IMPLEMENTATION STRATEGIES FOR FLOOD MITIGATION AND STORMWATER MANAGEMENT IN CECIL COUNTY, MARYLAND

Department of Land Use and Development Services

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EVNM 670

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Executive Summary

Flood mitigation involves the management and control of flood water movement, such as redirecting flood runoff using floodwalls and flood gates, rather than trying to prevent floods altogether. A large source of flood water comes from stormwater, which is created from rain or melting snow that does not soak into the ground but rather runs into nearby waterways. Stormwater is not treated by a water treatment system, so the water quality and habitat of creeks and rivers is often negatively affected. Some stormwater management practices include the use of wet ponds, dry ponds, swales, and bioretention areas. In Cecil County, flood mitigation is especially important because it has three physiographic regions that are susceptible to flooding: the Piedmont, the fall zone, and the Coastal Plain province. The five major rivers flowing through the county include the Susquehanna River, Northeast River, Elk River, Bohemia River, and Sassafras River. The County has proactively responded to flood mitigation by creating the Green Infrastructure Plan, which consists of identifying implementation strategies such as a Stormwater Management Incentive Management Program and an inventory of mitigation solutions for 12 facilities providing crucial services to the region. Incentives for the Stormwater Management Program include a discount fee, development inventive, grants, rebates and installation financing, and an awards and recognition program. The most common and easily implemented forms of green infrastructure for the County's facilities and residents are rain gardens and conservation landscaping. Green roofs/walls are also good options for newer and larger buildings that can support the weight and maintenance required. Porous pavement, often porous concrete or asphalt, is a form of gray infrastructure that is beneficial for parking lots that are cracked and outdated. The main objective of the Green Infrastructure Plan is to increase the resiliency to flood hazards from in environmentally sustainable ways and to provide private property owners with incentives for both businesses and residents to take action.

Introduction

Purpose and Background

Cecil County is vulnerable to flash floods and stormwater runoff, as well as, the effects of climate change such as flooding from sea-level rise. As a proactive response to, as well as improving community resiliency after flooding and other severe weather-related events, the Cecil County Department of Land Use and Development Services has created the Green Infrastructure Plan. This report supplements the plan, and identifies implementation strategies related to stormwater management incentives and potential flood mitigation solutions for 12 critical facilities that the County identified. Critical facilities defined within this report are those intended to be operational during disaster-related events, and include police stations, fire departments, town halls, water, and wastewater treatment plants. The main objective of the implementation strategies we identified and in the Green Infrastructure Plan is to increase local resiliency to flood hazards while protecting critical facilities and to provide property owners (both businesses and residents) with incentives to take necessary action.

The reference jurisdiction of this study is of Cecil County. Geographically, Cecil County is the northeast most county in the state of Maryland. Its borders include Pennsylvania to the north, Delaware to the east, Kent County to the south, and Harford County to the west. The population of Cecil County from the 2010 census is 101,108 making it the 13th most populated county in Maryland. Cecil County is unique in that it has three physiographic regions: the piedmont, the fall zone, and the coastal plain province.

The Piedmont: Mostly a broadly undulating to rolling topography underlain by metamorphic rocks, its relief is increased locally by low knobs or ridges and valleys. On the west are lowlands

developed either on Mesozoic clastics or early Paleozoic carbonates (Maryland Geographical Survey, 2008).

Fall Zone: A seaward sloping plain extending from Cape Cod to the southern tip of Florida. In Maryland, it consists of a fairly flat to moderately rolling upland and an even flatter lowland (Maryland Geographical Survey, 2008).

The Coastal Plain Province: A large peninsula extending south of the Elk River and separating Chesapeake Bay and Delaware Bay-Atlantic drainages; has grown by southward accretion during the Neogene. Consists of an axial "upland" bordered by a series of lowlands (Maryland Geographical Survey, 2008).

With the sea level is rising with and weather events are becoming more variable Cecil County is at risk of flooding events that can leave towns on the water like North East and Elkton vulnerable. Another factor is land subsidence which is lowering the land while the sea levels are rising. Cecil County is in the Chesapeake watershed where it puts more pressure on the rivers, streams, and waterways from large rain events upstream.

Natural Resource Inventory

Floodplains. A floodplain is defined as the land area along a river, stream or waterway that is expected to experience standing water during a storm event. The Federal Emergency Management Agency (FEMA) is responsible for keeping an inventory of the floodplains across the nation. Many coastal towns throughout the nation are currently susceptible to flooding. In Cecil County, the Town of Port Deposit is in the floodplain. Port Deposit is situated on the banks of the Susquehanna River, a large river that drains into the Chesapeake Bay only miles away. The Conowingo Dam was built in 1928 to try to regulate the floods on the river, but since the Town is still in the floodplain it floods frequently. In 1972, well after the dam was constructed

Tropical Storm Agnes brought the largest floods in Port Deposit history (Killar, 2011). The Susquehanna is not the only river in Cecil County that has an immense floodplain, lands adjacent to the Elk and North East Rivers are also in the floodplains.

Wetlands. Wetlands provide ecosystem services for humans, the environment, water quality, and for flood control (Allen & Dunn, 2007). The Chesapeake Bay watershed extends over five states, and all the water that is collected drains through Maryland and northern Virginia. The Susquehanna is one of the Bay's main tributaries and runs through Cecil County to the west. In Cecil County, wetlands are found along shores, floodplains, drainage ways, and depressions. There are 9,018 acres of wetlands in the county (1.5% of Maryland's total wetland area) (Tiner & Burke, 1995). Wetlands are important for many species of aquatic and estuarine animals and birds as well as natural flood reduction. Cecil County's wetlands can be separated by estuarine, palustrine, and lacustrine wetlands.

Palustrine wetlands, also known as marshes, swamps, or bogs, are inland from the shores. They lack flowing water. They contain traces of salt within the water, but it is below .5 parts per thousand (ppt). Ocean salinities, by comparison, are around 35 ppt (Cowardin et. al., 1979,). In Cecil County palustrine wetlands account for 6,646 acres at 73% (Tiner & Burke, 1995).

Estuarine wetlands, where rivers meet the sea are most prevalent in Cecil County. Four major rivers in Cecil County feed directly into the Bay. As a result of this the water is a brackish mixture of saltwater and freshwater. In Cecil County estuarine wetlands account for 2,184 acres at 24% (Tiner & Burke, 1997). The salinity fluctuates do to what kind of estuarine wetland is present.

Lacustrine wetlands are the least prevalent. They are permanently flooded in a lowland, they are typically very deep and have very little vegetation. The salt content in the water is low,

and this wetland has a significant number of waves (Cowardin et. al., 1979). An example of this wetland is Lake Superior itself which is part of the Great Lake System. In Cecil County lacustrine wetlands account for 38 acres (less than 1%) all of which are in or near the Conwingo Dam (Tiner & Burke, 1995).

