CECIL COUNTY
GREEN INFRASTRUCTURE PLAN

June 2019

FINAL

Acknowledgements

This project has been funded wholly or in part by the United States Environmental Protection Agency under assistance agreement CB96336601 to the Maryland Department of Natural Resources. The contents of this document do not necessarily reflect the views and policies of the Environmental Protection Agency, nor does the EPA endorse trade names or recommend the use of commercial products mentioned in this document.

Cecil County Department of Land Use and Development Services

Planning and Zoning Division Staff

Bryan Lightner, Zoning Administrator

Bethany Boniface, Resource Plans Reviewer

Matt Littlejohn, Plans Reviewer

David Black, GIS Coordinator

Maggie Tome, Unified Communications Specialist

The Conservation Fund

Ted Weber, Strategic Conservation Manager

Jean Akers, AICP, Professional Landscape Architect

The Susquehannock Wildlife Society
Scott McDaniel, Executive Director

Numerous State Agencies and Staff

With Special Thanks To:

University of Maryland University College Students – Capstone Project Report (Appendix K)

Adriene Thomas	Colin Swan
Tyler Shaw	Tyler Steele
Vy Ma	Advisors: Deborah Wakrat Schwartz and Daniel Grosse

And our Steering Committee members:

Name	Affiliation
Adams, Liz	Hollywood Beach HOA
Akers, Jean	Planning Consultant (CORE TEAM)
Antoshak, Janine	Town of Charlestown
Arellano, Ed	Cecil County Health Department
Aspinwall, Karen	Port House Grill, Town of North East
Bass, Jim	Eastern Shore Land Conservancy
Behnke, Doris	University of Maryland Extension
Booher, Angie	Cecil County Department of Public Works
Buehl, Eric	University of Maryland Extension
Cardo, Frank	Cecil County Public Schools
Carlson, Ann	Maryland Environmental Trust
DeWeese, Alex	MD DNR Critical Area Commission
DiNunzio, Joe	Artesian Water, Inc.
Eberly, Chris	Maryland Bird Conservation Partnership
Edwards, Sandra	Cecil County Office of Economic Development
Evans, Mike	Cecil County Department of Public Works
Francis, David	University of Delaware
Frederick, Tom	MD DNR Forest Service
Hannum, Tom	Cecil Land Trust
Hartman, Ron	Elk & North East Rivers Watershed Association
Hill, Deb	Town of Perryville
Kennedy, Virginia	West Nottingham Academy
Leader, Lesley	MD DNR Park Service
Lloyd, Michelle	Cecil County Department of Emergency Services
Lyall, Jen	Cecil County Public Information Officer
Markkula, Mari	Cecil Soil Conservation District
McCandless, Sean	Cecil County Department of Public Works
McDaniel, Scott	Susquehannock Wildlife Society (CORE TEAM)
McSorley, Marshall	Cecil County Department of Public Works
Minner, Jeanne	Town of Elkton
O'Connor, Steve	Cecil County Department of Land Use & Development Services
Oldham, Gabrielle	Cecil County Forest District Conservancy Board
O'Shea, Maureen	Cecil County Office of Economic Development
Righi, Kim	Shore Rivers
Rinkerman, Vicky	Town of Port Deposit
Roper, Ebony	Cecil College
Rossetti, Rupert	Octoraro Watershed Association
Strouss, David	McCrone Engineering, Inc.
Urian, Kevin	Cecil County Public Library
Vennel, Betsy	Town of North East
Webb, Alissa	Cecil Land Trust
Weber, Ted	The Conservation Fund (CORE TEAM)
Wilen, Kordell	Cecil County Department of Land Use & Development Services

COUNTY COUNCIL OF CECIL COUNTY, MARYLAND
LEGISLATIVE SESSION 2019-15

RESOLUTION NO. 46-2019

Title of Resolution: Approval – Cecil County Green Infrastructure Plan - 2019

Synopsis: A Resolution to adopt the Cecil County Green Infrastructure Plan 2019, in accordance with the Disaster Mitigation Act of 2000 and 40 CFR § 122.47, et seq.

Introduced by: Council President on behalf of the County Executive

Introduced and order posted on: August 6, 2019

Consideration scheduled on: August 20, 2019

By: James Massey
Council Manager

Notice of time and title of Resolution having been posted by August 6, 2019 at the County Administrative Building, 200 Chesapeake Blvd, Elkton, and consideration by the County Council of Cecil County having been scheduled on August 20, 2019.

By: James Massey
Council Manager

Explanation: CAPITALS INDICATE MATTER ADDED TO EXISTING ORDINANCE.
~~Strike through~~ indicate matter deleted from existing ordinance.
Underlining indicates language added by amendment.
~~Double Strike through~~ indicates language deleted by amendment.

WHEREAS, the County Executive and the County Council of Cecil County, Maryland, recognize the threat that natural hazards pose to people and property within Cecil County; and

WHEREAS, the Cecil County Department of Land Use and Development Services, under the direction of the County Executive, has prepared the Cecil County Green Infrastructure Plan (2019) in accordance with the Disaster Mitigation Act of 2000 40 CFR § 122.47, et seq.; and

WHEREAS, the Cecil County Green Infrastructure Plan (2019) identifies implementation strategies to reduce or eliminate long-term risk to people and property in Cecil County from the impacts of future hazards and disasters; and

WHEREAS, Natural Floodplain Functions Plan ("NFP") credit is provided for adopting plans that protect one or more natural functions within the local jurisdiction's floodplain; and

WHEREAS, a "green infrastructure plan" identifies open space corridors or connected networks of wetlands, woodlands, wildlife habitats, wilderness, and other areas that support native species, maintain natural ecological processes, and/or sustain air and water resources; and

WHEREAS, the Cecil County Green Infrastructure Plan will be incorporated by reference in future resolutions of the County Council within the following County management plans: (1) Comprehensive Plan; (2) Hazard Mitigation Plan; (3) Land Preservation, Parks, and Recreation Plan; (4) Stormwater Management Plan; and, (5) Strategic Plan; and

WHEREAS, adoption by the Cecil County Council demonstrates the Council's commitment to the implementation strategies outlined in the Cecil County Green Infrastructure Plan (2019), as shown in Appendix 1 with additional appendices A through K available on the Cecil County website.

NOW THEREFORE, BE IT HEREBY RESOLVED BY THE COUNTY COUNCIL OF CECIL COUNTY, MARYLAND, that the Cecil County Green Infrastructure Plan (2019) is hereby adopted.

AND BE IT FURTHER RESOLVED BY THE COUNTY COUNCIL OF CECIL COUNTY, MARYLAND, that this Resolution shall take effect on the date of its passage.

INTRODUCED: August 6, 2019

ADOPTED: August 20, 2019

President of the Council

ATTEST:

James Massey
Council Manager

Table of Contents

Executive Summary 1
Background and Purpose of the Green Infrastructure Plan 2
Green Infrastructure Concepts 5
Defining the Green Infrastructure Network 9
Green Infrastructure Locations 13
Public Involvement 15
Ranking Areas for Natural Resource Protection 19
Stormwater Green Infrastructure 21
Coastal Defense 24
Critical Infrastructure Protection 26
Nuisance Flooding 31
Ecosystem Service Value 33
Population Vulnerability 34
Priority Forests 36
Natural Floodplain Functions 38
Wildlife Surveys and Management Recommendations 41
Implementation Strategies 43
Plan Maintenance 49
Conclusion 50

Appendices

APPENDIX A: Data dictionary .....
APPENDIX B: Focal species for core areas, hubs, and corridors .....
APPENDIX C: Cecil County Natural Resource Identification .....
APPENDIX D: Cecil County Green Infrastructure Network Identification Methodology .....
APPENDIX E: Landscape ranking factors .....
APPENDIX F: Mature Forest Identification in Cecil County .....
APPENDIX G: Plant Survey and Wildlife Habitat Assessments .....
APPENDIX H: Inventory of Roads, Bridges, & Sewer Infrastructure with Flood Vulnerability .....
APPENDIX I: Species of Greatest Conservation Need in Cecil County Floodplains .....
APPENDIX J: Rare, Threatened, and Endangered Species Found in Cecil County .....
APPENDIX K: Implementation Strategies for Flood Mitigation & Stormwater Management in Cecil County

Executive Summary

Cecil County's Green Infrastructure (GI) Plan identifies key natural features that provide wildlife and fish habitat, as well as, a myriad of benefits to residents, like flood reduction, removal of water and air pollutants, erosion control, recreational opportunities, and many more. The GI network is composed of core areas, which provide high-quality natural habitat; hubs, which are large areas of natural and semi-natural (e.g., agriculture) land; and corridors, which are generally linear features that link core areas together and allow animal movement between them.

Within Cecil County's boundaries, including eight Towns, the mapping analyses identified 78,933 acres of core areas (36%) and 23,879 acres of corridors (11%), excluding open water. It's important to note that although 47% of the land throughout the County is mapped within the GI Network, this natural system actually provides over 75% of the ecosystem service benefits for the County. Cecil County's overall ecosystem service values are explained in more detail in a later section. Within the GI Network, 28% of core areas and 34% of corridors are located in parks, conservation easements, or other protected land. 49% of core areas and 57% of corridors are located within the County's current Priority Preservation Area. Areas throughout the County were ranked for conservation importance, for their suitability for managing stormwater runoff, and for their ability to reduce coastal storm hazards. Critical built infrastructure, such as police and fire stations, power plants, and water and wastewater facilities, were also examined for their flood vulnerability and potential mitigation solutions were developed.

The core team also performed vegetation and wildlife surveys at two county parks and verified that green infrastructure core areas and corridors do provide good habitat and wildlife connectivity. Invasive species and deer overbrowsing were problems at both sites, but in general, larger and more remote forest was in better condition, and supported more sensitive species, than small, isolated stands of trees.

The County held two public meetings to raise awareness about the plan and solicit feedback about priorities. In the first meeting, the attendees ranked clean water protection as the #1 goal, followed by natural resource protection and reducing flood risk for critical infrastructure. At the second meeting, the mapping assessments and key findings were shared. The attendees ranked the following as top implementation strategies: protecting high priority wetlands, requiring stream buffers (especially in growth areas), identifying high priority stream restoration sites, targeting preservation of high-value GI network connections with partners, and educating the public about best stormwater management practices.

The plan lists a number of possible actions to protect, restore, and manage County green infrastructure. These items are organized under the five themes of land use policies, planning, education, restoration, and land preservation, beginning on page 43. The main reason for developing the plan is to explore new land use planning techniques that can be implemented in the near term, while focusing preservation and restoration efforts on the GI network. The successful implementation of the plan will involve collaboration with community partners, incorporating action items into local capital improvement programs, and improving the communication about GI benefits.

Background and Purpose of the Green Infrastructure Plan

Green infrastructure is our natural life support system—an interconnected network of forests, wetlands, waterways, floodplains, and other natural areas; including parks, greenways, farms; and other open spaces that support native species, maintain natural ecological processes, sustain air and water resources that contribute to people's health and quality of life.

Focusing on green infrastructure promotes strategic conservation and restoration that is proactive, holistic, systematic, well integrated and applied at multiple scales (e.g., across landscapes, watersheds, regions, and jurisdictions). Green infrastructure can help coordinate land and water conservation efforts and integrate them into a cohesive strategy for reaching long-range goals. It can also help inform sustainable patterns of development, minimize negative environmental impacts, where restoration could provide tangible benefits, and planning for future water needs.

The land use coverage in Cecil County has been changing over the past four decades and is at risk of losing some of its most valuable resources, including forest and prime agricultural lands. Since 1973, Cecil County has lost over 35,000 acres of resource lands to development. Developed areas increased by 229%. From just 2002 until 2010, almost 3,000 acres of agricultural lands and over 3,000 acres of forest land were converted to development. While growth continues, this plan aims to identify those areas within the GI network that should be preserved in their natural state.

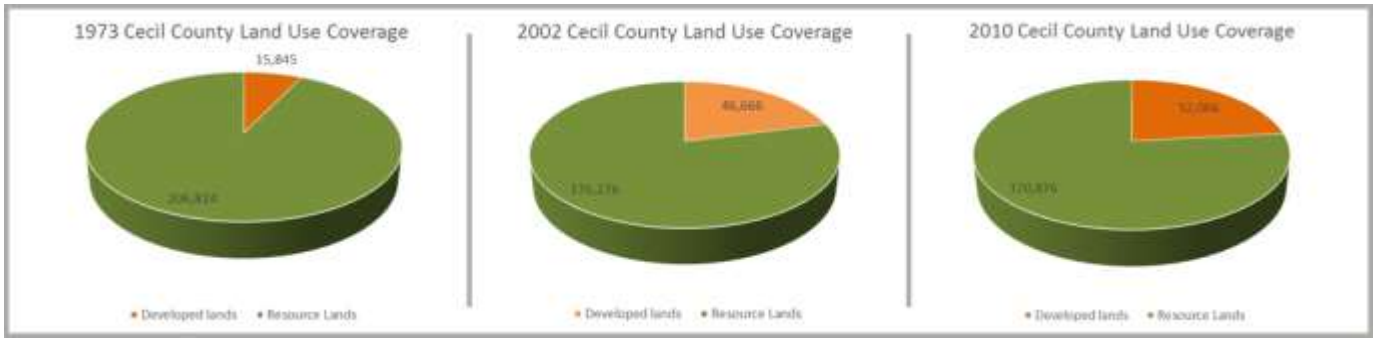


Figure 1. Land Use Change from 1973 to 2010

In partnership with the Conservation Fund (TCF), the Susquehannock Wildlife Society (SWS), and planner Jean Akers, Cecil County received a Community Resilience Grant from the Maryland Department of Natural Resources (DNR) to develop and refine a county-wide green infrastructure (GI) network and plan. In addition to this core team, a Steering Committee met bi-monthly during the grant term, to help provide guidance for establishing the GI network and plan. The new GI Plan has a ten-year planning horizon and will help the County accomplish some of its Watershed Implementation Plan (WIP) goals. The Department of Land Use and Development Services will provide assistance integrating GI strategies into future updates of the County's Comprehensive Plan; Hazard Mitigation Plan,; Land Preservation, Parks, and Recreation Plan; Stormwater Management Plan; and Strategic Plan.

Project Goals

1. Develop a science-based method for prioritizing and incentivizing the selection of green stormwater infrastructure opportunities.
2. Identify, understand, and mitigate nuisance flooding problems, targeting near term adaptation measures.
3. Identify vulnerabilities in coastal and riverine areas and protect with strategic land acquisition and conservation to adapt.
4. Preserve a better GI network and build a management system to address the cumulative effects of development, maintain no net loss of forest, reduce the fragmentation of wildlife habitat, and provide more connectivity.
5. Improve interdepartmental and interjurisdictional coordination.
6. Earn additional Community Rating System (CRS) points and foster partnerships with stakeholders to enhance outreach and education efforts.

Project Objectives

1. Prioritize where to develop subwatershed master plans, and incorporate hydrologic and hydraulic analyses to mitigate current and future flooding problems.
2. Evaluate capital projects proposed within the GI network, to effectively minimize risk caused by hazard events and loss of ecosystem service benefits.
3. Work with the Towns and the Artesian Water Company to protect drinking water resources and create efficiencies across County Departments.
4. Develop tree planting programs with the DNR Forest Service and other partners to enhance the GI network.
5. Create opportunities to develop complementary public information about GI, including the positive effects that tree planting and stormwater management projects have for improving quality of life.
6. Soften the development footprint in more urbanized areas by incorporating sustainable native plant demonstration gardens and grow heritage tourism around parks to enhance our sense of place.
7. Acquire structures in repetitive loss areas or mitigate their use.
8. Maintain viable fisheries for future generations.
9. Create additional recreational opportunities, incorporate more trails and paths, both to promote healthy lifestyles and alternative modes of travel.

Project Role for Natural Hazards

Sea level rise and storm surge scenarios developed by the State Highway Administration (SHA) and the Eastern Shore Climate Adaptation Partnership (ESCAP) were incorporated into the assessment for reducing flood risks to critical infrastructure. The increased ability to forecast where nuisance flooding associated with intense precipitation events could exacerbate maintenance issues for the County and Towns will lead to the development of more sustainable maintenance practices, and ultimately better mitigation strategies. Opportunities to ameliorate these effects through green stormwater management solutions were prioritized by identifying co-benefits derived from the other GI strategies developed during the planning process. Understanding and acting on what areas should be preserved to protect natural floodplain functions, will help to save costly restoration funds in the future.

Project Co-benefits

Identifying the GI network and engaging the community will broaden the base of support for strategic land preservation and restoration projects, including the development of new recreational opportunities. Wildlife conservation areas help to make Cecil County more livable, healthful, and appealing to potential employers,

investors, residents, and tourists. Earning additional CRS points to move up a class helps reduce flood insurance rates for county residents, and also overlaps with other current CRS initiatives, see program details here: https://www.fema.gov/media-library/assets/documents/15846. Connecting these co-benefits will have amplification effects by delivering similar messages from different groups. The County is also aware of the Chesapeake Bay Program's mid-term assessment process and believes mapping the GI network using strategies that anticipate climate effects will better equip the County to adjust its WIP at earlier stages and avoid burdensome changes in the future.

WIP Commitments

This project is a key component of the county's 2018-2019 Watershed Implementation Plan (WIP) strategies. The specific two-year milestones connected with the project are:

1. County departments seek and apply for grant funding opportunities from various NGO's, federal, and state agencies to assist with WIP milestones implementation.
2. Evaluate county-level ordinances, regulations and procedure guidance documents to align with WIP objectives and Phase II MS4 permit requirements.
3. Consider developing an incentive program for the implementation of SWM practices that are either above environmental site design to the maximum extent practicable or voluntary in nature, to complement state-level policy and nutrient trading efforts.
4. Update the Green Infrastructure Plan to help prioritize funding, programmatic changes, and implementation of riparian buffer planting projects.
5. Identify opportunities for further collaboration between departments regarding issues related to floodplain, stormwater management, critical areas, WIP, and agricultural preservation.
6. Develop and implement a tracking process for changes in land use.

Figure 2. Flooding in Port Deposit from Tropical Storm Lee. (Photo: Cecil County Department of Emergency Services)

Green Infrastructure Concepts

Overview

Green infrastructure exists at multiple scales (Figure 2). At broad scales, it includes large blocks of forest, wetlands, stream networks, and other natural systems. At local scales, smaller patches may be included. Site-scale green infrastructure may focus on natural or semi-natural solutions to reduce stormwater runoff or heat.

At landscape scales, green infrastructure analysis and design is based on principles of conservation biology and landscape ecology. The goal is to reduce habitat fragmentation, maintain viable populations of native species, preserve interior habitat, improve resiliency from disturbances and climate change, and protect ecosystem services like clean air, clean water, flood reduction, recreation, and many more (Table 1, on page 6).

Ecosystem Service	Description
REGULATING & SUPPORTING	
Hazard Amelioration	
Water Flow Regulation / Flood Control	Maintain water flow stability and protect areas against flooding (e.g., from storms).
Water Purification	Maintain water quality sufficient for human consumption, recreational uses like swimming and fishing, and aquatic life.
Erosion Control and Sediment Retention	Maintain soil and slope stability, and retain soil and sediment on site.
Groundwater Recharge	Maintain natural rates of groundwater recharge and aquifer replenishment
Air Purification	Remove particulates and other pollutants from the air
Climate	
Microclimate Moderation	Lower ambient and surface air temperature through shading
Regulation of Water Temperature	Moderate water temperature in streams
Carbon Storage	Sequester carbon in vegetation and soils, thereby reducing atmospheric CO_2 and global climate change
Biological	
Support Native Flora and Fauna	Maintain species diversity and biomass
Pollination	Provide pollinators for crops and other vegetation important to humans
Pest and Disease Control	Provide biota which consume pests and control diseases
Provisioning	
Food Production	Production of plant or fungal-based food for human consumption
Game and Fish Production	Production of wild game and fish for human consumption
Fiber Production	Production of wood and other natural fibers for human use
Soil Formation	Long-term production of soil and peat for support of vegetation and other uses
Biochemical Production	Provision of biochemicals, natural medicines, pharmaceuticals, etc.
Genetic Information	Genetic resources for medical and other uses, including those not yet realized
Cultural	
Recreation and Ecotourism	Outdoor, nature-based experiences like hiking, birding, hunting, camping, etc.
Savings in Community Services	Savings in community services from not converting natural land to houses
Increase in Property Values	Provide attractive locations for homes and businesses
Science and Education	The existence of natural systems and areas for school excursions, advancement of scientific knowledge, etc.
Spiritual and Aesthetic	Aesthetic enjoyment or spiritual or religious fulfillment
Bequest value	The value placed on knowing that future generations will have the option to utilize the resource.
Existence value	The non-use value of simply knowing that particular resources exist, even if they are not used.

Table 1. Some ecosystem services provided by green infrastructure (primary source: Millennium Ecosystem Assessment[1]).

[1] Millennium Ecosystem Assessment. 2005. Ecosystems and human well-being: synthesis. Island Press, Washington DC.

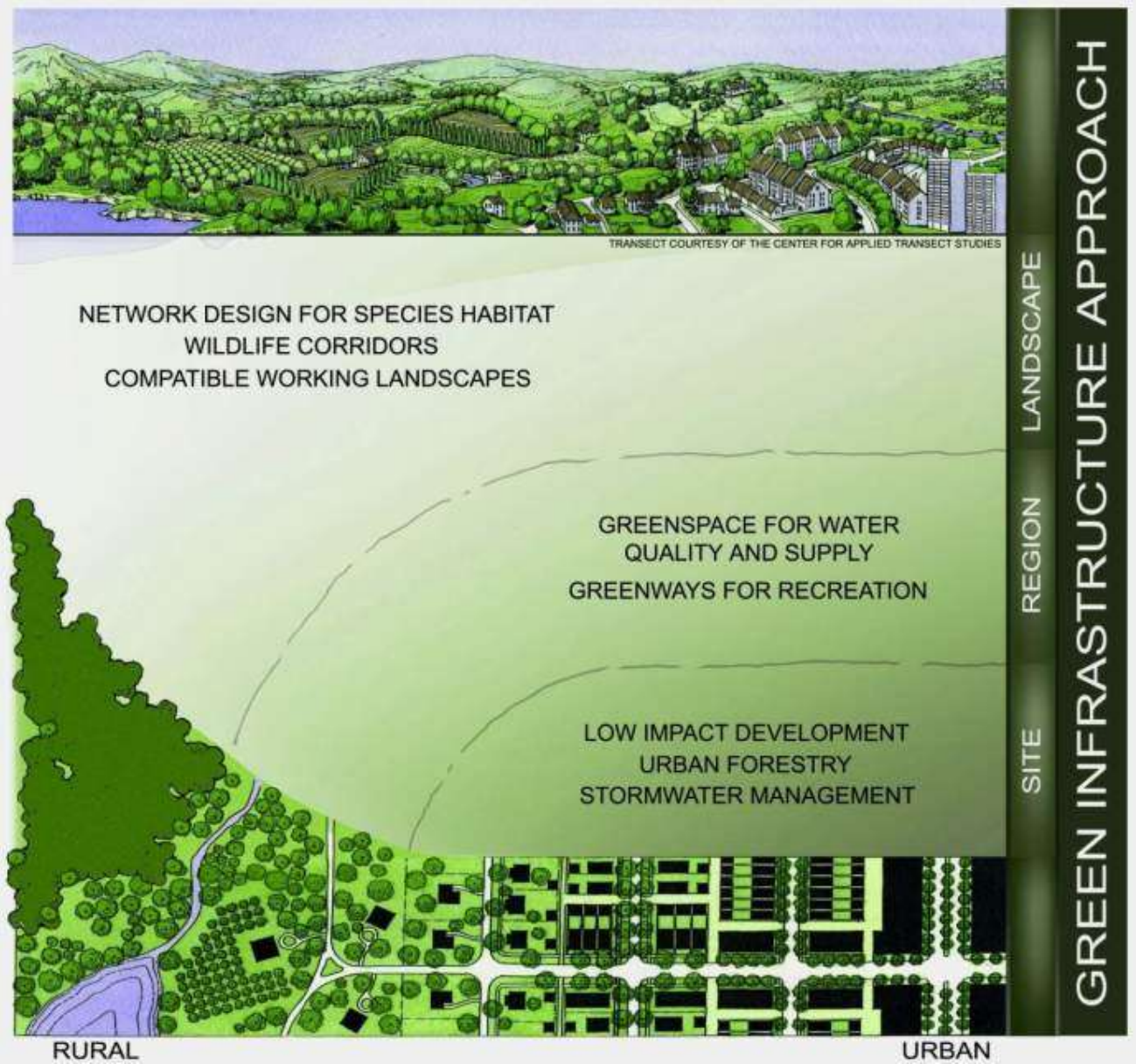


Figure 2. The Green Infrastructure approach at different scales.

Core Areas

The basic building blocks of the green infrastructure network include core areas, hubs and corridors (Figure 3). Core areas contain fully-functioning natural ecosystems and provide high-quality habitat for native plants and animals. These are the nuclei of the ecological network.

Hubs

Hubs are slightly fragmented aggregations of core areas, plus contiguous natural cover. Hubs are intended to be large enough to support populations of native species, and serve as sources for emigration into the surrounding landscape, as well as providing other ecosystem services like clean water, flood control, carbon sequestration, and

recreation opportunities. Large natural areas are usually more effective than small areas for protecting aquifers and watersheds, sustaining viable populations of most interior species, providing core habitat and escape cover for wide-ranging vertebrates, and allowing natural disturbance regimes.[2]

Corridors

Corridors are generally linear features, although still wide enough to provide adequate cover, that link core habitats together through an unsuitable matrix like row crops or development and allow animal and plant propagule movement between them. Retaining connectivity can help to mitigate habitat fragmentation by linking otherwise separated populations within discrete habitat patches.[3] The hope is that any localized extinction will be offset by recolonization, and genetic exchange will maintain fitness, ensuring the long-term persistence of the species in the region. Corridors are both context and species dependent: they depend on both the composition and spatial arrangement of the landscape, and the movement abilities and landscape preferences of target organisms.

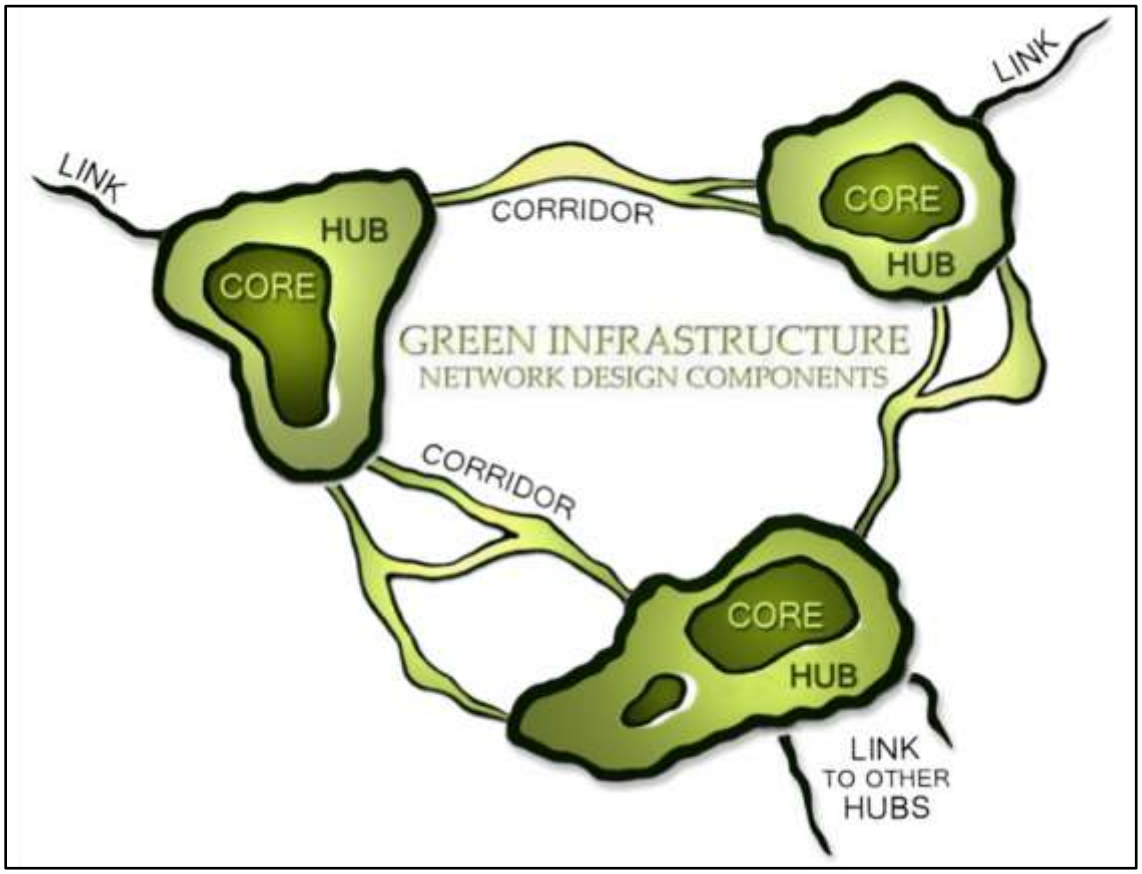


Figure 3. Conceptual diagram of a green infrastructure network (source: The Conservation Fund).

[2] Dramstad, W. E., J. D. Olson, and R. T. T. Forman. 1996. Landscape ecology principles in landscape architecture and land-use planning. Island Press, Washington, DC. 80 pp.

[3] Bennett, A. F. 1998. Linkages in the landscape: the role of corridors and sensitivity in wildlife conservation. IUCN, Gland, Switzerland and Cambridge, UK. 254 pp.

Aquatic systems

Aquatic systems can be examined at both the reach scale (including current and historic floodplains) and the watershed scale. With the loss of forests and increased urban development, Maryland has seen declines in stream stability, water quality, and habitat suitability for fish and invertebrates. Increased fluxes of sediment, nutrients, and other pollutants cause problems downstream as well, impairing large water bodies like the Chesapeake Bay.

Defining the Green Infrastructure Network

Focal Species

The types of landscapes and ecosystems incorporated into a green infrastructure network depend on the region's topography, climate, geology, historic and current species composition, present configuration, and other factors. We used focal species to help inform the green infrastructure network configuration. Focal species are species that are used to represent other species or aspects of the environment. They can thereby be used to guide conservation decision making in the absence of complete knowledge of all species present and all their requirements for persistence. Focal species can include umbrella species, indicator species, and keystone species:

- Umbrella species are a species or group of species who are well studied and whose habitat needs overlap those of other animals and plants, such as Forest Interior Dwelling Birds that require large blocks of forest to breed successfully.
- Indicator species, by their presence, indicate healthy ecosystems, like unpolluted streams, and these include salamanders like the Eastern Hellbender or fish like the Rosyface Shiner.
- Keystone species are those with an important role in ecosystem function, such as pollinators, seed dispersers, hydrologic engineers (beavers), and top carnivores (like bobcats).

We received a list of Rare, Threatened, and Endangered species in Cecil County from DNR's Natural Heritage Program (Appendix J). The Cecil Bird Club provided a list of birds found in the county, along with sighting probabilities and whether or not the species bred in the county. The Maryland Biological Stream Survey (MBSS) provided a list of fish found in stream surveys. We also queried the Maryland Biodiversity Project database for vertebrates recorded in the county. The Susquehannock Wildlife Society (SWS) reviewed these lists and provided corrections as needed. Our tally included 30 species of native mammals, 120 birds, 31 reptiles, 25 amphibians, and 60 fish. Appendix B lists these species and associated habitats.

Using NatureServe Explorer, the Maryland Breeding Bird Atlas, and other sources (see Appendix B for complete list), we identified these species' habitat preferences, habitat specificity, home range size, dispersal abilities, suitable landscape features for dispersal, barriers to dispersal (e.g., highways or development), and roles in ecosystem functions. For fish, we also considered the species tolerance for catchment urban and agriculture cover. From this information, we selected focal species native to the area to determine size, connectivity, and other thresholds in the green infrastructure network design. Focal species were not generalists or urban-adapted, and had to breed or overwinter in the county (i.e., not just migrating through).

Habitat preferences of focal species helped identify priority landscape features, associated optimal habitat, size considerations, and general recommendations for how to map core areas (Appendix B). We performed similar crosswalks for hubs. Connectivity requirements of less mobile species (e.g., amphibians and small mammals) were

used to model corridors, considering their dispersal abilities, suitable landscape features for dispersal, and barriers to dispersal.

DNR biologists provided feedback regarding our modeling process, and also identified areas of known biological and ecological importance.

Figure 4. Mature oak-beech forest in Elk Neck State Park

Core forest

Since the eastern U.S. was primarily unbroken forest before European colonization, many plant and wildlife species are adapted to interior forest conditions. Forest edges contain significant gradients of solar radiation, temperature, wind speed, and moisture between the forest patch interior and the adjacent land, especially if the adjacent land is developed. Increased solar radiation at the edge increases temperatures and decreases soil moisture and, with increased wind flow, decreases relative humidity, which can desiccate plants. Increased wind speed at a newly created edge commonly knocks down trees that are no longer buffered by the adjacent canopy and not structurally prepared. Wind can also carry dust or other small particles, which can adhere to vegetation. Noise from developed land disrupts natural activity in adjacent forest or marsh, by drowning wildlife cues for territorial boundary establishment, courtship and mating behavior, detection of separated young, prey location, predator detection, and homing. Sudden loud noises can also cause stress to animals. Changes in insolation and other physical parameters at created edges change plant and animal communities there, and processes like nutrient cycling.

Edge habitat differs from interior forest in tree species composition, primary production, structure, development, animal activity, and propagule dispersal capabilities. The edge communities shift to more shade-intolerant, more xeric tree and shrub species, and early successional species. Edges can favor invasive species, which can then displace native species in adjacent areas. Opportunistic animals like raccoons, opossums, and cowbirds also colonize patch edges, and often invade the interior. These edge species often influence ecosystem dynamics by preying on, outcompeting, or parasitizing interior species. Cats and dogs from developed areas can also prey on or harass wildlife.

We identified tree canopy from high-resolution land cover classified by the Chesapeake Conservancy (Appendix C). We subtracted roads, railroads, utility corridors, parking lots, buildings, driveways, orchards, and Christmas tree farms. From this, we identified forest patches with at least 1 acre of interior conditions (>30 m from the nearest edge). Core forest was a subset of this: either forest patches at least 100 acres in size (only 13% of patches, but 61% of total forest area); or overlapped core aquatic areas, core wetlands, or key biodiversity areas (BioNet Tiers 1-4).

Appendix D contains all core area methodology details.

Core wetlands

Wetlands, both tidal and non-tidal, provide not only vital habitat and ecosystem services, but are regulated features in Maryland. We defined core wetlands as relatively unimpaired wetlands that met the habitat needs of wetland-dependent species. From the DNR wetland layer, we identified all wetlands that had not been farmed, drained, ditched, or excavated. From these, we identified areas at least 100 feet from cleared or developed land, roads, railroads, ditches, or channelized streams. We then added buffers of natural land and water.

Core aquatic areas

We identified four classes of natural aquatic habitat and selected the best examples of each, based on indicator fish and other aquatic organisms:

- For non-tidal streams, we selected reaches with a "Good" combined (fish + benthic macroinvertebrate) Index of Biotic Integrity (IBI), which indicate good water quality and stream habitat. We also added stream reaches designated as high quality (Tier II) by the Maryland Department of the Environment (MDE).
- We also selected rivers and streams supporting populations of yellow lampmussels (*Lampsilis cariosa*), a rare freshwater mussel.
- For coldwater streams, we selected streams supporting reproducing populations of brown trout (*Salmo trutta*, an introduced European species) or benthic coldwater macroinvertebrates (*Tallaperla* spp. and *Sweltsa* spp.). *Tallaperla* spp. and *Sweltsa* spp. are sensitive to sedimentation and pollution and need cold water. No brook trout or hellbenders have recently been found in the county.
- Our focal species for tidal waters were Chesapeake logperch *(Percina bimaculata)*, anadromous fish (herring, perch, and striped bass), mummichog (*Fundulus heteroclitus*), and native submerged grasses (SAV). DNR supplied locations where Chesapeake logperch were found. We added 2015 SAV beds, High Priority Blue Infrastructure coastal watersheds, striped bass spawning habitat, and herring and perch spawning and juvenile habitat.

We combined these areas and added the associated riparian zone, using either the 1% (100 year) floodplain or a buffer of 100 feet, whichever was greater.

Hubs

Hubs were aggregations of core areas and other undeveloped land, separated by major roads or gaps. Hubs should be large enough to support populations of native species, and serve as sources for emigration into the surrounding landscape. Some core areas and other ecological features fell outside hubs, if they were isolated and below the size threshold. We added a 300 foot buffer of natural land or agriculture around core areas, and subtracted developed land and major roads. We then applied a size threshold of 250 acres.

Corridors

Corridors allow wildlife to move from one patch of habitat to another. Functional connectivity describes the degree to which landscapes facilitate or impede their movement. It is both context and species dependent, depending on both the composition and spatial arrangement of the landscape, and wildlife movement abilities and landscape preferences. Connectivity suitability depends on the type of organism. But most terrestrial non-aerial species are rarely able to cross busy roads or urban areas successfully. Most aquatic species are restricted to water, and unable to traverse dams and other blockages without fish ladders or similar structures.

We identified landscape permeability or impedance factors for each type of core area (forest, wetland, and aquatic), created impedance layers for each factor (land cover, roads, proximity to water, etc.), then combined them (Appendix D). Permeability reflects how easy it is for a particular organism to move from one area to another based on the intervening landscape features. Impedance is the inverse of permeability. A particular landscape feature (e.g., a pine plantation) might provide marginal habitat for forest-dependent organisms but still be highly permeable.

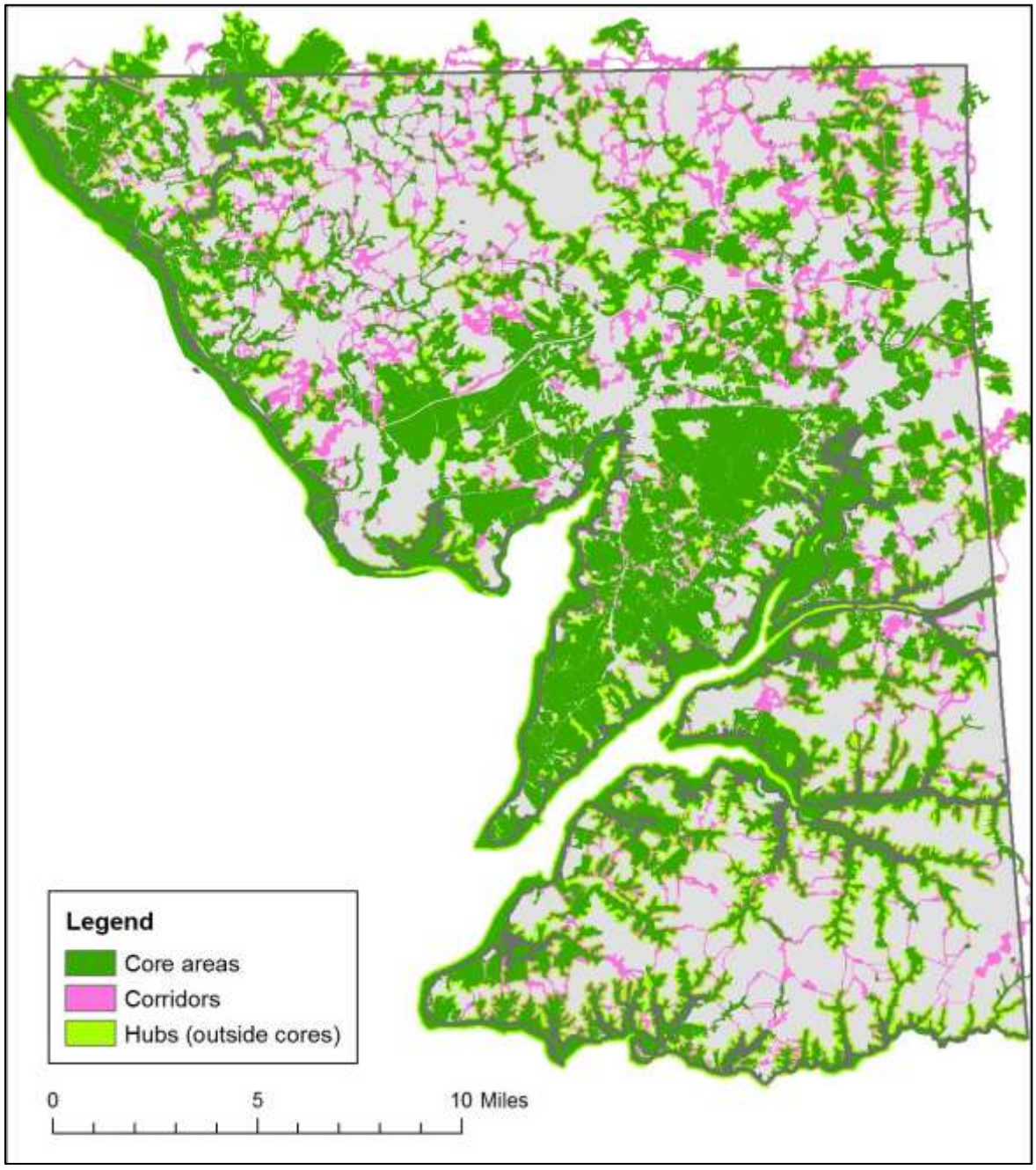
The impedance layers were varied randomly to reflect uncertainties. For example, for forest-dependent wildlife (e.g., gray fox, woodland vole), forest provides better cover than row crops. But *how much* better is less certain.

To model landscape connectivity, we used a program called the Terrestrial Movement Analysis (TMA) tool. It treats the landscape as a circulatory system, identifying those pathways most likely to be followed by wildlife. The tool generates random sets of starting locations (with each location corresponding to an individual organism) and then calculates optimal (or least cost) paths to all other habitat within the landscape. The cell values along the pathway are the summed area (the number of patch cells) that a pathway is connected to at that point. This process is executed iteratively, with each iteration having a different set of random start locations and corresponding least-cost paths. The tool identifies corridors by adding suitable land along this pathway. Finally, it calculates overall movement potential by considering both the amount of habitat connected by a linkage, and how good that linkage is (i.e., is it mostly natural land or are portions degraded or converted?). Note that connectivity potential exists both within and outside core areas.

We defined corridors as connectivity linkages that fell outside core areas (see Appendix D for details).

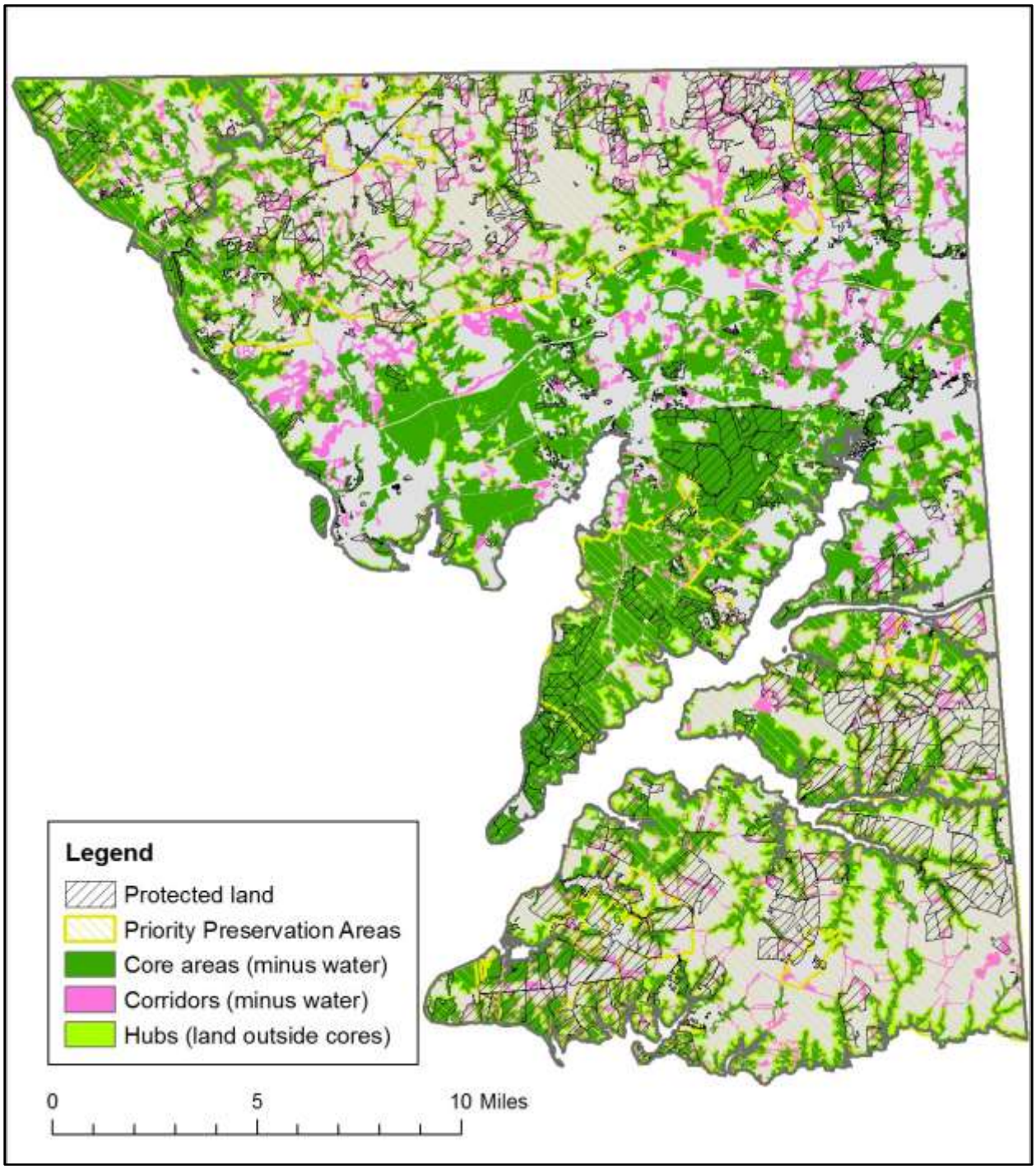
Green Infrastructure Locations

Map 1 shows core areas, hubs (the portions outside core areas), and corridors. Within Cecil County's boundaries, including municipal areas, the analyses identified 78,933 acres of core areas and 23,879 acres of corridors, excluding open water. 36% of land was in core areas and 11% in corridors.[4] 28% of core area land and 34% of corridor land were in parks, conservation easements, or other protected land (Map 2). 49% of core areas and 57% of corridors were inside the County's current Priority Preservation Area.



Map 1. Core areas, hubs, and corridors in Cecil County.

[4] Cecil County land total = 221,289 ac.



Map 2. Core area, hubs and corridor land (not including open water) compared to current locations of protected land and priority preservation areas.

Public Involvement

The Green Infrastructure Plan actively sought to gather public opinion and preferences about the direction of the planning effort and its role in implementing preservation and restoration of the green infrastructure network. A Steering Committee was formed and met regularly to help guide the engagement and focus the mapping and recommendations. A county website was established to announce activities and an on-line file sharing site was established to share planning information and resources. County staff managed an email list of key stakeholders from numerous sources related to natural resource protection, land use planning, non-profit organizations, business community, universities, and public schools throughout the County to aid in the communication and notices for meetings, workshops, special presentations, and related activities. Public workshops were planned for the initiation of the planning process (December, 2018) and the draft plan's findings and recommendations (May, 2019).

The first open house introduced the GI Plan and the concept of a green infrastructure network while also providing information about the planning process, schedule and ways to get involved. The workshop sought to confirm the priorities of key stakeholders and the community about the highest values offered through an effective green infrastructure network. The workshop also solicited ideas and opportunities to conduct restoration and preservation activities.

The second workshop was held in May and shared the findings and preliminary recommendations of the green infrastructure network mapping. Participants were asked to weigh in on their values and priorities by "voting" on relative importance of the different recommendations that the county would be responsible for implementing. Participants were also asked what their role might be in helping to implement parts of the Plan.

Community Workshops

On December 5, 2018, Cecil County and other members of its Green Infrastructure project team conducted a community workshop to initiate the broader outreach regarding green infrastructure planning. Display boards illustrated several resource maps for the County and solicited feedback on priorities for project goals and benefits. These display boards indicated similar results for priority ranking as the individual ranking exercises that followed the presentation (described below).

Over 40 participants attended to hear the presentation about the GI Plan's scope and timeline, and mapping approaches for four different resilience strategies. The workshop presentation also emphasized the importance of public participation to help guide the planning process and ensure its accurate representation of values and goals for the County and its plan implementation.

Workshop participants were asked to indicate the top three benefits that could be provided by an effective green infrastructure network in Cecil County. Clean Water, Wildlife Habitat, and Clean Air were ranked the top three benefits by participants.

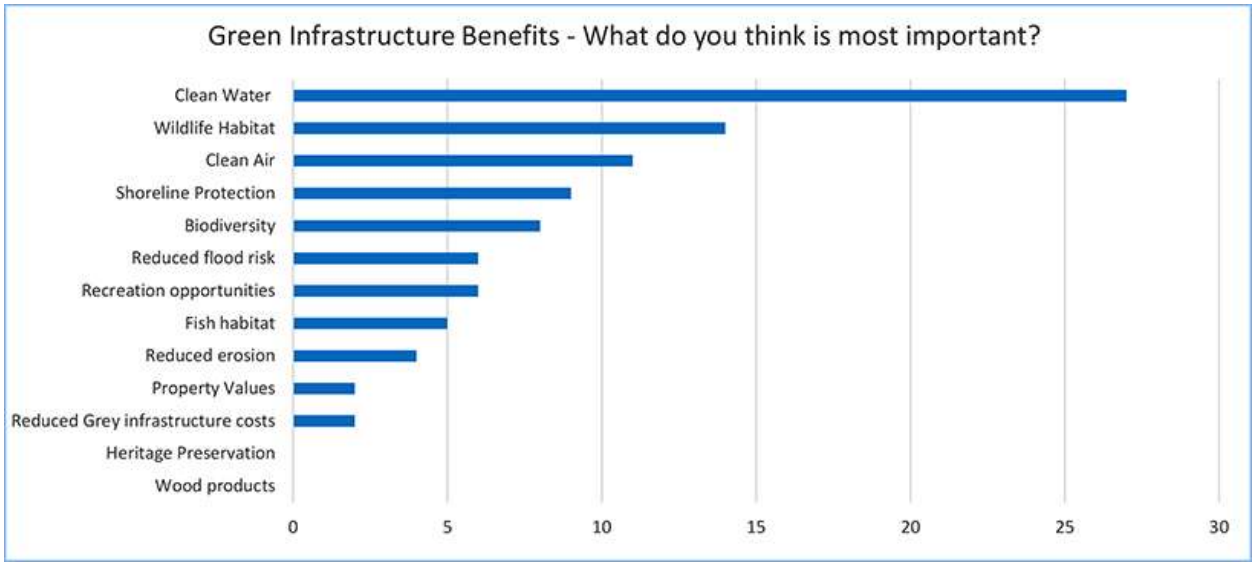


Table 2. Green Infrastructure Benefits from the First Community Workshop, Dec.5th, 2018.

A second engagement exercise asked participants to choose their top three goals for the GI network to guide the development of the plan and its future policies and implementation priorities. Clean Water Protection and Natural Resource Protection ranked the highest across the more focused individual ranking cards. Critical Infrastructure Protection and Wildlife Habitat Enhancement tied for third as a top goal of importance.

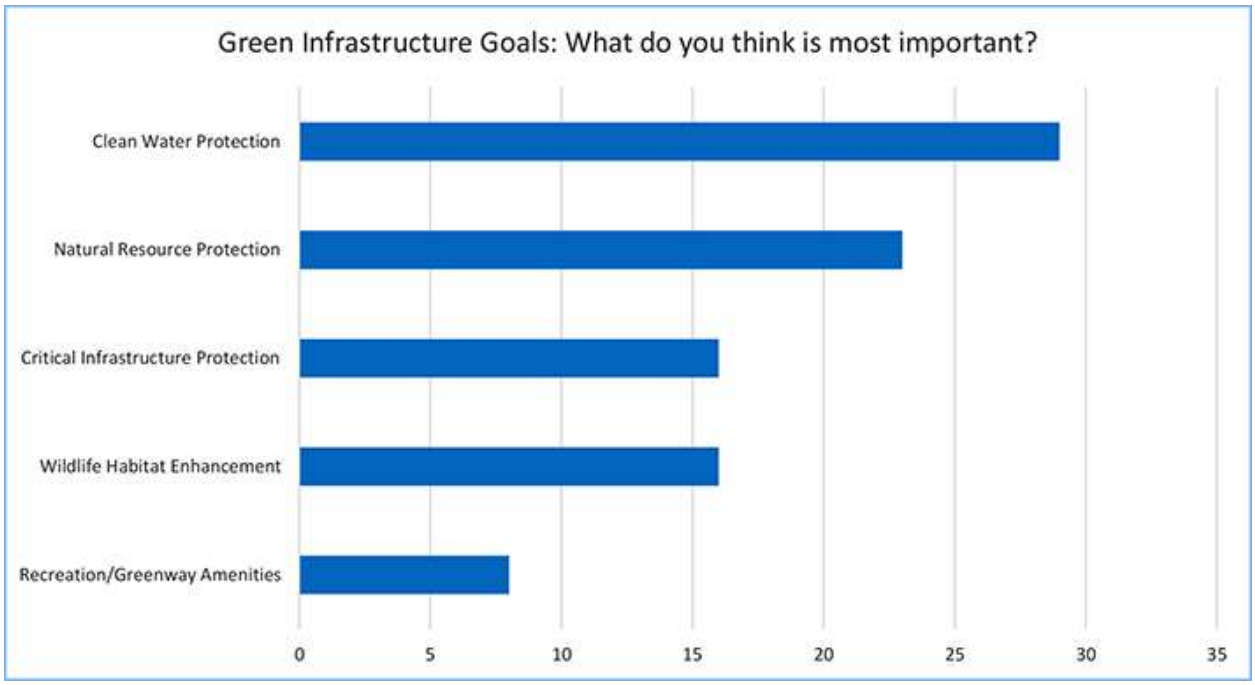


Table 3. Green Infrastructure Goals from the First Community Workshop, Dec.5th, 2018.

The second public workshop was conducted on May 15, 2019 and approximately 20 participants were shown the mapping results for the green infrastructure network with a presentation that included the County's new on-line GI mapping tool and a presentation by Maryland's Environmental Management Agency regarding flood hazard mitigation and its relationship to green infrastructure.

Display boards at the workshop included mapping highlights of the four resilience strategies. Some of the boards showed potential strategies for implementation and solicited further ideas and priorities from workshop attendees.

Following the presentation, workshop participants were asked to review a series of draft recommendations for implementing the GI network across the county. Two sets of recommendations focused on tasks to be conducted by the county and asked participants to rank their highest preferences for implementation in the near future. The first set of recommendations focused on the theme of land use policies, and requiring growth areas to protect stream buffers while limiting development in floodplains was the highest priority. The second highest priority was encouraging more voluntary preservation and restoration opportunities, along with more incentives for action, rather than implementing new regulations. The third was to protect adequate habitat areas when land is developed within designated growth areas to enhance the functioning ecosystems within the GI Network.

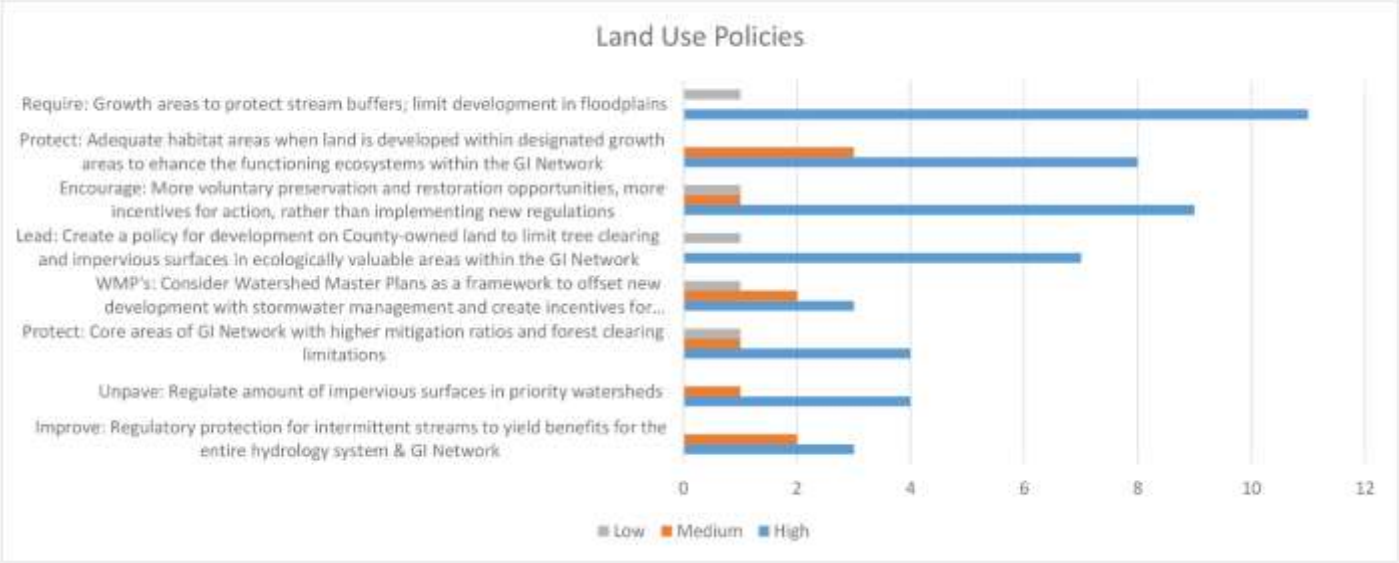


Table 4. Ranked Land Use Policies from the Second Community Workshop, May 15th, 2019.

The second set of recommendations revolved around the planning and program development theme. The highest ranking priorities dealt with the protection of wetlands and setting a goal to establish 70% of streams with riparian forest buffers using a combination of incentives and regulations. The third highest priorities included targeting flood mitigation efforts and identifying funding sources for implementing future GI programs and initiatives.

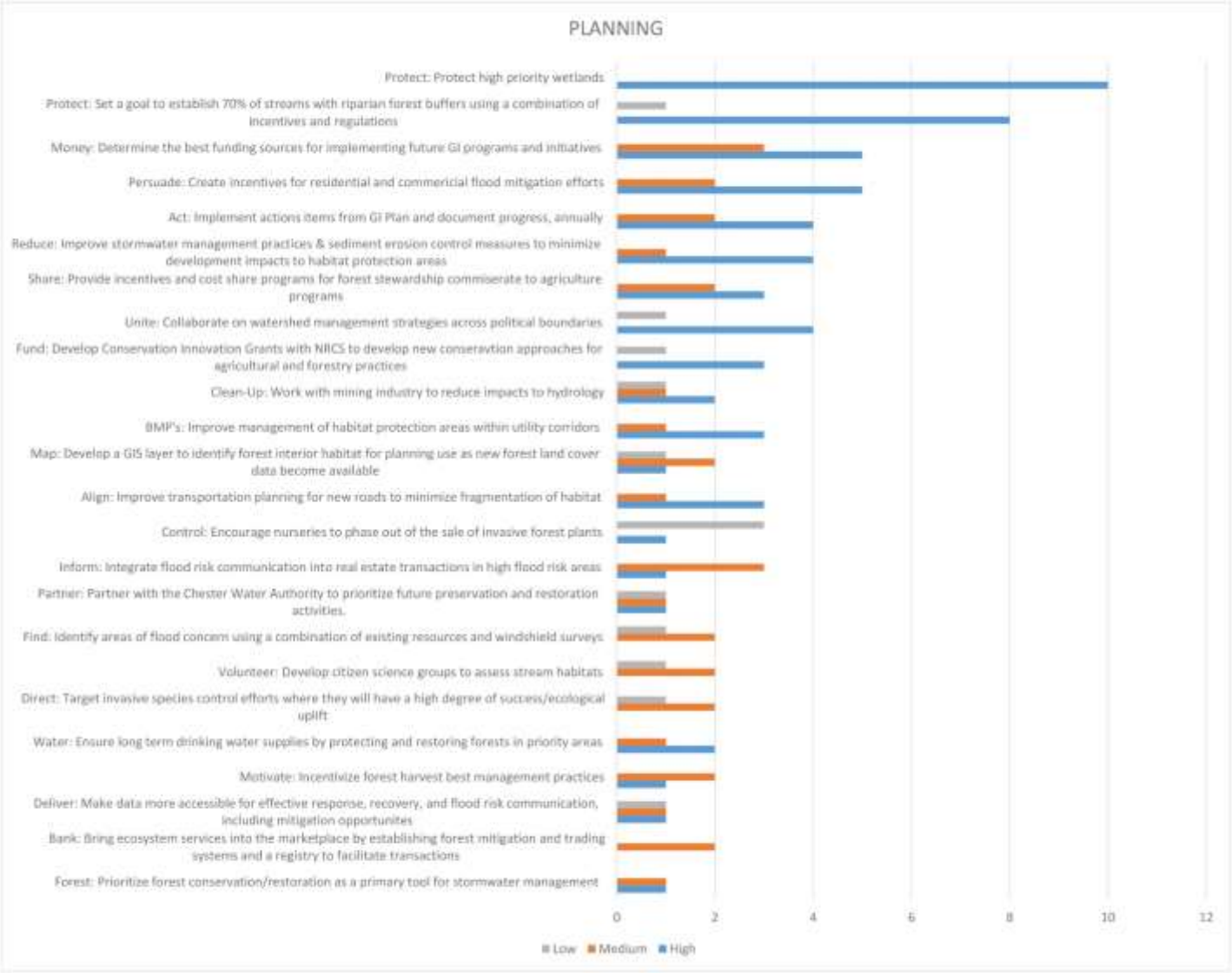


Table 5. Ranked Planning Programs from the Second Community Workshop, May 15th, 2019.

