MANAGING NONPOINT SOURCE WATER POLLUTION USING ENVIRONMENTAL SITE DESIGN IN BALTIMORE’S WESTPORT COMMUNITY

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The Clean Water Act (CWA) of 1972 is the primary federal law in the United States governing water pollution. Of the seven goals and objectives of the CWA, only one is dedicated to nonpoint source pollution.

The seventh goal states:

It is the national policy that programs for the control of nonpoint sources of pollution be developed and implemented in an expeditious manner so as to enable the goals of this Act be met through the control of both point and nonpoint sources of pollution.\(^1\)

The nature of nonpoint source pollution makes it very hard to monitor and control; it is a diffuse type of pollution stemming from stormwater discharges, irrigation return flows and urban runoff. In nonpoint source pollution, pollutants are carried via rainwater or snow melt and are eventually deposited into water sources. The sources of this form of pollution are very difficult to identify. Being unable to pinpoint the exact source also makes this type of pollution very costly to control. Despite the difficulties inherent in controlling nonpoint source pollution, research since the late 1970’s has indicated that it is a significant cause of water quality impairment in the U.S.

The state of Maryland and its counties have been utilizing stormwater management practices for the control of nonpoint source pollution for years. These practices have taken many forms, including environmental site design (ESD). ESD, as defined by Queen Anne’s County’s *Environmental Site Design Manual*:

…employs a variety of natural and built features that reduce the rate of runoff, filter out its pollutants, and facilitate the infiltration of water into the ground. By reducing water pollution/runoff and increasing groundwater recharge, ESD helps improve the quality of receiving surface waters and stabilize the flow rates of nearby streams.\(^2\)

ESD was pioneered in the 1990s in Prince Georges County, Maryland. At the time it was referred to as low impact development (LID). Prince Georges County’s ESD efforts began with the development and use of bioretention cells and eventually expanded into a full scale effort to incorporate ESD into the county’s resource protection program.\(^3\) The county's manual of ESD guidelines gained acclaim and were used by governments across the country.

On April 27, 2007, Maryland Governor Martin O’Malley signed the Stormwater Management Act of 2007, which requires that environmental site design (ESD), through the use of nonstructural best management practices be implemented to the maximum extent practicable.\(^4\) The act’s requirements include:\(^5\)

1. local governments update their zoning ordinances to allow for the implementation of environmental site design techniques in their stormwater management practices
2. that the Department of the Environment (DOE) adopt regulations that list environmental site design techniques as the primary method for managing stormwater under certain circumstances

In response, the City of Baltimore updated the City Code regulations for stormwater management, with the primary intent to:

Protect, maintain, and enhance the public health, safety, and general welfare through the management of stormwater; protect public and private property from damage; reduce the adverse effects of development; reduce stream channel erosion, pollution, siltation, and sedimentation; reduce local
flooding; restore, enhance, and maintain the chemical, physical, and biological integrity of streams; and maintain after development, as nearly as possible, pre-development runoff characteristics. This is done through the management of stormwater using nonstructural environmental site design practices for all new and redevelopment projects to the maximum extent practicable.

In light of the city’s broad intention to manage nonpoint source pollution using ESD practices, it is the intention of this project to review specific ESD solutions being considered by the city for use in developing an ESD project within Baltimore’s Westport community. This project will highlight nonpoint source pollution load reduction strategies, calculate pollutant load reductions, and suggest possible funding options that would be feasible in this low-income community.
For nearly 40 years, the United States has been managing pollution mainly through the regulation of point sources. While this has largely been effective, evidence indicates that the U.S. is fast approaching a threshold where controlling pollution from point sources is no longer enough to restore the chemical, physical, and biological integrity of the nation’s waters.

Recently, environmental site design (ESD) practices have proven to be effective in reducing nonpoint source pollution and restoring a site’s natural hydrologic function. The success of this project will illustrate that broad applications of these practices will be effective for reducing pollution loading. An explanation of innovative financing options will show that not only are these projects “doable,” but in this troubled economy, they can be financed in a manner that does not put additional pressure on already strained resources.

This project has four major sections:

- **Section One:** Lays out the research that will inform and influence the design of a stormwater management plan for Baltimore’s Westport community.
- **Section Two:** Is a design application that highlights some of the best management practices applicable to the Westport project.
- **Section Three:** Calculates pollution load reductions, estimates project cost, and assesses project viability based on a comparison of pollution load reduction cost to benefits gained.
- **Section Four:** Explores various financing options and their potential application toward the Westport nonpoint source pollution reduction project.
The Maryland Stormwater Management Act of 2007 requires that environmental site design (ESD), through the use of nonstructural best management practices and other innovative site design techniques be implemented to the maximum extent practicable. The act requires (amongst other things) that:

3. local governments update zoning ordinances to allow for the implementation of environmental site design techniques in stormwater management practices
4. the Department of the Environment (DOE) adopt regulations that specify environmental site design techniques as the primary method for managing stormwater under certain circumstances

Effective May 4, 2009, the Maryland State Legislature updated the Code of Regulations, Title 26 Department of the Environment, Subtitle 17 Water Management, Chapter 2 Stormwater Management (COMAR 26.17.02) for stormwater management. It’s stated purpose and scope includes:

1. The primary goals of the state and local stormwater management programs are to maintain after development, as nearly as possible, the predevelopment runoff characteristics, and to reduce stream channel erosion, pollution, siltation and sedimentation, and local flooding by implementing environmental site design to the maximum extent practicable and using appropriate structural best management practices only when necessary.
2. These regulations apply to the development or redevelopment of land for residential, commercial, industrial, or institutional use, but do not apply to agricultural land management practices.

Moreover, COMAR 26.17.02.03 requires all municipalities to revise their stormwater management ordinances by May 4, 2010, in order to ensure that all new development and redevelopment projects implement the policies and practices outlined in the state’s Stormwater Design Manual (manual).

In response, the City of Baltimore updated the City Code, Article 7 Natural Resources, Division II Stormwater Management, for stormwater management. It intends to:

Protect, maintain, and enhance the public health, safety, and general welfare through the management of stormwater; protect public and private property from damage; reduce the adverse effects of development; reduce stream channel erosion, pollution, siltation, and sedimentation; reduce local flooding; restore, enhance, and maintain the chemical, physical, and biological integrity of streams; and maintain after development, as nearly as possible, pre-development runoff characteristics.

This is done through the management of stormwater using nonstructural ESD practices, to the maximum extent practicable, for all new and redevelopment projects that have not received final stormwater management approval by May 4, 2010.

At first reading, it would appear that the city requires ESD practices on all development and redevelopment projects. However, in the realm of policy and policy development, there are almost always clarifications and exemptions to regulations. This is the case for the city’s stormwater management regulations.

Section 21-6 of the city code requires that the policies outlined in Division II are applicable to all development activities within the city’s corporate limits. However, this section also outlines instances where exemptions from implementing ESD practices may be granted:

1. Agricultural land management practices that employ methods and procedures to further crop and livestock production and conservation to conserve related soil and water resources;
2. A single family detached dwelling if the activity does not disturb more than 2,500 square feet of land area; and the tract, lot, or parcel has not previously been the subject of an exemption under this item;

3. Construction, grading, or development if the activity does not disturb more than 5,000 square feet of land area and the tract, lot, or parcel has not previously been the subject of an exemption under this item;

4. A single-family dwelling that disturbs more than 2,500 square feet of land area but less than 5,000 square feet of land area, subject to the payment of a “small-project” fee; and

5. Development that the State Water Management Administration determines will be regulated under specific state laws that provide for managing stormwater runoff.

In design and construction of the ESD practices, the city demands that the installed practices meet the requirements of the manual and Division II of the City Code. ESD practices must be designed using sizing, recharge volume, water quality volume, and channel protection storage volume criteria set forth in the manual. The maximum extent practicable (MEP) standard will be satisfied when “channel stability is maintained, predevelopment groundwater recharge is replicated, nonpoint source pollution is minimized, and structural stormwater management practices or alternative practices are used only if determined to be absolutely necessary”.

Though the city code requires that practices meet the sizing and performance requirements detailed in the manual, there are situations where a waiver for quantitative and qualitative measures may be issued for projects. This does not exempt the project from implementing ESD practices, but simply exempts them from meeting the standards set forth in the manual. Section’s 23-1 and 2 of the city code outline when a waiver may be granted.

A quantitative control waiver may be granted if ESD has been implemented to the MEP; and at least one of the following applies:

1. The project is within an area for which a watershed management plan has been developed;
2. The project has a direct, concentrated discharge of stormwater to tidal waters, tidally influenced receiving wetlands, or connected closed storm drainage systems of adequate capacity;
3. The project is an in-fill development;
4. The applicant demonstrates through engineering analysis that unmanaged 10-year and 100-year storm events for the proposed development will not cause erosion, flooding, or an adverse impact on the receiving waters or downstream stormwater conveyance system; or
5. The Baltimore City Department of Public Works (DPW) determines that circumstances exist that prevent the reasonable implementation of quantity control practices.

A qualitative control waiver may be granted if:

1. The project will return the disturbed area to a predevelopment runoff condition, such as pipeline or conduit projects, certain landscaping projects, certain maintenance projects, and certain underground projects;
2. The project is an in-fill development for which ESD has been implemented to the MEP and it has been demonstrated that other best management practices are not feasible;
3. The project is a redevelopment project for which the redevelopment requirements are satisfied; or
4. The DPW determines that circumstances exist that prevent the reasonable implementation of ESD to the MEP.
In the case of redevelopment activities, stormwater management plans are required and the installed ESD practices must be consistent with those outlined in the manual. However, under Section 23-7-b of the city code, a redevelopment project does not have to comply with manual requirements for recharge volume, channel protection storage volume, overbank flood protection volume, and extreme flood protection volume.\textsuperscript{16}

While redevelopment projects are allowed for non-compliance in the above categories, there are a number of requirements that are only applied to redevelopment activities. The requirements include:\textsuperscript{17}

1. All redevelopment projects must, in accordance with the manual, reduce existing site impervious areas within the limits of disturbance by at least 50 percent.
2. If site conditions prevent the reduction of impervious area, then ESD practices must be implemented to the MEP for at least 50 percent of the site’s existing impervious area within the limits of disturbance.
3. If a combination of impervious area reduction and stormwater management practice implementation is used, the combined area must equal or exceed 50 percent of the site’s existing impervious area within the limits of disturbance.