Surface Water Features. Cecil County has many different water features including rivers, the Chesapeake Bay, and many man-made small ponds/lakes. There are five major rivers within the county that include:

- Susquehanna River (Octoraro Creek)
- Northeast River (including Northeast Creek)
- Elk River (including Back Creek)
- Bohemia River (including Great Bohemia Creek and Little Bohemia Creek)
- Sassafras River (including Money Creek, Cox Creek, Foreman Creek, Back Creek, Hall Creek, Hen Island Creek, and Duffy Creek)

The other major water feature of note is the Conowingo Reservoir. Named after the town it now covers it was moved one mile north of its original location. The Conowingo Dam is a hydroelectric facility that was constructed in 1928 about 10 miles north of the mouth of the Susquehanna River. This reservoir provides recreational activities, provides hydroelectric power with no CO2 emissions, and flood control to the residents of the neighboring communities.

Mitigation Solutions for Critical Facilities

Figure 1: Port Deposit flooding post Tropical Storm Lee.

Cecil County has diverse surface water features. Furthermore, its proximity to the East Coast renders it susceptible to large rain events and hurricanes. In the recent past, these events caused considerable property and infrastructure damage. Up to 13 inches of rain during Tropical Storm Sandy in 2012 caused $100,000 in property damages in Cecil County (Scherzler, 2012). The remnants of Tropical Storm Lee in 2011 produced several days of rain across the County and subsequent flooding in Port Deposit and Perryville and is depicted in Figure 1 above. Flooding in Cecil County is most likely caused by excessive rain leading to riverine flooding, but it is also subject to possible tidal and/or storm surge flooding through a combination of powerful storms (hurricanes/tropical storms), astronomical high tides and northeast winds (Scott, n.d.)

An area of focus for the County's Green Infrastructure Plan will be predicated on flood mitigation planning for facilities providing crucial services to the region. Table 1 lists the County's "critical facilities." Threats to these facilities include their relative proximity to 100 and 500-year floodplains, sea level rise by 2050/2100, and a hazard vulnerability index. Existing natural protections like surrounding tree cover, open space or lack thereof are also provided for each facility. These factors were all taken into consideration for the ranking of criticality level for each facility in the table classified as high, medium or low. Finally, potential measures to protect these facilities from flooding and/or sea-level rise are suggested. In all cases, important utilities and other critical structures might be physically elevated to diminish risk of water damage, but in-person site analysis should be completed for each of the facilities to identify

plans specific to each site and its surroundings. Figures 2a, 2b and 2c display the locations of the County's critical facilities using Geographic Information Systems mapping tools.

Figure 2a: GIS Map of Cecil County's 12 Vulnerable Critical Facilities. Source: Cecil County

Figure 2b: Enlarged GIS Image of Vulnerable Critical Facilities in Port Deposit, MD. Source: Cecil County

Figure 2c: Enlarged GIS Image of Vulnerable Critical Facilities in Elkton, and North East, MD. Source: Cecil County

Solutions described in Table 1, under Potential Measures to Increase Protection, were also selected based on factors and criticality level. The potential solutions which could be implemented by the County are grey or green infrastructures, mixed use, as well as relocation efforts. Grey infrastructure refers to man-made interventions and structures while green infrastructures are a part of nature-based approaches like forests and wetlands; though also man-made, managers try to restore or replicate nature. Nature-based approaches are a part of sustainability management which can be used to help resolve socio-environmental challenges like climate change, water pollution and disaster risks. These nature-based approaches like green infrastructure mixed with some grey infrastructure are preferred for Cecil County as they can be beneficial for the environment, local economy and society (Glavovic & Smith, 2014).

An environmental benefit of using green infrastructure for flood mitigation and better stormwater management is improved water volume (that is, reduced quantity) and quality, because pollutants are taken up by native plants. Rain harvesting through rain barrels or cisterns can be used for accumulating rainwater for reuse on-site for this very purpose instead of allowing the water to run off (Maxwell-Gaines, 2018). Increased plant abundance from green

infrastructure subsequently improves air quality by reducing vehicle emissions through increasing carbon sequestration and by the uptake and filtering of pollutants and particulate matter.

The most common and easily implemented form of green infrastructure for both the County's facilities and residents are rain gardens and conservation landscaping which help with bioretention and exploiting the benefits explained above. A rain garden is an excavated, shallow surface that is planted with native vegetation used to treat and capture stormwater runoff (Worcester County Department of Comprehensive Planning, n.d., pg.1). Conservation landscaping can also "trap localized stormwater on site to ensure slow percolation and increase filtration of nutrients entering the ground water" (Alliance for the Bay, n.d., para.4). Though similar to rain gardens, the focus of conservation landscaping is to reduce the amount of pollution entering the environment by reducing mowable lawn areas and use of fertilizer and pesticides. The use of rain gardens and conservation landscaping can be easily integrated at almost all of the critical facilities because the design requirements are flexible and can be incorporated with other structures like parking lots and infiltration trenches (Pennsylvania Department of Environmental Protection, 2006, pg.49). The North East Town Hall has already installed a microbiotention area in the parking lot and the pump station in Port Deposit has a rain garden nearby. Likewise, with the abundance of wooded or forested area around most of the critical facilities, like the Elkton WTP11001 and Rising Sun Treatment Plant and Pump House, conservation landscaping can be utilized for less maintenance, and a more natural flood buffering system. For example, a vegetated bioswale,

Image 2: Rain Garden at Marina Park in Port Deposit.

which is a sloped drainage course filled in with vegetation or compost (PA DEP, 2006, pg. 84), can be used in combination with conservation landscaping to direct a large quantity of stormwater from the North East Police Department parking lot to the forested area behind the facility thereby minimizing flood risk. This potential solution could work well at this location as the soil drainage class on the GIS map indicates that the forested area behind the police station is well drained.

