancy's policy analysis identifies several near- and longer-term non-structural adaptation pathways. These strategies could help enhance Crisfield's existing adaptation investments and preserve current and future social and economic opportunities. The recommendations include:

- Prioritizing stormwater maintenance to extend the lifespan of flood-mitigating structures;
- Establishing early flood warning system to enhance community flood risk communication and preparedness;
- Investing in procedures for climate-driven land annexation that identifies parcels outside of the flood zone for relocating critical assets and creates inclusive processes for county and city residents to help define community benefits of annexation;
- Avoiding new development in designated critical areas to protect their wave attenuation value; consider harnessing these natural spaces to increase economic opportunities through eco-tourism and recreation;
- Establishing and supporting a Lower Eastern Shore Resilience Authority to increase Crisfield's capacity and political power to address flooding through coordinated and strategic resilience planning and implementation with other communities and counties facing similar challenges.
- Reflect on a community driven relocation strategy for Crisfield, and invest resources in proactive visioning of a phased, equitable, community led, and culturally appropriate relation strategy for the city.

Implementing these measures collectively can significantly contribute to the City's long-term resilience. To provide further recommendations, below are snapshots of each of these strategies and their top considerations.

Stormwater Management

Across the Eastern Shore, a critical method for managing stormwater is maintaining roadside drainage ditches. These ditch networks play a significant role in stormwater management by facilitating the flow of water, preventing flooding, and controlling runoff. Ditch maintenance activities may include clearing debris, removing sediment, managing vegetation, addressing erosion issues, and maintaining associated structures. However, challenges such as funding, jurisdictional responsibility, data gaps, and conflicting practices, prevent effective ditch maintenance and water control. Climate change will increase the likelihood of extreme weather events, flooding caused by storm events and high tides has made enhancement of ditch maintenance practices an urgent need for Crisfield.

Top recommendations:

→ Apply for funding eligible for equipment procurement and maintenance (i.e. EPA Community Change Grants);

→ Promote Deal Island's Partnership education campaign on landowner easements and rights-of-ways to increase private landowners' awareness of their critical role in ditch maintenance;

→ Continue investments in gathering information and mapping ditch systems in Crisfield to increase water flow understanding;
→ Consider establishing a Public Drainage Association for sustainable funds to maintain private property ditches.

Flood Early Warning Systems

Flood early warning systems are a suite of technology tools that can help city governments identify areas at risk of flooding, anticipate frequency of inundation, and understand the intensity of damage from flood events. These warning systems allow city managers to mobilize resources quickly, take preventative action, and reduce damage to critical resources. Due to their life-saving functions, flood-prone communities are increasingly embracing flood early warning systems. A flood early warning system monitors and collects data on weather and water levels and issues warnings to prevent flood disasters and to mitigate risks. These systems can vary from simple river gauge monitoring networks to sophisticated forecasting systems to predict floods, with lead times spanning from minutes to days. Of great importance, effective flood early warning systems are people-centered and inclusive of the needs of city residents.

Top Recommendations:

→ Establish the goals and objectives of a flood early warning system that could meets Crisfield's needs;
→ Add a "Flood Management" tab to the Crisfield Mitigation or City website to increase the community's flood risk awareness and understanding of what to do during a flood and existing resources for help (I.e. CodeRED);
→ Identify and place simple flood markers around City for community to better gauge depth of flood waters;
→ Consider opportunities for students to organize and develop trainings and workshops aiming to make information from the local tide gauge accessible to the community;
→ Invest in other technological tools to enhance CodeRED's effectiveness.

Land Annexation

Municipal annexation is the process of legally including within the corporate limits of a city or town an unincorporated area that is outside the municipality. It is the primary mechanism used by cities to grow their tax base and land area. Cities all over the US annex territory to provide an expanded region with municipal services and to exercise regulatory authority necessary to protect public health & safety and improve the quality of life for its residents. More recently, annexation of land has also been used as a proactive planning tool to adapt to impacts of climate change. In Maryland this process is overseen by the Maryland Department of Planning and to successfully annex surrounding land a city must comply with guidelines set forth by the Maryland Department of Environment and identify its own goals for annexation.

Top Recommendations:

- → Explore framing land annexation with a climate-driven purpose by examining flood maps before investing in floodplain areas and identifying elevated sites for critical infrastructure relocation;
- → Expand benefits of land annexation to residents to include improved and increased 1) access to services and amenities, 2) agency over future development, 3) political influence, and 4) options to reduce flooding severity;
- → Update Crisfield's comprehensive plan and collaborate with Somerset County on theirs to ensure Crisfield's priorities and necessities for annexation are met.

Critical Areas

Critical Area is defined as all land and water areas within 1,000 feet beyond the landward boundaries of tidal wetlands, the Bay and its tributaries. Maryland's Critical Area Law and Criteria was developed in 1984, in response to serious and far-reaching problems affecting Maryland's water resources. The Law and Criteria were designed to foster more sensitive land use and development activity along the shoreline of the Chesapeake Bay, Atlantic Coastal Bays, their tributaries, and tidal wetlands. The Critical Area Program is an important partnership between the state and local governments to continue stewarding Maryland's fragile and vulnerable tidal wetlands. Under the critical area law, each local jurisdiction has the responsibility for developing and implementing its own Critical Area program. In its four decades of operation, the Maryland Critical Area Program has successfully minimized adverse growth and development impacts on tidal wetlands. It has also created a pathway for local governments to approve growth plans in a manner consistent with ecological health metrics.

Top Recommendations:

- → Leverage critical area spaces to capitalize on the natural environment to support eco-tourism initiatives;
- → Proactively plan for climate change impacts by limiting residential and commercial development in critical areas, and low-lying land prone to frequent flooding;
- → Communicate regularly with Critical Area staff to consider necessary policy amendments to adapt existing structures within critical areas to climate impacts;
- → Continue conversations and building relationships with Critical Area staff to leverage their expertise and creatively using critical areas as natural buffers for storm impacts;
- → Continue participating in local and regional policy conversations to create and/or update regulations that would allow the building of common-sense climate adaptation infrastructure in critical areas to protect surrounding communities.

Resilience Authorities

A resilience authority is an innovative policy tool that allows cities and municipalities to establish a non-profit organization and grant it certain powers to advance projects and programs on behalf of the city and/or municipality that established it. Maryland Bill SB0457 is the enabling legislation that allows Resilience Authorities to be created in the state. Resilience authorities provide institutional flexibility to adapt to unforeseen impacts. They are community-driven, are supported by community buy-in, and

focus on local priorities. Furthermore, they can pursue innovative and diverse funding streams and solutions that neither a government body nor a non-profit could achieve alone.

Resilience authorities can allow climate adaptation planning and infrastructure projects (both green and grey) to move forward in harmony.

Top Recommendations:

- → Resilience Authorities are more effective on a larger scale, so consider how Crisfield could be part of a regional and multi-jurisdictional Resilience Authority (I.e. Lower Eastern Shore or Somerset County and Crisfield);
- → Reflect on Crisfield's role in a regional Resilience Authority, and continue participating in local and regional planning efforts;
- → Reflect on how and where a regional Resilience Authority could be established.

Conclusion

Our team recognizes, respects, and honors the relationships to land and community that the residents of Crisfiled hold. The livelihoods, histories, and a vision of a resilient Crisfield have been front and center in the development of this work.

These recommendations and considerations represent a snapshot of long-term resilience planning strategies based on thorough research and conversations with climate practitioners. We would like to emphasize that these strategies are not mutually exclusive nor following a linear path to climate resilience and adaptation. Rather, the pathway to resilience in Crisfield should be built by investing in interconnected strategies that align with the broader community resilience goals. For example, investing in annexation holds the potential for climate-driven benefits, allowing the relocation of critical infrastructure away from vulnerable areas as well as garnering public support for annexation. Similarly, exploring eco-tourism opportunities in critical area zones can serve as a long-term investment, promoting sustainable economic growth while preserving the natural environment. Introducing a resilience authority presents an avenue to secure crucial funding to further enhance community resilience goals, effective stormwater management, implementation of a more robust flood early warning systems, and other resilient infrastructure investments.

These strategies are by no means an exhaustive list, but rather a list of priorities we heard from the city and residents. Other strategies that are worth exploring include living shorelines, ecosystem restoration, floodable and floating development, insurance policy terms, and strategic movement to minimize risk.

For long term resilience of the Crisfield community, the city government and residents must reflect on a community driven relocation strategy for Crisfielders. We do not make this recommendation lightly, nor is it meant to supersede earlier and proactive climate adaptation recommendations. This recommendation is made with knowledge of climate science and the world's current emissions trajectory.

According to the US Fifth National Climate Assessment, "The more the planet warms, the greater the impacts. Without rapid and deep reductions in global greenhouse gas emissions from human activities,

the risks of accelerating sea level rise, intensifying extreme weather, and other harmful climate impacts will continue to grow. Each additional increment of warming is expected to lead to more damage and greater economic losses compared to previous increments of warming, while the risk of catastrophic or unforeseen consequences also increases." [23]

Proactively planning for strategic movement will minimize risk to human lives, and allows for the creation of a process that is community led, inclusive, and culturally appropriate. The White House and FEMA intentionally use the term, "community-driven relocation" in their guidance. The intent of our recommendations, and the work of federal agencies tackling this challenge at the national level is to collectively reinforce consideration for implementation of planned relocation projects that are grounded in a community's ability to define and determine their future.[24] We recommend the following actions for Crisfield;

- → Invest resources and capacity in visioning what this community driven relocation for Crisfield residents could look like with an emphasis on maintaining community bonds, though in geographies more protected from frequent floods;
- → Seek out partnerships for Crisfield that can help the residents access scientific knowledge and expert perspectives to support a Crisfield specific relocation strategy, this can be done by partnering with organizations in Maryland, and nationally who are investing time and resources into similar community driven relocation strategies;
- → In the next 3-5 years, identify what resources Crisfield would needs from the state government to implement a voluntary and community led relocation program
- → Build upon partnerships with advocacy organizations and advance legislation that would provide Crisfield with the resources and technical support to begin implementing a community led relocation program over time.

The City must prioritize planning for climate change, especially rising sea levels, to secure the sustainability and survival of both the City and its surrounding community. This is essential, especially considering Crisfield's ongoing exposure to exacerbating climate change impacts. Integrating climate change considerations into planning processes will help address the challenges and, importantly, enhances the competitiveness, resilience, and sustainability of funding proposals, projects, and initiatives. Finally, the city must start reflecting on and proactively planning for a community led relocation strategy to prepare residents for the worst impacts of sea level rise.

Addendum Report: Adaptation Pathways for Crisfield's Longer-Term Resilience

This report is an addendum to the Future Horizons section above and provides a more comprehensive understanding of the challenges and opportunities, as well as detailed implementation guidelines for the strategies outline above to enhance Crisfield's long-term climate resilience and adaptation efforts.

The strategies covered in this report include *(click on each header to read more)*:

1. Stormwater Maintenance
2. Flood Early Warning Systems
3. Land Annexation
4. Critical Areas in the Bay Watershed
5. Resilience Authorities

1. Stormwater Maintenance

Overview

Stormwater management is a comprehensive approach to control and mitigate the adverse impacts of stormwater runoff on the environment to protect water quality, infrastructure, and communities to prevent flooding. It involves a combination of infrastructure design, regulatory compliance, pollution prevention, monitoring and maintenance, and community engagement to create sustainable and resilient stormwater systems.

Across the Eastern Shore, a critical strategy for managing stormwater is maintaining roadside drainage ditches. Roadside ditches are a common feature in the landscape, running alongside nearly every mile of road and highway. These ditch networks play a significant role in stormwater management by facilitating the flow of water, preventing flooding, and controlling runoff. They intercept around 20 percent of the runoff and shallow interflow from nearby land areas. Proper maintenance of ditches is crucial to ensure their effectiveness in handling stormwater and runoff. Ditch maintenance activities may include clearing debris, removing sediment, managing vegetation, addressing erosion issues, and maintaining associated structures.

Although initially intended for agricultural drainage, these ditch systems now play a crucial role in managing storm drainage from urban town centers, state highways, county roads, as well as new commercial and residential developments. With increased extremes, associated with climate change, such as high-intensity rainfalls and flooding, enhancing ditch management and maintenance is already becoming more and more critical.

Challenges of Ditch Maintenance

Funding

While the ditch system exists, there are multiple challenges in maintaining them. To ensure the functionality of these ditch systems, comprehensive maintenance of all ditches is imperative, facilitating

the efficient drainage of water to designated areas, preferably infiltration and detention ponds to minimize environmental impacts. A critical factor in achieving this is securing adequate funding for maintenance. However, funding constraints have been identified as the primary obstacle across all jurisdictions in Maryland when it comes to implementing effective ditch maintenance.

For example, Somerset County faces a significant shortfall, with only $100,000 annually allocated for ditch maintenance, despite a calculated need of approximately $2.5 million. The City of Crisfield alone has indicated a need of $200,000 for maintenance efforts. The shortage extends beyond mere monetary allocations; there is often insufficient funding to expand staff capacity. Even if funding for additional staff is secured, a shortage of essential equipment further impedes the ability to properly maintain ditches. The success of grant applications in addressing these challenges has been varied, with many grants not earmarked for maintenance or the acquisition of necessary equipment.

Jurisdictional Responsibilities

Similar to roads, ditch systems cross multiple jurisdictions (i.e. state, county, and municipality) and there is an absence of an efficient communication network spanning the numerous independently operating jurisdictions within the Chesapeake Bay watershed. This challenge is compounded by the general lack of awareness of private landowners who hold control over road right-of-ways. Beyond public lands, many ditches exist on private land, and maintenance staff only have access for management purposes. Landowners often perceive the widening of ditches as a reduction of their lawn space, and they generally resist accommodating changes to ditch management practices. This situation leads to a pervasive issue of determining "responsibility" for maintaining these ditch systems, resulting in inconsistent maintenance practices and, consequently, the shortcoming of the entire ditch system.