Moreover, if the impervious area reduction has been maximized and ESD has been implemented to the MEP, alternative measures, such as structural practices, may be used to meet the above requirements.

The DPW may also establish separate water quality treatment policies for redevelopment projects if the provisions described above have been implemented to the MEP. These policies may include retrofitting to improve water quality by the construction of structural practices or modification of existing structural practices, watershed or stream restoration, pollution trading, payment of offset fees that are dedicated for stormwater management within the same watershed, or a partial waiver of the treatment requirements.\textsuperscript{18}
While there are numerous definitions of environmental site design (ESD), Queen Anne’s County’s 
*Environmental Site Design Manual* gives one of the most thorough descriptions:  

- A stormwater management strategy concerned with maintaining or restoring the natural hydrologic 
  functions of a site to achieve natural resource protection objectives and fulfill environmental regulatory 
  requirements. ESD employs a variety of natural and built features that reduce the rate of runoff, filter out 
  its pollutants, and facilitate the infiltration of water into the ground. By reducing water pollution and 
  increasing groundwater recharge, ESD helps improve the quality of receiving surface waters and 
  stabilize the flow rates of nearby streams. 

- ESD incorporates a set of overall site design strategies as well as highly localized, small-scale, 
  decentralized source control techniques known as Integrated Management Practices…ESD takes a 
  landscape based, micro-scale, decentralized approach that disperses flows and manages runoff closer to 
  where it originates. Because ESD embraces a variety of useful techniques for controlling runoff, designs 
  can be customized according to local regulatory and resource protection requirements, as well as site 
  constraints. 

There are countless structural and non-structural design strategies in ESD practices; the goal of all of them is to 
reduce the hydrologic impact of development by incorporating techniques that maintain or restore the sites 
hydrologic and hydraulic functions. ESD strategies include:  
1. Grading to encourage sheet flow and lengthen flow paths 
2. Maintain natural drainage divides to keep flow paths dispersed 
3. Disconnect impervious areas from storm drain networks 
4. Preserve naturally vegetated areas and soil types 
5. Direct runoff into or across vegetated areas 
6. Treat pollution loads where they are generated 

Just as nonpoint source pollution is difficult to monitor and control, it is also challenging to establish an 
acceptable level of impervious cover that determines ideal runoff characteristics. Maryland’s *Stormwater 
Design Manual* (manual) states:  
There is no simple formula, rule, or threshold for determining how much impervious cover may be sustained 
in a given watershed. Generally, stream quality and watershed health diminish when impervious cover 
exceeds 10 percent and become severely degraded beyond 25 percent . . . Integrating the fundamental 
principles of ESD during the planning process helps to minimize the adverse impacts of imperviousness. 

The manual examines two options for establishing runoff characteristics. The first is to evaluate each sites 
predevelopment characteristics and develop ESD practices to meet those characteristics. The second is to 
establish one standard for each and every site. The manual states:  
To accomplish the goal of maintaining predevelopment runoff characteristics, there must be a reasonable 
standard that is easily recognized, reproducible, and applied without opportunity for misrepresentation. 
The simplest and most effective solution is to eliminate the need for evaluating predevelopment 
conditions on a site-by-site basis and apply the same standard to all sites...To best maintain 
predevelopment runoff characteristics, the target for ESD implementation should be “woods in good 
condition.”  

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The manual outlines three different groups of acceptable ESD practices, all of which are to be sized and designed to meet the runoff characteristic standard of “woods in good condition”. These groups are:

1. Alternative Surface Design
2. Nonstructural Practices
3. Micro-Scale Practices

Each practice within these groups are investigated below. For further reference, images of ESD practices are provided at the end of this section.

**Alternative Surface Design**

A simple method to reducing impervious area in any given project is to reduce the impervious materials. The manual lists three design options for reducing impervious area

**Green Roofs**

Roof structures are often overlooked as opportunities to reducing impervious area, yet they are frequently the largest impervious areas on a property. The manual defines a green roof as “alternative surfaces that replace conventional construction materials and include a protective covering of planting media and vegetation.” Green roofs, also called eco-roofs or garden roofs, work by acting like an open grassy space. They slow stormwater runoff by detaining water and forcing it to move through a natural filtration system. Sustainable vegetation is integral to the success of a green roof, so the manual recommends vigorous, drought-tolerant, native species.

**Permeable Pavements**

Paved areas are one of the largest areas on a property contributing to stormwater runoff troubles. An acceptable way to reduce site runoff is to replace impervious pedestrian or vehicular areas with permeable structures. The manual defines a permeable pavement structure as “a porous surface course and open graded stone base/subbase or sand drainage system.” Permeable pavement structures work by draining stormwater through the surface, capturing it in a drainage system, and then allowing it to infiltrate into the soil. These structures have the runoff characteristics of vegetated areas, however, they do have a maximum load bearing capacity lower than conventional paving systems. Therefore they should be limited to lower weight travel areas such as side walks, driveways, access roads, plazas, and small parking lots.

**Reinforced Turf**

Reinforced turf is nearly identical to permeable pavement systems, though the center spaces are traditionally filled with grass as opposed to gravel. The manual defines reinforced turf as “interlocking structural units with interstitial areas for placing grass or gravel.” Reinforced turf systems work by trapping stormwater in the interstitial spaces and allowing it to infiltrate into the surrounding soil. Like permeable pavement systems, reinforced turf also has a low load bearing capacity and should only be used in light travel areas.

**Non-Structural Practices**

Another practice to reduce runoff is to simply divert it into vegetated areas and away from traditional storm drain systems. This is done by grading and landscaping areas so that the runoff flows into vegetated areas where it can be filtered and then infiltrate back into the ground. The manual lists three acceptable non-structural practices.
Disconnection of Rooftop Runoff
Disconnecting rooftop runoff, also called disconnecting downspouts, is another overlooked opportunity to reduce runoff. The manual states that “rooftop disconnection involves directing flow from downspouts onto vegetated areas where it can filter over and soak into the ground.” Rooftop disconnection practices work by preventing stormwater from flowing directly into the storm sewer system. This reduces the runoff volume and the amount of pollutants delivered into the receiving waters. In most cases rooftop disconnection is relatively simple (can be completed in under five steps) and is something that the homeowner can do themselves. Some municipalities pay the homeowners to disconnect the downspout or will do it for them free of charge.

Disconnection of Non-Rooftop Runoff
Like rooftop disconnection, non-rooftop disconnection involves directing the flow of runoff away from storm drains and across vegetated areas. The manual states that it “involves directing flow from impervious surfaces onto vegetated areas where it can soak into or filter above the ground…Non-rooftop disconnection is commonly applied to smaller or narrower impervious areas like driveways, open section roads, and small parking lots.” Though non-rooftop disconnection is generally used in smaller applications, it can be applied to commercial and industrial projects as long as the treatment area is equal to the flow path length and it is located on a gradual (<5 percent) downslope area.

Sheetflow to Conservation Areas
Like the disconnection programs discussed above, sheetflow to conservation areas directs runoff to protected natural areas. According to the manual, “stormwater runoff is effectively treated when flow from development or redevelopment projects is directed to adjacent natural areas where it can soak into or filter over the ground.” Directing sheetflow to conservation areas does come with some stipulations. The protected area can be created during project planning, however, if the intent is to discharge into an existing protected area, it is necessary to ensure that the location can handle the additional stormwater volume. Also, formal legal protection is essential for the long term viability of the protected area. If additional landscaping is required, the plans will have to specify how the plants (native/adapted) will be established and managed.

Micro-Scale Practices
The most commonly discussed ESD practices are micro-scale practices. These practices use natural systems, vegetation, and soils to capture and treat runoff from relatively small (<1 acre) areas. These practices can be interconnected to create a more natural and/or efficient system. The manual lists nine acceptable forms of micro-scale practices.

Rainwater Harvesting
Rainwater harvesting intercepts and stores rainfall in rain barrels for future non-potable use. The manual states “the capture and re-use of rainwater promotes conservation, as well as reduces runoff volumes and the discharge of pollutants downstream.” Because the harvested water is not filtered, it can only be used for non-potable applications, such as irrigation and car washing. The harvested water is usually used for projects that allow for filtration across vegetated surfaces and subsequent infiltration into the immediate soils. These systems can be used in larger commercial, municipal, or industrial projects, but the pollutant removal capacity is proportional to the amount of runoff captured, stored, and used.

Submerged Gravel Wetlands
Like its name implies, submerged gravel wetlands are small scale filtration systems that use wetland plants
embedded in a rock and gravel media. According to the manual, “pollutant removal is achieved through biological uptake from algae and bacteria growing within the filter media. Wetland plants provide additional nutrient uptake and physical and chemical treatment processes allow filtering and absorption of organic matter.” The image on the right shows the design characteristics of a submerged gravel wetland. Water flows through a pretreatment area to prevent sediment and debris from clogging the wetland. It then travels through an inflow control structure to prevent flooding and to allow water to move efficiently through the system. While slopes should be relatively flat, the system should be designed with a sufficient drop in elevation to maintain positive flow through the media. At the end of the cycle, water flows out of the wetland and into a receiving system where it is either discharged into receiving waters or moved along to traditional treatment plants. The manual requires the use of at least three different wetland species and an aggregate layer with a porosity of 40 percent; for maximum efficiency.

**Landscape Infiltration**

Like the non-structural practices, landscape infiltration uses vegetative planting areas to capture, store, and filter runoff. According to the manual, “rainwater is stored initially, filters through the planting soil and gravel media below, and then infiltrates into native soils…storage may be provided in constructed planters made of stone, brick, concrete, or in natural areas excavated and backfilled with stone and topsoil.” Flow splitters or inlets are installed to prevent the system from flooding. If the landscape is too steep, check dams or terraces can be installed to maintain the sheetflow. The manual recommends that effective treatment areas should be less than 10,000 square feet, which limits the application of this type of system. Also, to prevent issues that arise from standing water (mosquito nests, etc.), the facility must fully de-water within 48 hours of a storm event.