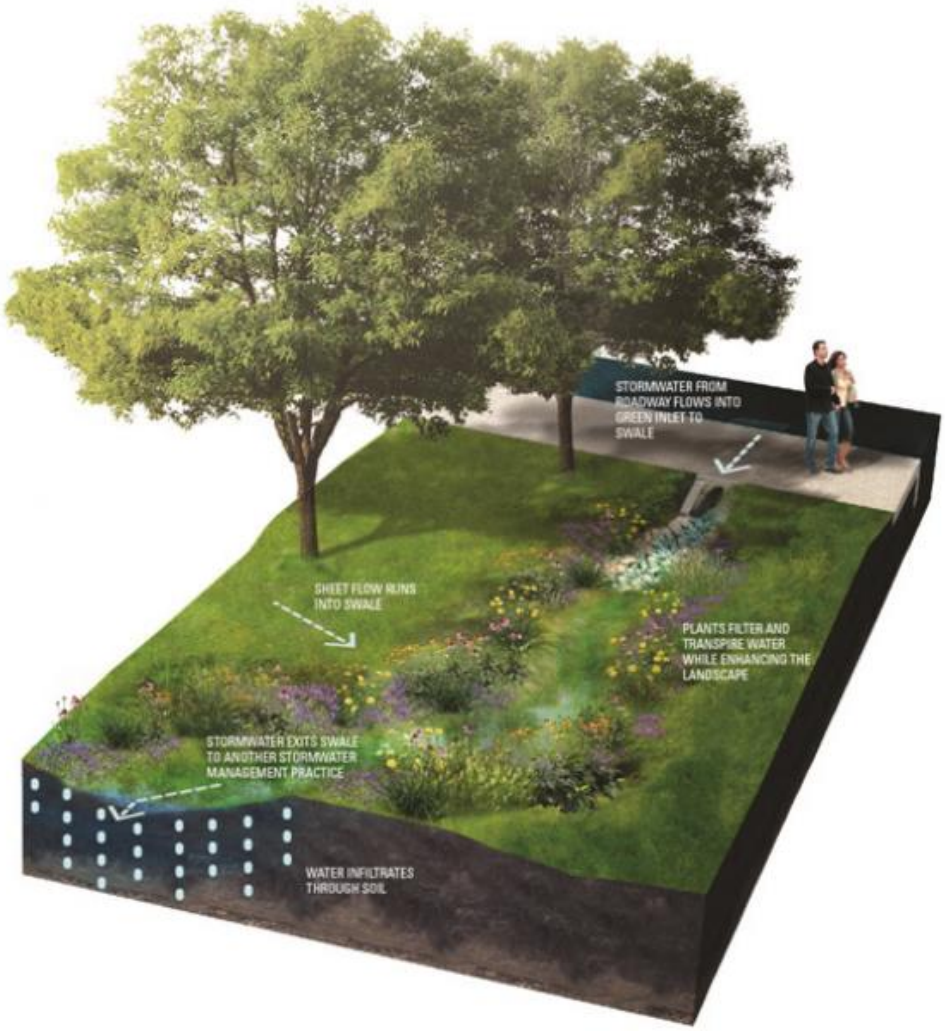

Figure 3: Example of typical layout for a bioswale. Source: Philadelphia Water Department.

Green roofs and/or walls are another good option especially for newer, larger buildings which can support the weight and maintenance of green roof vegetation. In addition to prolonging roof life, reduction of heating and cooling costs by functioning as a heat sink; depending on the thickness of vegetated cover selected, the roof can have "…significant rainfall retention and detention functions" (PA DEP, 2006, pg. 125). Another requirement for the utilization of a green roof is as follows:

> "… a conventional flat or pitched roof (<30-degree slope). The overall thickness of the veneer may range from 2 to 6 inches and may contain multiple layers, consisting of waterproofing, synthetic insulation, non-soil engineered growth media, fabrics, and synthetic components." (PA DEP, 2006, pg. 125)

There are several standards and guidelines for the successful implementation of green roofs that the County could use like the ASTM E2397/E2397M: *Standard Practice for Determining Dead Loads and Live Loads Associated with Vegetative (Green) Roof System* (2019) and the ANSI /SPRI RP-14: *Wind Design Standard for Vegetative Roofing System* (2010). But based on aerial views via GIS maps, the North East Town Hall, North East Police Department, and Perryville Volunteer Fire Department buildings would be good candidates for a green roof based on the large, flat and underutilized surface area of their current roofs.

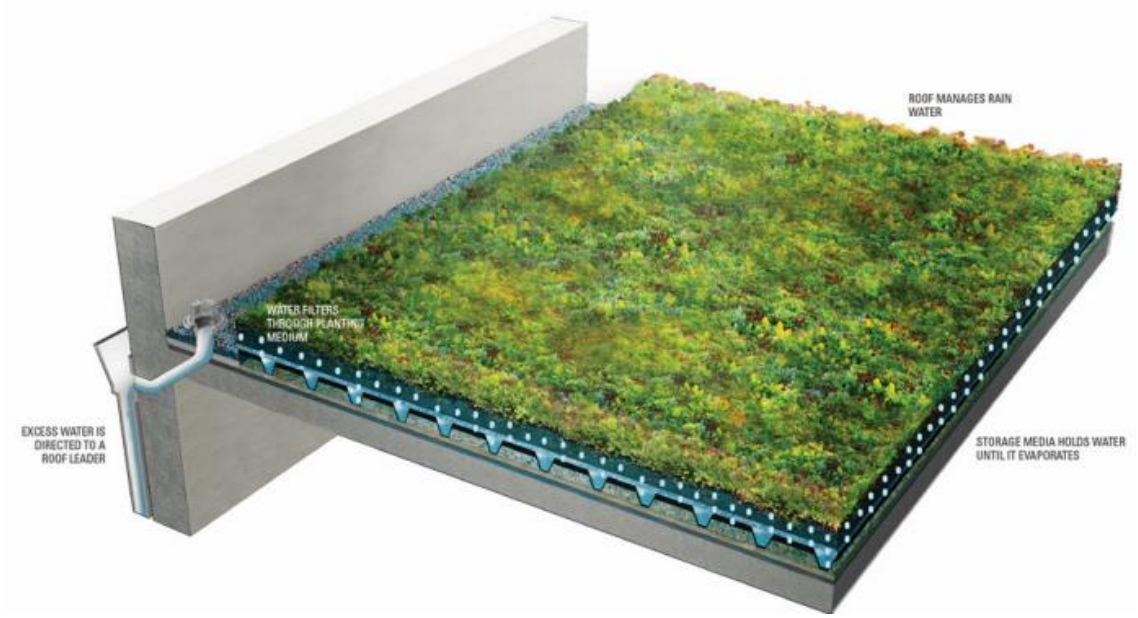

Figure 4: Layout of a green roof. Source: Philadelphia Water Department.

Natural and constructed wetlands are another green infrastructure solution, considering several of the critical facilities are situated on the banks of the Susquehanna, North East, and Elk rivers, leaving them extremely vulnerable to both flooding and erosion. Natural and constructed wetlands are shallow marsh systems, especially in areas of high stormwater runoff, which can be beneficial in treating and controlling runoff with emergent vegetation (PA DEP, 2006, pg. 151). Both the Port Herman Condominiums Treatment Plant and Harborview WWTP are located along the Elk River which can provide a water source and a sustained baseflow to maintain the wetland. Also, the properties surrounding the facilities are large enough to support the drainage area again for sustained baseflow (PA DEP, 2006, pg. 151).