Data and Information Gaps

Many jurisdictions have never mapped or inventoried their ditch networks, and even fewer have assessed the volume flow or materials moving through their ditch systems. This lack of mapping and information further exacerbates the jurisdictional responsibility challenge. While the information required to create these maps exists, such as previous easement or right-of-ways agreements with private landowners, they are often in paper format and difficult to access. Furthermore, staff turnover can result in significant loss of institutional knowledge, emphasizing the need for documentation of processes. However, there is an overall lack of staff capacity to document, digitize, and create these maps, processes, and operating procedures.

Conflicting Policies and Practices

There is a lack of clear guidance and established protocols for effectively overseeing the maintenance of ditches among local governments, practitioners, and landowners. The common practice of scraping without re-vegetation can lead to increased erosion problems, and the deepening of ditches is capturing more subsurface flow. Instead, reestablishing natural filters, like bio-swales, compound or "two-stage" channels, and level lip spreaders, can enhance groundwater recharge and address contaminant issues. Shaping ditch excavations into shallow, trapezoidal, or rounded profiles, rather than V-cuts, not only reduces concentrated, incisive flow and sediment erosion but also facilitates routine mowing while minimizing the potential for storm flow to undercut and destabilize roadbeds. Proper design and

implementation of best management practices, customized to the specific location, are crucial for effectively managing water volume and quality, as well as maintaining habitat conditions.

In communities where ditches are linked to tidal or non-tidal water, obtaining additional permits is necessary for ditch maintenance and debris removal. Invasive species, like phragmites, present additional challenges in management. The impacts of sea level rise and climate change further compound flooding and erosion issues, emphasizing the need for centralized guidance.

Recommendations and Considerations to Pursuing more Effective Ditch Maintenance

Funding Sources

As outlined above, a major challenge is having enough funding to maintain these ditch systems. As part of this analysis, below are some funding opportunities that Crisfield can pursue to enhance staff capacity and equipment purchase (more considerations for funding can be found in previous Funding and financing options Section).

- EPA Community Change Grant
- HUD Preservation and Reinvestment Initiative for Community Enhancement (PRICE) Competition

Public Drainage Associations

Another avenue to have the funds needed could be to establish a Public Drainage Association. Public Drainage Associations and Public Watershed Associations maintain approximately 821 miles of ditches that help drain 183,000 acres of land on the Eastern Shore. These associations operate as independent entities of government and possess rights-of-way and easements for maintenance and construction purposes as codified by Maryland Law in 1957. In Somerset County, there are multiple PDAs east of Route 13, however none west of it due to historic and environmental contexts.

Public Drainage Associations, guided by a local board of managers and supported by the Maryland Department of Agriculture and Soil Conservation Districts, are responsible for overseeing the yearly maintenance of public drainage systems. Additionally, they have the authority to levy assessments on landowners who derive benefits from the ongoing maintenance efforts (I.e. they are funded by beneficiary landowner taxes). The process to establishing a Public Drainage Association (also coined as tax ditch association) is challenging because a petition needs to be signed by one-third of the landowners and a public hearing needs to be convened, during which the County council determines the formation of the association. However, it could provide and sustain funding needs for ditch maintenance on private lands. This map of the Public Drainage Associations shows the ditch systems their respective associations are responsible for.

Similarly, Delaware also has passed legislation that allows for a tax ditch to be established within a given watershed. These are organized by tax ditch organizations, which are entirely composed of landowners and are officially supervised and supported by the Department of Natural Resources and Environmental Control.

Mapping and Information Gathering

Multiple ditch mapping efforts, led by the Eastern Shore Regional GIS Cooperative, have resulted in a better understanding of the existing ditch systems. Recently, in 2023, an initiative to build off of George Mason University's data on Crisfield drainage system was completed. The City of Crisfield Ditch Map and corresponding StoryMap can be found on Crisfield's Flood Mitigation website. This map allows users to view parcel data, water and sewer infrastructure, and address points. The map also helps understand and identify the flow of water through the existing ditch infrastructure to help plan for management to improve flood control, such as strategically identifying areas for stormwater retention ponds.

Education and Centralized Framework

Due to the lack of guidance and protocol, especially as flooding, erosion, invasive species, and more exacerbate with climate change, a centralized framework on best management practices for ditch management and maintenance for practitioners and crews is needed. Recognizing this imperative, the Science and Technical Advisory Committee of the Chesapeake Bay Program has published a report in 2016 emphasizing the necessity of such a framework and outlining the leadership role they would play in addressing this issue.

The education initiative extends beyond practitioners to include private landowners. Many landowners, especially newcomers to the Eastern Shore, may not be aware that jurisdictional governments offer ditch maintenance services. Moreover, there is a lack of awareness regarding the requirement for easements or rights-of-way agreements to facilitate ditch maintenance on private property. To address this gap in knowledge, an education campaign targeting private landowners is crucial.

The Deal Island Peninsula Partnership is actively engaged in developing a relevant education campaign for all residents on the Lower Eastern Shore, aiming to inform them the importance of ditch management and the role of easements or rights-of-way agreements to facilitate proper maintenance on their properties.

Other considerations

Similar to the "Adopt-a-Highway" concept, "Adopt-a-Ditch" has been proposed as strategy, though with little success. By designing an education campaign and community conversation campaign, this idea could be revisited. Another idea proposed by Somerset County was to consider annexing ditches from private property to sustain and provide the much needed management and maintenance without encountering the challenges of rights- of-ways and easements.

2. Flood Early Warning Systems

Overview

Flood early warning systems are a suite of technology tools that can help city governments identify areas at risk of flooding, anticipate frequency of inundation, and understand the intensity of damage from flood events. These warning systems allow city managers to mobilize resources quickly, take preventative action, and reduce damage to critical resources. Most importantly, flood forecasting helps city managers to move residents out of harm's way. Due to their life-saving functions, flood-prone communities are increasingly embracing flood early warning systems.

A flood early warning system monitors and collects data on weather and water levels and issues warnings to prevent flood disasters and to mitigate risks. These systems can vary from simple river gauge monitoring networks to sophisticated forecasting systems to predict floods, with lead times spanning from minutes to days. Of great importance, effective flood early warning systems are people-centered and inclusive of the needs of city residents.

While there are several ways to categorize flood early warning systems, the Texas Water Development Board delineates two types of systems based on their forecasting capabilities: 1) flood monitoring systems and 2) flood forecasting systems. As implied in the name, flood monitoring systems collect real-time monitoring data via a suite of tools, such as gauges, cameras, and sensors, to help assess potential flood risks, whereas forecasting systems use additional predictive models to estimate future impacts at specific locations under certain conditions.

Typically, the primary factor in choosing between flood monitoring and flood forecasting systems is the availability of funding, although the complexities of local hydrology are also important factors to consider. While it is essential to evaluate the long-term economic impacts for all flood early warning systems, many are initially set up as monitoring systems, with forecasting capabilities added later.

All flood early warning systems have three key components to them: data collection, data analysis and visualization, and information dissemination and communication. To ensure the success of a flood early warning system, these components should be seamlessly integrated and coordinated. Assessing community flood risk tolerance and communicating flood risk hazards are also essential to begin this process.

General Process

While there are various approaches communities can develop a flood early warning systems, the general process includes four phases: 1) planning, 2) financing, 3) deployment, and 4) managing.

During the planning phase, it is important to set clear goals and objectives of establishing a flood early warning system. These goals and objectives will set a foundation to determine the complexity of the system, the equipment and/or model analysis, financing, and collaborations required to achieve the goals.

While the financing phase is an extension of the planning phase, it merits its own phase due its pivotal role in implementing a flood early warning system. Similarly to most infrastructure projects, the costs associated with a flood warning system can be broken into upfront costs and recurrent costs. The estimated costs of a flood early warning system vary greatly depending on the complexity, purpose, size, and needs of the location and communities. According to the Texas Water Development Boards, costs of flood early warning systems established across Texas have ranged from $23,000 to $1.5 million.

The deployment phase operationalizes components from the planning phase and incorporates the financial considerations from the financing phase. The deployment phase can be seen as project tasks, which can be further broken into 1) coordination, 2) data collection and site selection, 3) design, 4) procurement and installation, and 5) testing and closeout tasks. While timeline to complete these tasks

depends on the size of the system, existing resources, equipment types, and capacity available, it typically takes 1-2 years to build a flood early warning system.

Ideally, a robust team is needed to organize and manage an effective flood early warning system. Example roles include directors, FEWS project manager, grant specialist and legal counsel, system design personal, and public outreach personnel. Another critical component of the system is managing the operations and maintenance of equipment (such as rain gauges, cameras, flood markers). For a flood warning system to be successful, the community needs to understand their own flood risk and the alerts they receive from the system. As such, accessible and transparent information dissemination, public outreach, and education is key.

For more detailed information and steps, please see the Texas Water Development Board Flood Early Warning Systems Guidance Document.

Case Studies

As there is a such a breadth and variance in how to implement a flood early warnings system, through two interviews, we have outlined how two municipalities have implemented them in their communities. The first case that we explore is the flood early warning system established by Raleigh, NC and the second is in the Town of Oxford, MD. While Raleigh has heavily invested in a flood early warning system with state-of-the-art technology and tools, the Town of Oxford has implemented a simple yet effective flood marker system to help its residents be better informed. These two cases present how different flood warning systems can be and exemplifies the need to establish a flood early warning system based on the community's needs.

Raleigh, North Carolina

In 2016 and 2018, the City of Raleigh experienced unprecedented historical flooding as a result of Hurricanes Matthew and Florence. The impact, particularly from Hurricane Florence, served as a catalyst, garnering significant public and policy support for the implementation and investment in a comprehensive flood early warning system. While the City had existing gauges, they were collecting data without being utilized. As such, in 2019 the City decided to prioritize and build upon those existing resources. Currently, Raleigh is in the process of piloting a flood forecasting system in four phases over five years (see more information on the phases here).

Flood Forecasting System

Raleigh has invested in a suite of technological tools and software programs to build their flood forecasting systems. In 2019, Raleigh entered into a five-year contracted with Vieux and Associates Inc to **develop a software program and platform to predict flooding across Raleigh** from two main streams and creeks. The software integrates input from stream gauges and rain gauges and incorporates additional subscription-based data on weather forecasts, drainage networks, watershed properties, soil conditions, and reservoir information.

In partnership with USGS, the City installed and strategically placed **16 stream and 14 rain gauges**[2] in locations of repeated flooding. The gauges operate continuously, monitoring water levels, including rainfall and stream flow, every 5 minutes. This is a significant improvement from the previous

monitoring interval of every 15 minutes to an hour. The collected data also helps in assessing whether it is necessary to lower the water level of a local lake before an approaching storm to further mitigate flood risks.

In partnership with the Department of Transportation (DOT), Raleigh has **access to traffic camera systems to help monitor and observe flood prone areas**. Furthermore, as part of their partnership, Raleigh can purchase additional traffic cameras, which the DOT will install, connect to the system, and maintain. However, the locations of these cameras can only be deployed where a transportation network exists.

To allow for greater flexibility and camera placement in locations outside of the transportation network, Raleigh purchased Arlo Go 2 home security cameras equipped with solar panels and cellular data to access streams. Initially partnering with Verizon, they later switched to T-Mobile, as the latter offered a free camera in exchange for monthly data services.

The **16 cameras from DOT and T-Mobile** are exclusively dedicated to tracking and monitoring road flooding. Future plans include integrating camera streams into the Vieux and Associates software program. Additionally, Raleigh hopes to implement artificial intelligence (AI) systems for identifying flooding conditions, leveraging periodic screenshots from cameras to reduce data burden, and sending notifications to the program as needed.

The City of Raleigh has further invested in **10 high water warning signs**, with plans to acquire an 11th from a company called TAPCO. These state-of-the-art high water warning signs flash and activate a sign with customizable warning messages when sensors reach a set threshold of rising water levels[4]. Each high water warning sign costs approximately $15,000, covering the sensor pole, battery cabinet, solar panel, radio frequency for sending alerts, and customization options for the sign's message. TAPCO also provides its own software and an associated app called "Blink Blink," offering residents the option to opt-in for alerts, thereby enhancing community awareness and preparedness.

Lastly, the City of Raleigh also **provides a** map **that tracks storms and water levels** collected from the gauges via USGS which is open to the public to use.

For a succinct video description of Raleigh's flood early warning system, see here.

Communications and Partnerships

Although community consultation has not yet taken place, Raleigh is proactively initiating efforts to disseminate information about the flood early warning system to its residents. Key considerations include determining who should be notified, recognizing that Raleigh is expansive, and not all incidents of flooding or road closures will be relevant to every resident. Identifying the preferred means of communication for residents is a priority, considering diverse preferences. Despite the County having its own alert system, Raleigh is exploring the establishment of its independent system to enhance responsiveness. The goal is to efficiently report and send out notifications, particularly when high water warning signs activate and when the flood warning system predicts potential flooding.

Partnerships have been instrumental in establishing the flood forecasting system in Raleigh. Partnerships include partners from local governments (i.e. the County and neighboring cities), state agencies (i.e. Departments of Transportation, Parks and Recreation, Fire, and Emergency), federal agencies (e.g. USGS, ArmyCorps, National Weather Service), and private industry (i.e. Vieux and Associates, T-Mobile, and TAPCO). These partnerships help with cost-sharing, data and information exchanges and agreements, and coordination. For more details on specific partnership relations, please see our Conversation Summaries document.