Additional sets of recommendations approached the restoration, education, and land preservation theme by asking if and how participants could contribute to implementing the green infrastructure network. From the results, a majority of participants support identifying high priority stream candidates for restoration. A majority also support informing public audiences about stormwater and runoff retention practices, along with targeting preservation of high-value GI connections with partners. The key leader outside local government in land preservation is the Cecil Land Trust and the leader for stormwater education is Shore Rivers. The top partners willing to help develop new implementation strategies are DNR's Critical Area Commission and the Cecil County Watershed Stewards Academy. This information was gathered to help County staff prioritize their focus for the GI plan recommendations and expand their potential network of supporting partners for future GI activities, including grant opportunities.

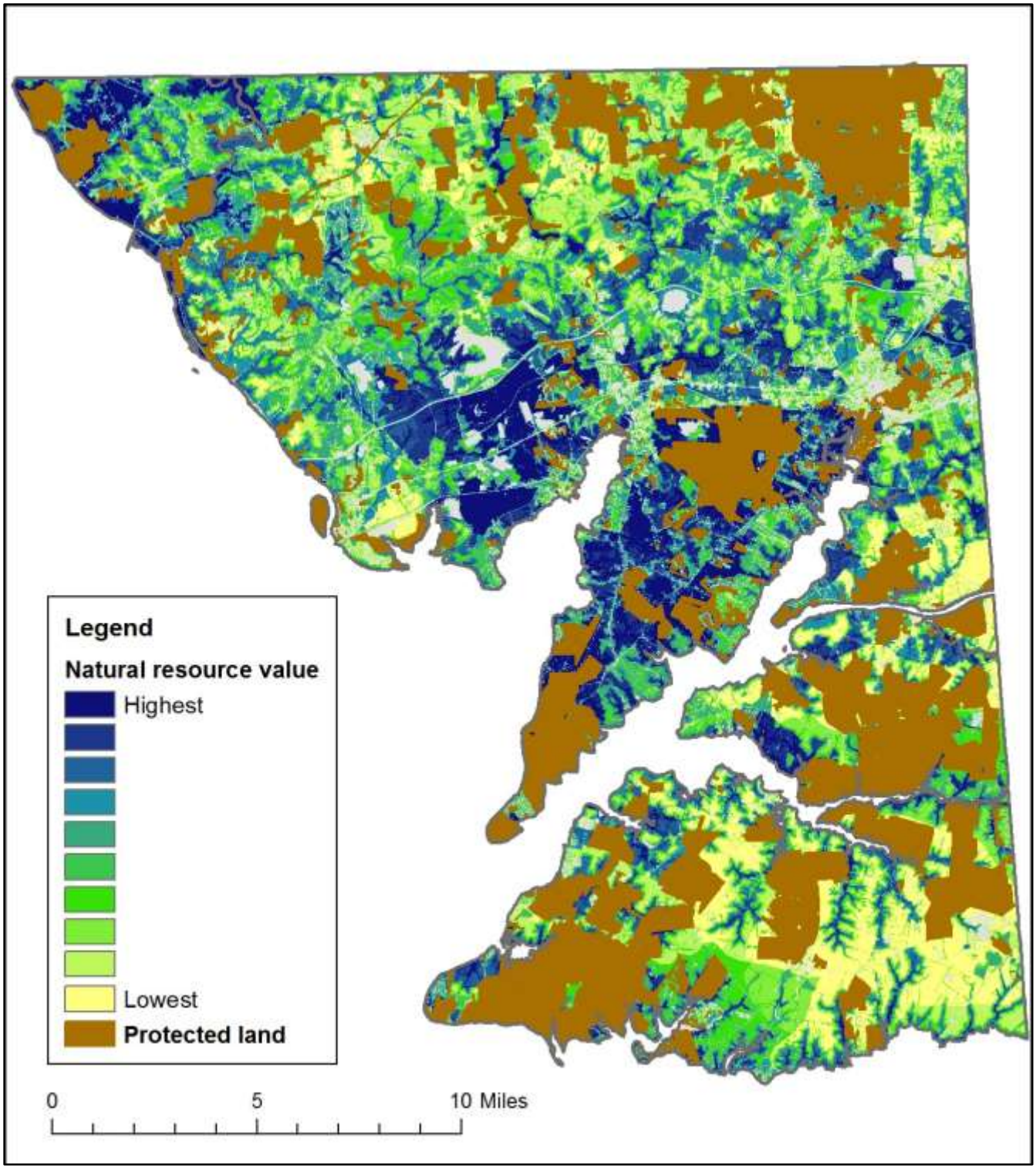
The Steering Committee for the GI plan met approximately every other month over a one year period, to review information, guide decisions, refine the GI network mapping assessments, and comment on the draft plan.

Ranking Areas for Natural Resource Protection

To prioritize conservation actions, we ranked all currently unprotected and undeveloped land for its natural resource value, giving a score between 0 (lowest value) and 100 (highest). Table 6 lists the factors used for ranking, following feedback from the steering committee and examining output from different weightings. Appendix E shows this in more detail, including how the factors were weighted. Map 3 shows how each 3-meter cell was scored for conservation importance.

Mandatory criteria	Not already protected Not a building or paved Not open water
State-designated ecological significance	Statewide Green Infrastructure Hub-Corridor Network Targeted Ecological Areas Significant for Biodiversity Conservation (BioNet Tiers 1-5) Wetlands of Special State Concern + 100 ft buffer
Watershed characteristics	Percent forest cover (more forest preferred) Percent impervious surface (<5%/5-10%/10-20%/>20%) Watersheds with surface drinking water intakes 100-foot buffers of Stronghold Watershed streams, trout bearing streams, streams feeding municipal drinking water reservoirs, and Tier II High Quality Waters (Forests of Recognized Importance)
Cecil County green infrastructure network	Core areas Hubs Forest movement importance Wetland movement importance
Natural Resource Features	Wetlands + buffers Streams + buffers and 1% (100 year) floodplains Forest patches with at least 1 acre of interior Highly erodible soils
Existing priorities	Rural Legacy Areas Priority Preservation Areas
Park equity	Distance to nearest existing park

Table 6. Factors used to rank unprotected land for natural resource conservation importance.



Map 3. Unprotected land in Cecil County ranked for natural resource conservation importance.

Stormwater Green Infrastructure

Green infrastructure is a cost-effective, resilient approach to managing stormwater that also provides other benefits (see Table 1 list). Trees and other vegetation intercept rainfall, reduce surface runoff, and allow water to infiltrate into the soil. In contrast, impervious surfaces like roof tops, roads, and parking lots rush water across the land, typically into a storm drain and then to a stream or other body of water. Peak flows from urban runoff can create hazardous floods, scour streams, and release sediment and other pollutants that impair downstream water bodies like the Chesapeake Bay.

At the site scale, best management practices (BMPs) can be implemented to manage stormwater runoff. This includes retaining existing forests and wetlands, using environmental site design (ESD) where areas are developed or redeveloped, and preventing erosion and sediment runoff during construction. Areas already developed without adequate stormwater controls can be retrofitted to mitigate their impacts.

We identified areas that might be suitable for stormwater BMPs like bio-retention areas, constructed wetlands, wet or dry ponds, infiltration basins or trenches, grass swales, porous pavement, sand filters, and vegetated filterstrips to reduce flooding and water pollution. We used EPA's BMP site suitability criteria to identify potential locations for 11 types of BMPs (Table 7). Other BMPs like green roofs, rain barrels, and cisterns could be placed anywhere and did not require site targeting.

	Site Suitability Criteria							
BMP	**Drainage Area (acre)**	**Slope (%)**	**Hydrological Soil Group**	**Water Table Depth (cm)**	**Road Buffer (ft)**	**Stream Buffer (ft)**	**Wetland Buffer (ft)**	**Land cover**
Bioretention	< 2	< 5	A–D	> 61	< 100	> 100	> 100	Grass, bare earth, parking lots
Constructed Wetland	> 25	< 15	A–D	> 122	--	> 100	> 100	Grass, bare earth
Dry Pond	> 10	< 15	A–D	> 122	--	> 100	> 100	Grass, bare earth
Grassed Swale	< 5	< 4	A–D	> 61	< 100	--	--	Grass, bare earth, parking lots
Infiltration Basin	< 10	< 15	A–B	> 122	--	> 100	> 100	Grass, bare earth
Infiltration Trench	< 5	< 15	A–B	> 122	--	> 100	> 100	Grass, bare earth, parking lots
Porous Pavement	< 3	< 1	A–B	> 61	--	--	--	Parking lots
Sand Filter (non-surface)	< 2	< 10	A–D	> 61	--	> 100	> 100	Grass, bare earth, parking lots
Sand Filter (surface)	< 10	< 10	A–D	> 61	--	> 100	> 100	Grass, bare earth, parking lots
Vegetated Filterstrip	--	< 10	A–D	> 61	< 100	--	--	Grass, bare earth, parking lots
Wet Pond	> 25	< 15	A–D	> 122	--	> 100	> 100	Grass, bare earth

Table 7. Stormwater Management Site Suitability Criteria.

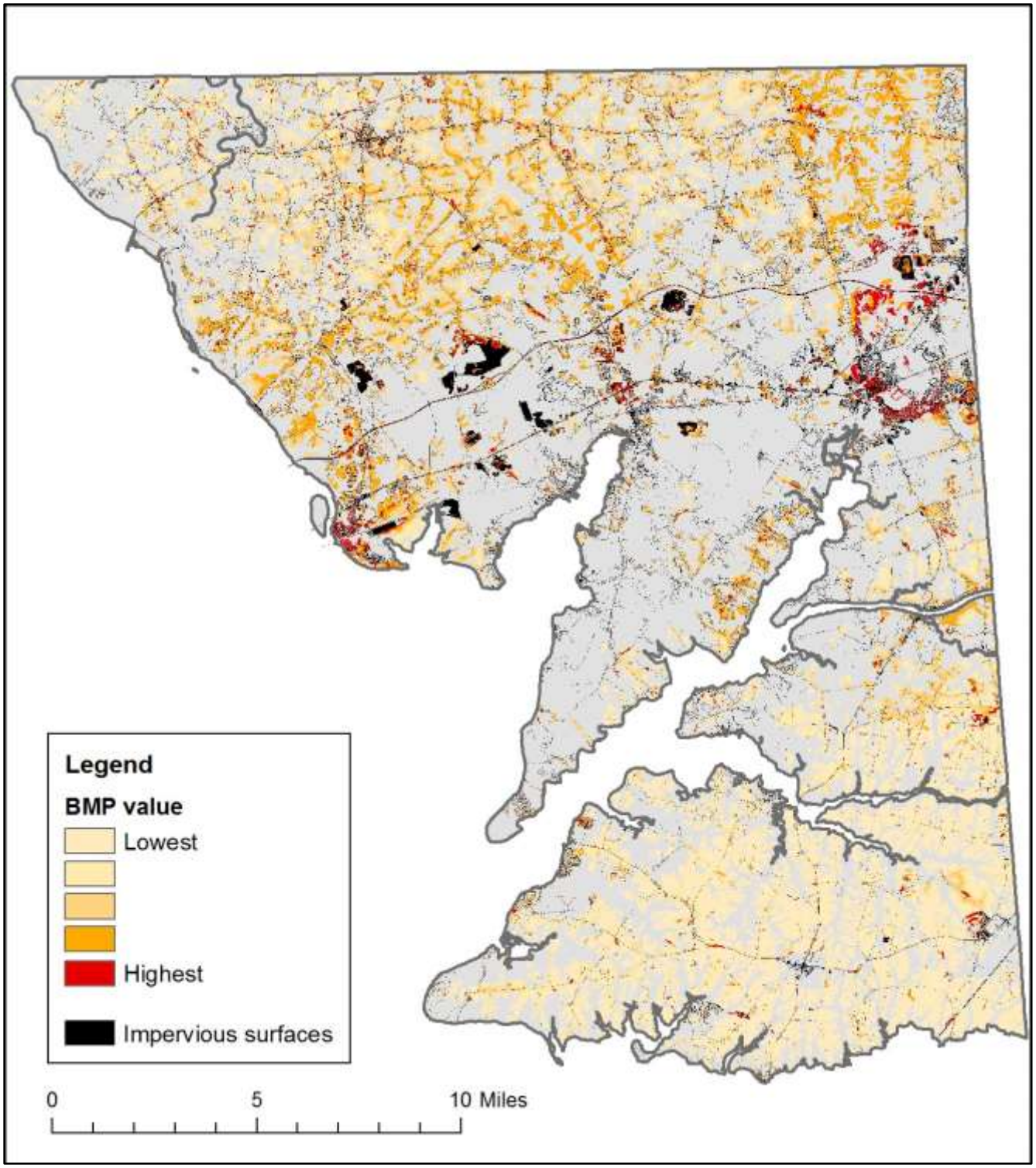
The scan for potential BMPs was a broad initial step; locations have to be examined in the field to confirm their suitability and engineer appropriate designs.

Figure 5. Rain garden to hold and treat stormwater.

To help prioritize BMP placement, we then ranked all suitable sites, giving a score between 0 (lowest value) and 100 (highest). Table 8 lists the factors used for ranking, following feedback from Public Works staff and the steering committee, and examining output from different weightings. Appendix E shows this in more detail, including how the factors were weighted. Map 4 shows how each 3-meter cell was scored for BMP importance.

Mandatory criteria	Identified using EPA criteria for bioretention, constructed wetland, dry pond, grassed swale, infiltration basin, infiltration trench, porous pavement, sand filter (both surface and non-surface), vegetated filter strip, or wet pond
Land ownership	Public ownership preferred Privately owned with easement acceptable but less preferred Privately owned with no easement least preferred
Potential for stormwater capture	Area of impervious surface draining to the site Presence/absence of existing BMPs
Watershed characteristics (HUC-12 watersheds)	Percent forest cover (less forest preferred) Percent impervious surface (10-20% most preferred, 5-10% and >20% less preferred, <5% not preferred) Within a watershed with surface drinking water intake
Small catchment characteristics (NHD catchment)	Amount of older development (less likely to have any stormwater structures) Non-point local nitrogen (TN) urban runoff (SPARROW) Non-point local phosphorus (TP) urban runoff (SPARROW)
Constructability and visibility	Distance to nearest road, parking lot, or driveway (closer is better)

Table 8. Factors used to rank areas for stormwater BMP construction.



Map 4. Site suitability for construction of stormwater control green infrastructure.

Coastal Defense

Natural habitats, such as coastal forests, marshes, and submerged aquatic vegetation (SAV), can buffer coastal areas from the impacts of flooding, storm surge, and sea level rise. Coastal vegetation attenuates waves, increases infiltration, and stabilizes sediments.

Maryland DNR, in partnership with the Nature Conservancy, conducted a statewide coastal resiliency assessment in 2015-16 by examining potential hazards, their risk to people, and the role of natural habitats in reducing that risk. Priority areas for restoration and conservation actions were identified based on the presence of existing habitat, its current role in risk reduction along the shoreline, and the presence of nearby coastal neighborhoods.[5]

DNR ranked shoreline segments both statewide and within Cecil County, which has over 200 miles of shoreline. Tier I Shorelines were shorelines with a high habitat role, or would create a high hazard if the habitats were removed. Tier II shorelines had a moderate habitat role, or would create a moderate hazard if the habitats were removed. Calibrated within the county, 29% of shoreline fell in Tier 1 and 39% in Tier 2.

We used a recent study commissioned by the Maryland State Highway Administration (SHA) to identify coastal flood-prone areas.[6] It used the best estimates of sea level change and flood heights available at the time of the study. We used their predicted 1% chance flood extent in 2100 (equivalent to 5.5 feet of sea level rise plus the storm surge from a Category 3 hurricane).

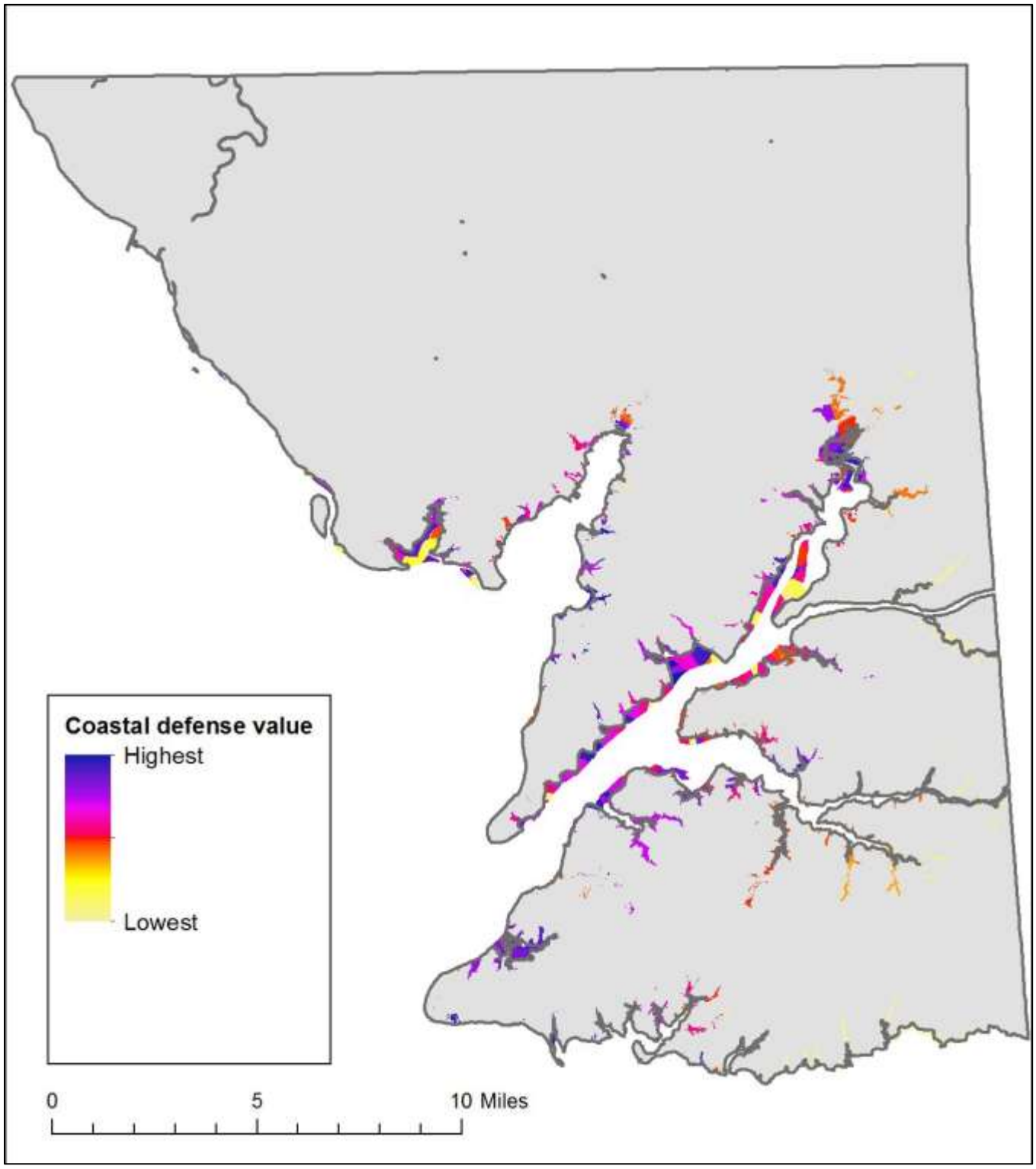
To prioritize conservation for coastal defense, we scored all currently unprotected forests, wetlands, and SAV beds within the flood-prone zone for their ability to reduce flood risk to people, as well as their provision of coastal habitat (Table 9). Appendix E shows the ranking criteria in more detail, including how the factors were weighted. As an illustration, Map 5 shows how areas scored.

Mandatory criteria	Not developed Not already protected Within predicted coastal flood extent Existing natural features within storm surge zone (forest, wetlands, or underwater grass)
State-designated Blue Infrastructure shoreline segments	Blue Infrastructure total rank, allocated to nearest natural features in storm surge zone
Maryland Coastal Resiliency Assessment	Habitat role in hazard risk reduction (High/Moderate/Low or None)

Table 9. Factors used to rank preservation of natural features for coastal defense importance.

[5] Canick, M. R., N. Carlozo and D. Foster. 2016. Maryland Coastal Resiliency Assessment. The Nature Conservancy, Bethesda, MD. http://dnr.maryland.gov/ccs/Documents/MARCH-2016_MDCoastalResiliencyAssessment.pdf

[6] Eastern Shore Regional GIS Cooperative. 2016. GIS data products to support climate change adaption planning. Maryland State Highway Administration, Baltimore, MD.



Map 5. Natural features ranked for their coastal defense importance in Cecil County.

Critical Infrastructure Protection

Green infrastructure can buffer critical infrastructure from extreme weather impacts like flooding and high winds. Critical infrastructure includes power production and transmission facilities, hospitals, police stations, fire stations, emergency management centers, water supplies, waste water treatment facilities, evacuation routes, and more.

We compared locations of critical infrastructure in Cecil County to SHA's predicted 1% flood extent in the year 2100 in coastal areas (described in previous section), as well as, the current 0.2% flood extent in riverine areas. Scientists typically use statistical probability to put a context to floods and their occurrence. For example, 0.2% has a 1 in 500 chance of occurring any given year, 1% has a 1 in 100 chance, and 10% has a 1 in 10 chance. We found 49 potentially vulnerable facilities, each with varying degrees of threat level, current protection, and recommended flood reduction measures (Table 10).

Facility Name	**Hazard**	**Threat Level**	**Current Protection**	**Potential GI Measures to Reduce Flood Risk**
Port Herman Condominiums Treatment Plant	• Not in 100yr or 500yr floodplain • 1% 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 WWTP	• Within 100yr floodplain • 0.2% chance storm with sea level rise by 2050 • 1% chance storm with sea level rise by 2100	**High**	existing forest provides some protection, most plant components have been relocated outside of 100 yr floodplain	• Constructed wetland with infiltration berms and retentive grading • Restoration of floodplain once relocation is complete
Elkton WTP11001	• Within 100yr floodplain • 1% chance storm with sea level rise by 2100 • 0.2% chance storm with sea level rise by 2050, level 3 Hazard Vulnerability on Delaware Ave	**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
Cecil County Detention Center	• Within 500yr floodplain • 1% chance storm with sea level rise by 2100	**Medium**	Minimal pervious surfaces surrounding facility	• Retention or detention pond on the grounds • Upgrade to porous pavement and addition of filter strips • Constructed wetland

North East Town Hall	• Within 100 Yr floodplain • 0.2% storm with sea level rise by 2050, level 3 Hazard Vulnerability on Main St; level 2 on West St. • 0.2% chance storm with sea level rise by 2050	**High**	little natural protection, microbioretention project installed in parking lot in May of 2016	• Green roof or wall • Rain gardens and cisterns • Upgrade to porous pavement
North East Police Department	• Within 100yr floodplain • 0.2% storm with sea level rise by 2050, level 3 Hazard Vulnerability on Cecil Ave; level 2 on Race St. • 1% chance storm with sea level rise by 2100	**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 • Managed retreat if other options are unsuccessful
Perryville Vol. Fire Department	Within 500yr floodplain	**Low**	wooded areas surrounding 2/3 of facility	• Conservation landscaping • Rain garden and cisterns • Upgrade to porous pavement • Bio-swale and/or detention ponds on ground • Green roof and/or wall
Port Deposit WWTP	• Within 100 year floodplain • 10% chance storm with sea level rise by 2050	**High**	large forested area behind facility	• Possible relocation out of 100yr floodplain • Higher floodproofing
Port Deposit Town Hall and Police Station	• Withn 500yr floodplain • 1% chance storm with sea level rise by 2100; level 3 Hazard Vulnerability on S Main St	**Medium**	large forested area behind facility	• Bio-swale to forested area • Upgrade to porous pavement in parking lot • Backfill foundation crawlspaces • Improve flood openings and Elevate utilities
Water Witch Vol. Fire Department	• Within 100yr floodplain • 1% chance storm with sea level rise by 2100; level 3 Hazard Vulnerability on S Main St	**High**	wooded area behind adjacent structures	• Upgrade to porous pavement in parking lot and addition of filter strips or bio-swale • Rain garden and cisterns
Port Deposit WTP	• Within 100yr floodplain • 1% chance storm with sea level rise by 2100 ; level 2 Hazard Vulnerability on Rock Run Landing	**Medium**	Adjacent wooded strip between facility and shoreline	• Constructed wetland with infiltration berms and retentive grading • Conservation landscaping and bio-swale into forested area

Meadowview WWTP influent pump station	• Within 100yr floodplain	**High**	wooded area behind adjacent structures	• Constructed wetland with infiltration berms and retentive grading • Rain garden and cisterns
Persimmon Creek Pump Station	• Within 500yr floodplain	**Medium**	wooded area behind adjacent structures, detention pond on the grounds	• Bio-swale to forested area • Floodproofing
W.L.Gore Elk Mills Campus Pump Station	• Within 500yr floodplain	**Medium**	wooded area behind adjacent structures, detention pond on the grounds	• Bio-swale to forested area • Floodproofing
Carpenter's Point Grinder Station #11	• Within 100yr floodplain, 1% chance storm with sea level rise by 2100	**High**	little natural protection	• Constructed wetland with infiltration berms and retentive grading • Rain garden and cisterns • Floodproofing • Backup generator
143 Greenbank Grinder Station	• Within 100yr floodplain, 1% chance storm with sea level rise by 2100	**High**	little natural protection	• Constructed wetland with infiltration berms and retentive grading • Rain garden and cisterns • Floodproofing • Backup generator
121 Kirk Road Grinder Station	• Within 100yr floodplain, 1% chance storm with sea level rise by 2100	**High**	little natural protection	• Constructed wetland with infiltration berms and retentive grading • Rain garden and cisterns • Floodproofing • Backup generator
72 Little River Road Grinder Station	• Within 100yr floodplain, 1% chance storm with sea level rise by 2100	**High**	little natural protection	• Constructed wetland with infiltration berms and retentive grading • Rain garden and cisterns • Floodproofing • Backup generator
Newport Landing Grinder Station	• Within 100yr floodplain, 1% chance storm with sea level rise by 2100	**High**	little natural protection	• Constructed wetland with infiltration berms and retentive grading • Rain garden and cisterns • Floodproofing • Backup generator
Charlestown Manor Pump Station	• Within 100yr floodplain, 1% chance storm with sea level rise by 2100	**High**	little natural protection	• Conservation landscaping • Rain garden and cisterns • Floodproofing
Church Point Pump Station	• Within 100yr floodplain, 1% chance storm with sea level rise by 2100	**High**	little natural protection	• Conservation landscaping • Rain garden and cisterns • Higher floodproofing • Managed retreat if other options are unsuccessful
Greenbank Pump Station	• 1% chance storm with sea level rise by 2100	**Low**	wooded area behind adjacent structures	• Conservation landscaping • Rain garden and cisterns • Floodproofing
Mechanic's Valley Pump Station	• Within 100yr floodplain	**High**	adjacent bridge culvert has been enlarged	• Higher floodproofing • Managed retreat if other options are unsuccessful

North East Isles Pump Station	• 1% chance storm with sea level rise by 2100	**Low**	little natural protection	• Conservation landscaping • Rain garden and cisterns • Higher floodproofing
Rt. 40 Pump Station	• Within 500yr floodplain	**Low**	large forested area surrounds facility	• Higher floodproofing
Price Marina Pump Station	• Within 100yr floodplain, 1% chance storm with sea level rise by 2100	**High**	little natural protection	• Conservation landscaping • Rain garden and cisterns • Higher floodproofing • Managed retreat if other options are unsuccessful
Port Deposit Town Hall Pump Station	• Within 100yr floodplain, 1% chance storm with sea level rise by 2100	**High**	little natural protection	• Constructed wetland with infiltration berms and retentive grading • Rain garden and cisterns • Floodproofing • Backup generator
Port Deposit Vannort Pump Station	• Within 100yr floodplain, 1% chance storm with sea level rise by 2100	**High**	little natural protection	• Constructed wetland with infiltration berms and retentive grading • Rain garden and cisterns • Floodproofing • Backup generator
Chesapeake Estates Pump Tank #9	• 1% chance storm with sea level rise by 2100	**Low**	wooded area behind adjacent structures	• Bio-swale to forested area • Floodproofing
Chesapeake Estates Pump Tank #11	• 1% chance storm with sea level rise by 2100	**Low**	wooded area behind adjacent structures	• Bio-swale to forested area • Floodproofing
Elkton Pump Station 13002	• Within 500yr floodplain, 1% chance storm with sea level rise by 2100	**Medium**	little natural protection	• Constructed wetland with infiltration berms and retentive grading • Rain garden and cisterns • Floodproofing • Backup generator
Elkton Pump Station 17001	• 1% chance storm with sea level rise by 2100	**Low**	wooded area behind adjacent structures	• Bio-swale to forested area • Floodproofing
Frenchtown Road Pump Station #49	• Within 500yr floodplain	**Medium**	large forested area surrounds facility	• Constructed wetland with infiltration berms and retentive grading • Rain garden and cisterns • Floodproofing, Backup generator
South Chesapeake City Pump Station	• Within 100yr floodplain, 1% chance storm with sea level rise by 2100	**High**	little natural protection	• Constructed wetland with infiltration berms and retentive grading • Rain garden and cisterns • Floodproofing • Backup generator

Table 10. Potentially vulnerable critical facilities in Cecil County.

Map 6. The Town of North East with projected sea level rise by year 2100, coupled with a 1 percent chance storm event.

Nuisance Flooding

Flooding is one of the most common natural hazards experienced in Cecil County. Given the varied topography, flooding occurs in both coastal and riverine areas, as both storm surge and flash floods. The National Oceanic and Atmospheric Administration (NOAA) defines nuisance flooding, as "flooding that leads to public inconveniences such as road closures." In Cecil County, nuisance flooding occurs along major waterbodies and in particular riverine and coastal floodplains and typically includes problems associated with flooded homes, blocked roads, critical facility threats, and drainage system maintenance. In fact, water damage is the main driver of growing insurance costs throughout the region. There are a number of properties at risk around the County that have repeatedly flooded and can be found in neighborhoods including Port Deposit, Carpenter's Point, Charlestown, Locust Point, and Hollywood Beach.

Multiple Departments within Cecil County Government have identified locations that are prone to nuisance flooding, including Emergency Services, Land Use and Development Services, and Public Works. Our Towns have also contributed information on some of these locations. Geographic Information Systems (GIS) has been used to create the first ever comprehensive inventory of roads, bridges, and sewer infrastructure that are vulnerable to nuisance flooding problems, (please see Appendix H for more details).

Cecil County is a Storm Ready community. When warranted, severe weather alerts are repeated by the Department of Emergency Services, however, flood warnings are initiated by the National Weather Service. When local nuisance flooding is anticipated, it may be necessary for the County to initiate a message to flood hazard areas via the County's mass notification system, and/or social media outlets, with details about flood severity, duration, or impacts such as road closures. Thresholds should be developed for Cecil County which direct a set of actions based on a particular inundation level or frequency of flooding. These thresholds are intended to supplement actions directed by the County's Emergency Operations Plan.

Documenting the extent and impacts of nuisance flooding is critical to public safety and the long-term resilience of Cecil County. A review of flood documentation should provide the County with a comprehensive view of trends in flooding over time. The following factors should be recorded by the County and Towns for tracking and subsequent mapping in GIS. These should also include instances of nuisance flooding addressed by the State Highway Administration (SHA) and communicated over the radio.

- Date, time, and location of nuisance flooding
- Impacts (e.g. water depths and extent)
- Agency notified and action taken

The Green Infrastructure Plan can be used as a tool to help identify natural flood mitigation solutions in appropriate areas, serving to highlight priorities for land preservation and restoration opportunities that can be used in concert with each other, to increase resilience to extreme precipitation events and coastal storm surge. Green Infrastructure deserves to be a part of every discussion about flood mitigation. In addition, there will be overlap with key strategies found within both the Comprehensive and Hazard Mitigation Plans to help confirm the top priorities for mitigation. As planners, we shall have special concern for the long-range consequences of present actions.

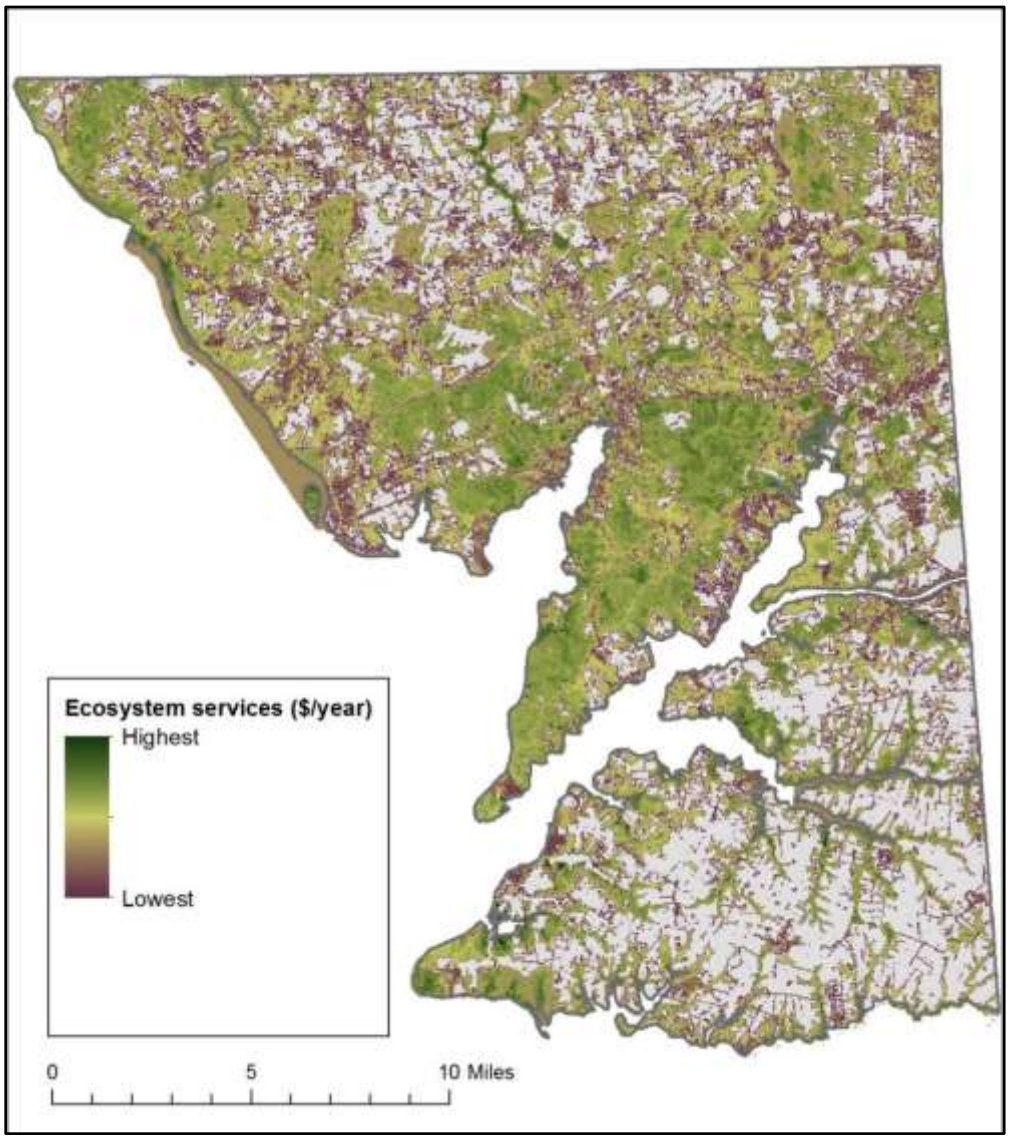
Below are a few action items from the Hazard Mitigation Plan that will help Cecil County plan for a safer future and also address nuisance flooding problems:

- Arrange training sessions with County and Town staff; and local insurance companies, on the National Flood Insurance Program.
- Provide letters and hold public meetings with the owners of structures in repetitive loss areas with high flood risk to discuss potential participation in flood mitigation projects, including acquisition and relocation.
- Work with SHA and local Public Works Departments to identify areas of frequent roadway flooding and develop appropriate mitigation strategies.

An inventory of roads, bridges, and sewer infrastructure that are vulnerable to flooding are provided in Appendix H.

Ecosystem Service Value

As shown in Table 1, natural areas provide benefits to people in many ways. The Maryland Department of Natural Resources quantified seven of these "ecosystem services" provided by forests and wetlands: carbon sequestration, nitrogen removal, stormwater mitigation and flood prevention, wildlife habitat and biodiversity, air pollutant removal, groundwater recharge, and surface water protection.[7] DNR mapped these values throughout the state (see Map 7). Within Cecil County, forests and wetlands provided an estimated $237 million/year. This was only a subset of services, and did not include the value of timber, recreation, or aesthetics, for example. It's important to note that although 47% of the land throughout the County is mapped within the GI Network, this natural system actually provides over 75% of the ecosystem service benefits for the County.



Map 7. Relative provision of ecosystem services in Cecil County.

[7] Campbell, E., R. Marks, and C. Conn. 2018. Accounting for Maryland's ecosystem services: integrating the value of nature into decision making. Maryland Dept. Nat. Res., Annapolis, MD. DNR 14-081518-92.

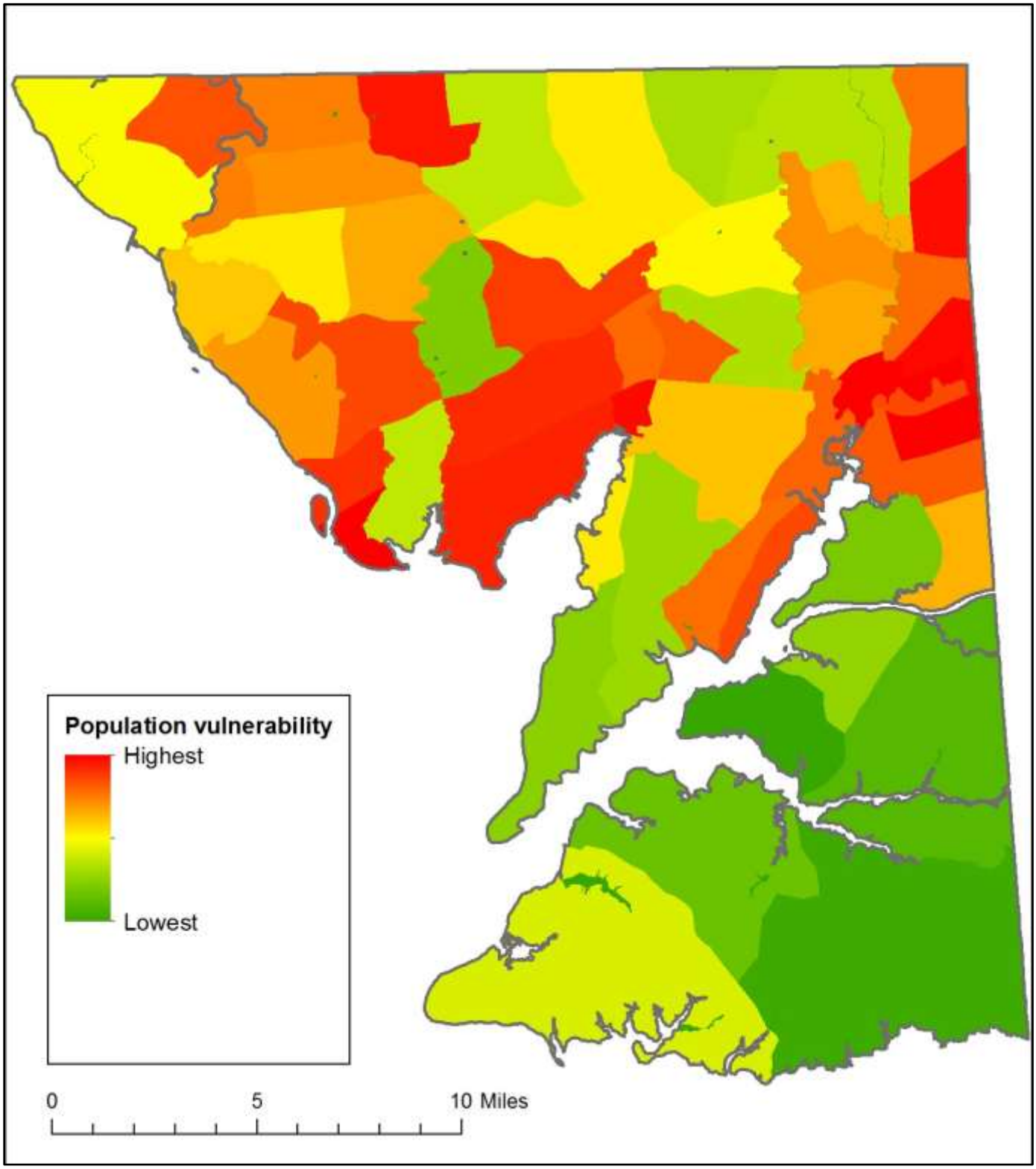
Population vulnerability

Population density and three metrics of social vulnerability (income, English proficiency, and age) were used to identify communities that might be more impacted by flooding and other natural hazards, and less equipped to prepare for, respond to, and/or recover from them. Equity concerns tend to be more common in urbanized coastal areas, but they also exist in rural riverine areas. The population vulnerability factors selected for this analysis were consistent with Maryland's Coastal Resiliency Assessment, and were derived from census block data (Table 11). The census block data includes overlap with the eight Towns, which account for approximately 30% of the County's population. The factors below were equally weighted before combining into an overall metric of population vulnerability (Map 8).

Per discussion at the Feb. 6, 2019 Steering Committee meeting, we removed population vulnerability as a factor in weighting natural resources protection and stormwater BMP placement, and set it aside as an independent variable to be considered in the planning process.

Factor	**Metric**	**Weight**
Population Density	# of people/mi^2	0.25
Household Income	% Population with income below poverty (12 mo.)	0.25
Ethnicity/Minority	% Population of non-proficient English speakers	0.25
Age	% Population <18 or >= 65 years of age	0.25

Table 11. Population vulnerability factors.



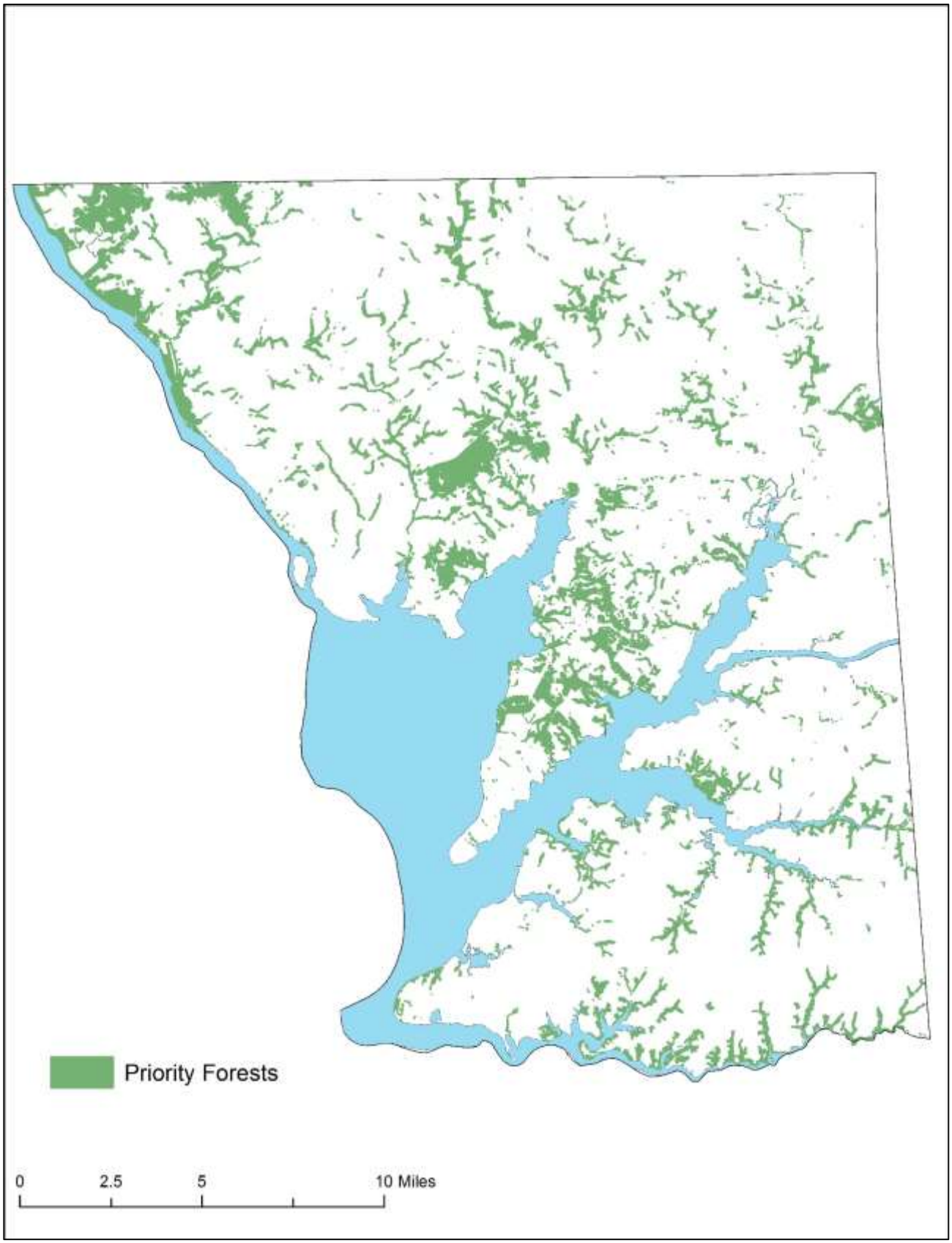
Map 8. Relative population vulnerability in Cecil County.

Priority Forests

Priority Forests are an essential component of Cecil County's GI network. Land use types which are designated as Priority Forests include floodplains, intermittent and perennial streams and their buffers, steep slopes over 25%, critical habitats for endangered species, and non-tidal wetlands. Forests which exhibit these land use types have been identified on Map 9 and will be prioritized for preservation using the natural resource protection and other mapping assessments provided as part of this plan. Priority Forests can be further identified through conducting a Forest Stand Delineation in which an inventory of forest characteristics are assessed and evaluated. Additional guidance found in the State and County forest conservation manuals include identifying forest patches at least 100 acres in size and forest corridors at least 300 feet wide, which is similar to the methodology used to delineate the GI network. High structural diversity in forest is also valued, although this is more difficult to map, and the concept is explored in further detail within the Mature Forest Estimation section found in Appendix F.

Appendix F also includes some of the findings of the recent forest assessments conducted throughout the region. Later successional forests tended to have fewer invasive plants than younger earlier successional, especially when over 150 feet from the edge. Core forest also had significantly fewer invasive plants than non-core forest. Forest bird richness was higher in undisturbed, mature broadleaf forest with streams and wetlands nearby. Areas with oaks dominant or co-dominant in the canopy were less likely to have more than 5% invasive plant coverage. Many sites had little native groundcover plants and it would be wise to implement deer control measures such as controlled hunting and fencing to benefit the forest understory. Since it was determined that tree canopy heights were not a strong indication of mature forest, it's recommended to digitize the forested areas shown on the 1930's aerial photos, to compare to current forests, and to conduct similar forest assessments in the future.

Providing financial incentives to land owners to implement Best Management Practices for Timber Harvests and other operations which may cause disturbance, is a potential implementation strategy Cecil County could implement to protect Priority Forests. This could be accomplished through Deed Restrictions held with Cecil County on sites designated as Priority Forests. Deed Restrictions would outline specific criteria, such as where to limit disturbance and employ Best Management Practices based on the Priority Area(s) within the site.



Map 9. Priority Forests in Cecil County

Natural Floodplain Functions

Floodplains are an important community asset. The rise and fall of flowing water, combined with the connections to upland and aquatic resources, is what makes riparian ecosystems so special. Moisture in the soil leads to a greater diversity of plant species. But floodplains don't only provide for wildlife conservation areas, they are also commonly found in parks and other open spaces, where passive trails tend to make our neighborhoods more appealing to citizens, potential employers, and visitors. Some of the best outdoor community amenities are those preserved and developed according to their original functions and because of their scenic value, can become sources of neighborhood pride.

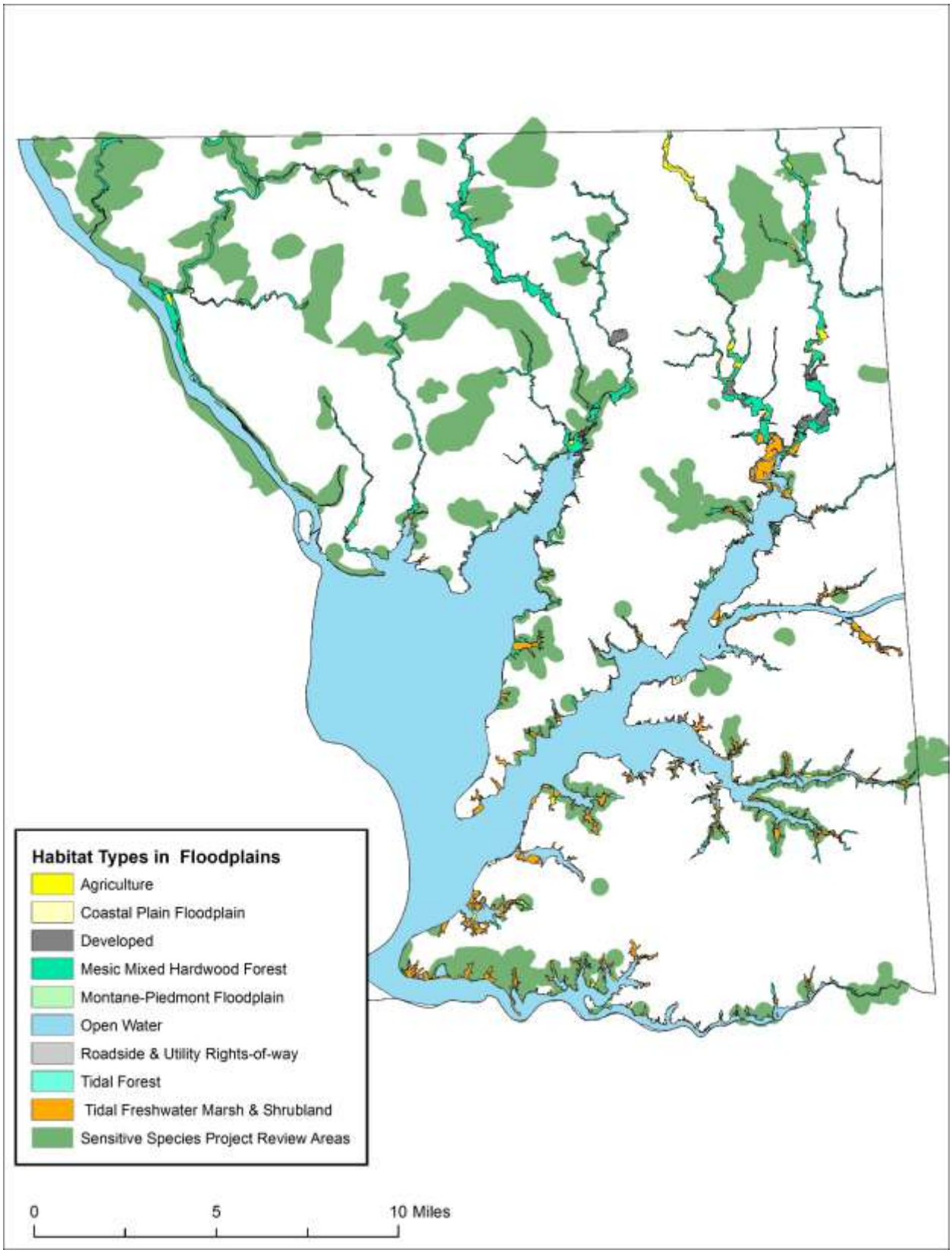
Some of our more important natural areas, including coastal wetlands, non-tidal wetlands, intermittent, and perennial streams are worth adapting to, rather than trying to control, since lower cost investments made by preserving Green Infrastructure can help to offset expensive capital improvements for pollution control in the future. For example, groundwater supply quality is greatly improved when healthy vegetation is found within intact, connected stream and wetland systems. Floodplains provide many benefits, including storage and conveyance of flood waters, recharging of groundwater, maintenance of surface water quality, limiting erosion, and providing for fish and wildlife habitat. Many different government agencies and community partners with different goals can find common ground in floodplains, and it's important to tap this energy to plan and collaborate together.

There are a number of plant and animal species that are only found within floodplains and throughout various part of their life cycles. For example, coastal wetlands and marshes are ecologically significant as habitat for aquatic organisms, including fish, shellfish, waterfowl, and other wildlife. The Susquehanna River flats includes the largest stand of submerged aquatic vegetation in the State of Maryland. This area is an integral component of the tidal bass fishery in the upper Chesapeake Bay, including the North East, Elk, and Sassafras Rivers, and is a major regional economic engine that draws in roughly $10 million in annual expenditures by anglers. Table 12 below gives an indication of the different habitats found within floodplains countywide.

% Floodplain	**Acres**	**Habitat Types**
7.3	875.9	Agriculture
0.7	79.8	Coastal Plain Floodplain
12.4	1482.5	Developed
50.5	6017.6	Mesic Mixed Hardwood Forest
0.9	103.8	Montane-Piedmont Floodplain
0.3	34.5	Roadside & Utility Rights-of-Way
3.5	415.6	Tidal Forest
24.4	2913.5	Tidal Freshwater Marsh & Shrubland
	2438.2	

Table 12. Percentage of floodplain by different habitat types, excluding open water & including Town floodplains.

These habitat types correspond with the wildlife species identified as those with the Greatest Conservation Need in the 2015 Maryland State Wildlife Action Plan. The lists of species that could be found within Cecil County floodplain habitats are provided in Appendix I. A list of rare, threatened, and endangered species found within Cecil County and prepared by Maryland's Department of Natural Resources, Wildlife and Heritage Service, is provided in Appendix J.



Map 10. Habitat Types in Floodplains and Sensitive Species Project Review Areas in Cecil County.

Wildlife Surveys and Management Recommendations

The research team from Susquehannock Wildlife Society (SWS) visited each of the two hub / corridor sites multiple times during the project period to document wildlife diversity and assess the quality of the habitat. The two sites were chosen both geographically, to cover different regions of the county, and based on their connectivity through green corridors.

The SWS team of biologists, naturalists, researchers and volunteers chose trails through each site that crossed through as many habitat types as possible while taking into account which would have the highest yield of wildlife sightings. They recorded the general status of the forest, plant diversity, presence of invasives and quality of the understory. They mapped out what types of habitats were available for wildlife at each site with a focus on those that would support species like amphibians that are more sensitive to poor quality habitat.

Seasonal wetlands (vernal pools) were sought out during the spring surveys to capture the brief breeding season of frogs, toads and salamanders which included listening for calls, lifting debris, searching for egg masses and visual encounters around wetlands. Other wildlife species recorded during surveys were mammals (including tracks and scat), birds, reptiles, and larger / significant insects. Fish, mollusks, and crustaceans were not specifically targeted due to existing extensive stream surveys previously performed by others. High resolution trail cameras with nighttime infrared illumination were placed at each site for a period of at least two weeks to record the diversity and density of species that might be nocturnal, weary of humans, or just not encountered during the on-site visits. Camera locations were selected based on animal signs, trails, or just significant natural features of the site such as habitat transition zones. Upon the conclusion of the site surveys SWS consolidated its findings to focus on the status of each site's wildlife diversity, habitat quality, and recommendations for how to improve each site to better benefit wildlife.

Site Descriptions and Findings:

Elk River Park - This actively used county park in the coastal plain has a wide variety of habitat types that transition from an open waterfront park, mixed hardwood forest, natural and man-made wetlands, and the freshwater tidal coastline of the Elk River. This site is part of a network of protected lands within the Elk Neck peninsula.

While there is a higher amount of human activity, significant deer graze along some of the understory and invasive plant species at this site, the habitat diversity that includes tidal marsh, several man made wetlands and transition areas is able to support a wide variety of species including some sensitive species. This site is also an important stop over for migrating birds and can support more diversity than most locations due to its location in the flight path and the different habitat types all found within close proximity. The site would benefit from a portion of the mowed grass areas being converted into a native meadow or native forest so that part of the unused open space can benefit wildlife and stormwater while not disrupting the use as a park. Early results from the avian surveys found three forest interior dwelling bird species (FIDS).

Elk Mills Road Site - This infrequently accessed green space has a small parcel of mixed forest, spring seep wetlands and a creek surrounded by and bisected by agricultural lands. While some of the species diversity is reduced due to the sedimentation of the stream and agricultural influence, there are some valuable spring seeps and forest habitat that may benefit a variety of species. The forest is alternates from pine to deciduous with

enough to provide some habitat but some invasive species are present throughout and deer graze is evident. Most importantly this site may be able to act as a corridor for species that may utilize the larger habitat to the north at Fair Hill Natural Resource Management Area.

Although this site is a narrow protected area between agriculture and residential areas, it is clear that wildlife moves through it as a corridor and the habitat diversity is beneficial. The forest to the north has some beech tree monoculture where there should be more native tree diversity. There are some spring seep wetlands that support sensitive amphibian breeding. Early results from the avian surveys found three forest interior dwelling bird species (FIDS) the south tract and 2 in the north tract. Early results from the plant surveys found some old beech and oak tree species in the north tract, as well as, some very old tupelo tree species.

Summary of Results and Recommendations:

The overall observation of the effectiveness of these two county-owned parks as hub and corridor sites was positive. Wildlife is certainly concentrated in these places to varying degrees depending on type and quality of habitat but each did allow for species that require connectivity between sites to exist in some capacity. The biggest consistent threat to the future health of all sites were invasive plants outcompeting native plants, overgrazing by white-tailed deer, and sedimentation of wetlands or waterways.

At Elk River Park, wildlife can be enhanced by adding and monitoring more nest boxes, installing fishing line disposal stations, planting native plants with wildlife value, removing or controlling invasive plants, and creating additional habitat areas such as meadow strips to replace unused grass areas.
At Elk Mills, wildlife can be enhanced by adding and monitoring nest boxes, removing invasive plants, restoring and preventing further erosion and sedimentation of the stream, and creating a strip meadow corridor with native flowers and grasses to connect the two forested areas across the agricultural area so wildlife can move safely between the habitat areas.

In conclusion, the hub and corridor concept as a model for a land conservation tool is incredibly effective and provides not only habitat for wildlife but allows it to move between sites, creating the necessary ingredients to ensure populations remain resilient. Some species, especially mammals with larger home ranges and birds with migratory habits will follow these green corridors from one site to another, as shown but the types and density we found of many species. Others may just use these corridors for incremental range expansion and genetic dispersal over time which is incredibly valuable to the long term survival of many species. The quality of these sites was shown by the diversity of species from a decent range within the expected local ecosystem including more sensitive amphibians. All of the sites to some degree included a mix of habitat types that not only serve a variety of species but the complex life cycle of species that, for instance may require seasonal wetlands to lay eggs and develop their young. It is our opinion that these sites are important wildlife hotspots in Cecil County and with some focused management and enhancements along with further protection of interconnecting lands, we can maintain a rich and healthy home for both wildlife and our residents alike.

Appendix G contains a full list of species found at the sites, as well as, notes on site conditions.

Implementation Strategies

Various action items to protect, restore, and manage County green infrastructure are listed below, and are organized under five different themes. County staff worked with the steering committee, public and community partners, to identify and consider which agencies could support which action items, and whether that support would be through discussion, funding, or both. A list of acronyms for partners and funding sources is provided before the action item tables.

Government Agencies & Community Partners

Abbreviation	Name
ACB	Alliance for the Chesapeake Bay
AWI	Artesian Water Inc.
BGE	Baltimore Gas & Electric Company
CFDCB	Cecil County Forest District Conservancy Board
Choptank	Choptank Electric Cooperative Inc.
CLT	Cecil Land Trust
Colonial	Colonial Pipeline
CWA	Chester Water Authority
Delmarva	Delmarva Power
DES	Cecil County Department of Emergency Services
DNR CAC	Maryland Department of Natural Resources Critical Area Commission
DNR CCS	Maryland Department of Natural Resources Chesapeake & Coastal Service
DNR F	Maryland Department of Natural Resources Fisheries
DNR FS	Maryland Department of Natural Resources Forest Service
DNR WHS	Maryland Department of Natural Resources Wildlife & Heritage Service
DPR	Cecil County Department of Parks and Recreation
DPW	Cecil County Department of Public Works
ECG	East Coast Greenway
ESCAP	Eastern Shore Climate Adaptation Partnership
ESLC	Eastern Shore Land Conservancy
ESNG	Eastern Shore Natural Gas Pipeline
Exelon	Exelon Corporation
FEMA	Federal Emergency Management Agency
LSHG	Lower Susquehanna Heritage Greenway
MD PS	Maryland Park Service
MDE	Maryland Department of the Environment
MDOT	Maryland Department of Transportation
NRCS	U.S. Department of Agriculture Natural Resource Conservation Service
PIO	Cecil County Public Information Officer
SCD	Cecil County Soil Conservation District
SHA	Maryland State Highway Administration
SR	Shore Rivers
Town DPZ/DPW	Town Department of Planning & Zoning or Public Works Staff
UMSE	University of Maryland Extension Sea Grant

USACOE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
WNA	West Nottingham Academy
WSA	Cecil County Watershed Stewards Academy

Funding Sources

Abbreviation	**Name**
CBT G3	Chesapeake Bay Trust Green Streets, Green Jobs, Green Towns Grant Program
CBT WAGP	Chesapeake Bay Trust Watershed Assistance Grant Program
County/Town CIP	Cecil County or Town Capital Improvement Program
CREP	USDA Farm Service Agency Conservation Reserve Enhancement Program
DNR CR	Maryland Department of Natural Resources Community Resilience Grant Program
FMA	FEMA Flood Mitigation Assistance Grant Program
HMGP	FEMA Hazard Mitigation Assistance Grant Program
NFWF	National Fish and Wildlife Foundation Chesapeake Bay Stewardship Fund
PDM	FEMA Pre-Disaster Mitigation Grant Program
Staff Time	Personnel Hours required to develop program
VLT	Cecil County Video Lottery Terminal Grant Program

Land Use Policies

The County is considering the adoption of new policies to protect the GI network in priority areas, including land within designated preservation and growth areas.