Floodplain restoration is another possible option that should be considered as many of the County's critical facilities are located within a 100- to 500-year floodplain. The construction or restoration of wetlands should help this green infrastructure effort. The restoration of the floodplain includes "mimicking the interaction of groundwater, stream base flow and root systems to pre-settlement (pre-1600s) conditions" (PA DEP, 2006, pg. 231). This solution should

especially be implemented after the relocation of a critical facility like the Port Deposit WWTP and the Harbor View WWTP, which have already relocated most of their plant components outside of the 100-year floodplain.

The County can also develop greenway trails connecting parks and other green open spaces which would be beneficial for flood control, aesthetics, and recreation while supporting native species of plants and additional wildlife habitats. Furthermore, greenway trails help maintain the natural ecological process facilitating wildlife movement and connection of wildlife populations between habitats (Environmental Protection Agency, 2018). A successful greenway system is located in southern Florida, which is a 200,000-acre system of greenways which includes protected open space used for both conservation and recreation. The Loxahatchee Greenways Project connects parks and management areas while protecting the Loxahatchee River, allowing wildlife travel between different areas, and sustaining communities within its watershed (Historical Society of Palm Beach County, 2009). Cecil County could use the Loxahatchee Greenway Project as a model plan because they share a roughly similar topography when comparing the County's three rivers flowing into the Chesapeake Bay and subsequently the Atlantic Ocean. The new greenway trail could also connect to the James F. Hall Trail which already runs through the County as part of the East Coast Greenway.

Figure 5: Map of current greenway route in Maryland. Source: East Coast Greenway Alliance.

Though green infrastructure is preferred by the county, some grey infrastructure in certain areas, or a combination of the two, would help manage stormwater and protect vulnerable facilities from flooding. Especially for some facilities where the cost and time of upgrading or retrofitting older buildings or sidewalks with curb cuts and bioswales may not be feasible. Streamlined integration of both infrastructure types both above and below ground can help to create sustainable and aesthetically pleasing communities. Mixed use of both infrastructure types includes permeable pavement and rain gardens and sewer pipes and pump stations or porous pavement parking lots with filter strips, tree wells or bioswales. Project Clean Lake in Ohio is a good example of mixed use infrastructure. Through the construction of seven tunnels and increasing stormwater treatment capacities with lower-energy treatment technology at three plants combined with green infrastructure will facilitate "…stor(age), infiltrat(ion), and evapotranspirat(ion) of stormwater before it even makes its way to the combined sewer system" (Northeast Ohio Regional Sewer District, 2017). As part of the green infrastructure project efforts it will also include the building of parks, private-sector developments, and vacant lot or land reconversion in strategic locations of the city (Northeast Ohio Regional Sewer District, 2017). Due to the large number of critical facilities in Cecil County being water treatment plants, the Project Clean Lake could provide some valuable insights for upgrading the facilities and incorporating green and grey infrastructure within the county.

Image 3: Use of Green Infrastructure at North East Town Hall

The other forms of grey infrastructure mentioned as potential solutions for flood mitigation are the installation of porous pavements, especially for parking lots, that are cracked and outdated, as well as seawalls or jetties, filter strips, level spreaders, and detention basins. Porous pavement can refer to porous concrete, asphalt or pavers which are interlocking units (often concrete) with openings that can be filled with a pervious material such as gravel or even grass (Philadelphia Water Department, n.d., pg. 75).

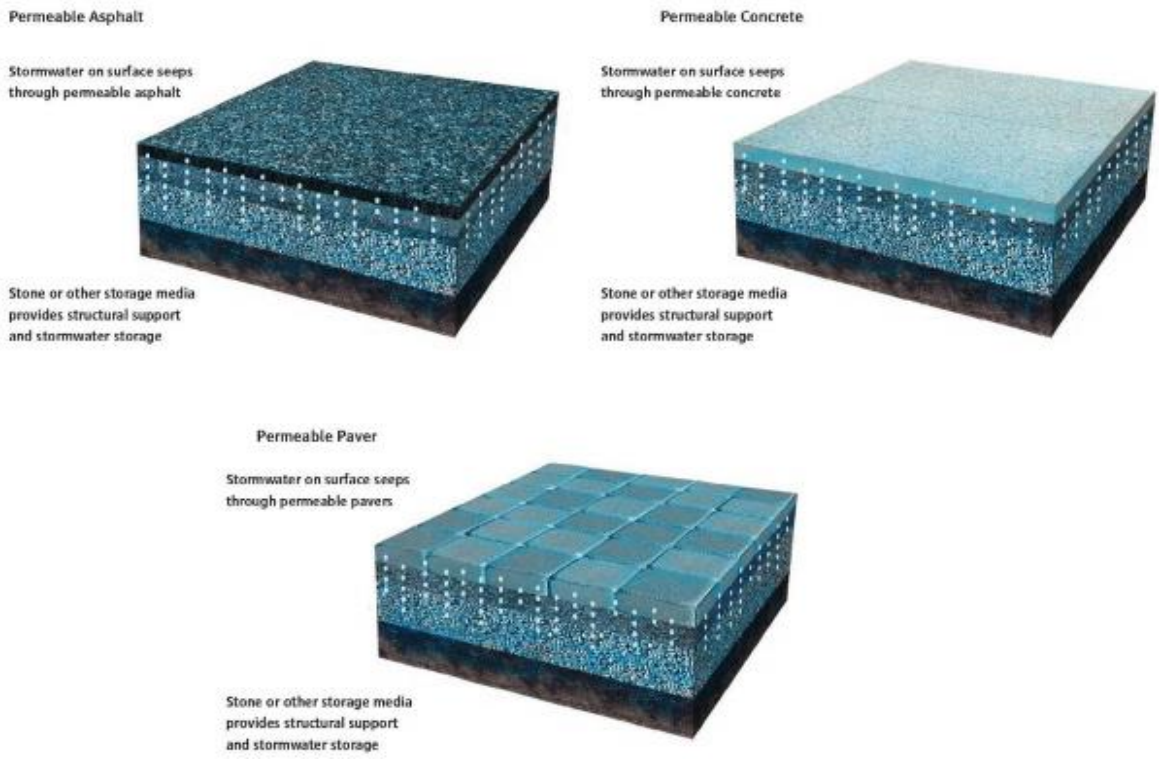

Figure 6: Examples of different types of porous pavement. Source: Philadelphia Water Department.