Capacity and Costs

After two years into their pilot program, the City recognized the necessity of establishing a full-time position to manage the flood early warning system they were implementing. This led to the creation of a dedicated position whose role is to manage, coordinate, and deploy the flood forecasting system.

Overall, the **primary sources of funding** for this initiative are derived from the **Stormwater Utility Fee** and collaborative partnership agreements outlined earlier. The **build-up cost** of investing in a software program, 16 stream gauges, 14 rain gauges, 16 cameras, and 11 high flood warnings signs is **approximately $1.7 million**. This does not include the **annual maintenance cost** (i.e. out-of-house software platform cost and subscriptions, gauge maintenance, data plans and more), which is **approximately $210,000**.

The City is currently in the last phase of this initiative, which will include greater public outreach efforts and final equipment procurements and implementation.

Town of Oxford, Maryland

Similarly to Crisfield, the Town of Oxford on the Eastern Shore frequently experiences flood events. Due to the regularity of these floods, many residents have developed methods to assess water levels, such as using a mailbox post to determine if it's safe to drive out of their driveways. However, accurately gauging the depth of the water remains challenging. In an effort to simplify this process, the Town decided to install flood markers in areas prone to repeated flooding based on local knowledge.

The flood marker design consists of a 4"x4" fence post painted with four blocks of 6" in different shades of blue (refer to the image below). The various shades of blue provide residents with an indication of the depth and severity of flooding. Originally, they had measurements indicators of 18”, 24”, 30” on the post but later realized that they weren’t necessary and would require extra maintenance.

Figure 14. Town of Oxford flood marker.

These markers were installed without intentional communication to the wider community, but those who needed them found them useful, and there were no complaints. The primary beneficiaries of these markers are residents and local communities versus the public or tourists. They are exceptionally low-cost, created within the Public Works budget, painted in the Town shop, and installed similar to fence posts with cement. Additionally, maintenance requirements are minimal. The simplicity is what makes it work for them.

For more details on these case studies, please see Conversation Summaries.

Other case study examples

- Flood Early Warning System- Austin, TX
  https://www.austintexas.gov/department/flood-early-warning-system
- Sea Level Sensors- Savannah, GA
  https://www.savannahga.gov/2937/Sea-Level-Sensors
- Flood Marker Installation- Lexington Fayette, KY
  https://www.bereadylexington.com/final-public-notice-flood-marker-installation/
- Flood Early Warning Examples from USGS
  https://www.usgs.gov/centers/oklahoma-texas-water-science-center/science/science-topics/flood-early-warning

Recommendations for Crisfield on how to implement a Flood Early Warning System

Crisfield has already made investments in advancing this work by being a member of CodeRED, a cloud-based software platform that allows the City to send alerts to residents that have signed up to receive them. Crisfield has emphasized its preference to integrate CodeRED into any plans to expand its flood early warning system. With that in mind, below are some recommendations, most of which fall into the "planning" phase mentioned above.

Identifying Goals and Objectives

Establish the goals and objectives of a flood early warning system that could meets Crisfield's needs

This work can begin by understanding what kind of information the City and its residents need to receive to feel prepared for flood events. From our conversations with the City, it was stated that it would be helpful to have software that can relay real-time data and disseminate this information so that it's understandable and accessible to residents. Some community members from Crisfield have also expressed that they would like to know 1) what actions to take if there is a flood risk, 2) how long they have before flooding is predicted to occur, 3) how long the flood risk will last. For example, topology maps could be used to see where Crisfield could designate areas to park cars during flood events. To better integrate CodeRED in the community, understanding how receptive residents are to CodeRED and what kind of alerts they are interested in (i.e. advised actions during flood events) would be beneficial. This feedback could be received via open survey that could be added to the City or Crisfield Mitigation website.

Flood Awareness and Risk Communication

Add a "Flood Management" tab to the Crisfield Mitigation or City website"

If desired, a Flood Management tab could be added to the City or Crisfield Mitigation website for the residents and public to access. Contents could include a list of resources, advised actions, and contacts. Here are some examples: Floodplain information tab- Oxford, MD.

Make local tide gauge information accessible to the community of Crisfield and public

While Crisfield has a local tide gauge, the information received may be inaccessible and hard to understand to the public. To better utilize this existing resource, the information must be communicated better to the community of Crisfield. This information dissemination and communication strategy could be integrated with an educational program, such as the Tech HS. This would support the Youth Development resilience goal that Crisfield has defined. Furthermore, the education program could develop training sessions and bring awareness of the flood warning system in community spaces, further supporting another resilience goal of Crisfield's, to enhance community spaces.

Flood Markers and Other Technological Investments

Identify and place simple color-coded flood markers

Similarly to the Town of Oxford, MD, Crisfield could establish color-coded flood markers in community spaces, other locations of interest to the community, and areas of repeated and historical flooding to help community members gauge water levels when flooding occurs.

Invest in other technological tools and software program to establish flood early warning system

Through funding sources, Crisfield could invest in further technological equipment to enhance their flood warning system, such as rain and stream gauges and technologically advanced flood markers like those in the Raleigh case study. The City of Crisfield has also expressed interest in an integrated software program that could help predict flood risks and warnings from the local tide gauge, and any other equipment investments too. Similarly to investing in other technological tools, this software would require certain investments and could be useful to partner in such investments to share costs, as exemplified in the Raleigh case.

Resources

Raleigh Flood Early Warning System
Flood markers Town of Oxford
Austin Flood Early Warning System
Sea Level Sensors- Savannah, GA
IFlood GMU- Integrated Flood Forecast System
How do you build an effective Early Warning System?
USGS Flood Early Warning
Flood markers in Queensland, Australia
Flood Marker Installation Lexington Fayette
Community based flood early warning system
Flood early warning systems Guidance Document

[2] The cost of these gauges, as quoted by the USGS, ranges from $2,000 to $3,000, with maintenance and upkeep costs totaling approximately $7,000 per gauge annually. The entire station, maintenance, quality assurance and quality control, repair, discharge calculations, and integration into a website platform incurs an annual cost of $20,000, all of which USGS provides. While less expensive gauge options exist, they may lead to increased maintenance costs and time.

[3] Initially, the City paid for a $30/monthly data plan, but transitioned to a pay-as-you-go plan, lowering data cost plans to approximately $5-10 per month.

[4] Previously utilizing "eye sensors" with the signs, the City encountered issues as these sensors were triggered by factors other than rising waters. Subsequently, Raleigh switched to float sensors, which have proven effective for the past 1.5 years.

3. Annexing Land from Somerset County

Overview

Municipal annexation is the process of legally including within the corporate limits of a city or town an unincorporated area that is outside the municipality. It is the primary mechanism used by cities to grow

their tax base and land area. Cities all over the US annex territory to provide an expanded region with municipal services and to exercise regulatory authority necessary to protect public health & safety and improve the quality of life for its residents. Each state has its own guidelines governing the requirements a city must meet to annex surrounding areas.

In Maryland this process is overseen by the Department of Planning. Within Maryland, cities that have annexed land include Baltimore and Salisbury to name a few. For cities and towns in Maryland, annexation of surrounding areas plays an important role in influencing the economic growth, environmental protection, quality of life, and municipal fiscal well-being of their communities.

Annexation of land can be used as a proactive planning tool to adapt to impacts of climate change. For example, Princeville, North Carolina, and Punta Gorda, Florida have both successfully implemented annexation policies as part of their climate adaptation planning process. Princeville annexed surrounding county land, while Punta Gorda has adopted a voluntary annexation policy allowing surrounding areas to opt-in.

Annexation is a tool that could help Crisfield expand and make long-term investments in areas that are safer from flooding, while allowing surrounding marsh to recover and grow in spaces that will become frequently inundated with rising sea levels. To successfully annex surrounding land a city must comply with guidelines set forth by the MD Department of Environment (MDE) and identify its own goals for annexation. Below, we provide a summary of regulatory requirements and a discussion of various advantages and disadvantages that this strategy could have for Crisfield's long-term planning.

Legal Requirement and Annexation Procedures in Maryland

1. The Municipal League of Maryland has prepared an annexation handbook (handbook shared as a separate attachment) with information regarding annexation procedures and requirements in the state. An overview version and steps to annexation are as follows:
2. A city can annex surrounding land within its own county that is contiguous to the city's existing boundaries. A city cannot create an enclave of unincorporated area though its annexation proposal.
3. To annex surrounding land, at least 25% of the qualified voters along with the owners of 25% of total assessed property must agree and this petition can be filed with the county – Somerset County in Crisfield's case. A copy of the filling must be forwarded to the county and the Maryland Department of Planning.
4. Upon receipt of the required number of petition signatures from the property owners and voters in the area to be annexed, the municipal elected body (the Crisfield City Council) can introduce a resolution proposing the annexation. This resolution should describe the area to be annexed, and any other conditions or circumstances applicable to the area.
    a. Crisfield would need to update its comprehensive plan to add a future growth area element that would serve as the foundation of the annexation plan. The future growth areas must include parcels of land the city wants to annex.
5. An annexation plan must be prepared, adopted, presented to the public with ample time for public comment and review. The annexation plan for Crisfield must be consistent with the

growth element in the comprehensive plan. The City cannot proceed with the preparation of annexation plan for any parcel of land not already covered in the comprehensive plan

6. The annexation plan must include the following components:
    a. Proposed land use or uses in the area to be annexed
    b. Available land that could be used for anticipated public facilities that may be needed,
    c. A schedule for extending municipal services to the area to be annexed
    d. Anticipated means of financing the extension of services.
7. A public hearing in the county is required for annexation proposal. The application for annexation must be submitted to the county and the Maryland Department of Planning at least 30 days prior to the scheduled public hearing. Residents should also be given 30 days' notice or longer prior to the public hearing for meaningful engagement
8. Once an annexation resolution has been introduced, Crisfield must publish the resolutions at least four times with a minimum of weekly intervals in one of more local newspapers that are easily accessible to the residents. The publication schedule can be reduced to twice at weekly intervals if the maximum area to be annexed is 25 acres. A copy of the public notice should also be provided to the Somerset County Board and Maryland Department of Planning upon first publication.
9. At the annexation hearing, the Somerset County Board and the Maryland Department of Planning may pass or reject the resolutions, the public is also given an opportunity to make a comment. The resolution decision becomes effective 45 days after its passage unless it's petitioned to referendum.
10. The annexation decision can be petitioned to referendum by at least 20% of the registered voters in Crisfield or in the area to be annexed. Alternatively, two-thirds of the Somerset County Board may also petition to call for a referendum.
11. The annexation referendum can be held 15-90 days following the publication of public notice of the referendum. If the referendum passes, the annexation decision becomes effective 14 days following the referendum.
12. Once the annexation decision is passed (with or without a referendum) the new city boundaries must be registered with the county clerk for Somerset County, the Maryland Department of Legislative Services.

Case Studies

Below is a case study of Princeville, North Carolina that utilizes land annexation as a proactive tool for climate adaptation in addition to increasing a city's tax base. Crisfield could use a similar model or pathway as Princeville to support a land annexation strategy and pathway.

Princeville, North Carolina

In 2017, the Town of Princeville, North Carolina engaged experts and communities in a long-term, comprehensive planning process to annex a 53-acre parcel of land located outside of the town's 100-year floodplain to develop a safer, higher ground area where residents, structures, and infrastructure can be relocated. After experiencing flooding impacts from Hurricane Matthew in 2016, Princeville invested resources in and looked for funding opportunities to develop a long-term climate adaptation

plan for the city. Princeville provides an example for other municipalities either in a pre-or post-disaster context for how to balance the preservation of original townships while dealing with flooding vulnerabilities, and simultaneously, increasing the resiliency of core community assets and services through adaptation actions. Crisfield may consider Princeville's example for relocating vulnerable residences and community facilities and services to higher and safer ground by utilizing annexation as tool.

In coordination with the town's disaster recovery plan Princeville is implementing a three-part approach to comprehensively evaluate opportunities for facilitating the transition of residents out of the 100-year floodplain by making investments in higher ground receiving areas. The town utilized a Land Suitability Analysis to identify a priority 53-acre parcel outside of Princeville for annexation. Since annexing the land, the city is working with experts and the community to plan for the resilient development of this area through ongoing processes, including by convening a Design Workshop and regular community meetings.

Princeville is engaging with community members and stakeholders to work through the different considerations involved in planning for annexation and relocation, including respecting historical and cultural values. The culmination of the annexation and relocation planning efforts in Princeville present a model for how states and local governments can align post-disaster recovery efforts with proactive managed retreat strategies for rebuilding out of harm's way before the next disaster. Princeville offers an example of how annexing land and engaging the community in this planning process can help to better prepare communities, improve infrastructure resiliency, and maintain local communities, tax bases, and economies.

You can learn more about Princeville's climate adaptation planning here. Another city that has adopted a similar climate focused annexation polices is Punta Gorda, Florida.

Recommendations and Considerations for Crisfield in Pursuit of Annexation

The city must carefully consider its reasons for annexation, and how it would help the City's long-term goals. When done right, annexation can help cities to achieve logical city/town growth and boundaries, and proactively plan for challenges down the road. Many reasons and benefits to pursue annexation are listed in the Municipal League of Maryland's handbook. However, below is a discussion of specific recommendations and considerations relevant to Crisfield.

Utilizing a Climate-Driven Approach to Land Annexation

Similarly to the case study above, Crisfield can utilize a climate-driven approach to annexation as a proactive tool to adapt to climate impacts as well as frame benefits of annexation from a climate adaptation perspective.

Planning for climate change to protect Crisfield's rich cultural heritage

The city's long term planning efforts must consider the rich cultural heritage connected to the bay and the medium and long-term impacts of climate change. The additional considerations for Crisfield in

preparing an annexation plan is understanding how future storms and sea level rise will impact not only the city, but also the surrounding land that may get flooded during storms.