Action Items	**Lead Agency**	**Partners & Support**	**Funding options**	**Timeline**
Protect core areas and priority forests within the GI network with forest clearing limitations and higher mitigation ratios.	DLUDS	DNR FS, DNR WHS, ACB	staff time	1-3 years
Protect intermittent streams with variable width buffers, which can yield benefits for the entire hydrology system and GI network.	DLUDS	DPW, MDE	staff time	0-1 years
Expand the lateral extent of the regulatory flood zone boundaries to include the 0.2-percent chance or 500-year floodplain and determine the base flood elevations.	DLUDS	FEMA, MDE	PDM, HMGP	1-3 years
Limit the amount of allowable impervious surfaces on land within cold-water fishery watersheds.	DLUDS	DPW, MDE, DNR WHS, DNR F	staff time	1-3 years

Create a policy for development on County owned land within the GI network to limit forest clearing, provide mitigation, and limit impervious surface amounts.	DLUDS	DPW, SCD, ACB, DNR CCS, DNR CAC	County CIP	0-1 year
When the GI network is developed within designated growth areas, ensure adequate habitat protection areas and wildlife corridors are maintained on-site, in order for natural ecosystem processes to function normally in adjacent rural areas.	DLUDS	DPW, SCD, DNR WHS, USFWS	staff time	1-3 years
Develop watershed master plans as a framework to offset new development and create incentives to implement targeted and strategic stormwater management solutions that benefit the entire watershed.	DLUDS	DPW, SCD	County CIP, CBT WAGP	1-3 years

Planning and Program Development

The County wants to explore the creation of local funding sources to offer new programs that preserve and restore priority areas within the GI network. Collaboration with community partners, including identification of outside funding sources, will be critical to increasing strategic protection programs and initiatives. Staff time will also be necessary for long term planning, coordination, and implementation.

Action Items	**Lead Agency**	**Partners & Support**	**Funding options**	**Timeline**
Consider establishing a County run native plant nursery, collect seedlings from partner utility company right of way areas, and use native plants to both beautify and create lower maintenance landscapes for utilities and County owned lands.	DLUDS	DPR, DPW, Town DPW, Exelon, Delmarva, ESNG, Colonial, BGE, Choptank	staff time	1-3 years
Improve management of habitat protection areas within utility corridors and on County owned land.	DLUDS	DPR, DPW, Town DPW, DNR WHS, Exelon, Delmarva, ESNG, Colonial, BGE, Choptank	County/Town CIP, CBT WAGP, DNR CR	1-3 years
Identify the transmission lines and incentivize the location of renewable energy projects towards mining reclamation areas, parking lots, and	DLUDS	DNR CCS	staff time	0-1 year

warehouse rooftops, and away from the GI network and prime agricultural lands.				
Collaborate on watershed management strategies across political boundaries and with community partners to help increase grant funding opportunities.	DPW	DLUDS, Town DPZ/DPW, WNA, UMSE	County CIP, CBT WAGP	1-3 years
Make data more accessible for effective response, recovery, and flood risk communication, including to help identify additional mitigation opportunities.	DES	DLUDS, FEMA	PDM, DNR CR	0-1 year
Develop a local cost share program or other mechanism to fund the preservation of priority forests in and around the GI network.	DLUDS	DNR FS, SCD, ACB, UMSE	County CIP	0-1 year
Set a goal to establish 70% of streams with riparian forest buffers using a combination of incentives and regulations, building on past programs like DNR's Stream Releaf or Healthy Forests/Healthy Waters.	DLUDS	DPW, SCD, ACB, DNR FS	County CIP, DNR CR, CREP, CBT WAGP	1-3 years
Establish forest conservation and restoration as a primary tool for stormwater management and maintain forest cover in floodplains.	DLUDS	DPW, MDE, DNR FS, UMSE, ACB	staff time	0-1 year
Consider incorporating the GI network as a new land use designation in the next update of the Comprehensive Plan.	DLUDS		staff time	1-3 years
Ensure long term drinking water supplies by preserving and restoring priority forests in places like the Big Elk and North East Creek watersheds.	DLUDS	DPW, Town DPW, AWI, CWA, ESLC, CLT	County/Town CIP, CBT WAGP, DNR CR	1-3 years
Focus invasive species control efforts where they will have a high degree of success and ecological uplift.	DLUDS	DPW, DPR, ACB, DNR FS, DNR WHS	staff time	1-3 years
Provide development incentives for minimizing impacts to the natural hydrology system.	DLUDS	DPW	staff time	1-3 years
Implement Conservation Innovation Grants to explore new approaches for agricultural and forestry best management practices.	SCD	DLUDS, NRCS	CIG, CREP	1-3 years

Land Preservation

The GI Plan Steering Committee wants to preserve land and water resources that provide hazard mitigation and wildlife habitat protection, including floodplains, wetlands, forests, streams, and steep slopes.

Action Items	Lead Agency	Partners & Support	Funding options	Timeline
Provide public access to coastal areas, which can increase public interest and support for living shoreline programs.	DPR	DLUDS, FEMA	PDM, HMGP	1-3 years
Identify and acquire vacant lots in flood risk areas for habitat conservation and potential inclusion within public open space systems.	DLUDS	DPR, DES, FEMA, ESLC, CLT	PDM, HMGP, FMA	0-1 year
Identify opportunities to both preserve gaps in the GI network and create recreational greenways or trails, such as creating linkages with the Lower Susquehanna Heritage Greenway and connecting some of the Towns.	DLUDS	DPR, DPW, LSHG, ECG	CBT G3	1-3 years
Review Montgomery County, MD Legacy Open Space program as a model for improving local land preservation programs.	DLUDS	DPR	staff time	1-3 years
Increase funding and incentives for the Purchase of Development Rights (PDR) program, to strategically preserve more of the GI network, and collaborate with community partners to target high priority areas including wetlands, natural shorelines, and other open spaces.	DLUDS	DPW, Town DPZ/DPW, DNR WHS, DNR CCS, DNR CAC, FEMA, SR, ESLC, CLT	County CIP	0-1 year

Restoration

The GI Plan Steering Committee wants to re-create natural areas, relocate and protect structures and critical facilities where appropriate, and implement natural solutions to reduce vulnerability to flooding and associated soil and nutrient pollution using stormwater management best practices like rain gardens, rain barrels, conservation landscaping, and living shorelines. The design of future projects should also take into account increased rainfall intensity, duration, and frequency.

Action Items	Lead Agency	Partners & Support	Funding options	Timeline
Remove unnecessary dams in streams to improve migratory fish passage.	DLUDS	DPW, DNR WHS, DNR F	CBT WAGP, NFWF	1-3 years
Design ways for existing open space areas to better address flood hazards, such as holding water and collecting sediment and debris, using places like Meadow Park in Elkton as a demonstration project.	DLUDS	DPR, DPW, Town DPZ/DPW, FEMA	CBT G3, CBT WAGP, PDM, HMGP, FMA, DNR CR	1-3 years
Identify areas of flood concern in close proximity to capital improvements and prioritize mitigation solutions for high-risk assets, incorporating nature-	DLUDS	DES, DPW, Town DPZ/DPW, FEMA, ESLC	County/Town CIP, CBT G3, PDM, HMGP, FMA, DNR CR	1-3 years

based solutions to the maximum extent practicable.				
Create habitats for pollinators along County roads, utility corridors, and County parks, using Brantwood Park as a demonstration project for natural meadow maintenance.	DLUDS	DPR, SCD, NRCS, DPW, DNR WHS, UMSE	CBT WAGP, CBT G3, DNR CR, NFWF, VLT	0-1 year
Identify high priority stream restoration candidate sites.	DPW	DLUDS, CLT	CBT WAGP, DNR CR, NFWF	0-1 year
Partner with Exelon to determine best management practices for debris removal within local waterways.	DPW	DLUDS, MDE, Exelon,	CBT WAGP, VLT	1-3 years
Use the University of Maryland Extension Smart Tool to track various stormwater management practices throughout the County and partner with the Cecil County Watershed Stewards Academy to help with implementation.	DPW	DLUDS, WSA, UMSE	CBT WAGP	0-1 year
Identify opportunities to use dredge material for living shoreline projects and determine candidate sites for developing a local grant program potentially using some Critical Area Buffer fee-in-lieu funds.	DLUDS	DNR CAC, USACOE, MDE, UMSE	CBT WAGP, DNR CR	1-3 years

Education

The GI Plan Steering Committee wants to communicate the cost savings of using natural solutions for flood mitigation and continue to publicize efforts and solicit feedback on GI planning program modifications and improvements.

Action Items	**Lead Agency**	**Partners & Support**	**Funding options**	**Timeline**
Promote hunting on County owned land to help manage deer populations.	DPR	DLUDS, MD PS, USFWS	staff time	1-3 years
Develop and implement habitat management guidelines for use by foresters and land managers.	DLUDS	DNR WHS, DNR FS, ACB, SCD	staff time	1-3 years
Reduce impacts from road salt, herbicides, and other contaminants within the GI network, by working with the appropriate agencies at MDOT, SHA, County, and Towns.	DPW	DLUDS, Town DPW, MDOT, SHA	staff time	1-3 years
Inform and motivate the public to implement stormwater management practices and runoff	DPW	DLUDS, Town DPW, SCD, SR, UMSE	County CIP, DNR CR	0-1 year

retention, including rain barrels, rain gardens, and conservation landscaping with native plants.				
Measure cost savings of nature-based restoration projects to citizens via the GI plan webpage, press releases, and other communication tools, and showcase the North East Town Hall as a demonstration project.	DLUDS	DPW, PIO, SCD, Town DPZ/DPW, UMSE	County/Town CIP, DNR CR	1-3 years
Target areas in and around the GI network to market available cost share programs.	DLUDS	DPW, SCD, NRCS, ACB, DNR FS, CFDCB	CREP, DNR CR	0-1 year
Develop flood risk communication and messages for different audiences, and consider creating a regional program for public information with other community partners and jurisdictions, including Towns and Counties.	DLUDS	DES, PIO, ESCAP, UMSE, FEMA, MDE	County CIP, DNR CR, PDM	1-3 years
Identify structures with flood risk and target outreach related to purchasing flood insurance and mitigating risk with design considerations for sill elevations, foundations, and utilities.	DLUDS	DES, FEMA, MDE	County CIP, DNR CR, PDM	1-3 years
Develop an online map viewer of the GI network and associated mapping assessments with the capability of tracking ongoing preservation and restoration activities.	DLUDS	DNR CCS	staff time	0-1 year
Encourage local plant nurseries to phase out the sale of non-native and invasive forest plants.	DLUDS	DNR WHS	staff time	1-3 years
Encourage the creation of citizen science groups to assess stream habitats and conditions.	DLUDS	DPW, DNR WHS, DNR F	NFWF	1-3 years

Plan Maintenance

Implementation and maintenance of the GI plan is critical to the success of this planning process. Once adopted, plan maintenance will adhere to a schedule of developing an annual progress report on the action items identified in the section on Implementation Strategies. Members of the GI plan steering committee will be invited to an annual meeting conducted by the Department of Land Use and Development Services to discuss collaborative efforts with community partners, monitor funding sources, and recommend any adjustments to lead and support agencies, funding sources, and timeframes for completion. Understanding local capacity will be a key part of the discussions and will revolve around new approaches getting projects into the ground, engaging different groups and new technical experts, and developing incentive programs.

The Department of Land Use and Development Services is responsible for preparing the annual progress report and will submit the document to the appropriate agencies for review and comment. The Department is also responsible for coordinating with other Departments and the Towns to integrate the appropriate Green

Infrastructure strategies into future updates of the Comprehensive Plan, Hazard Mitigation Plan, Stormwater Management Plan, Land Preservation, Parks, and Recreation Plan, and Strategic Plan. Finally, the plan must be updated every ten years and include any changes within the GI network, mapping assessments, and implementation strategies. This plan is anticipated for adoption in 2019, so the next plan update should occur in 2029.

Conclusion

This plan was developed over a one-year time frame and began with data collection, identifying focal species for the hubs and corridors analyses, and conducting the mapping assessments. The steering committee met throughout the planning process to provide input and refinements along the way. Two community meetings were held to acquire additional feedback from the public and to develop priorities for the action items. The action items include revising land use policies and existing programs to support the planning and implementation of the GI network, as well as, identifying partners to collaborate with on future land preservation, restoration, and educational activities. The implementation of the action items contained herein will go a long way towards ensuring the wise use of our resource lands when making future land use decisions.

APPENDIX A: Data dictionary

Category	Data set	Data set name	Type of data	Year of ground condition	Spatial accuracy
Biodiversity	BioNet - Biodiversity Conservation Network	BioNet	polygon shapefile	2011	1:24,000
Biodiversity	Ecologically Significant Areas	MDDNR_ESA_CecilCounty_2018	polygon shapefile	2018	
Biodiversity	Red salamander locations	RedSalamander_CecilCounty_MBSSrecords.xlsx	Excel spreadsheet	2014	
Biodiversity	Vernal pool locations	VernalPools_CecilCounty_MBSSrecords.xlsx	Excel spreadsheet	2016	
Biodiversity	Wetlands of special state concern (linear)	SWwsscL	line shapefile	1998	1:24,000
Biodiversity	Wetlands of special state concern (polygon)	SWwsscP	polygon shapefile	1998	1:24,000
Census	Census block groups	harfblkgrp2010_83f	polygon shapefile	2010	
Census	Census blocks	2010_Block	polygon shapefile	2010	
Census	Est. 2015 pop. by age group	ACS_15_5YR_B01001_POP_AGE_BG_ALL_AGE.xlsx	Excel spreadsheet	2015 (est.)	
Census	Language spoken	ACS_15_5YR_B16002_Language_Spoken.xlsx	Excel spreadsheet	2015 (est.)	
Census	Poverty status	ACS_15_5YR_B17021_POVERTY_STATUS.xlsx	Excel spreadsheet	2015 (est.)	
Critical infrastructure	Fire stations	MEMA_USNG_Critical_Infrastructure.mdb	Access database		
Critical infrastructure	Hospitals	MEMA_USNG_Critical_Infrastructure.mdb	Access database		
Critical infrastructure	Police stations	MEMA_USNG_Critical_Infrastructure.mdb	Access database		
Critical infrastructure	Schools	MEMA_USNG_Critical_Infrastructure.mdb	Access database		
Critical infrastructure	Utility Structures	Utilities Structures.shp	polygon shapefile	2008	
Critical infrastructure	Wastewater treatment plants	WWTP	point shapefile		
Ecosystem services	Air Pollution Removal	aq_kg_yr	raster (GRID)		30 m
Ecosystem services	Air Pollution Removal Economic Value	aq_d_yr	raster (GRID)		30 m
Ecosystem services	Carbon Sequestration	carb_seq_g_yr	raster (GRID)		30 m
Ecosystem services	Carbon Sequestration Economic Value	carb_seq_d_yr	raster (GRID)		30 m
Ecosystem services	Groundwater Recharge	gw_cm3_m2_yr	raster (GRID)		30 m
Ecosystem services	Groundwater Recharge Economic Value	gw_d_yr	raster (GRID)		30 m
Ecosystem services	Nitrogen Uptake	nutr_kg_m2_yr	raster (GRID)		30 m
Ecosystem services	Nitrogen Uptake Economic Value	nutr_d_yr	raster (GRID)		30 m
Ecosystem services	Stormwater Mitigation Economic Value	sw_d_yr	raster (GRID)		30 m
Ecosystem services	Stormwater Mitigation Potential Index	sw_index	raster (GRID)		30 m
Ecosystem services	Surface Water Protection Economic Value	wtr_prot_d_yr	raster (GRID)		30 m
Ecosystem services	Total Ecosystem Service Economic Value	sum_es_d_yr	raster (GRID)		30 m
Ecosystem services	Wildlife Habitat and Biodiversity Economic Value	wild_d_yr	raster (GRID)		30 m
Ecosystem services	Wildlife Habitat and Biodiversity Potential Index	wild_index	raster (GRID)		30 m
Fish blockages	Fish blockages	MD_fish_blockages	point shapefile		
Floodplains	Floodplains (0.2%)	500_YR_FLOODPLAIN	polygon shapefile		
Floodplains	Floodplains (1%)	Floodplain	polygon shapefile		
Hydrology	Hydrology polygons	Hydrology_Polygons	polygon shapefile		
Hydrology	Northeastern Aquatic Habitat Classification System	MD_flowlines_NAHCS.shp	line shapefile	2006	1:100,000
Hydrology	Streams, rivers, and ditches	Hydrology_Lines	line shapefile		
Land cover	Buildings	Buildings_2013	polygon shapefile	2013	
Land cover	Impervious surfaces	impervious2014	polygon shapefile	2014	

Category	Data set	Data set name	Type of data	Year of ground condition	Spatial accuracy
Land cover	Land cover	HARF_24025_USGS.tif	raster (TIFF)	2013-2014	1 m
Land cover	Parking lots	Parking_2013	polygon shapefile	2013	
Land cover	Vegetation	Vegetation_2013	polygon shapefile	2013	
Parcels	Parcels	24025_parcel	polygon shapefile	2014	
Protected land	Ag Districts and Easements	agpres2	polygon shapefile	2013?	
Protected land	Ag Districts and Easements	AgPreservation	polygon shapefile	2017?	
Protected land	Federal lands (includes military)	SWplfe	polygon shapefile	2014	
Protected land	Forest Conservation Easements	SWFCA	polygon shapefile	2013	
Protected land	Forest Legacy Easements	ForestLegacyEasement	polygon shapefile	2017?	
Protected land	Historic Easements	HistoricEasements	polygon shapefile	2009?	
Protected land	Lower Deer Creek Valley Rural Legacy Easement properties	DeerCreekValleyRuralLegacyEasements	polygon shapefile	2017?	
Protected land	Manor Rural Legacy Easements	manorlease	polygon shapefile	2010	
Protected land	Maryland Environmental Trust Easements	Maryland_Environmental_Trust_Easements	polygon shapefile	?	
Protected land	Parks and recreation areas	Parks	polygon shapefile	2009	
Protected land	Rural Legacy Easements	Rural_Legacy_Easements	polygon shapefile	?	
Roads & railroads	Bridges maintained by Cecil County	Bridges	point shapefile	2011	
Roads & railroads	Railroads	Railroads_2013	line shapefile	2013	
Roads & railroads	Roads	Roads_2013	polygon shapefile	2013	
Shorelines	Blue Infrastructure Baywide Rank Segments (Aquatic near-shore)	BI_2010_AQ	polygon shapefile	2010	1:24,000
Shorelines	Blue Infrastructure Baywide Rank Segments (Terrestrial near-shore)	BI_2010_LD	polygon shapefile	2010	1:24,000
Shorelines	Chesapeake Bay Critical Area	Chesapeake_Bay_Critical_Area	polygon shapefile		
Shorelines	Coastal Resiliency Assessment	CRP_Cecil.gdb	Geodatabase		250 m segments
Shorelines	Hurricane storm surge extents (SLOSH model)	GBW_HurricaneStormSurge_USACE	polygon shapefile		
Slope	Areas of >25% slope over 40,000 ft2	over25over40k	polygon shapefile		
Slope	Slope	MD_Cecil_slope_m	ImageServer link		5 ft
Soils	Hydric soils	HydricSoils	polygon shapefile		
Soils	Soil Classifications	Soil_Classifications	polygon shapefile		
Soils	SSURGO soils	soils_SSURGSDM_md025_2955787_01	Geodatabase		
State GI	State GI corridors	corridors2014clipped	polygon shapefile	2014	30 m
State GI	State GI hubs	hubs2014clipped	polygon shapefile	2014	30 m
State GI	Targeted Ecological Areas	Targeted_Ecological_Areas	polygon shapefile	2016	
Stormwater BMPs	Retrofit and stream restoration drainage areas	Retrofit_and_Stream_Restoration_Drainage_Areas	polygon shapefile	2015	
Stormwater BMPs	Stormwater BMP drainage areas		polygon shapefile	2015	
Stormwater BMPs	Stormwater BMP locations		point shapefile	2015	
Stream buffers	150 foot buffer around streams with a drainage area >400 acres	new150buffer_ActualBufferArea	polygon shapefile		
Trails	Trails	Trails_Area_2013	polygon shapefile	2013	
Utilities	Electric Utilities	Utilities Electric.shp	line shapefile	2008	
Water quality	BMP Drainage Areas	Drainage_Areas	polygon shapefile	2015	
Water quality	BMP locations	BMP	point shapefile	2015	

Category	Data set	Data set name	Type of data	Year of ground condition	Spatial accuracy
Water quality	MD Biological Stream Survey Sites	Maryland_Stream_Health__MD_Biological_Stream_Survey_Sites	point shapefile	1995-2016	
Water quality	Point Source Discharges	Maryland_Point_Source_Discharges	point shapefile	2015	
Water quality	Retrofit and Stream Restoration Drainage Areas	Retrofit_and_Stream_Restoration_Drainage_Areas	polygon shapefile	2015	
Water quality	SPARROW data	MD_SPARROW.gdb	Geodatabase	2015	
Water quality	State restoration priorities	TrustFund11_2014	point shapefile	2014	
Water quality	Stream reach condition	Maryland_Stream_Health__Stream_Reaches	line shapefile	1995-2009	
Water quality	Stream wader sites	Maryland_Stream_Health__Stream_Wader_Sites_volunteer_collected	point shapefile	2000-2012	
Water quality	Tier II stream reaches	Cecil_TierII_segments_2016	line shapefile	2003-2012	
Watersheds	3rd order watersheds	swshed12	polygon shapefile	1998	
Watersheds	Blue Infrastructure High Priority Watersheds	High_percentage_rank_area_BI	polygon shapefile	2010	
Wetlands	Wetlands	DNR wetlands	polygon shapefile	1988-1995	1:12,000

APPENDIX B: Focal species for core areas, hubs, and corridors

Native vertebrate species found in Cecil County, and associated habitat

(note: a separate spreadsheet is available with home range size, dispersal distance, separation distance for suitable habitat, separation distance for unsuitable habitat, dispersal barriers, dispersal conduits, watershed sensitivity, and other information.)

Species type	Scientific Name	Common Name	Landscape Specificity	Habitat (unless general)
Mammal	*Blarina brevicauda*	Northern short-tailed shrew	Specialist	Most abundant in hardwood forests with deep leaf-litter and abundant food; avoids areas with little cover and extremes of temperature and moisture.
Mammal	*Canis latrans*	Coyote	Generalist	Highly adaptable
Mammal	*Castor canadensis*	Beaver	Specialist	Forest along 2nd - 4th order streams, ponds, or lakes, with gradient <15% and valleys not too narrow
Mammal	*Cryptotis parva*	Least shrew	Intermediate	Generally occurs in open country with dense herbaceous vegetation. Also brushy areas, forest edges, and sometimes salt and freshwater marshes.
Mammal	*Didelphis virginiana*	Virginia opossum	Generalist	Highly adaptable
Mammal (bat)	*Eptesicus fuscus*	Big brown bat	Generalist	Various wooded and semi-open habitats, including cities. Much more abundant in deciduous forest than in coniferous forest. Summer roosts generally are in buildings; also hollow trees, rock crevices, tunnels, and cliff swallow nests; prefers sites that do not get hot. Typically roosts in twilight part of cave. Maternity colonies form in attics, barns and occasionally tree cavities.
Mammal	*Glaucomys volans*	Southern flying squirrel	Intermediate	Mature deciduous and mixed forest, particularly beech-maple, oak-hickory and poplar.
Mammal (bat)	*Lasiurus borealis*	Eastern red bat	Generalist	Wide range of forested and semi-forested areas
Mammal	*Lontra canadensis*	River otter	Specialist	Open water (e.g., perennial streams, ponds) with riparian forest
Mammal	*Lynx rufus*	Bobcat	Intermediate	Primarily large tracts of forest, including edges. Primarily terrestrial. When inactive, occupies rocky cleft, cave, hollow log, space under fallen tree, etc.; usually changes shelter daily. Young are born in a den in a hollow log, under a fallen tree, in a rock shelter, or similar site. Hess: Requires large area of habitat with relatively low levels of human activity.
Mammal	*Marmota monax*	Woodchuck	Generalist	Open habitats (meadows, pastures, old fields, orchards) that often border wooded areas, which may be used for hibernation
Mammal	*Mephitis mephitis*	Striped skunk	Generalist	Prefers semi-open country with woodland and meadows interspersed, brushy areas, bottomland woods. Frequently found in suburban areas.
Mammal	*Microtus pennsylvanicus*	Meadow vole	Generalist	Found in a wide variety of habitats from dry pastures and wooded swamps to marshes and orchards. Needs loose organic soils for tunneling.
Mammal	*Microtus pinetorum*	Woodland vole	Specialist	Upland wooded areas with a thick layer of loose soil and humus. Spends most of time underground in shallow burrow systems.
Mammal	*Mustela frenata*	Long-tailed weasel	Generalist	Found in a wide variety of habitats, usually near water
Mammal	*Myotis lucifugus*	Little brown bat	Generalist	Uses human-made structures for resting and maternity sites; also uses caves and hollow trees. Foraging habitat requirements are generalized; usually forages in woodlands near water. In winter, a relatively constant temperature of about 40 F and 80% relative humidity is required; uses caves, tunnels, abandoned mines, and similar sites. Maternity colonies commonly are in warm sites in buildings and other structures; also infrequently in hollow trees.
Mammal	*Neovison vison*	American mink	Intermediate	Wetlands and riparian areas
Mammal	*Odocoileus virginianus*	White-tailed deer	Generalist	Various habitats from forests to fields with adjacent cover.
Mammal	*Ondatra zibethicus*	Common muskrat	Intermediate	Marsh
Mammal	*Oryzomys palustris*	Marsh rice rat	Intermediate	Marsh

Species type	Scientific Name	Common Name	Landscape Specificity	Habitat (unless general)
Mammal	*Peromyscus leucopus*	White-footed mouse	Generalist	Old fields, marshes, and wet meadows.
Mammal	*Procyon lotor*	Raccoon	Generalist	Various habitats; usually in moist situations, often along streams and shorelines
Mammal	*Scalopus aquaticus*	Eastern mole	Generalist	Most commonly occurs in open areas with moist soils
Mammal	*Sciurus carolinensis*	Eastern gray squirrel	Generalist	Mature tree canopy
Mammal	*Sorex cinereus*	Masked shrew	Generalist	Occupies most terrestrial habitats excluding areas with very little or no vegetation. Thick leaf litter in damp forests may represent favored habitat, although appears adaptable to major successional disturbances.
Mammal	*Sylvilagus floridanus*	Eastern cottontail	Generalist	Very adaptable
Mammal	*Tamias striatus*	Eastern chipmunk	Intermediate	Prefers deciduous woodlands with ample cover. Also found in brushlands and hedgerows.
Mammal	*Urocyon cinereoargenteus*	Gray fox	Intermediate	Forest. Usually avoids open areas.
Mammal	*Vulpes vulpes*	Red fox	Generalist	Very adaptable
Mammal	*Zapus hudsonius*	Meadow jumping mouse	Intermediate	Moist lowland habitats; prefers relatively thick vegetation of open grassy and brushy areas of marshes, meadows, swamps, and streamsides.
Bird	*Accipiter cooperii*	Cooper's hawk	Intermediate	Robbins: Intermediate or mature forest. NatureServe: Primarily mature broadleaf interior forest. Generally inhabits deep woods, utilizing thick cover both for nesting and hunting.
Bird	*Agelaius phoeniceus*	Red-winged blackbird	Intermediate	Fresh-water and brackish marshes, bushes and small trees along watercourses, and upland cultivated fields. Usually nests near water, in cattails, rushes, sedges; occasionally in shrubs or trees.
Bird	*Aix sponsa*	Wood duck	Specialist	Robbins: Wetlands or riparian areas with old trees. NatureServe: Quiet inland waters near woodland, such as wooded swamps, flooded forest, ponds, marshes, and along streams. Nests in holes in large trees in forested wetlands, and in bird boxes, usually within 0.5 km of water and near forest canopy openings, sometimes 1 km or more from water. Elms and maples are important habitat components in most areas because they provide protein-rich samaras in spring and suitable nest cavities. Shallowly flooded habitat with good understory cover is important cover for broods.
Bird	*Ammodramus savannarum*	Grasshopper sparrow	Specialist	Robbins: Short fields. NatureServe: Grasslands of intermediate height and often with clumped vegetation interspersed with patches of bare ground. Other habitat requirements include moderately deep litter and sparse coverage of woody vegetation.
Bird	*Anas crecca*	Green-winged Teal		Does not normally breed in Cecil County
Bird	*Anas discors*	Blue-winged Teal		Does not normally breed in Cecil County
Bird	*Anas platyrhynchos*	Mallard duck	Generalist	Pretty much any place with open water
Bird	*Anas rubripes*	Black duck	Intermediate	Shallow margins of lakes, streams, bays, mud flats, and open waters. Nests in both dry and wet woodlands. Wide variety of wetland habitats in both freshwater and marine situations, in and around marshes, swamps, ponds, lakes, bays, estuaries, and tidal flats. Frazer et al. (1990) recommended maintaining large (30-50 ha) marshes containing dense emergent vegetation near a complex of diverse wetland types.
Bird	*Antrostomus carolinensis*	Chuck-will's-widow	Specialist	Robbins: Nesting occurs in well-drained portions of coniferous and mixed coniferous-deciduous woodlands with little underbrush. Eggs are laid on fallen leaves. Forages over fields and clearings.
Bird	*Archilochus colubris*	Ruby-throated hummingbird	Generalist	
Bird	*Ardea herodias*	Great Blue Heron	Specialist	Freshwater and brackish marshes, along lakes, rivers, bays, lagoons, ocean beaches, mangroves, fields, and meadows. Nests commonly high in trees in swamps and forested areas
Bird	*Baeolophus bicolor*	Tufted Titmouse	Generalist	
Bird	*Bombycilla cedrorum*	Cedar Waxwing	Generalist	
Bird	*Branta canadensis*	Canada goose	Generalist	
Bird	*Bubo virginianus*	Great horned owl	Intermediate	Robbins: Medium to large blocks of forest with large trees and nearby fields.
Bird	*Buteo jamaicensis*	Red-tailed hawk	Generalist	

Species type	Scientific Name	Common Name	Landscape Specificity	Habitat (unless general)
Bird	*Buteo lineatus*	Red-shouldered hawk	Specialist	Robbins: Mature forest, esp. along streams. NatureServe: Mature forest with a well-developed high canopy, variable amounts of understory vegetation, and near streams, swamps, or other water.
Bird	*Buteo platypterus*	Broad-winged hawk	Specialist	Hess: "Requires extensive forested uplands." NatureServe: Broadleaf and mixed forest with large trees. Robbins: Large blocks of mature deciduous forest containing streams or other sources of water.
Bird	*Butorides virescens*	Green heron	Intermediate	Swamps, mangroves, marshes, and margins of ponds, rivers, lakes, and lagoons. Eggs are laid in platform nest in tree, thicket, or bush over water or sometimes in dry woodlands or orchards
Bird	*Caprimulgus vociferus*	Whip-poor-will	Intermediate	Robbins: Mature upland deciduous woods with fields nearby. NatureServe: Forest and open woodland with well spaced trees and a low canopy.
Bird	*Cardinalis cardinalis*	Northern Cardinal	Generalist	
Bird	*Cathartes aura*	Turkey vulture	Generalist	
Bird	*Catharus fuscescens*	Veery	Specialist	Extensive moist forests with mature trees and a dense shrub layer. In the Piedmont, Veeries breed most abundantly in deep wet ravines (Robbins)
Bird	*Certhia americana*	Brown Creeper	Specialist	Preferred habitat includes forest, woodlands, forested floodplains and swamps. Nests usually behind loose slab of bark still attached to living or dead tree, average of 1.5-5 m above ground. A component of dead trees is essential for nesting, so brown creepers tend to be associated with older forests.
Bird	*Chaetura pelagica*	Chimney swift	Generalist	
Bird	*Charadrius vociferus*	Killdeer	Generalist	Habitat includes various open areas such as fields, meadows, lawns, pastures, mudflats, and shores of lakes, ponds, rivers, and seacoasts. Nests are on the ground ground in open dry or gravelly situations, sometimes in similar situations on roofs, driveways, etc.
Bird	*Chordeiles minor*	Common Nighthawk	Generalist	Nests in bare open areas and gravel rooftops
Bird	*Cistothorus palustris*	Marsh wren	Specialist	Robbins: marsh. NatureServe: Freshwater and brackish marshes in cattails, tule, bulrush, and reeds. Nesting success may be greatest in marshes with relatively dense vegetation and deep water.
Bird	*Coccyzus americanus*	Yellow-billed cuckoo	Generalist	Open woodland (especially where undergrowth is thick), parks, deciduous riparian woodland. Nests in deciduous woodlands, moist thickets, orchards, overgrown pastures.
Bird	*Coccyzus erythropthalmus*	Black-billed cuckoo	Intermediate	Forest edge and open woodland, both deciduous and coniferous, with dense deciduous thickets. Nests in groves of trees, forest edges, moist thickets, overgrown pastures; in deciduous or evergreen tree or shrub. Is a low or ground nesting species.
Bird	*Colaptes auratus*	Northern flicker	Generalist	
Bird	*Colinus virginianus*	Northern Bobwhite	Intermediate	Hess: "Needs abandoned fields, thickets, and woodland margins. Sensitive to development." Robbins: Forest-field or shrub-field edges. NatureServe: Heterogeneous, patchy landscapes comprised of moderate amounts of row crops and grasslands and abundant woody edges.
Bird	*Contopus virens*	Eastern wood-pewee	Generalist	
Bird	*Coragyps atratus*	Black Vulture	Generalist	Nearly ubiquitous except in heavily forested regions; more common in lowland than in highland habitats. In Maryland/Pennsylvania, nested in areas that were roadless, forested, and undeveloped.
Bird	*Corvus brachyrhynchos*	American crow	Generalist	
Bird	*Corvus ossifragus*	Fish crow	Generalist	
Bird	*Cyanocitta cristata*	Blue jay	Generalist	
Bird	*Dendroica cerulea*	Cerulean warbler	Specialist	Large tracts of mature, semi-open deciduous interior forest, particularly in floodplains or other mesic conditions. In MD, rarely nests in forest <250 ha; in TN, not found in forest <1600 ha. TN DNR: not found within 1/4 mile of clearcut.
Bird	*Dendroica discolor*	Prairie warbler	Intermediate	Scrub-shrub or early successional forest
Bird	*Dendroica dominica*	Yellow-throated warbler	Intermediate	Robbins: Riparian forest. NatureServe: Pine forest, sycamore-bald cypress swamp, riparian woodland, floodplain forest, live oak woodland. Nests in tall trees.
Bird	*Dendroica pinus*	Pine warbler	Specialist	Highest densities in pine forest at least 40 years old
Bird	*Dolichonyx oryzivorus*	Bobolink	Intermediate	Native and tame grasslands, haylands, lightly to moderately grazed pastures, no-till cropland, small-grain fields, old fields, wet meadows, and planted cover

Species type	Scientific Name	Common Name	Landscape Specificity	Habitat (unless general)
Bird	*Dryocopus pileatus*	Pileated Woodpecker	Intermediate	Hess: "Requires large area of mature forest and large snags for breeding." NatureServe: Deciduous or mixed forest with a tall closed canopy and a high basal area. Most often in areas of extensive forest or minimal isolation from extensive forest. Robbins: Mature deciduous forest and woodlands
Bird	*Dumetella carolinensis*	Gray Catbird	Generalist	
Bird	*Empidonax traillii*	Willow flycatcher	Intermediate	Moist old-field habitats with willows and other shrubs or small trees (Robbins)
Bird	*Empidonax virescens*	Acadian flycatcher	Specialist	Robbins: Interior, mature riparian forest. NatureServe: Moist deciduous forests, primarily mature, with a moderate understory, generally near a stream. Requires a high dense canopy and an open understory. Tends to be scarce or absent in small forest tracts, unless the tract is near a larger forested area. Floodplain forests must be >400-500 feet wide for nesting.
Bird	*Eremophila alpestris*	Horned lark	Generalist	Flat areas with areas of exposed soil (Robbins)
Bird	*Falco sparverius*	American kestrel	Generalist	
Bird	*Geothlypis trichas*	Common Yellowthroat	Intermediate	Marshes (especially cattail), thickets near water, bogs, brushy pastures, old fields, and, locally, undergrowth of humid forest.
Bird	*Haliaeetus leucocephalus*	Bald Eagle	Intermediate	Breeding habitat most commonly includes areas close to (within 4km) coastal areas, bays, rivers, lakes, or other bodies of water. Typically roosts in larger, more accessible trees. Robbins: Wooded tidal shorelines
Bird	*Helmitheros vermivorum*	Worm-eating warbler	Specialist	Robbins: Large (>150 ha) blocks of upland deciduous forest. B&T: mature forest. NatureServe: Well-drained upland deciduous forest with understory patches of mountain laurel or other shrubs, drier portions of stream swamps with an understory of mountain laurel, deciduous woods near streams; almost always associated with hillsides. Most abundant in mature woods but also may be in young and medium-aged stands.
Bird	*Hirundo rustica*	Barn swallow	Generalist	
Bird	*Hylocichla mustelina*	Wood thrush	Intermediate	Deciduous or mixed forests with a dense tree canopy and a fairly well-developed deciduous understory, especially where moist. Bottomlands and other rich hardwood forests are prime habitats. Also frequents pine forests with a deciduous understory and well-wooded residential areas. Thickets and early successional woodland generally not suitable. Vulnerable to edge predators and cowbirds. Nest survival positively correlated with forest area, interior forest area, and % forest within 2 km.
Bird	*Icteria virens*	Yellow-breasted chat	Specialist	Early successional shrub-scrub. “Although chats will tolerate moderate amounts of grass and other herbaceous plant cover, a considerable amount of dense woody vegetation in the shrub/sapling successional stage must be present. These conditions generally develop from clear-cutting within two years, but abandoned agricultural fields often take several years to reach a shrub/young tree dominated successional stage. With either situation, the shrubland habitat created persists no longer than five-ten years. Shrubland habitats typically have a good diversity of wildlife due to the mix of grasses, herbs, small trees, and shrubs. However, once the canopy closes and the growing space becomes dominated by trees, the habitat is no longer suitable for chats. In clear-cut situations, where all the trees are of equal age, this phase occurs when the canopy reaches approximately three meters in height.” (Esley)
Bird	*Icterus galbula*	Baltimore Oriole	Generalist	
Bird	*Icterus spurius*	Orchard Oriole	Generalist	
Bird	*Ixobrychus exilis*	Least bittern	Specialist	Unimpaired marsh at least 5 contiguous ha, with 30m upland buffer
Bird	*Lophodytes cucullatus*	Hooded merganser	Intermediate	Streams, lakes, swamps, marshes, and estuaries. Nests usually in tree cavities in forested regions near water, often near fast-flowing streams, also forest ponds and lakes, flooded forest, riverside swamps.
Bird	*Megaceryle alcyon*	Belted kingfisher	Intermediate	Along water with adjacent trees
Bird	*Megascops asio*	Eastern screech owl	Generalist	
Bird	*Melanerpes erythrocephalus*	Red-headed woodpecker	Intermediate	Open woodland, especially with beech or oak, open situations with scattered trees, parks, cultivated areas and gardens.
Bird	*Meleagris gallopavo*	Wild turkey	Intermediate	NatureServe: Mature forest with clearings or fields nearby. Robbins: forest

Species type	Scientific Name	Common Name	Landscape Specificity	Habitat (unless general)
Bird	*Melospiza georgiana*	Swamp sparrow	Intermediate	Robbins: Marshes, or wet meadows with scattered shrubs and small trees. NatureServe: Marshes, wet brushy fields, meadows, lakeshores, stream borders, swamps, pine barrens shrub-sedge bogs; also brackish marshes along mid-Atlantic coast. Nests in tussock of grass, sedge, or in low bush, commonly over water.
Bird	*Melospiza melodia*	Song Sparrow	Generalist	
Bird	*Mimus polyglottos*	Northern Mockingbird	Generalist	
Bird	*Mniotilta varia*	Black-and-white warbler	Intermediate	Robbins: Large blocks (>300 ha) of intermediate or mature forest. NatureServe: young, medium-aged and mature deciduous and mixed forests. Forest-interior, area sensitive species
Bird	*Molothrus ater*	Brown-headed Cowbird	Generalist	
Bird	*Myiarchus crinitus*	Great crested flycatcher	Generalist	Robbins: Mature deciduous forest (although adaptable). NatureServe: Deciduous (mainly), mixed, or pine woodland or somewhat open forest, parks, orchards, wooded residential areas, areas of scattered trees in cultivated regions, clearings and edges of wooded areas, and swamps. Prefers semi-open habitats and edges.
Bird	*Nycticorax nycticorax*	Black-crowned night heron	Intermediate	Marshes, swamps, wooded streams, shores of lakes, ponds, lagoons; salt water, brackish, and freshwater situations.
Bird	*Oporornis formosus*	Kentucky warbler	Specialist	Robbins: Large blocks of mature, diverse, deciduous forest with a heavy shrub layer. NatureServe: Rich, moist deciduous forest; bottomland hardwoods and woods near streams are ideal as long as they have a dense hardwood understory. Being a ground-nester, requires well-developed ground cover, and a thick understory is essential. Occurs in stands of various ages but is most common in medium-aged forests.
Bird	*Pandion haliaetus*	Osprey	Intermediate	Primarily along rivers, lakes, reservoirs, and seacoasts. Nests in dead snags, living trees, cliffs, utility poles, wooden platforms on poles, channel buoys, chimneys, windmills, etc.; usually near or above water.
Bird	*Parula americana*	Northern parula	Specialist	Bushman and Therres (1988): mature interior forest (>100 m from edge). Robbins: Large blocks of mature floodplain or moist forest. NatureServe: Primarily a riparian species associated with epiphytic growth. Found in open deciduous, coniferous, or mixed forest, woodland, floodplain and swamp forest. Prefers mature forest but also occurs in young deciduous woods. Favors woods with a very dense understory of saplings and shrubs near slow or non-flowing water; canopy may range from poorly developed to mainly closed.
Bird	*Passerculus sandwichensis*	Savannah sparrow	Intermediate	Habitat with short to intermediate vegetation height, intermediate vegetation density, and a well developed litter layer. These preferred habitats cover a wide range of vegetation types, including coastal salt marshes, sedge bogs, grassy meadows, and native prairie.
Bird	*Passerina caerulea*	Blue Grosbeak	Generalist	
Bird	*Passerina cyanea*	Indigo Bunting	Generalist	
Bird	*Petrochelidon pyrrhonota*	Cliff swallow	Generalist	
Bird	*Phalacrocorax auritus*	Double crested cormorant	Intermediate	Lakes, ponds, rivers, lagoons, swamps, coastal bays, marine islands, and seacoasts; usually within sight of land. Nests on the ground or in trees in freshwater situations, and on coastal cliffs.
Bird	*Picoides pubescens*	Downy woodpecker	Generalist	
Bird	*Picoides villosus*	Hairy woodpecker	Specialist	Large blocks of mature deciduous forest (>7 ha). Most abundant in mature woods with large old trees suitable for cavity nesting; also common in medium-aged forests; prefers woods with a dense canopy.
Bird	*Pipilo erythrophthalmus*	Eastern Towhee	Generalist	
Bird	*Piranga olivacea*	Scarlet tanager	Specialist	Robbins: Blocks at least 10ha of mature deciduous forest (preferably oak). NatureServe: Deciduous forest and mature deciduous woodland, including deciduous and mixed swamp and floodplain forests and rich moist upland forests; prefers oak trees. Most common in areas with a relatively closed canopy, a dense understory with a high diversity of shrubs, and scanty ground cover; able to breed in relatively small patches of forest. Breeds in various forest stages but most abundant in mature woods.
Bird	*Piranga rubra*	Summer tanager	Intermediate	Robbins: Dry open pine, oak, and pine-oak woods. NatureServe: Deciduous woods (often near gaps and edges).

Species type	Scientific Name	Common Name	Landscape Specificity	Habitat (unless general)
Bird	*Podilymbus podiceps*	Pied-billed grebe	Specialist	Ponds or streams with open water, some aquatic vegetation, and little wave action (Robbins)
Bird	*Poecile carolinensis*	Carolina Chickadee	Generalist	
Bird	*Polioptila caerulea*	Blue-gray gnatcatcher	Intermediate	Robbins: Most common in extensive forests with a high canopy. Common victim of cowbird parasitism. NatureServe: Deciduous forest, open woodland, second growth, scrub, brushy areas, often near water.
Bird	*Progne subis*	Purple martin	Generalist	
Bird	*Protonotaria citrea*	Prothonotary warbler	Specialist	Mature swamp or floodplain forest with standing water (Robbins), at least 300m wide (Mason et al, 2003). Bushman and Therres (1988) cite a minimum area of 100 ha, preferring interior forest (>100 m from edge). NatureServe: Mature deciduous floodplain, river, and swamp forests; wet lowland forest. Primary habitats are almost always near standing water; swamps that are somewhat open with scattered dead stumps are preferred. Bottomland forests and extensive willow thickets near lakes or ponds are also quite suitable. Requires dense underbrush along streambanks. Nests in cavity, in snag or living tree, often or always near or over water, at average height of 1.5-3 m.
Bird	*Quiscalus quiscula*	Common Grackle	Generalist	
Bird	*Rallus elegans*	King rail	Specialist	NatureServe: marsh. Largest minimum area required (60 ha) of marsh-dependent birds in PA GAP habitat models (Pennsylvania GAP Analysis Project, 2000).
Bird	*Rallus limicola*	Virginia rail	Intermediate	Freshwater and occasionally brackish marshes, mostly in cattails, reeds, and deep grasses, also in or close to other emergent vegetation. Inhabits shallow, freshwater, emergent wetlands of every size and type, from roadside ditches and borders of lakes and streams to large cattail marshes. Capable of using very small marshes (e.g., 5 nests have been found in a half-acre marsh). Interspersion of open water and vegetation is an important habitat component.
Bird	*Riparia riparia*	Bank swallow	Intermediate	Robbins: River valleys with sandy banks. NatureServe: Nests in steep sand, dirt, or gravel banks, in a burrow dug near the top of the bank, along the edge of inland water or along the coast, or in gravel pits, road embankments, etc.
Bird	*Sayornis phoebe*	Eastern phoebe	Generalist	
Bird	*Scolopax minor*	American woodcock	Generalist	Young forests and abandoned farmland mixed with forested land. Generally considered an edge species. Robbins: Early successional forest with bare ground; damp woodlands
Bird	*Seiurus aurocapilla*	Ovenbird	Specialist	Hess: "Prefers mature uplands with well-developed understory." Robbins: Large blocks of tall upland forest. B&T: mature forest. NatureServe: Typically nests in mid-late successional, closed-canopied deciduous or deciduous-coniferous forests that have deep leaf litter and limited understory.
Bird	*Seiurus motacilla*	Louisiana waterthrush	Specialist	Riparian deciduous forest along natural perennial streams at least 300m wide. Bushman and Therres (1988) cite a minimum area of 100 ha, preferring interior forest (>100 m from edge). NatureServe: Moist forest, woodland, and ravines along streams; mature deciduous and mixed floodplain and swamp forests. Prefers areas with moderate to sparse undergrowth near rapid-flowing water of hill and mountain streams. Nests on the ground along stream banks, hidden in the underbrush or among the roots of fallen trees, in crevices or raised sites in tree roots, or in rock walls of ravines over water.
Bird	*Setophaga petechia*	Yellow Warbler	Generalist	
Bird	*Setophaga ruticilla*	American redstart	Intermediate	NatureServe: most abundant in mature deciduous forest, but also may occur in young woods <15 years old; requires closed canopy and prefers dense midstory and understory and well-developed undergrowth. Robbins: Large blocks of deciduous forest with an extensive understory. B&T: mature forest.
Bird	*Sialia sialis*	Eastern Bluebird	Generalist	
Bird	*Sitta carolinensis*	White-breasted nuthatch	Intermediate	Robbins: Extensive tall deciduous forest. NatureServe: Most frequent in open woodlands of mature trees (primarily oak or pine). Also in clearings, forest edges, parks, and partly open situations with scattered trees.
Bird	*Spinus tristis*	American Goldfinch	Generalist	
Bird	*Spiza americana*	Dickcissel	Intermediate	Grassland, meadows, savanna, cultivated lands, brushy fields
Bird	*Spizella passerina*	Chipping Sparrow	Generalist	

Species type	Scientific Name	Common Name	Landscape Specificity	Habitat (unless general)
Bird	*Spizella pusilla*	Field sparrow	Intermediate	Old fields with some woody vegetation, or adjacent shrubs
Bird	*Stelgidopteryx serripennis*	Northern rough-winged swallow	Generalist	
Bird	*Strix varia*	Barred owl	Specialist	Hess: "Nests in mature, large trees; rarely forages far from bottomland." Rubino and Hess: "Barred owls occupy bottomland hardwood forests, which we identified using land cover, soils, and wetlands data. We eliminated from consideration bottomland forest habitat within 100 m of a road and within 60 m of open vegetative cover. Patches of the remaining bottomland forest larger than 86 ha in size were considered large enough to meet all barred owl habitat needs. Simple presence/absence surveys detected barred owls in approximately 65% of patches identified by our model as suitable habitat. Robbins: Mature deciduous forest, esp. along streams
Bird	*Sturnella magna*	Eastern meadowlark	Intermediate	Robbins: Fields or pastures that are undisturbed during breeding. NatureServe: Grasslands, savanna, open fields, pastures, cultivated lands, sometimes marshes. Nests on the ground in concealment.
Bird	*Tachycineta bicolor*	Tree swallow	Generalist	Robbins: Shorelines with nearby snags. NatureServe: Open situations near water, including streams, lakes, ponds, marshes and coastal regions; savanna, pastures, etc. Nests usually near water in a natural tree cavity or abandoned woodpecker hole, less frequently in open woodland away from water. Also nests in bird boxes or in a crevice in a building.
Bird	*Thryothorus ludovicianus*	Carolina Wren	Generalist	
Bird	*Toxostoma rufum*	Brown Thrasher	Generalist	
Bird	*Troglodytes aedon*	House Wren	Generalist	
Bird	*Turdus migratorius*	American Robin	Generalist	
Bird	*Tyrannus tyrannus*	Eastern kingbird	Generalist	
Bird	*Tyto alba*	Barn owl	Intermediate	Need large grassland habitats including herbaceous wetlands for foraging and nest in cavities (which also could occur in wetlands).
Bird	*Vermivora cyanoptera*	Blue-winged warbler	Specialist	Early successional shrubby areas, such as brushy hillsides, young forest (<7m, and preferably <3m), partly open situations with saplings, bogs, woodland edge and clearings, stream edges, overgrown pastures, swamps, shrubby powerline corridors.
Bird	*Vireo flavifrons*	Yellow-throated vireo	Specialist	Robbins: Floodplain forest. B&T: mature forest. NatureServe: Primarily open deciduous forest and woodland, riparian woodland, tall floodplain forest, lowland swamp forest, and less frequently, mixed forest. Most abundant in mature woods but also occurs in medium-aged forests and some pioneer stands; requires a high, partially open canopy and prefers woods with an intermediate tree density or basal area. Relatively low tolerance to forest fragmentation, though this may depend on forest quality and proximity to other forested areas.
Bird	*Vireo gilvus*	Warbling vireo	Generalist	
Bird	*Vireo griseus*	White-eyed vireo	Intermediate	Robbins: Scrub-shrub wetlands or riparian areas. NatureServe: Inhabits early-late successional, shrubby habitats such as deciduous scrub, old fields, abandoned pastures, regenerating clearcuts or other heavily logged areas, drainage and streamside thickets, forest edges, and reclaimed strip mines.
Bird	*Vireo olivaceus*	Red-eyed vireo	Specialist	B&T: mature forest. NatureServe: Most abundant in mature deciduous forest with sapling undergrowth. In much of the range, prefers shady oak forests with a high, well-developed closed canopy and a fairly open understory with scanty ground cover. Most common in forest tracts of at least 15-20 ha but may occur in patches as small as a few hectares. Prefers closed canopy but tolerates a wide range of canopy closures. In PA, more sensitive than other area-dependent birds to increased fragmentation via forest clear-cutting.
Bird	*Wilsonia citrina*	Hooded warbler	Specialist	Robbins: Extensive mature deciduous forest with dense shrub layers, often on floodplains. NatureServe: Nests in understory of deciduous forest, especially along streams and ravine edges, and thickets in riverine forests. Most abundant in mature forest. A dense shrub layer is important. Generally favors large tracts of uninterrupted forest, but sometimes nests in forest patches as small as 5 ha, probably where these are close to larger forested areas.
Bird	*Zenaida macroura*	Mourning dove	Generalist	

Species type	Scientific Name	Common Name	Landscape Specificity	Habitat (unless general)
Reptile (turtle)	*N/A*	Turtles	N/A	Data from Burke and Gibbons (1995) indicated that freshwater turtles require a 275 m upland buffer zone to protect 100% of the nest and hibernation sites. Insulating 90% of the sites required a 73 m buffer zone.
Reptile (turtle)	*Chelydra serpentina*	Snapping turtle	Intermediate	Fresh water. Nests in soft soil in open area, often hundreds of meters from water. Also nests in muskrat houses.
Reptile (turtle)	*Chrysemys picta*	Painted turtle	Intermediate	Slow-moving, shallow water with soft bottom, basking sites, and aquatic vegetation: streams, marshes, ponds, lakes, creeks. May colonize seasonally flooded areas near permanent water. Hibernates in water in bottom mud. Nests in soft soil in open area up to several hundred meters from water (1-621 m, average 90 m, in Quebec; 1-164 m, average 60 m, in Michigan).
Reptile (turtle)	*Clemmys guttata*	Spotted turtle	Specialist	Mostly unpolluted, small, shallow bodies of water such as small marshes, marshy pastures, bogs, fens, woodland streams, swamps, small ponds, and vernal pools; also occurs in brackish tidal streams. Ponds surrounded by relatively undisturbed meadow or undergrowth are most favorable. Favors waters with soft bottom and aquatic vegetation. Eggs laid in open areas up to hundreds of meters away.
Reptile (turtle)	*Glyptemys insculpta*	Wood turtle	Specialist	Perennial streams and riparian areas within 150-300m
Reptile (turtle)	*Graptemys geographica*	Map turtle	Specialist	Slow rivers and lakes with mud bottoms, basking logs, and abundant aquatic vegetation. Often in mill ponds, oxbows, and river overflow ponds.
Reptile (turtle)	*Glyptemys muhlenbergii*	Bog turtle	Specialist	Generally inhabit small, open canopy, herbaceous sedge meadows and fens, bordered by more thickly vegetated and wooded areas. Includes slow, shallow, muck-bottomed rivulets of sphagnum bogs, calcareous fens, marshy/sedge-tussock meadows, spring seeps, wet cow pastures, and shrub swamps; the habitat usually contains an abundance of sedges or mossy cover. The turtles depend on a mosaic of microhabitats for foraging, nesting, basking, hibernation, and shelter. Unfragmented riparian systems that are sufficiently dynamic to allow the natural creation of open habitat are needed to compensate for ecological succession. Beaver, deer, and cattle may be instrumental in maintaining the essential open-canopy wetlands.
Reptile (turtle)	*Kinosternon subrubrum*	Eastern mud turtle	Intermediate	Wetlands + adjacent (135m) upland
Reptile (turtle)	*Pseudemys rubriventris*	Red-bellied cooter	Intermediate	Relatively large deep bodies of water: creeks, rivers, marshes, ponds, lakes. Soft bottom and abundant aquatic vegetation preferred. Wanders on land, fall and spring. Eggs are laid in nests dug in soft soil in open areas usually within 100m of water. Often nests in tilled or disturbed soil.
Reptile (turtle)	*Sternotherus odoratus*	Eastern musk turtle/Stinkpot turtle	Intermediate	Inhabits virtually any permanent body of freshwater having a slow current and soft bottom. Eggs are laid up to about 50 m (average 7 m in Pennsylvania) from water in soil; under logs, stumps, and vegetable debris; and in walls of muskrat houses; sometimes on open ground.
Reptile (turtle)	*Terrapene carolina*	Eastern box turtle	Intermediate	Forests, fields with nearby cover, and wetlands. Eggs are laid in sandy or loamy soil in open areas. In Maryland, females extended home range from bottomlands to lay eggs in drier and warmer upland sites; moved several hundred meters from center of bottomland range.
Reptile (turtle)	*Trachemys scripta*	Red-eared slider	Intermediate	Usually in quiet water with abundant aquatic vegetation, soft bottom, and basking sites.
Reptile (snake)	*Agkistrodon contortrix*	Copperhead	Intermediate	Deciduous forest
Reptile (snake)	*Carphophis amoenus*	Eastern wormsnake	Generalist	Mesic, wooded or partially wooded areas (hardwood or pine), often along edges or ecotones
Reptile (snake)	*Coluber constrictor constrictor*	Northern black racer	Generalist	Wide range of habitats
Reptile (snake)	*Diadophis punctatus edwardsii*	Northern ring-necked snake	Intermediate	Prefers moist wooded areas, but also found in field edges or backyards
Reptile (snake)	*Elaphe obsoleta*	Black rat snake	Generalist	Habitats include hardwood forest and woodland, wooded canyons, swamps, rocky timbered upland, wooded areas of streams and rivers, farmland near woods, old fields, barnyards, and rural buildings in wooded areas. Often occurs where wooded and open habitats (such as fields or farmland) are intermixed.