A seawall or jetty is a stone structure extending into a river used to protect the riverbed or shoreline. A jetty could also be particularly appropriate for both Port Deposit water treatment plants considering their proximity to the Susquehanna River shoreline. Another grey solution is level spreaders (similar to bioswales), which help to "…reduce the erosive energy of concentrated flows by distributing runoff as sheet flow to stabilized, vegetative surfaces" (PA DEP, 2006, pg. 244). These level spreaders are generally used in conjunction with filter strips,

infiltration basins or detention areas. Detention areas such as parking lots and rooftops can be temporarily used to detain stormwater for peak rate mitigation like the ballfield in Elkton (PA DEP, 2006, pg. 254).

Relocation or managed retreat is mentioned as a solution when critical facilities that cannot be conserved by either green or grey infrastructure solutions. Managed retreat is the relocation or demolition of vulnerable buildings and other infrastructure inland and away from eroding soils to a more favorable area further removed from nuisance flooding. Managed retreat can be part of a comprehensive, sustainable and resiliency-based future plan for land development. An example of successful execution of managed retreat was undertaken by Pacifica State Beach, California in 1990. Flooding of a local creek and coastal erosion at the state beach was a recurring issue despite the use of stabilizing hard structures. The movement and demolition of homes, restoration of natural beach system and reconstruction of wetlands has resulted in significant reduction in flood hazards for 100 years, a functioning wetland habitat, and increase in beach recreational use (Climate Adaptation Knowledge Exchange, 2018). As mentioned, Cecil County and its towns will need to continually assess and plan to relocate, e.g., the Elkton municipal sewage treatment plant to a higher elevation if other flood mitigation attempts prove to be unsuccessful.

The use of Green infrastructure, when possible, within Cecil County would be the most favorable for managing flooding and environment health but it can also help to provide social and economic benefits. Improved human health from the addition of more parks can provide recreational activities and increased exercise opportunities while supplying clean, fresh air and water. Cleaner air can help to reduce health problems such as asthma, cancer, heart disease, and premature death (EPA, 2017). While increased outdoor physical activity can help to reduce

obesity, Type II diabetes, and arthritis, "…Additionally, vegetation and permeable pavements can reduce noise pollution by damping traffic, train, and plane noise" (EPA, 2018). Economically speaking and based on cost-benefit analyses, the use of green infrastructure could potentially be more cost effective and less expensive in comparison to using grey infrastructure. This is especially evident in developers' capital costs which can be reduced from "…site grading, paving, and landscaping; and smaller or eliminated piping and detention facilities" (EPA, 2018). Another economic benefit of using green infrastructure is increase in land and property value and tourism, which in itself is an important incentive for developers, residents and businesses in Cecil County.

Critical Facilities Table

Table 1: Critical facilities with current protection and potential solutions for flood mitigation.

Facility Name	Threat	Criticality Level	Current Protection	Potential Measures to Increase Protection
Port Herman Condominiums Water Treatment Plant	-Not in a 100 or 500yr floodplain -0.2% chance storm with sea level rise by 2100	**Low**	-Permeable surfaces surrounding, little wooded area	-Retention or detention pond nearby -Constructed wetland and/or submerged gravel wetlands
Harbour View Waste Water Treatment Plant	-Within a 100yr floodplain -0.2% chance of storm with sea level rise by 2050 -10% chance of storm with sea level rise by 2100	**High**	-Existing forest provides some protection -Most plant components have been relocated outside of 100yr floodplain	-Constructed wetland with infiltration berms and retentive grading -Conservation landscaping -Restoration of floodplain once relocation is complete
Elkton Water Treatment Plant 11001	-Within a 100yr floodplain -0.2% chance of sea level inundation by 2100 -0.2% chance of storm with Level 3 Hazard Vulnerability on Delaware Ave by 2050	**Medium**	-Wooded areas surrounding facility and lining adjacent creek	-Bio-swale into adjacent forested area -Conservation landscaping -Constructed wetland with infiltration berms and retentive grading

Threat analysis was based on location in relation to the 100 & 500-year floodplains, mean sea level rise by 2050 & 2100 and hazard vulnerability index levels on adjacent roadways providing access to facilities. Facilities were then given "criticality levels" according to the relative severity of threats and current protections in place.

Cecil County Detention Center	-Within a 500yr floodplain -0.2% chance of storm with sea level rise 2050 -10% chance of storm with sea level rise by 2100	**Medium**	-Minimal impervious surfaces surrounding facility -Wooded area along adjacent shoreline	-Retention or detention pond on the grounds -Upgrade to porous pavement and addition of filter strips -Constructed wetland
North East Town Hall	-Within a 100yr floodplain -0.2% chance of storm with sea level rise by 2050 -0.2% chance of storm with Level 3 Hazard Vulnerability on Main St & Level 2 on Race St by 2050	**High**	-Little natural protection -Microbioretention project installed in parking lot in May 2016	-Green roof and/or wall -Rain garden and barrels -Upgrade to porous pavement
North East Police Department	-Within a 100yr floodplain -0.2% chance of storm with sea level rise by 2050 -10% chance of storm with sea level rise by 2100 -0.2% chance of storm with Level 3 Hazard Vulnerability on Cecil Ave & Level 2 on Race St by 2050	**High**	-Forested area behind facility	-Detention area on grounds or in parking lot and/or filter strips -Upgrade to porous pavement -Conservation landscaping and bio-swale into forested area -Dry wells or green roof -Managed retreat if other options are unsuccessful
Perryville Volunteer Fire Department	-Within a 500yr floodplain	**Low**	-Wooded areas surrounding 2/3 of facility	-Conservation landscaping, rain garden and/ barrels -Upgrade to porous pavement -Bio-swale and/or detention ponds on grounds -Green roof and/or wall
Port Deposit Water Treatment Plant	-Within a 100yr floodplain -0.2% chance of storm with sea level rise by 2100 -0.2% chance of storm with Level 2 Hazard Vulnerability on Rock Run Lndg by 2100	**Medium**	-Adjacent wooded strip between facility and shoreline	-Constructed wetland with infiltration berms and retentive grading -Conservation landscaping and bio-swale into forested area

Threat analysis was based on location in relation to the 100 & 500-year floodplains, mean sea level rise by 2050 & 2100 and hazard vulnerability index levels on adjacent roadways providing access to facilities. Facilities were then given "criticality levels" according to the relative severity of threats and current protections in place.