We recommend carefully reviewing flood maps developed as part of this project before landing on a parcel of land and embarking upon an annexation exercise. Any undeveloped land around the city within a 100-year floodplain zone is vulnerable to future storms and flooding issues and should not be brought into the city limits for purposes of new development.

Identifying safe high-ground and/or inland areas potentially moving critical infrastructure such as sewer processing facilities, the fire department, the police department, city administrative buildings and records and more, out of vulnerable flood zones would be a valuable planning exercise. Crisfield is investing resources in strategies that allow the community to adapt in place and make its current infrastructure more resilient. These investments buy the city time to learn about and explore long-term transformational and transitional strategies for future strategies focused on moving out of harms way.

Framing benefits of climate change adaptation to increase public support for annexation

Framing land annexation with a climate-driven approach can be used as a benefit to promote that critical infrastructure is improved and the City will be able to provide safer and better access to the public's needs. It also demonstrates that Crisfield is forward thinking and making investments that are more sustainable in the future. This will be especially beneficial to MPD and MDE to support the benefits and reasons for annexation. It could also build the foundation for greater public support due to improved and safer access to public services.

Extend Municipal Services to Communities

Annexation can extend municipal services to communities that are adjacent to existing city/town corporate limits and that may not have such services. Crisfield must consider what services it can provide surrounding residents that they don't already have to make annexation a compelling proposal. Services could include improvements to flood infrastructure or flood water manager, provision of expanded or improved emergency services, and provision of expanded or improved municipal services. Properties outside the Crisfield are covered by a Sanitary District Agreement that provides them with sewer services, as this agreement already provides residents with sewer services, the city would need to consider specific improvements to the sewer system for annexation to be an attractive proposal for residents. Similarly, residents outside the city are already able to access Crisfield's emergency policy and ambulance services, property owners in potential parcels to be annexed would need a compelling reason to consider this new proposal.

Increase Political Influence

Annexation can be used to expand the size, population base, property tax assessable base, and—in some cases—the political influence of a city or town. As shared above, a city may want to expand its tax base to be able to improve municipal services it provides, but this case must be made to the residents within the area to be annexed. Annexation is a voluntary process that cannot be mandated without agreement of the community. Furthermore, Annexation can empower residents of areas adjacent to

cities and towns by allowing them a direct role in local community affairs through access to municipal election voting rights and the opportunity to serve in municipal elected and appointed offices.

Local Input for Future Development

Annexation is a useful tool to allow for local input into and control over future development around the periphery of existing municipal corporate boundary. This local input can be used to inform legal agreements with developers, to exact concessions that will meet adequate public facility requirements and provide added amenities (for example: roads, parks, affordable housing) that are beneficial to the community. Local input is also vital for supporting economic and community development goals by negotiating annexation agreements to attract business, industry and housing development.

Unify Incorporated and Unincorporated Areas

Annexation can be used to unify currently incorporated and fringe unincorporated areas that share common sociological, economic, cultural, and geographic characteristics. The Down-Neck area is an example of a great Crisfield community that is technically outside the city boundaries and could benefit from investments in flood and sewage management systems coming from the city.

4. Critical Areas in the Bay Watershed

Overview

Critical Areas are defined as all land and water areas within 1,000 feet beyond the landward boundaries of tidal wetlands, the Bay and its tributaries. Maryland's Critical Area Law and Criteria was developed in 1984, in response to serious and far-reaching problems affecting Maryland's water resources. The Law and Criteria were designed to foster more sensitive land use and development activity along the shoreline of the Chesapeake Bay, Atlantic Coastal Bays, their tributaries, and tidal wetlands and to ensure the implementation of appropriate long-term conservation measures to protect important habitats.

The Critical Area Program is an important partnership between the state and local governments to continue stewarding Maryland's fragile and vulnerable tidal wetlands. In its four decades of operation, the Maryland Critical Area Program has successfully minimized adverse growth and development impacts on tidal wetlands. It has also created a pathway for local governments to approve growth plans in a manner consistent with ecological health metrics.

Critical Area designation[17] requires special considerations for projects. Local jurisdictions are responsible for implementing and enforcing the Critical Area program in coordination with the local Critical Area planner. Projects must concur with the Critical Area ordinance within the Comprehensive Plan.[18]

[17] https://dnr.maryland.gov/criticalarea/Pages/background.aspx

[18] https://dnr.maryland.gov/criticalarea/Documents/Municipal-Model-Ordinance-2023.pdf

Under the critical area law, each local jurisdiction has the responsibility for developing and implementing its own Critical Area program that would be sufficiently comprehensive to accomplish the following overall goals for the State:

- Minimize adverse impacts on water quality that result from pollutants that are discharged from structures or conveyances or that have runoff from surrounding lands.
- Conserve fish, wildlife, and plant habitat in the Critical Area.
- Establish land use policies for development in the Chesapeake and Atlantic Coastal Bays Critical Area which accommodate growth and address the fact that even if pollution is controlled, the number, movement, and activities of persons in an area can create adverse environmental impacts.

Legal Designations, Permitting, and Future Policies

There are three types of critical area designations, the map below shows how land around Crisfield is designated.

Intensely Developed Areas (IDAs)

IDAs are typically areas of mixed and relatively urbanized land use. They are areas of concentrated development where little natural habitat occurs. In IDAs, the Critical Area Program's focus is improving water quality. New development and redevelopment must include measures to reduce pollutants from stormwater runoff. These techniques include site design, practices that promote runoff permeating naturally into the soil, and stormwater treatment measures such as sand filters and swales.

Limited Development Areas (LDAs)

LDAs are areas of low or moderate intensity development that also contain forests, fields, wetlands, and woodlands. The predominant land use is typically residential, but other uses are permitted. Within LDAs, local zoning regulations specify what uses and residential densities are permitted. The Critical Area regulations require that development activities must maintain or improve water quality and conserve existing areas of natural habitat.

Resource Conservation Areas (RCAs)

make up approximately 80 percent of the Critical Area. These areas include a combination of farms, forests, wetlands, and sparsely developed areas. RCAs make up most of the Critical Area and provide the best opportunity for meeting the goals of the Critical Area Program. Within RCAs, new development is limited to residential uses, with a density limit of one unit per 20 acres and activities related to resource-oriented uses. These include agriculture, forestry, fisheries activities, and aquaculture.

In addition to the land classification system, development activities in Crisfield must also comply with the critical area buffer regulations. **The Critical Area Buffer** is the area of at least one 100 feet located directly adjacent to the State's tidal waters, tidal wetlands, and tributary streams. Ideally, this Buffer is composed of trees, shrubs, and other plants that catch sediments and other pollutants coming from buildings, lawns, and paved areas.

Permitting

Section 404 Permits

If there is any development that impacts or affects tidal wetlands and non-tidal wetlands in Maryland, there are several permits through different agencies that are required to proceed with a project. These permits can be categorized by jurisdiction. For instance, any "waters of the United States" is under federal jurisdiction and if impacted, will require a Section 404 permit under Clean Water Act. Jurisditional waters include any bodies of water that are navigable, interstate, territorial seas, impoundments, tributatiers, adjacent wetlands, other waters with a significant nexus within the 100-year floodplain or 4,000 feet of jurisdictional waters. The Section 404 permit is issued by the US Army Corps of Engineers with oversight by EPA (though the Corps does not require EPA's approval to issue a permit).

Maryland Department of Environment Permits

The MDE Permit website outlines four distinct steps to identify the right permits and begin the process. There are two permits required if there are any altercations to a tidal and nontidal wetlands or waterway and 100-year floodplain:

- Joint Federal/State Application for the Alteration of Any Tidal Wetland in Maryland (application) for a Tidal Wetland License and Permit (guide)
- Joint Federal/State Application for the Alteration of Any Floodplain, Water way, Tidal or Nontidal Wetland in Maryland (application) for a Nontidal Wetlands (guide) and Waterways Permit (guide)

Applying to a joint-permit applications (like the ones listed above), will provide applicants to present their project to a Joint-Evaluation meeting, where permitting agencies across government levels (federal and state) can provide feedback on their project.

Critical Area Permits

In Maryland, it is important to stay in compliance with the Critical Area Law. To do so, the Critical Area Commission has provided local governments with a checklist to ensure new projects within critical areas meet all program requirements. For Crisfield, we recommend the city use an expanded checklist that includes consideration of future sea level rise and flooding expected on the proposed development parcel. Local government resources for critical area management can be found here.

Process

It is important to initiate the permitting process as early as possible. The different permits may conflict with one another or may be difficult to satisfy, as such it is critical for project sponsors to establish early communication across agencies to facilitate collaboration in resolving permit issues. For example, it could be beneficial to pair Critical Area conversations with other agencies (like EPA) that review the project in later stages to confirm that all permitting agencies are on the same page. Joint Evaluation is beneficial for this cross collaboration as well.

Even if the application for permits was submitted to both the appropriate federal and state agencies through a joint-permit applications, timelines for processing can often be separate which can prolong the review process. Furthermore, with each amendment to the permit, more time is added to the review process. As such, it is important to consider the time required to acquire a permit.

It is also important to explain the intention of the project, clearly outline the process, and provide options if the project needs to be amended. It is easier to review applications that provide tiered scenarios that reduce environmental impacts. The main goal of the permit application should be to demonstrate that your project will have minimal impact on the environment and provide supporting evidence for the project. Mitigation measures, including compensatory mitigation if necessary, should be considered.

From the perspective of regulatory and permitting agencies, these laws and permits are crucial for safeguarding the environment, such as the Clean Water Act (CWA) and the principle of "no net loss" for Critical Area. Permitting agencies should not be viewed as adversaries; rather, they are essential partners in the project development process. Cooperation with these agencies is not only necessary for project advancement but also facilitates expedited permit issuance through collaborative efforts.

Climate Adaptation within Critical Areas

Crisfield geographic location within the Chesapeake Bay makes Critical Area regulations highly relevant to the city's long term climate planning goals. The city is bordered on three sides by wetlands, depending on the critical area designation for a parcel there are various development density regulations in place for the city.

The land classification system, and the critical area buffer are important designations not only to maintain and protect resources within the Chesapeake Bay but also for communities living along the shoreline. For example, the critical area buffer serves the dual purpose of absorbing and lessening the impact of sea level rise and extreme weather events thus protecting coastal communities, and it protects the bays ecosystem from harmful runoff and pressures of development.

The Critical Area law, in its current state doesn't incorporate climate change and equity considerations within the implementation of regulations. This means that the critical area programs for various counties in Maryland do not account for rising sea levels and extreme weather events in their land classification system. This gap in climate conscious planning can lead to new projects being approved and built in vulnerable areas that are prone to increased flooding – putting coastal communities in harm's way.

During the 2024 Maryland General Assembly session, lawmakers are considering updating critical area regulations to incorporate climate change adaptation, and environmental justice criteria within the Critical Area Law.

Senate Bill 306 (SB306), and the corresponding House Bill 233 (HB233) if enacted simplifies administrative processes for local governments by aligning timelines for comprehensive plan updates with critical area planning requirements, thus reducing administrative burdens. Maryland's critical areas need to be assessed with climate change impacts in mind, including sea level rise, wetland migration, storm surge, increased precipitation, coastal flooding and other extreme weather events. SB 306 builds in requirements that ensure the program's benefits flow to historically under-served and over-burdened communities by establishing a grant program for local governments to undertake climate-conscious critical area planning activities.

SB 306 also updates critical area mapping requirements to provide Maryland with accurate and high-resolution information regarding the state's changing coastline – this information is especially relevant for local governments as sea level rises and tidal wetlands migrate landwards. Through this bill, mapping shoreline areas that are suitable for creating recreational spaces with consideration given to increasing waterfront and recreational access for under-served communities will be prioritized.

Critical Area Recommendations for Crisfield

Leveraging Crisfield's Natural Beauty

Although we discourage investments in residential and commercial constructuon development in critical areas, there are alternative approaches to foster economic opportunities that align with Crisfield's resilience goals. While Crisfield residents appreciate the town's beauty, the aesthetic and recreational potentiAL of Crisfield's waterfront lacks widespread recognition in Maryland and surrounding areas. Investments in building minimal impact recreational access to the waterfront and in Crisfield's critical areas, to highlight the city's beauty could attract visitors and toursim funds. We encourage the city to adopt an approach articulated by Mayor Taylor as, "Come for the Crabs and Stay for the Sunset." Preserving critical area zones contributes to long-term benefits, such as boosting eco-tourism opportunities while simultaneously providing protection from flooding and storms.

Developing amenities like boardwalks and improving public transportation infrastructure, such as a ferry system, to enhance accessibility to Crisfield as a tourist destination is a viable investment. Leveraging critical areas for low impact tourism can capitalize on the natural environment to support economic development via eco-tourism initiatives.

Planning Ahead for Climate Change

While the state considers updating and improving critical area regulations, Crisfield can act now to proactively plan for climate change impacts by using publicly available mapping tools to identify vulnerable and flood prone areas within Crisfield. Parcels of land with existing critical area designations should not be upzoned for development as these will be most vulnerable to future flooding caused by high tides, sea level rise, and extreme weather.

There are several mapping tools publicly available to compare and view relevant sea level, and land cover data. The MD critical area boundary map viewer, NOAA sea-level rise viewer, NOAA land cover atlas all provide easy to access high resolution information through user friendly interfaces.

Amending Policies through Regular Communication

Providing compelling and sustainable justifications for modifying critical area policies is essential. This involves building relationships and regular communication pathways. For instance, the Town of Oxford has introduced its 2100 Project to the Critical Area Commission, initiating discussions on necessary policy amendments to align with their vision. Incorporating climate change considerations into planning will provide leverage for these amendments.