**Infiltration Berms**

According to the manual, “an infiltration berm is a mound of earth composed of soil and stone that is placed along the contour of a relatively gentle slope…stormwater flowing downslope to the depressed area filters through the berm in order to maintain sheetflow.” Berms promote sheetflow capabilities and dissipate runoff velocities, allowing for stormwater detention, and infiltration into the surrounding soils. Because stormwater will be flowing downhill, the manual calls for slopes with high shear strength, scarified or un-compacted soils, and dense mats of native vegetation.

**Dry Wells**

Dry wells, like rain barrel systems, collect and store rooftop runoff. According to the manual, “a drywell is an excavated pit or structural chamber filled with gravel or stone that provides temporary storage of stormwater runoff from rooftops…rooftop runoff is directed to these storage areas and infiltrates into the surrounding soils prior to the next storm event. The pollutant removal capability of dry wells is directly proportional to the amount of runoff that is stored and allowed to infiltrate.” Dry wells are more sophisticated than rain barrel systems because they allow for infiltration through the bottom of the well. The manual recommends that dry wells be used on smaller applications where the drainage area is less than 1,000 square feet. It also recommends that the well be located downslope away from underground structures (pipes, basements, sewage systems, etc) and that it should de-water within 48 hours of a storm event.

**Micro-Bioretenion**

Micro-bioretention is one of the more broadly applied practices. According to the manual, “micro-bioretention practices capture and treat runoff from discrete impervious areas by passing it through a filter bed mixture of sand, soil, and organic matter. Filtered water is either returned to the conveyance system or partially infiltrated into the soil.” In a micro-bioretention system runoff enters through depressed curbs, curb cuts, or is conveyed
directly (downspouts) and filters through the planting media. From this point systems can either allow infiltration into the surrounding soils, or it can enter a perforated underdrain to be carried downstream to receiving waters. If the practice allows for soil infiltration, there must be a 4 foot gap between the bottom of the system and the high water table.

**Rain Gardens**

Rain gardens trap, filter, and infiltrate stormwater runoff. According to the manual, “a rain garden is a shallow, excavated landscape feature or a saucer-shaped depression that temporarily holds runoff for a short period of time…captured runoff from downspouts, roof drains, pipes, swales, or curb openings temporarily ponds and slowly filters into the soil over 24 to 48 hours.” This is the primary practice in residential ESD applications. They are typically designed to treat areas less than 2,000 square feet, but can be applied in areas up to 10,000 square feet. The manual requires that in planning a rain garden, the area must be in full to partial sun, situated two feet above the high water table, be sized as 2 percent of the drainage area and 18 inches deep, and be planted with native plants adapted to saturated and dry conditions.

**Swales**

Swales act in the same way as micro-bioretention, but on a larger scale. Typically, these are linear structures and can be installed as curbs or gutters along highways, residential streets, and property boundaries. According to the manual, “swales are channels that provide conveyance, water quality treatment, and flow attenuation of stormwater runoff. Swales provide pollutant removal through vegetative filtering, sedimentation, biological uptake, and infiltration into underlying soil media.” There are some concerns with installing swales due to damage from off-street parking. Also, all road side swales are subject to damage from winter salt applications.

**Enhanced Filters**

Enhanced filters are added to the applications described above to increase filtration and performance. According to the manual, “an enhanced filter is a modification applied to specific practices to provide water quality treatment and groundwater recharge in a single facility. This design variant uses a stone reservoir under a conventional filtering device to collect runoff, remove nutrients, and allow infiltration into the surrounding soil.” For example, in a micro-bioretention project a stone reservoir is placed below the project. This allows for additional filtration and groundwater recharge. The underdrain can be used to carry outflow and overflow to receiving waters down stream. Because enhanced filters increase the depth of the system, the manual requires that the system not intercept groundwater systems, as this can lead to a failure in the system.

**ESD Imagery from 2000 Maryland Stormwater Design Manual: Chapter 5 Environmental Site Design**

**Green Roofs**

**Permeable Pavements**
Since its discovery in the 1660s, the Patapsco River and its Middle Branch have gone through many changes. The lands along the river banks have developed from farmlands to resorts to heavy industry, and finally, to the many vacant and abandoned spaces seen today.

The 1700s and 1800s saw the first major industrial development in Westport, a small community on the south side of Baltimore City. The installation of the Carr-Lowery Glass Works factory, the Westport Power Station, and an iron furnace at the mouth of the Gwynns Falls, along with the intersection of the B&O Railroad and the Western Maryland Railway, created an ideal location for commerce and recreation.37

The 1800s also saw Westport thrive as a resort community. The Middle Branch River’s sandy beaches and abundant resources became known as the “Monte Carlo” of Maryland. The shoreline resort’s food, drink, and entertainment created an ideal getaway for Baltimoreans.36

In 1918, the Westport community was annexed into the City of Baltimore, bringing not only desirable city services, but also sharp tax increases. The subsequent financial burdens caused most of the remaining landholders to convert their property for industrial use. Westport’s proximity to roads, railways, and the waterfront made it ideal for burgeoning industrial activities. In 1923, the city zoned all of Westport for industrial use, marking the beginning of the decline of the community as a recreational space for more than 50 years.39

In the late 1970s, the city renewed its interest in Westport’s natural spaces. The City of Baltimore’s Middle Branch Master Plan: Executive Summary indicates that its primary goal is “to highlight and capitalize on the uniquely green character of the Middle Branch estuary to build a model community based on sustainable principles. These sustainable principles include economic prosperity, environmental improvement and social equity.”40

The Baltimore Neighborhood’s Indicators Alliance report, Community Statistical Area Profile: Vital Signs from U.S. Census 2000, indicates that there are about 7,631 people living in the Westport area of which the majority population is African American. There are 2,657 households, of which 8 percent are abandoned or vacant at years end. Only 56 percent of the population is employed wherein over 40 percent of the average household income is less than $25,000 per year. Concerning education, 28 percent of Westport’s residents have a high school diploma and possibly some college. The Westport area has a 15 percent tree canopy, and as of 2008 there were no community gardens or parks, and no environmental stewardship groups. There are three community organizations in the area, but no community development corporations. In 2008, there were also 4 reported incidents of clogged storm drains (per 1,000 people) and 50 reported incidents of dirty streets and alleys (per 1000 people). Note that this census data was compiled based on a community statistical area; as such it is an aggregation of the three neighborhoods: Westport, Mount Winans and Lakeland.41

In 2004, Turner Development Company purchased the waterfront properties once occupied by the Carr-Lowery Glass Company and Baltimore Gas & Electric for mixed use development. Turner’s project, simply called Westport, will be one of the largest waterfront redevelopments in Baltimore’s history, comprising more than 50 acres and 3,200 linear feet of waterfront, along with more than 100 acres of surrounding parkland. In meeting
the requirements for the Middle Branch master plan, Westport will be one of only a few projects in the nation to seek the U.S. Green Building Council’s Leadership in Energy and Environmental Design for Neighborhood Development (LEED ND) Platinum certification for its master plan. The plan encourages resident to reduce their carbon footprint by walking and biking, provides residential and commercial buildings that utilize less energy and water, and protects and restores open spaces buffering the Chesapeake Bay.\textsuperscript{42}

A key component in the revitalization of the Westport Community, and Turner’s project (for which it will receive full LEED Innovation Points), is a plan to improve the existing community. In 2008, Turner tapped Bonnie Crockett, an attorney and Baltimore native with over ten years of experience in community activism, revitalization, and public/private partnerships, to develop and implement a community activist, revitalization and improvement plan, which became the Westport Community Partnership. The partnership’s primary goal is to partner “with neighborhood associations, business associations, nonprofit organizations, city agencies, developers, and stakeholders to build strong productive relationships and to make Westport a cleaner, greener, and safer place to live work and raise a family.”\textsuperscript{43}

Through partnerships with Parks & People, Westport Academy, The Westport Neighborhood and Business Associations, The Living Classrooms Foundation, The Baltimore Rowing Club and other organizations, several projects are underway, including:\textsuperscript{44}

- Greening and revitalizing “Main Street” (Annapolis Road and Russell Street) with Westport Neighborhood Association, Neighborhood Design Center, Parks & People and community volunteers. The goal is to enhance the overall image of “Main Street,” improve walkability and reduce traffic speed, reconnect to the waterfront, enhance gateways and promote community identity, and incorporate sustainability practices;
- Greening and beautifying the neighborhood through the Westport Community Partnerships and the Living Classrooms Foundation’s Project SERVE and Clean Team Westport;
- Improving existing housing through Façade Improvement Grants supplied by Turner Development Group for up to 50 percent of the project cost up to a total grant award of $2,000;
- Providing workforce development opportunities for residents through the Living Classrooms Foundation’s Workforce Development Center in Westport;
- Youth education and development programs through Greening for Kids, an effort between Westport Academy, Westport Community Partnerships and the Parks and People Foundation;
- Joining the Baltimore Neighborhood Energy Challenge, an effort to raise awareness and reduce community energy consumption, one house at a time.
In architectural design and planning applications, an inventory and analysis study is conducted prior to any design activities taking place. It is a graphic representation of current and proposed site conditions that will inform, influence, and constrain the design.

For the Westport nonpoint source pollution reduction project, a base map of the Westport community was developed using MERLIN Online. MERLIN Online is a collection of spatial data maintained by Maryland Department of Natural Resources that allows users to create a customized map of any site in the state of Maryland. Base map data included streets, parcel boundaries, and satellite imagery. Topographic data was also collected using ESRI’s ArcGIS Explorer USA Topo Maps and the Westport Neighborhood Association/Neighborhood Design Center’s topographic studies. Google Earth was also used for supplemental satellite imagery and distance measurements.

As in traditional architectural studies, the base map was redrawn by hand using trace paper and ink to create blank maps whereby a series of selected specific elements and conditions have been represented. Four inventory and analysis maps studying hydrology, streets, vegetation and soils, and development projects are shown on the following pages.

The hydrology map represents rivers and streams, overland flow, slope and elevations, and USGS Ground and Surface Water Monitoring sites. The topographic characteristics of the site change in slope steepness from south to north. From the highest point at 110 feet above sea level at the Westport Academy, the slope towards the Patapsco River on the east drops by 8 percent. However, from the same point, the slope towards the confluence of the Gwynns Falls and Patapsco River on the north drops by only 5 percent. Analysis indicates that from the highest point, the slopes running north are flatter than those running east. In informing this project, this means that more overland flow will be moving east rather than north, as such, environmental site design (ESD) projects closer to the Patapsco River should be designed to handle more flow than those situated on the northern end of the community.