Port Deposit Waste Water Treatment Plant	-Within a 100 yr floodplain -10% chance of storm with sea level rise by 2050	**High**	-Large forested area behind facility	-Managed retreat and restoration of floodplain -Seawall or jetty -Constructed wetland and/or submerged gravel wetlands -Conservation landscaping and bio-swale into forested area
Port Deposit Town Hall and Police Department	-Within a 500yr floodplain -0.2% chance of storm with sea level rise by 2100 -0.2% chance of storm with Level 3 Hazard Vulnerability on S Main St by 2100	**Medium**	-Forested area behind facility	-Bio-swale to forested area -Dry well, rain barrels and/or green roof
Water Witch Volunteer Fire Department	-Within a 100yr floodplain -0.2% chance of storm with sea level rise by 2100 -0.2% chance of storm with Level 3 Hazard Vulnerability on S Main St by 2100	**High**	-Wooded area behind adjacent structures	-Upgrade to porous pavement in parking lot and addition of filter strips or bio-swale -Rain garden and barrels
Rising Sun Water Treatment Plant and Pump House	-Within a 100yr floodplain	**Medium**	-Forest surrounding 2/3 of facility	-Conservation landscaping and bio-swale into forested area -Retention or detention pond nearby

Threat analysis was based on location in relation to the 100 & 500-year floodplains, mean sea level rise by 2050 & 2100 and hazard vulnerability index levels on adjacent roadways providing access to facilities. Facilities were then given "criticality levels" according to the relative severity of threats and current protections in place.

Cecil County Critical Facilities Table .pdf

Stormwater Incentive Program

Background on Stormwater Management

Stormwater is water created from rain or melting snow that does not soak into the ground but runs into nearby waterways. Stormwater does not flow into a wastewater treatment system unless it is designed to with the use of combines sewers. It flows directly into surface waters.

Water quality and the habitat of creeks and rivers is affected by what is done on the land. This also affects the quality of life for people, their recreation, fish, and wildlife. There are two main concerns with stormwater: quality and quantity. Quality is related to various pollution sources like sediment, trash, yard waste, fertilizers, herbicides, and road salt. Also, changes in temperature can degrade water quality. Quantity is related to the amount of water discharged and the length of the discharge.

Watersheds are areas of land that drains water, sediment, and dissolved materials to a common receiving body or outlet. Cecil County is located in the Chesapeake Bay Watershed, which is covering 64,000 square miles. There are 11,684 miles of shoreline, 150 major rivers and streams in the Watershed, and it is home to over 17 million people (Cecil County Watershed, n.d.). Regarding suburban or urban developments, there are several questions to ask about stormwater such as: Where does the water come from? Where does it go now? What impact does it have on the environment? In urban or suburban areas, there are fewer places for the water to soak into the ground naturally (Cecil County Stormwater Management Division, n.d.).

In terms of managing stormwater, multiple practices that are used. Water collected is slowly discharged to a stream to reduce downstream flooding and erosion. Wet ponds release stored water gradually to reduce downstream flooding and erosion. Swales convey water and allow water to infiltrate into the soil (Montgomery County, MD Department of Environmental Protection, n.d.). Bioretention areas temporarily hold stormwater, after which it is filtered through the porous soil, infiltrated, and used for vegetation. The grasses, shrubs, and flowers are part of the facility. Bioswales are landscape elements designed to concentrate or remove debris and pollution out of surface runoff water. They consist of a swaled drainage course with gently sloped sides and filled with vegetation, compost, and/or riprap. Infiltration trenches capture

stormwater runoff to remove pollutants and slowly infiltrate the water into the ground to replenish the groundwater supply (Types of Stormwater Management Facilities, n.d.). There are some common identifying features for stormwater management practices that are not typically part of an environmental site design. These include concrete infall/outfall pipes, observation wells, riser structures, drains, and rip-rap.

Table 2: Pictorial images of implemented stormwater management practices.

Examples of Stormwater Management Practices	
 *Rainwater Cisterns*	 *Rain Barrels*
 *Swale*	 *Bioswale*
 *Bioretention*	 *Infiltration Trench*

Concrete Infall Pipe

Observation Wells

Riser Structure

Drain

One way to help protect streams and other waterways is by implementing an Environmental Site Design (ESD), which is an assortment of techniques, structures, and practices that work together to minimize stormwater runoff. The goal of an ESD is not to replace developed land but make development in balance with natural water cycles (Montgomery County, MD Department of Environmental Protection, n.d. b). A key part of this effort is to have developed land that mimics "woods in good condition," which the state of Maryland coined to represent a natural state before development.

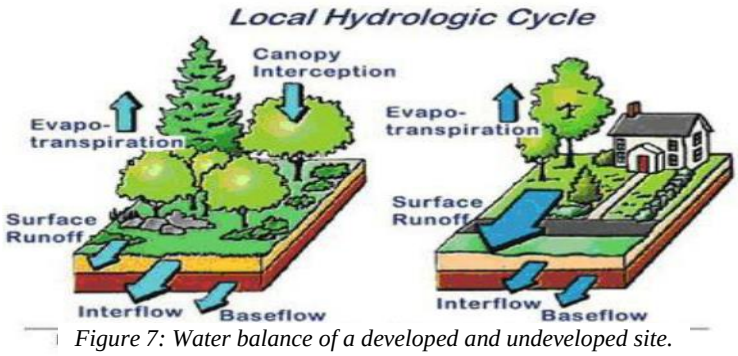

Figure 7: Water balance of a developed and undeveloped site.

Some examples of ESD stormwater practices include green infrastructures like green roofs, permeable pavements, reinforced turf, rainwater harvesting, submerged gravel wetlands, landscape infiltration, infiltration berms, dry wells, micro-bioretention, rain gardens, grass swales, bioswales, and enhanced filters. While pervious pavement can be used as an alternative to asphalt or concrete because it allows stormwater to infiltrate through it to a stone reservoir underneath. The reservoir then stores the runoff temporarily before infiltrating it into the subsoil (Environmental Site Design, n.d.).

In Cecil County, the Stormwater Management Division operates under the Department of Public Works and is responsible for the development, management, and execution of the Cecil County Erosion and Sediment Control and Stormwater Management programs (Cecil County, n.d.). Their mission statement reads “Promote environmental stewardship of natural resources within the county during the development process to ensure the protection of those resources from the effects of sedimentation and stormwater pollution” (Cecil County, n.d.). The department is committed to working towards maintaining and improving water quality of the water resources in the County while also preserving the quality of all residents by: 1. Holding public and private institutions accountable for meeting standards and specifications to which they have agreed upon to pursue development activities; 2. Working with the development community prior to, during and following construction activities to set achievable expectations and objectives; 3. Working cooperatively with other local, state and federal agencies with similar missions; 4.Providing educational opportunities and outreach programs and activities; and 5. Providing enforcement of the local erosion and sediment control and stormwater management ordinances (Cecil County, n.d.).

Incentive Mechanisms

Incentive programs are being used in cities across the United States to encourage residents and business owners to implement stormwater management devices like rain barrels, rain gardens, conservational landscaping, and bioswales. Each type of mitigation tactic provides different benefits to both the county, resident, owner and environment. Giving the County residents and business owners some incentives to implement these strategies could greatly increase participation in the programs while increasing interest in environmental preservation and stormwater management. The goal of the incentives is to get new and older residential neighborhoods to participate. This allows for a possible city, town or County-wide increase in stormwater management and provide several benefits like the elimination of combined sewer overflows, increasing groundwater recharge, enhancing drainage in neighborhoods, increasing green space use and improving walkability of cities and towns (Water Environment Federation, 2013).