Species type	Scientific Name	Common Name	Landscape Specificity	Habitat (unless general)
Reptile (snake)	*Heterodon platirhinos*	Eastern hog-nosed snake	Generalist	Openly wooded upland hills, forest edges, fields, woodland meadows, prairies, forest-grassland ecotones, sand plains, barrier islands, fire-managed pinelands, river valleys, riparian zones, and various other habitats with loose soils and amphibian prey.
Reptile (snake)	*Lampropeltis getula*	Eastern kingsnake	Generalist	Wide range of habitats
Reptile (snake)	*Lampropeltis triangulum*	Milksnake	Generalist	Wide range of habitats
Reptile (snake)	*Nerodia sipedon*	Northern water snake	Intermediate	Water, wetlands and riparian banks
Reptile (snake)	*Opheodrys aestivus*	Northern rough green snake	Intermediate	Dense vegetation (vines, shrubs, trees) near water; often at forest edges or in fairly open forests
Reptile (snake)	*Regina septemvittata*	Queen snake	Specialist	Occurs only where crayfish are present and fairly abundant, generally in moderate to fast-flowing streams with ample cover, wooded or open conditions, and good exposure to sun.
Reptile (snake)	*Storeria dekayi*	Dekay's brownsnake	Generalist	Wide range of habitats
Reptile (snake)	*Storeria dekayi dekayi*	Northern brownsnake	Generalist	Wide range of habitats
Reptile (snake)	*Storeria occipitomaculata*	Northern red-bellied snake	Generalist	Wide range of habitats
Reptile (snake)	*Thamnophis sauritus*	Eastern ribbon snake	Intermediate	Wet meadows, marshes, seasonally flooded prairies, bogs, ponds, lake shorelines, swamps, and shallow slow streams; also hardwood hammocks and other wet or moist forest in some areas; usually this snake is in or near vegetative cover (often shrubs or clumps of sedges or grasses) in sun-exposed sites along the edge of standing or flowing water; it climbs into low vegetation, rarely into tree canopy.
Reptile (snake)	*Thamnophis sirtalis*	Common gartersnake	Generalist	Wide range of habitats
Reptile (snake)	*Virginia valeriae*	Eastern smooth earthsnake	Generalist	Wide range of habitats
Reptile (lizard)	*Plestiodon fasciatus*	Five-lined skink	Intermediate	Forest
Reptile (lizard)	*Plestiodon laticeps*	Broad-headed skink	Intermediate	Wooded areas and woodland edges
Reptile (lizard)	*Sceloporus undulatus*	Eastern fence lizard	Generalist	In most areas these lizards are arboreal in wooded landscapes. They usually occur in open/sunny situations.
Amphibian (salamander)	*N/A*	Salamander spp.	N/A	Semlitsch and Jensen (2001) said that upland buffer zones 164m from a breeding wetland would encompass 95% of salamanders. The authors also recommended a 50m terrestrial buffer beyond this.
Amphibian (salamander)	*Ambystoma maculatum*	Spotted salamander	Specialist	vernal pools + adjacent hardwood or mixed forest (>200-250m)
Amphibian (salamander)	*Ambystoma opacum*	Marbled salamander	Intermediate	vernal pools + adjacent hardwood forest (>200-250m). More tolerant of dry habitats than are most salamanders; can be found on rocky bluffs and slopes and wooded sand dunes. Adults terrestrial; usually under surface objects or underground. Eggs laid in forest depressions such as vernal pool basins and sometimes at the edges of permanent ponds, swamps, and slow-moving streams; in areas likely to be flooded by fall rains.
Amphibian (salamander)	*Cryptobranchus alleganiensis*	Eastern Hellbender	Specialist	Rocky, clear creeks and rivers, usually where there are large shelter rocks. Usually avoids water warmer than 20 C. Males prepare nests and attend eggs beneath large flat rocks or submerged logs. Maintenance of unpolluted, free-flowing rivers with a rocky substrate is the primary management need. Buffer zones around streams should be maintained.
Amphibian (salamander)	*Desmognathus fuscus*	Dusky salamander	Intermediate	forested floodplains

Species type	Scientific Name	Common Name	Landscape Specificity	Habitat (unless general)
Amphibian (salamander)	*Eurycea bislineata*	Northern two-lined salamander	Intermediate	Rocky brooks, springs, seepages; may disperse into wooded terrestrial habitats in wet warm weather
Amphibian (salamander)	*Eurycea longicauda*	Long-tailed salamander	Specialist	Streamsides, spring runs, cave mouths, abandoned mines; also ponds in northern New Jersey. May disperse into wooded terrestrial habitats in wet weather.
Amphibian (salamander)	*Hemidactylium scutatum*	Four-toed salamander	Intermediate	forested or scrub-shrub wetlands
Amphibian (salamander)	*Notophthalmus viridescens*	Eastern newt	Intermediate	Ponds, swamps, and quiet stream pools with adjacent forest
Amphibian (salamander)	*Plethodon cinereus*	Eastern red-backed salamander	Specialist	Riparian forest
Amphibian (salamander)	*Plethodon glutinosus*	Slimy salamander	Intermediate	Wooded slopes, ravines, floodplains, shalebanks, and cave entrances; most often in hardwood forest, sometimes in pinelands.
Amphibian (salamander)	*Pseudotriton ruber*	Northern Red Salamander	Specialist	Cold, clear, rocky streams and springs in wooded or open areas. Adults occur in or near water in leaf litter and under rocks, and in crevices and burrows near water. Adults sometimes disperse into woods. Eggs are attached to underside of rocks in water. Larvae occur in still pools.
Amphibian (frog)	*Acris crepitans*	Northern cricket frog	Intermediate	marsh and pond edges
Amphibian (frog)	*Anaxyrus americanus*	American toad	Generalist	Wide variety of habitats
Amphibian (frog)	*Anaxyrus fowleri*	Fowler's toad	Generalist	Wooded areas, river valleys, and floodplains, including agricultural and residential areas, usually in areas with deep friable soils, up to at least several hundred meters from breeding sites.
Amphibian (frog)	*Hyla chrysoscelis*	Cope's gray treefrog	Intermediate	wetlands or other water + adjacent forest (few hundred meters)
Amphibian (frog)	*Hyla cinerea*	Green treefrog	Intermediate	Wetlands
Amphibian (frog)	*Hyla versicolor*	Gray treefrog	Intermediate	Forest with wetlands, vernal pools, or other standing water
Amphibian (frog)	*Pseudacris crucifer*	Spring peeper	Intermediate	Forest with wetlands, vernal pools, or other standing water
Amphibian (frog)	*Pseudacris kalmi*	New Jersey chorus frog	Intermediate	Various moist habitats, including grassy floodplains and wet woodlands containing shallow wetlands (ephemeral pools, ditches, wooded swamps, freshwater marshes) in which breeding occurs.
Amphibian (frog)	*Rana catesbeiana*	American bullfrog	Generalist	still, permanent water
Amphibian (frog)	*Rana clamitans*	Green frog	Generalist	permanent or temporary water
Amphibian (frog)	*Rana palustris*	Pickerel frog	Intermediate	Wetlands and riparian areas
Amphibian (frog)	*Rana sylvatica*	Wood frog	Specialist	Forest with wetlands, vernal pools, or other standing water
Amphibian (frog)	*Rana utricularia*	Southern leopard frog	Intermediate	Vicinity of virtually any freshwater habitat; also slightly brackish marshes. In summer disperses from water into moist vegetation.
Amphibian (frog)	*Scaphiopus holbrookii*	Eastern spadefoot toad	Generalist	Areas of sandy, gravelly, or soft, light soils in wooded or unwooded terrain. Burrows underground when inactive. Eggs and larvae develop in temporary pools formed by heavy rains.
Fish	*Alosa aestivalis*	Blueback herring	Intermediate	Spawning occurs in fresh or brackish water, in tidally influenced portions of coastal rivers. Larvae occur in or slightly downstream from spawning areas; juveniles may exhibit net upstream movement until emigration from freshwater in summer or fall (or, in some areas, the next spring).

Species type	Scientific Name	Common Name	Landscape Specificity	Habitat (unless general)
Fish	*Alosa pseudoharengus*	Alewife	Intermediate	Spawn in quiet portions of rivers or streams. Larvae occur in or slightly downstream from spawning areas; juveniles may exhibit net upstream movement until leaving nursery areas in summer or fall (or, in some areas, in spring of the next year).
Fish	*Alosa sapidissima*	American shad	Intermediate	dults occur in marine waters except during the breeding season. Larvae summer in rivers, enter sea by fall; return to fresh water when mature. Premigratory juveniles appear to be habitat generalists, whereas earlier life stages and spawning adults are more selective.
Fish	*Ambloplites rupestris*	Rock Bass	Intermediate	Pools and brushy margins in creeks and small to medium rivers
Fish	*Ameiurus catus*	White Catfish	Intermediate	Sluggish lower reaches of coastal streams, sloughs, warmwater lakes, reservoirs, farm ponds, and tidal freshwater estuaries
Fish	*Ameiurus natalis*	Yellow bullhead	Generalist	Shallow, soft-bottomed, weedy parts of clear warm lakes, ponds, reservoirs, or slow-moving streams or canals. It is more tolerant of pollution than are most other ictalurids.
Fish	*Ameiurus nebulosus*	Brown bullhead	Generalist	Ponds, lakes, sluggish creeks and small to large rivers, sloughs, backwaters, and reservoirs.
Fish	*Anchoa mitchilli*	Bay anchovy	Intermediate	Lower freshwater and estuarine reaches of coastal rivers, bays, sounds, and high salinity nearshore marine waters; usually it occurs in shallow waters, at depths of less than 20 meters.
Fish	*Anguilla rostrata*	American Eel	Generalist	
Fish	*Carpiodes cyprinus*	Quillback	Intermediate	Pools, backwaters, and main channels of clear to turbid waters of creeks, small to large rivers, and lakes. It spawns over sand and mud bottoms in quiet waters of streams or overflow areas in bends of rivers or bays of lakes.
Fish	*Campostoma anomalum*	Central Stoneroller	Intermediate	Headwater creeks and small to medium rivers with cool clear water, moderate or sometimes rapid current, and gravel or rubble bottoms; it commonly occurs in pools with current, riffles of small rocky streams; also in medium to large rivers, and sometimes in slow-moving, turbid water
Fish	*Catostomus commersonii*	White Sucker	Generalist	Wide variety of lake and stream habitats.
Fish	*Clinostomus funduloides*	Rosyside Dace	Intermediate	Small to medium streams with clear to turbid water and moderate current, and rocky flowing pools of headwaters, creeks, and small rivers; this fish is most common in small clear streams.
Fish	*Cottus caeruleomentum*	Blue Ridge Sculpin	Specialist	Rocky riffles of headwaters and creeks, and springs. Habitat on the coastal plain is limited to cold, spring-fed streams.
Fish	*Cyprinella analostana*	Satinfin Shiner	Specialist	Rocky and sandy runs (less often pools) of creeks and small to medium rivers, usually near riffles
Fish	*Cyprinella spiloptera*	Spotfin Shiner	Intermediate	Moderate to large streams and rivers of low to high turbidity, with bottom of sand, gravel, mud or rubble
Fish	*Erimyzon oblongus*	Creek Chubsucker	Intermediate	Small rivers and creeks of various types; seldom in impoundments
Fish	*Dorosoma cepedianum*	Gizzard shad	Intermediate	Medium to large rivers, reservoirs, lakes, swamps, bays, sloughs, and similar quiet open waters, from clear to very silty; this is an open water species; it often ascends creeks and small rivers that have well-developed pools; it commonly enters brackish water. Juveniles occur in quiet surface waters, adults in deeper water or near bottom. Spawning occurs in shallow water usually over sandy/rocky substrates; eggs are scattered, adhere to objects. This fish may ascend smaller streams or ditches to spawn.
Fish	*Enneacanthus gloriosus*	Bluespotted sunfish	Intermediate	Common over sand or mud in pools and backwaters of heavily vegetated sluggish creeks and medium-sized rivers, and similar situations in ponds, lakes, and small impoundments.
Fish	*Enneacanthus obesus*	Banded sunfish	Specialist	Occurs over sand or mud in sluggish, acidic, heavily vegetated waters, including ponds, pools and backwaters of creeks, small to large rivers, and boggy brooks
Fish	*Esox americanus*	Redfin pickerel	Intermediate	Small, quiet, heavily vegetated waters: pools and backwaters of streams, canals, ponds, and bays of small lakes; this fish more often occurs in streams than in lakes.
Fish	*Esox niger*	Chain pickerel	Intermediate	Vegetated lakes, swamps, and backwaters and quiet pools of creeks and small to medium rivers.
Fish	*Etheostoma olmstedi*	Tessellated Darter	Intermediate	Sand- and mud-bottomed pools, slow runs, and backwaters of headwaters, creeks, and small to large rivers.
Fish	*Exoglossum maxillingua*	Cutlip Minnow	Intermediate	Clear creeks and small to medium rivers with gravel, rubble, and boulder bottom relatively free of rooted plants; usually under or near boulders in quiet pools and runs

Species type	Scientific Name	Common Name	Landscape Specificity	Habitat (unless general)
Fish	*Fundulus diaphanus*	Banded Killifish	Intermediate	Habitat includes quiet waters of lakes, ponds, and sluggish streams, usually over sand, gravel, or detritus-covered bottom where there are patches of submerged aquatic plants.
Fish	*Fundulus heteroclitus*	Mummichog	Specialist	Salt marsh flats, estuaries, and tidal creeks, especially where there is abundant submergent and emergent vegetation.
Fish	*Gambusia holbrooki*	Eastern mosquitofish	Generalist	Often in shallow, often stagnant, ponds and shallow edges of lakes and streams where predatory fishes are largely absent and temperatures are high. It also can be found in brackish sloughs and coastal saltwater habitats.
Fish	*Hybognathus regius*	Eastern Silvery Minnow	Intermediate	Quiet weedy inshore waters of lakes, and pools and backwaters of low gradient creeks and small to large rivers
Fish	*Hypentelium nigricans*	Northern Hogsucker	Specialist	Rocky riffles, runs, and pools of clear creeks and small rivers; occasionally large rivers and impoundments
Fish	*Lampetra aepyptera*	Least brook lamprey	Specialist	Clean, clear gravel riffles and runs of creeks and small rivers; larvae burrow in bottom of quiet water.
Fish	*Leiostomus xanthurus*	Spot	Intermediate	Shallow coastal waters and estuaries, prefers mud or sand bottoms. Juveniles especially abundant in estuaries throughout year, return to more saline waters as they grow older. Adults tend to move offshore for winter. Reported to occur in freshwater as far as 23 miles upstream from brackish water.
Fish	*Lepomis auritus*	Redbreast Sunfish	Intermediate	Rocky and sandy pools and margins of creeks and small to medium rivers, including tidal freshwater areas; also rocky and vegetated lake margins.
Fish	*Lepomis cyanellus*	Green Sunfish	Intermediate	Sluggish warm streams, ponds, and shallow weedy margins of lakes. Usually in vicinity of weed beds. Tolerates both clear and turbid water.
Fish	*Lepomis gibbosus*	Pumpkinseed	Intermediate	Lakes, reservoirs, ponds, sloughs, and sluggish streams; prefers quiet, clear water with aquatic vegetation and some organic debris.
Fish	*Lepomis macrochirus*	Bluegill	Generalist	Warm shallow lakes, reservoirs, ponds, swamps, sloughs, and slow-flowing rivers and streams. Bluegill often are associated with rooted aquatic plants and with bottoms of silt, sand, or gravel.
Fish	*Luxilus cornutus*	Common Shiner	Intermediate	Creeks and small to medium rivers with clear cool weedless water, moderate to swift current, gravel to rubble bottom, and alternating pools and riffles (usually avoids riffles). Also lakes and reservoirs.
Fish	*Menidia beryllina*	Inland Silverside	Generalist	Coastal and freshwater habitats.
Fish	*Micropterus dolomieu*	Smallmouth Bass	Intermediate	Large clear lakes and clear midorder streams with many large pools, abundant cover (rocks, shelves, logs, etc.), and cool summer temperatures.
Fish	*Morone americana*	White Perch	Intermediate	Occurs predominately in brackish water and generally close to shore in saltwater. It is common in quiet water, usually over mud, far up medium to large rivers in fresh water.
Fish	*Morone saxatilis*	Striped Bass	Intermediate	Marine and estuarine coastal species that moves far upstream in channels of medium to large rivers during spawning migrations.
Fish	*Moxostoma macrolepidotum*	Shorthead Redhorse	Intermediate	Rocky pools, runs, and riffles of small to large rivers, natural lakes, and impoundments. Spawns usually over gravel in runs and riffles
Fish	*Nocomis micropogon*	River Chub	Specialist	Swift current and flowing pools of small to medium rivers with high to moderate gradient, usually clear warm water, and gravel to boulder bottoms.
Fish	*Notemigonus crysoleucas*	Golden Shiner	Intermediate	Usually occupies clean, quiet, vegetated water with access to extensive shallows. It is generally common to abundant in ponds and lakes, and often inhabits sluggish sections of streams and rivers. It spawns over beds of submerged vegetation
Fish	*Notropis hudsonius*	Spottail Shiner	Intermediate	Large sluggish coastal rivers and brackish water to small clear rapidly flowing montane streams.
Fish	*Notropis procne*	Swallowtail Shiner	Generalist	Warm, moderate to low gradient, clear to often turbid, creeks and small to large rivers; usually occupies pools and slow runs with sand, gravel, or rock bottom
Fish	*Notropis rubellus*	Rosyface Shiner	Specialist	Typically in clear, swift, large creeks and small rivers with bottoms of clean gravel or rubble; usually in or around riffles
Fish	*Noturus gyrinus*	Tadpole madtom	Intermediate	Typically in quiet or slow-moving waters, especially over soft muddy bottom with extensive vegetation; lakes, reservoirs, sloughs, swamps, backwaters, lowland creeks and small to large rivers. Usually in fairly clear water.

Species type	Scientific Name	Common Name	Landscape Specificity	Habitat (unless general)
Fish	*Noturus insignis*	Margined madtom	Specialist	Chiefly in clearwater streams of moderate current; usually about riffles of gravel and rubble. Also rocky riffles and runs of clear, fast creeks and small to medium rivers.
Fish	*Perca flavescens*	Yellow Perch	Intermediate	Usually in clear weedy backwaters or pools of creeks and small to large rivers, shallow waters of lakes, and large ponds. They occur and spawn in brackish water in some areas.
Fish	*Percina bimaculata*	Chesapeake Logperch	Intermediate	Common logperch: Small creeks to rivers, lakes, and reservoirs. Prefers clean riffles and runs over mixed sand and gravel.
Fish	*Percina caprodes*	Logperch	Intermediate	Small creeks to rivers, lakes, and reservoirs. Prefers clean riffles and runs over mixed sand and gravel.
Fish	*Percina peltata*	Shield Darter	Specialist	Moderate gradient riffles and runs of creeks and small to medium rivers. Most common over fine gravel on downstream side of rubble riffles. Sometimes aggregates in summer and fall in beds of aquatic plants. In same habitat all year. Eggs are buried in gravel.
Fish	*Petromyzon marinus*	Sea lamprey	Intermediate	Adults migrate from the ocean or lake to spawning streams
Fish	*Pimephales notatus*	Bluntnose Minnow	Generalist	Lakes, ponds, rivers, and creeks in a variety of habitats. Most common in clear rocky streams.
Fish	*Rhinichthys atratulus*	Eastern Blacknose Dace	Intermediate	Typically in cool, gravelly or rocky headwaters, creeks, and small rivers of high to moderate gradient; generally found in pools and slower runs. Often rests on bottom under or beside stones. Under banks in deepest water in winter. Spawns over gravel in fast water of shallow riffles.
Fish	*Rhinichthys cataractae*	Longnose Dace	Intermediate	Clean, swiftly flowing, gravel or bouldery creeks and small to medium rivers; also in inshore waters of lakes over gravel or boulder bottoms. May move offshore to deeper water in summer in warm lakes.
Fish	*Sander vitreus*	Walleye	Intermediate	Lakes; pools, backwaters, and runs of medium to large rivers; generally in moderately deep waters.
Fish	*Semotilus atromaculatus*	Creek Chub	Intermediate	Clear headwaters, creeks, and small rivers; prefers streams less than 12 m wide and with gravel-sand-silt substrate; occasionally in shallows of small clear lakes. Spawns in small gravelly streams in smooth water near a riffle, or over littoral areas of gravel in lakes.
Fish	*Semotilus corporalis*	Fallfish	Specialist	Clear, flowing, gravel- to rubble-bottomed small to medium rivers; lake margins. Young occur in more rapid water upstream but large adults seem to seek large pools and expanded regions of the lower reaches.
Fish	*Umbra pygmaea*	Eastern Mudminnow	Intermediate	Quiet, mud-bottomed, often heavily vegetated streams, sloughs, swamps, and ponds, particularly along margins, over sand, mud, and debris.

Sources:

NatureServe Explorer (http://explorer.natureserve.org/), unless otherwise indicated, as below.

Burke, V.J. and J. W. Gibbons. 1995. Terrestrial buffer zones and wetland conservation: a case study of freshwater turtles in a Carolina bay. Conservation Biology vol. 9 no. 6:1365-1369.

Bushman, E. S., and G. D. Therres. 1988. Habitat management guidelines for forest interior breeding birds of coastal Maryland. Wildlife Tech. Pub. 88-1, Maryland Dept. of Nat. Res., Annapolis, MD.

Crawford, J.A. and R.D. Semlitsch. 2007. Estimation of core terrestrial habitat for stream-breeding salamanders and delineation of riparian buffers for protection of biodiversity. Conservation Biology vol. 21 no. 1:152-158.

Esley, J. Yellow-breasted chat (Icteria virens) management/conservation profile. http://faculty.ncwc.edu/mbrooks/pif/Fact%20Sheets/Species%20Fact%20Sheets/Yellow-breasted%20Chat%20profile.pdf. Accessed 19 June 2009.

FEIS: Fire Sciences Laboratory (U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory). Fire Effects Information System, Online at http://www.fs.fed.us/database/feis.

Hess, G. 2000. Regional Planning for Wildlife in the Triangle. Online at http://www4.ncsu.edu/~grhess/research/regplan/. Accessed 5 Jan. 2008.

NEPARC: Northeast Partners in Amphibian and Reptile Conservation. Species Data Matrices: biological attributes that may contribute to vulnerability. Version 1.0.

Robbins, C. S. (ed.). 1996. Atlas of the breeding birds of Maryland and the District of Columbia. Univ of Pittsburgh Press.

Rubino, M. and G. Hess. 2003. Planning open spaces for wildlife. 2. Modeling and verifying focal species habitat. Landscape and Urban Planning 64: 89–104.

Southerland et al. 2005. New biological indicators to better assess the condition of Maryland streams. Publication # DNR-12-0305-0100, , Maryland Dept. of Nat. Res., Annapolis, MD.

Core area focal species

Core area type	Landscape feature	Focal species (may not overlap exactly) or criteria	Optimal habitat	Size	GIS delineation
aquatic	Nontidal streams	Pollution-sensitive fish and invertebrates	Stream reaches with "Good" combined (fish + benthic macroinvertebrate) IBI scores (>4), which can indicate good water quality and stream habitat.		Stream reaches with (a) "Good" combined (fish + benthic macroinvertebrate) MBSS IBI scores, or (b) MDE Tier II designation; plus associated 500 year floodplain
aquatic	Coldwater streams	Brown trout (non-native), coldwater benthic macroinvertebrates (Tallaperla spp. and Sweltsa spp.)	Cold water natural streams with good water quality		Stream reaches containing reproducing brown trout or coldwater benthic macroinvertebrates, plus associated 500 year floodplain
aquatic	Rivers with rare species	Yellow lampmussel	Larger streams and rivers with a moderate-to-fast stream flow, especially in riffles. Negatively affected by eutrophication and siltation.		Stronghold watersheds (Bohemia River)
aquatic	Chesapeake logperch locations	Chesapeake logperch	Found in Susquehanna River and some of the flats and tributaries		Chesapeake logperch locations
aquatic	Tidal streams and rivers	Anadromous fish, Mummichog, native submerged grasses	High Priority Blue Infrastructure		Stream reaches in High Priority Blue Infrastructure catchments, plus associated 500 year floodplain
aquatic	Offshore water	Striped bass, native submerged grasses	High Priority Blue Infrastructure		Open water in High Priority Blue Infrastructure catchments, plus associated shoreline
aquatic	Streams and rivers connected to ocean	Anadromous fish	Natural streams and rivers with stable hydrology and geomorphology, riffles and pools, minimal pollution, high D.O., low sedimentation, unimpounded, unchannelized, riparian forest on both banks, and connected to ocean.	<500 km from ocean, without dams or other barriers	Streams supporting anadromous fish, plus associated 500 year floodplain
forest	Mature broadleaf forest	Forest interior breeding birds	Presence of 100+ yr old trees, a variety of ages and sizes of trees, a mix of native species dominated by oak in the canopy (25% oak), presence of herbaceous and shrub layers in patches/variability, presence of standing dead trees/snags, downed logs and woody debris, thick leaf litter/organic matter in duff, and occasional canopy gaps due to tree fall.	>100 ha of interior forest (>100 m from edges), preferably >700 meters maximum depth, and preferably >80% forest cover within 2 km of centroid.	Forest blocks with >100 ha of interior forest (>100 m from edges)
forest	Mature broadleaf forest	Cooper's hawk, Red-shouldered hawk, Broad-winged hawk, Pileated Woodpecker, Worm-eating warbler, Wood thrush, Black-and-white warbler, Kentucky warbler, Hairy woodpecker, Scarlet tanager, Ovenbird, American redstart, Yellow-throated vireo, Red-eyed vireo	Mature broadleaf interior forest, preferably containing streams or other surface water, with large trees, a tall closed canopy, a mix of native hardwood species (including oaks), structural complexity (including some areas with thick subcanopies, some with thick shrub layers, and some with thick herbaceous layers), presence of snags, downed logs and woody debris, deep leaf litter, and occasional canopy gaps due to tree falls.	>100-300 ha (the larger, the better), with most >100m from edge. Blocks >4000 ha are optimal for all spp.	Forest blocks containing nests of these indicator birds
forest	Mature broadleaf forest	Cerulean warbler	Large tracts of mature, semi-open deciduous interior forest, particularly in floodplains or other mesic conditions.	>4000 ha, with most >400m from edge	Forest blocks containing Cerulean warbler nests

Core area type	Landscape feature	Focal species (may not overlap exactly) or criteria	Optimal habitat	Size	GIS delineation
forest	Riparian forest	Stream salamanders	Streams (perennial or intermittent) with good water quality and riparian hardwood forest.	At least 93m of forest on each side of stream (salamanders)	Riparian forest at least 93 m from stream reaches with (a) "Good" combined (fish + benthic macroinvertebrate) MBSS IBI scores, or (b) MDE Tier II designation (see aquatic cores)
forest	Riparian forest	Acadian flycatcher	Large tracts of mature riparian deciduous forest, with a high dense canopy and a relatively open understory.	>30-120 ha, and >150m wide	Riparian deciduous forest >30 ha, and >150m wide
forest	Riparian forest	Louisiana waterthrush	Riparian deciduous forest along natural perennial streams at least 300m wide.	>100 ha of interior forest (>100 m from edges)	Forest blocks containing Louisiana waterthrush nests
forest	Riparian forest	Hooded warbler	Large tracts of mature deciduous forest with a dense shrub layer, and containing streams.	>30-600 ha of forest, mostly interior (>100 m from edges)	Forest blocks containing Hooded warbler nests
forest	Riparian forest	Wood turtle	Riparian forest along natural perennial streams	2km of streams with 150-300m of natural buffer	Forest blocks containing Wood turtles
forest	Pine forest	Pine warbler	Pine forest at least 40 years old	>=30 ha	Forest blocks containing Pine warbler nests
forest	Young deciduous forest	Whip-poor-will	Young to mid-aged deciduous forest with fields nearby	>120-400 ha (pref. 64,000 ha)	Forest blocks containing Whip-poor-will nests
forest	Scrub-shrub	Blue-winged warbler, Prairie warbler	Scrub-shrub or early successional forest (preferably <3m tall)	10-15 ha	Forest blocks containing Blue-winged warbler or Prairie warbler nests
forest	Natural forest (in general)	Natural forest communities	Large enough and far enough from edges, roads, and trails to provide resistance against invasive plants.	>400m from forest edges or trails and >1 km from developed land.	Forest blocks with interior area(s) >400m from forest edges or trails and >1 km from developed land
wetland	Wetlands of special concern		Wetlands of special state concern	N/A	Wetlands of special state concern plus min. 100 ft buffer
wetland	Forested wetland	Northern parula, Prothonotary warbler, Barred owl	Large blocks of mature bottomland hardwood forest (floodplains or swamps) containing standing water, and usually with streams	>100 ha of interior forest (>100 m from edges)	Forest blocks containing Northern parula, Prothonotary warbler, or Barred owl nests
wetland	Forested wetland	Wood duck	Large blocks of mature bottomland hardwood forest (floodplains or swamps) and adjacent open water	>200 ha	Forest blocks containing productive wood duck nests
wetland	Vernal pools	mole salamanders, wood frog	Unpolluted ephemeral pools (vernal pools) with at least 215m of surrounding forest.	>=215m of surrounding forest	Forest blocks containing vernal pools at least 215 m from the nearest edge
wetland	Fens and sedge meadows	Bog turtle	Unpolluted herbaceous sedge meadows and fens, usually spring-fed, bordered by more thickly vegetated and wooded areas. Includes slow, shallow, muck-bottomed rivulets of sphagnum bogs, calcareous fens, marshy/sedge-tussock meadows, spring seeps, wet cow pastures, and shrub swamps; the habitat usually contains an abundance of sedges or mossy cover.	>0.2 ha on natural or agricultural land	Bog turtle locations and catchments

Core area type	Landscape feature	Focal species (may not overlap exactly) or criteria	Optimal habitat	Size	GIS delineation
wetland	Marsh	Least bittern, King rail, Marsh wren, Marsh rice rat, Muskrat	Unimpaired freshwater or brackish marshes with tall emergent vegetation.	>5 ha, with 30m upland buffer	Marsh blocks >5 ha, with 30m upland buffer
wetland	Open water with turtle nesting areas nearby	Freshwater turtles	Unpolluted wetlands, ponds, and other bodies of open water, with open nesting areas with sandy or loamy soil within 100m. The nesting sites should not be subject to frequent disturbance.	>=100m buffer (preferably >=275m)	Turtle nesting sites and nearby water bodies and intervening land
grassland	Open fields and meadows	Grasshopper sparrow, Eastern meadowlark	Grasslands of intermediate height and often with clumped vegetation interspersed with patches of bare ground. Other habitat requirements include moderately deep litter and sparse coverage of woody vegetation. Undisturbed during breeding.	>=30 ha	Grassland patches containing Grasshopper sparrow or Eastern meadowlark nests
grassland	Old fields	Breeding grassland bird diversity	Old fields with some woody vegetation, or adjacent shrubs	>=30 ha	Grassy patches not mowed between spring and fall, and >=30 ha

Hub focal species

Landscape feature	Focal species	Habitat	Hub size (ha)
Forest hubs	Gray fox	Forest. Usually avoids open areas.	hundreds
Riparian forest hubs	River otter	Open water (e.g., perennial streams, ponds) with riparian forest	hundreds
Riparian forest hubs	Beaver	Riparian forest (2nd - 4th order streams or ponds)	>125
Forest hubs with nearby fields	Bobcat	Primarily large tracts of non-flooded forest, including edges. Requires relatively low levels of human activity.	hundreds
Forest hubs with nearby fields	Wild turkey	Mature forest with clearings or fields nearby	hundreds
Forest hubs with nearby fields	Great horned owl	Medium to large blocks of forest with large trees and nearby fields	hundreds
Wetland hubs with nearby fields	Barn owl	Need large grassland or wet meadow areas for foraging and nest in tree cavities (which also could occur in wetlands).	hundreds
Aquatic hubs	Pollution-sensitive fish and invertebrates	Catchments containing core aquatic areas	

Connectivity focal species

Core areas	Focal species	Best linkages	Search radius (km)
All core forest	Forest mammals, wild turkey, five-lined skink	Forest cover with interior habitat	10
Riparian forest and wetlands	River otter, mink, beaver, turtles, semi-aquatic snakes, salamanders, frogs	Wide riparian forest and wetlands preferred. Other wetlands and forest are generally better than open areas.	5
Wetlands (forested wetlands or vernal pools)	Salamanders, frogs, turtles	Moist woods with vernal pools, wetlands, and unpolluted streams	5
Wetlands (marsh)	Muskrat, marsh rice rat, meadow jumping mouse	Marsh, waterways	3
Wetlands (herbaceous fens, bogs, and sedge meadows)	Bog turtle	Clean streams in sedge meadows, fens, bogs, etc.	3
Streams and rivers	Fish and mussels	Unblocked perennial streams with unpolluted water	10
Meadows	Meadow butterflies	Old fields, pasture, or powerline corridors	10

Note: For all target species, urban areas and major roads (except under bridges) were considered barriers. Some species like turtles may avoid steep slopes (e.g., ravine sides). Linkages should pass through hubs and protected land where possible; hubs because they represent larger, more intact natural areas, and protected land to ease corridor implementation

APPENDIX C: Cecil County Natural Resource Identification

1. Boundary and source data
   1.1. The assessment boundary was all of Cecil County, plus out to the extent of USGS SPARROW watersheds (based on NHD) draining into the county, or the nearest road outside the county, whichever was further.
   1.2. All raster calculations were done in ESRI Grid format, with a cell size = 3 m. It took too long to run computations at 1 m, and possibly some computations would not run at all.
   1.3. We merged 1 m land cover classified by the Chesapeake Conservancy for Cecil county and the neighboring counties in PA and DE, out to the assessment boundary. The neighboring MD counties were separated by rivers.

2. Forest

   2.1. Forest patches with at least 1 ac of interior
      2.1.1. Rationale:
         2.1.1.1. Forest edges contain significant gradients of solar radiation, temperature, wind speed, and moisture between the forest patch interior and the adjacent land, especially if the adjacent land is developed. Increased solar radiation at the edge increases temperatures and decreases soil moisture and, with increased wind flow, decreases relative humidity, which can desiccate plants. Increased wind speed at a newly created edge commonly knocks down trees that are no longer buffered by adjacent canopy and not structurally prepared. This poses a problem especially for wetland trees, which have shallow roots and less stable soil. Wind can also carry dust or other small particles, which can adhere to vegetation. Noise from developed land disrupts natural activity in adjacent forest or marsh, by drowning wildlife cues for territorial boundary establishment, courtship and mating behavior, detection of separated young, prey location, predator detection, and homing. Sudden loud noises can also cause stress to animals. Changes in insolation and other physical parameters at created edges change plant and animal communities there, and processes like nutrient cycling.
         2.1.1.2. Since the eastern U.S. was primarily unbroken forest prior to European colonization, many species are adapted to interior forest conditions. Edge habitat differs from interior forest in tree species composition, primary production, structure, development, animal activity, and propagule dispersal capabilities. The edge communities shift to more shade-intolerant, more xeric tree and shrub species, and early successional species. These then broadcast propagules that invade the forest interior. Edges can favor invasive species, which can then displace native species in adjacent areas. Opportunistic animals like raccoons, opossums, and cowbirds also colonize patch edges, and often invade the interior. These edge species often influence ecosystem dynamics by preying on, outcompeting, or parasitizing interior species. Cats and dogs from developed areas can also prey on or harass wildlife.

2.1.1.3. Source: *Maryland's Green Infrastructure Assessment: A Comprehensive Strategy for Land Conservation and Restoration*. http://www.dnr.state.md.us/greenways/gi/gidoc/gidoc.html.

2.1.2. Data layer: D:\Cecil_GI\Cecil_GI_GIS\forest\for_w_1ac_int

2.1.2.1. ESRI Grid format; cell size = 3 m

2.1.3. Methodology:

1.1.1.1. Identify tree canopy from the combined land cover.

1.1.1.2. Identify orchards (apples, peaches) and Christmas trees from the 2016 Cropland Data Layer, and remove from tree layer.

1.1.1.3. Convert building polygons and other impervious surfaces to grid format.

1.1.1.4. Buffer roads, railroads, and utility corridors 3 m and convert to grid format.

1.1.1.5. Convert road and railroad centerlines to grids so there are no artificial breaks as happenes when converting polygons to grids.

1.1.1.6. Subtract impervious surfaces, roads, railroads, and utility corridors from tree canopy.

1.1.1.7. Identify interior forest (>30 m from nearest edge)

1.1.1.8. Identify contiguous groupings of at least 1 ac of interior forest, and add 30 m transition back.

3. Wetlands

3.1. Wetlands + buffer

3.1.1. Data layer: Cecil_wetland_100ft_buffers.shp

3.1.1.1. ESRI shapefile

3.1.2. Methodology:

3.1.2.1. From DNR wetland layer, remove wetlands not within the county boundary

3.1.2.2. Remove farmed wetlands (“Pf”) and permanent open water.

3.1.2.3. Buffer 100 feet

3.1.3. To note, an effective buffer width will vary according to type of wetland, sensitivity to disturbance, intensity of adjacent land use, groundwater depth and hydraulic conductivity, proximity and characteristics of drainage ditches and other water control structures, slope and soil characteristics, species present, and buffer characteristics such as vegetation density and structural complexity, soil condition, etc. (Brown et al, 1990; North Carolina State University, 1998).

3.2. Wetlands of Special State Concern + buffer

3.2.1. Rationale: Regulatory

3.2.2. In Maryland certain wetlands with rare, threatened, endangered species or unique habitat receive special attention. The Code of Maryland Regulations (COMAR) Title 26, Subtitle 23, Chapter 06, Sections 01 & 02 identifies these Wetlands of Special State Concern (WSSC) and affords them certain protections including a 100 foot buffer from development. The Maryland Department of the Environment is responsible for identifying and regulating these wetlands. In general, the US Fish and Wildlife Service's National Wetlands Inventory wetlands provide the basis for identifying these special wetlands. Additional information, determined from field inspections, is used to identify and classify these areas.

3.2.3. Data layer: Cecil_WSSC_100ft_buffers.shp
3.2.3.1. ESRI shapefile
3.2.4. Methodology:
3.2.4.1. Remove WSSC not within the county boundary
3.2.4.2. Buffer 100 feet

4. Floodplains

4.1. 1% (100 year) floodplain
4.1.1. Rationale: Regulated
4.1.2. Data layer: Cecil_100_year_floodplain.shp
4.1.2.1. ESRI shapefile

4.2. 0.2% (500 year) floodplain
4.2.1. Rationale: Areas vulnerable to severe storms. E.O. 13690 (1/30/15) established a new standard for flood risk reduction, which included delineating floodplains based on:
4.2.1.1. "(i) the elevation and flood hazard area that result from using a climate-informed science approach that uses the best-available, actionable hydrologic and hydraulic data and methods that integrate current and future changes in flooding based on climate science. This approach will also include an emphasis on whether the action is a critical action as one of the factors to be considered when conducting the analysis;
4.2.1.2. "(ii) the elevation and flood hazard area that result from using the freeboard value, reached by adding an additional 2 feet to the base flood elevation for non-critical actions and by adding an additional 3 feet to the base flood elevation for critical actions;
4.2.1.3. "(iii) **the area subject to flooding by the 0.2 percent annual chance flood**; or
4.2.1.4. "(iv) the elevation and flood hazard area that result from using any other method identified in an update to the FFRMS."
4.2.2. Data layer: Cecil_500_year_floodplain.shp
4.2.2.1. ESRI shapefile

5. Riparian buffers

5.1. Buffered streams and shorelines (frpm hydro_ln) 100 feet
5.2. Buffered lakes and ponds (frpm hydro_poly) 100 feet
5.3. Merge buffers
5.4. Dissolve overlaps

6. Steep slopes

6.1. Steep slopes (>25% in Cecil County) have development restrictions if >10,000 ft^2
6.2. From Slopes_LidarBlocks1_thru_6, select value = 3 (>25% slope)
6.3. Select aggregations of slopes >25% that are >10,000 ft^2

7. Highly erodible soils

7.1. “Highly erodible soils” are defined as those soils with a slope greater than 15 percent or those soils with a K value greater than 0.35 and with slopes greater than 5 percent. Cecil County protects erodible soils when they occur in the Critical Area (usually within 1000’ of tidal shorelines/wetlands), and if they occur within the Critical Area Buffer, the buffer is extended to incorporate them.

7.2. Slopes >15%

7.2.1. Slope grid was obtained from http://lidar.geodata.md.gov/imap/services

7.2.2. Reclassify slope values >15% to a value of 1; elsewhere No Data.

7.3. Soils with K > 0.35 and slopes > 5%

7.3.1. Reclassify slope values >5% to a value of 1; elsewhere No Data.

7.3.2. Multiply by soils with K > 0.35.

7.3.2.1. Grid of highly erodible soils with slope >5% is K_gt35_sl_gt5

7.4. Mosaic the above two grids

7.4.1. Grid: high_erodible

APPENDIX D: Cecil County Green Infrastructure Network Identification Methodology

Core areas

1. Core aquatic areas

    1.1. Identify all riparian zones (including intermittent streams)
        1.1.1. 1% (100 year) floodplain
            1.1.1.1. Data layer: Cecil_100_year_floodplain.shp
        1.1.2. Riparian buffers
            1.1.2.1. Buffered streams and shorelines (frpm hydro_ln) 100 feet
            1.1.2.2. Buffered lakes and ponds (frpm hydro_poly) 100 feet
        1.1.3. Merge buffers
        1.1.4. Dissolve overlaps
        1.1.5. Save as Cecil_riparian_zones.shp
    1.2. Identify perennial riparian zones
        1.2.1. 1% (100 year) floodplain
            1.2.1.1. Data layer: Cecil_100_year_floodplain.shp
        1.2.2. Riparian buffers
            1.2.2.1. Buffered perennial streams and shorelines (frpm hydro_ln) 100 feet
            1.2.2.2. Buffered lakes and ponds (frpm hydro_poly) 100 feet
        1.2.3. Merge buffers
        1.2.4. Dissolve overlaps
        1.2.5. Save as Cecil_perennial_riparian.shp
    1.3. Nontidal streams
        1.3.1. Focal species: Pollution-sensitive fish and invertebrates
        1.3.2. Optimal habitat: Stream reaches with "Good" combined (fish + benthic macroinvertebrate) IBI scores (>4), which can indicate good water quality and stream habitat.
        1.3.3. Identify stream reaches with "Good" combined (fish + benthic macroinvertebrate) MBSS IBI scores
        1.3.4. Add stream reaches with MDE Tier II designation
        1.3.5. Add associated perennial riparian zone
    1.4. Rivers with rare species
        1.4.1. Focal species: Yellow lampmussel
        1.4.2. DNR provided a map of HUC12 stronghold watersheds in Cecil County (Bohemia River), which supports populations of this species.
        1.4.3. Select connected streams (i.e., not isolated by impoundment dams, etc. in these watersheds.
        1.4.4. Add associated perennial riparian zones.
    1.5. Coldwater streams
        1.5.1. Focal species:
            1.5.1.1. Brown trout

1.5.1.2. Benthic coldwater macroinvertebrates (*Tallaperla* spp. and *Sweltsa* spp.). Both are sensitive to sedimentation and pollution and need coldwater (similar stream temperatures to brook trout). These are the two species that MDE uses to fulfill the biological requirement for thermal protection of a stream.

1.5.2. Optimal habitat: Cold water natural streams with good water quality.

1.5.3. DNR Freshwater Fisheries provided a map of HUC12 watersheds that contain wild trout and benthic coldwater macroinvertebrates.

1.5.4. Select connected streams (i.e., not isolated by impoundments, dams, etc.) in these watersheds.

1.5.5. Add associated perennial riparian zones.

1.5.6. No brook trout or hellbenders currently in the county; not found in recent surveys.

1.6. Tidal waters

1.6.1. Focal species: Chesapeake logperch, anadromous fish, mummichog, native submerged grasses

1.6.2. Optimal habitat: High Priority Blue Infrastructure, SAV beds, Chesapeake logperch habitat, anadromous fish spawning and juvenile habitat

1.6.3. DNR supplied locations where Chesapeake logperch were found. We selected corresponding water and riparian zones.

1.6.4. Identify 2015 SAV beds

1.6.5. Identify High Priority Blue Infrastructure coastal watersheds

1.6.6. Add striped bass spawning habitat

1.6.7. Add herring and perch spawning and juvenile habitat

1.6.8. Clip above three to Blue Infratructure nearshore segments (delineated out to a depth of 2 meters) and shoreline buffers (up to 100 m from shoreline). Note: All 316 segments fell into one or more of these habitat categories.

1.6.9. Save as Cecil_nearshore_habitat.shp.

1.7. Combine

1.7.1. Created model to run much of this.

1.7.2. Removed isolated areas

2. Core Wetlands

2.1. Identify wetlands + buffer

2.1.1. To note, an effective buffer width will vary according to type of wetland, sensitivity to disturbance, intensity of adjacent land use, groundwater depth and hydraulic conductivity, proximity and characteristics of drainage ditches and other water control structures, slope and soil characteristics, species present, and buffer characteristics such as vegetation density and structural complexity, soil condition, etc.

2.1.2. From DNR wetland layer, remove wetlands not within the county boundary

2.1.3. Remove farmed wetlands (“Pf”) and permanent open water.

2.1.4. Buffer 100 feet

2.1.5. Data layer: Cecil_wetland_100ft_buffers.shp

2.2. Wetlands of Special State Concern + 100 ft buffer

2.2.1. In Maryland certain wetlands with rare, threatened, endangered species or unique habitat receive special attention. The Code of Maryland Regulations (COMAR) Title 26, Subtitle 23, Chapter 06, Sections 01 & 02 identifies these Wetlands of Special State Concern (WSSC)

and affords them certain protections including a 100 foot buffer from development. The Maryland Department of the Environment is responsible for identifying and regulating these wetlands. In general, the US Fish and Wildlife Service's National Wetlands Inventory wetlands provide the basis for identifying these special wetlands. Additional information, determined from field inspections, is used to identify and classify these areas.

2.2.2. Remove WSSC not within the county boundary

2.2.3. Buffer 100 feet

2.2.4. Data layer: Cecil_WSSC_100ft_buffers.shp

2.3. Identify wetlands that have not been farmed, drained, ditched, or excavated.

2.3.1. Note: impounded wetlands (-b; -h) often provide good habitat

2.3.2. Note: filled (-s) may only be a small portion of the wetland, and this is not generally labeled consistently

2.3.3. ("CLASS" LIKE '%f') OR ("CLASS" LIKE '%d') OR ("CLASS" LIKE '%x')

2.3.4. Saved as Cecil_unmodified_wetlands.shp.

2.4. Compatible land cover includes unimpaired wetlands, forest patches, and open water.

2.5. Identify unimpaired wetlands (or portions of wetlands) that are at least 30 m from cleared or developed land, roads, railroads, ditches, or channelized streams.

2.6. Add 30 m buffers

2.7. Add WSSC's + 100 ft buffers (even if not all the land cover is natural).

3. Core Forest

3.1. Background:

3.1.1. Forest edges contain significant gradients of solar radiation, temperature, wind speed, and moisture between the forest patch interior and the adjacent land, especially if the adjacent land is developed. Increased solar radiation at the edge increases temperatures and decreases soil moisture and, with increased wind flow, decreases relative humidity, which can desiccate plants. Increased wind speed at a newly created edge commonly knocks down trees that are no longer buffered by adjacent canopy and not structurally prepared. This poses a problem especially for wetland trees, which have shallow roots and less stable soil. Wind can also carry dust or other small particles, which can adhere to vegetation. Noise from developed land disrupts natural activity in adjacent forest or marsh, by drowning wildlife cues for territorial boundary establishment, courtship and mating behavior, detection of separated young, prey location, predator detection, and homing. Sudden loud noises can also cause stress to animals. Changes in insolation and other physical parameters at created edges change plant and animal communities there, and processes like nutrient cycling.

3.1.2. Since the eastern U.S. was primarily unbroken forest prior to European colonization, many species are adapted to interior forest conditions. Edge habitat differs from interior forest in tree species composition, primary production, structure, development, animal activity, and propagule dispersal capabilities. The edge communities shift to more shade-intolerant, more xeric tree and shrub species, and early successional species. These then broadcast propagules that invade the forest interior. Edges can favor invasive species, which can then displace native species in adjacent areas. Opportunistic animals like raccoons, opossums, and cowbirds also colonize patch edges, and often invade the interior. These edge species often influence ecosystem dynamics by preying on, outcompeting, or

parasitizing interior species. Cats and dogs from developed areas can also prey on or harass wildlife.

3.1.3. Age, structure, composition, disturbance history, etc. of forest is often more important to functions like wildlife habitat than patch size. This information was not readily available throughout the county.

3.1.4. Note: took too long to run computations at 1 m, so we ran at 3 m.

3.2. Forest patches with at least 1 acre of interior (>30 m from edges)

3.2.1. We decided that this would be the minimum patch size for consideration. Forest patches dominated by edge effects may not contain suitable conditions for forest obligates.

3.2.2. Identify tree canopy from the combined land cover (imagery flown 2013, LiDAR flown 2014).

3.2.3. Identify orchards (apples, peaches) and Christmas trees from the 2016 Cropland Data Layer, and remove from tree layer.

3.2.4. Convert building polygons and other impervious surfaces to grid format.

3.2.5. Buffer roads, railroads, and utility corridors 3 m and convert to grid format.

3.2.6. Convert road and railroad centerlines to grids so there are no artificial breaks as happenes when converting polygons to grids.

3.2.7. Subtract impervious surfaces, roads, railroads, and utility corridors from tree canopy.

3.2.8. Identify interior forest (>30 m from nearest edge)

3.2.9. Identify contiguous groupings of at least 1 ac of interior forest, and add 30 m transition back.

3.2.10. Data layer: D:\Cecil_GI\Cecil_GI_GIS\forest\for_w_1ac_int

3.3. Forest patches with >100 ha (250 ac) of interior forest (>100 m from edges)

3.3.1. This patch size and depth is based on habitat requirements for forest interior birds (FIDS) in Maryland (Bushman and Therres, 1988).

3.3.2. There were only 6 such patches.

3.4. Key forest patches would best be identified from the ≥1 interior acre subset through presence of indicator species or surveys of forest quality. We lacked such data, though. We downloaded EBIRD data from GBIF, but the positions were not sufficiently accurate.

3.5. Calculate area of each forest patch with ≥1 acre of interior (>30 m from edge). Area calculated here includes the 30 m edge transition.

Patch area (ac)	% of patches	% of area
0-10	33%	4%
10-30	32%	11%
30-100	21%	24%
100-250	9%	27%
250-1227	4%	34%

3.6. From above, identify forest patches ≥100 acre (only 13% of patches, but 61% of area).

3.6.1. Save grid as forest_100ac

3.7. Add forest patches that overlap core aquatic areas, core wetlands, and BioNet Tiers 1-4.

3.7.1. 982 out of 1630 forest patches met one or more of these four criteria.

3.7.2. These were designated core forest.

4. Core Grassland - unable to identify grassland habitat

4.1. Identify grasslands
    4.1.1. From land cover, select Low Vegetation
    4.1.2. From Cropland Data Layer (CDL; 12/12/2016 publication), select Pasture/Grass and Grassland Herbaceous
    4.1.3. Comparing to aerial photos, it didn't seem accurate.

5. Combine core areas. Remove developed land and add forest within these areas.

    5.1. Convert polygons to rasters with value of 1.
        5.1.1. Used same map extent and cell size (3 m) as the forest grid
    5.2. Mosaic rasters together.
    5.3. Subtract impervious surfaces from fine-scale land cover and other data (see forest patch methodology)
    5.4. Add adjacent tree cover
    5.5. Remove areas only tenuously connected (<30 m wide) to core forest, wetland, or aquatic areas.
    5.6. Remove areas <1 ac

Hubs

1. Buffer core areas 100 m
2. Add small areas (<10 acres) within buffers
    2.1. 1 cell = 9 m^2 = 0.00222395 acre.
    2.2. 10 acres = 4497 cells
3. Subtract major roads
    3.1. Data source: streets_5km
    3.2. Select speed ≥40 mph
    3.3. Also select primary roads (roadclass = 1 or 2)
    3.4. Clip to study boundary
    3.5. Save as Cecil_major_roads.shp
    3.6. Buffer 10 m
    3.7. Convert to grid and subtract from core area buffers
4. Subtract areas within 30 m of buildings (likely to be frequently disturbed)
5. Subtract impervious surfaces and large areas of barren land (>1/4 ac)
6. Add core areas back in
7. Remove areas only tenuously connected (<30 m wide) to core areas.
8. Clip to study boundary.
9. Apply size threshold of 250 ac (112,444 cells)

Corridors

Had to run this at 10 m due to computer constraints.

Forest Corridors

1. Set environments and resample core forest

a. Set projection (Maryland State Plane, NAD 1983, meters), snap, mask, and cell size (10 m).
b. Resample or re-rasterize data to this.

Forest movement impedance

1. Bridges
   a. Merge bridge point files:
      i. Cecil_state_bridges.shp
      ii. Cecil_US_bridges.shp
      iii. county bridges.shp (except for ones replaced with culverts)
   b. Based on examination of data, buffer 20 meters
   c. From hydro_ln, select lakes, ponds, marsh, reservoirs, shorelines, and streams
      i. ("LAYER" = 'X-Lake-Pond') OR ("LAYER" = 'X-Marsh-Line') OR ("LAYER" = 'X-Reservoir') OR ("LAYER" = 'X-SHORELINE') OR ("LAYER" = 'X-STREAM')
   d. From Hydrology_Polygons, select lakes, ponds, and marsh
      i. ("Layer" = 'X-LAKE-POND') OR ("Layer" = 'X-MARSH-LINE')
   e. From land cover, select water and wetlands
   f. Identify water within 20 meters of bridge points.
   g. Had to manually digitize some bridges where the crossings were big, and the point buffer method didn't work. Also, some bridges were missing from the point files.
   h. Assign these areas the same code as water in the land cover raster (1).
2. Water
   a. From hydro_poly, select ("Layer" = 'X-LAKE-POND') OR ("Layer" = 'X-SW-Pond')
   b. Assign these areas the same code as Water in the land cover raster (1).
3. Assign buildings the same code as Structures in the land cover raster (7).
4. Assign major roads a unique code (99)
5. Assign roads and streets the same code as Roads in the land cover raster (9).
6. Assign impervious surfaces the same code as Impervious Surfaces in the land cover raster (8).
7. Assign railroads the same code as Impervious Surfaces in the land cover raster (8).
8. Assign abandoned railroads the same code as Barren in the land cover raster (6).
9. Assign gas line ROWs the same code as Low Vegetation in the land cover raster (5). No data was available for other utility ROWs.
10. Assign orchards the same code as Shrubland in the land cover raster (4).
11. Overlay buildings, bridges, major roads, other roads and streets, impervious surfaces, railroads, abandoned railroads, gas line ROWs, and orchards over land cover data. Save as grid bldg_rd_rr_lc.
12. Based on tests while performing the Greater Baltimore Wilderness resiliency assessment, reclass modified land cover as follows (No Data = impassable for non-aerial forest animals):

Code	Description	Forest corridor impedance
1	Water	250
2	Wetlands	20
3	Tree Canopy	10
4	Shrubland	20
5	Low Vegetation	50
6	Barren	250
7	Structures	No Data

8	Impervious Surfaces	1250
9	Impervious Roads	1250
10	Tree Canopy over Structures	No Data
11	Tree Canopy over Impervious Surfaces	1250
12	Tree Canopy over Impervious Roads	1250
No Data	Outside study area	No Data

   a. Give major roads an impedance of No Data (impassable except under bridges)
   b. Grid name: imp_lc_x5
6. Interior forest
   a. Reclass distance from forest edge (using grid tree_patches) as follows:

Distance from forest edge	Divide impedance by:
>100 m	3
30-100 m	2
<30 m, or non-forest	1

   b. Saved divisor grid as imp_intfor.
7. Proximity to buildings and roads: Multiply impedance by 2 within 30 m of buildings or roads
   a. Reclass road/street and building grids to 1 or No Data, and mosaic together.
   b. Reclass distance from roads and buildings as follows:

Distance from nearest road or building	Divide impedance by:
<15 m (1 cell diag.)	3
15-30 m	2
>30 m	1

   c. Saved divisor grid as near_rd_bldg.
8. Set impedance of offshore water (>30 m from shore) to NoData, so the program does not select forest corridors across large rivers or bays.
   a. Use water from land cover (specifically, grid bldg_rd_rr_lc, which reclassifies bridges as water)
   b. Save grid as imp_offshore
9. Protected lands
   a. From the layer ProtectedLands_Combined, we removed unprotected Rural Legacy Area land.
   b. For remaining, parks, easements, other public land, common open space, etc., the level of protection varied.
   c. Based on results from past projects, exclude paved surfaces and open water, using grid bldg_rd_rr_lc. Only trees, grass/shrubs, and bare earth receive a discount for being within a protected area.
   d. Reclass protected undeveloped land = 2; elsewhere = 1. Saved as imp_protect.
10. Combine
   a. Divide land cover impedance grid by interior forest impedance (i.e., lower impedance in forest interior), offshore water (i.e., no corridors >30 m from shore), protected land (i.e., lower impedance in undeveloped protected land), and multiply by proximity to roads and buildings (higher impedance near roads and buildings).
   b. Note that processing extent, cell size, etc. must align exactly between impedance and core area grids for the TMA tool to work.

Forest connectivity modeling

1. Created uncertainty grid for impedance layer, to be used with the new TMA version, such that each impedance value could vary but retain their rank order.

Impedance value	Min. value	Max. value	Fractional change to min.	Fractional change to max.	Smallest fractional change	Final min. value	Final max. value
1	1	1	0.000000	0.000000	0.0000	1	1
2	2	2	0.000000	0.000000	0.0000	2	2
3	3	4	0.000000	0.333333	0.0000	3	3
5	4	7	0.200000	0.400000	0.2000	4	6
10	8	12	0.200000	0.200000	0.2000	8	12
15	13	17	0.133333	0.133333	0.1333	13	17
20	18	22	0.100000	0.100000	0.1000	18	22
25	23	27	0.080000	0.080000	0.0800	23	27
30	28	35	0.066667	0.166667	0.0666	28	32
40	35	45	0.125000	0.125000	0.1250	35	45
50	45	55	0.100000	0.100000	0.1000	45	55
60	55	67	0.083333	0.116667	0.0833	55	65
75	68	79	0.093333	0.053333	0.0533	71	79
83	79	91	0.048193	0.096386	0.0481	79	87
100	92	112	0.080000	0.120000	0.0800	92	108
125	113	137	0.096000	0.096000	0.0960	113	137
150	138	200	0.080000	0.333333	0.0800	138	162
250	200	312	0.200000	0.248000	0.2000	200	300
375	313	437	0.165333	0.165333	0.1653	313	437
500	438	625	0.124000	0.250000	0.1240	438	562
750	625	1000	0.166667	0.333333	0.1666	625	875
1250	1000	1875	0.200000	0.500000	0.2000	1000	1500
2500	1875	3125	0.250000	0.250000	0.2500	1875	3125
3750	3125	4375	0.166667	0.166667	0.1666	3125	4375

2. Run TMA
    a. Impedance X5
    b. maximum movement from start locations = 1,000,000
    c. minimum pathway threshold = 1
    d. maximum movement around pathway = 1000
        i. Equivalent to 40 m of bare earth or 200 m of grass (seems kind of high)
        ii. Through ag fields, width was ~60-80 m.
    e. analysis iterations = 50
    f. start location % = 1
    g. It took 3 hours, 55 minutes.
3. Rank corridors

a. Use the "Remove Cores from corridors" tool to remove core areas and areas that do not connect at least two core areas (they may connect different parts of the same core area, or function as buffers, or, in some cases, act as dead ends.)
b. Reclassify all output values from above tool to 1
c. Multiply above corridors by movement potential grid (which combines area connected and impedance)
d. Make grid more normal (it is strongly right-skewed) by taking natural log (Ln)
e. Slice into ten equal-area increments (grid = for_corr_rank). 10 is best and 1 is worst. They are not truly equal-area because the program is imperfect.

Wetland Corridors

Wetland movement impedance

1. First, identify core wetlands to connect
   a. Set processing extent same as forest impedance layer.
   b. Relatively unimpacted wetlands (ce_wet_unimp) within core areas (ce_core_areas)
   c. Note: All unimpacted wetlands fell within core areas.
   d. Save grid as core_wetl_10m
2. Bridges – same as for forest
3. Water – same as for forest
4. Assign buildings the same code as Structures in the land cover raster (7).
5. Assign major roads a unique code (99)
6. Assign roads and streets the same code as Roads in the land cover raster (9).
7. Assign impervious surfaces the same code as Impervious Surfaces in the land cover raster (8).
8. Assign railroads the same code as Impervious Surfaces in the land cover raster (8).
9. Assign abandoned railroads the same code as Barren in the land cover raster (6).
10. Assign gas line ROWs the same code as Low Vegetation in the land cover raster (5). No data was available for other utility ROWs.
11. Assign orchards the same code as Shrubland in the land cover raster (4).
12. Assign DNR wetlands (other than farmed or open water) the same code as Wetlands in the land cover raster (2).
13. Overlay buildings, bridges, major roads, other roads and streets, impervious surfaces, railroads, abandoned railroads, gas line ROWs, wetlands, and orchards over land cover data. Save as grid lc_mod_wetl.
14. Reclass modified land cover as follows (No Data = impassable for non-aerial wetland animals):

Code	Description	Forest corridor impedance
1	Water	20
2	Wetlands	10
3	Tree Canopy	20
4	Shrubland	35
5	Low Vegetation	50
6	Barren	250
7	Structures	No Data

8	Impervious Surfaces	1250
9	Impervious Roads	1250
10	Tree Canopy over Structures	No Data
11	Tree Canopy over Impervious Surfaces	1250
12	Tree Canopy over Impervious Roads	1250
No Data	Outside county	No Data

   a. Give major roads an impedance of No Data (impassable except under bridges)
   b. Grid name: imp_lc_wetl
11. Core wetlands and other relatively unimpaired wetlands
   a. Reclass as follows:

Wetland context	Divide impedance by:
Core wetlands	3
Other relatively unimpaired wetlands	2
Elsewhere	1

   b. Saved divisor grid as imp_wetclass.
12. Floodplains
   a. Reduce impedance of stream buffers and 1% floodplains, except for open water, mined land, and impervious surfaces.
   b. Reclassify to 2 = inside, 1 = outside. Save grid as imp_floodpln.
13. Proximity to buildings and roads: Same as for forest impedance
14. Set impedance of offshore water (>30 m from shore) to NoData, so the program does not select forest corridors across large rivers or bays. (Same as for forest impedance)
15. Protected lands: Same as for forest impedance
16. Combine
   a. Divide land cover impedance grid by wetland impedance (i.e., lower impedance in core wetlands), floodplain impedance (i.e., lower impedance in floodplains), offshore water (i.e., no corridors >30 m from shore), protected land (i.e., lower impedance in undeveloped protected land), and multiply by proximity to roads and buildings (higher impedance near roads and buildings).
   b. Set minimum impedance to 1 (cannot be less than this)

Wetland connectivity modeling

1. Created uncertainty grid for impedance layer, to be used with the new TMA version, such that each impedance value could vary but retain their rank order.

Impedance value	Min. value	Max. value	Fractional change to min.	Fractional change to max.	Smallest fractional change	Final min. value	Final max. value
1	1	1	0.000000	0.000000	0.0000	1	1
2	2	2	0.000000	0.000000	0.0000	2	2
3	3	3	0.000000	0.000000	0.0000	3	3
4	4	4	0.000000	0.000000	0.0000	4	4
5	5	5	0.000000	0.000000	0.0000	5	5
6	6	6	0.000000	0.000000	0.0000	6	6

7	7	7	0.000000	0.000000	0.0000	7	7
8	8	9	0.000000	0.125000	0.0000	8	8
10	9	11	0.100000	0.100000	0.1000	9	11
12	11	12	0.083333	0.000000	0.0000	12	12
15	14	16	0.066667	0.066667	0.0666	14	16
17	16	18	0.058824	0.058824	0.0588	16	18
20	19	22	0.050000	0.100000	0.0500	19	21
25	23	25	0.080000	0.000000	0.0000	25	25
26	26	28	0.000000	0.076923	0.0000	26	26
30	28	32	0.066667	0.066667	0.0666	28	32
35	33	36	0.057143	0.028571	0.0285	34	36
37	36	38	0.027027	0.027027	0.0270	36	38
40	39	45	0.025000	0.125000	0.0250	39	41
50	45	51	0.100000	0.020000	0.0200	49	51
52	51	56	0.019231	0.076923	0.0192	51	53
60	56	61	0.066667	0.016667	0.0166	59	61
70	65	72	0.071429	0.028571	0.0285	68	72
75	73	87	0.026667	0.160000	0.0266	73	77
100	88	102	0.120000	0.020000	0.0200	98	102
105	103	115	0.019048	0.095238	0.0190	103	107
125	115	137	0.080000	0.096000	0.0800	115	135
150	138	200	0.080000	0.333333	0.0800	138	162
250	200	312	0.200000	0.248000	0.2000	200	300
375	313	437	0.165333	0.165333	0.1653	313	437
500	438	625	0.124000	0.250000	0.1240	438	562
750	625	1000	0.166667	0.333333	0.1666	625	875
1250	1000	1875	0.200000	0.500000	0.2000	1000	1500
2500	1875	3125	0.250000	0.250000	0.2500	1875	3125
3750	3125	4375	0.166667	0.166667	0.1666	3125	4375

2. Run TMA
    a. Impedance X5
    b. maximum movement from start locations = 1,000,000
    c. minimum pathway threshold = 1
    d. maximum movement around pathway = 1000
        i. Equivalent to 40 m of bare earth or 200 m of grass (seems kind of high)
        ii. Through upland fields, width was ~50 m.
    e. analysis iterations = 50
    f. start location % = 1
    g. It took 3 hours, 40 minutes.
    h. Most (but not all) of the corridors were in floodplains.
3. Rank corridors

a. Use the “Remove Cores from corridors” tool to remove core areas and areas that do not connect at least two core areas (they may connect different parts of the same core area, or function as buffers, or, in some cases, act as dead ends.)
b. Reclassify all output values from above tool to 1
c. Multiply above corridors by movement potential grid (which combines area connected and impedance)
d. Make grid more normal (it is strongly right-skewed) by taking natural log (Ln)
e. Slice into ten equal-area increments (grid = for_corr_rank). 10 is best and 1 is worst. They are not truly equal-area because the program is imperfect.