The Westport nonpoint source pollution reduction project proposes to manage stormwater runoff through the redevelopment of impervious areas. As streets account for the largest proportion of impervious surfaces a careful assessment of street conditions is imperative. The streets map represents Westport’s streets – their names, length, width, calculated areas and soil classes. In designing ESD projects, drainage areas, limits of disturbance, area of impervious cover and soil classes are necessary elements in sizing calculations. Calculations based on this data will determine which ESD projects are most suitable, what dimensions they should be, whether or not specific areas are unsuitable for siting a project, how much runoff will be collected and where additional ESD projects may be sited. Streets determined to be unsuitable for an ESD installation are Russell Street (State Highway 295), I-95, and Annapolis Road (State Highway 648). Russell Street and I-95 are major highways, separated by overpasses from the community. Closing off these sections to install an ESD project would likely not be accepted, nor would the ESD installation be effective as it would be required to accept a large volume of runoff over a very small area. Annapolis Road is slated for an ESD installation in its planned redevelopment, therefore designing an ESD project for this area would be unnecessary. Traveling and parking width requirements will pose a challenge to the implementation of ESD practices. Traveling lanes are generally 9 to 10 feet wide and parallel parking allowances are typically 7 feet wide. These requirements will
limit the widths of each design and must therefore be accounted for in the installation of ESD practices. Therefore, ESD practices will be limited to those that are effective in lengthy, linear and often narrow installations. Swales and bio-retention cells will work well under these conditions and will therefore be the primary selection for ESD installations. Permeable pavements will also be a primary selection for ESD installations, but should be applied with caution, as their installation requirements demand HSG B soil classes and areas of lighter traffic loads.

The vegetation and soils map represents green spaces, overstory and understory, and soil classes. Soils are largely HSG D class soils. These soils contain over 40 percent clay and often restrict water movement which will likely impose a limit on the types of ESD practices that may be implemented. Green spaces and overstory and understory were also identified as potential areas for directing overland flow, as some ESD practices call for these types of areas. ESD practices suitable for directing overland flow to green or woody spaces, if the calculations call for them, will likely be placed in the areas around Westport Academy. While there are other areas that have larger green spaces and more vegetative cover, many of these areas border or are contained within industrial and commercial spaces, streets and railways, and a cemetery; all areas where overland flow should not be directed.

The development projects map represents present and future development projects including Turner’s Westport Waterfront development and Westport Neighborhood Association and Neighborhood Design Center’s designs for Main Street and the Gateway Design Plan for Annapolis Road. These project areas are identified as no disturbance areas as they are either under or entering construction and are already planned for ESD practices. It is the intent that this project be integrated into and enhance the intended community design, not change it. As such, ESD installations bordering these projects should be visually complementary and provide a seamless transition from the development project to the Westport ESD installation.
The Maryland Stormwater Management Act of 2007 requires that environmental site design (ESD), through the use of nonstructural best management practices and other innovative site design techniques be implemented to the maximum extent practicable. In assisting municipalities fulfill the act’s requirements, Maryland Department of the Environment (MDE) developed and published technical requirements for the design of ESD practices in its 2009 *Stormwater Design Manual* (Manual). Additionally, in 2010, MDE published a supplemental document *Environmental Site Design Process and Computations* (supplement) for additional guidance on the technical procedures and calculations necessary for implementing ESD practices.

The sizing requirements for ESD practices are based on the United States Department of Agriculture’s Natural Resources Conservation Services runoff curve number (RCN) hydrology method. The RCN, established in 1954, was originally designed to be a tool used in the estimation of agricultural runoff. Today the RCN is used to compute peak runoff rates and volumes for various types of sites (agricultural, urban, commercial, etc). Essentially it is a coefficient that reduces total precipitation to runoff potential. The RCN coefficient is used to determine target rainfall, which is in turn used to calculate volume capture targets for the sizing of ESD practices. According to the manual, “The goal is to provide enough treatment using ESD practices to address channel protection volume (Cp) requirements by replicating a runoff curve number (RCN) for woods in good condition for a 1-year rainfall event.”

In order to simplify the process for determining stormwater management requirements, MDE developed Table 5.3 Rainfall Targets/Runoff Curve Number Reductions used for ESD (Chapter 5.2 of the manual). According to the supplement:

> When soil type and proposed site imperviousness is known, Table 5.3 is used to determine the amount of rainfall required to be captured and treated in ESD practices (target rainfall, P<sub>E</sub>) to mimic wooded conditions…The maximum extent practicable (MEP) standard is met after all reasonable options for implementing ESD are exhausted.

The design process is divided into six sections, with numerous calculations for each stage.

- **Section One** determines the stormwater management requirements. This section involves
  - Collection of site data including drainage areas, soil types, and impervious area
  - Determining RCNs for “woods in good condition” using Table 5.3
  - Determining rainfall targets (P<sub>E</sub>) and runoff volume capture targets (ESD<sub>V</sub>)

- **Section Two** integrates practices into the proposed layout of the site.

- **Section Three** estimates the amount of rainfall captured and treated in the proposed practices. Calculations based on proposed practice dimensions will indicate total rainfall volume captured in each ESD practice.

- **Section Four** determines the final site layout.

- **Section Five** assesses the “soundness” of the design in order to determine if the criteria of “woods in good condition” has been met. If the ESD<sub>V</sub> is provided for in all practices then ESD has been implemented to the MEP and the plan is finalized. If it ESD<sub>V</sub> is not provided for, then the project is reevaluated to determine if resizing or additional ESD practices will provide greater volume capture.

- **Section Six** finalizes the design and allows it to move on to construction.

The charts on the following page summarize the results from the project design and sizing calculations.
<table>
<thead>
<tr>
<th>STREET</th>
<th>DRAINAGE AREA SO FT</th>
<th>PRACTICE</th>
<th>PRACTICE SIZE SO FT</th>
<th>TARGET ESD+ CU FT</th>
<th>ACTUAL ESD+ CU FT</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waterview Ave</td>
<td>123,603.21</td>
<td>Bio-Swale</td>
<td>33,912.00</td>
<td>25,441.00</td>
<td>51,251.51</td>
<td>Will receive additional runoff from Westport Homes (WV) permeable installation</td>
</tr>
<tr>
<td>Hollins Ferry Rd</td>
<td>78,141.27</td>
<td>Bio-Swale</td>
<td>18,338.00</td>
<td>15,583.00</td>
<td>28,845.99</td>
<td>Will receive additional runoff from Westport Homes (WV) permeable installation</td>
</tr>
<tr>
<td>Nevada St</td>
<td>52,295.45</td>
<td>Bio-Swale, Micro-Bioretention</td>
<td>11,372.00</td>
<td>9,107.26</td>
<td>15,524.71</td>
<td>Oversized to receive additional runoff from large impervious commercial lot</td>
</tr>
<tr>
<td>Wabash St</td>
<td>48,697.72</td>
<td>Micro-Bioretention</td>
<td>9,143.00</td>
<td>7,154.97</td>
<td>12,912.73</td>
<td>Oversized to receive additional runoff from Westport Academy, also soil conditions</td>
</tr>
<tr>
<td>Sidney Ave N</td>
<td>47,607.15</td>
<td>Micro-Bioretention</td>
<td>5,725.00</td>
<td>7,555.30</td>
<td>7,555.30</td>
<td>Cannot reduce ESD installation without rendering practice ineffective</td>
</tr>
<tr>
<td>Koman St</td>
<td>42,727.01</td>
<td>Bio-Swale</td>
<td>15,696.00</td>
<td>6,692.91</td>
<td>25,561.04</td>
<td>Oversized to receive additional runoff due to low elevation and proximity to large impervious commercial/industrial lot</td>
</tr>
<tr>
<td>Norfolk St</td>
<td>40,950.13</td>
<td>Bio-Swale, Micro-Bioretention</td>
<td>9,657.00</td>
<td>7,296.02</td>
<td>12,697.53</td>
<td>Oversized to receive additional runoff from large impervious commercial lot</td>
</tr>
<tr>
<td>Kent St</td>
<td>35,830.00</td>
<td>Micro-Bioretention</td>
<td>5,874.00</td>
<td>5,609.04</td>
<td>8,108.46</td>
<td>Oversized to receive greater volume of pollutants from high vehicular traffic due to light rail station</td>
</tr>
<tr>
<td>Westport St</td>
<td>34,162.13</td>
<td>Bio-Swale, Micro-Bioretention</td>
<td>9,000.00</td>
<td>5,782.72</td>
<td>7,773.10</td>
<td>Oversized to receive additional runoff from Westport Academy</td>
</tr>
<tr>
<td>Cowley St</td>
<td>30,908.70</td>
<td>Micro-Bioretention</td>
<td>11,066.00</td>
<td>4,830.05</td>
<td>16,864.52</td>
<td>Oversized to receive additional runoff due to low elevation and soil conditions</td>
</tr>
<tr>
<td>Clare St</td>
<td>25,432.64</td>
<td>Bio-Swale</td>
<td>9,240.00</td>
<td>3,710.16</td>
<td>15,286.71</td>
<td>Oversized to receive additional runoff due to low elevation and proximity to large impervious commercial/industrial lot</td>
</tr>
<tr>
<td>Amherst Ct (WH)</td>
<td>21,953.64</td>
<td>Farmable Pavers</td>
<td>21,654.00</td>
<td>4,518.76</td>
<td>4,563.91</td>
<td>Excess runoff (215.88 cu ft) to Waterview Avenue and Hollins Ferry Road</td>
</tr>
<tr>
<td>Tacoma St</td>
<td>21,165.28</td>
<td>Micro-Bioretention</td>
<td>3,700.00</td>
<td>3,356.07</td>
<td>5,163.00</td>
<td>Oversized to receive additional runoff due to proximity to large impervious commercial lots</td>
</tr>
<tr>
<td>Manneh St</td>
<td>20,610.85</td>
<td>Micro-Bioretention</td>
<td>3,450.00</td>
<td>3,169.33</td>
<td>4,812.92</td>
<td>Cannot reduce ESD installation without rendering practice ineffective</td>
</tr>
<tr>
<td>Alaka St (WH)</td>
<td>18,633.68</td>
<td>Farmable Pavers</td>
<td>18,633.68</td>
<td>3,940.43</td>
<td>3,540.52</td>
<td>Excess runoff (182.59 cu ft) to Waterview Avenue and Hollins Ferry Road</td>
</tr>
<tr>
<td>Kent St W</td>
<td>15,849.19</td>
<td>Micro-Bioretention</td>
<td>4,465.00</td>
<td>2,590.46</td>
<td>6,020.71</td>
<td>Oversized to receive additional runoff from prior demolition project</td>
</tr>
<tr>
<td>Alaska St</td>
<td>15,657.23</td>
<td>Micro-Bioretention</td>
<td>2,056.00</td>
<td>2,479.06</td>
<td>2,762.50</td>
<td>Cannot reduce ESD installation without rendering practice ineffective</td>
</tr>
<tr>
<td>Wauhambury St</td>
<td>14,462.69</td>
<td>Micro-Bioretention</td>
<td>2,476.00</td>
<td>2,239.93</td>
<td>3,445.90</td>
<td>Cannot reduce ESD installation without rendering practice ineffective</td>
</tr>
<tr>
<td>Saumo St</td>
<td>13,015.00</td>
<td>Farmable Pavers</td>
<td>13,015.00</td>
<td>2,565.40</td>
<td>2,565.40</td>
<td>Excess runoff (686.45 cu ft) to Hollins Ferry Road</td>
</tr>
<tr>
<td>Mature St</td>
<td>10,014.50</td>
<td>Farmable Pavers</td>
<td>10,015.00</td>
<td>2,091.32</td>
<td>1,962.84</td>
<td>Site conditions prevent additional ESD. Underdrain to pass excess runoff (62.32 cu ft) to stormwater system.</td>
</tr>
<tr>
<td>Dummeo Ct (WH)</td>
<td>8,473.35</td>
<td>Farmable Pavers</td>
<td>8,473.35</td>
<td>1,744.16</td>
<td>1,660.78</td>
<td>Excess runoff (215.88 cu ft) to Water lever Avenue</td>
</tr>
<tr>
<td>Orchard St</td>
<td>7,946.02</td>
<td>Farmable Pavers</td>
<td>7,946.02</td>
<td>1,035.56</td>
<td>1,557.42</td>
<td>Site conditions prevent additional ESD. Underdrain to pass excess runoff (71.36 cu ft) to stormwater system.</td>
</tr>
<tr>
<td>Indiana Ave</td>
<td>7,890.10</td>
<td>Micro-Bioretention</td>
<td>960.00</td>
<td>1,219.02</td>
<td>1,372.62</td>
<td>Cannot reduce ESD installation without rendering practice ineffective</td>
</tr>
<tr>
<td>Willowly Ct (WH)</td>
<td>7,217.50</td>
<td>Farmable Pavers</td>
<td>7,218.00</td>
<td>1,485.81</td>
<td>1,414.25</td>
<td>Cannot reduce ESD installation without rendering practice ineffective</td>
</tr>
<tr>
<td>Sidney Ave S</td>
<td>5,677.09</td>
<td>Micro-Bioretention</td>
<td>640.00</td>
<td>698.87</td>
<td>952.77</td>
<td>Site conditions prevent additional ESD. Underdrain to pass excess runoff (71.36 cu ft) to stormwater system.</td>
</tr>
<tr>
<td>Dairy St</td>
<td>5,185.47</td>
<td>Micro-Bioretention</td>
<td>2,865.47</td>
<td>817.60</td>
<td>7,276.44</td>
<td>Cannot reduce ESD installation without rendering practice ineffective</td>
</tr>
<tr>
<td>Kemper Ct (WH)</td>
<td>3,830.02</td>
<td>Farmable Pavers</td>
<td>3,830.00</td>
<td>378.35</td>
<td>376.65</td>
<td>Install underdrain to pass excess runoff (37.07 cu ft) to Hollins Ferry Road</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td>245,149.00</td>
<td>134,054.31</td>
<td>250,688.45</td>
</tr>
</tbody>
</table>