5. Resilience Authorities

Overview

A resilience authority is an innovative policy tool that allows cities and municipalities to establish a non-profit organization and grant it certain powers to advance projects and programs on behalf of the city and/or municipality that established it. Maryland Bill SB0457 is the enabling legislation that allows Resilience Authorities to be created in the state. Charles County and Anne-Arundel County (including the city of Annapolis) have both established Resilience Authorities to undertake and support resilient infrastructure projects in their respective jurisdictions. During the establishment of a Resilience Authority, the city or county government can decide how much "authority" to grant to the new organization.

The benefits of Resilience Authorities include, but are not limited to, diversified funding options, responding to impacts of climate change, and implementing resilient infrastructure projects. Resilience Authorities can pursue innovative funding streams and solutions that neither a government body nor a non-profit could achieve alone. The work of Resilience Authorities also allows the conversation of climate change to be front and center with tangible, visual, and actionable planning and infrastructure projects as a pathway forward. In a fast-paced and unpredictable changing environment, Resilience Authorities provide institutional flexibility to adapt to unforeseen impacts.

The greatest challenge of Resilience Authorities is the longevity of all infrastructure projects and the need to find ways to stay engaged and incentivized while doing due diligence and upholding good practices. Another challenge is that it is easier to delay and stop physical projects to be put on the ground, especially if they are new or innovative. However, with the urgency of the climate crisis, there is a need to implement resilient infrastructure across the coastline. Resilience Authorities are an important tool to move these projects forward.

Legislation and Requirements

Maryland Bill SB0457 was passed on May 8, 2020, and authorized local governments to establish and fund Resilience Authorities under local law. The law allows flexibility on 1) the range of projects, 2) funding options, 3) appointment or hiring of staff and employees, and 4) organizational, budgetary, and financial procedures the Resilience Authority would like to pursue. When establishing the Authority, local governments and jurisdictions have the power to make those decisions so they can best accommodate their communities and needs.

The law provides a non-exclusive range of projects a Resilience Authority could fund and implement, including green spaces, flood barriers, stormwater infrastructure, building elevation, and more. Essentially, the Authority can exercise all powers, except eminent domain[1], to finance, acquire, manage, convey, support, construct, alter, and operate infrastructure projects.

The law also allows the Resilience Authorities to seek various and diversified funding options for resilient infrastructure investments and projects. For instance, an Authority can charge and collect non-tax related fees for its services, as well as issue or sell state or local tax-exempt bonds. However, the

authority is not permitted to levy any taxes. Furthermore, an Authority can decide if they would like to be funded via local and state governments, non-profit contributions, or a combination of both.

Finally, the law allows for Resilience Authorities to be established across a single or multiple jurisdictions, including a combination of municipalities and counties, to facilitate climate adaption on a local or regional scale.

To establish a Resilience Authority, the chief executive of the local government must submit articles of incorporation to the 1) Senate Budget and Taxation Committee and the Senate Education, Health, and Environmental Affairs Committee and 2) House Appropriations Committee and the House Environment and Transportation Committee. Upon acceptance of the articles of incorporation, the Resilience Authority is established. If multiple counties or municipalities want to establish a Resilience Authority, they may file joint articles of incorporation.

The requirement of an established Resilience Authority includes the submission of an annual report to its local government and the state 1) Senate Budget and Taxation Committee and the Senate Education, Health, and Environmental Affairs Committee and 2) House Appropriations Committee and the House Environment and Transportation Committee. The report, at minimum, must outline the infrastructure projects being pursued and their respective funding sources.

Case Studies

Charles County and Anne-Arundel County (including the city of Annapolis) have both established resilience authorities to undertake and support resilience infrastructure projects in their respective jurisdictions. In December 2022, Baltimore County contracted Throwe Environmental to develop a comprehensive financing plan to examine how they can establish a Resilience Authority, which will be delivered by fall 2023. This section will outline the mission, establishment, and projects the Resilience Authorities in Charles County and Annapolis and Anne-Arundel County have committed to as examples to be inspired by.

Charles County Resilience Authority

In December 2020, the Charles County Board of Commissioners passed a local law to establish the first Resilience Authority in Maryland. By September 2021, the Resilience Authority was official recognized with the approval of its Articles of Incorporation. They established a 501c3 non-profit organization that prioritizes equity and operates for the public purpose to respond to impacts of climate change in communities across Charles County and the state. Their mission is to

"undertake and support resilience infrastructure projects, that mitigate the effects of climate change by offering a range of financing structures, forms, and techniques and leverages public and private investment and stimulates demand for resilience infrastructure projects throughout Charles County."[2]

They currently have 11 Board members, which were appointed by the Charles County Board of Commissioners. The County wanted to the Authority Board to reflect the racial, ethnic, and geographic diversity of Charles County. Members of the Board include:

- 1-2 members of the Charles County Government Executive Leadership Team

- 1 member who represents a Charles County municipality
- 1 member of the business community
- 1 member from the banking and finance industry
- 1 or more Charles County citizens
- 1 Ex-officio member from the Maryland State Government, and
- 1 Ex-officio member from the climate change science community.

Since implementation, the Board has held quarterly virtual meetings that are open to all. In accordance to Maryland Bill SB0457, they have submitted annual reports in 2021 and 2022. In January 2023, the Resilience Authority appointed Stacey Shaefer as the Executive Director, who will be responsible for overseeing and implementing all resilience-related programs and projects, advancing climate resilience education, and developing partnerships. They are also looking to eventually find a Sustainability Officer and Legal Officer.

The Resilience Authority has received $100,000 through the Charles County Budget for FY23 and FY24 as 'seed' money. Furthermore, the County has stated that they are willing to invest $10.1 million over the years. They are also looking at developing their own procurement policy and explore creative options and avenues to get more funding. The Authority has committed to kick-off two projects:

  - Applied Social Vulnerability Screen to prioritize neighborhoods throughout Charles County for the Residential Stormwater Drainage Improvement Program, and
  - Urban Tree Canopy program targeted to Urban Heat Zones and Underserved Communities.

To access to all this information and more, please visit their website.

Annapolis and Anne-Arundel County Resilience Authority

In May 2021, Anne-Arundel County passed a local law to establish the joint municipality and county Annapolis and Anne-Arundel County Resilience Authority. Similarly, to Charles County, upon approval of its Articles of Incorporation, the city and county established a 501c3 non-profit organization with a mission to "develop, finance, and support infrastructure projects on behalf of Anne-Arundel County and the City of Annapolis."[3]

The decision to become a joint Resilience Authority was a decision made together by Annapolis and Anne Arundel County officials due to their interlinked-relationship and culture, as well as to increase resource efficiency. As a multi-jurisdictional Resilience Authority, there are associated challenges and opportunities. The greatest challenge is that they are independent jurisdictions and may have greater differences of opinions that take time and resources to resolved. However, generally as a rule, finance favors scale and efficiency, and any barriers that may come from multi-jurisdictions can be balanced by this advantage. As the Resilience Authority is primarily a financial institution, the Authority thought it was worth the risks.

As written in their local legislation, the Authority must have 12 Board members. Their inaugural Board of Directors meeting was in October 2022 and they will continue to have quarterly meetings which are open to all. Nine members of the Board must be residents of Anne-Arundel County, who are appointed by the County Executive. The remaining three members must be residents of the City of Annapolis, who

are appointed by the mayor. No members may be County or City elected officials, appointed officials, or employees. Board members serve for four-year terms and may be reappointed. The County Executive shall appoint the Chair of the Board annually. Furthermore, there are non-voting advisers including 1) the County Director of Public Works, the County Director of Emergency Management, 2) the County Planning and Zoning Officer, 3) the Director of the Department of Public Works for the City of Annapolis, 4) the Director of Emergency Management for the City of Annapolis, and 5) the Director of Planning and Zoning for the City of Annapolis.

The County Executive and Mayor appoint the Executive Director, with recommendation by members of the Resilience Authority. The Director is responsible for daily operations, supervision of tasks, and appointment of all employees. Dan Nees, with Throwe Environmental, served as the Interim Director of the Resilience Authority until December 2022, when the Authority announced Matt Fleming as the new Executive Director. The Authority is seeking a Chief Financial Officer and may create new positions as needed.

The Annapolis and Anne- Arundel Resilience Authority has contracted Throwe Environmental to further establish the new organization. For more information and meeting minutes, please visit their website.

Benefits and Considerations for Crisfield in Establishing a Regional Resilience Authority

Scalability and Coordination

The finance sector favors scalability, and a crucial aspect of a Resilience Authority's role is as a financial institution. As such, opting for a regional Resilience Authority would enhance efficiency and effectiveness. There are multiple ways a regional resilience authority including Crisfield could be established. For instance, there could be an option for a larger regional resilience authority, such as a Lower Eastern Shore Resilience Authority, or a joint-jurisdiction approach between Somerset and Crisfield.

Coordination, partnership, and scalability are crucial aspects, especially considering the interjurisdictional impacts of climate change. By scaling projects across boundaries, multi-jurisdictional projects and programs can be more easily implemented and funded, likely with significant cost savings. For instance, the Resilience Authority could manage the funds for ditch maintenance, which is a prevailing issue across the Lower Eastern Shore.

Community Driven and Local Priorities

Attributes of a Resilience Authority of any configuration should be community-driven, with a focus on local and community buy-in and priorities. For example, as outlined in the case studies above, the Resilience Authority of Charles County prioritizes stormwater issues, while the Annapolis and Anne Arundel Resilience Authority prioritizes flooding concerns. Resilience definitions should align with community values, and the governance structure should be representative of Eastern Shore communities. The Authority should possess the ability to advance equity and resilience, with dedicated capacity and leadership, serving as a point of contact for resilience planning.

The primary challenge lies in the logistical establishment of the Resilience Authority. This would involve determining the jurisdictions it would serve, enacting the necessary legislation, meeting specific requirements, deciding on its location, and establishing its Board members and staffing. Crisfield would need to determine its role and assess whether an institution like a Resilience Authority would meet the City's needs.

However, due to the flexibility in pursuing funds solely focused on resilience work, the Resilience Authority could serve as the primary funding mechanism to achieve Crisfield's community resilience goals, including building resilient infrastructure, affordable housing, and community spaces in flood-safe or safer locations. These in turn can support other community goals, such as economic and youth development.

Removed from Partisan Politics

While established by local governments, the Authority should operate independently and be removed from partisan politics. This can secure the sustainability of programs or implementation of long-term projects without concerns about changes in administration and build public confidence. Additionally, the Resilience Authority can take on the appearance of whatever is prioritized, providing flexibility to learn, shift, and adapt according to the goals.

Resources and Local Experts

- Stacy Schafer (Charles County Resilience Authority Executive Director)
- Matt Flemming (Annapolis and Anne-Arundel County Resilience Authority Executive Director)
- Throwe Environmental (Contracted for Annapolis and Anne-Arundel County and Baltimore County Resilience Authorities)
    - Dan Nees (Interim Annapolis and Anne-Arundel County Executive Director)

Annapolis and Anne-Arundel Resilience Authority

Annapolis and Anne-Arundel County Legislation to establish Resilience Authority

Blue Water Baltimore Webinar: What Are Resilience Authorities and How do they work?

Charles County Resilience Authority

Charles County Legislation to establish Resilience Authority

Charles County Resilience Authority 2022 Annual Report

Maryland Senate Bill 457: Resilience Authorities

Georgetown Climate Center explanation of MD Senate Bill 457

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Appendix A. George Mason University - Methodology for Creating Inundation Maps

This appendix provides a concise overview of the flood hazards modeling framework that was implemented by the AdSci project's team to delineate potential flood risks in Crisfield (MD) based on the community co-production activities described in the report. The framework was developed to estimate the inundation depth and extent as a result of selected hazard scenarios combined with different adaptation strategies, created in collaboration between the AdSci Project's team and the City of Crisfield Community Advisory Committee (CAC). Our modeling efforts were divided into five different tasks:

Task 1: Mapping the as-built City of Crisfield Drainage System

A geographic database was developed to characterize the current state of the existing stormwater infrastructure. Spatial information was gathered based on the City of Crisfield Drainage Assessment Report (CCDAR), Maryland iMAP, aerial imagery, and field visits, and refined in collaboration with the project's CAC and City staff. A web application[19] was developed to provide the resulting product to the broader community. It is important to note that there was no further ground truthing for the resulting existing infrastructure database, therefore these maps might still not completely accurately represent the city's as-built infrastructure. However, this is the most up-to-date representation that our team had access to. We recommend further developing this mapping to support the City's future resilience projects.

Task 2: Hazard selection

A breakout activity was conducted during the project's second workshop with the CAC to identify the hazards that were of interest to the CAC based on a series of flood maps and local statistics regarding historical water levels from the NOAA Solomons Island station. During the workshop, the community decided to focus their activities on high-frequency nuisance flood events, and two water level scenarios were selected: 1.5ft and 2.5ft. Note that the project team also developed coastal inundation models based on hydrodynamic and wave models (ADCIRC+SWAN) to provide historical and extreme events boundary conditions to the local scale flood inundation models. These simulations included a winter storm (December 2020) and Hurricane Isabel (2003).

Task 3: Adaptation Strategies

The set of adaptation strategies that formed the basis for our analysis was also co-developed with the CAC during our third workshop. During this event, CAC members were actively engaged in a breakout activity where they qualitatively evaluated a range of potential adaptation strategies based on the

[19] the maps are available at https://arcg.is/1THzmG

recommendations proposed on the CCDAR. Additionally, the CAC members contributed with community-specific ideas to enhance the overall approach to adaptation. Incorporating CAC members' insights ensured our chosen adaptation strategies were aligned with the community's specific needs and aspirations. Finally, four different adaptation strategies were selected to be combined and assessed under the selected hazards (Task 2): a) Tide Gates; b) Roadway Elevation; c) Dike/Berm; and d) Seawall.