Aquatic Corridors

1. All the core aquatic areas were already connected except for the West Branch Christiana River, which drains into Delaware; Mill Creek south of the Amtrak line; and a section of Little Elk Creek north of I-95. We selected the 100 year floodplain connecting the two latter stream reaches to the Elk River, and that was our aquatic corridor.
2. Save grid as aqua_corridor.

Combine corridors

1. Merge forest, wetland, and aquatic corridors (versions with value = 1 or NoData).
2. Remove core areas (output grid = ce_corridors; shapefile cecil_corridors_poly.shp).

APPENDIX E: Landscape ranking factors

Table E-1. Factors used to rank unprotected land for natural resource conservation importance, and their relative weighting.

Level 2	Level 3	Level 4	Level 5	Combined weight	Classification	Numeric Value	Reclassified Value (0-100)	Reclass function
Mandatory criteria	Not developed			(Mandatory)	Impervious surfaces	1	0	step
	Not open water			(Mandatory)	Open water	1	0	step
	Not already protected (with fee simple or easement restrictions)			(Mandatory)	Protected land (with fee simple or easement restrictions on land conversion)	1	0	step
Statewide Green Infrastructure	State Designated Ecological Significance	Statewide Green Infrastructure Hubs		0.0125	Statewide hubs	1	100	step
		Statewide Green Infrastructure Corridors		0.0125	Statewide corridors	1	100	
		Targeted Ecological Areas		0.0250	All TEA sites	1	100	step
		BioNet Significance		0.1000	Tier 1 – Critically Significant for Biodiversity Conservation	1	100	step
					Tier 2 – Extremely Significant for Biodiversity Conservation	2	80	
					Tier 3 – Highly Significant for Biodiversity Conservation	3	60	
					Tier 4 – Moderately Significant for Biodiversity Conservation	4	40	
					Tier 5 – Significant for Biodiversity Conservation	5	20	
		Wetlands of Special State Concern + 100 ft buffer		0.0500	All WSSC + 100 foot buffers	1	100	step
	Watershed Characteristics (USGS HUC-12 level)	Forest Cover by Watershed		0.0500	% forest cover in watershed (see "Maryland's Forests for Healthy Watersheds")	0-78%	0-100	val/max * 100
		Impervious Surface by Watershed		0.0500	Able to support sensitive species and stable stream banks (source: MD DNR)	0-5%	100	step

Level 2	Level 3	Level 4	Level 5	Combined weight	Classification	Numeric Value	Reclassified Value (0-100)	Reclass function
					Most sensitive species absent, some erosion and pollution	5-10%	50	
					Only tolerant species, obvious erosion	10-20%	25	
					Severely impaired	>20%	0	
		Watersheds with surface drinking water intakes		0.0500	Within a HUC-12 watershed containing a drinking water intake	1	100	step
		Forests of Recognized Importance		0.1000	100 foot buffers of Stronghold Watershed streams, trout bearing streams, streams feeding municipal drinking water reservoirs, and Tier II High Quality Waters	1	100	step
County Scale Resource Features	Natural resource features	Wetlands and floodplains	Wetlands + buffers	0.0500	Wetlands + 100 foot buffer	1	100	step
			Streams + buffers and 1% (100 year) floodplains	0.0500	Streams + 100 foot buffer + 1% (100 year) floodplain	1	100	step
		Forest	Forest patches with at least 1 acre of interior	0.0500	Forest patches with at least 1 acre of interior	1	100	step
		Highly erodible soils	Highly erodible soils	0.0500	Soils on slopes >15%, or soils with K > 0.35 on slopes > 5%	1	100	step
	County green infrastructure network	Core areas		0.1000	Core areas	1	100	step
		Hubs		0.0333	Hubs	1	100	step
		Forest movement importance		0.0333	Movement potential for forest organisms (area linked + linkage suitability)	0-1	0-100	equal area slice
		Wetland movement importance		0.0333	Movement potential for wetland organisms (area linked + linkage suitability)	0-1	0-100	equal area slice
Other Considerations	Existing conservation priorities	Rural Legacy Areas		0.0250	Inside a Rural Legacy Area	1	100	step
		Priority Preservation Areas		0.0250	Inside a Priority Preservation Area	1	100	step
	Park equity	Distance to nearest existing park		0.1000	Distance in meters to nearest park	0-9555	0-100	equal area slice

Table E-2. Factors used to rank areas for siting new stormwater treatment BMPs, and their relative weighting.

Level 2	Level 3	Level 4	Combined weight	Classification	Numeric Value	Reclassified Value (0-100)	Reclass function
Mandatory criteria	Suitable BMP site		(mandatory)	Identified using EPA criteria for bioretention, constructed wetland, dry pond, grassed swale, infiltration basin, infiltration trench, porous pavement, sand filter (both surface and non-surface), vegetated filter strip, and/or wet pond	1	1	step
	Existing BMP location?			yes	1	0.33	step
				no	No Data	1	
Land ownership			0.050	Publicly owned	1	100	step
				Privately owned with easement	1	25	
				Privately owned, no easements		0	
Area of impervious surface draining to site			0.350	Acres of impervious surface draining to site (maximum impervious flow accumulation)	<0.5	0	step
					0.5 - 2	20	
					2 - 5	40	
					5- 10	60	
					10 - 25	80	
					>25	100	
Watershed characteristics	Watershed Characteristics (HUC- 12 watersheds)	Forest Cover by Watershed	0.060	% forest cover in watershed (see "Maryland's Forests for Healthy Watersheds")	0-78%	0-100	equal interval slice, then subtract from 100
		Impervious Surface by Watershed	0.060	Able to support sensitive species and stable stream banks (source: MD DNR)	0-5%	0	step
				Most sensitive species absent, some erosion and pollution	5-10%	50	
				Only tolerant species, obvious erosion	10-20%	100	
				Severely impaired	>20%	25	
		Watersheds with surface drinking water intakes	0.030	Within a HUC-12 watershed containing a drinking water intake	1	100	step

Level 2	Level 3	Level 4	Combined weight	Classification	Numeric Value	Reclassified Value (0-100)	Reclass function
	Development preceding stormwater regulations (by NHD catchment)		0.100	% of NHD catchment developed in 1992 (closest available land cover to 1984, when local ordinances were implemented)	0-100%	0-100	none
	Nutrient loading (NHD catchment)	Incremental TN flux attributable to undifferentiated urban sources	0.125	TN_MEAN_PLOAD_INC_URBAN (kg N/year)	0-7800	0-100	% of maximum
		Incremental TP flux attributable to undifferentiated urban sources	0.125	TP_MEAN_PLOAD_INC_URBAN (kg P/year)	0-826	0-100	% of maximum
Constructability and visibility	Distance to nearest road, parking lot, or driveway		0.100	Distance to nearest road, parking lot, or driveway (m)	0-10	100	step
					10-50	75	
					50-150	50	
					150-250	25	
					>250	0	

Table E-3. Factors used to rank preservation of natural features for coastal defense, and their relative weighting.

Level 2	Level 3	Combined weight	Classification	Numeric Value	Reclassified Value (0-100)	Reclass function
Mandatory criteria	Not developed	(Mandatory)	Impervious surfaces	1	0	step
	Not already protected (with fee simple or easement restrictions)	(Mandatory)	Protected land (with fee simple or easement restrictions on land conversion)	1	0	step
	MDOT predicted 0.2% flood extent in 2100 (equivalent to 5.5 feet of SLR plus Category 3 hurricane)	(Mandatory)	Vulnerable to storm surge by 2100	1	1	step
	Existing natural features within storm surge zone (forest, wetlands, or underwater grass)	(Mandatory)	Within storm surge zone, forest >1 ac and >=120 ft wide, DNR wetlands, and 2015 SAV with at least 40% cover	1	1	step
Blue Infrastructure shoreline segments	Allocate to nearest natural features in storm surge zone	0.333	Total rank	0 - 165	0-100	Equal interval slice
Maryland Coastal Resiliency Assessment - Habitat Role in Hazard Reduction	Allocate to nearest natural features in storm surge zone	0.667	Tier I Shorelines (Shorelines with a high habitat role, OR shorelines that transition to High Hazard when habitats are removed.)		100	step
			Tier II Shorelines (Shorelines with moderate habitat role, OR shorelines that transition to Moderate Hazard when habitats are removed.)		25	
			Neither Tier I nor Tier II		0	

Appendix F: Mature Forest Identification in Cecil County

Purpose

As forests mature, they grow in biomass, structure, and complexity (Weber and Boss, 2009). Beneath the canopy, shade-tolerant plants replace shade-intolerant plants. Mature ecosystems have greater stored biomass and organic matter, higher diversity, increased cycling of detritus and nutrients, improved efficiency, and greater stability (Odum, 1969). Significantly, they also have more stored carbon. In Charles and Prince George's counties, Maryland, Weber and Allen (2010) found that later successional forest stands had fewer exotic plants than earlier successional stands. In Harford County, Weber (Conservation Fund et al., 2018) similarly found that later successional forest had fewer exotic plants than earlier successional, especially where >50 m from the nearest edge.

Forest-dependent breeding birds, many of which are of conservation concern, are considered "umbrella species" whose needs encompass those of many other animal and plant species (Canterbury et al., 2000; Jones et al., 2000; O'Connell et al., 2000). Weber et al. (2008) found that in eastern Maryland, forest bird richness and abundance were highest in undisturbed, mature broadleaf forest with wetlands and streams nearby.

Although young forest also provides numerous benefits to wildlife and humans, we wanted to be able to identify mature forest in Cecil County, as potentially being exceptionally important to conserve.

Methodology

As part of the Cecil County green infrastructure assessment, we identified forest patches from 1-m land cover and other data (see associated document for details). Within these, we examined canopy height (MD-wide data, 30 m pixels), and 1992 land cover (NLCD). We used a 28 m height threshold; following findings in Weber and Boss (2009), if canopy height >28 m and the NLCD class was deciduous forest or forested wetland in 1992, forest was likely to be mature, especially if in a floodplain or ravine.

Some early successional trees, notably tulip poplar (*Liriodendron tulipifera*), grow quickly, and could reach a 28 m height in 35-45 years (Beck, 1990). However, we lacked a remotely-sensed means to discriminate between different species of deciduous trees.

We therefore tested the GIS model by comparing it to aerial photos and ground observations. To visit as many points as possible in a limited amount of time, we selected points using the following criteria:

- On state-owned land or county parks
- <100 m from a parking area
- >30 m from the nearest forest edge or different modeled age class (mature/non-mature). (>50 m didn't generate enough points)

Combining these criteria left polygons for mature and non-mature forest <100 from a parking lot and >30 m from the nearest forest edge or different modeled age class. From these, we selected

one site each within three of the four county parks that were finalists for wildlife surveys (the fourth did not contain forest that met the above criteria). To increase the sample size to 20 mature sites and 20 young, we selected the 18 largest (by area) mature forest candidates and 19 largest young forest candidates. The reason for picking the largest was because these were more likely to be relatively homogenous. We then identified the center point of each of these polygons. These were our sample sites.

We found that 69% of forest with canopy height >28 m was classified as deciduous forest or forested wetland in 1992. Examining ESRI aerial imagery and 1995 Google Earth imagery, the 1992 land cover contained notable inaccuracies. Comparing canopy height to 2011 NLCD, the vast majority of height >28 m was classified as deciduous forest or woody wetlands. Very little was mixed or evergreen (2%). We therefore decided to just rely on canopy height >28 m within forest patches identified from the 1 m land cover.

First, we examined aerial photos. From Allen and Weber (2016), mature canopy trees were likely to have crown diameters >35-40 ft. Crown diameters in aerial photos were too variable to be of use, though.

Therefore, we relied on visiting the points in the field. At each point, we measured the diameter at breast height (dbh) of the 10 nearest canopy trees and recorded their species and whether there were vines on the trunk. We also recorded signs and extent of disturbance; coverage of invasive species; the % cover and most common species in the upper and lower subcanopy, shrub layer, and ground layer; and the abundance and composition of tree seedlings.

Results

Table 1 shows our findings. Canopy height and diameter (dbh) were strongly correlated (78%), as expected. Canopy height was uncorrelated, however, with the number of layers or the percent invasive plant cover.

Plots with oaks dominant or co-dominant in the canopy were less likely to have >5% invasive plant coverage ($X^2 = 12.408$, $p < 0.0005$). Early successional forest was more likely to have >5% invasive plant coverage than later successional forest ($X^2 = 8.269$, $p < 0.005$).

Table 1. Plot data

ID	LiDAR ht (m)	Community type	Dominant canopy trees	mean canopy dbh (cm)	# layers ≥25% (excluding non-native)	% invasive cover	Oaks dominant or co-dom.	Tulip poplar dominant or co-dom.	Early successional?	Invasives <10%?
1	41	Successional mesic hardwood forest	*Liriodendron tulipifera, Juglans nigra*	67.4	3	85	n	y	y	n
2	35	Mid-successional mesic mixed hardwood forest	*Liriodendron tulipifera, Quercus coccinea*	69.4	2	5	y	y	n	y
4	38	Mid-successional mesic mixed hardwood forest	*Liriodendron tulipifera*	62.3	3	20	n	y	n	n
5	33	Floodplain forest	*Platanus occidentalis, Liriodendron tulipifera*	42.9	2	10	n	y	y	n
6	34	Silver maple floodplain forest	*Acer saccharinum*	37.3	3	5	n	n	y	y
7	31	Successional mesic hardwood forest	*Liquidambar styraciflua*	36.6	5	10	n	n	y	n
8	32	Floodplain forest	*Platanus occidentalis*	38.5	1	85	n	n	n	n
9	35	Successional tuliptree forest	*Liriodendron tulipifera*	49.2	3	85	n	y	y	n
11	32	Oak-heath forest	*Quercus prinus*	52.6	3	0	y	n	n	y
12	32	Mesic mixed hardwood forest	*Quercus falcata, Liquidambar styraciflua*	70.3	3	25	y	n	n	n
13	34	Oak-heath forest	*Liquidambar styraciflua, Quercus alba*	46.9	4	0	y	n	n	y
14	29	Mesic mixed hardwood forest	*Liriodendron tulipifera, Fagus grandifolia, Quercus alba*	37.6	3	0	y	y	n	y
16	37	Successional tuliptree forest	*Liriodendron tulipifera*	67.8	2	90	n	y	y	n
17	38	Mesic mixed hardwood forest	*Liriodendron tulipifera, Quercus falcata, Q. alba*	69.6	3	5	y	y	n	y
18	31	Successional tuliptree forest	*Liriodendron tulipifera*	49.4	2	85	n	y	y	n
21	21	Early successional mesic hardwood forest	*Acer rubrum, Sassafras albidum*	20.2	1	85	n	n	y	n
22	11	Old field	*Diospyros virginiana*	10.8	2	95	n	n	y	n
29	21	Young floodplain forest	*Liquidambar styraciflua, Acer rubrum*	15.2	3	65	n	n	y	n

ID	LiDAR ht (m)	Community type	Dominant canopy trees	mean canopy dbh (cm)	# layers ≥25% (excluding non-native)	% invasive cover	Oaks dominant or co-dom.	Tulip poplar dominant or co-dom.	Early successional?	Invasives <10%?
32	26	Successional mesic hardwood forest	*Acer rubrum*	21.3	2	40	n	n	y	n
33	26	Successional mixed hardwood forest	*Liriodendron tulipifera, Liquidambar styraciflua*	46.2	3	90	n	y	y	n
34	22	Successional mixed forest	*Pinus virginiana, Betula nigra, Prunus serotina*	41.9	3	80	n	n	y	n
35	15	Early successional mixed hardwood forest	*Prunus serotina*	33.7	3	85	n	n	y	n
36	24	Mixed hardwood forest	*Liquidambar styraciflua, Quercus prinus*	45.0	4	0	y	n	n	y
40	23	Successional mesic hardwood forest	*Liriodendron tulipifera, Acer rubrum*	38.5	4	25	n	y	y	n
41	32	Oak-heath forest	*Quercus alba, Q. prinus*	63.9	3	10	y	n	n	n
42	24	Oak-heath forest	*Quercus coccinea*	41.5	4	0	y	n	n	y
43	25	Mid-successional oak-pine forest	*Quercus alba, Pinus taeda, Q. coccinea*	33.7	3	0	y	n	n	y

Discussion

We found that LiDAR canopy height alone could not be used to predict forest condition. Trees do not all grow at the same rate. In particular, tulip poplars are a fast-growing early successional tree and can reach a height >28 m in just 35-45 years, forming a monoculture or near-monoculture above a ground layer dominated by invasive non-natives. Figure 1 was taken in oak-heath forest 32 m in height. No invasive species were present. The plot in Figure 2 had an even taller canopy (37 m), but was dominated by *Liriodendron tulipifera*. The ground was almost entirely covered by invasive species, outcompeting native *Claytonia virginica* and *Arisaema triphyllum*.

Figure 1. Mature oak-heath forest in Elk Neck State Park with a LiDAR canopy height of 32 m. Canopy dominated by Quercus prinus, mean dbh = 52.6 cm, and no invasive plants present.

Figure 2. Successional tuliptree forest in Elk Neck State Park with a LiDAR canopy height of 37 m. Canopy dominated by Liriodendron tulipifera, mean dbh = 67.8 cm, and ground 90% covered by Microstegium vimineum and Berberis thunbergii.

It would be interesting to digitize 1930's aerial photos, and see if forest patches existing back then corresponded to mature forest today, with large canopy trees, a complex structure and a diversity of late successional species. This would have been our first option if such data had been available.

We did not test core vs. non-core forest or distance to edge, but in neighboring Harford County, we found that invasive exotic plants were a problem at all county parks, dominating the ground and shrub cover in half the plots. However, core forest had, on average, significantly fewer invasive plants than non-core forest. All plots with <40% invasives were in core forest. Only 3 of 12 plots in core forest had >40% invasives. Core forest also had higher total scores than non-core forest.

Invasive plants were more common near forest edges than when >50 m from the edge. Wetter soils tended to have more invasives than dryer soils, and younger forest tended to have more invasives than older forest. A few of the plots (12.5%) had no invasive plants. All of these were in

late-successional core forest, and were at least 80 meters from the nearest edge. Two were dry forest communities and one was mesic.

Many of the sites had little native groundcover (especially herbaceous plants). In the case of mesic sites, this might have been from deer overbrowsing, and we did spot a lot of deer or signs of deer (browsed plants, hoof prints, or droppings). Some sites dominated by invasives had few native plants, but some had many. At sites with too many deer, population control, coupled with fencing and restoration, might benefit forest understory composition.

Literature cited:

Allen, W., and T. Weber. 2016. Bat species mitigation framework for the Midwest wind energy multi-species habitat conservation plan (MWE). The Conservation Fund, Arlington, VA.

Beck, D. E. 1990. *Liriodendron tulipifera* L. In Burns, R. M., and B. H. Honkala, tech. coords. Silvics of North America: Vol. 2. Hardwoods; Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. pp. 406-416.

Canterbury, G., Martin, T., Petit, D., Petit, L., Branford, D. 2000. Bird communities and habitat as ecological indicators of forest condition in regional monitoring. Conservation Biology 14, 544-558.

Conservation Fund (The), Susquehannock Wildlife Society, J. Akers, and Harford County Dept. of Planning and Zoning. 2018. Harford County green infrastructure plan (Draft). Harford County Dept. of Planning and Zoning, Bel Air, MD.

Jones, C., McCann, J., McConville, S. 2000. A guide to the conservation of forest interior dwelling birds in the Chesapeake Bay Critical Area. Chesapeake Bay Critical Area Commission, Annapolis, MD, USA.

O'Connell, T. J., Jackson, L. E., Brooks, R. P. 2000. Bird guilds as indicators of ecological condition in the Central Appalachians. Ecological Applications 10, 1706-1721.

Odum, E. P. 1969. The strategy of ecosystem development. Science 164, 262-270.

Weber, T. C., and W. L. Allen. 2010. Beyond on-site mitigation: An integrated, multi-scale approach to environmental mitigation and stewardship for transportation projects. Landscape and Urban Planning 96, 240-256.

Weber, T. C., Blank, P. J., Sloan, A. 2008. Field validation of a conservation network on the eastern shore of Maryland, USA, using breeding birds as bio-indicators. Environmental Management 41, 538–550.

Weber, T. C., and D. E. Boss. 2009. Use of LiDAR and supplemental data to estimate forest maturity in Charles County, Maryland, USA. Forest Ecology and Management 258:2068-2075.

FOREST AGE RAPID FIELD ASSESSMENT

(VERSION 2019-03)

Site name (e.g., park name) _____ Sample point ID_____

Latitude_____ Longitude_____ Date _____

Investigators _____ Photos taken (yes/no) 1-N; 2-E; 3-S; 4-W

Signs of human and/or natural disturbances (describe):

Approximate percent of site visibly disturbed (e.g., % of area selectively logged or mowed):

Signs of past history, wildlife observed, and other notes:

Size and species of ten canopy trees closest to center point. (*make sure they are canopy trees!*)

	Species (write "snag" if dead)	**dbh in inches (if cm, please note)**	**Vines on trunk? (y/n)**
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Mean dbh of live trees _____

Community type (ECG if known): _____

Invasive exotic species % ground covered by exotic species: _____	**Extent of invasive exotic species (circle one)**				
	Absent	Present, but uncommon	Common but not dominant	Dominant	Site overrun
List the most common invasive species observed:					

Would the forest community benefit from active management such as invasive species control or tree planting?

VEGETATION STRUCTURE AND DOMINANT SPECIES

Stratum (note: not all strata may be present)	**% cover**	**Most common species**
Canopy layer		
Upper subcanopy (>10m; below canopy)		
Lower subcanopy (3-10m)		
Shrub layer (1-3m)		
Ground layer (<1 m)		

TREE SEEDLINGS (Check one)

(note: abundant is defined as >10 seedlings within a 5m radius center plot)

Seedlings of nut-producing trees (oaks, hickories, beech) abundant	
Seedlings of other late successional trees (hemlock, dogwood, etc.) abundant.	
Seedlings of nut-producing trees (oaks, hickories, beech) present, but not abundant	
Seedlings of other late successional trees present, but not abundant. Seedlings dominated by pioneer trees, or few seedlings of any type.	
Seedlings of only pioneer trees (e.g., pines, red cedar, sumac, sweetgum, sycamore, tulip poplar, red maple) present	
No seedlings present	
Only exotic seedlings present	

APPENDIX G: Plant Survey & Wildlife Habitat Assessments

123 Elk Mills Road Plant Survey Report

Note: Comparison of 1977 and 1938 aerial photographs shows both pieces of woodland in the same places, and wooded as present. Especially the north woods looks mature.

Common weedy species of chickweed, and Crucifers, etc. are omitted.
"N", "F" – native or foreign to Maryland.
"*" – in flower on the date indicated.

A). Wet Zone, mainly east of the stream.
This is mostly covered with a thin woods that ends at the edge of a field to the north. Much of the ground is muddy in April, poorly drained by a small stream.

aa Real Name	Common Name	N,F	Dates, locations, notes
Acer rubrum	Red maple	N	4/19/19, scattered
Albizia julibrissin	Mimosa	F	5/21/19
Alnus sp.	alder		5/21/19, by the stream.
Anemone quinquefolia	windflower	N	4/19/19 at 39.91/50.82, a colony 6' in diameter, not flowering.
Anthoxanthum odoratum	Sweet vernal grass	F	*5/21/19
Arisaema triphyllum	Jack in the pulpit	N	*4/19/19; a few, scattered
Barbarea vulgaris	Wintercress	F	*4/19/19
Bromus commutatus (prob.)	Hairy chess	F	*5/21/19
Carex atlantica ssp. atlantica	Sedge	N	*5/21/19. Very common in wet places.
Carex laevivaginata	Sedge	N	*5/21/19
Carex lurida (prob.)	Sedge	N	*5/21/19
Claytonia virginica	Spring beauty	N	4/19/19 near 39.88/50.82, under pines
Cornus florida	dogwood	N	*4/19/19, in the Northwestern extension of the wet zone
Dactylis glomerata	Orchard grass	F	*5/21/19
Elaegnus umbellata	Autumn olive	F	4/19/19 at the edge of a field
Eleocharis tenuis (?)	Slender spike-rush	N	*5/21/19
Erigeron philadelphicus	Daisy fleabane	N	*5/21/19
Glechoma hederacea	Gill-over-the-ground	F	*5/21/19
Glyceria striata	Fowl mannagrass	N	*5/21/19
Ilex opaca	American holly	N	5/21/19
Ilex opaca	American holly	N	4/19/19, scattered, biggest ~6" diam
Impatiens sp.	Touch-me-not	N	5/21/19. Widespread, but not yet in flower.
Juncus effusus	Soft rush	N	*5/21/19
Juncus tenuis (?)	Path rush	N	*5/21/19. These plants seem too fragile to be this species.
Lilium sp. (?)			4/19/19 at 39.95/50.80; 3 single leaves at base of a tree, more later S of here.
Lindera benzoin	spicebush	N	5/21/19
Liriodendron tulipifera	Tulip poplar	N	4/19/19
Lonicera japonica	Japanese honeysuckle	F	4/19/19, scattered
Luzula multiflora	Wood rush	N	4/19/19 on mounds
Malus coronaria	Sweet crabapple	F	*4/19/19 at the edge of the wood.

Nyssa sylvatica	tupelo	N	*5/21/19
Onoclea sensibilis	Sensitive fern	N	4/19/19, scattered
Parthenocisses quinquefolia	Virginia creeper	N	4/19/19
Phalaris arundinacea	Reed canary grass	N	*5/21/19. A 5-foot patch.
Pinus strobus	White pine	~N	4/19/19. These are scattered in the south west quadrant. They range from 7 inches to over 2 feet in diameter. I saw no cones or seedlings.
Pinus virginiana	Virginia pine	N	4/19/19; near the entrance
Platanus occidentalis	Sycamore	N	5/21/19. Scattered saplings.
Podophyllum peltatum	May apple	N	4/19/19 in groups of 2 or 3 only, in the drier SW quadrant.
Potentilla canadensis	Cinquefoil	N	*5/21/19
Potentilla simplex	Old-field cinquefoil	N	*4/19/19
Prunus serotina	Black cherry	N	5/21/19
Quercus palustris	Pin oak	N	5/21/19
Quercus phellos	Willow oak	N	5/21/19. Only seedlings seen
Ranunculus sp.	buttercup		*5/21/19. In flower, but seedsare necessary to identify it to species.
Rhus typhina	Staghorn sumac	N	5/21/19
Rosa multiflora	Multiflora rose	F	*5/21/19
Rubus allegheniensis	Common blackberry	N	*5/21/19
Rumex obtusifolia	Bitter dock	F	5/21/19
Sambucus canadensis	elderberry	N	5/21/19, not yet in flower
Sisyrinchium angustifolium	Blue eyed grass	N	*5/21/19
Smilacina racemosa	False Solomon's seal	N	4/19/19 at 39.88/50.82, a few.
Smilax rotundifolia	catbrier	N	5/21/19
Smilax rotundifolia	Cat brier	N	4/19/19, scattered
Symplocarpus foetidus	Skunk cabbage	N	4/19/19, scattered densely in the wettest spots.
Toxicodendron radicans	Poison ivy	N	4/19/19 scattered
Trifolium dubium/campestre	Hop-clover	F	*5/21/19
Viburnum dentatum	Arrow-wood	N	5/21/19, by the stream
Viola soraria	Common blue violet	N	*4/19/19, scattered
Vitis labrusca	Fox grape	N	5/21/19
Zizia aurea	Golden alexander	N	*4/19/19 at N39deg 39.90 minW75deg50.79 min, in a wet place; and elsewhere

B). Woodland.

This upland wood is unusual in the large number of beech trees that it contains, in the paucity of shrubs (such as spicebush), and in the almost total lack of understory herbs. (Could they have been eliminated by drifting of weedkiller from adjacent fields?)
It looks like mature woodland on both the 1938 the 1977 aerial photographs.

Acer rubrum	Red maple	N	5/21/19
Carya sp.	Hickory	N	5/21/19
Celastrus scandens	Oriental bittersweet	F	4/19/19
Euonymus americanus	Hearts-a-bursting	N	4/19/19, a few
Fagus grandifolia	American beech	N	5/21/19
Liriodendron tulipifera	Tulip poplar	N	5/21/19
Medeola virginiana	Indian cucumber root	N	4/19/19 one small colony in the older, south part of the wood.
Nyssa sylvatica	Tupelo	N	5/21/19. Two big ones at N 40.265/50.834 on opposite sides of a path: one is 22 inches in diameter (228 cm. in circumference).
Parthenocissus quinquefolia	Virginia creeper	N	4/19/19
Podophyllum peltatum	mayapple	N	4/19/19 many large patches .
Quercus alba	White oak	N	5/21/19
Quercus falcata	Spanish oak	N	5/21/19
Quercus palustris	Pin oak	N	5/21/19
Quercus rubra	Red oak	N	5/21/19
Tipularia discolor	Cranefly orchid	N	4/19/19 one leaf seen in the younger, northern sector of the wood.
Viburnum dentatum	Arrow wood	N	4/19/19 one shrub in the middle of the wood
Viola soraria	Common blue violet	N	*4/19/19 scattered thinly

The following table shows the numbers and frequency of each tree in these woods. The data was obtained by walking randomly through the south western part of the woods and recording the size and species of each tree encountered whose diameter at breast height was greater than 4 inches. Species that I could not immediately identify, were lumped in “other”. The frequency of beech is much higher than in most wood patches in the Fair Hill park

Species	number	frequency
Fagus grandifolia.	82	0.44
Liriodendron tulipifera.	42	0.22
Carya sp.	6	0.03
Acer rrubrum.	12	0.06
Quercus alba.	8	0.04
Quercus falcata.	1	0.005
Nyssa sylvatica.	11	0.06
Quercus palustris.	7	0.04
Quercus rubra.	5	0.03
Other	14	0.07

Also, the diameter of each tulip poplar was recorded, for use in estimating the date of the most recent clearing event.

SUSQUEHANNOCK WILDLIFE SOCIETY
1725 Trappe Church Road Darlington, MD 21034
443-333-WILD (9453) contact@suskywildlife.org
www.suskywildlife.org

Wildlife Habitat Assessment

For: Cecil County Government Green Infrastructure Project

Site: Elk Mills Park

Overview: Members of the Susquehannock Wildlife Society including a master naturalist and field researchers surveyed the county property within hub/corridor network to determine both wildlife habitat and document any wildlife present during multiple visits during winter and spring of 2019.

Methods: Strategic placement of digital trail cameras, visual surveys, review of recent historic data for adjoining and nearby sites.

Habitat Types with Species: The property exhibits a unique variety of habitat zones that support the needs of many wildlife species despite being a somewhat narrow corridor.

Forest: Forest is the main feature of this area with half being in the floodplain of a small creek and the other half being an agricultural area. The forest appears to be healthy in sections with some diversity of tree species in different age classes in the southern section but many stretches to the north are dominated by beech trees and much is grazed heavily by deer. Invasive plant presence is noticeable in areas but has not yet overtaken. Along the forest floor many logs and rocks were found that provide cover for amphibians such as toads and salamanders as well as snakes and insect species. The forest provides an adequate expanse that acts as a corridor between other protected areas such as Fairhill Natural Resource Management Area to the north that will support eastern box turtles, several native owl species, a variety of song birds, woodpeckers, red fox, white-tailed deer, gray squirrel, chipmunks, opossum, striped skunk, raccoon, and other species.

Creek and Spring Seeps: The creek certainly has some heavy sedimentation due to the agricultural area runoff, which appears to have occurred more recently with modifications to the stormwater runoff grading of the farm fields. The creek provides water for woodland birds and mammals, including the potential for mink as well as habitat for a variety of small fish and salamanders if restored. There are several spring seeps that provide additional habitat, a water source, and saturated soil that can support additional plant and animal species. This site provide opportunity for spring amphibian breeding and egg laying for red salamanders and other springhead focused species. With the several springhead areas that we confirmed, a handful of sensitive species could use them to breed and go through their metamorphosis.

Trail Camera Survey Species Confirmation (On Site):

Red fox
Groundhog
Red-tailed hawk
Raccoon
Opossum
Gray squirrel
White-tailed deer
Red-shouldered hawk
Blue jay
Turkey vulture

Observed Survey Species Confirmation (On Site):

Deer mouse
Red-tailed hawk
Green frog
Painted lady butterfly
White-tailed deer
Barn swallow
Tree swallow
White-throated sparrow
Cope’s gray treefrog
Blue azure butterfly
Racoon (tracks)
Cabbage white butterfly
Leopard slug
Water strider
Wolf spider
American toad
Spring peeper (call)
American pipet
Horned lark
Northern red salamander (larvae)

Downy woodpecker
American crow
Common grackle
Yellow-bellied sapsucker
Tufted titmouse
American goldfinch
Blue jay
Feral cat
Eastern bluebird
Great crested flycatcher
Red-eyed vireo
Carolina wren
House wren
Cedar waxwing
Blackpoll warbler
Northern parula
Blue-gray gnatcatcher
Northern cardinal
Common yellow-throat
American red-start
Ruby throated hummingbird
Gray catbird
Field sparrow
Brown headed cowbird
Grasshopper sparrow
Eastern wood pewee

Basic Plant Overview:

Much of the north forest is dominated by beech trees and the southern tract is a mix of pine and common deciduous trees. Due to deer grazing there are a fair number of invasive plants present, especially along creek and forest edge such mile-a-minute, multiflora rose, and Japanese stiltgrass. There is some healthy variety of ferns along the creek and wetland areas. Springfed wetland areas have skunk cabbage and jack-in-the-pulpit.

Recommendation: Due to the location as part of the ecologically valuable Fair Hill corridor, habitat and species diversity, a manageable number of invasive species, connectivity to other preserved areas, and more developed areas surrounding this corridor, the Susquehannock Wildlife Society strongly recommends that any connected properties and corridors be purchased, protected, and enhanced so that it may continue to provide a much needed refuge for species moving along the this corridor. We noticed a fair amount of human traffic on our trail cameras, predominantly horseback riding. We recommend use be limited to hiking. Increased use, a substantial increase in traffic or other destructive change of this property would be a loss for local conservation. We recommend that invasive species be kept in check and if deer herds are being managed then it should continue. Native trees and plants should be introduced where possible. Bird nesting boxes could be installed to enhance populations of species such as bluebirds, owls, kestrels, woodpeckers, etc. We feel the most significant management recommendation is to create a native grass and wildflower corridor between the southern and northern forest tracts to connect habitat across the agricultural tract which likely prevents much of the movement across the property. Meadow habitat will increase diversity of species, provide cover, and food sources.

Susquehannock Wildlife Society

May 28, 2019

SUSQUEHANNOCK WILDLIFE SOCIETY
1725 Trappe Church Road Darlington, MD 21034
443-333-WILD (9453) contact@suskywildlife.org
www.suskywildlife.org

Wildlife Habitat Assessment

For: Cecil County Government Green Infrastructure Project

Site: Elk River Park

Overview: Members of the Susquehannock Wildlife Society including a master naturalist and field researchers surveyed the county property within hub/corridor network to determine both wildlife habitat and document any wildlife present during multiple visits during winter and spring of 2019.

Methods: Strategic placement of digital trail cameras, visual surveys, review of recent historic data for adjoining and nearby sites.

Habitat Types with Species: The property exhibits a unique variety of habitat zones that support the needs of many wildlife species despite being an island near larger conservation conservation lands, it's proximity to a major water source allows it more connectivity

Forest: The forest appears to be fairly sparse in many areas of the park with some of the buffer along the shoreline having somewhat more diversity. Some areas with previously planted reforestation trees appears to be doing well. Invasive plant presence is noticeable in areas along the shoreline and understory where mowed grass isn't present. Along the forest floor there aren't many logs or rocks to provide cover for amphibians such as toads and salamanders habitat for hiding. Some of the interior areas have well established older trees but much of the forest is successional forest dominated by sweet gum and maple. The forest, especially along the Elk river and the more mature forest area does support edge habitat for eastern box turtles, hawks, a variety of song birds, woodpeckers, red fox, white-tailed deer, gray squirrel, opossum, striped skunk, raccoon, and other species that are tolerant of human activities.

Open Space & Sediment Pond: While no significant wetlands were discovered within the land areas, a large sediment pond that receives dredge materials and a few smaller stormwater ponds hold water and provides habitat for wading birds and reptiles and amphibians. The ponds were subject to invasive plants due to disturbance and characteristics and habitat where little else can grow. Many areas of park are grass and paved road / parking. These areas may allow wildlife to move from one area to another but only for species that tolerant of human activity and not threatened moving in open areas.

Tidal Marsh and River: The surrounding edge of the property borders the Elk River north of where it transitions to the Chesapeake Bay, a freshwater tidal area. The main connecting corridor of this site is the waterfront where species that can swim may move to and from this park to other protected areas such as the nearby state park. This area provides adequate habitat for species that are accepting of open water. Some of the species using this area may include a variety of wading birds, wood ducks, beaver, muskrat, river otter, mink, great blue heron, eastern painted turtles, northern red-bellied turtles, eastern snapping turtles, green frogs, bullfrogs, southern

leopard frogs, Cope's gray tree frogs, spring peepers, northern water snakes, several species of fish, mollusks, crustaceans, and many insects.

Trail Camera Survey Species Confirmation (On Site):

Red Fox
Raccoon
White-tailed deer
River otter
Opossum
American robin

Observed Survey Species Confirmation (On Site):

Eastern painted turtle
Cope's gray treefrog
Northern water snake
Bald eagle
Bullfrog
Red-winged blackbird
Forster's tern
Blue jay
Mallard
Northern harrier
White-tailed deer
American toad
Eastern garter snake
Eastern bluebird
Spring peeper
Turkey vulture
Carolina chickadee
Northern mockingbird
Dark-eyed junco
Common grackle
Great blue heron
Common merganser

Bufflehead
Muskrat (lodges)
Beaver (sign)
American crow
Eastern cricket frog
Eastern box turtle
Double crested cormorant
Song sparrow
Brown headed cowbird
Tree swallow
Northern cardinal
Chipping sparrow
Great crested flycatcher
Barn swallow
Orchard oriole
Carolina wren
Scarlet tanager
Greater yellowlegs
Osprey
Least tern
Blue-gray gnatcatcher
American robin
American goldfinch
Indigo bunting
Red-eyed vireo
Wood thrush
Northern flicker
Prairie warbler
Yellow-breasted chat
Wood duck
European starling
Chipping sparrow
Black & white warbler
Blackpoll warbler

Solitary sandpiper
Lesser yellowlegs
Least sandpiper

Basic Plant Overview:

The forest contains mixed hardwoods with half early successful, sweet gum and maple dominated with some more mature forest further away from the disturbed areas. Deer grazing is prevalent in many locations at this site and continued or enhanced management of deer is recommended to maintain a healthy understory and a healthy deer population. High invasive understory diversity in areas, especially along river and forest edge such as multiflora rose, Japanese stiltgrass, English ivy and Japanese honeysuckle. Bradford pear is prevalent along the sediment pond and successional areas. Tidal wetland areas and sediment pond include cattails and invasive phragmites.

Recommendation: Due to the location as part of the ecologically valuable Elk River ecosystem, the Susquehannock Wildlife Society strongly recommends that any connected properties and corridors be purchased, protected, and enhanced so that it may continue to provide a much needed refuge for species moving along the Elk river corridor. We noticed a fair amount of human traffic at the site that while not possible to restrict, some actions may be able to prevent with signage and enforcement. There was multiple instances of metal detecting and disruption of our trail cameras while surveying. The feeding of wildlife, intentional or not, may be common at this park, and availability of food via the outdoor trash cans pose a threat to the health and survival of wildlife. We recommend more active enforcement of wildlife feeding policies and wildlife proof trash cans. Fishing line litter was also prevalent so we recommend that fishing line receptacles be installed to prevent wildlife injuries from monofilament entanglement. We recommend that some of the grass mowing areas be converted into a native wildflower meadow to create more habitat diversity and prevent additional sediment or runoff into the Elk River. Additional native trees should be planted in a different areas to provide an understory and create some diversity of species. Increased use, a substantial increase in traffic or other destructive change of this property would be a major loss for local conservation. We recommend that invasive species be kept in check and if deer herds are being managed then it should continue. Bird nesting boxes could be installed to enhance populations of species such as bluebirds, owls, kestrels, woodpeckers, etc. The existing bluebird box had a breeding pair of bluebirds using it so it is working well. The existing bat box should be better maintained as it was currently full of bee nests.

Susquehannock Wildlife Society

May 28, 2019

Appendix H: Roads, Bridges, & Public Sewer Infrastructure with Flood Vulnerability

Roads/Bridges/Sewer Lines

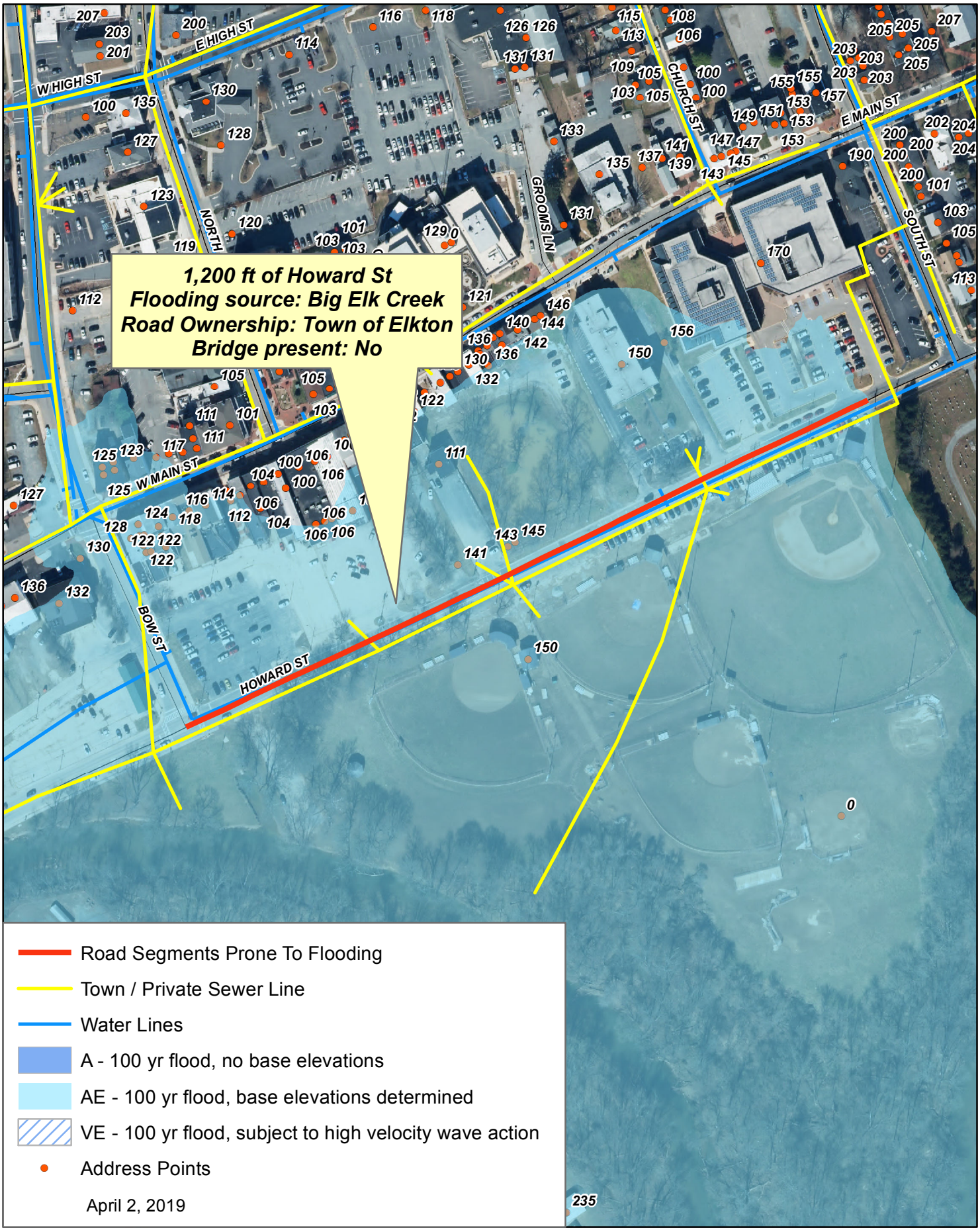
1. 200 block of Delaware Avenue.
2. 100 block of Howard Street.
3. 100-200 blocks of South Bridge Street (MD 213).
4. 300 block of Fletchwood Road.
5. Deaver & South Simpers Roads.
6. Elkton Road (MD 279) & West Pulaski Highway (US Rt. 40).
7. Ricketts Mill & Appleton Roads.
8. 900 block of Broad Street (MD 7).
9. 1400 block of Frenchtown Road.
10. 0-100 blocks of Edgewater Avenue.
11. 0 block of Shore Drive.
12. 0 block of North Main Street & 0-200 blocks of South Main Street (MD 272).
13. 100-200 blocks of West Cecil Avenue (MD 7).
14. 0 block of Washington Street.
15. 0-100 blocks of West Race Street.
16. 300-400 blocks of West Old Philadelphia Road (MD 7) & North East Isles Drive.
17. 500 block of Calvert Rd.
18. 300 block of Bank Street.
19. 300-500 blocks of Slicer's Mill Road.
20. Crothers and England Creamery Roads.
21. 0-100 block of Moore Road.
22. 1800 block of Principio Road.
23. 300 block of Wilson Road.
24. Oldfield Point Road at Jones Creek.

Other Public Sewer Infrastructure

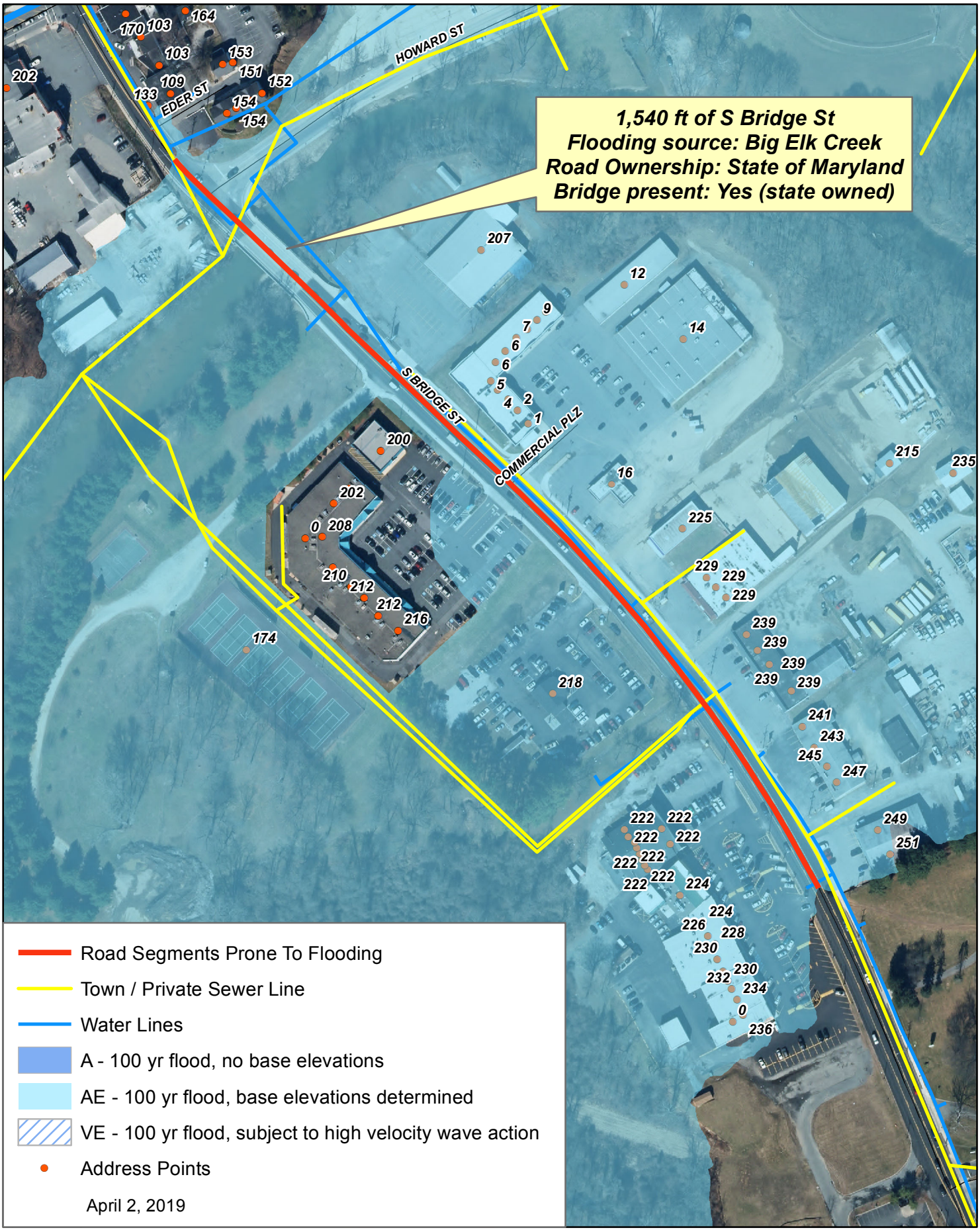
25. Stony Run Interceptor, Manholes 806 to 811.
26. Stony Run Interceptor, Manholes 831 to 850.
27. Stony Run Interceptor, Manholes 837 to 845.
28. Stony Run Interceptor, Manholes 856 to 858.
29. Stony Run Interceptor, Manholes 858 to 871.
30. Stony Run Interceptor, Manholes 872 to 876.
31. Stony Run Interceptor, Manholes 875 to 1211.
32. Stony Run Interceptor, Manholes 1282 to 1287.
33. Stony Run Interceptor, Manholes 1288 to 1396.

Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
200 block of Delaware Ave, Elkton, MD

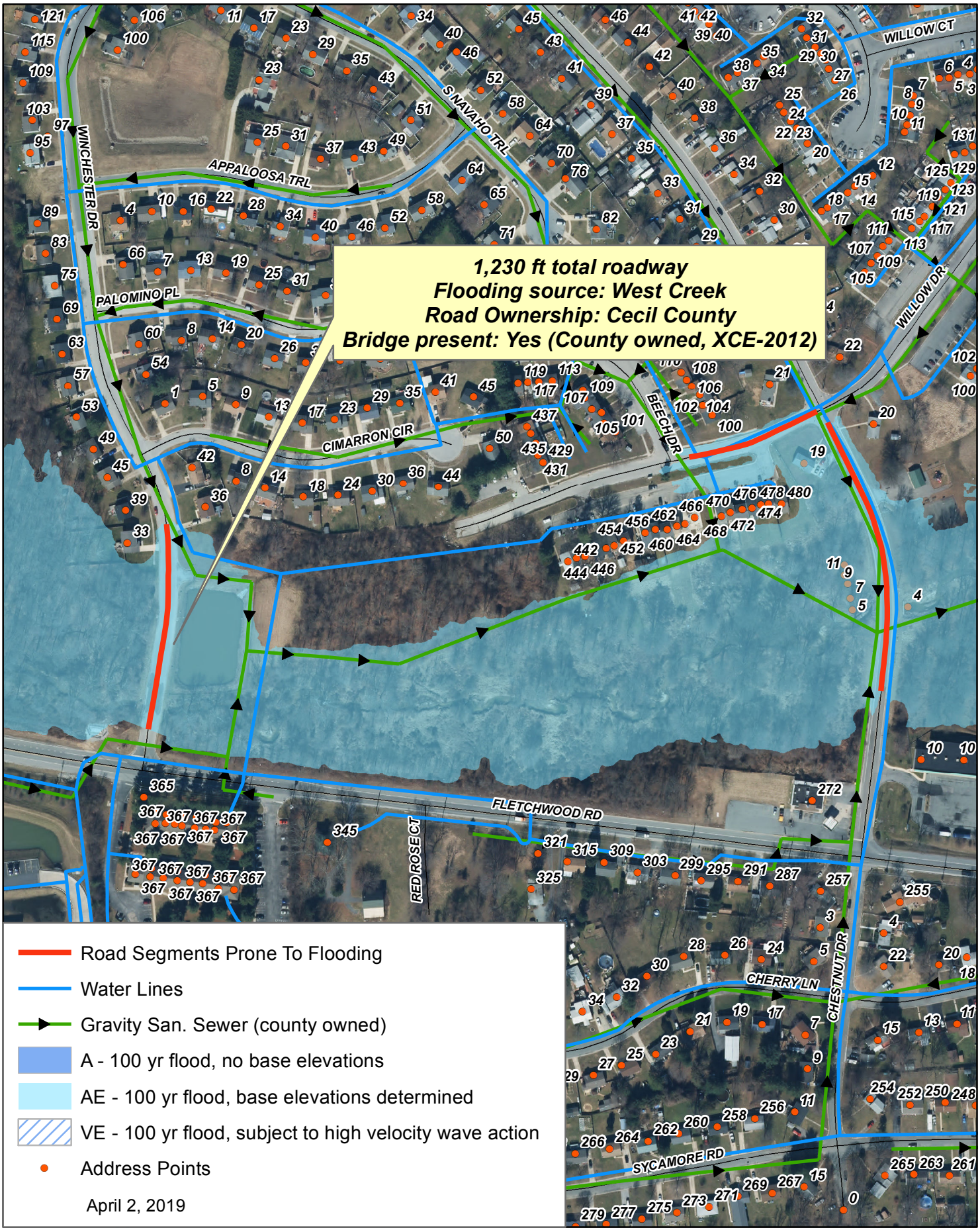
Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
100 block of Howard St, Elkton, MD



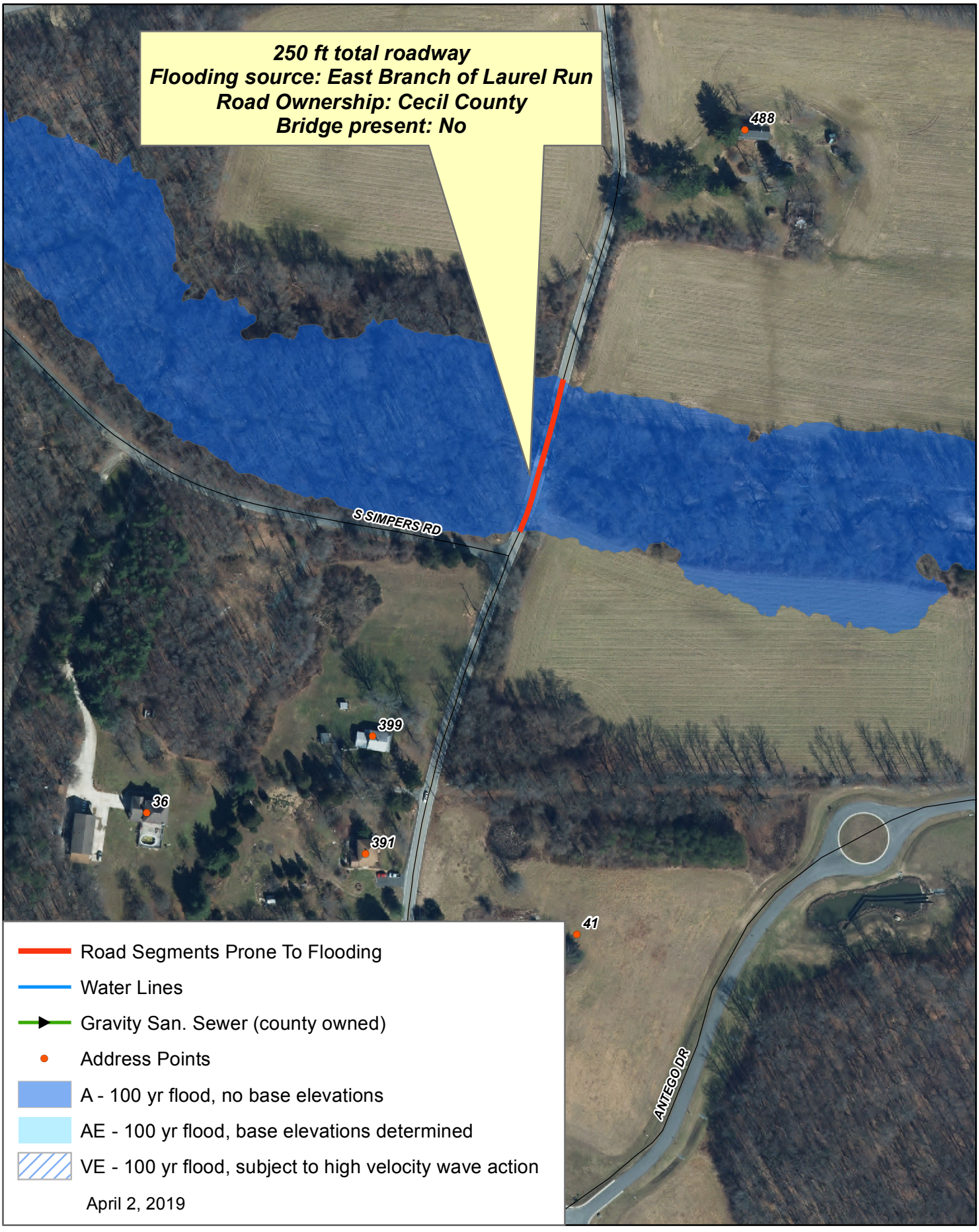
Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
100 and 200 block of S Bridge St, Elkton, MD



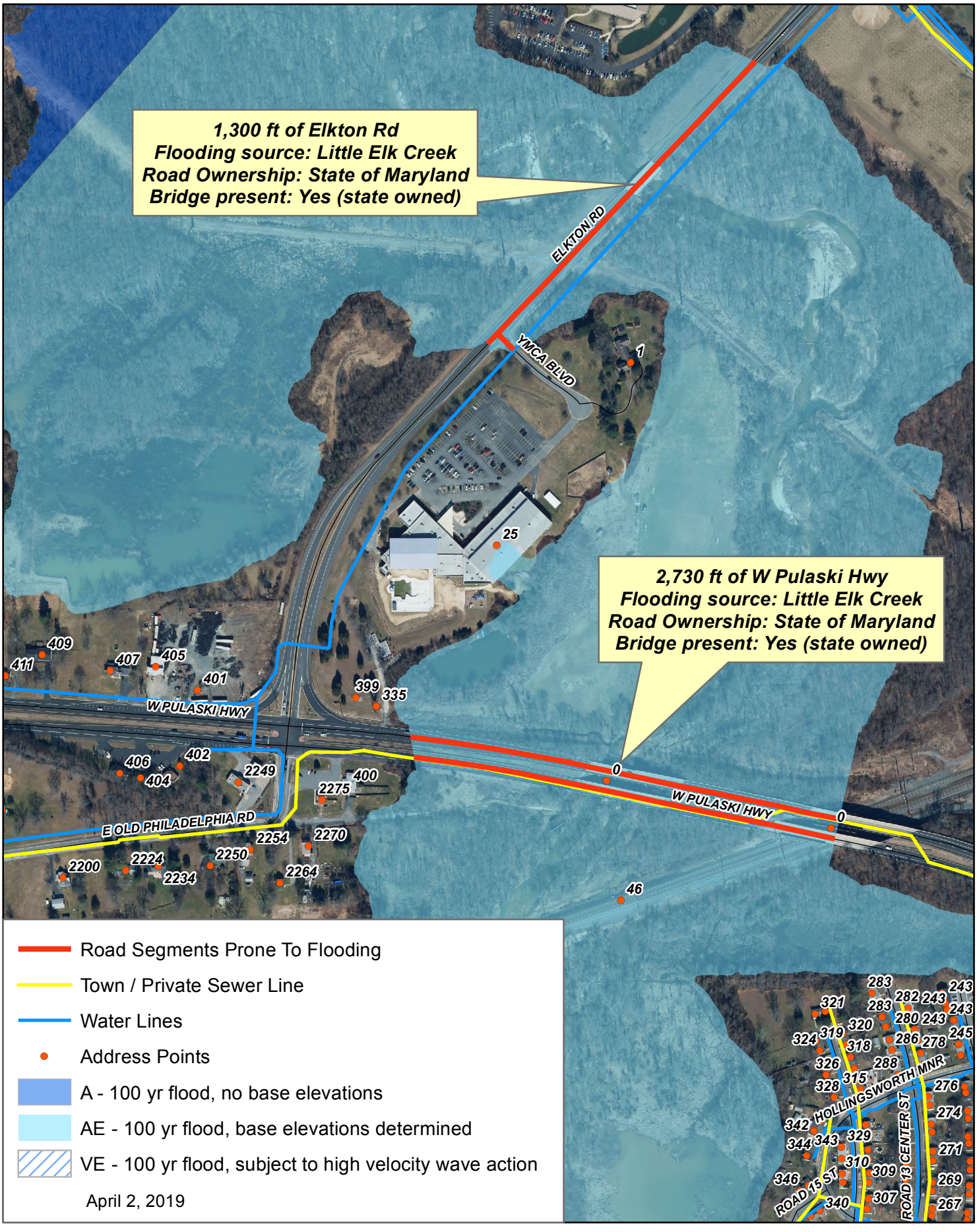
Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
Vicinity of 300 block of Fletchwood Rd, Elkton, MD