Commercial Incentives

Incentives for business owners could be:

- Expedited permitting during developmental stages of a business
- Reduced fees for land developing, licensing and plan review
- Rebates for the installation of large rainwater collection tanks
- Reduced billing rates on stormwater system use on utility bills
- Stormwater project grants for existing companies
- Reduced property tax fees
- Smart Tool: Developed by the University of Maryland Extension (University of Maryland, n.d.)

- County awards and recognition

Financial incentives, especially for businesses, are shown to increase participation in movements and programs (Environmental Protection Agency, 2018). Implementing some of the above-mentioned financial systems could boost industrial participation, it has actually been found that

Grants for implementation of stormwater management practices and systems would be specifically for current companies not in the developmental or building part of the business. It would cost more money for a company to build and implement stormwater management strategies if they need to rebuild, build or remove structures to implement them. These grants could help to offset several costs in order encourage business owners to adopt stormwater management practices. Funding for grants and other economic incentives could come from a few different places including:

- Environmental Protection Agency programs
- Taxes
- Environmental Trust Fund
- Donated funds

Installation of large rainwater tanks for companies would help in two different areas. It would lighten the load on stormwater drains and the system in general, and the tanks would decrease the freshwater consumption of the business. Companies could set up the tank for freshwater uses like watering lawns, watering

Figure 8: Example of an underground rainwater collection tank.

plants or during the working process when water is needed like cooling machinery, water lawns and flower beds and as grey water for use in restrooms instead of using public freshwater.

Awards and county recognition would help businesses show the public they are environmentally friendly, saving other resources and saving money; this would provide great publicity and most importantly, ensure their participation in the program and mitigation of stormwater system use and pollution.

Use of the Smart Tool or Stormwater Management and Restoration Tracker, which was created by the University of Maryland Extension, would be made available for business owners and residents of Cecil County (University of Maryland, n.d.). The Smart Tool is used to create and track an inventory of business and homeowner BMP's. Signing up for approved practices within the program will list one's stormwater practice into the system and a SMART Team member will certify that one's practice is set up to work properly. Once the practice is approved and the customer is listed into the SMART Tool system, they will begin to receive credits for the County's stormwater management program. The Cecil County Watershed Stewards Academy could help implement this tool.

Another aspect is residential participation. If residents see companies participating and implementing green strategies, they may become more interested in the program and participate at home.

Residential Incentives

Residential incentives would be similar to commercial ones such as reduction in property tax fees, reduced billing on stormwater system use on utility bills, grants and/or rebates for rain barrels or installation of other mitigation tools, and neighborhood or individual awards to post for recognition. A good example of an active rebate program in another Maryland county is

RainScapes, details for the program are found in Table 3 below. The money savings for residential incentive programs would come from reduced water bills when saving, for example, rain water and using it for gardens or for pools which were previously cleaned with pool chemicals like chlorine.

Table 3: Example rebate incentive from Montgomery County's RainScapes Program. Source: Montgomery County Government.

Stormwater Solution	**Residential Rebate**	**Commercial Rebate**
Rain Gardens	$10/sq. ft. of total garden area (min. size is 75 sq. ft.)	$10/sq. ft. of total garden area (min. size is 100 sq. ft.)
Conservation Landscaping	$5/sq. ft. if < 3" temporary ponding, $6/sq. ft. if ≥ 3" of temporary ponding. Project must replace turf, invasives or erosion. Project needs to intercept runoff. (min. size is 250 sq. ft.)	$5/sq. ft. if < 3" temporary ponding, $6/sq. ft. if ≥ 3" of temporary ponding. Project must replace turf, invasives or erosion. Project needs to intercept runoff. (min. size is 350 sq. ft.)
Permeable Paving Retrofit	$14/sq. ft. (min. size is 100 sq. ft.)	$4/sq. ft. (min. size is 200 sq. ft.)
Pavement Removal	$3 - $7/sq. ft. depending on what replaces the pavement. Turf is lower, conservation landscape is higher. (min. size is 100 sq. ft.)	$3 - $7/sq. ft. depending on what replaces the pavement. Turf is lower, conservation landscape is higher. (min. size is 200 sq. ft.)
Cisterns	$1/gallon: 250 gallons (min.) and 500 gallons (max.) (max. is $500rebate/property)	$1/gallon: 250 gallons (min.) and 2,000 gallons (max.) (max. is $2,000 rebate/property)
Rain Barrels	$1/ gallon: 200-gallon min. for single family home and 100-gallon min. for townhome. 50 gallons minimum per barrel. (max. is $250 rebate/property)	$1/ gallon: 200-gallon min. for commercial property. (max. is $250 rebate/property)
Green Roofs	$9/sq. ft. of total garden area (min. size is 100 sq. ft.)	$9/sq. ft. of total garden area (min. size is 200 sq. ft.)

Introduction of free classes at local community centers or neighborhood gardens would teach people how to install the projects and/or how they help, which could really push residents into participating in the stormwater management program and ease the burden on the overall system. These classes would cover conservation techniques and how they help residents save

money, aside from rebates that may be provided. There are several examples of residential techniques that can mitigate stormwater erosion and they include:

- Rain barrels
- Rain gardens
- Curtain drains

Rain barrels are simply barrels that collect rain, these usually connect to the guttering of a home (Orion Magazine, n.d.). This prevents the stormwater from reaching the soil or running into the street, in times of heavy rain they can prevent erosion of the soil around your home. Rain gardens are a simple and effective tool that is aimed at reducing stormwater runoff. The gardens are placed in key areas and slow the flow of the stormwater so that it can be properly absorbed into the ground and avoid being pushed out onto the street into the storm drains (Soil Science Society of America, n.d.). The design of the garden usually acts as a bowl for the water and is usually made up of native plants. The gardens can also enhance landscaping and provide food and habitats for wildlife. Curtain drains are similar to French drains but are dug on the surface of the ground (Guerra, 2017).

Partnerships and Grants

Federal

The Federal Emergency Management Agency (FEMA) is responsible for controlling the National Flood Insurance Program (NFIP). This program allows insurance options for individuals that live in flood-prone areas, as traditional homeowners' insurance does not cover flood damage. With running the NFIP, FEMA keeps detailed maps of 100 and 500-year floodplains across the country. This can help local governments find where the flood-prone areas are in their communities. With sea level rise, land subsidence, and the chance for more powerful

storm events occurring due to global climate change, these resources for planners are going to be at the utmost importance.