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**Notes:**

- Install underdrain as required in HSD D cells.
- Install underdrain as required in HSG D cells.
- Excess runoff (215.88 cu ft) to Waterview Avenue.
- Excess runoff (215.88 cu ft) to Waterview Avenue.
- Site conditions prevent additional ESD. Underdrain to pass excess runoff (62.32 cu ft) to stormwater system.
- Site conditions prevent additional ESD. Underdrain to pass excess runoff (71.36 cu ft) to stormwater system.
- Install underdrain to pass excess runoff (37.07 cu ft) to Hollins Ferry Road.
This project illustrates nonpoint source pollution reduction strategies through the development of a community-wide site plan that focuses on the redevelopment of impervious areas as the primary method for managing stormwater runoff.

The site plan and sections on the following pages are a result of information ascertained from (1) a study of existing and proposed conditions, and (2) requirements outlined in Baltimore’s City Code and sizing and practice selection guidance from chapter five of Maryland’s Stormwater Design Manual (manual).

Limitations imposed by various site conditions including soil classes and street traveling and parking widths narrowed environmental site design (ESD) practices for installation to bio-swales, micro-bioretention cells and permeable pavers.

In compliance with the City Code, each drainage area has an ESD practice installed to the maximum extent practicable (MEP), regardless of disturbance area (recall that disturbance areas <5,000 square feet are not necessarily required to install an ESD practice⁵⁰). City Code also requires redevelopment projects to reduce site imperviousness by at least 50 percent.⁵¹ This goal has not been achieved due to restrictions regarding traveling and parking lane width standards. The City Code accounts for instances where this impervious reduction standard cannot be met and requires that in those instances ESD is implemented to the MEP for at least 50 percent of the sites impervious area.⁵² In meeting this standard, the installed ESD practices will absorb all of the runoff for the entire sites imperviousness plus full to partial runoff from extraneous sources including large impervious commercial lots, and as the Westport community is not isolated, some runoff from adjacent communities.

Bio-swale installations will all have an underdrain installed as is required in HSG D (clay) soils in order to convey excess runoff downstream, to another ESD installation or to the stormwater system. To prevent interaction with the water table, all swales will be installed with a 2ft minimum channel bottom (planting bed) width, 4ft maximum planting depth and a 4in stone bridging gap between the planting media and the underdrain. As required in the manual, swales will be installed with a 3:1 slope between the road shoulder and the planting bed. Roads will be graded to ensure that runoff flows into the swales via curb cuts.⁵³

Micro-bioretention cells will all have an underdrain installed as is recommended, though not required in HSG D soils in order to prevent interaction with the water table and to convey excess runoff downstream, to another ESD installation or to the stormwater system. To prevent interception with a higher groundwater table, bioretention cells on Manokin St and Eyon St may not be used as infiltration practices and must have an underdrain installed to safely convey all treated water downstream or to the stormwater system. All bioretention cells will be installed with a 2ft maximum planting depth and a 4in stone bridging gap between the filter bed and the underdrain. In areas, especially on the south eastern side of the community, where slopes are steeper (>8%), check dams or weirs will be installed to decrease flow velocity and increase stormwater storage. Roads will be graded to ensure that runoff flows into the bioretention cells via curb cuts.⁵⁴

Permeable pavement installations area all slightly undersized and will all be installed with an underdrain to convey excess runoff either to an adjacent ESD installation (Annor Ct, Alaska Ct, Salerno Pl, Maisel Ct, Kermit
Ct) or to the stormwater system (Dumfries Ct, Wilgrey Ct). Permeable pavement installations will be installed as open jointed paving blocks (concrete blocks with open spaces between the units) with a 3ft maximum subbase depth to prevent interaction with the water table. Permeable pavers will be installed with a 2in surface course below the blocks, a 4in middle surface course, and a 6in to 12in lower subbase course. The variance in the subbase thickness will allow for level distribution across the project area which will prevent ponding. Stone thickness will vary from 3/4in near the surface to 2in at the subbase.\(^{55}\)

Maintenance and inspection of each ESD installation should be performed one to twice a year as recommended by the manual. Swales and bioretention cells should be pruned, re-planted, re-mulched, and mowed annually. Also, silt and sediment should be removed when accumulations exceed one inch.\(^{56}\) Permeable pavement installations should have their surfaces and underdrains cleaned no less than twice a year. To prevent damage to the paving surface in the winter months, snow removal activities must not come into direct contact with the pavement surface, nor may any snow be piled or stored directly on the pavement surface.\(^{57}\)

Concerning plantings, swales and bioretention cells will be planted with hardy native species. Permeable pavement installations will not be bordered with plantings, as root penetration may damage the installation. Plant choices will range in size from groundcover to understory trees. Plant choices must be tolerant to different soil moisture conditions and should thrive under full to partial sun exposure. The University of Maryland’s Home and Garden Information Center’s 2005 publication *Native Plants of Maryland: What, When, and Where* was used to determine which native species in each category will thrive under the above mentioned soil moisture and sun conditions. Recommended plantings are outlined in the chart below.\(^{58}\) To ensure planting survival, those that require drier soil conditions should be planted on the periphery of each system, those that are tolerant to both dry and wet conditions should be planted in the middle, and those that are tolerant of persistent wet conditions should be planted at the base. To maintain an “organic” or unplanned aesthetic in regards to the planning, plants should be placed at random intervals with random groupings, so long as the balance of various planting selections is maintained within each installation.