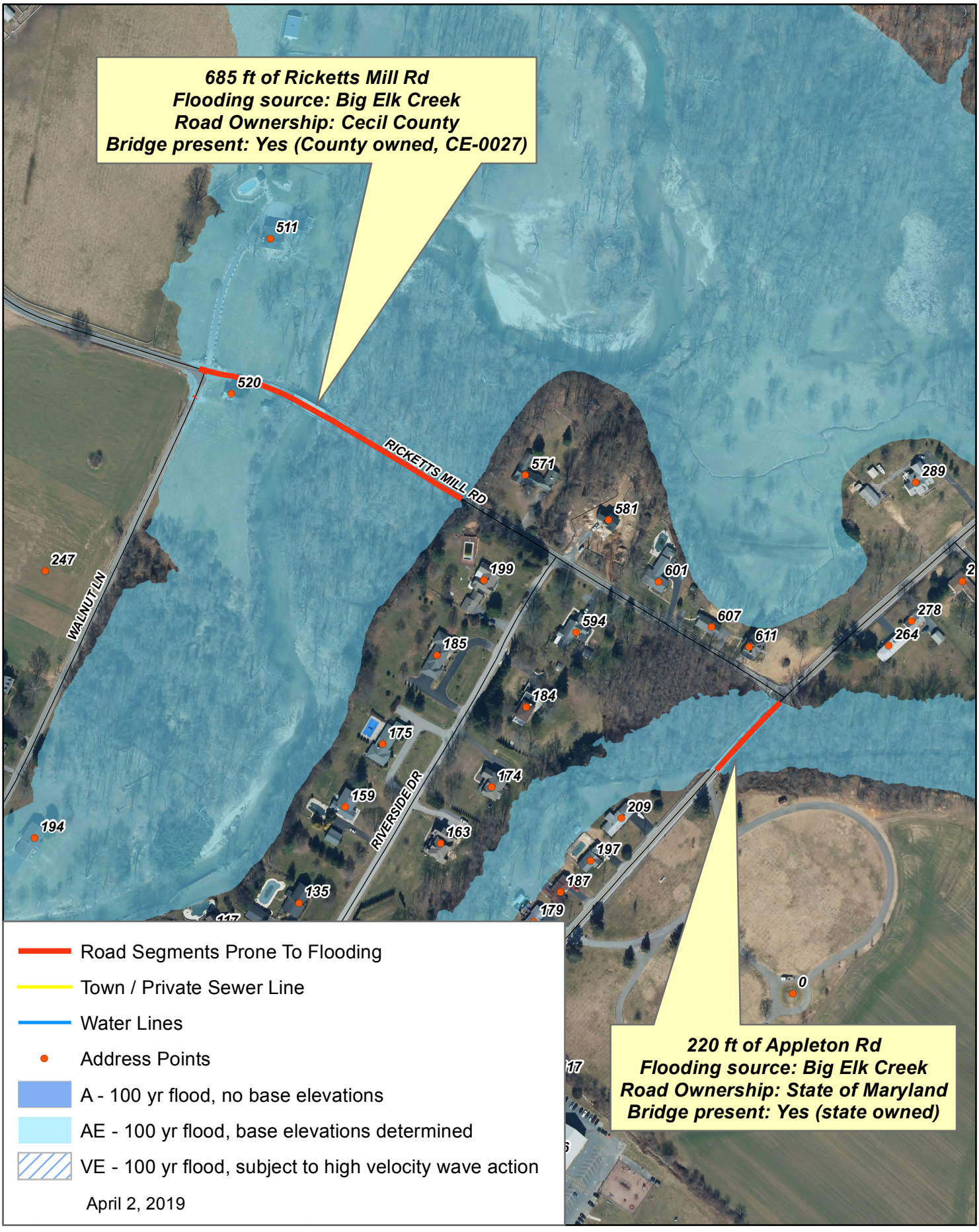
Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
Intersection of Deaver Rd and S Simpers Rd, Elkton, MD



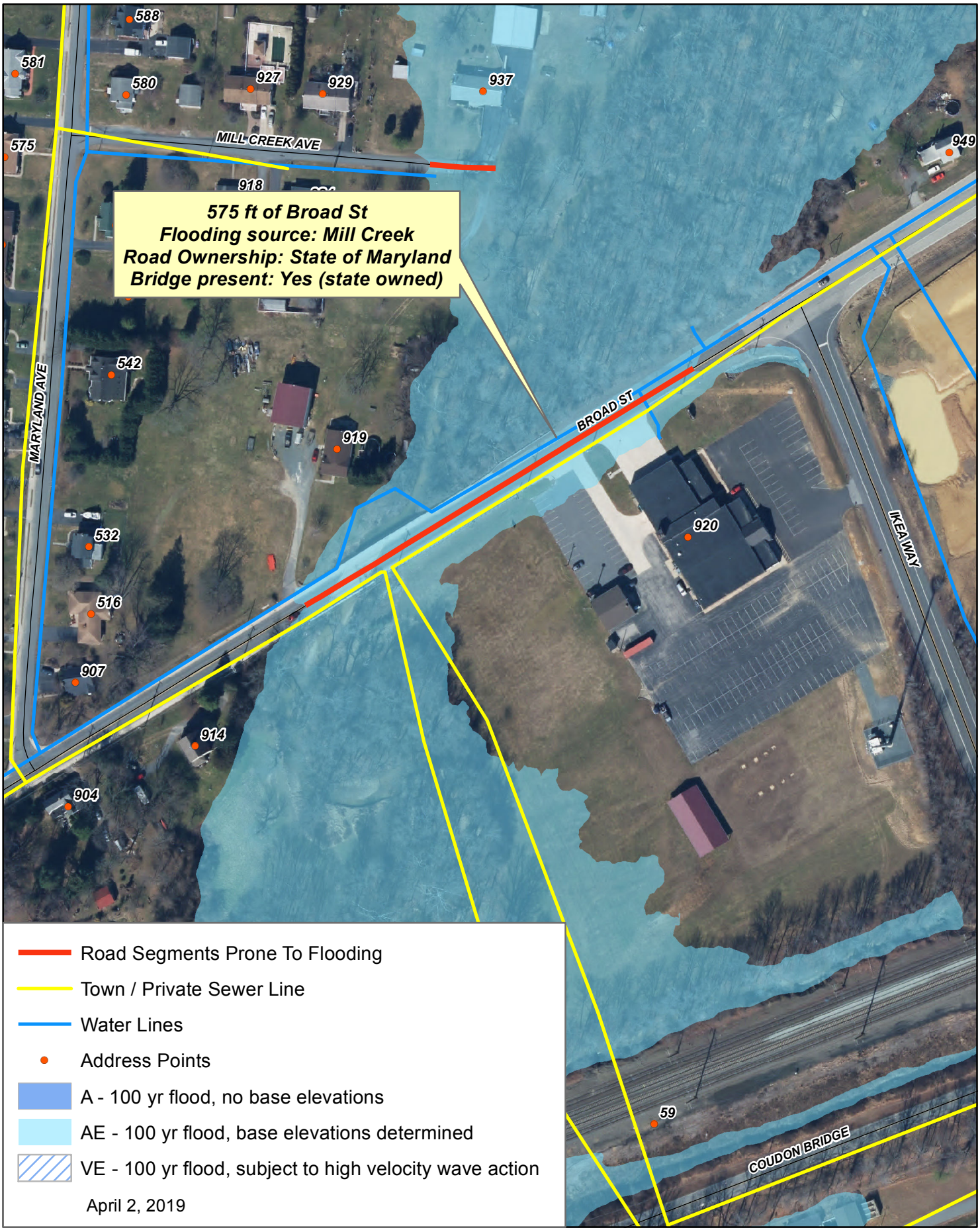
Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
Elkton Rd and W Pulaski Hwy, Elkton, MD



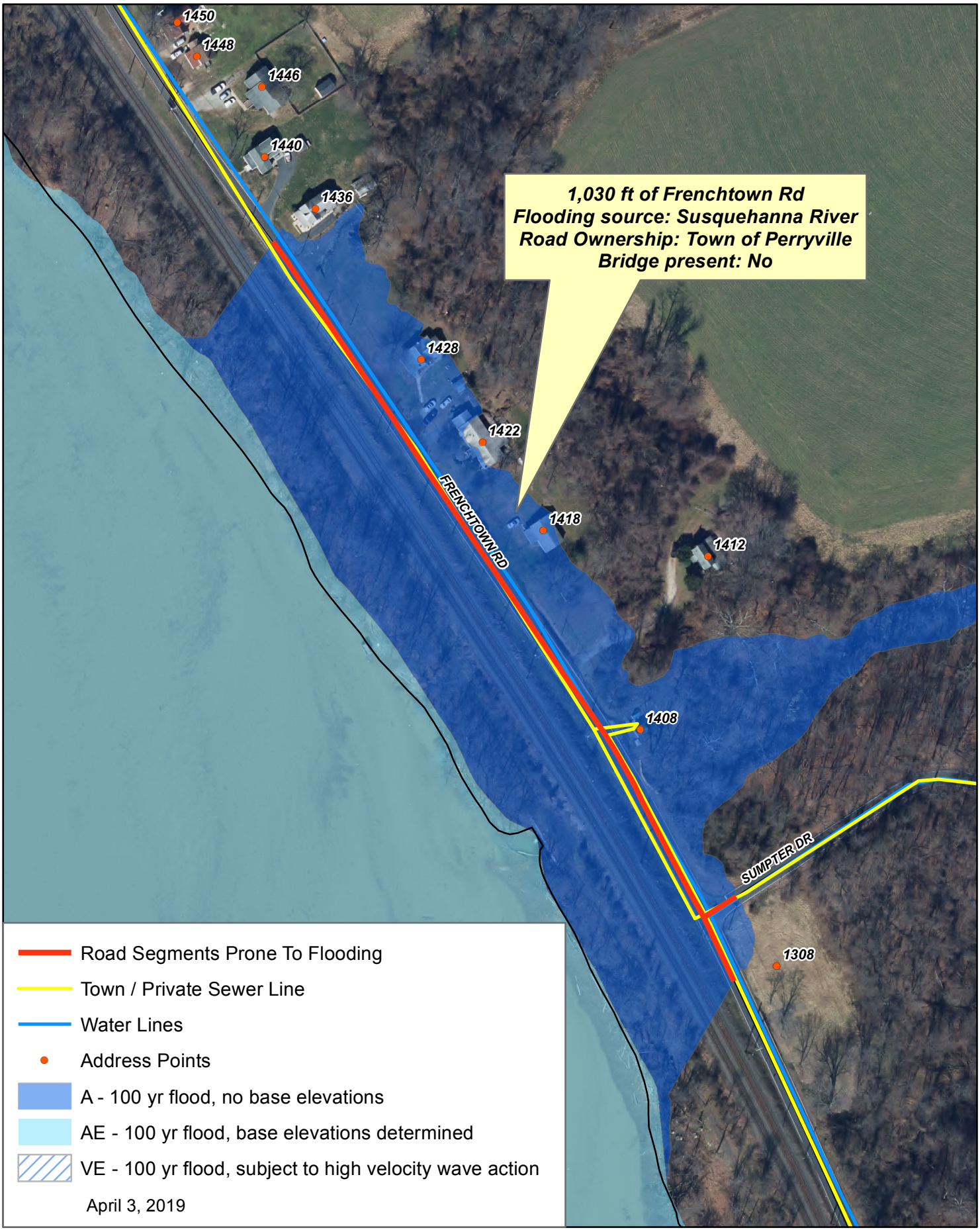
Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
Ricketts Mill Rd and Appleton Rd, Elkton, MD



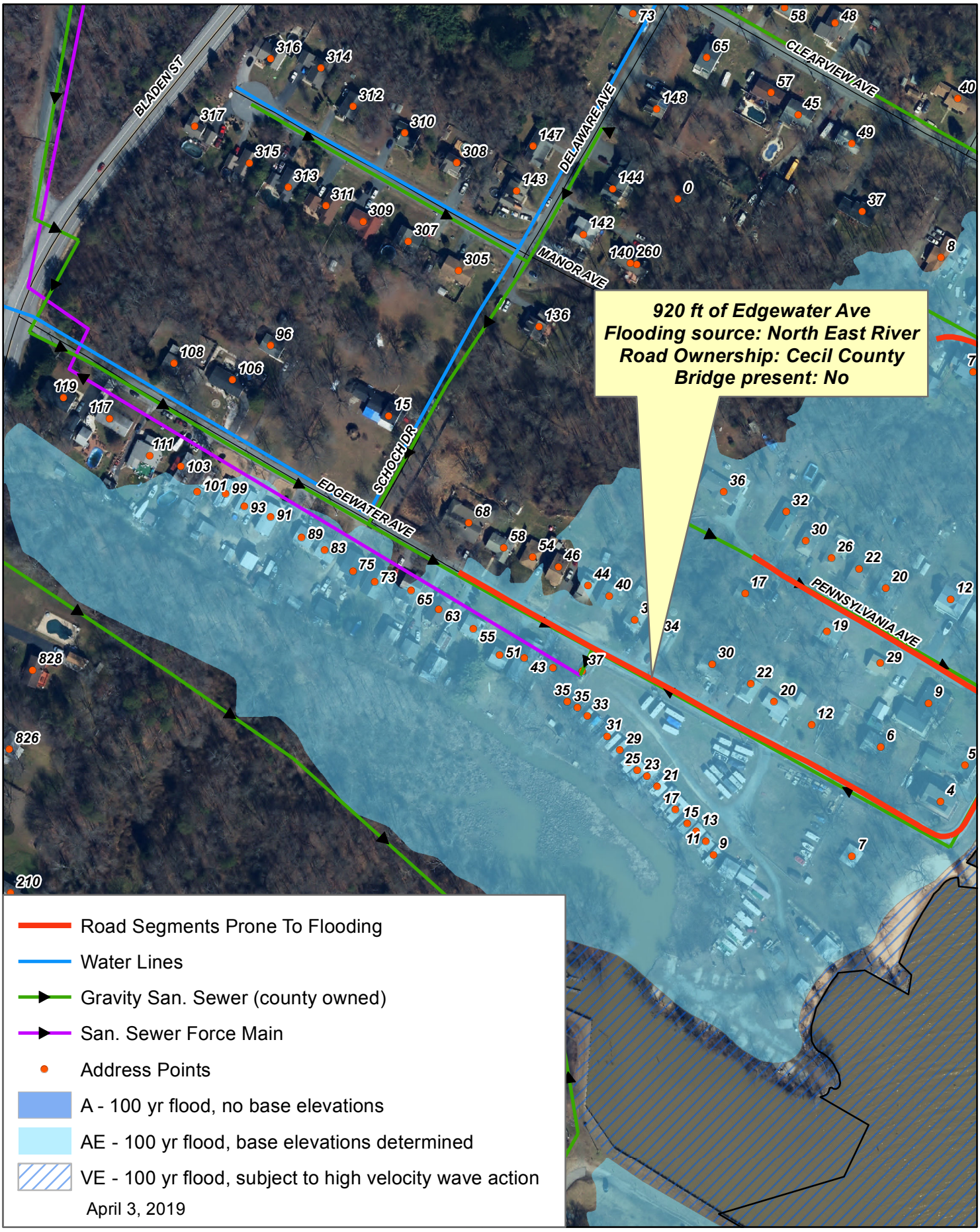
Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
900 block of Broad St, Perryville, MD



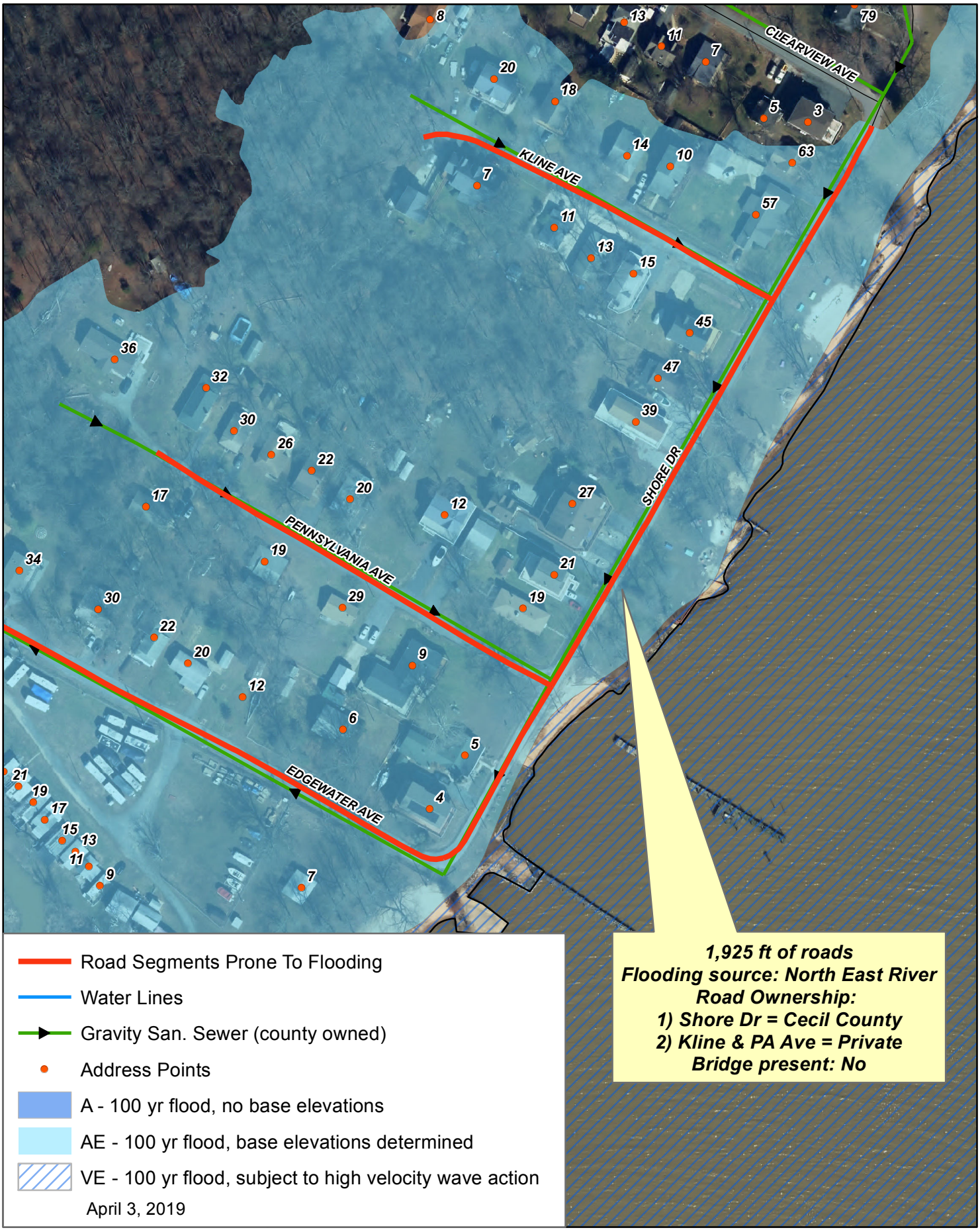
Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
1400 block of Frenchtown Rd, Perryville, MD



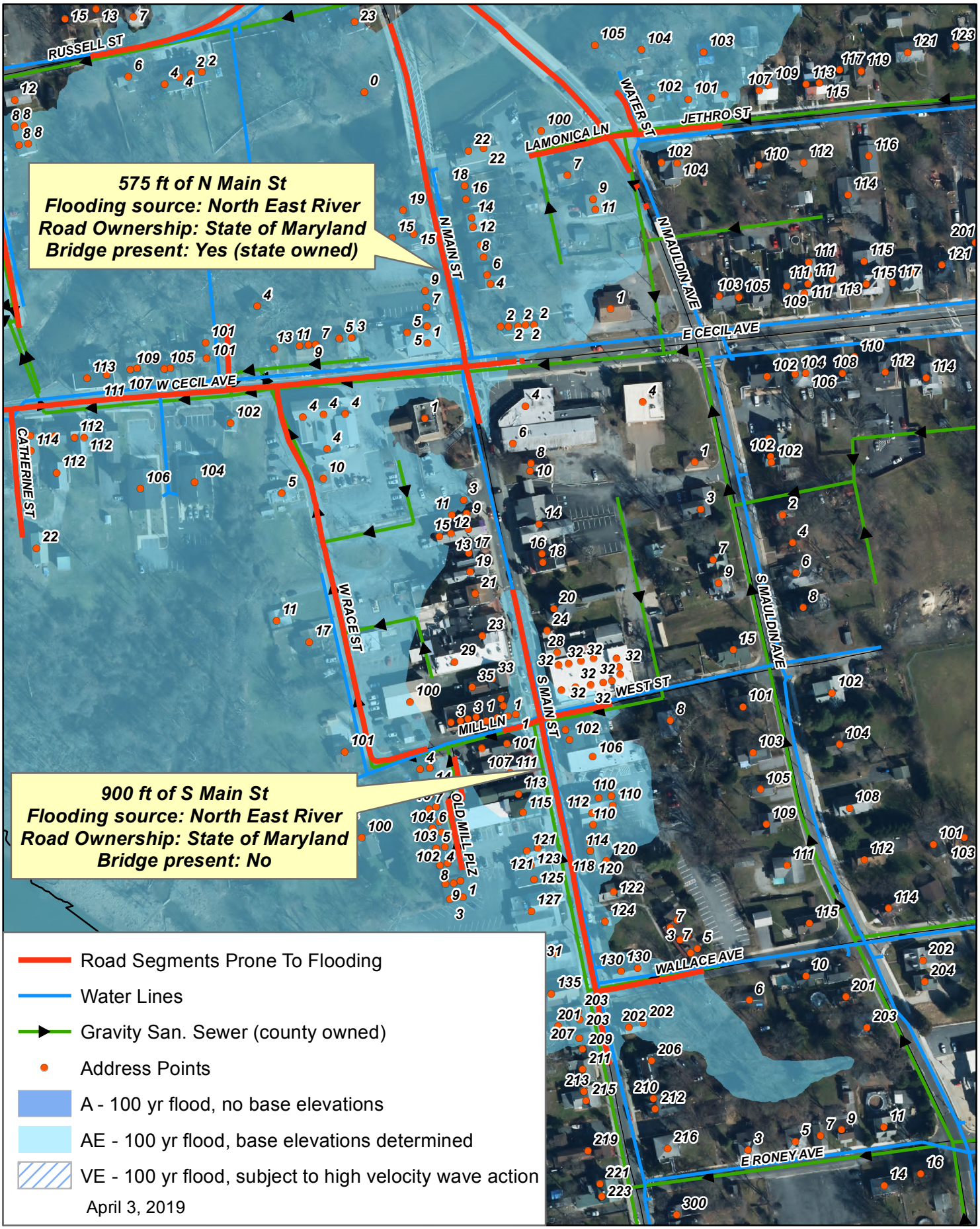
Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
Edgewater Ave, Charlestown, MD



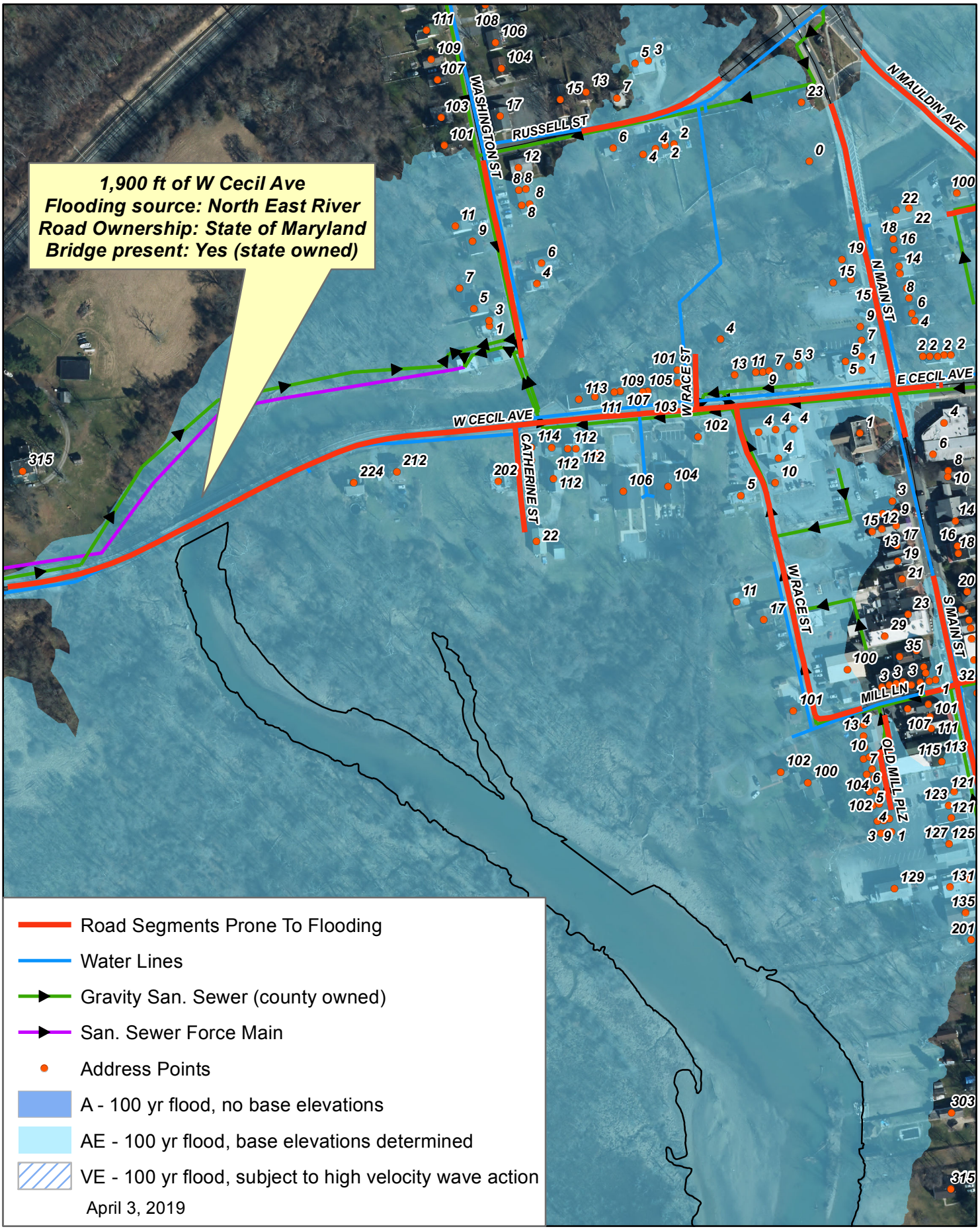
Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
Shore Dr, Pennsylvania Ave, and Kline Ave, Charlestown, MD



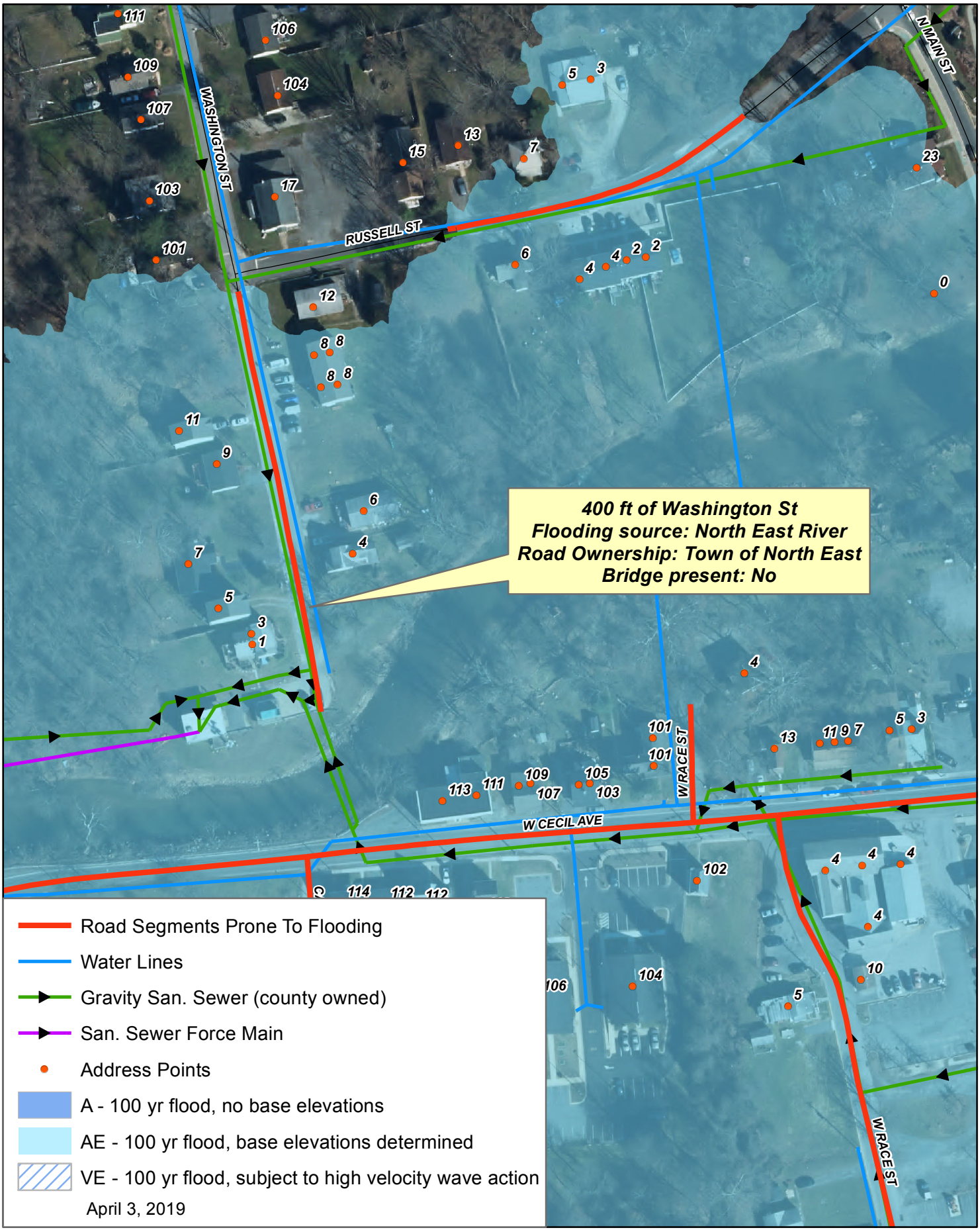
Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
N Main St (unit block) and S Main St (0-100 block), North East, MD



Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
W Cecil Ave (0-200 block), North East, MD

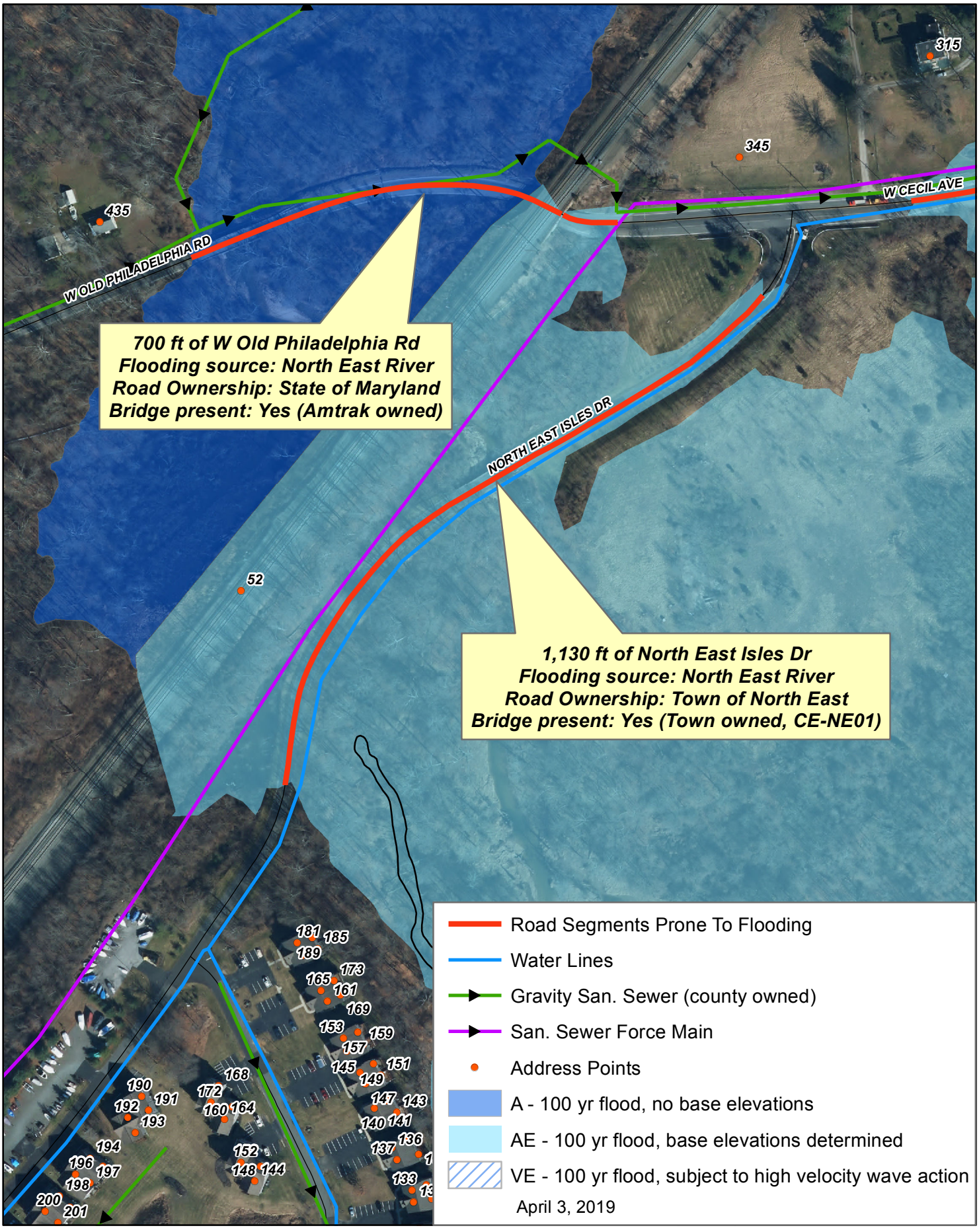


Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
Washington St (unit block), North East, MD

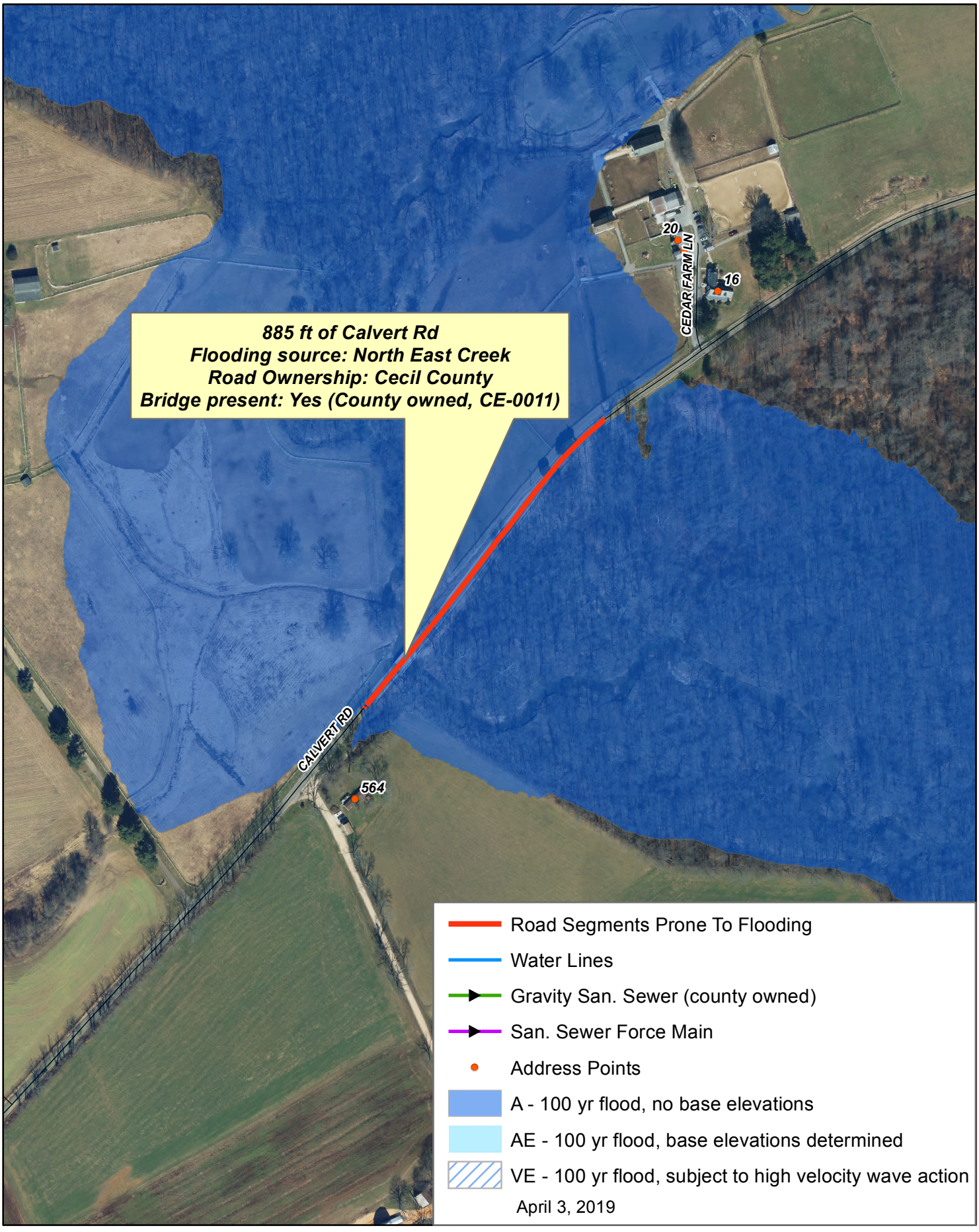


Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
W Race St (0-100 block), North East, MD

Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
W Old Philadelphia Rd & North East Isles Dr, North East, MD

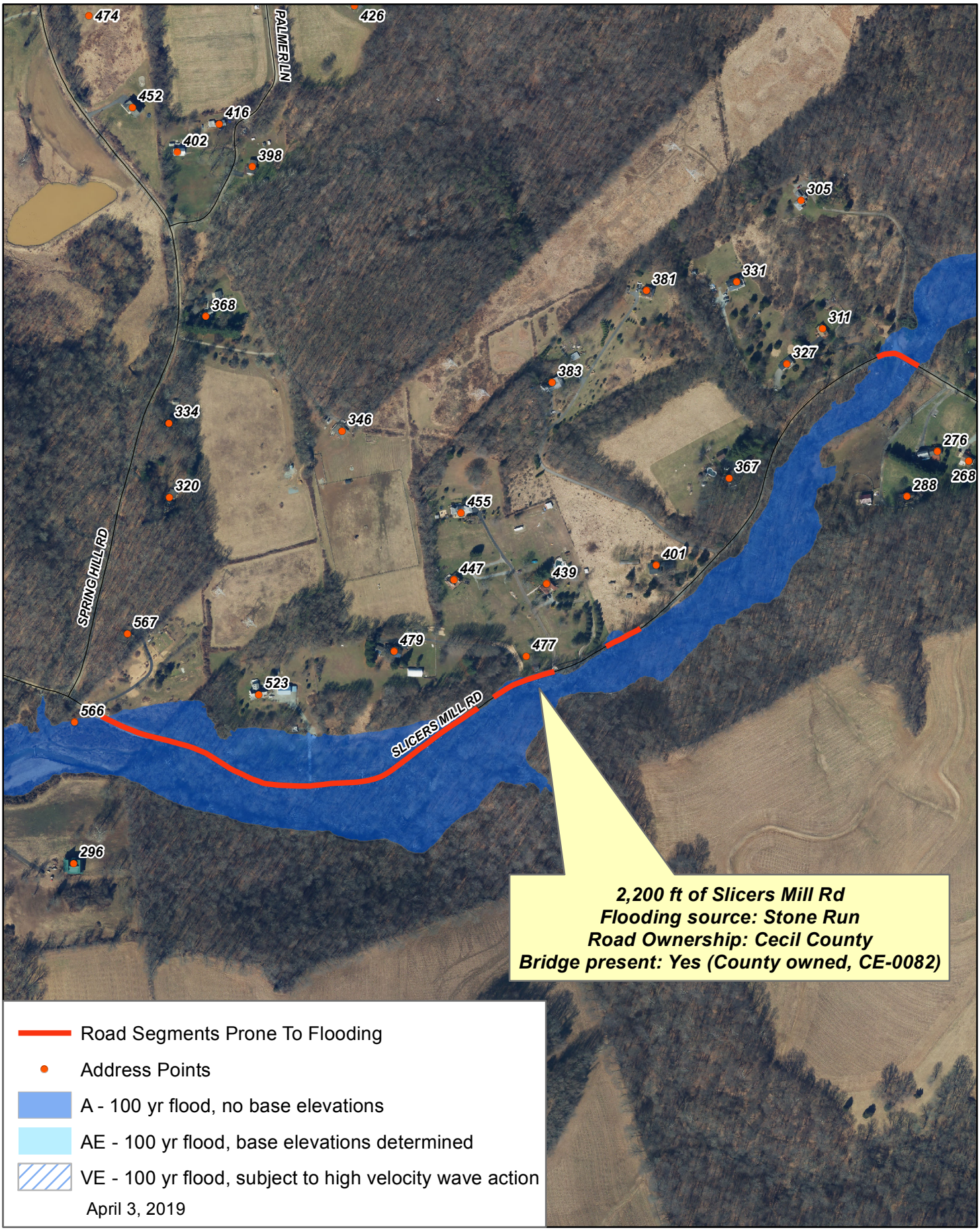


Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
500 block of Calvert Rd, Rising Sun, MD

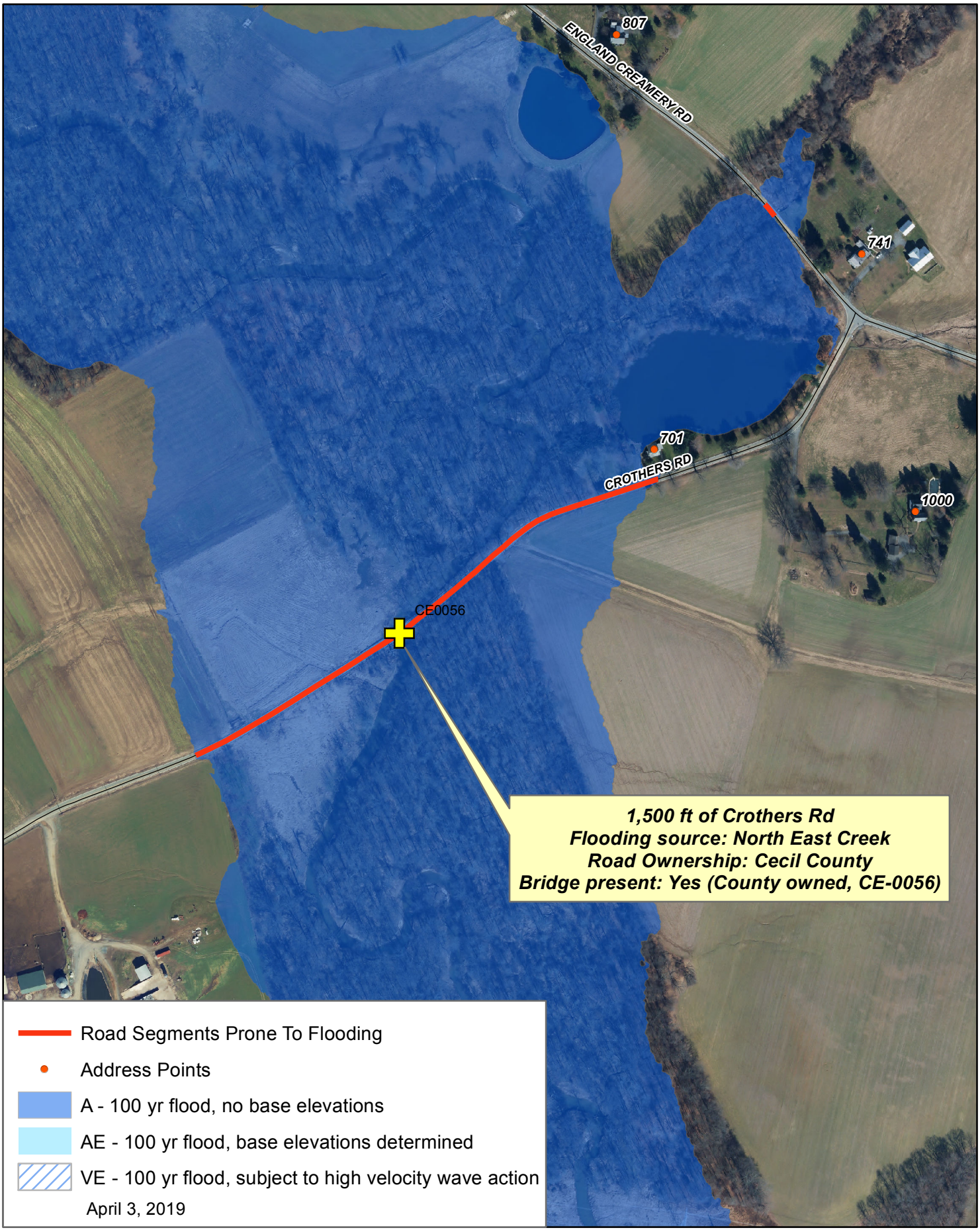


Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
Bank St, Chesapeake City, MD

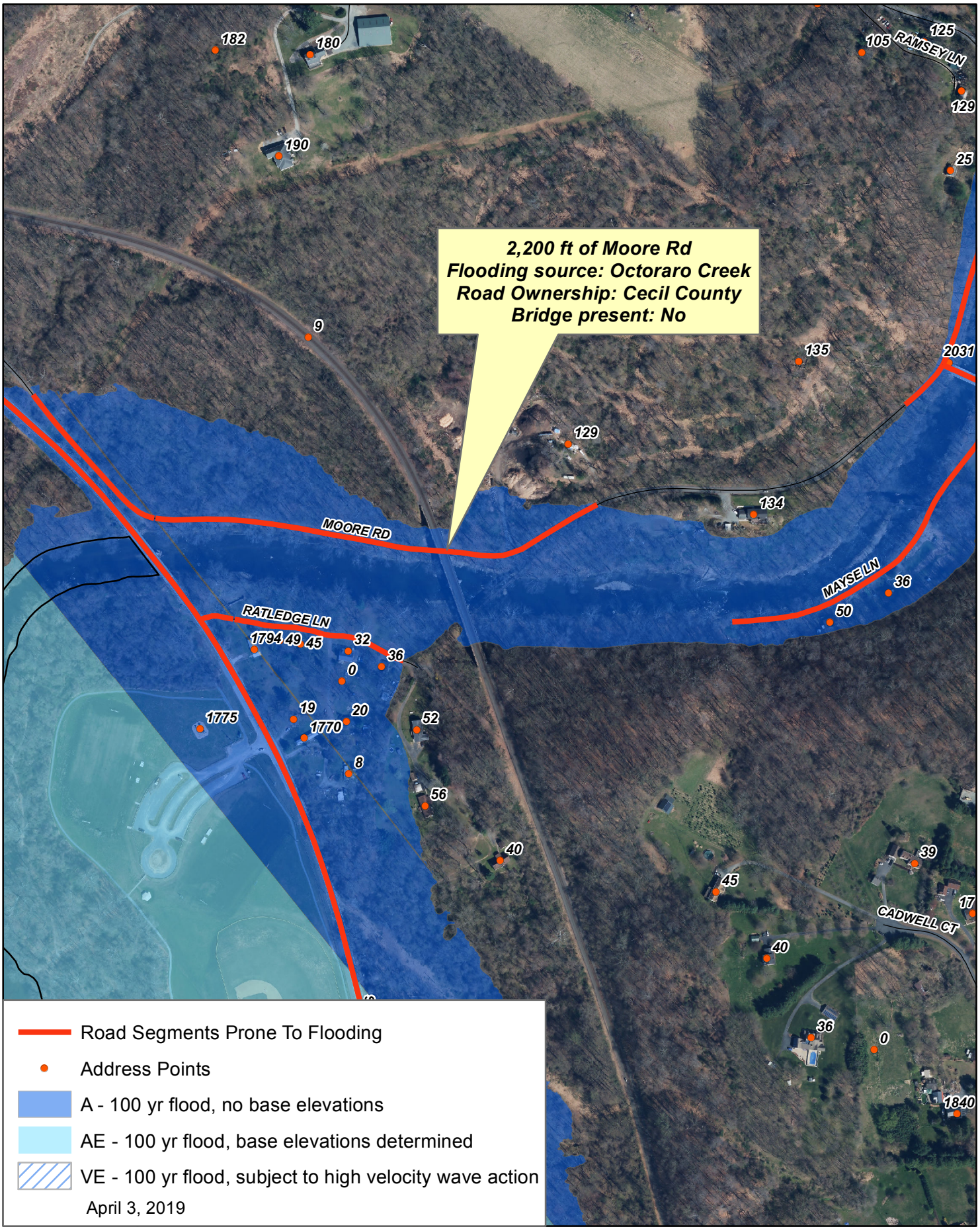
Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
300-500 block of Slicers Mill Rd, Rising Sun, MD



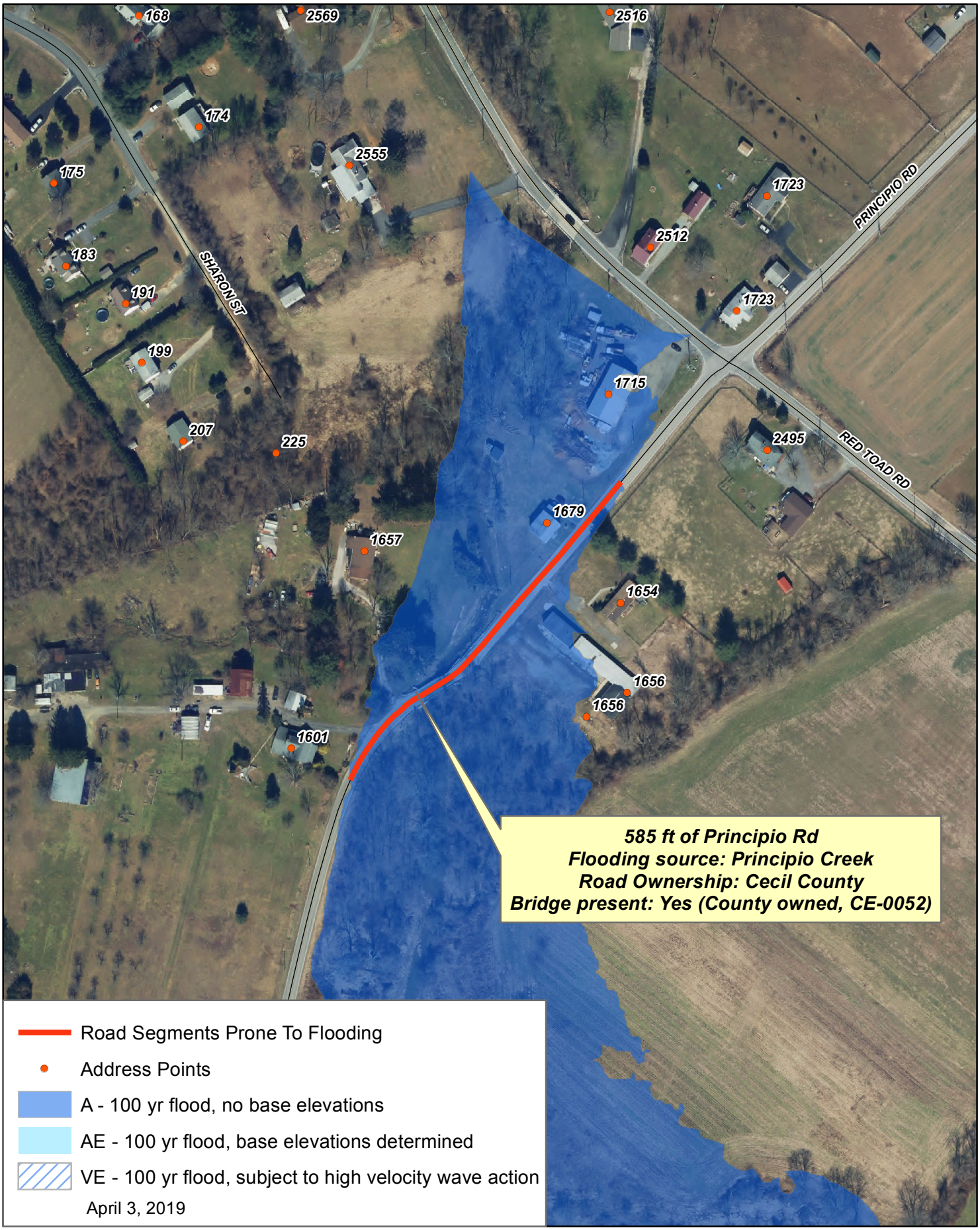
Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
Crothers Rd & England Creamery Rd, Rising Sun, MD



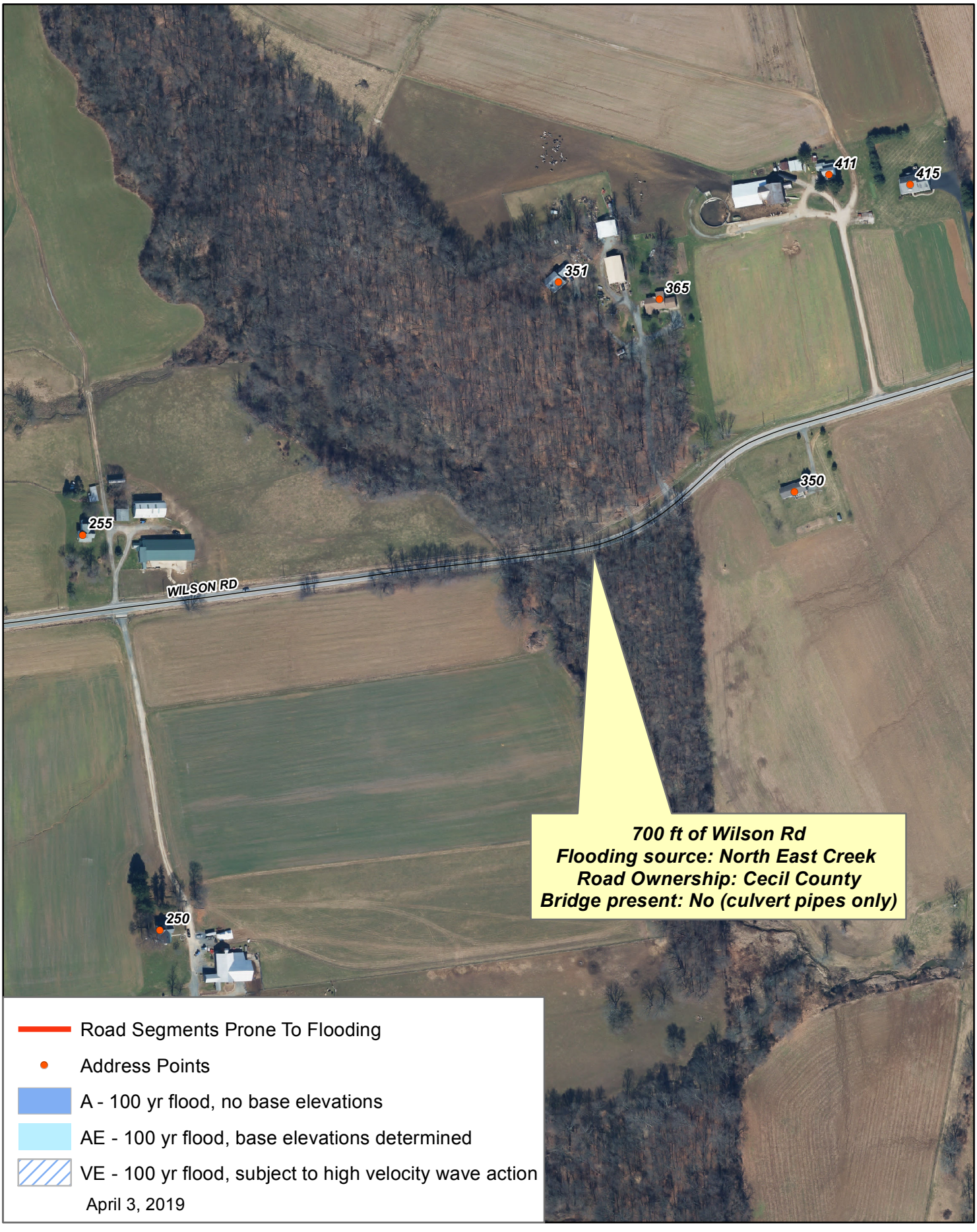
Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
Moore Rd (0-100 block), Conowingo, MD



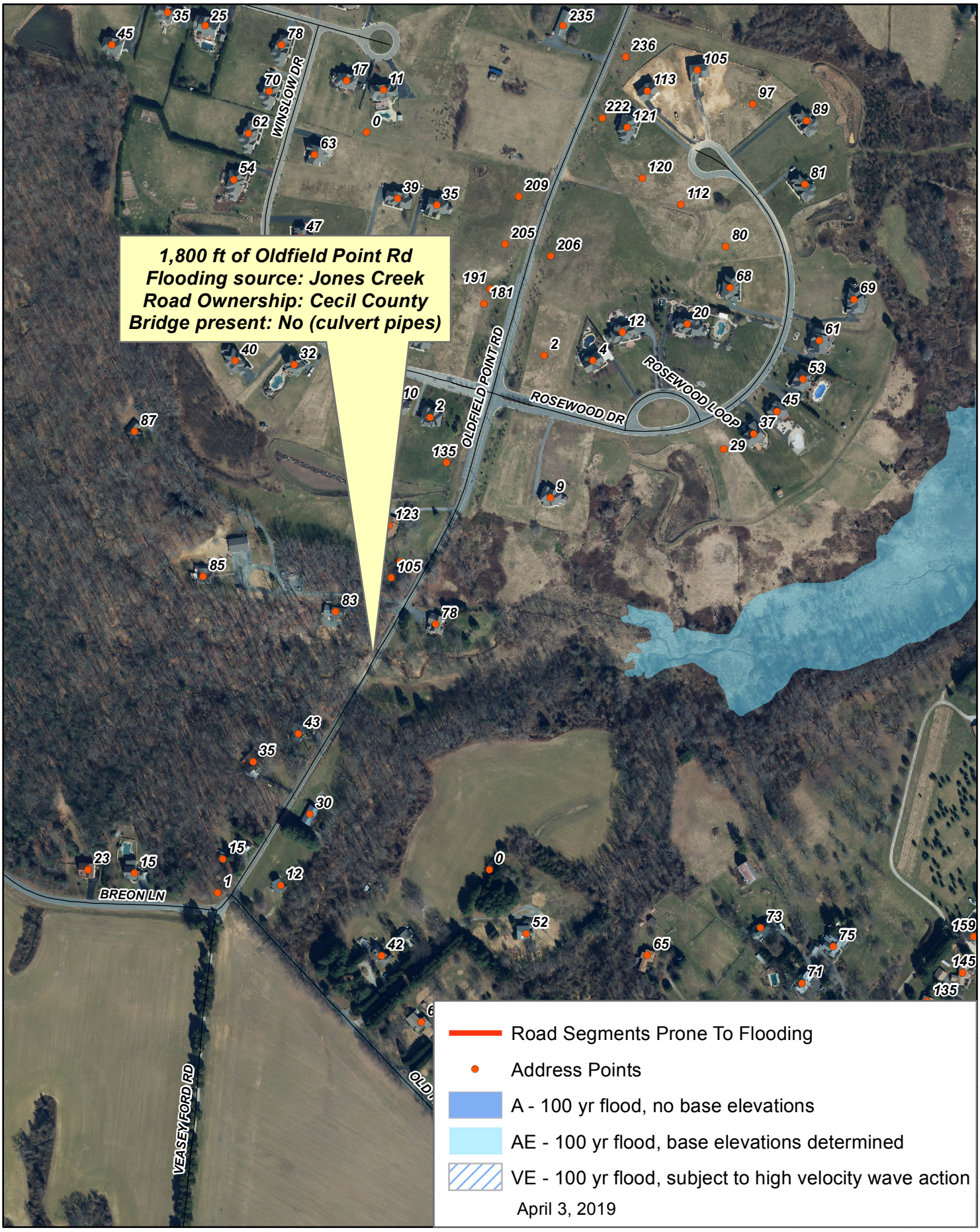
Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
Principio Rd (1800 block), Port Deposit, MD