Task 4: Flood Scenarios

The final task consisted of combining the selected hazards with the recommended adaptation strategies to create flood maps based on multiple scenarios (Table A. 1).

Table A. 1- Modeling Scenarios

Scenario ID	Hazard	Strategies	Condition
S1 (baseline)	1.5ft Water Level	NA	Current Infrastructure and Existing Tide Gates **FAIL**
S2 (baseline)	2.5ft Water Level	NA	Current Infrastructure and Existing Tide Gates **FAIL**
S3 (baseline)	2.2ft Water Level (*December 2020*)	NA	Current Infrastructure and Existing Tide Gates **FAIL**
S4 (baseline)	3.4ft Water Level (*Hurricane Isabel*)	NA	Current Infrastructure and Existing Tide Gates **FAIL**
S5	1.5ft Water Level	Tide Gates	Current Infrastructure and Existing Tide Gates **FUNCTIONING**
S6	2.5ft Water Level	Tide Gates	Current Infrastructure and Existing Tide Gates **FUNCTIONING**
S7	1.5ft Water Level	Tide Gates, Berm, Roadway Elevation, Seawall	Current Infrastructure and Existing Tide Gates **FUNCTIONING**
S8	2.5ft Water Level	Tide Gates, Berm, Roadway Elevation, Seawall	Current Infrastructure and Existing Tide Gates **FUNCTIONING**

Task 5: Flood modeling framework

A customized bathtub approach was employed in the project to develop proof-of-concept flood scenarios for the study area. The local-scale flood modeling framework utilizes the same principles as the Sea Level Rise Viewer[20] developed by NOAA's Office for Coastal Management to develop higher-resolution flood maps and incorporate adaptation strategies.

[20] https://coast.noaa.gov/slr/

Our local scale approach utilizes topographical information to delineate terrain elevations and to identify locations susceptible to flooding under varying water level scenarios. The fundamentals of this method are described in the “detailed method for mapping sea level rise inundation”[21]. The NOAA methodology was further modified in order to integrate the drainage system's existing features obtained from Task 1 and the adaptation strategies from Task 3. This allowed for an enhanced depiction of flood extents that considered the effects of the stormwater infrastructure in the inundation extents.

The model uses the water level input as a hazard scenario (from Task 2) and calculates potentially flooded areas by comparing the elevation of the terrain with the predetermined threshold elevation, designating areas at or below this threshold as flooded while those above it remain dry. However, although the approach allows for rapid preliminary assessments of flood risk, it does not capture all the nuances of complex flood processes such as hydrodynamic processes (e.g., bottom friction), which can lead to inaccuracies in flood extent and depth predictions.

This framework was chosen because a) it facilitates conceptualizing and communicating flood risk in a community co-development environment, making it an effective tool for building capacity with the CAC; b) it can quickly identify flood-prone areas without the need for a highly detailed numerical model; c) it offers a cost-effective alternative for assessing flood risk in data-scarce areas where computational power is also limited; and d) it can serve as a starting point for flood risk assessment and management, helping local stakeholders identify areas that require more attention.

Task 5.1: Developing a hydrologically conditioned Digital Elevation Model

The local scale model is based on a 1m Lidar-based Digital Elevation Model (DEM[22]) that was hydrologically conditioned in order to accurately depict water flow patterns (as shown in Figure A. 1. Raw lidar-based DEM (left) and hydrologically conditioned DEM (right).

). This terrain-cleaning process was conducted by employing a combination of GIS tools across the entire model domain, covering approximately 36mi^2. During this process, we assessed and refined 110 miles of existing streams and ditches to enhance connectivity between water pathways. In QGIS, the "r.carve" tool was applied to modify the terrain, eliminating irregularities in the existing ditch network, where most of the blockages in waterways were identified. Finally, in ArcGIS Pro, the "Pixel Editor" was utilized for fine-grained editing and manipulation of individual pixels within the DEM to further refine the terrain.

[21] https://coast.noaa.gov/data/digitalcoast/pdf/slr-inundation-methods.pdf

[22] *MD_Southeast_2019_D20 Bare Earth DEM* - provided by the USGS and the Eastern Shore Regional GIS Cooperative (ESRGC)

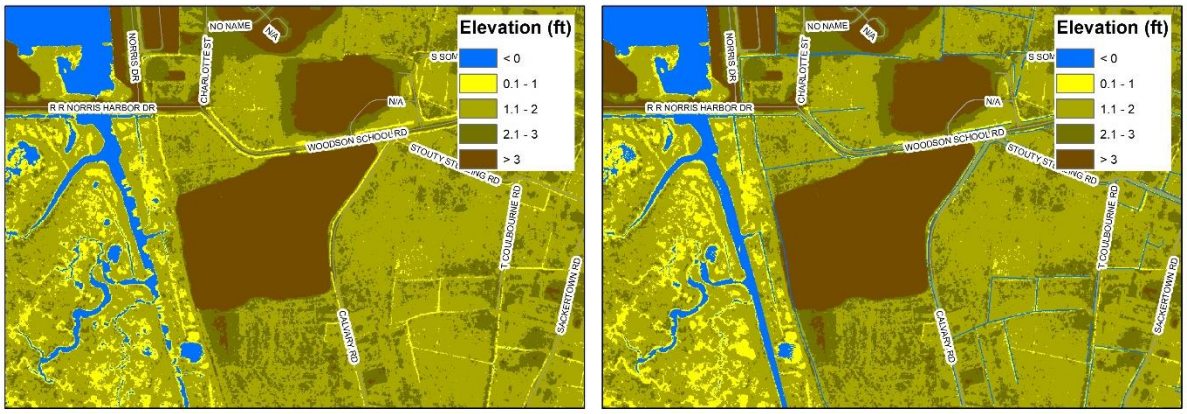

Figure A. 1. Raw lidar-based DEM (left) and hydrologically conditioned DEM (right).

Task 5.2: Local-scale flood inundation mapping

The model integrates pre-existing stormwater system components such as pipes, culverts, and tide gates into its two-dimensional (2D) framework. This integration is crucial to account for the impact of such infrastructure in the inundated areas thus allowing for modifications to the flood extent by considering the interaction between inundated areas and the existing infrastructure, as illustrated in **Error! Reference source not found.**. Once the areas below the water level thresholds are identified, the next step involves utilizing an intersect tool. This intersect tool is employed to combine the flooded areas that are interconnected with the ocean via existing stormwater pipes. By following these steps, the model ensures a comprehensive assessment of flood-prone regions and the influence of existing stormwater infrastructure on flood dynamics. Additionally, when the flooded area is connected to a tide gate and there is no overwash in the ditch or surrounding areas, we also used the same process to identify areas potentially protected by tide gates, as illustrated in **Error! Reference source not found.**. Furthermore, this approach enables us to distinguish and isolate areas without hydrological connections (potentially ponded areas), focusing specifically on areas linked to the ocean, thus effectively converging coastal hazard concerns from the CAC.

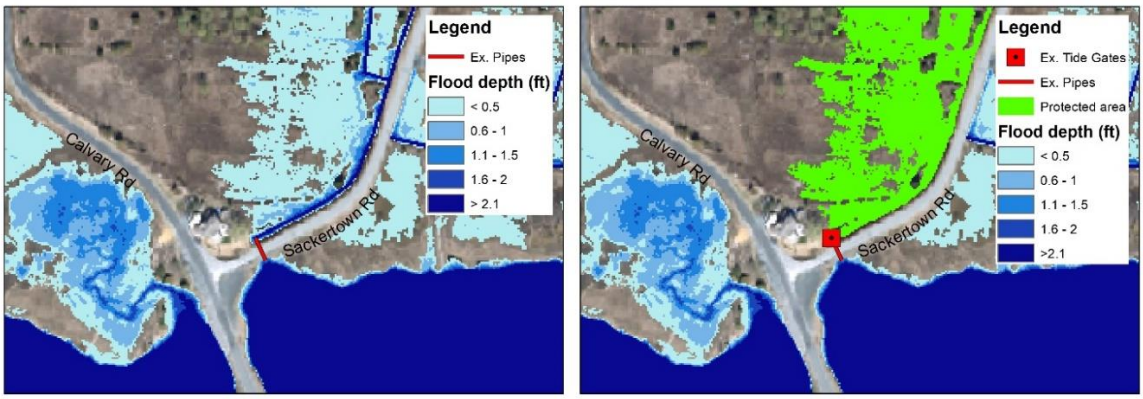

Figure A. 2. Flood extent and depth under baseline condition (left) and the influence of stormwater infrastructure (right), both under the 1.5ft water level scenario.

Task 5.3: Implementing adaptation strategies into the flood model framework

Within the same model framework, structural defense strategies such as Roadway Elevation, Dike/Berm, and Seawall were integrated by introducing artificial changes to the DEM using ArcGIS Pro. These elevation barriers play a pivotal role in identifying areas situated below the water level threshold but isolated from the primary flooded zones. This approach allows us to gauge the potential benefits of implementing these structural strategies for flood mitigation, providing valuable insights into the effectiveness of such measures in safeguarding vulnerable areas from inundation (**Error! Reference source not found.**).

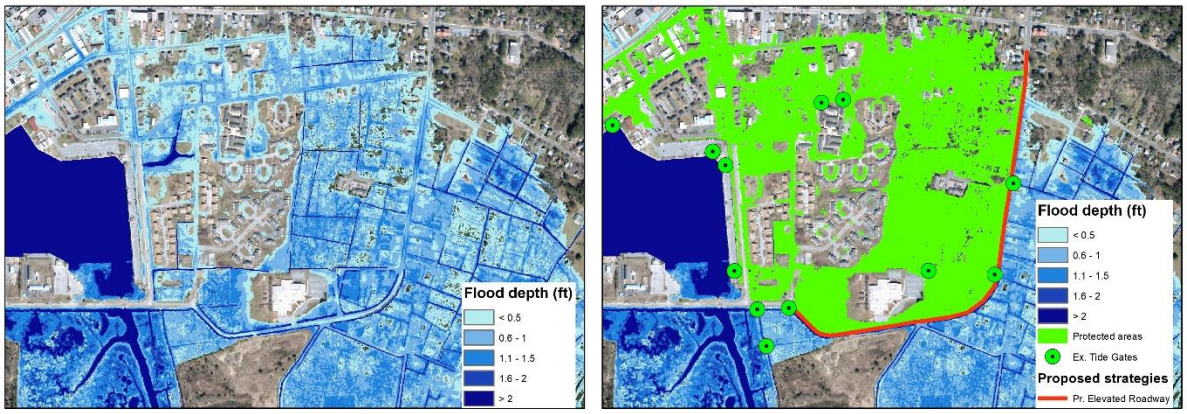

Figure A. 3. Flood extent and depth under baseline condition (left) and the influence of roadway elevation (right), both under the 2.5ft water level scenario.

Flood model outputs are described in Table A. **2**:

Table A. 2- Model outputs

Type	**Format**	**Name**	**Resolution**	**Vertical Unit**	**Vertical Datum**	**Coord. System**
Raster	.tif	Flood depth	1m	Meters and Feet	NAVD88	NAD 1983 UTM Zone 18N (EPSG: 26918)
Vector	.shp	Flood extent	-	-	NAVD88	NAD 1983 UTM Zone 18N (EPSG: 26918)
Raster	.tif	Areas potentially protected by infrastructure (depth)	1m	Meters and Feet	NAVD88	NAD 1983 UTM Zone 18N (EPSG: 26918)
Vector	.shp	Areas potentially protected by infrastructure (extent)	-	-	NAVD88	NAD 1983 UTM Zone 18N (EPSG: 26918)

Both the hydrologically conditioned DEM and the model results are available for download[23].

[23] de Lima, A., C. Ferreira (2023). Flood Adaptation Assessment for Enhanced Community Resilience in Crisfield, MD, HydroShare, https://doi.org/10.4211/hs.a31346551d3f447fbfbd9e4b57ec7a8b

Appendix B. NOAA Projections of Daily Inundation Depths

https://coast.noaa.gov/stormwater-floods/assess/

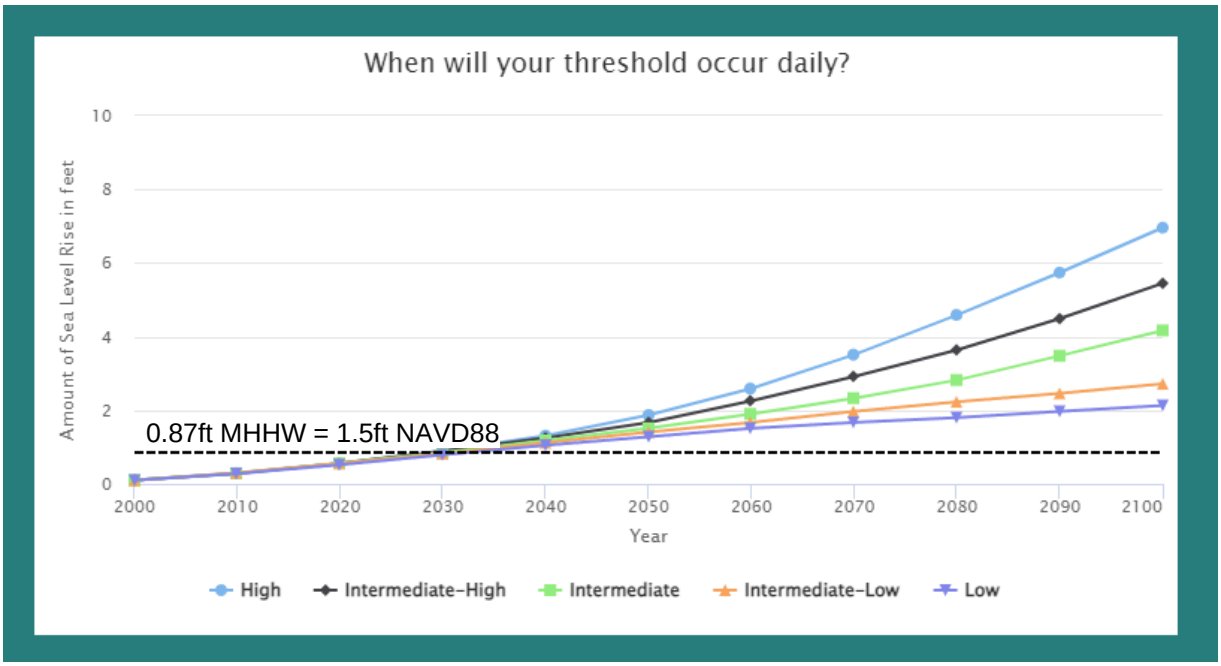

Figure A. 4. NOAA Projections of Daily Inundation Depths at 1.5 food water level.