Table 4: Cecil County insured loss statistics. Source: FEMA.

Area	**Losses** (Flood related structure loss of those insured)	**Total Payment** (NFIP payouts from 1/1/1978 - 9/30/2018)
Cecil County	315	6,532,543.62
Maryland	18,766	304,245,194.69

The Flood Mitigation Grant Assistance Program. This program is the largest grant program for the mitigation of flooding. The money is disseminated through the state, territory, or tribal region. In order to be eligible for these funds a hazard mitigation plan needs to be enacted. A timeline for local governments can be found at: https://www.fema.gov/hazard-mitigation-grant-program-guide-state/local-governments

State

The State of Maryland has the coast, the bay, the mountains, and a few other features too. The Chesapeake Bay watershed and much of the water collected goes through the Susquehanna River extends through Cecil and Harford Counties. To protect human life and property, the state of Maryland implements protocol to limit the impact of human development in flood prone areas. One strategy that Maryland is working on is updating all of their NFIP maps to bring them up to current conditions (Maryland Department of the Environment, n.d.).
These are called Digital Flood Insurance Rate Maps and can be found at: https://mdfloodmaps.net/dfirmimap/index.html.

The Comprehensive Flood Management Grant Program. This program allows local communities to develop flood plans, studies of watersheds, and projects to help improve flood resilience. The program also provides grant funding to flood-prone areas to allow property buy-outs, so that the same home or group of homes are not continually inundated with water during large rain events. The flood-prone space can then be turned into open areas for the good of the community as flood reduction and recreation. Along with land acquisition this grant program also assists with raising or relocating homes.
https://mde.maryland.gov/programs/water/floodhazardmitigation/pages/floodmgmt.aspx

The Water Quality Financing Administration (WQFA). Under the Maryland Department of the Environment, WQFA provides low-interest loans to local governments to relocate or upgrade of wastewater treatment plants. This will help a place that susceptible to flooding like the Port Deposit wastewater treatment plant.
https://mde.maryland.gov/programs/Water/WQFA/Pages/drinking_water_fund.aspx

Land Acquisition and Planning Programs. This unit under the Maryland Department of Natural Resources works to advance land conservation and outdoor recreational opportunities. Through these programs they provide grants, such as the ones listed below, which may be applicable for the Cecil County Department of Land Use & Development Services can pursue as part of its green infrastructure plan.

- Program Open Space: Funding is provided to local communities to acquire outdoor recreation and open space through the Outdoor Recreation Land Loan of 1969 and from the Land and Water Conservation Fund of the National Park Service, U.S. Department of the Interior.
  https://dnr.maryland.gov/land/Pages/ProgramOpenSpace/home.aspx

- Community Parks & Playgrounds Program: Funding is provided to local governments for restoration of existing and creation of new park and green space systems. https://dnr.maryland.gov/land/Pages/ProgramOpenSpace/CPP-Grant-Process.aspx

Non-Governmental Organizations

Non-governmental organizations (NGOs) along with public sources can provide expertise and resources for communities.

American Planning Association. This program helps economically challenged and disaster-devastated communities affected by hazards such as floods. The foundation provides their expertise in technical assistance for the community's specific needs. https://www.planning.org/foundation/initiatives/assistance/

The Eastern Shore Land Conservancy. The Land Conservancy currently works with the County. They are an excellent resource to consult with when needed expertise. To apply for expertise the county must simply ask. The Conservancy reviews the request to determine if the community is deemed suitable for their services. They provide expertise in technical support, networking, partnerships, and funding opportunities that the county could use. This organization is in good standing with Cecil County and should be considered when requiring additional expertise for future projects. https://www.eslc.org/town-projects/

Chesapeake Bay Organizations. Due to its proximity to the bay and some of its major tributaries, it is imperative for Cecil County to have a working relationship with the many Chesapeake Bay organizations. These organizations provide resources, expertise, and education

to the community. Working with organizations like these will not only help improve water quality but also help protect critical facilities. The organizations teach the importance of reducing stormwater run-off, helping plant native species (including planting trees), and restoration/protection of natural barriers. This can be particularly helpful in places that have a large amount of impervious surfaces to reduce flooding during large rain events.

Alliance for the Chesapeake Bay. The mission of this NGO is to "lead, support, and inspire local action to restore and protect the lands, rivers, and streams of the Chesapeake Bay watershed". The key programs that they assist in are building stewardship, conserving Chesapeake forests, reducing stormwater runoff, assisting local governments, and networking & education. All of these programs would help Cecil County mitigate flooding. Although this organization does not provide financial assistance, they provide volunteers, educational opportunities, and experts in the field to assist with any environmental initiatives that could potentially impact the Chesapeake Bay.

https://www.allianceforthebay.org/our-work/programs-projects/

Chesapeake Bay Trust. Green Streets, Green Jobs, Green Towns (G3) Grant Program. This program allows communities to develop and implement plans to reduce their amount of stormwater runoff. Along with reducing the amount of stormwater runoff this grant hopes to increase the amount of green spaces, and something that is needed in Cecil County increase the water quality of local streams. This program provides expertise and finances to the awardee of the grant.

https://cbtrust.org/grants/green-streets-green-jobs-green-towns/

Stroud Water Research Center. The mission of this NGO is to research and innovate solutions for preservation and restoration of freshwater ecosystems, educate and empower

students and landowners to become stewards of freshwater systems, and watershed restoration. Restoration projects completed by this organization have been provided by the U.S. Department of Agriculture through the Regional Conservation Partnership Program to implement natural resources conservation practices. Applications for financial and technical assistance can be applied to specific project areas such as Environmental Quality Incentives Program. https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/programs/financial/eqip/?cid=stelprdb1044009

Conclusion

Cecil County residents and businesses are currently vulnerable to flooding after heavy rain events and are at risk for sea-level rise due to climate change by either 2050 or 2100. Therefore, the implementation of flood mitigation strategies recommended in this report is critical for the County. The report focuses on potential flood reduction solutions for 12 critical facilities that were identified by the county. Green, grey, or mixed-use infrastructure solutions such as rain gardens and upgrades to porous pavement for the critical facilities were recommended based on a criticality level rating, topography and location, and the current threats and flood reduction measures. The County could employ incentive programs like stormwater utility discount fees and rebates to promote the construction and practices of green infrastructure by both residents and businesses. Since most of the recommended incentives are monetary, some funding opportunities that the local County government, businesses and residents could exploit are also discussed. This report should aid Cecil County's Department of Land Use and Development Services to develop a more comprehensive and robust Green Infrastructure Plan. Through green infrastructure and upgrades to grey infrastructure, Cecil County could be more protected and resilient to inundation and the effects of climate change.

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