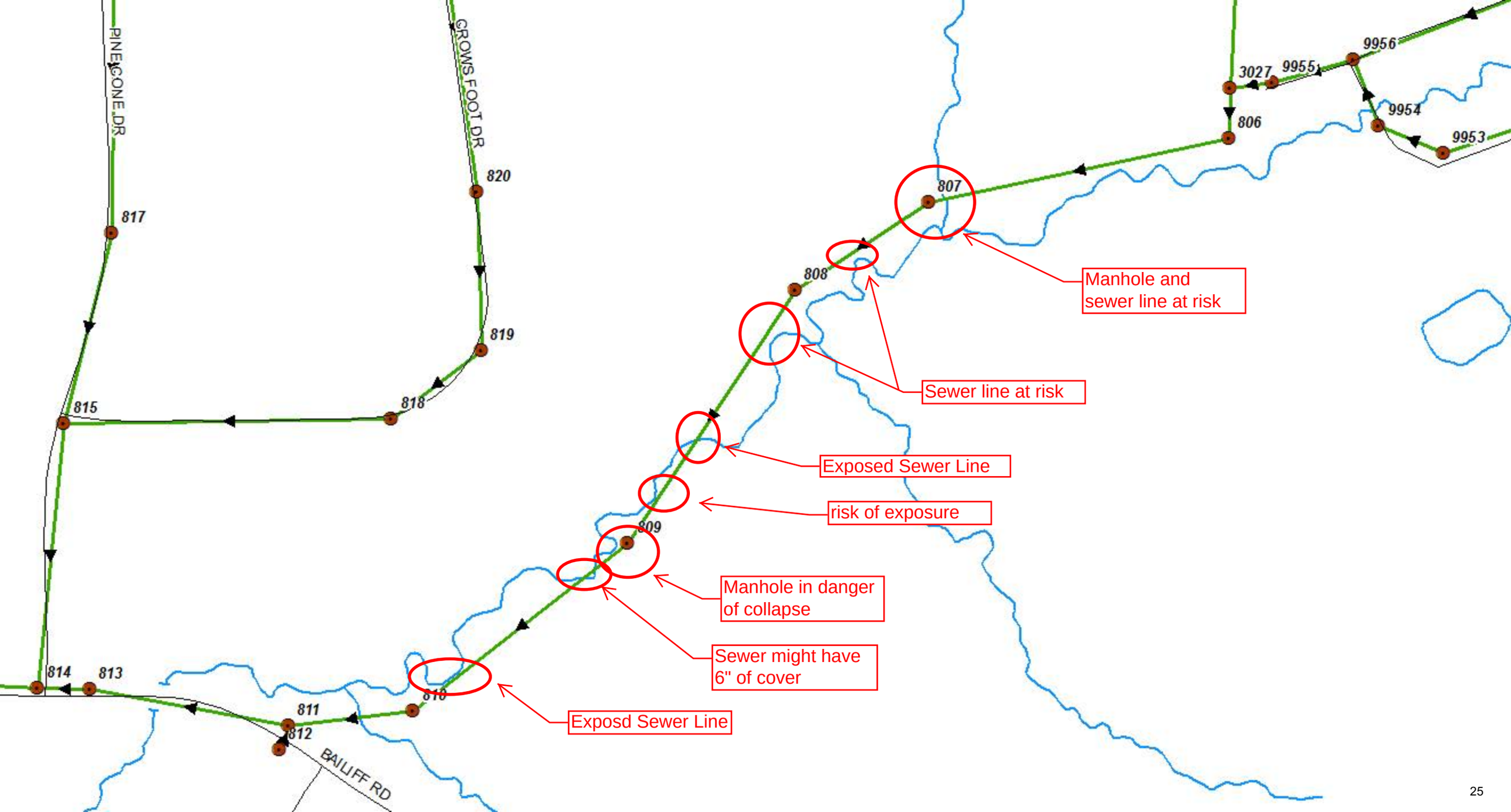


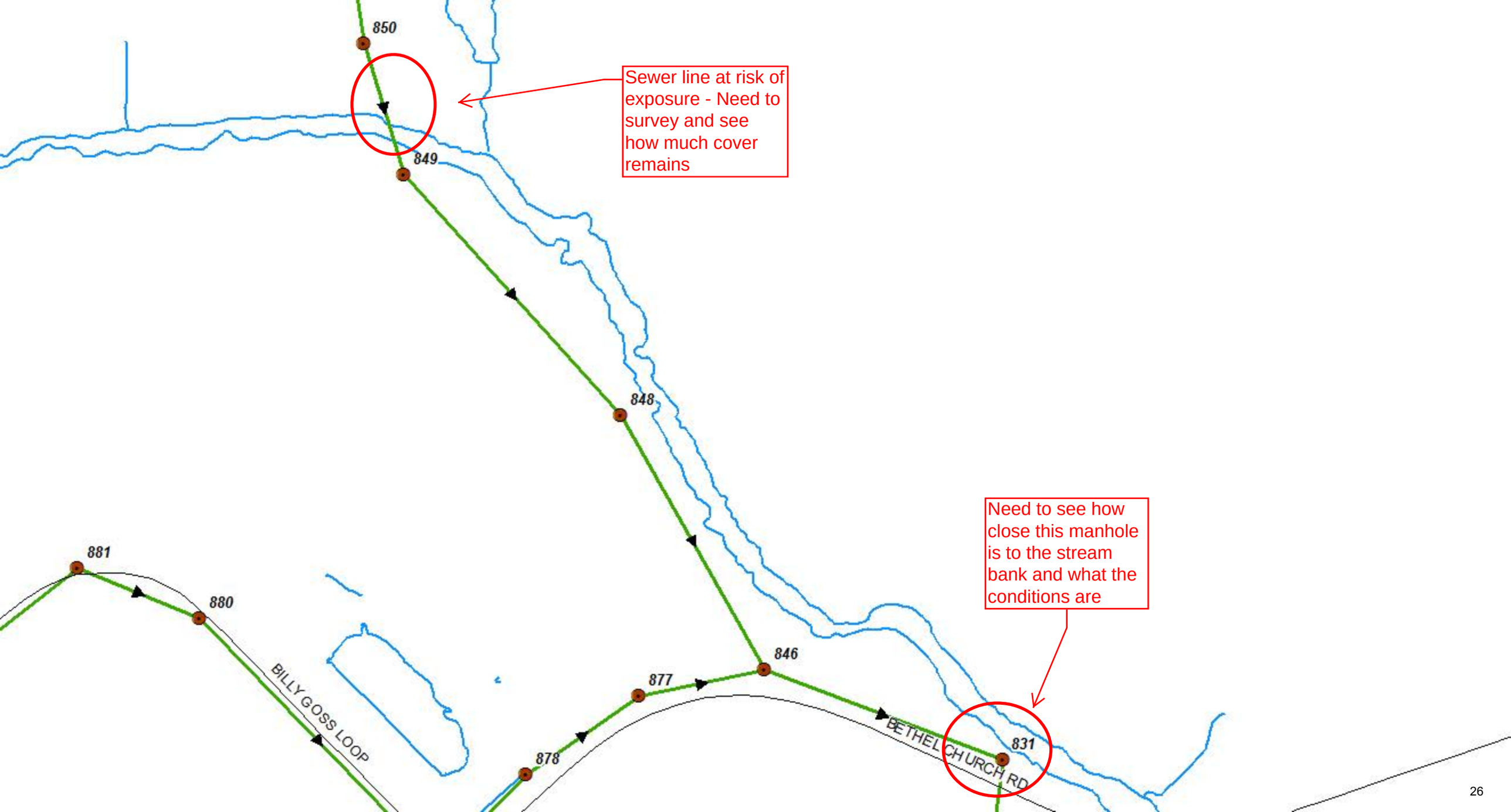
Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
Wilson Rd (300 block), Rising Sun, MD

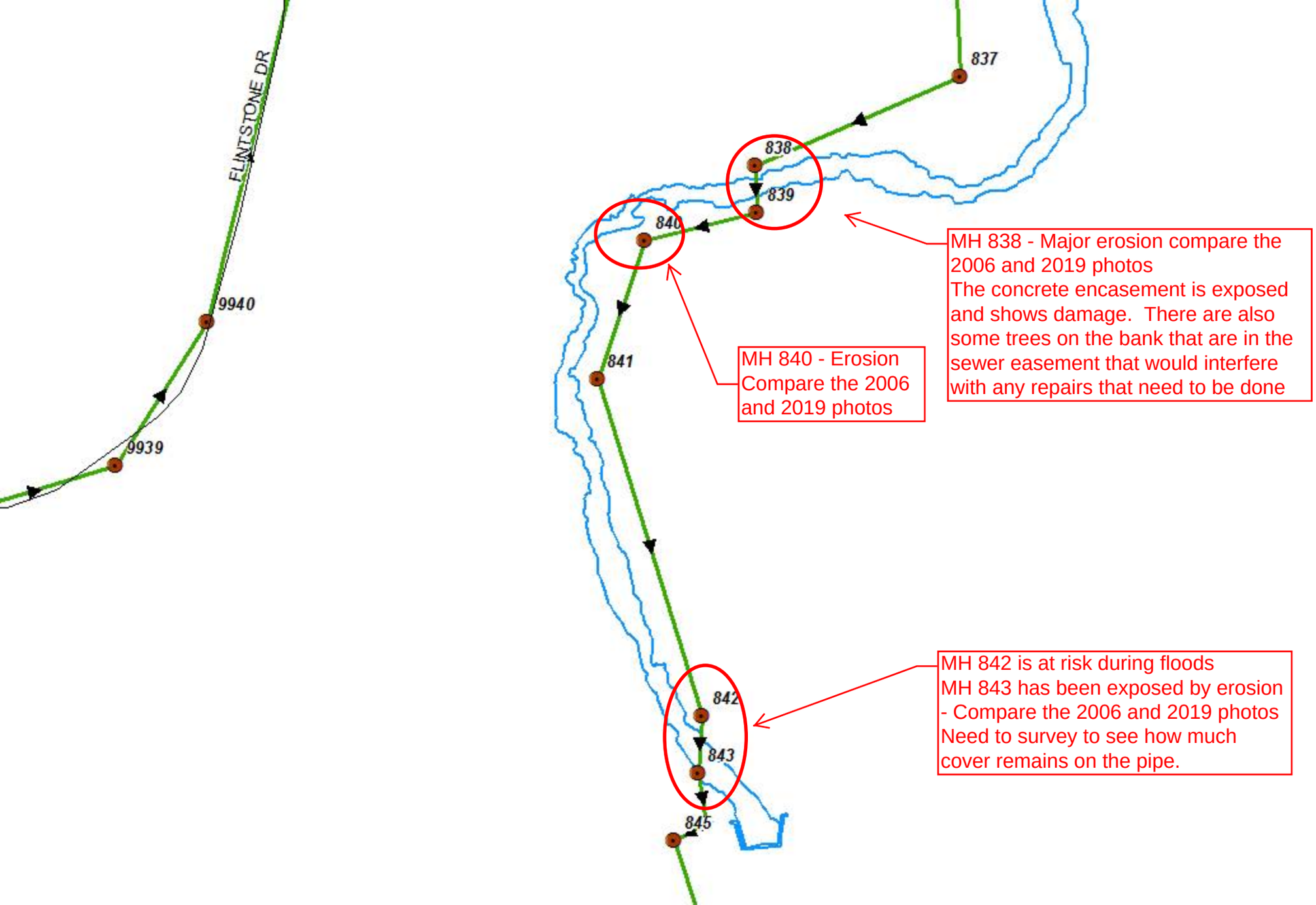


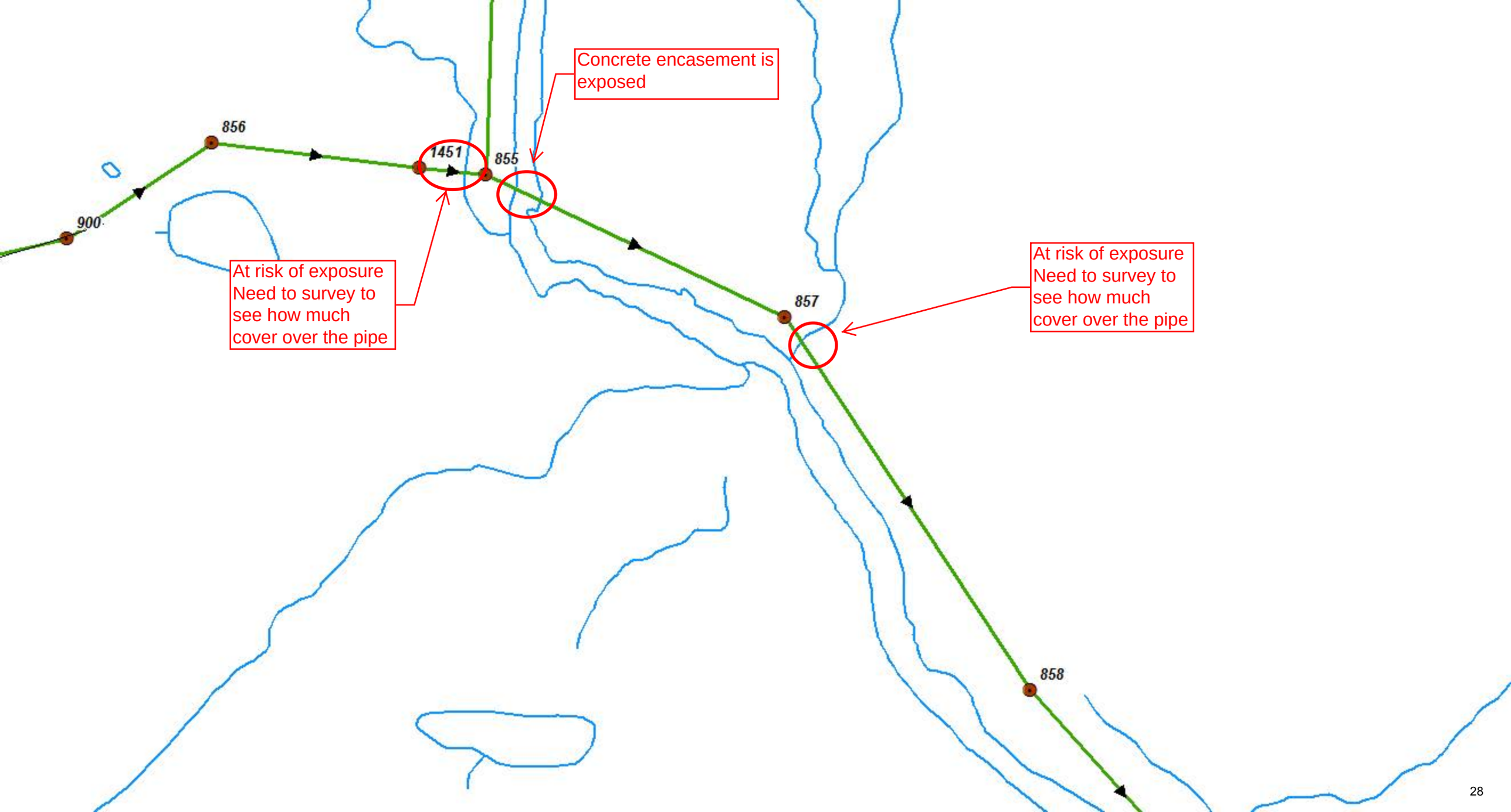
Cecil County Green Infrastructure Plan
Road Segments Prone to Flooding
Oldfield Point Rd at Jones Creek, Elkton, MD

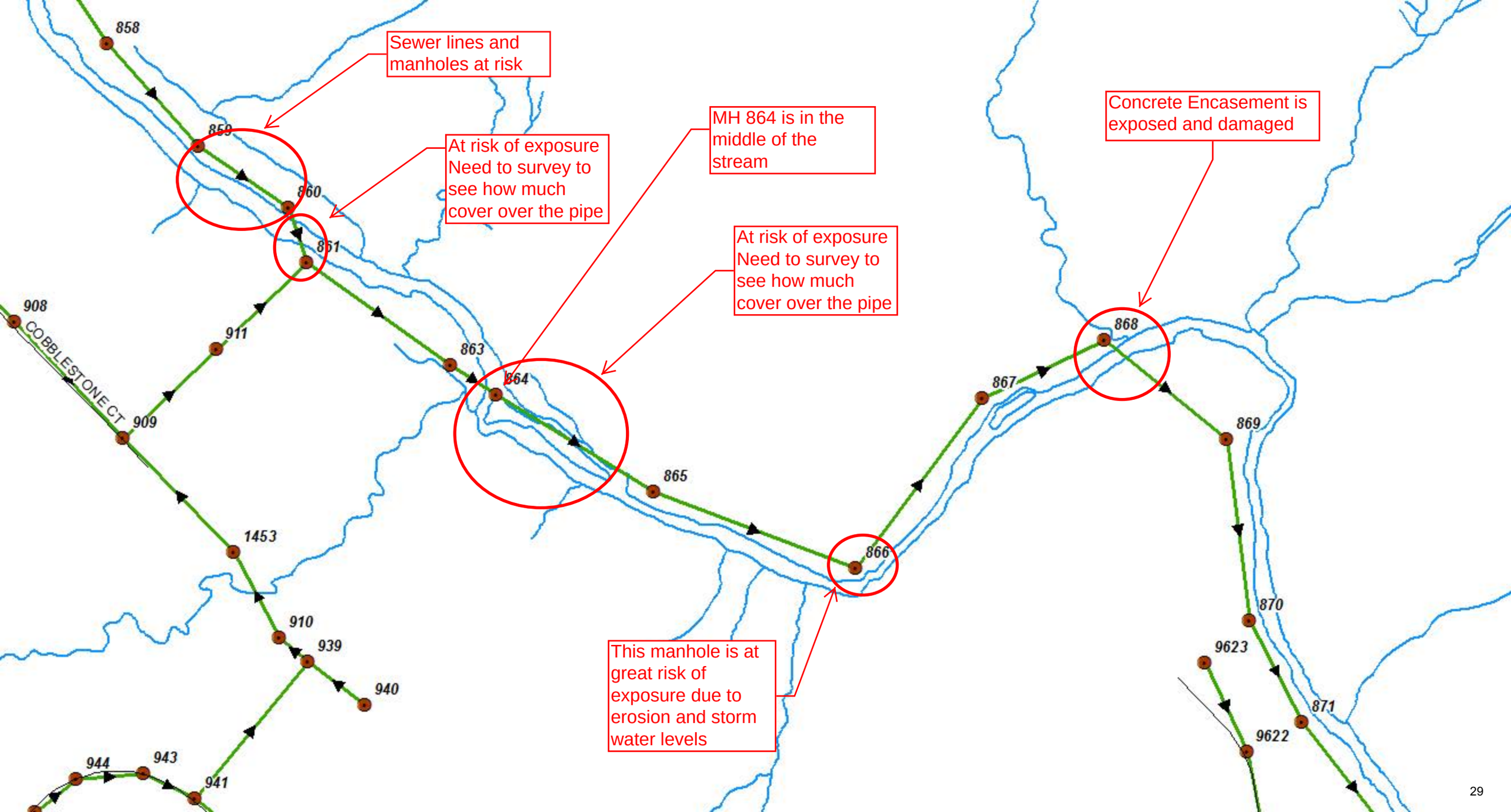


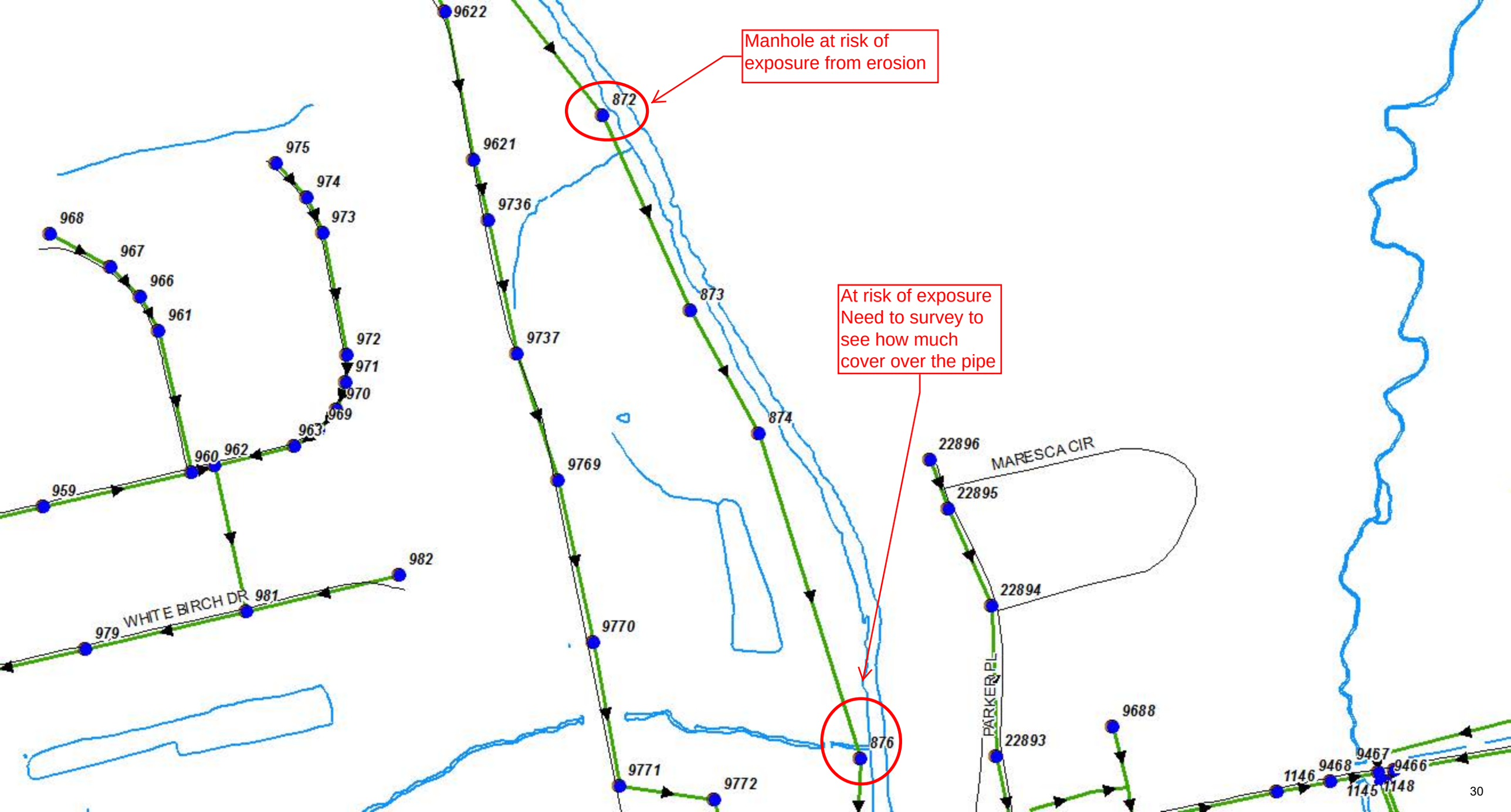

PINECONE DR
GROWS FOOT DR
BAILIFF RD
817
820
819
818
815
814
813
812
811
810
809
808
807
806
3027
9955
9956
9954
9953
Manhole and sewer line at risk
Sewer line at risk
Exposed Sewer Line
risk of exposure
Manhole in danger of collapse
Sewer might have 6" of cover
Exposd Sewer Line

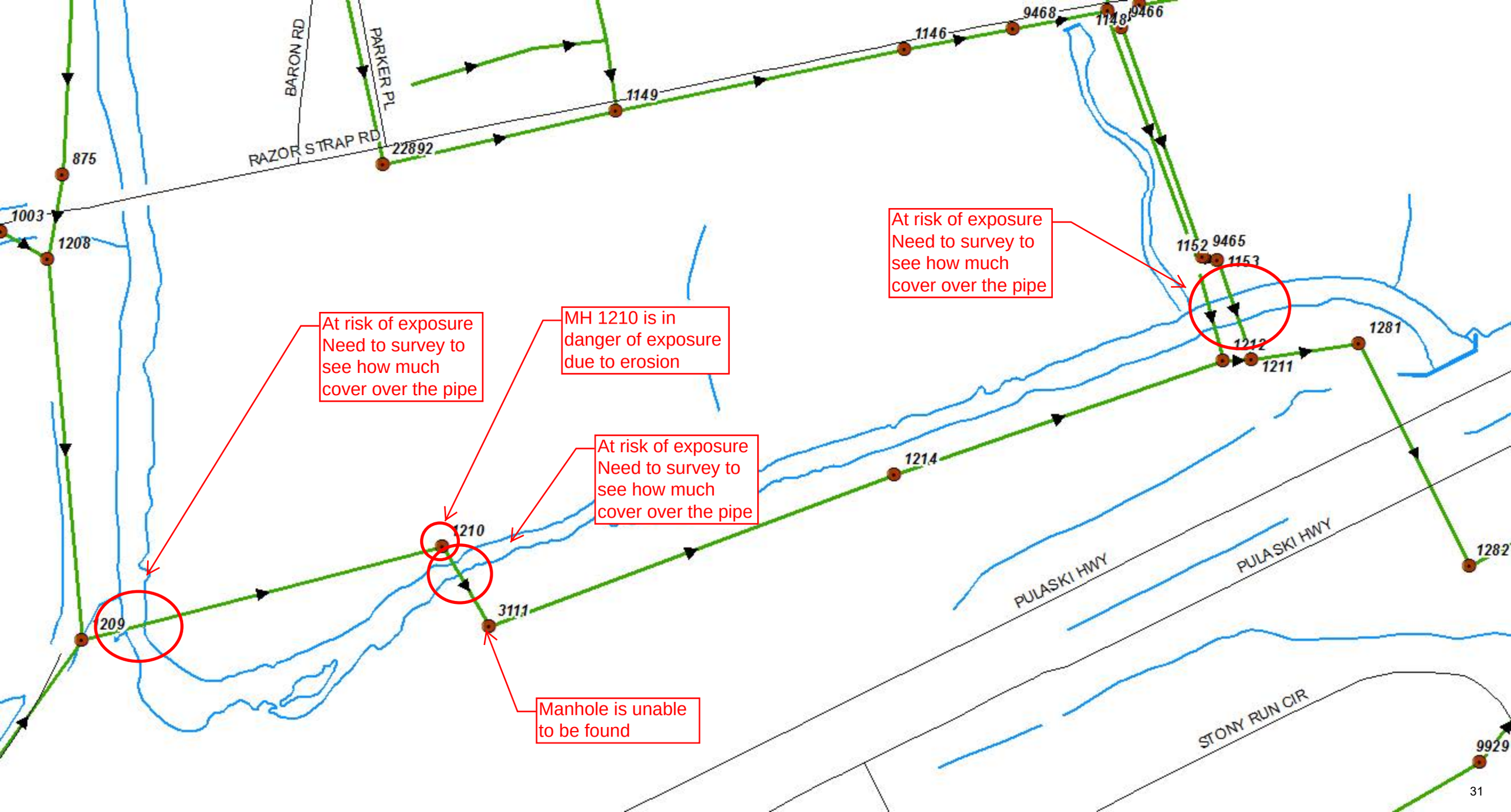

850
849
848
846
877
878
881
880
831
BILLY GOSS LOOP
BETHEL CHURCH RD
Sewer line at risk of exposure - Need to survey and see how much cover remains
Need to see how close this manhole is to the stream bank and what the conditions are

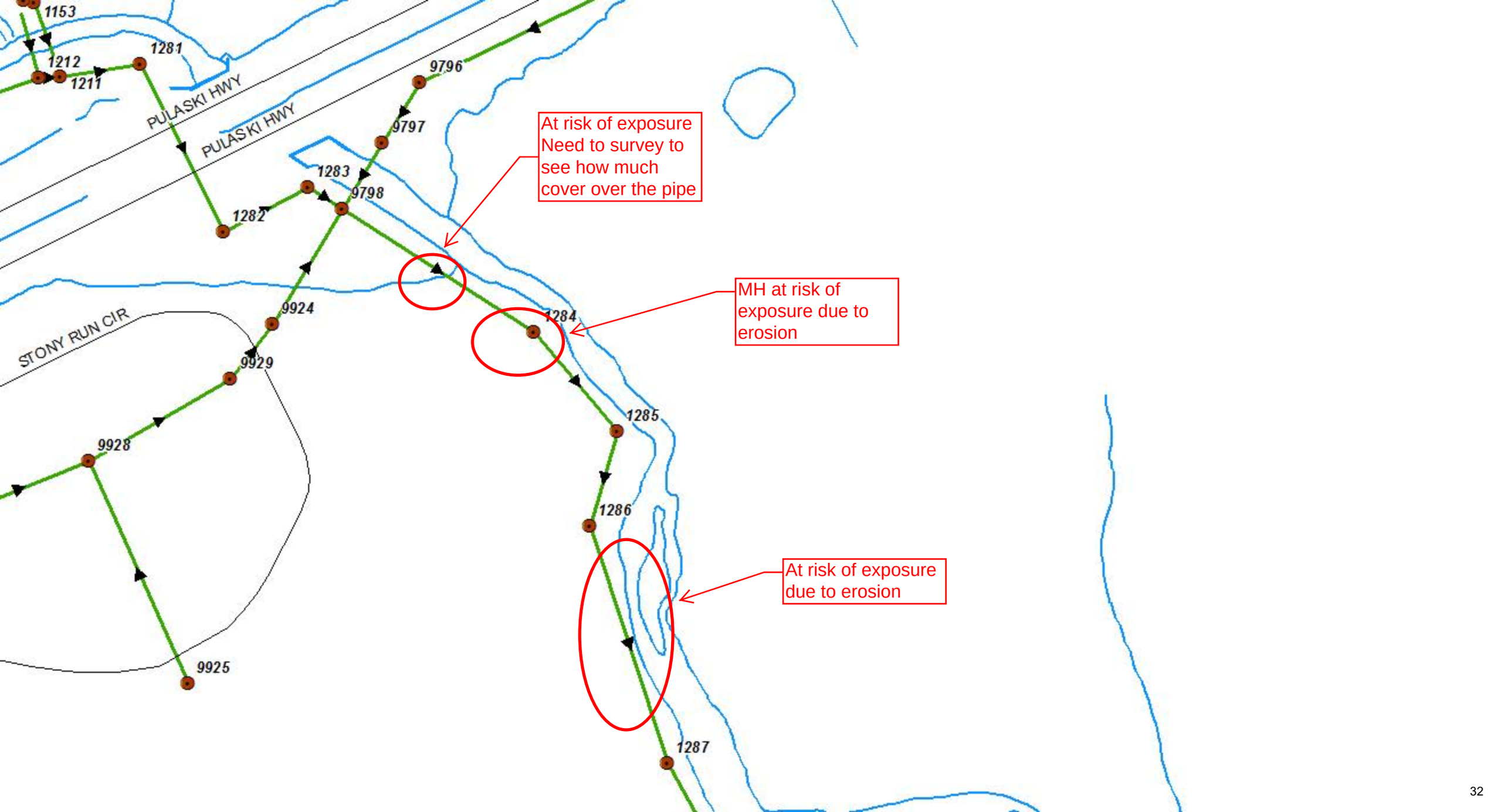

FLINTSTONE DR
9940
9939
837
838
839
840
841
842
843
845
MH 838 - Major erosion compare the 2006 and 2019 photos
The concrete encasement is exposed and shows damage. There are also some trees on the bank that are in the sewer easement that would interfere with any repairs that need to be done
MH 840 - Erosion
Compare the 2006 and 2019 photos
MH 842 is at risk during floods
MH 843 has been exposed by erosion - Compare the 2006 and 2019 photos
Need to survey to see how much cover remains on the pipe.

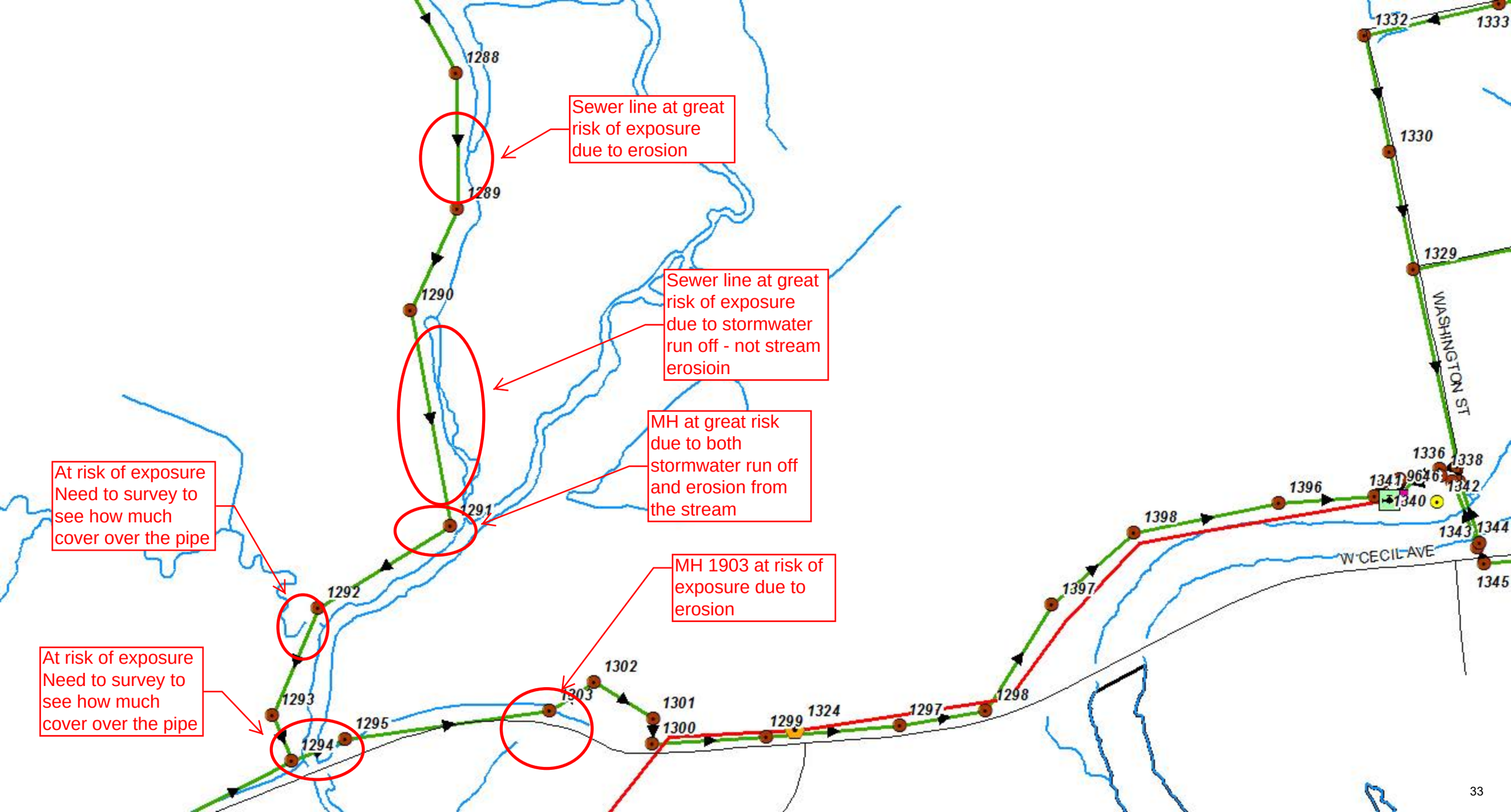

Concrete encasement is exposed
856
1451
855
900
At risk of exposure Need to survey to see how much cover over the pipe
857
At risk of exposure Need to survey to see how much cover over the pipe
858


Sewer lines and manholes at risk
At risk of exposure Need to survey to see how much cover over the pipe
MH 864 is in the middle of the stream
At risk of exposure Need to survey to see how much cover over the pipe
Concrete Encasement is exposed and damaged
This manhole is at great risk of exposure due to erosion and storm water levels
858
859
860
861
908
COBBLESTONE CT
911
909
863
864
865
866
867
868
869
870
871
9623
9622
1453
910
939
940
944
943
941


Manhole at risk of exposure from erosion
At risk of exposure Need to survey to see how much cover over the pipe
9622
872
9621
9736
873
9737
874
9769
9770
9771
9772
876
975
974
973
968
967
966
961
972
971
970
969
963
960
962
959
982
WHITE BIRCH DR
981
979
22896
MARESCA CIR
22895
22894
PARKER PL
22893
9688
9467
9468
9466
1146
1145
1148


BARON RD
PARKER PL
RAZOR STRAP RD
PULASKI HWY
PULASKI HWY
STONY RUN CIR
875
1003
1208
22892
1149
1146
9468
1148
9466
1152
9465
1153
1212
1211
1281
1282
1214
1210
3111
209
9929
At risk of exposure
Need to survey to
see how much
cover over the pipe
MH 1210 is in
danger of exposure
due to erosion
At risk of exposure
Need to survey to
see how much
cover over the pipe
At risk of exposure
Need to survey to
see how much
cover over the pipe
Manhole is unable
to be found


1153
1212
1211
1281
PULASKI HWY
PULASKI HWY
9796
9797
1283
9798
1282
STONY RUN CIR
9924
9929
9928
9925
1284
1285
1286
1287
At risk of exposure
Need to survey to
see how much
cover over the pipe
MH at risk of
exposure due to
erosion
At risk of exposure
due to erosion

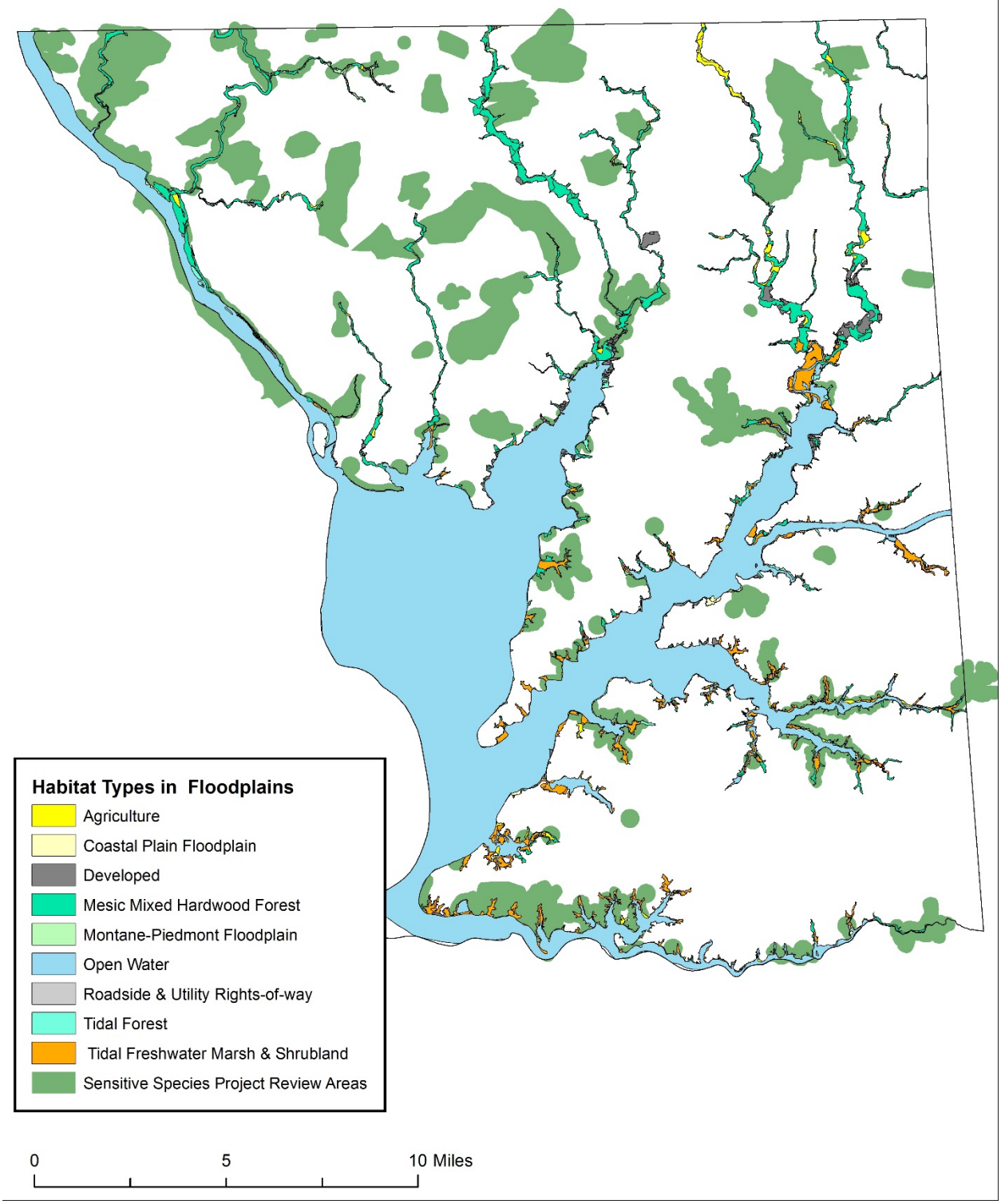

Sewer line at great risk of exposure due to erosion
Sewer line at great risk of exposure due to stormwater run off - not stream erosioin
MH at great risk due to both stormwater run off and erosion from the stream
At risk of exposure Need to survey to see how much cover over the pipe
MH 1903 at risk of exposure due to erosion
At risk of exposure Need to survey to see how much cover over the pipe
1288
1289
1290
1291
1292
1293
1294
1295
1302
1303
1301
1300
1299
1324
1297
1298
1397
1398
1396
1340
1342
1343
1344
1345
1336
1338
1329
1330
1332
1333
WASHINGTON ST
W CECIL AVE

APPENDIX I: Species of Greatest Conservation Need in Cecil County Floodplains

Cecil County staff coordinated with DNR's Wildlife and Heritage Service to prepare this section of the plan. The DNR biologists compiled lists of species of greatest conservation need that could be found within Cecil County's floodplain habitats. County staff mapped the various habitat types within the floodplains using a combination of information on land use, vegetation, wetlands, and aerial photography. However, not all of the floodplain habitats could be mapped due their smaller size and infrequent occurrence throughout the County. Following the 2015 Maryland State Wildlife Action Plan, descriptions of the various habitats are provided below, including both the mapped habitats and those not mapped.

Species of greatest conservation need are those animals, both aquatic and terrestrial, that are at risk or are declining in Maryland. They include threatened and endangered species, as well as many other species whose populations are of concern in the state. They include mammals, birds, reptiles, amphibians, fishes, insects, freshwater mussels, and other invertebrates. A breakdown of the percentage of various floodplain habitats is provided below, followed by a map, and then the listings of species of greatest conservation need that can be found within each habitat type.

% Floodplain	**Acres**	**Habitat Types**
7.3	875.9	Agriculture
0.7	79.8	Coastal Plain Floodplain
12.4	1482.5	Developed
50.5	6017.6	Mesic Mixed Hardwood Forest
0.9	103.8	Montane-Piedmont Floodplain
0.3	34.5	Roadside & Utility Rights-of-Way
3.5	415.6	Tidal Forest
24.4	2913.5	Tidal Freshwater Marsh & Shrubland
	2438.2	


Habitat Types in Floodplains
Agriculture
Coastal Plain Floodplain
Developed
Mesic Mixed Hardwood Forest
Montane-Piedmont Floodplain
Open Water
Roadside & Utility Rights-of-way
Tidal Forest
Tidal Freshwater Marsh & Shrubland
Sensitive Species Project Review Areas
0
5
10 Miles

Mapped Floodplain Habitats

Coastal Plain Floodplain

This habitat is characterized by a variety of flooded habitats that border Coastal Plain streams and rivers. These floodplain habitats are influenced by temporary or seasonal overbank flooding, groundwater seepage, and beaver activity. The vegetation of Coastal Plain Floodplains is both structurally and compositionally diverse, and often occurs as a mosaic of forests, woodlands, shrublands, and herbaceous communities. Species composition varies widely with stream order, soil type, and flooding regime. Floodplain forests of small intermittent streams and braided streams may support combinations of sycamore, green ash, red maple, sweetgum, black gum, river birch, swamp chestnut oak, and willow oak. Diverse understories are often present and characterized by mixtures of American hornbeam, pawpaw, American elm, American holly, spicebush and herbs of Jack-in-the-pulpit, false nettle, poison-ivy, Virginia creeper, sweet woodreed, and various sedges. Similarly, floodplain forests of larger Coastal Plain Rivers with well-drained terraces or natural levees will often support species such as tulip poplar, beech, and box elder. Poorly drained floodplains, backswamps, and depressions of small Coastal Plain streams and rivers may support seasonally flooded swamps dominated by green ash, red maple, and plants tolerant of fluctuating water levels such as lizard's-tail. Floodplain pools, beaver ponds, and other open water habitats are also characteristic of Coastal Plain Floodplains. These habitats are subjected to irregular disturbances that change water levels, such as the breaching of beaver dams and storm events. These habitats are highly variable in size, structure, and species composition. They often support a variety of floating aquatic, emergent, and woody vegetation. Species common to these habitats include white water-lily, spatterdock, pondweeds, duckweeds, bladderworts, rice cutgrass, common rush, smartweeds, pickerelweed, arrow-arum, three-way sedge, common cattail, American bur-reed, swamp loosestrife, and buttonbush.

Species

Group	**Scientific Name**	**Common Name**
Amphibian	Lithobates kauffeldi	Atlantic Coast leopard frog
Bird	Anas rubripes	American black duck
Bird	Ardea alba	Great egret
Bird	Ardea herodias	Great blue heron
Bird	Nyctanassa violacea	Yellow-crowned night-heron
Bird	Nycticorax nycticorax	Black-crowned night-heron
Bird	Buteo platypterus	Broad-winged hawk
Bird	Haliaeetus leucocephalus	Bald eagle
Bird	Actitis macularius	Spotted sandpiper
Bird	Scolopax minor	American woodcock
Bird	Tringa flavipes	Lesser yellowlegs
Bird	Tringa melanoleuca	Greater yellowlegs
Bird	Melanerpes erythrocephalus	Red-headed woodpecker
Bird	Empidonax traillii	Willow flycatcher

Bird	Empidonax virescens	Acadian flycatcher
Bird	Vireo flavifrons	Yellow-throated vireo
Bird	Riparia riparia	Bank swallow
Bird	Certhia americana	Brown creeper
Bird	Catharus fuscescens	Veery
Bird	Hylocichla mustelina	Wood thrush
Bird	Geothlypis formosa	Kentucky warbler
Bird	Helmitheros vermivorus	Worm-eating warbler
Bird	Icteria virens	Yellow-breasted chat
Bird	Mniotilta varia	Black-and-white warbler
Bird	Parkesia motacilla	Louisiana waterthrush
Bird	Protonotaria citrea	Prothonotary warbler
Bird	Seiurus aurocapillus	Ovenbird
Bird	Setophaga americana	Northern parula
Bird	Setophaga citrina	Hooded warbler
Bird	Setophaga ruticilla	American redstart
Bird	Vermivora pinus	Blue-winged warbler
Bird	Piranga olivacea	Scarlet tanager
Insect	Gomphaeschna furcillata	Harlequin darner
Insect	Libellula axilena	Bar-winged skimmer
Insect	Lycaena hyllus	Bronze copper
Mammal	Cryptotis parva	Least shrew
Mammal	Sorex hoyi winnemana	Southern pygmy shrew
Mammal	Eptesicus fuscus	Big brown bat
Mammal	Lasiurus borealis	Eastern red bat
Mammal	Nycticeius humeralis	Evening bat
Mammal	Perimyotis subflavus	Tricolored bat
Mammal	Neovison vison	American mink
Mammal	Lynx rufus	Bobcat
Reptile	Clemmys guttata	Spotted turtle
Reptile	Glyptemys insculpta	Wood turtle
Reptile	Graptemys geographica	Northern map turtle
Reptile	Terrapene carolina	Eastern box turtle
Reptile	Lampropeltis getula	Eastern kingsnake
Reptile	Thamnophis sauritus	Common ribbonsnake

Mesic Mixed Hardwood Forest

This habitat develops over acidic, nutrient poor soils of the Coastal Plain and Piedmont in a variety of moist landscape settings including ravines, lower slopes, undulating uplands, and flatwoods. They are characterized by mixed canopies of tulip poplar, American beech, white oak, northern red oak, mockernut hickory, pignut hickory and understories of white flowering dogwood, paw paw, American strawberry-bush, and American hornbeam. Many of the oaks and other associated trees of these forests vary by region. For example, loblolly pine and American holly are occasionally prominent in Coastal Plain Mesic Mixed Hardwood Forests, but are absent in Piedmont stands. The infertile soils of these forests rarely support lush layers of herbaceous vegetation like those in basic mesic forests; however, ferns such as Christmas fern and New York fern may be locally abundant in patches. Other plants common to this

key wildlife habitat include pink lady's-slipper, false Solomon's-seal, perfoliate bellwort, Indian cucumber root, cranefly orchid, and spotted wintergreen.

Species

Group	Scientific Name	Common Name
Bird	Buteo platypterus	Broad-winged hawk
Bird	Haliaeetus leucocephalus	Bald eagle
Bird	Scolopax minor	American woodcock
Bird	Caprimulgus vociferus	Eastern whip-poor-will
Bird	Empidonax virescens	Acadian flycatcher
Bird	Certhia americana	Brown creeper
Bird	Catharus fuscescens	Veery
Bird	Hylocichla mustelina	Wood thrush
Bird	Geothlypis formosa	Kentucky warbler
Bird	Helmitheros vermivorus	Worm-eating warbler
Bird	Mniotilta varia	Black-and-white warbler
Bird	Seiurus aurocapillus	Ovenbird
Bird	Setophaga americana	Northern parula
Bird	Setophaga citrina	Hooded warbler
Bird	Setophaga discolor	Prairie warbler
Bird	Setophaga ruticilla	American redstart
Bird	Piranga olivacea	Scarlet tanager
Mammal	Sorex fumeus	Smoky shrew
Mammal	Sorex hoyi winnemana	Southern pygmy shrew
Mammal	Eptesicus fuscus	Big brown bat
Mammal	Lasiurus borealis	Eastern red bat
Mammal	Myotis lucifugus	Little brown myotis
Mammal	Myotis septentrionalis	Northern myotis
Mammal	Nycticeius humeralis	Evening bat
Mammal	Perimyotis subflavus	Tricolored bat
Mammal	Neovison vison	American mink
Mammal	Lynx rufus	Bobcat
Reptile	Glyptemys insculpta	Wood turtle
Reptile	Terrapene carolina	Eastern box turtle

Montane-Piedmont Floodplain

This habitat encompasses a wide variety of floodplain habitats along small streams and large river systems in the Piedmont region of Cecil County. These habitats are very diverse with species distributions influenced by geology, soil properties, and flooding regimes. Temporarily and intermittently flooded bottomland forests are prominent along many of the rivers and are frequently characterized by species such as sycamore, silver maple, black walnut, river birch, boxelder, paw-paw,

and American elm. Distinct alluvial landforms such as gravel bars, levees, terraces, old oxbows, and sloughs are usually present at varying scales along larger rivers. Young, flood-scoured woodlands sometimes occur along shoreline areas and islands, especially in high-gradient rocky sections and along flood-deposited sand and gravel bars. Such areas are frequently dominated by dense, nearly pure stands of small (2-8 m tall) sycamore, boxelder, river birch and green ash trees. Frequently embedded within floodplain forests are floodwater pools and seasonally flooded backswamps and sloughs dominated by red maple, silver maple, sweetgum, and hydrophytic oaks such as pin oak and swamp white oak. These backwater areas usually exhibit distinctive hummock-and-hollow microtopography with maximum flood depths of 50-70 cm. Along smaller, higher gradient streams, where the floodplain is narrower and alluvial landforms develop at much smaller scales, mesophytic species may occur. Commonly encountered is a mixture of bottomland and mesophytic species which include tulip poplar, sugar maple, basswood, American beech, and white pine. At higher elevations, eastern hemlock, black cherry, yellow birch, and dense thickets of great laurel are usually prominent.

Species

Group	Scientific Name	Common Name
Bird	Mergus merganser	Common merganser
Bird	Ardea alba	Great egret
Bird	Ardea herodias	Great blue heron
Bird	Nyctanassa violacea	Yellow-crowned night-heron
Bird	Nycticorax nycticorax	Black-crowned night-heron
Bird	Buteo platypterus	Broad-winged hawk
Bird	Haliaeetus leucocephalus	Bald eagle
Bird	Actitis macularius	Spotted sandpiper
Bird	Scolopax minor	American woodcock
Bird	Tringa flavipes	Lesser yellowlegs
Bird	Tringa melanoleuca	Greater yellowlegs
Bird	Melanerpes erythrocephalus	Red-headed woodpecker
Bird	Empidonax traillii	Willow flycatcher
Bird	Empidonax virescens	Acadian flycatcher
Bird	Vireo flavifrons	Yellow-throated vireo
Bird	Riparia riparia	Bank swallow
Bird	Certhia americana	Brown creeper
Bird	Catharus fuscescens	Veery
Bird	Hylocichla mustelina	Wood thrush
Bird	Geothlypis formosa	Kentucky warbler
Bird	Helmitheros vermivorus	Worm-eating warbler
Bird	Icteria virens	Yellow-breasted chat
Bird	Mniotilta varia	Black-and-white warbler
Bird	Parkesia motacilla	Louisiana waterthrush
Bird	Protonotaria citrea	Prothonotary warbler
Bird	Seiurus aurocapillus	Ovenbird
Bird	Setophaga americana	Northern parula
Bird	Setophaga cerulea	Cerulean warbler

Bird	Setophaga citrina	Hooded warbler
Bird	Setophaga ruticilla	American redstart
Bird	Vermivora pinus	Blue-winged warbler
Bird	Piranga olivacea	Scarlet tanager
Insect	Anax longipes	Comet darner
Insect	Gomphaeschna furcillata	Harlequin darner
Insect	Libellula axilena	Bar-winged skimmer
Insect	Atrytone logan	Delaware skipper
Insect	Boloria selene	Silver-bordered fritillary
Insect	Euphydryas phaeton	Baltimore checkerspot
Insect	Euphyes conspicua	Black dash
Insect	Poanes massasoit massasoit	Mulberry wing
Mammal	Cryptotis parva	Least shrew
Mammal	Sorex hoyi winnemana	Southern pygmy shrew
Mammal	Eptesicus fuscus	Big brown bat
Mammal	Lasiurus borealis	Eastern red bat
Mammal	Myotis lucifugus	Little brown myotis
Mammal	Myotis septentrionalis	Northern myotis
Mammal	Nycticeius humeralis	Evening bat
Mammal	Perimyotis subflavus	Tricolored bat
Mammal	Neovison vison	American mink
Mammal	Lynx rufus	Bobcat
Reptile	Clemmys guttata	Spotted turtle
Reptile	Glyptemys insculpta	Wood turtle
Reptile	Glyptemys muhlenbergii	Bog turtle
Reptile	Graptemys geographica	Northern map turtle
Reptile	Terrapene carolina	Eastern box turtle
Reptile	Thamnophis sauritus	Common ribbonsnake

Roadside & Utility Rights-of-Way

These habitats comprise a mixture of managed grasslands and shrub-dominated early successional forest areas that are maintained along roadsides, gas pipelines, and in powerline rights-of-way. Vegetation composition includes both native and non-native species and varies across the region. Depending on site conditions (e.g., soils, geology, slope, aspect, etc.) and how vegetation along the roadside or right-of-way is managed, these areas may, to some degree, mimic the natural disturbances and early successional phases of adjacent natural systems. Because these areas are usually rather narrow, although long, strips of habitat, they are usually not suitable for vertebrates that are area-sensitive and require the interior of large habitat patches for optimal breeding conditions. Therefore, these areas are more valuable as habitat for species, especially invertebrates, that may not require large habitat patches, as migratory or dispersal corridors for birds and other vertebrates, or as additional “linkage” habitat that connects and expands the size of adjacent patches of managed successional forests or grasslands. In highly fragmented or mosaic landscapes, connectivity between habitat patches may be important for the survival of wildlife on a species-specific basis.

Species

Group	Scientific Name	Common Name
Bird	Empidonax traillii	Willow flycatcher
Bird	Setophaga discolor	Prairie warbler
Bird	Vermivora pinus	Blue-winged warbler
Insect	Bombus citrinus	Lemon cuckoo bumble bee
Insect	Danaus plexippus	Monarch
Insect	Hesperia leonardus	Leonard's skipper
Insect	Hesperia metea	Cobweb skipper
Mammal	Eptesicus fuscus	Big brown bat
Mammal	Lasiurus borealis	Eastern red bat
Mammal	Myotis lucifugus	Little brown myotis
Mammal	Myotis septentrionalis	Northern myotis
Mammal	Nycticeius humeralis	Evening bat
Mammal	Perimyotis subflavus	Tricolored bat
Mammal	Neovison vison	American mink

Tidal Forest

The Tidal Forest habitat includes a variety of tidally flooded forests that border the upper reaches of Coastal Plain Rivers and tributaries. These habitats are species rich and structurally complex with open canopies and floristically diverse lower strata. In much of our region, these freshwater habitats are dominated by mixtures of hardwoods such as ash, gum, and maple. These communities often develop in narrow ecotones between regularly tidally flooded areas and the upland interface. The shrub layer in freshwater Tidal Forests is usually dense and diverse often including species such as northern arrow-wood, winterberry, silky dogwood, swamp azalea, swamp rose, fetterbush, and sweet pepperbush. Climbing vines are common in multiple layers and may include species such as common wild yam, poison-ivy, common greenbrier, and Virginia creeper. Pronounced hummock-and-hollows microtopography is characteristic of tidal forests. Hollows are regularly inundated by tidal water, whereas hummocks are less frequently flooded thus supporting the establishment of trees and numerous herbs. The exceptional species diversity and richness in these habitats can be attributed to the flooding frequency and hummock-and-hollow microtopography. Regularly flooded hollows support many flood-tolerant swamp species, such as jewelweed, arrow arum, halberd-leaved tearthumb, lizard's-tail, and sedges such as tussock sedge. Elevated above normal high tides, hummocks provide habitat for marsh blue violet, water hemlock, clearweed, false nettle, and ferns such as royal fern, cinnamon fern, and marsh fern.

Species

Group	Scientific Name	Common Name
Amphibian	Lithobates kauffeldi	Atlantic Coast leopard frog

Bird	Ardea alba	Great egret
Bird	Ardea herodias	Great blue heron
Bird	Haliaeetus leucocephalus	Bald eagle
Bird	Scolopax minor	American woodcock
Bird	Melanerpes erythrocephalus	Red-headed woodpecker
Bird	Empidonax virescens	Acadian flycatcher
Bird	Vireo flavifrons	Yellow-throated vireo
Bird	Hylocichla mustelina	Wood thrush
Bird	Geothlypis formosa	Kentucky warbler
Bird	Helmitheros vermivorus	Worm-eating warbler
Bird	Icteria virens	Yellow-breasted chat
Bird	Mniotilta varia	Black-and-white warbler
Bird	Parkesia motacilla	Louisiana waterthrush
Bird	Protonotaria citrea	Prothonotary warbler
Bird	Seiurus aurocapillus	Ovenbird
Bird	Setophaga americana	Northern parula
Bird	Setophaga citrina	Hooded warbler
Bird	Setophaga ruticilla	American redstart
Bird	Piranga olivacea	Scarlet tanager
Insect	Lycaena hyllus	Bronze copper
Mammal	Eptesicus fuscus	Big brown bat
Mammal	Lasiurus borealis	Eastern red bat
Mammal	Neovison vison	American mink
Mammal	Lynx rufus	Bobcat
Reptile	Clemmys guttata	Spotted turtle
Reptile	Graptemys geographica	Northern map turtle
Reptile	Terrapene carolina	Eastern box turtle
Reptile	Lampropeltis getula	Eastern kingsnake
Reptile	Thamnophis sauritus	Common ribbonsnake

Tidal Freshwater Marsh & Shrubland

Tidal Freshwater Marshes and Shrublands are flooded twice daily by lunar tides. In Maryland, they are widely distributed along tidal rivers and shores of the Chesapeake Bay. This habitat occurs in upper sections of tidal rivers and creeks where water is consistently fresh (salinity less than 0.5 ppt). Pulses of higher salinity are common during spring high tides and episodes of low river discharge during drought cycles. Typically, there are two distinct zones in a tidal freshwater marsh; a low elevation zone dominated by short, broad-leaf emergents bordering mudflats or open water, and a slightly higher-elevation area dominated by tall graminoids. Plants in the low zone may include spadderdock, arrow arum, and pickerelweed while higher zones often support species such as wild rice, jewelweed, sweetflag, dotted smartweed, rice cutgrass, tearthumbs, and beggar-ticks. This zonation can be attributed to flooding depth, duration, and frequency. Tidal freshwater shrublands commonly form small, linear patches on floodplains between tidal emergent marshes and Tidal Forests. On narrow or constricted floodplains, discrete shrub-dominated communities occur along ecotones or transitional areas and may not be physiognomically distinct. Stands occupying rather expansive marshes or large estuary meanders on broader floodplains are commonly fronted or surrounded by emergent marshes forming depositional

islands. The vegetation of tidal freshwater shrub wetlands is very diverse and typically contains species characteristic of both tidal marshes and tidal forests. Common are shrubs such as smooth alder, winterberry, marsh rose, smooth arrow-wood, southern bayberry, and silky dogwood. Pronounced hummock and hollow microtopography is characteristic and contributes to relatively high species richness with most species confined to irregularly flooded hummocks. Hollows are regularly flooded and typically contain only those species tolerant of frequent inundation.