<table>
<thead>
<tr>
<th>COMMON NAME</th>
<th>SCIENTIFIC NAME</th>
<th>SOIL MOISTURE</th>
<th>SUN PENETRATION</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GROUNDCOVER</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partridge Berry</td>
<td>Mitchella repens</td>
<td>Moist</td>
<td>Full Sun to Shade</td>
<td></td>
</tr>
<tr>
<td>Sheep Lily</td>
<td>Uvularia sessilifolia</td>
<td>Moist</td>
<td>Full Sun to Shade</td>
<td></td>
</tr>
<tr>
<td><strong>PEAK</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitive Fern</td>
<td>Osmunda cinnamomea</td>
<td>Wet to Moist</td>
<td>Partial Sun to Shade</td>
<td>Groundcover in wet areas</td>
</tr>
<tr>
<td>Ebony Spleenwort</td>
<td>Asplenium platyneuron</td>
<td>Moist</td>
<td>Partial Sun to Shade</td>
<td>Can tolerate more sun</td>
</tr>
<tr>
<td><strong>GRASS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Big Bluestem</td>
<td>Andropogon gerardii</td>
<td>Wet to Dry</td>
<td>Full Sun to Partial Sun</td>
<td></td>
</tr>
<tr>
<td>Tussock Sedge</td>
<td>Carex elata</td>
<td>Wet to Moist</td>
<td>Full Sun to Partial Sun</td>
<td>Easy to grow, Tolerates shade</td>
</tr>
<tr>
<td><strong>ERECTACEOUS PLANTS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweet Flag</td>
<td>Acorus calamus</td>
<td>Wet to Moist</td>
<td>Full Sun to Partial Sun</td>
<td>Fragrant</td>
</tr>
<tr>
<td>Rose Mallow</td>
<td>Hibiscus moscheutos</td>
<td>Wet to Moist</td>
<td>Full Sun to Partial Sun</td>
<td></td>
</tr>
<tr>
<td>Blue Flag</td>
<td>Salvia verticillata</td>
<td>Wet to Moist</td>
<td>Full Sun to Partial Sun</td>
<td>Moisture Tolerant</td>
</tr>
<tr>
<td>Dwarf Blue Larkspur</td>
<td>Delphinium ajacis</td>
<td>Wet to Moist</td>
<td>Full Sun to Shade</td>
<td>Attracts hummingbirds</td>
</tr>
<tr>
<td><strong>LOW SHRUB</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black Chokeberry</td>
<td>Aronia melanocarpa</td>
<td>Wet to Dry</td>
<td>Full Sun to Partial Sun</td>
<td>Good for wildlife, Important for wildlife, Dry soil in winter</td>
</tr>
<tr>
<td>Dandylion</td>
<td>Galeopsis tinctoria</td>
<td>Wet to Dry</td>
<td>Full Sun to Partial Sun</td>
<td>Important for wildlife, Wet soil in spring, Dry soil in summer</td>
</tr>
<tr>
<td><strong>MEDIUM SHRUB</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red Chokeberry</td>
<td>Aronia arbutifolia</td>
<td>Wet to Dry</td>
<td>Full Sun</td>
<td>Fruit, bark, foliage important for wildlife</td>
</tr>
<tr>
<td>Mock Aster</td>
<td>Symphyotrichum novae-angliae</td>
<td>Wet to Moist</td>
<td>Full Sun to Partial Sun</td>
<td>Important for wildlife, Winter persistent</td>
</tr>
<tr>
<td>Swamp Azalea</td>
<td>Rhododendron canescens</td>
<td>Moist</td>
<td>Partial Sun to Shade</td>
<td>Well drained soil, Excellent fall color</td>
</tr>
<tr>
<td>Skunk Cabbage</td>
<td>Symplocarpus foetidus</td>
<td>Wet to Wetter</td>
<td>Full Sun to Partial Sun</td>
<td>Useful for wet areas, Not for lawns</td>
</tr>
<tr>
<td><strong>TALL SHRUB</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black Haw</td>
<td>Viburnum prunifolium</td>
<td>Wet to Moist</td>
<td>Full Sun to Partial Sun</td>
<td>Important for wildlife, Winter persistent</td>
</tr>
<tr>
<td><strong>UNDERSTORY TREE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Southern Thorn</td>
<td>Crataegus viridis</td>
<td>Wet to Moist</td>
<td>Partial Sun to Shade</td>
<td>Winter Persistent</td>
</tr>
<tr>
<td>Sweetbay Magnolia</td>
<td>Magnolia virginiana</td>
<td>Moist</td>
<td>Full Sun to Partial Sun</td>
<td>Well drained soil, Strong scent</td>
</tr>
<tr>
<td>Red Maple</td>
<td>Acer rubrum</td>
<td>Wet to Moist</td>
<td>Full Sun to Partial Sun</td>
<td>Good shade tree</td>
</tr>
</tbody>
</table>

To ensure survival, those that require drier soil conditions should be planted on the periphery of each system, those that are tolerant to both dry and wet conditions should be planted in the middle, and those that are tolerant of persistent wet conditions should be planted at the base. To maintain an “organic” or unplanned aesthetic in regards to the planning, plants should be placed at random intervals with random groupings, so long as the balance of various planting selections is maintained within each installation.

| **Wet** | | | | |
| **Mesic** | | | | |
| **Dry** | | | | |
| **Full** | | | | |
In architectural design and planning projects, vignette studies are conducted to illustrate scenes that focus on a single characteristic, idea or setting. Precedent studies take vignette studies one step further and show actual projects where these characteristics, ideas or settings have been implemented. These studies together provide insight as to what the final constructed project will look like.

The vignette and precedent studies on the following pages illustrate how the environmental site design (ESD) projects will be installed at various points in the Westport community and what they may look like once construction is complete.
Vignettes
Precedents - Bio-Swales
Since the 1990s the city of Seattle, Washington has funded a series of green infrastructure projects. The Street Edge Alternative (SEA) project replaced the 660 foot block of 2nd avenue with a wide variety of environmental site design projects including extensive swale installations. Successful implementation of the SEA project in 2001 eliminated nearly all (99%) potential surface runoff and reduced impervious cover by 18% over the entire project site. As the absorption of significant amounts of stormwater runoff is a primary goal in the Westport nonpoint source pollution reduction project, Seattle’s SEA project is an excellent candidate for a precedent study. The following images from Seattle’s SEA Streets Tour show what the bio-swales may look like once construction is complete.
Precedents - Micro-Bioretention
In 2007 the Portland City Council approved the Green Street Program to “promote and incorporate the use of green street facilities in public and private development.” The guiding principles of this program are to (1) manage stormwater runoff at the source, (2) use plants and soil to slow, filter, and infiltrate runoff, and (3) design aesthetically pleasing facilities. As it is the primary purpose of the Westport nonpoint source pollution reduction project to manage stormwater on site and provide pollution reduction through natural processes the Portland Green Streets Program is an ideal project for a precedent study. The images shown below from Portland’s Green Streets Tour indicate what the micro-bioretention cells may look like upon project completion.
**Precedents - Permeable Pavers**
The City of Vancouver’s Country Lane projects replace traditional asphalt or concrete streets with one of two design installations. Center strip installations leave the center of the road as a vegetated strip, while the surrounding area is paved in a permeable or porous concrete or paver. County Lane installations cover the entire road surface in vegetative areas, save for two permeable pavement strips on which vehicles may travel. As of October 2003, three pilot projects have been installed all of which have reduced the amount of stormwater entering the storm/sewer system and increased the amount of clean filtered water reentering the groundwater cycle. As it is a goal of the Westport nonpoint source pollution reduction project to limit the amount of stormwater entering the storm/sewer system through the use of pervious paver installations, Vancouver’s Country Lane project is suitable for a precedent study. While the Westport ESD project will likely not be able to install an exact replica of the country lane design (as higher traffic volumes may destroy the vegetated surfaces) the center strip installation will likely be more feasible. Center vegetated strips could be used to delineate travel lanes and parking areas, whereas the rest of the travel area would be formed of open jointed paving blocks. The following images from Vancouver’s Country Lane projects show what the permeable paver installations may look like once construction is complete.

![Image of Country Lane project](image1.png)

![Image of permeable pavers](image2.png)

![Image of permeable pavers](image3.png)
The primary purpose of the Westport nonpoint source pollution reduction project is to provide effective pollutant removal through the capture of stormwater runoff and nutrient load reduction through natural processes. The Environmental Protection Agency’s (EPA) Spreadsheet Tool for the Estimation of Pollutant Load (STEPL) was used to estimate the nutrient load reduction of each environmental site design (ESD) installation.

In 2001 Tetra Tech, Inc contracted with the EPA to develop a user friendly tool to calculate nutrient and sediment loads from different land uses and the associated nutrient load reductions that would result from the installation of various best management practices (BMP, ESD, LID, etc). According to Tetra Tech, Inc:

STEPL provides a user-friendly Visual Basic (VB) interface to create a customized spreadsheet-based model in Microsoft (MS Excel). It computes surface runoff; nutrient loads, including nitrogen, phosphorus, and 5-day biological oxygen demand; and sediment delivery based on various land uses and management practices. The land uses considered are urban land, cropland, pastureland, feedlot, forest, and a user-defined type. The pollutant sources include major nonpoint sources such as cropland, pastureland, farm animals, feedlots, urban runoff, and failing septic systems. The types of animals considered in the calculation are beef cattle, dairy cattle, swine, horses, sheep, chickens, turkeys, and ducks. For each watershed, the annual nutrient loading is calculated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as the land use distribution and management practices. The annual sediment load (from sheet and rill erosion only) is calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. The sediment and pollutant load reductions that result from the implementation of BMPs are computed using the known BMP efficiencies.

STEPL has been updated seven times (with the last update occurring in 2007) with data relating to BMP efficiencies, watershed information, and a GIS platform, to most accurately reflect nutrient loading and reduction estimations in any selected community in the Untied States.

STEPL takes the user through a step by step process where information regarding the watershed, land use, and best management practices are entered. STEPL guides the user through four interacting worksheets (Input, BMPs, Total Load, and Graphs) to estimate nutrient loads and reductions.

The Input worksheet requires the user to select a state, county, weather station, and land use by area. Additional data that may be entered (but is not required) includes agricultural animal data, septic system parameters, and modifications to default nutrient concentrations.

The BMP worksheet requires the user to select appropriate BMPs for the watershed. BMPs can be entered for croplands, pastures, forests, feedlots, and urban areas. According to Tetra Tech, “the Urban BMP Tool is used for select LIDs or BMPs for different urban land uses.” This tool allows the user to specify a particular urban land use (commercial, industrial, multi-family, etc), select a BMP, and specify the area to which the practice would apply.
The Total Load and Graphs worksheets show the final results of the calculations. The Total Load worksheet contains two tables. Table 1 summarizes the total nutrient loads (before and after BMP installation), load reductions, and reduction percentages. Table 2 itemizes the loads from the various sources.\textsuperscript{70}

While STEPL operates on a watershed scale, careful entry of data on the Input and BMP worksheets allows its estimation of nutrient loading and reductions to be applied to the Westport ESD project. For the Westport ESD project, each project was treated individually.