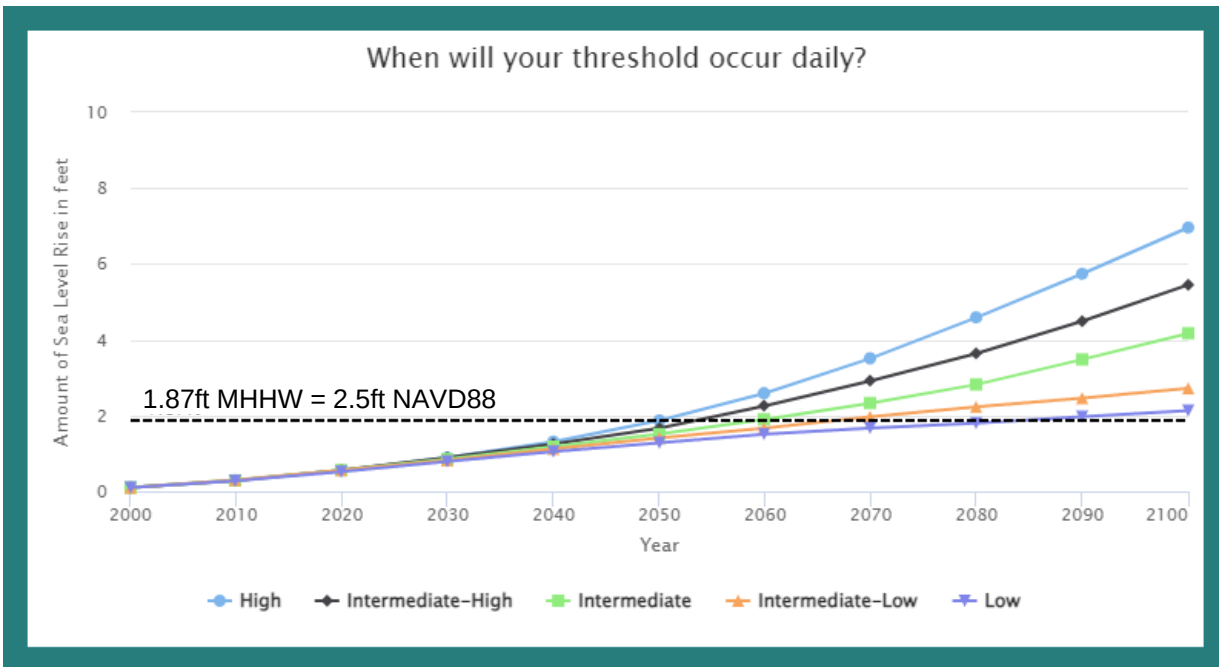

Figure A. 5. NOAA Projections of Daily Inundation Depths at 2.5 foot water level.

Appendix C. Property Data and Zoning

https://docs.google.com/spreadsheets/d/1K8nuWt5Xb9Etyys_RM8gvEWZwGfNd2uY/edit?usp=sharing&ouid=101345513069626461813&rtpof=true&sd=true

Appendix D. HAZUS Depth Damage Data

https://docs.google.com/spreadsheets/d/1V2ZcTenZ6ZCF8-nmCgmhwc0F-eJ04BAy4b81Z2THEY8/edit?usp=sharing

Appendix E. Method of Damage Cost Evaluation

Damage Cost Methods

UMD EFC conducted analysis to determine how many structures may be exposed to and damaged by flooding at each of the two water levels. This analysis involved overlaying geospatial data on buildings and parcels (property boundaries) with the outputs of the flood hazard models—water level layers—and then using information on the impacted structures to calculate economic damages. UMD EFC collected publicly available building footprint and zoning data, as well as information on structure characteristics and values. The data was entered into ArcGIS Pro and projected into the coordinate system NAD 1983 (Maryland State Plane).

Table A. 3- Data layers used for exposure and vulnerability assessment.

Data Layers	Source	Link
Building Footprints	Microsoft GitHub Footprint Data USA	https://github.com/microsoft/USBuildingFootprints
Real Property Data	Maryland Department of Assessments And Taxation	https://sdat.dat.maryland.gov/RealProperty/Pages/default.aspx
Flood Depth Raster	George Mason University	Maps in Appendix D
Damage Functions	FEMA HAZUS Inventory	Extracted from HAZUS software - https://www.fema.gov/flood-maps/products-tools/hazus

Data Preparation for ArcGIS Pro

The property data were amended in Excel for import to ArcGIS Pro. The property data were imported with all of the fields for each parcel in Crisfield and areas slightly outside of the Crisfield juridicational boundary (study area, see Figure 1). A new zoning column was added with zoning assigned for each parcel based on the building descriptions in the property database that matched zoning types in the

HAZUS inventory. For example a structure may be zoned “R-1” in the MD property database and further detail indicates it is a one story residential with no basement. That description is coded to match HAZUS “RES1.” Commercial building may have various zoning from “CBD,” T-M,” “C-2” but detail indicates they are restaruants which HAZUS code is “COM8.” The building foot print and adjusted zoning are in Appendix B.

The adjusted zoning is important because it links to the HAZUS depth-damage functions. The Coastal A Zone damage functions were used and a zonal statistic for each building footprint was calculated in ArcGIS Pro as part of the workflow. Zonal statistics is a tool for raster data that analyzes basic statistics like average maximum and minimum in defined zones such as the building footprints. Zonal statistic of the maximum water level inside the building footprint was used as the water depth of each scenario.

ArcGIS Pro WorkFlow

The “Flood Depth” digital elevation model (DEM) was obtained from project partner GMU. These are referred to as water levels in this report. Six water levels reflecting each of the scenarios (1.5 ft baseline, 2.5 ft baseline, and the two adaptation scenarios for each baseline) were used in this process. The rasters were imported into ArcGIS Pro to analyze the depth of water within each building footprint. As mentioned above, the zonal statistics table contains the maximum water depth in the building footprint. The output of the zonal statistics is joined with the elevation of the footprint. Damage functions are assigned based on the zoning code that relates to the HAZUS damage functions. The fair market value property data is multiplied by the percent damage different water levels cause within particular structures based on the zoning code. Appendix D contains the HAZUS depth damage functions used for Crisfield. For example, Table 3 in that report shows the percent of market value damage for a house zoned RES1, which is described as having no basement and built on a slab foundation in Coastal A zone. Between 0 – 0.50 feet there is 12% damage and between 0.51 and 1.0 feet there is 25% damage.

Table A. 4- HAZUS Water depth and percent structure damage for RES1 zoning.

Water level	-4 ft	-3 ft	-2 ft	-1 ft	0 ft	1 ft	2 ft	3 ft	4 ft
Percent value damage	0	0	0	0	12	25	50	75	100

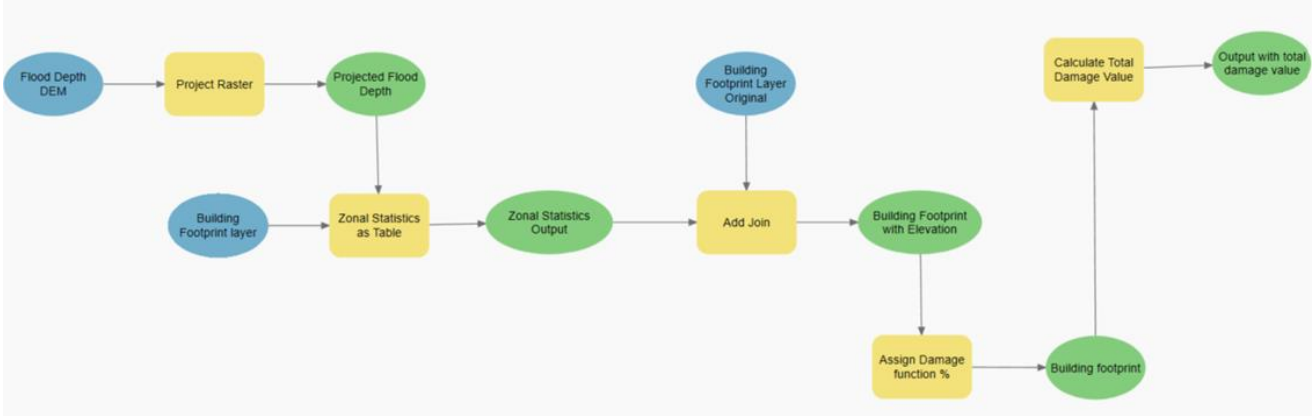

Figure A. 6. ArcGIS Pro workflow for damage value calculations.

Appendix F. Nuisance Flood Survey Responses Summary

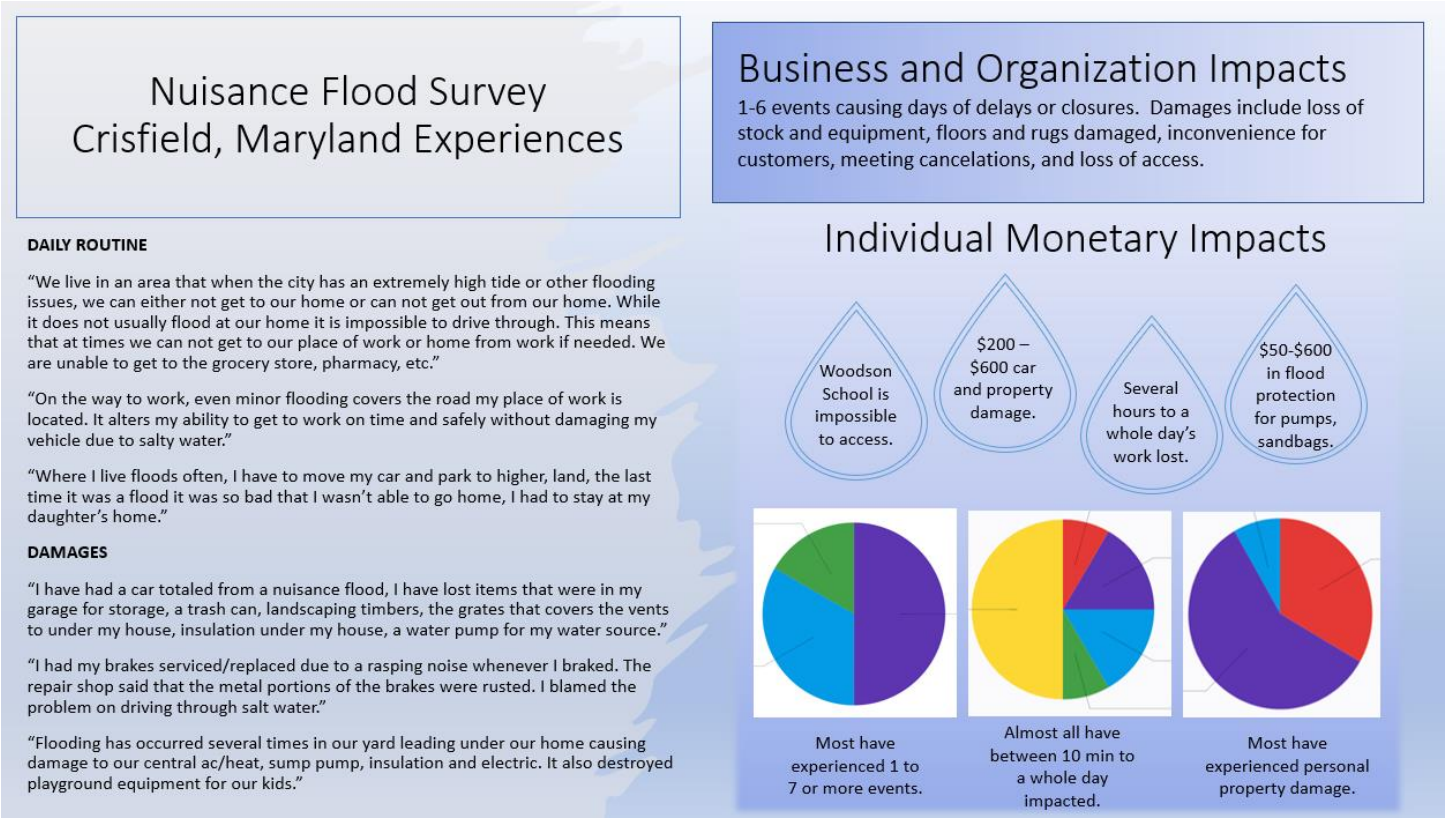

Figure A. 7. Nuisance flood survey responses summary.

Appendix G. NOAA Adaptation Strategy Options for Coastal Communities

Table A. 5- NOAA Adaptation strategy options for coastal communities.