Species

Group	Scientific Name	Common Name
Insect	Atrytone logan	Delaware skipper
Insect	Lycaena hyllus	Bronze copper
Amphibian	Lithobates kauffeldi	Atlantic Coast leopard frog
Reptile	Clemmys guttata	Spotted turtle
Reptile	Malaclemys terrapin terrapin	Northern diamond-backed terrapin
Reptile	Lampropeltis getula	Eastern kingsnake
Bird	Anas rubripes	American black duck
Bird	Oxyura jamaicensis	Ruddy duck
Bird	Podilymbus podiceps	Pied-billed grebe
Bird	Ardea alba	Great egret
Bird	Ardea herodias	Great blue heron
Bird	Ixobrychus exilis	Least bittern
Bird	Nyctanassa violacea	Yellow-crowned night-heron
Bird	Nycticorax nycticorax	Black-crowned night-heron
Bird	Haliaeetus leucocephalus	Bald eagle
Bird	Actitis macularius	Spotted sandpiper
Bird	Arenaria interpres	Ruddy turnstone
Bird	Calidris alba	Sanderling
Bird	Calidris alpina	Dunlin
Bird	Calidris pusilla	Semipalmated sandpiper
Bird	Tringa flavipes	Lesser yellowlegs
Bird	Tringa melanoleuca	Greater yellowlegs
Bird	Cistothorus palustris	Marsh wren
Mammal	Cryptotis parva	Least shrew
Mammal	Eptesicus fuscus	Big brown bat
Mammal	Lasiurus borealis	Eastern red bat
Mammal	Neovison vison	American mink
Mammal	Lynx rufus	Bobcat

Floodplain Habitats Not Mapped

Artificial Impoundment and Wetland

No natural lakes occur in Cecil County; the County lies well south of the southern extent of glaciation and

lacks other natural lake–forming, geologically-based processes. However, numerous man-made wetlands, ponds, and lakes of varying sizes exist. These habitats are usually the result of water diversion. In many cases, impoundments were created at the expense of natural streams and river systems. Cecil County does, however, contain some small natural, open freshwater areas in the form of beaver impoundments, wetland openings (e.g., Carolina bays, vernal pools, montane bogs and fens, flooded riverine floodplain openings) and river oxbows. A variety of species of conservation need inhabit such areas and also use man-made impoundments and wetlands. In a few cases (e.g., black-banded sunfish), where natural aquatic habitats have been destroyed or degraded, artificial impoundments provide critical refugia. Today, the number and overall extent of the state's natural open water areas and wetlands have been greatly reduced due to various forms of wetland, stream and river habitat loss and degradation. Also, beaver populations in many parts of the state have never fully recovered from pre-1900 declines due to fur trapping pressure; the effects on aquatic ecosystems and associated wildlife have been significant.

Species

Group	Scientific Name	Common Name
Bird	Anas rubripes	American black duck
Bird	Aythya americana	Redhead
Bird	Aythya valisineria	Canvasback
Bird	Clangula hyemalis	Long-tailed duck
Bird	Melanitta americana	Black scoter
Bird	Melanitta fusca	White-winged scoter
Bird	Melanitta perspicillata	Surf scoter
Bird	Oxyura jamaicensis	Ruddy duck
Bird	Gavia immer	Common loon
Bird	Podiceps auritus	Horned grebe
Bird	Podilymbus podiceps	Pied-billed grebe
Bird	Ardea alba	Great egret
Bird	Ardea herodias	Great blue heron
Bird	Ixobrychus exilis	Least bittern
Bird	Nycticorax nycticorax	Black-crowned night-heron
Bird	Aquila chrysaetos	Golden eagle
Bird	Haliaeetus leucocephalus	Bald eagle
Bird	Actitis macularius	Spotted sandpiper
Bird	Arenaria interpres	Ruddy turnstone
Bird	Calidris alba	Sanderling
Bird	Calidris alpina	Dunlin
Bird	Calidris pusilla	Semipalmated sandpiper
Bird	Limnodromus griseus	Short-billed dowitcher
Bird	Phalaropus fulicarius	Red phalarope
Bird	Phalaropus lobatus	Red-necked phalarope
Bird	Pluvialis squatarola	Black-bellied plover
Bird	Tringa flavipes	Lesser yellowlegs
Bird	Tringa melanoleuca	Greater yellowlegs
Bird	Tringa semipalmata	Willet

Freshwater Mussel	Elliptio fisheriana	Northern lance
Freshwater Mussel	Lampsilis radiata	Eastern lampmussel
Mammal	Eptesicus fuscus	Big brown bat
Mammal	Lasiurus borealis	Eastern red bat
Mammal	Myotis lucifugus	Little brown myotis
Mammal	Myotis septentrionalis	Northern myotis
Mammal	Nycticeius humeralis	Evening bat
Mammal	Perimyotis subflavus	Tricolored bat
Mammal	Neovison vison	American mink
Reptile	Clemmys guttata	Spotted turtle
Reptile	Malaclemys terrapin terrapin	Northern diamond-backed terrapin
Reptile	Terrapene carolina	Eastern box turtle

Coastal Plain Seepage Swamp

This habitat is characterized by gently sloping forests of small headwaters, ravine bottoms, and toe-slopes where groundwater is discharged at ground surface and carried away as stream flow. Often the groundwater seepage is perennial and characterized by diffuse drainage and braided channels with sand, gravel, or peaty substrates. Soils are typically moderately to strongly acidic and nutrient-poor; however, basic seepage swamps may develop in ravines that have downcut into tertiary-aged shell marl deposits. Coastal Plain Seepage Swamps are associated with mostly closed to semi-open canopies of red maple, blackgum, tulip polar, sweetbay magnolia, green ash, white ash, and pitch pine. The shrub and herbaceous layers in many Coastal Plain Seepage Swamps are diverse and recognized by dense patches of skunk cabbage and colonies of ferns such as cinnamon fern, marsh fern, royal fern, New York fern, and netted chainfern. Other notable plants include jewelweed, small green orchid, Virginia water horehound, Jack-in-the-pulpit, false nettle, and numerous sedges. In addition, hummocks of peat mosses can be quite abundant and diagnostic to Coastal Plain Seepage Swamps of acidic substrates. The shrub layer may include winterberry, sweet pepperbush, swamp azalea, spicebush, possum-haw, highbush blueberry, and vines of poison-ivy, greenbrier, and Virginia creeper. Coastal Plain Seepage Swamps are naturally small-patched habitats vulnerable to hydrological disturbances, beaver activity, logging, and surface runoff.

Species

Group	**Scientific Name**	**Common Name**
Amphibian	Pseudotriton ruber	Northern red salamander
Bird	Scolopax minor	American woodcock
Bird	Empidonax virescens	Acadian flycatcher
Bird	Hylocichla mustelina	Wood thrush
Bird	Geothlypis formosa	Kentucky warbler
Bird	Mniotilta varia	Black-and-white warbler
Bird	Parkesia motacilla	Louisiana waterthrush

Bird	Protonotaria citrea	Prothonotary warbler
Bird	Seiurus aurocapillus	Ovenbird
Bird	Setophaga americana	Northern parula
Bird	Setophaga citrina	Hooded warbler
Bird	Setophaga ruticilla	American redstart
Bird	Piranga olivacea	Scarlet tanager
Insect	Cordulegaster erronea	Tiger spiketail
Insect	Libellula axilena	Bar-winged skimmer
Insect	Libellula flavida	Yellow-sided skimmer
Insect	Tachopteryx thoreyi	Gray petaltail
Insect	Lycaena hyllus	Bronze copper
Mammal	Sorex hoyi winnemana	Southern pygmy shrew
Mammal	Eptesicus fuscus	Big brown bat
Mammal	Lasiurus borealis	Eastern red bat
Mammal	Nycticeius humeralis	Evening bat
Mammal	Perimyotis subflavus	Tricolored bat
Mammal	Neovison vison	American mink
Mammal	Lynx rufus	Bobcat
Reptile	Clemmys guttata	Spotted turtle
Reptile	Glyptemys muhlenbergii	Bog turtle
Reptile	Terrapene carolina	Eastern box turtle
Reptile	Lampropeltis getula	Eastern kingsnake
Reptile	Thamnophis sauritus	Common ribbonsnake

Coastal Plain Stream

Cecil County's coastal plain streams extend from the fall line southward toward the Chesapeake Bay. These streams are typically low gradient (<1%) and found at elevations of less than 50' above sea level. Silt, sand, gravel, and small cobble are the dominant substrates. Most coastal plain streams contain only runs, glides and pools; however, gravel riffles are common in those streams draining the rolling hills on the western and upper eastern shore. Because coastal plain streams lack stable substrates such as bedrock and boulders, wood and submerged aquatic vegetation are important channel features. Submerged logs and tree roots slow the flow of nutrients and sediment, provide cover for fishes and stream insects, and control stream bank erosion. Eastern mudminnow, golden shiner, creek chubsucker, and fallfish are common in these systems. These streams are also important habitat to the American eel from the juvenile to adult stage. The Elk and Lower Susquehanna river basins contain non-blackwater coastal plain streams.

Species

Group	**Scientific Name**	**Common Name**
Amphibian	Pseudotriton ruber	Northern red salamander
Bird	Ardea herodias	Great blue heron

Bird	Nyctanassa violacea	Yellow-crowned night-heron
Bird	Parkesia motacilla	Louisiana waterthrush
Fish	Alosa mediocris	Hickory shad
Fish	Alosa sapidissima	American shad
Fish	Notropis bifrenatus	Bridle shiner
Fish	Percina bimaculata	Chesapeake Logperch
Freshwater Mussel	Anodonta implicata	Alewife floater
Freshwater Mussel	Elliptio fisheriana	Northern lance
Freshwater Mussel	Lampsilis radiata	Eastern lampmussel
Freshwater Mussel	Leptodea ochracea	Tidewater mucket
Insect	Cordulegaster erronea	Tiger spiketail
Mammal	Eptesicus fuscus	Big brown bat
Mammal	Lasiurus borealis	Eastern red bat
Mammal	Myotis lucifugus	Little brown myotis
Mammal	Perimyotis subflavus	Tricolored bat
Mammal	Neovison vison	American mink
Reptile	Clemmys guttata	Spotted turtle
Reptile	Glyptemys insculpta	Wood turtle
Reptile	Glyptemys muhlenbergii	Bog turtle
Reptile	Thamnophis sauritus	Common ribbonsnake

Hemlock-Northern Hardwood Forest

The Hemlock – Northern Hardwood Forest habitat is characterized by cool, mesic forests of low mountain slopes and valleys in Cecil County. The composition of Hemlock – Northern Hardwood Forests varies with site conditions and has been heavily influenced by destructive fires and extensive logging of eastern hemlock, red spruce, white pine, and hardwoods in the early 1900's. Today's stands are typically dominated by northern hardwoods such as sugar maple, American beech, black cherry, and yellow birch with mixtures of eastern hemlock. Other tree associates may include northern red oak, white oak, white pine, sweet birch, red spruce, white ash, basswood, and red maple. The understory of Hemlock-Northern Hardwood Forests may include species such as striped maple, witch hazel, maple-leaf viburnum, and dense patches of great laurel and mountain laurel. It is not uncommon to discover the herbaceous layers in some stands entirely dominated by patches of hayscented fern or New York fern. Other characteristic herbs include Indian cucumber-root, whorled wood aster, Canada mayflower, bellworts, violets, and wood-ferns. This habitat is related in part to small outlying stands of eastern hemlock that occur along north-facing river bluffs and ravines in the Piedmont and Coastal Plain.

Species

Group	Scientific Name	Common Name
Bird	Buteo platypterus	Broad-winged hawk

Bird	Haliaeetus leucocephalus	Bald eagle
Bird	Scolopax minor	American woodcock
Bird	Caprimulgus vociferus	Eastern whip-poor-will
Bird	Empidonax virescens	Acadian flycatcher
Bird	Certhia americana	Brown creeper
Bird	Catharus fuscescens	Veery
Bird	Hylocichla mustelina	Wood thrush
Bird	Geothlypis formosa	Kentucky warbler
Bird	Helmitheros vermivorus	Worm-eating warbler
Bird	Mniotilta varia	Black-and-white warbler
Bird	Seiurus aurocapillus	Ovenbird
Bird	Setophaga americana	Northern parula
Bird	Setophaga citrina	Hooded warbler
Bird	Setophaga ruticilla	American redstart
Bird	Piranga olivacea	Scarlet tanager
Mammal	Sorex fumeus	Smoky shrew
Mammal	Sorex hoyi winnemana	Southern pygmy shrew
Mammal	Eptesicus fuscus	Big brown bat
Mammal	Lasiurus borealis	Eastern red bat
Mammal	Myotis lucifugus	Little brown myotis
Mammal	Myotis septentrionalis	Northern myotis
Mammal	Perimyotis subflavus	Tricolored bat
Mammal	Neovison vison	American mink
Mammal	Lynx rufus	Bobcat
Reptile	Glyptemys insculpta	Wood turtle
Reptile	Terrapene carolina	Eastern box turtle

Intertidal Mud Flat and Sand Flat

This habitat is characterized by mud flats and sand flats of embayed areas along the coast. They are best developed in shallow protected estuarine bays, pools, and along small tidal creeks and guts. The depth and frequency of tidal flooding is variable depending on the landscape setting, but most flats are exposed twice daily during low tide cycles. Though not species rich, vascular aquatic species can be abundant and often include species such as eelgrass, beaked ditch-grass, horned pondweed, and sago pondweed. Aquatic algae can be also abundant and may frequently include species of sea-lettuces.

Species

Group	Scientific Name	Common Name
Bird	Anas rubripes	American black duck
Bird	Ardea alba	Great egret
Bird	Ardea herodias	Great blue heron
Bird	Nyctanassa violacea	Yellow-crowned night-heron

Bird	Nycticorax nycticorax	Black-crowned night-heron
Bird	Haliaeetus leucocephalus	Bald eagle
Bird	Actitis macularius	Spotted sandpiper
Bird	Arenaria interpres	Ruddy turnstone
Bird	Calidris alba	Sanderling
Bird	Calidris alpina	Dunlin
Bird	Calidris pusilla	Semipalmated sandpiper
Bird	Limnodromus griseus	Short-billed dowitcher
Bird	Numenius phaeopus	Whimbrel
Bird	Pluvialis squatarola	Black-bellied plover
Bird	Tringa flavipes	Lesser yellowlegs
Bird	Tringa melanoleuca	Greater yellowlegs
Reptile	Malaclemys terrapin terrapin	Northern diamond-backed terrapin

Montane-Piedmont Acidic Seepage Swamp

This habitat of the Piedmont region is characterized by gently sloping seepage swamps of small headwaters, large spring seeps, ravine bottoms, and toe-slopes. Seepage swamps develop where groundwater is forced to the surface along an impermeable clay or rock layer due to hydrostatic pressure resulting from gravity or artesian flow. They often have a diffuse drainage pattern of braided channels and rivulets that typically remain saturated throughout the year due to perennial groundwater seepage. The soils are acidic and derived from the weathering of sandstone, quartzite, and granitic bedrock. In this case, the hydrology and acidic soils of seepage swamps in the piedmont region combine to support a very distinctive flora. Acidic Seepage Swamps are structurally forests and woodlands with canopies ranging from closed to semi-open canopy. Canopy trees commonly include red maple, tulip poplar, and blackgum. Small openings of shrubs and herbs are typical in areas of windfall or beaver activity. Shrubs vary depending on the region but common species may include winterberry, swamp azalea, highbush blueberry, great-laurel, mountain-laurel, speckled alder, and arrowwoods. The forest floor is comprised of spaghnum moss covered hummocks and mucky hollows frequently dominated by skunk cabbage, American false-helleborne and cinnamon fern. Other common associates may include long sedge, bog sedge, three-seed sedge, white-edged sedge, marsh marigold, orchids, buttercups and asters.

Species

Group	**Scientific Name**	**Common Name**
Bird	Scolopax minor	American woodcock
Bird	Empidonax traillii	Willow flycatcher
Bird	Empidonax virescens	Acadian flycatcher
Bird	Catharus fuscescens	Veery
Bird	Hylocichla mustelina	Wood thrush
Bird	Geothlypis formosa	Kentucky warbler
Bird	Mniotilta varia	Black-and-white warbler
Bird	Parkesia motacilla	Louisiana waterthrush
Bird	Protonotaria citrea	Prothonotary warbler
Bird	Seiurus aurocapillus	Ovenbird

Bird	Setophaga americana	Northern parula
Bird	Setophaga citrina	Hooded warbler
Bird	Setophaga ruticilla	American redstart
Bird	Vermivora pinus	Blue-winged warbler
Bird	Piranga olivacea	Scarlet tanager
Insect	Cordulegaster erronea	Tiger spiketail
Insect	Tachopteryx thoreyi	Gray petaltail
Insect	Euphydryas phaeton	Baltimore checkerspot
Insect	Euphyes conspicua	Black dash
Insect	Hesperia sassacus	Indian skipper
Insect	Poanes massasoit massasoit	Mulberry wing
Mammal	Eptesicus fuscus	Big brown bat
Mammal	Lasiurus borealis	Eastern red bat
Mammal	Myotis lucifugus	Little brown myotis
Mammal	Myotis septentrionalis	Northern myotis
Mammal	Nycticeius humeralis	Evening bat
Mammal	Perimyotis subflavus	Tricolored bat
Mammal	Neovison vison	American mink
Mammal	Lynx rufus	Bobcat
Reptile	Clemmys guttata	Spotted turtle
Reptile	Terrapene carolina	Eastern box turtle
Reptile	Thamnophis sauritus	Common ribbonsnake

Piedmont Stream

Piedmont streams, defined by their western boundary of the County line to the eastern border at the fall line, are among the most biologically productive systems in the County. The physical and chemical nature of Piedmont streams is governed largely by the varying topography and geology of the Piedmont physiographic province. Streams along the eastern edge share similar physical characteristics with the neighboring Coastal Plain. Here, streams are typically low to moderate gradient (1-2%) with silt, sand, and gravel substrates common. Juxtaposition of these two physiographic provinces results in a mixing of aquatic biota, with several predominantly Coastal Plain species commonly found within Piedmont streams draining this transition zone. Fish species common to these streams include tessellated darter, eastern blacknose dace, common shiner, and bluntnose minnow. High- gradient Piedmont streams are characterized by cobble-boulder substrates with bedrock outcrops common. Blue Ridge sculpin, brown trout, brook trout, and longnose dace are frequently encountered in these systems. Streamside trees and logs play an important role in shaping the stream channel and banks, creating pools and slow-water areas beneficial to many aquatic species. Logs and leaf litter are also a primary source of organic matter forming the base of the food web in these streams.

Species

Group	**Scientific Name**	**Common Name**
Amphibian	Pseudotriton ruber	Northern red salamander
Bird	Nyctanassa violacea	Yellow-crowned night-heron

Bird	Parkesia motacilla	Louisiana waterthrush
Crustacean	Orconectes obscurus	Allegheny crayfish
Fish	Notropis bifrenatus	Bridle shiner
Fish	Percina bimaculata	Chesapeake Logperch
Freshwater Mussel	Anodonta implicata	Alewife floater
Freshwater Mussel	Lampsilis radiata	Eastern lampmussel
Insect	Cordulegaster erronea	Tiger spiketail
Mammal	Eptesicus fuscus	Big brown bat
Mammal	Lasiurus borealis	Eastern red bat
Mammal	Myotis lucifugus	Little brown myotis
Mammal	Myotis septentrionalis	Northern myotis
Mammal	Nycticeius humeralis	Evening bat
Mammal	Perimyotis subflavus	Tricolored bat
Mammal	Neovison vison	American mink
Reptile	Clemmys guttata	Spotted turtle
Reptile	Glyptemys insculpta	Wood turtle
Reptile	Glyptemys muhlenbergii	Bog turtle
Reptile	Thamnophis sauritus	Common ribbonsnake

Piedmont Seepage Wetland

This habitat is characterized by open, graminoid-dominated meadows and shrub swamps scattered throughout low stream valleys of the Piedmont. They are common features at the toeslopes of rolling hills and margins of floodplains where groundwater seepage can be found throughout much of the year. The water table is usually at or near the surface throughout much of the growing season causing most habitats to remain saturated, but conditions may vary yearly from site to site. The substrates of Piedmont Seepage Wetlands are primarily comprised of mineral soils with mucky, organic surficial layers. The vegetation structure varies from graminoid-dominated meadows of tussock sedge, common rush, wood reed, and rice cutgrass to a patchwork of shrub swamps dominated by alder, meadowsweet, southern arrowwood, buttonbush, spicebush, marsh rose, and black willow. Other common species include jewelweed, skunk cabbage, sensitive fern, wood reed, wool-grass, Joe pye-weed, American golden saxifrage, shallow sedge, tearthumbs, and marsh fern. In addition, purple loosestrife, common reed, Japanese stilt-grass and reed canary grass are frequently reported non-native invasive plants in these habitats. Though trees are relatively unimportant in these habitats, woody plant succession of red maple is a common problem that usually indicates a cessation of grazing.

Species

Group	Scientific Name	Common Name
Amphibian	Pseudotriton ruber	Northern red salamander
Bird	Scolopax minor	American woodcock

Bird	Empidonax traillii	Willow flycatcher
Bird	Empidonax virescens	Acadian flycatcher
Bird	Setophaga ruticilla	American redstart
Bird	Vermivora pinus	Blue-winged warbler
Insect	Cordulegaster erronea	Tiger spiketail
Insect	Libellula flavida	Yellow-sided skimmer
Insect	Tachopteryx thoreyi	Gray petaltail
Insect	Danaus plexippus	Monarch
Insect	Euphydryas phaeton	Baltimore checkerspot
Insect	Euphyes conspicua	Black dash
Insect	Hesperia sassacus	Indian skipper
Insect	Lycaena hyllus	Bronze copper
Insect	Poanes massasoit massasoit	Mulberry wing
Mammal	Sorex hoyi winnemana	Southern pygmy shrew
Mammal	Eptesicus fuscus	Big brown bat
Mammal	Lasiurus borealis	Eastern red bat
Mammal	Myotis lucifugus	Little brown myotis
Mammal	Myotis septentrionalis	Northern myotis
Mammal	Nycticeius humeralis	Evening bat
Mammal	Perimyotis subflavus	Tricolored bat
Mammal	Neovison vison	American mink
Mammal	Lynx rufus	Bobcat
Reptile	Clemmys guttata	Spotted turtle
Reptile	Glyptemys muhlenbergii	Bog turtle
Reptile	Terrapene carolina	Eastern box turtle
Reptile	Thamnophis sauritus	Common ribbonsnake

Spring

The Spring habitat is a concentrated discharge of groundwater at a small (usually < 1 m2), distinct site or opening in the ground. Springs are uncommon, isolated features and most occur west of the Fall Line. They provide critical habitat for highly rare aquatic snails and subterranean invertebrates, salamanders, crayfish and other invertebrates. Because some Springs discharge directly into streams or wetlands, they also play a vital role in maintaining the ecological integrity of these habitats which, in turn, may harbor species of conservation concern (e.g., Pearl Dace, Brook Trout, rare dragonflies and damselflies). Springs emit groundwater due to hydrostatic pressure resulting from gravity or artesian flow, although other physical forces may play a role (e.g., buoyant effect of dissolved gases). Several types of Springs exist including contact, scree and fault springs. Perhaps the most common type is fracture or crevice springs. Here, groundwater moves downward due to gravity, flowing through fractures and crevices underneath the ground and emerging as a spring where a major fracture in a rock formation occurs at the earth's surface, usually along a ravine or swale. The flow or discharge rate of springs can range from less than one gallon per minute to nearly 10,000 gallons per minute. Springs differ from seeps in that the latter appear on the ground surface as broad, diffuse zones of wetness or percolation rather than distinct discharge sites. Also, seeps and associated wetlands often support distinct plant communities while springs are essentially aquatic and geological features.

Species

Group	Scientific Name	Common Name
Crustacean	Stygobromus caecilius	Cecil groundwater amphipod
Crustacean	Stygobromus felleri	Feller's groundwater amphipod
Crustacean	Stygobromus pizzinii	Pizzini's amphipod
Crustacean	Stygobromus tenuis tenuis	Tenuis amphipod
Flatworm	Sphalloplana sp 1	A planarian

List of Rare, Threatened, and Endangered Species of Cecil County

February 2018

Maryland Wildlife and Heritage Service
Natural Heritage Program

Larry Hogan, Governor
Mark Belton, Secretary

Wildlife & Heritage Service
Natural Heritage Program
Tawes State Office Building, E-1
580 Taylor Avenue
Annapolis, MD 21401
410-260-8540
Fax 410-260-8596
dnr.maryland.gov/wildlife

Additional Telephone Contact Information:
Toll free in Maryland: 877-620-8DNR ext. 8540 OR
Individual unit/program toll-free number
Out of state call: 410-260-8540
Text Telephone (TTY) users call via the Maryland Relay

ACKNOWLEDGMENTS

The Maryland Department of Natural Resources would like to express sincere appreciation to the many scientists and naturalists who willingly share information and provide their expertise to further our mission of conserving Maryland's natural heritage.

Publication of this list is made possible by taxpayer donations to Maryland's Chesapeake Bay and Endangered Species Fund.

IMPORTANT NOTES

This list is a subset of the main reports:
Maryland Natural Heritage Program. 2016. List of Rare, Threatened, and Endangered Plants of Maryland DNR 03-010418-42 and
Maryland Natural Heritage Program. 2016. Rare, Threatened, and Endangered Plants of Maryland DNR 03-010418-43 and
Maryland Natural Heritage Program. 2016. List of Rare, Threatened, and Endangered Animals of Maryland DNR 03-1272016-633

Please refer to these for important information including history, purpose, governing laws and regulations, understanding state and federal conservation status ranks and legal statuses, and for additional resources.

This list is derived from an extensive data collection effort and numerous field surveys to determine distribution and abundance of plants and animals native to Maryland. Although based on a large volume of information, this list should not be viewed as complete or definitive. While much is known about some species, very little is known about others. The Maryland Natural Heritage Program welcomes additional information or recommendations regarding any of the taxa listed herein.

HOW YOU CAN HELP

You can take an active part in conserving Maryland's rare species by contacting the Wildlife and Heritage Service with the following types of information:

1. Location details should be included (exact mapped location using GPS is preferred, but not required). Online applications such as Google Earth are invaluable but precise, written directions including driving and walking are acceptable.

2. Documentation that includes a photograph, description of the species, identification source, and habitat description should accompany the report.

3. Information on the ecology and or biology of the species including observed and/or identified pollinators should accompany the report.

**Additional information, including a downloadable PDF of our rare plant reporting form can be found at:
dnr.maryland.gov/wildlife/Pages/plants_wildlife/rte_reportinginst.aspx

Definitions of qualifiers used in the county distribution of species.

Distributional Qualifier	Definition
{species}$^{?}$	Record for the county is reported but unverified or may indicate that the record occurs outside of the known range or in atypical habitat.
{species}^{h}	Record for the county is based upon a historical collection but no extant population is known.
{species}^{I}	Record for the county is the result of an introduction.

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	STATE STATUS	FEDERAL STATUS
Animals					
Acipenser brevirostrum	Shortnose Sturgeon	G3	S1	E	LE
Ameiurus catus	White Catfish	G5	SU		
Cryptobranchus alleganiensis	Eastern Hellbender	G3G4	S1	E	
Glyptemys muhlenbergii	Bog Turtle	G3	S2	T	LT
Graptemys geographica	Northern Map Turtle	G5	S1	E*	
Haliaeetus leucocephalus	Bald Eagle	G5	S3S4		
Ixobrychus exilis	Least Bittern	G5	S2S3B	I	
Percina bimaculata	Chesapeake Logperch	G1G2	S1S2	T	
Percopsis omiscomaycus	Trout-perch	G5	SX	X	
Sciurus niger cinereus	Delmarva Fox Squirrel	G5T3	S1	I	
Caecidotea pricei	Price's Cave Isopod	G5	S3		
Cicindela puritana	Puritan Tiger Beetle	G1G2	S1S2	E	LT
Lampsilis radiata	Eastern Lampmussel	G5	SU		
Leptodea ochracea	Tidewater Mucket	G3G4	S1S2		
Speyeria idalia	Regal Fritillary	G3	SH	X	
Strophitus undulatus	Creeper	G5	S2	I	
Stygobromus pizzinii	Pizzini's Cave Amphipod	G3G4	S1		
Stygobromus tenuis tenuis	Slender Amphipod	G4T4	SU		
Plants					
Agrimonia microcarpa [h]	Small-fruited Agrimony	G5	S1?		
Agrimonia striata [h]	Woodland Agrimony	G5	S1	E	
Amianthium muscitoxicum	Fly-poison	G4G5	S2		
Ammannia latifolia [h]	Koehne Ammannia	G5	S2		
Anaphalis margaritacea [h]	Pearly Everlasting	G5	S3		
Antennaria solitaria	Single-head Pussytoes	G5	S2	T	
Aronia x prunifolia	Purple Chokeberry	GNA	S3		
Asclepias purpurascens	Purple Milkweed	G5?	S2		
Asclepias verticillata	Whorled Milkweed	G5	S3		
Asplenium pinnatifidum [h]	Lobed Spleenwort	G4	S1	E	
Aureolaria flava	Smooth Yellow False Foxglove	G5	S3		
Bartonia paniculata	Twining Screwstem	G5	S3		
Betula populifolia	Gray Birch	G5	S1?		
Bidens bidentoides	Maryland Bur-marigold	G3G4	S3.1		
Borodinia dentata	Short's Rockcress	G5	S3		
Bromus latiglumis	Broad-glumed Brome	G5	S1	E	
Buchnera americana [h]	Bluehearts	G5?	SH	X	
Campanula rotundifolia	American Harebell	G5	S2		
Cardamine douglassii	Purple Cress	G5	S3		
Cardamine longii [h]	Long's Bittercress	G3?	S2	E	
Carex albursina	White Bear Sedge	G5	S3		
Carex bullata	Button Sedge	G5	S3		
Carex buxbaumii	Buxbaum's Sedge	G5	S2	T	

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	STATE STATUS	FEDERAL STATUS
Carex conoidea	Field Sedge	G5	S1	E	
Carex cristatella	Crested Sedge	G5	S1?		
Carex echinata	Prickly Sedge	G5	S3		
Carex hirtifolia	Pubescent Sedge	G5	S3		
Carex hitchcockiana	Hitchcock's Sedge	G5	S1	E	
Carex hystericina	Porcupine Sedge	G5	S1	E	
Carex interior	Inland Sedge	G5	S1		
Carex lacustris	Lake-bank Sedge	G5	S2		
Carex lucorum	Blue Ridge Sedge	G5	S1		
Carex lupuliformis	False Hop Sedge	G4	S2		
Carex pellita	Wooly Sedge	G5	S2?		
Carex planispicata	Flat-spiked Sedge	G4Q	S1S2		
Carex polymorpha [h]	Variable Sedge	G3	SH	X	
Carex richardsonii	Richardson's Sedge	G5	S1	E	
Carex shortiana	Short's Sedge	G5	S3S4	E	
Carex sparganioides	Bur-reed Sedge	G5	S1S2		
Carex striatula	Lined Sedge	G4G5	S3		
Carex tenera [h]	Slender Sedge	G5	SH	X	
Carex tetanica var. *canbyi*	Rigid Sedge	G4G5 T1T2Q	S1	E	
Carex vestita	Velvety Sedge	G5	S2	T	
Castilleja coccinea [h]	Scarlet Indian-paintbrush	G5	S1	E	
Cerastium velutinum var. villosissimum	Octoraro Creek Chickweed	G5T1	S1		
Chamaelirium luteum	Devil's-bit	G5	S2		
Chenopodium standleyanum [h]	Standley's Goosefoot	G5	S2S3	E	
Cicuta bulbifera	Bulb-bearing Water-hemlock	G5	S1	E	
Cirsium horridulum	Yellow Thistle	G5	S3		
Cirsium muticum	Swamp Thistle	G5	S3		
Clematis occidentalis [h]	Purple Clematis	G5	S1	E	
Coreopsis tripteris [h]	Tall Tickseed	G5	S1	E	
Crocanthemum bicknellii	Plains Frostweed	G5	S1	E	
Cuscuta coryli [?]	Hazel Dodder	G5?	S1	X	
Cyperus dentatus [h]	Toothed Sedge	G4	SH	X	
Cyperus hystricinus	Flatsedge	G4	S2		
Cyperus lancastriensis	Many-flowered Umbrella-sedge	G5	SU		
Cyperus refractus [h]	Reflexed Flatsedge	G5	S2?		
Cypripedium parviflorum var. pubescens	Large Yellow Lady's-slipper	G5T5	S3		
Deschampsia cespitosa	Tufted Hairgrass	G5	S1	E	
Desmodium laevigatum	Smooth Tick-trefoil	G5	S3		
Desmodium obtusum	Stiff Tick-trefoil	GNRQ	S1	E	
Desmodium sessilifolium [h]	Sessile-leaf Tick-trefoil	G5	SH	X	
Dichanthelium oligosanthes var. scribnerianum	Scribner's Witchgrass	G5T5	S2		

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	STATE STATUS	FEDERAL STATUS
Diphasiastrum tristachyum	Deep-root Clubmoss	G5	S3		
Dirca palustris	Eastern Leatherwood	G4	S2	T	
Drosera rotundifolia	Roundleaf Sundew	G5	S3		
Dryopteris celsa	Log Fern	G4	S3		
Dryopteris goldiana	Goldie's Fern	G4G5	S2		
Elatine americana	American Waterwort	G4	SU		
Elatine minima	Small Waterwort	G5	S1?	E	
Eleocharis compressa	Flat-stem Spikerush	G4	S1	E	
Eleocharis engelmannii	Engelmann's Spikerush	G4G5	S3		
Eleocharis erythropoda [h]	Bald Spikerush	G5	SU		
Eleocharis melanocarpa	Black-fruit Spikerush	G4	S1	E	
Epilobium strictum [h]	Downy Willowherb	G5	S1	E	
Equisetum fluviatile	Water Horsetail	G5	S1	E	
Erigenia bulbosa	Harbinger-of-spring	G5	S3		
Eriocaulon parkeri	Parker's Pipewort	G3	S2	T	
Erythronium albidum [h]	White Trout Lily	G5	S2	T	
Eupatorium altissimum	Tall Boneset	G5	S3		
Euphorbia purpurea	Glade Spurge	G3	S1	E	
Eurybia radula	Rough Wood Aster	G5	S1	E	
Festuca paradoxa [h]	Cluster Fescue	G5	S1?		
Fimbristylis annua	Annual Fimbry	G5	S3		
Fraxinus nigra [h]	Black Ash	G5	S3		
Galium boreale	Northern Bedstraw	G5	S1	E	
Gentiana andrewsii [h]	Fringe-top Bottle Gentian	G5?	S2	T	
Gentiana villosa [h]	Striped Gentian	G4	S1	E	
Gentianopsis crinita [h]	Fringed Gentian	G5	S1	E	
Geum laciniatum	Rough Avens	G5	S3		
Gymnocladus dioicus [l]	Kentucky Coffeetree	G5	S1		
Helonias bullata	Swamp Pink	G3	S2	E	LT
Heracleum maximum	Cow-parsnip	G5	S3		
Hibiscus laevis	Halberd-leaf Rosemallow	G5	S3		
Hybanthus concolor	Green Violet	G5	S3		
Hydrastis canadensis	Golden-seal	G3G4	S2	T	
Hylodesmum pauciflorum [h]	Few-flowered Tick-trefoil	G5	S2	E	
Hypericum ellipticum [?]	Pale St. John's-wort	G5	SU		
Iris prismatica	Slender Blueflag	G4G5	S2	E	
Isoëtes engelmannii	Engelmann's Quillwort	G4	S3		
Isoëtes riparia	Riverbank Quillwort	G5	SU		
Juglans cinerea	Butternut	G4	S2S3		
Juniperus communis [h]	Dwarf Juniper	G5	SH	X	
Kalmia angustifolia	Sheep Laurel	G5	S3S4		
Lathyrus palustris	Vetchling Peavine	G5	S1	E	
Lilium philadelphicum [h]	Wood Lily	G5	SH	X	
Limnobium spongia	American Frog's-bit	G4	S1	E	

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	STATE STATUS	FEDERAL STATUS
Limosella australis	Mudwort	G4G5	S2	E	
Linum intercursum [h]	Sandplain Flax	G4	S2	T	
Lithospermum latifolium	American Gromwell	G4	S1	E	
Lygodium palmatum	Climbing Fern	G4	S2	T	
Lysimachia lanceolata [h]	Lanceleaf Loosestrife	G5	S3		
Matelea carolinensis [h]	Carolina Anglepod	G4	S2S3	E	
Matteuccia struthiopteris	Ostrich Fern	G5	S2S3		
Minuartia michauxii	Michaux's Stitchwort	G5	S2	T	
Monarda media [?]	Purple Bergamot	G4?	SH		
Morella caroliniensis	Evergreen Bayberry	G5	S1	E	
Muhlenbergia sylvatica [h]	Woodland Muhly	G5	S3		
Myosotis macrosperma	Large-seed Forget-me-not	G5	S3S4		
Panax quinquefolius	American Ginseng	G3G4	S2S3		
Panicum philadelphicum [h]	Philadelphia Panicgrass	G5	SU		
Pedicularis lanceolata	Swamp Lousewort	G5	S1	E	
Persicaria robustior [h]	Stout Smartweed	G4G5	SU	X	
Phaseolus polystachios	Wild Kidney Bean	G5	S3		
Phemeranthus teretifolius	Roundleaf Fameflower	G4	S2	T	
Physalis virginiana	Virginia Ground-cherry	G5	S3		
Pilea fontana	Springs Clearweed	G5	S3		
Platanthera cristata	Crested Yellow Orchid	G5	S3		
Platanthera peramoena	Purple Fringeless Orchid	G5	S1S2	T	
Platanthera psycodes [h]	Small Purple Fringed Orchid	G5	SH	X	
Podostemum ceratophyllum	Threadfoot	G5	S3		
Polygala incarnata	Pink Milkwort	G5	S2S3		
Polygala senega [h]	Seneca Snakeroot	G4G5	S2	T	
Potamogeton amplifolius [h]	Large-leaved Pondweed	G5	S1S2		
Potamogeton perfoliatus	Claspingleaf Pondweed	G5	S3		
Potamogeton pusillus	Slender Pondweed	G5	S2S4		
Potamogeton robbinsii [h]	Flatleaf Pondweed	G5	S1?	X	
Potamogeton zosteriformis	Flatstem Pondweed	G5	S1	E	
Prunus alleghaniensis [h]	Allegheny Plum	G4	S2	T	
Pycnanthemum torreyi [?]	Torrey's Mountainmint	G2	S1	E	
Pycnanthemum verticillatum	Whorled Mountainmint	G5	S1	E	
Pycnanthemum virginianum	Virginia Mountainmint	G5	S2		
Ranunculus ambigens [h]	Water-plantain Spearwort	G4	S1	X	
Ranunculus carolinianus [?]	Carolina Buttercup	G5T5	S1S3	X	
Ranunculus hederaceus	Long-stalked Crowfoot	G5	S1	E	
Rhynchospora alba	White Beakrush	G5	S3		
Rhynchospora recognita	Cymose Beakrush	G5?	S2		
Ruellia strepens [h]	Limestone Wild Petunia	G4G5	S2S3		
Rumex altissimus	Tall Dock	G5	S1	E	
Sabatia dodecandra	Large Marsh Pink	G5?	S3		
Sagittaria graminea	Grassleaf Arrowhead	G5	SU		

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	STATE STATUS	FEDERAL STATUS
Sagittaria spatulata	Spongy Arrowhead	G5	S2		
Sagittaria subulata	Strap-leaf Arrowhead	G4	SU		
Salix bebbiana [h]	Bebb's Willow	G5	SH	X	
Salix discolor [?]	Pussy Willow	G5	SH		
Salix exigua	Narrowleaf Willow	G5	S1	E	
Salix lucida [h]	Shining Willow	G5	SH	X	
Salix occidentalis	Dwarf Prairie Willow	G5T4T5	S2		
Sanguisorba canadensis	Canada Burnet	G5	S2	T	
Sanicula trifoliata	Large-fruited Sanicle	G4	S3		
Schoenoplectus novae-angliae	Salt-marsh Bulrush	G5	S2		
Scirpus expansus	Woodland Bulrush	G4	S3		
Scleria muehlenbergii	Muhelenberg's Nutrush	G5	S1S2		
Scrophularia lanceolata	Hare Figwort	G5	S3		
Scutellaria galericulata	Hooded Skullcap	G5	S2		
Scutellaria incana	Hoary Skullcap	G5	S3		
Scutellaria leonardii	Shale Barren Skullcap	G4T4	S2	T	
Scutellaria nervosa	Veined Skullcap	G5	S1S2	E	
Scutellaria serrata [h]	Showy Skullcap	G4G5	S3		
Senecio suaveolens [h]	Sweet-scented Indian-plantain	G4	S1	E	
Sida hermaphrodita	Virginia Mallow	G3	S1	E	
Smilax ecirrata	Upright Greenbrier	G5	S1S3		
Smilax pseudochina	Long-stalk Greenbrier	G4G5	S2	T	
Solidago arguta var. arguta	Late Goldenrod	G5T4T5	S1?		
Solidago rigida [h]	Prairie Goldenrod	G5	S1	X	
Sparganium eurycarpum	Giant Bur-reed	G5	S3		
Sphenopholis pensylvanica	Swamp Wedgescale	G4	S2	T	
Spiranthes lucida	Shining Ladies'-tresses	G4	S1	E	
Spiranthes tuberosa [h]	Little Ladies'-tresses	G5	S1?		
Sporobolus clandestinus [h]	Rough Dropseed	G5	S2		
Sporobolus heterolepis	Northern Dropseed	G5	S1	E	
Stachys aspera [h?]	Gritty Hedge-nettle	G4?	S1	E	
Stellaria alsine	Trailing Stitchwort	G5	S1	E	
Stenanthium gramineum	Eastern Featherbells	G4G5	S1	T	
Stenanthium leimanthoides	Death-camas	G4Q	S1	E	
Symphyotrichum depauperatum	Serpentine Aster	G2	S1	E	
Symphyotrichum laeve var. concinnum [h]	Smooth Blue Aster	G5T4	S1?	X	
Thaspium trifoliatum [h]	Purple Meadow Parsnip	G5	S1	E	
Trichophorum planifolium	Bashful Bulrush	G4G5	S2		
Trillium flexipes [?]	Nodding Trillium	G5	S1	E	
Triosteum angustifolium	Yellowleaf Tinker's-weed	G5	S1	E	
Triphora trianthophoros [h]	Nodding Pogonia	G3G4	S1	E	
Valeriana pauciflora	Valerian	G4	S1	E	
Veratrum hybridum	Broadleaf Bunchflower	G5	S1	E	

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	STATE STATUS	FEDERAL STATUS
Veratrum virginicum	Virginia Bunchflower	G5	S3		

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

Department of Land Use and Development Services

Adrienne Thomas, Colin Swan, Tyler Shaw, Tyler Steele, and Vy Ma
EVNM 670

Table of Contents

EXECUTIVE SUMMARY **1**

INTRODUCTION **2**

PURPOSE AND BACKGROUND 2
NATURAL RESOURCE INVENTORY 3
Floodplains. *3*
Wetlands. *4*
Surface Water Features. *5*

MITIGATION SOLUTIONS FOR CRITICAL FACILITIES **6**

Critical Facilities Table *17*

STORMWATER INCENTIVE PROGRAM **19**

BACKGROUND ON STORMWATER MANAGEMENT 19

INCENTIVE MECHANISMS **24**

COMMERCIAL INCENTIVES 24
RESIDENTIAL INCENTIVES 26

PARTNERSHIPS AND GRANTS **28**

FEDERAL 28
The Flood Mitigation Grant Assistance Program. *29*
STATE 29
The Comprehensive Flood Management Grant Program *30*
The Water Quality Financing Administration (WQFA). *30*
Land Acquisition and Planning Programs *30*
NON-GOVERNMENTAL ORGANIZATIONS 31
American Planning Association. *31*
The Eastern Shore Land Conservancy. *31*
Chesapeake Bay Organizations. *31*
Alliance for the Chesapeake Bay *32*
Chesapeake Bay Trust. *32*
Stroud Water Research Center. *32*

CONCLUSION **34**

REFERENCES **35**

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.

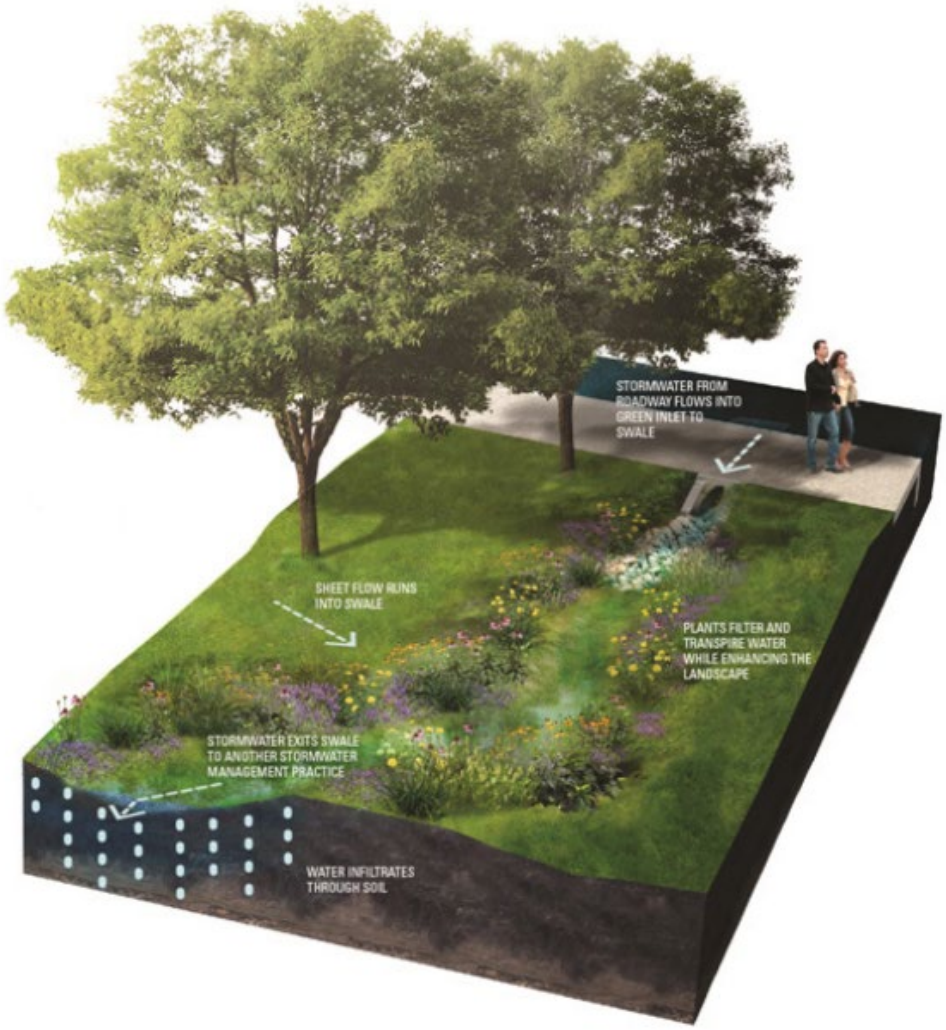


Figure 3: Example of typical layout for a bioswale. Source: Philadelphia Water Department.

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.

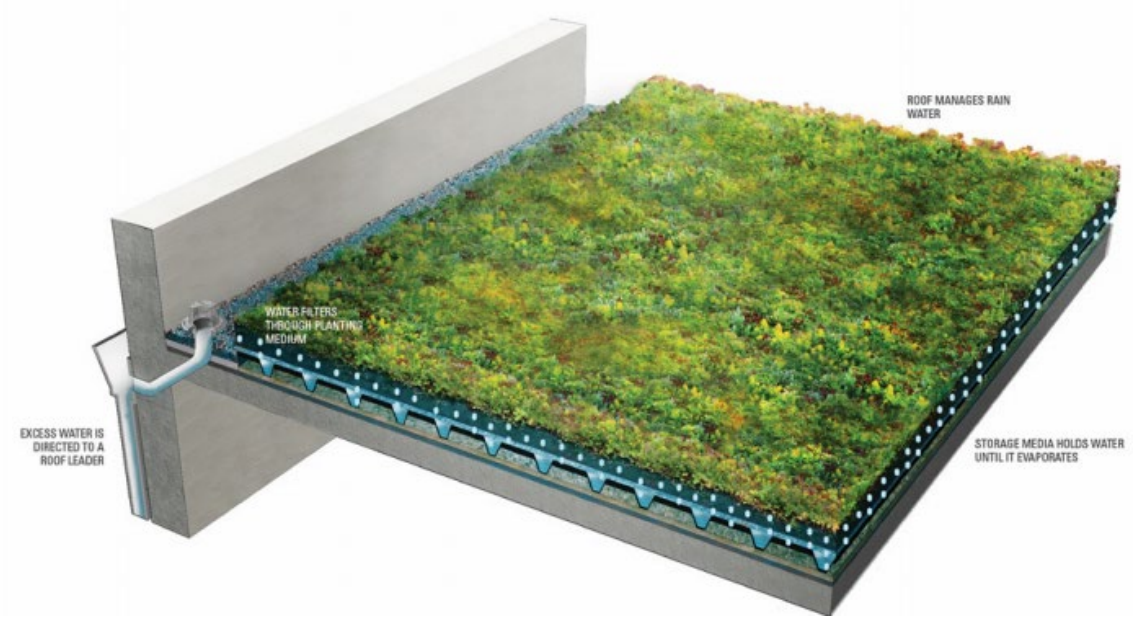


Figure 4: Layout of a green roof. Source: Philadelphia Water Department.

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).

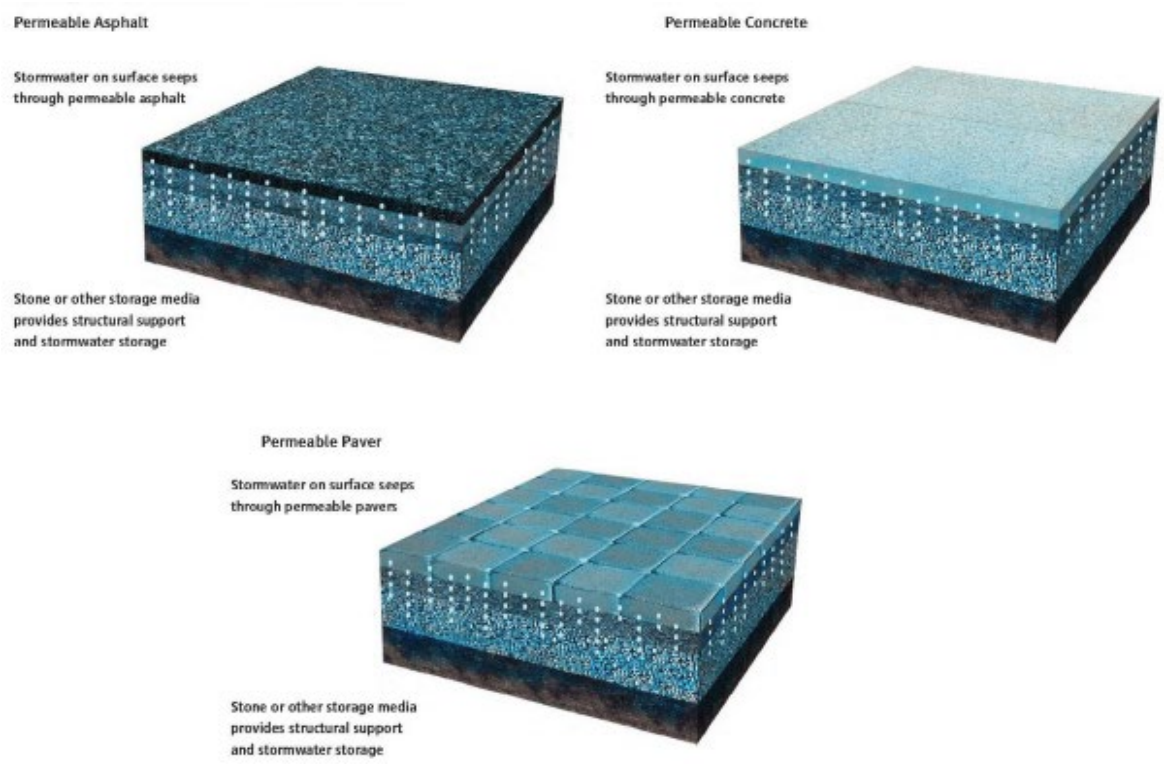


Figure 6: Examples of different types of porous pavement. Source: Philadelphia Water Department.

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.

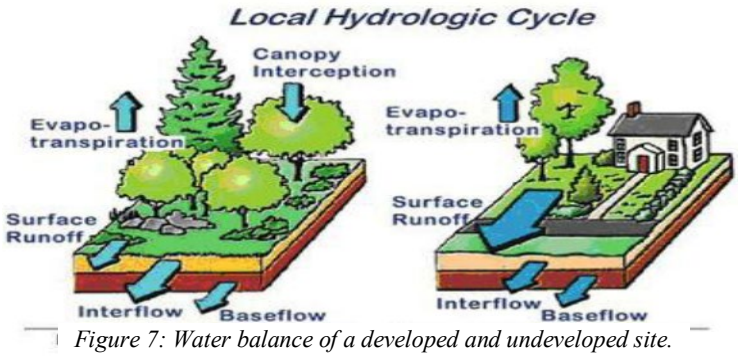


Figure 7: Water balance of a developed and undeveloped site.

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.

References

Allen, W, and T. Weber (2007). *Cecil County, Maryland Green Infrastructure Plan.* The Conservation Fund. Retrieved from https://www.conservationfund.org/images/projects/files/Green-Infrastructure-Plan-Cecil-County-Maryland-The-Conservation-Fund.pdf

Alliance for the Bay. (n.d.). *Conservation Landscaping*. Retrieved March 22, 2019 from http://www.stormwater.allianceforthebay.org/take-action/installations/conservation-landscaping

Blankenship, K. (2011, October 1). *Storms leave trail of debris, sediments in their wake*. Bay Journal. Retrieved April 1, 2019, from https://www.bayjournal.com/article/storms_leave_trail_of_debris_sediments_in_their_wake

Cecil County Stormwater Management Division. (n.d. a). Retrieved from www.ccgov.org/government/public-works/public-works-divisions/stormwater-management-division

Cecil County Stormwater Management Division (n.d. b). *Cecil County Watersheds*. Retrieved from www.ccgov.org/government/public-works/public-works-divisions/stormwater-management-division/watersheds

City of Lexington. (n.d.). *Stormwater Incentive Grant Program.* Retrieved from https://www.lexingtonky.gov/stormwater-incentive-grant-program

City of Sandy Oregon. (n.d.). *Stormwater Management Incentive Program.* Retrieved from https://www.ci.sandy.or.us/stormwater-management-incentive-program

Climate Adaptation Knowledge Exchange. (2018, November 29). *Restoration and Managed Retreat of Pacifica State Beach*. Retrieved March 22, 2019 from https://www.cakex.org/case-studies/restoration-and-managed-retreat-pacifica-state-beach

Cowardin, L, et. al. (1979). *Classifications of Wetlands and Deepwater Habitats in the United States.* The Fish and Wildlife Service. Retrieved from https://www.fws.gov/wetlands/documents/classification-of-wetlands-and-deepwater-habitats-of-the-united-states.pdf

Department of Agriculture. (n.d.). *Natural Resources Conservation Service*. Retrieved April 12, 2019 from https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/ccpi/

DNR. (n.d.). *Land Acquisition and Planning*. Retrieved April 12, 2019 from https://dnr.maryland.gov/land/Pages/ProgramOpenSpace/home.aspx

East Coast Greenway Alliance. (n.d.). *Maryland*. Retrieved March 22, 2019 from https://www.greenway.org/states/maryland

"Environmental Site Design." (n.d.). *Montgomery County Department of Environmental Protection*. Retrieved from www.montgomerycountymd.gov/DEP/Resources/Files/downloads/water/wqpc/How-Is-My-WQPC-Credit-Calculated-Guide.pdf

Environmental Protection Agency. (2018, December 05). *Benefits of Green Infrastructure*. Retrieved March 22, 2019 from https://www.epa.gov/green-infrastructure/benefits-green-infrastructure#waterquality

Environmental Protection Agency. (2018, December 26). Economic Incentives. Retrieved from https://www.epa.gov/environmental-economics/economic-incentives

Environmental Protection Agency. (n.d.). *Protect Your Home from Flooding*. Retrieved from https://www.fema.gov/media-library-data/1528734155205-

EPA. (2017, August 30). *Exploring the Link Between Green Infrastructure and Air Quality*. Retrieved March 22, 2019 from https://www.epa.gov/green-infrastructure/exploring-link-between-green-infrastructure-and-air-quality

EPA. (2009, June). *Managing Wet Weather with Green Infrastructure Municipal Handbook*. Retrieved March 25, 2019 from https://www.epa.gov/sites/production/files/2015-10/documents/gi_munichandbook_incentives_0.pdf

Glavovic, B. C., & Smith, G. P. (2014). Introduction: Learning from Natural Hazards Experience to Adapt to Climate Change. *Adapting to Climate Change,* 1-38. doi:10.1007/978-94-017-8631-7_1

Guerra, T. (2017, July 21). French Drain Vs. Curtain Drain. Retrieved from https://www.hunker.com/13425283/french-drain-vs-curtain-drain

Historical Society of Palm Beach County. (2009). *Loxahatchee Greenways Project*. Retrieved from http://www.pbchistoryonline.org/page/loxahatchee-greenways-project

Hutton, R., & Markley, F. (1991). The Effects of Incentives on Environment-Friendly Behaviors: a Case Study. Retrieved from http://acrwebsite.org/volumes/7238/volumes/v18/NA-18

Killar, S (2011). *History of Port Deposit has been defined by high water.* The Baltimore Sun. Retrieved from https://www.baltimoresun.com/news/maryland/bs-md-flood-insurance-history-20111001-story.html

Maryland Department of the Environment (n.d.). *Regulations for Floodplain Development.* Maryland Department of the Environment. Retrieved from

https://mde.maryland.gov/programs/Water/FloodHazardMitigation/Pages/floodplainregs.aspx

Maryland Department of Natural Resources. (n.d.). *Land Acquisition and Planning*. Retrieved April 12, 2019 from https://dnr.maryland.gov/land/Pages/About-Us.aspx

Maryland Energy Administration. (n.d.). *Solar Energy Progress*. Retrieved March 25, 2019 from https://energy.maryland.gov/Pages/Info/renewable/solar.aspx

Maryland Geographical Survey (2008). *Physiographic Map of Maryland.* Maryland Department of Natural Resources. Retrieved from http://www.mgs.md.gov/geology/physiographic_map.html

Maxwell-Gaines, C. (2018, May 05). *What is Rainwater Harvesting and its Benefits?*. Retrieved March 22, 2019 from https://www.watercache.com/faqs/rainwater-harvesting-defined

Montgomery County Government. (2019). *RainScapes Rewards Rebates*. Retrieved April 12, 2019 from https://www.montgomerycountymd.gov/water/rainscapes/rebates.html

Northeast Ohio Regional Sewer District. (2017). *About Project Clean Lake*. Retrieved March 22, 2019 from https://www.neorsd.org/community/about-the-project-clean-lake-program/

Orion Magazine. (n.d.). Nature, Culture & Place. Retrieved from https://orionmagazine.org/2016/08/concrete-progress-rain-barrel-people/

Pennsylvania Department of Environmental Protection. (2006, December 30). *Pennsylvania Stormwater Best Management Practices Manual*. Retrieved March 22, 2019 from https://pecpa.org/wp-content/uploads/Stormwater-BMP-Manual.pdf

Philadelphia Water Department. (n.d.). *Stormwater Management Practice Design Guidelines*. Retrieved March 22, 2019 from https://www.phila.gov/water/PDF/SWRetroManual.pdf

Sanderson, K. (2008). Trees eat pollution products. *Nature*. doi:10.1038/news.2008.1046

Scherzler, N. (2010, October 30). After the Storm: Cecil County Recovers but Bay, Susquehanna Still a Worry. The Cecil Times. Retrieved March 15, 2019, from http://ceciltimes.com/2012/10/after-the-stgorm-cecil-county-recovers-but-bay-susquehanna-still-a-worry/

Scott, M. (n.d.). Cecil County Coastal Flood Vulnerability Study [Scholarly project]. In Eslc.org. Retrieved April 1, 2019, from https://www.eslc.org/wp-content/uploads/2019/02/IV.b.-Cecil-County-Flood-Vulnerability-Study.pdf

Soil Science Society of America. (n.d.). *Rain Gardens and Bioswales*. Retrieved from https://www.soils.org/discover-soils/soils-in-the-city/green-infrastructure/important-terms/rain-gardens-bioswales

Stormwater Capture Co. (n.d.). *Incentives and Programs*. Retrieved from https://stormwatercaptureco.com/category/incentives-and-programs/

Stroud Water Research Center. (n.d.). *Watershed Restoration: A Shared Public and Private Investment*. Retrieved April 12, 2019 from https://stroudcenter.org/restoration/shared-investment/

The Chesapeake Bay Trust. (n.d.). *Green Streets, Green Jobs, Green Towns*. Retrieved April 12, 2019 from https://cbtrust.org/grants/green-streets-green-jobs-green-towns/

"Types of Stormwater Management Facilities." (n.d.). *Stormwater Management Facilities*. Retrieved from www.montgomerycountymd.gov/water/stormwater/practices.html

Tiner, R. W, and D.G. Burke (1995). *Wetlands of Maryland. U.S. Fish and Wildlife Service, Ecological Services*, Maryland Department of Natural Resources. Retrieved from https://www.fws.gov/wetlands/Documents%5CWetlands-Of-Maryland.pdf

University of Maryland. (n.d.). *SMART Tool*. Retrieved from https://extension.umd.edu/watershed/smart-tool

Water Environment Federation. (2013, January 10). *Five Types of Green Infrastructure Incentive Programs.* Retrieved from https://stormwater.wef.org/2013/01/five-types-of-green-infrastructure-incentive-programs/

Water Environment Research Foundation. (n.d.). *Incentive Programs*. Retrieved from https://www.werf.org/liveablecommunities/toolbox/incentives.htm

Worcester County Department of Comprehensive Planning. (n.d.). *Rain Gardens Across Maryland*. Retrieved March 22, 2019, from http://extension.umd.edu/sites/extension.umd.edu/files/_docs/articles/Rain_Gardens_Across_MD.pdf