On the Input worksheet, the following data was entered:

- 1 Subwatershed, 0 Special Sediment Sources
- State: Maryland
- County: Baltimore City
- Weather Station: Baltimore-Washington International Airport
- Watershed Land Use Area: Drainage area for each site, urban land use only.

STEPL automatically breaks down the acreage for urban land by a ratio of land use types. 15\% of the acreage is allocated to commercial uses; 10\% each is allocated to industrial, institutional, transportation, and multifamily uses; 30\% is allocated to single family uses; and 5\% each is allocated to urban cultivated, vacant, and open space uses. STEPL requires the user to utilize these proportions and does not allow the user to select or eliminate specific land use types.

On the BMP worksheet, using the Urban BMP Tool, the following data was entered

- BMP land use type and area
  - For each land use type, the same ratio of the ESD installation area was entered. For example, as 15\% of the drainage area is applied to commercial land uses, then 15\% of the ESD installation area is applied to commercial land uses. Each proportion was entered for each land use type, such that 100\% of the ESD installation was applied proportionally across the various land use types. As STEPL does not allow the user to select proportions or select or eliminate specific land use types, entering BMP areas in this manner ensures that the ESD installation is accounted for proportionally across the drainage area and ensures that the estimated loads and reductions are proportionally accounted for. While one may assume that this could introduce a certain margin of error, comparison of load reduction results with Maryland Department of the Environment’s Nonpoint Source Pollution Reduction Calculator produces similar results and therefore indicates that the results produced by STEPL are correct.
  - BMP Practice: Four different BMPs were used, based on the ESD installation for each project site.
    - For Bio-Swale installations, LID/Vegetated Swale was selected. As Bio-Swale is not a selectable option, and the EPA’s definition of a vegetated swale (“a broad, shallow channel with a dense stand of vegetation covering the side slopes and bottom…designed to trap particulate pollutants, promote infiltration, and reduce the flow velocity of stormwater runoff.”\textsuperscript{71}) closely matches the bio-swale defined in the ESD section of this project, the LID/Vegetated Swale option was the best selectable choice.
    - For Micro-Bioretention installations, where the cell replaces existing green spaces, Vegetated Filter Strip was selected. As EPA’s definition of a vegetated filter strip (“a strip or area of vegetation for removing sediment, organic matter, and other pollutants from runoff and wastewater before they reach water bodies or water sources, including wells.”\textsuperscript{72}) closely matches the micro-bioretention cell defined in the Environmental Site Design section of this project, and
does not reduce impervious areas as a replacement of green spaces does not do, the Vegetated Filter Strip option was the best selectable choice.

- For Micro-Bioretention installations, where the cell replaces impervious surfaces, Bioretention Facility was selected. As EPA’s definition of a bioretention facility (“a shallow depression or basin with a flow-regulating structure to control flow and a floor covered with specially engineered soil and plants to promote biological degradation of pollutants.”) closely matches the micro-bioretention cell defined in the ESD section of this project, the bioretention facility option was the best selectable choice.

- For Permeable Pavement installations, Porous Pavement was selected. As EPA’s definition of a porous pavement (“a variety of porous media, often supported by a structural matrix, concrete grid, or modular pavement. The media allow water to percolate through the pavement to a subbase for gradual infiltration into the underlying soil.”) closely matches the permeable paver defined in the ESD section of this project, the porous pavement option was the best selectable choice.

- In the three instances where multiple ESD installations are used on a single site, best selectable BMPs were entered based on their designs. All three contained a bio-swale (entered as LID/Vegetated Swale). Two contained an impervious area reducing micro-bioretention cell (entered as Bioretention Facility), and one contained a green space replacing micro-bioretention cell (entered as Vegetated Filter Strip). Each BMP was entered into STEPL individually based on the BMPs area and reductions were summed based on those results.

Nutrient loading and reductions are estimated by STEPL based on the data entered in the two sections above. STEPL calculates nutrient and sediment loading based on known runoff volumes, pollutant concentrations, the USLE and sediment delivery ratios. Nutrient and sediment reductions are calculated from the known efficiencies of the selected practices. The chart below lists the known reduction efficiencies of the BMP strategies selected for estimating nutrient reductions for the Westport ESD project. Note that for project sites that include multiple ESD installations, the performance efficiency is a calculated average.

<table>
<thead>
<tr>
<th></th>
<th>Nitrogen</th>
<th>Phosphorus</th>
<th>Sediment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetated Swale</td>
<td>7.5%</td>
<td>17.5%</td>
<td>47.5%</td>
</tr>
<tr>
<td>Vegetated Filter Strip</td>
<td>40%</td>
<td>45.3%</td>
<td>73%</td>
</tr>
<tr>
<td>Bioretention Facility</td>
<td>63%</td>
<td>80%</td>
<td>0%</td>
</tr>
<tr>
<td>Porous Pavement</td>
<td>85%</td>
<td>65%</td>
<td>90%</td>
</tr>
<tr>
<td>Veg Swale &amp; Bioret Facil</td>
<td>35.3%</td>
<td>48.8%</td>
<td>23.8%</td>
</tr>
<tr>
<td>Veg Swale &amp; Veg Filt St</td>
<td>23.8%</td>
<td>31.4%</td>
<td>60.3%</td>
</tr>
</tbody>
</table>

It is interesting to note in reviewing efficiencies, that while it appears that numerous installations are operating at a low efficiency, their efficiency is directly related to the proportion of practice size to drainage area. Basically, as practice size approaches drainage area, performance efficiency increases.

The charts on the following pages summarize the estimated reductions and operating efficiencies for each project site.
<table>
<thead>
<tr>
<th>STREET</th>
<th>DRAINAGE AREA</th>
<th>PRACTICE</th>
<th>PRACTICE SIZE</th>
<th>PRACTICE SIZE V. DRAINAGE</th>
<th>KNOWN EFFICIENCIES</th>
<th>ACTUAL EFFICIENCY</th>
<th>PERFORMANCE</th>
<th>STEPL BMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waterline Ave</td>
<td>2.84</td>
<td>BS</td>
<td>0.78</td>
<td></td>
<td>3.62</td>
<td>1.088</td>
<td>0.49</td>
<td>0.98</td>
</tr>
<tr>
<td>Hollins Ferry Rd</td>
<td>1.02</td>
<td>BS</td>
<td>0.42</td>
<td>15.11</td>
<td>2.33</td>
<td>683.27</td>
<td>0.26</td>
<td>0.09</td>
</tr>
<tr>
<td>Nevada St</td>
<td>1.06</td>
<td>BS, MI</td>
<td>0.30</td>
<td>9.66</td>
<td>1.50</td>
<td>457.10</td>
<td>0.13</td>
<td>0.22</td>
</tr>
<tr>
<td>Northern Ave</td>
<td>1.12</td>
<td>MI</td>
<td>0.21</td>
<td>9.20</td>
<td>1.40</td>
<td>428.63</td>
<td>0.70</td>
<td>0.13</td>
</tr>
<tr>
<td>Northern Ave N</td>
<td>1.10</td>
<td>MI</td>
<td>0.13</td>
<td>9.13</td>
<td>1.40</td>
<td>419.00</td>
<td>0.68</td>
<td>0.13</td>
</tr>
<tr>
<td>Klamath St</td>
<td>0.97</td>
<td>BS</td>
<td>0.36</td>
<td>8.05</td>
<td>1.24</td>
<td>369.49</td>
<td>0.22</td>
<td>0.08</td>
</tr>
<tr>
<td>Norstaff St</td>
<td>0.54</td>
<td>BS, MI</td>
<td>0.22</td>
<td>7.90</td>
<td>1.20</td>
<td>358.06</td>
<td>0.83</td>
<td>0.17</td>
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<td>Kent St</td>
<td>0.52</td>
<td>BS</td>
<td>0.13</td>
<td>8.08</td>
<td>1.04</td>
<td>312.35</td>
<td>0.66</td>
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<td>Weasenton St</td>
<td>0.21</td>
<td>BS, MI</td>
<td>0.14</td>
<td>6.48</td>
<td>1.00</td>
<td>297.11</td>
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<td>Chrysl St</td>
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<td>0.82</td>
<td>245.53</td>
<td>0.81</td>
<td>0.14</td>
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<td>Clare St</td>
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<td>BS</td>
<td>0.21</td>
<td>4.48</td>
<td>0.50</td>
<td>205.69</td>
<td>0.13</td>
<td>0.05</td>
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<tr>
<td>Amor Ct (Wh)</td>
<td>0.50</td>
<td>PP</td>
<td>0.45</td>
<td>4.15</td>
<td>0.64</td>
<td>190.45</td>
<td>3.53</td>
<td>0.42</td>
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<td>Tacoma St</td>
<td>0.49</td>
<td>MB</td>
<td>0.08</td>
<td>3.69</td>
<td>0.57</td>
<td>199.45</td>
<td>0.38</td>
<td>0.07</td>
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<td>0.46</td>
<td>MB</td>
<td>0.08</td>
<td>3.47</td>
<td>0.53</td>
<td>159.08</td>
<td>0.36</td>
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<tr>
<td>Alaska Ct (Wh)</td>
<td>0.38</td>
<td>PP</td>
<td>0.38</td>
<td>3.16</td>
<td>0.46</td>
<td>144.75</td>
<td>2.66</td>
<td>0.31</td>
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<tr>
<td>Kent St</td>
<td>0.36</td>
<td>MB</td>
<td>0.10</td>
<td>2.77</td>
<td>0.42</td>
<td>124.50</td>
<td>0.47</td>
<td>0.02</td>
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<tr>
<td>Alaska St</td>
<td>0.30</td>
<td>MB</td>
<td>0.05</td>
<td>2.71</td>
<td>0.42</td>
<td>124.50</td>
<td>0.23</td>
<td>0.05</td>
</tr>
<tr>
<td>Wenburn St</td>
<td>0.23</td>
<td>MB</td>
<td>0.06</td>
<td>2.49</td>
<td>0.38</td>
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<td>0.28</td>
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<td>Salmoni Pt</td>
<td>0.30</td>
<td>PP</td>
<td>0.30</td>
<td>2.49</td>
<td>0.38</td>
<td>114.27</td>
<td>2.12</td>
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<td>Mason Ct (Wh)</td>
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<td>PP</td>
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<td>1.91</td>
<td>0.29</td>
<td>87.61</td>
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<td>0.24</td>
<td>72.37</td>
<td>1.34</td>
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<tr>
<td>Indianna Ave N</td>
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<td>MB</td>
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<td>Wingitzy Ct (Wh)</td>
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<tr>
<td>Elyon St</td>
<td>0.12</td>
<td>MB</td>
<td>0.07</td>
<td>1.00</td>
<td>0.15</td>
<td>45.71</td>
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<td>Kernell Ct (Wh)</td>
<td>0.09</td>
<td>PP</td>
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<td>0.12</td>
<td>34.28</td>
<td>0.78</td>
<td>0.09</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td><strong>17.31</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>6.64</strong></td>
<td><strong>141.42</strong></td>
<td><strong>33.07</strong></td>
</tr>
</tbody>
</table>

**TOTAL LOAD = 6,670.21** DRAINAGE REDUCTION = 1,223.35 LOAD WITH ESD = 5,453.54
The viability of the Westport nonpoint source pollution reduction project lies in its ability to reduce pollution loading in relationship to the project cost. The Center for Neighborhood Technology’s (CNT) National Green Values Calculator was used to estimate the cost of each environmental site design (ESD) installation.