Adaptation Strategy	How This Adaptation Strategy Changes the Impacts of Coastal Flooding
Managed Retreat Policies	
Transfer of development rights (TDR)	Encourages future development to be located out of harm's way.
Purchase of development rights (PDR)	Encourages future development to be located out of harm's way.
Rolling easements	May discourage future development from being located in harm's way. Can lead to removal of existing development from harm's way as shorelines move inland.
Fee-simple acquisition (buyout)	Prevents new development from being located in harm's way and/or removes development currently in harm's way.
Infrastructure relocation	Relocates the infrastructure out of harm's way.
Tidal Management	
Storm-surge barriers	Prevents higher water from traveling through inlets or into estuaries up to a certain water-level increase.
Engineered Barriers	
Levees and dikes	Prevents flooding up to a certain water-level increase.
Sea walls	Prevents flooding up to a certain water-level increase.
Beach nourishment	Prevents flooding up to a certain water-level increase.
Sandbagging	Prevents flooding up to a certain water-level increase.
Infrastructure Modification/Design	
Elevated development	Reduces the damage caused by flooding by raising the infrastructure above ground level.
Flood-proofing infrastructure	Reduces the damage caused by flooding.
Floating development	Prevents flooding to structure as the development rises with the water.
Floodable development	Prevents structural damage up to a certain height. May contain some water which can prevent flooding of other assets.
Movable buildings	Allows for relocating the infrastructure out of harm's way.
Drainage systems	Manages flood water to reduce damage.
Land Use Policy	
Preservation of open space	Prevents future development from being located in harm's way. Preserved open space may also absorb flood water and/or serve as a buffer during inundation events.
Zoning in vulnerable areas	Minimizes or prevents future development from being in harm's way or requires future development to be more resilient to flooding.

Adaptation Strategy	How This Adaptation Strategy Changes the Impacts of Coastal Flooding
Development fees in vulnerable areas	Can be used to pay for flood mitigation measures and may encourage future development to be located out of harm's way.
Green Infrastructure	
Wetlands	Absorb water to reduce the overall water-level increase, and dissipate wave and storm surge energy.
Mangroves	Reduce the wave power, typically resulting in a smaller storm surge and a slightly lower water-level increase.
Oyster and coral reefs	Reduce the wave power, typically resulting in a smaller storm surge and a slightly lower water-level increase.
Living dunes	Prevent flooding up to a certain water-level increase.
Barrier island restoration	Reduces the wave power, typically resulting in a smaller storm surge and a slightly lower water-level increase.

Appendix H. CAC-Identified Community Assets Supporting Resilience

Table A. 6- CAC-Identified community assets supporting resilience.

Group	Name	Description
	American Legions Club	Local social institution and organization that provides community charity
	Arc Bridge	Watermen shanties and boat launch in Down Neck
Church	Asbury United Methodist	An important faith-based institution that supports the community; a predominantly White congregation
Church	Blancia Rose Faith and Healing Chapel	A faith-based institution that importantly supports Crisfield's African American community
Residential	Captain's Quarters Condos	Has become a real estate draw in town, several condos are also now being used as AirBNBs
	Carvel Hall	Recently transferred from the City to a private investor who will be using it to grow hemp and marijuana, which is anticipated to bring around 50 jobs to Crisfield. Has also been used by the community for holding cars when flooding inundates Crisfield.
Environment	Cedar Island Marsh Sanctuary	Draws visitors to the area for birding and other nature-based tourism
Church	Charity Holiness Deliverance Center (Church)	A faith-based institution that importantly supports the African American community
Church	Church of God	An important faith-based institution that supports the community; the predominantly White congregation
	City Dock / "The Depot"	Ferry landing for Smith and Tangier islands, social gathering site, sunset viewing point, historical significance
Public Service	City of Crisfield Municipal Offices	Mayor's office, City of Crisfield staff, Police Department
Public Service	City of Crisfield Wastewater Treatment Plant	City's public works infrastructure
Public Service	Community Center	Recreational outlet, but has been closed for structural repairs
Public Service	Corbin Library	Building where City Council meetings are held, also houses community meeting space and gallery space as part of the Crisfield Arts and Entertainment District
Restaurant	Crab Pot Depot	

Public Service	Crisfield Fire Department	Volunteer fire department
Education	Crisfield High School	The only high school in Crisfield, and an important community institution. Important local employer
Public Service	Crisfield Housing Authority	Public housing that serves 1/3 of Crisfielders
Stores	Dollar General	Important local shopping option in town for household needs that is within walking distance for many. Particularly important for those without cars.
Church	Enon Baptist Church of Deliverance	A faith-based institution that importantly supports the African American community
Group	**Name**	**Description**
Church	First Baptist Church	An important faith-based institution that supports the community; a predominantly White congregation
Restaurant	Fisherman's Grille	
Stores	Food Lion	The only grocery store in town
	Gordon's Confectionary	
	Handy Seafood	Important employer, one of a handful of local seafood processors left in town
Residential	Harbor Light Condos	Has become a real estate draw in town, several condos are also now being used as AirBNBs
	Hearts Ease	Local retirement community
Church	Holiness Christian Church	An important faith-based institution that supports the community
Church	Immanuel United Methodist Church	A faith-based institution that importantly supports the community; a predominantly White congregation
	It Takes A Village to Help Our Children (ITAV)	A local community-based organization that provides childcare support for at-risk youth
Environment	Janes Island State Park	Important tourism asset for Crisfield also protects from storms
Public Service	Library	Community meeting space
	Little Boat Harbor	Primary commercial harbor, where a lot of local watermen have their shanties and where
	Little League Park	
	MeTompkin Bay Oyster Company	Important employer, one of a handful of local seafood processors left in town
Church	Mt. Pleasant United Methodist Church	A faith-based institution that importantly supports the community; a predominantly White congregation
	Rails to Trail	A new bike trail was installed to connect Crisfield to Marion Station, one of the 5 tourism zones.

	Rodeway Inn at Somers Cove	Primary hotel in town
	Rubberset/Sherwin Williams	An important employer in town
Church	Shiloh Memorial Episcopal Church	A faith-based institution that importantly supports Crisfield's African American community
	Somers Cove Marina	One of the largest marinas in Maryland, state-owned and well-protected. Draws recreational boaters to Crisfield from across the Chesapeake Bay. Also supplies gas to local watermen.
Church	Somerset Free Methodist Church	An important institution that supports the community; a predominantly White congregation
Church	St Paul African Episcopal Church	A faith-based institution that importantly supports the African American community
	Tawes Armory	The building is being developed into a new community center with recreational space
	Tawes Historical Museum	local heritage museum
	The Crab Bowl	Festival grounds, especially important for the Crab Derby
Group	**Name**	**Description**
	The Elks Club	
Restaurant	The Water’s Edge	
Health	Tidal Health Hospital/McCready's	Local medical facility and important local employer
	Ward Brother's Workshop	Important Crisfield cultural resource in Down Neck
	Wellington Beach	The only beach in town draws visitors to the area
Education	Woodson Elementary	The only elementary school in Crisfield

Appendix I. Community Asset Protection from the 2.5ft Flood with adaptation scenarios

Table A. 7- Community asset protection from the 2.5ft Flood with adaptation scenarios.

Adaptation Scenarios Benefits: Reduced Exposure and Vulnerability for Community Resilience Assets at 2.5ft Water Levels				
Exposed Assets	**Damage Costs: Baseline Flood Scenario**	**Description of Vulnerability**	**Damage Costs: Functioning Tide Gates Scenario**	**Damage Costs: Functioning Tide Gates + 3 Structures Scenario**
City Dock / "The Depot"	$129,000	The asset is vulnerable to damage.	$129,000	$129,000
Harbor Light Condos	0	Built after 1981; estimated structural damage of $0. May experience access challenges.	0	0
Fisherman's Grille	0	Built after 1981; estimated structural damage of $0. May experience access challenges.	0	0
MeTompkin Bay Oyster Company	$24,000	Estimated structural damage. May experience access challenges.	$24,000	$24,000
The Water's Edge	0	Built after 1981; estimated structural damage of $0. May experience access challenges.	0	0
Captain's Quarters Condos	0	Built after 1981; estimated structural damage of $0. May experience access challenges.	0	0
Ward Brothers' Workshop	0	Insufficient property data for analysis; however,	0	0

		damages are estimated at <$1,000.		
Gordon's Confectionary	0	Flood depths remain below damage threshold*.	0	Impact removed
St. Paul African Episcopal Church	0	Flood depths remain below damage threshold*.	0	Impact removed
Blancia Rose Faith and Healing Chapel	$2,200	Estimated structural damage. The asset may experience access challenges.	$2,200	Impact removed
Charity Holiness Deliverance Center (Church)	$1,000	Estimated structural damage. The asset may experience access challenges.	$1,000	Impact removed
Mt. Pleasant United Methodist Church	0	Flood depths remain below damage threshold*.	0	Impact removed
Enon Baptist Church of Deliverance	0	Flood depths remain below damage threshold*.	0	Impact removed
Shiloh Memorial Episcopal Church	0	Flood depths remain below damage threshold*.	0	Impact removed
**based on damage functions used*				

Appendix J. Community Goals for Resilience and scenario comparison

Table A. 8- Community goals for resilience and scenario comparison.

<table>
<tr><th>Community Resilience Goals</th><th>Changes in flood impacts from 1.5 feet (NAVD88) – Tide Gates + Three Structures Scenario</th><th>Changes in flood impacts from 2.5 feet (NAVD88) – Tide Gates Scenario</th><th>Changes in flood impacts from 2.5 feet (NAVD88) – Tide Gates + Three Structures Scenario</th></tr>
<tr><td>Flood Safe Affordable Housing</td><td>Reduces flooding for 1.5ft event</td><td>Reduces flooding for the 2.5ft event in the north of town</td><td>Reduces flooding City-wide for the 2.5ft event</td></tr>
<tr><td rowspan="3">Resilient Infrastructure</td><td colspan="3">The City of Crisfield's work with the EPA CREAT utility cost benefit software estimated that complete stormwater system maintenance, including maintaining existing tide gates and ditches, would cost approximately $200,000 per year. There is a need for stronger City-County partnerships to get more money and reach the areas outside of the city (Down Neck).</td></tr>
<tr><td rowspan="2"></td><td>Improved roadway access north of Main Street. West Main Street near downtown is still flooded.</td><td>Accessing schools from the Housing Authority improves.

Access to the hospital and downtown area improves.</td></tr>
<tr><td>Economic Development through Job Creation, Recreation, and Tourism</td><td>Road access improves. No change to structure damage for assets (no assets impacted).</td><td>Continued flooding of roads may still present a challenge to existing and new businesses.</td><td>Businesses around the Main Street area where the boardwalk and berm are proposed would/could be revitalized, but in the future, the high tide could still flood part of the street. The boardwalk would bring in tourism, but there is still a strip of unprotected shoreline.</td></tr>
</table>

			Improves potential private property and investor interest due to the reduced number of flood days. Commercial and residential developers could use municipal bonds to pay the cost of construction. More walking and open spaces could lead to community revitalization.
			Down Neck is flooded but has very few residents; their access to downtown is inhibited. A lot of watermen have already moved. If we develop a plan to watertight the community more, this could lead to more commerce and activity.
Youth Development	Road access improves. No change to structure damage for assets (no assets impacted).	The high school is dry but there is significant flooding of streets south of Main Street. Elementary school access is still challenging for the housing authority.	Public housing is protected as an important youth asset because of the number of kids. The new It Takes a Village (ITAV) site is more accessible from the west but still on the edge of a flooded area. Asbury entrance is dry.
			Down Neck – three school buses go down there, but maybe not many students. The new ITAV site is still on the edge of flooding. Drainage problems on the property. The road by Crisfield High has flooded, but as you get closer to the high school, it's not as

			flooded as the side streets are. Columbia has flooding.
		This scenario does not improve loss of school time due to flooding, e.g., either a 2-hour delay so buses don't have to drive through flooded streets or closing for the day.	This scenario may improve loss of school time due to flooding, e.g., a 2-hour delay so buses don't have to drive through flooded streets or closed for the day. Improved access to after-school program time when schools closed. The new ITAV new site is not flooded.
			The high school is dry but some side streets flood. Elementary school access improves for the housing authority.
			Down Neck – "This leaves them stuck; they're just going to swim."
Enhanced Public Spaces to Grow and Support Community	Road flooding shows improvement, and Down Neck can access the community spaces.	Still significant flooding in the south of town and Down Neck.	Less corrosion and salt water over time would lead to less building damage (Pastor Jackson's church experienced this). An elevated road to the hospital would be a game changer.
		Lack of access to It Takes a Village (ITAV) site from the Housing Authority and the southern area of the City.	This scenario would provide good protection for the majority of the churches in the city, which serve a key purpose in the community in normal times, and in times of flooding/storms.
			Down Neck residents cannot access any of the community

		spaces during flooding conditions. This is a climate justice issue that needs to be addressed.

Appendix K. Subject Matter Experts Interviewed for Policy Analysis

Table A. 9- Subject matter experts interviewed for policy analysis.

Name	Organization
Stacy Shaefer	Charles County Resilience Authority
Mayor Darlene Taylor	City of Crisfield
Jennifer Merritt	City of Crisfield
Kelly Daniel	City of Raleigh
Kate Durant	Critical Area Commission
Lana Kashuba	EPA Office of Research and Development
Megan Fitzgerald	EPA Region 3
Bill Jenkins	EPA Region 3
Ju-Ching Huang	Georgetown University
Sasha Land	Maryland Department of Natural Resources
Tracey Taylor	Maryland Department of Planning
Keith Lackie	Maryland Department of Planning
Suzanne Dorsey	Maryland Department of the Environment
Rachel Lamb	Maryland Department of the Environment
Lisa Ramjohn	Maryland Department of the Environment
Woody Barnes	Somerset County
Charles Cavanaugh	Somerset County
John Redden	Somerset County
Jesse Drewer	Somerset County
Mary Phillips	Somerset County
Cheryl Lewis	Town of Oxford
Allison Coffey Reilly	University of Maryland