The CNT collaborated with the Nonpoint Source Branch of the US EPA’s Office of Wetlands, Oceans, and Watersheds, Assessment and Watershed Division, in 2004 to develop the Green Values Calculator (GVC). According to the CNT, “it (the GVC) compares green infrastructure (ESD) performance, costs, and benefits to conventional stormwater practices.” In 2009 CNT issued an updated version of the GVC, the National GVC. The National GVC is designed to more accurately reflect results in any community in the United States because the user inputs specific site data, runoff reduction goals, and ESD installation options. The National GVC was also updated with recent cost data to better support financial analysis.

While the National GVC is used to compare the performance, costs, and benefits of ESD installations, for the purpose of this project, only the costs data will be used.

The National GVC attempts to account for all costs (construction, operation, and lifecycle) that need to be considered over the full life of the ESD installation. Note however that the estimated costs apply only to the costs of the ESD components themselves and not to other incurred costs such as street re-grading. The calculator then compares those costs to the costs of conventional stormwater designs. According to the CNT:

Construction costs, maintenance costs, and lifespan data were gathered from the available literature for both green infrastructure and standard stormwater infrastructure. This data is provided through the “See how costs are calculated” link on the Cost results tab. A table in that section gives low, middle and high estimates of construction costs, annual maintenance costs, and design life for each component. In each case, CNT has used the middle cost.

CNT has collected the most recent cost data regarding conventional stormwater and ESD installations from municipalities, public utilities, industry participants, and educational institutions actively engaged in ESD projects in order to reflect a range of real world costs in the National GVC calculator results.

The National GVC takes the user through a step by step process where information regarding lot information, predevelopment characteristics, runoff reduction goals, conventional development and green improvement options are entered. Results based on user input, according to CNT, “include progress toward the specified volume reduction goal, changes in the total runoff volume annually for the average storm event for the predevelopment, conventional, and green scenarios, changes in the land use between the conventional and green scenarios, and detail on the lifecycle cost/benefit analysis.”

For the Westport nonpoint source pollution reduction project, data was entered for each individual project site. Entered site data included average precipitation (42 in. as per Maryland Department of the Environment’s Nonpoint Source Reduction Calculator), site size and hydrologic soil group. Predevelopment characteristics included the percent of various land types. As this project focuses on the redevelopment of impervious areas as the primary method for managing stormwater runoff, the entered percentage data was always 100 percent impervious area. The runoff reduction goal entered is the target P_E for each project site. Conventional development data entered remained identical to lot dimensions, as the reduction in impervious area is accounted.
for in the green improvements section. Entering a reduced impervious area at this point would double the area reductions and skew the estimated cost results. Green improvement options were entered based on the ESD practice for each site. Note that micro-bioretention cells are not a listed option. In instances where a micro-bioretention cell is installed in place of green space it is entered as a vegetated filter strip. In instances where a micro-bioretention cell is installed as a road center or road side unit, it is entered as a bio-swale with a reduced prepared soil depth (recall that planting depths for a bioretention cell is less than a bio-swale).

The chart on the following page summarizes the estimated costs for each project site.
<table>
<thead>
<tr>
<th>STREET</th>
<th>DRAWN AREA</th>
<th>SUCC PRACTICE</th>
<th>SQ FT</th>
<th>PROJECT COST</th>
<th>CONSTRUCTION</th>
<th>YRLY MAINTENANCE</th>
<th>END PROJ COST</th>
<th>30 YR L.C.C.</th>
<th>TOTAL COST</th>
<th>MAINT. GROWTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waverley Ave</td>
<td>123,803.3</td>
<td>BS</td>
<td>16,27</td>
<td>$1,021.00</td>
<td>$969.21</td>
<td>$81.97</td>
<td>$1,003.45</td>
<td>$1,003.45</td>
<td>$266,428</td>
<td>$266,428</td>
</tr>
<tr>
<td>Dallas Ave</td>
<td>154,421.27</td>
<td>BS</td>
<td>15,75</td>
<td>$1,021.00</td>
<td>$969.21</td>
<td>$81.97</td>
<td>$1,003.45</td>
<td>$1,003.45</td>
<td>$266,428</td>
<td>$266,428</td>
</tr>
<tr>
<td>Maple Ave</td>
<td>154,421.27</td>
<td>BS</td>
<td>16,27</td>
<td>$1,021.00</td>
<td>$969.21</td>
<td>$81.97</td>
<td>$1,003.45</td>
<td>$1,003.45</td>
<td>$266,428</td>
<td>$266,428</td>
</tr>
<tr>
<td>Beverly Dr</td>
<td>154,421.27</td>
<td>BS</td>
<td>16,27</td>
<td>$1,021.00</td>
<td>$969.21</td>
<td>$81.97</td>
<td>$1,003.45</td>
<td>$1,003.45</td>
<td>$266,428</td>
<td>$266,428</td>
</tr>
<tr>
<td>Elgin Dr</td>
<td>154,421.27</td>
<td>BS</td>
<td>16,27</td>
<td>$1,021.00</td>
<td>$969.21</td>
<td>$81.97</td>
<td>$1,003.45</td>
<td>$1,003.45</td>
<td>$266,428</td>
<td>$266,428</td>
</tr>
<tr>
<td>York Ave</td>
<td>154,421.27</td>
<td>BS</td>
<td>16,27</td>
<td>$1,021.00</td>
<td>$969.21</td>
<td>$81.97</td>
<td>$1,003.45</td>
<td>$1,003.45</td>
<td>$266,428</td>
<td>$266,428</td>
</tr>
<tr>
<td>Wood St</td>
<td>154,421.27</td>
<td>BS</td>
<td>16,27</td>
<td>$1,021.00</td>
<td>$969.21</td>
<td>$81.97</td>
<td>$1,003.45</td>
<td>$1,003.45</td>
<td>$266,428</td>
<td>$266,428</td>
</tr>
<tr>
<td>Washington St</td>
<td>154,421.27</td>
<td>BS</td>
<td>16,27</td>
<td>$1,021.00</td>
<td>$969.21</td>
<td>$81.97</td>
<td>$1,003.45</td>
<td>$1,003.45</td>
<td>$266,428</td>
<td>$266,428</td>
</tr>
<tr>
<td>Madison St</td>
<td>154,421.27</td>
<td>BS</td>
<td>16,27</td>
<td>$1,021.00</td>
<td>$969.21</td>
<td>$81.97</td>
<td>$1,003.45</td>
<td>$1,003.45</td>
<td>$266,428</td>
<td>$266,428</td>
</tr>
<tr>
<td>Crescent St</td>
<td>154,421.27</td>
<td>BS</td>
<td>16,27</td>
<td>$1,021.00</td>
<td>$969.21</td>
<td>$81.97</td>
<td>$1,003.45</td>
<td>$1,003.45</td>
<td>$266,428</td>
<td>$266,428</td>
</tr>
<tr>
<td>Oaklake Ave</td>
<td>154,421.27</td>
<td>BS</td>
<td>16,27</td>
<td>$1,021.00</td>
<td>$969.21</td>
<td>$81.97</td>
<td>$1,003.45</td>
<td>$1,003.45</td>
<td>$266,428</td>
<td>$266,428</td>
</tr>
<tr>
<td>West Ave</td>
<td>154,421.27</td>
<td>BS</td>
<td>16,27</td>
<td>$1,021.00</td>
<td>$969.21</td>
<td>$81.97</td>
<td>$1,003.45</td>
<td>$1,003.45</td>
<td>$266,428</td>
<td>$266,428</td>
</tr>
<tr>
<td>Other Ave</td>
<td>154,421.27</td>
<td>BS</td>
<td>16,27</td>
<td>$1,021.00</td>
<td>$969.21</td>
<td>$81.97</td>
<td>$1,003.45</td>
<td>$1,003.45</td>
<td>$266,428</td>
<td>$266,428</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The feasibility of the Westport nonpoint source pollution reduction project lies in its ability to reduce pollution loading in relationship to the project cost. However, feasibility cannot be determined based solely on capital investment versus realized nutrient load reductions. A broader perspective of the actual costs and realized benefits is required in order to fully rationalize the projects capital investment.

A cost versus volume reduction and pollutant removal analysis was conducted based on the St. Paul, MN Capitol Region Watershed District’s presentation on best management practice (BMP) performance and cost effectiveness. Melissa Baker, a water resource technician with the Capitol Region Watershed District, presents a simplified cost benefit analysis based on two mathematical equations:  

- Annual Volume Reduction cost = Annual Cost ($) / Volume Reduction (cu ft)  
- Annual Pollutant Removal Cost = Annual Cost ($) / Nutrient Load Removed (lbs)

The cost per pound reduction analysis for the Westport nonpoint source pollution project was calculated in precisely the same manner. For each project site, annual cost was calculated as the 30-yr life time cost estimation (see Project Cost) divided by 30. Volume reduction for each site is the actual ESD\(_V\) captured (see Sizing Requirements), and nutrient load removal is the estimated load reductions in nitrogen, phosphorus, and sediment (see Pollution Load Reductions).

The chart below summarizes the estimated annual project cost per each pound in nutrient reduction and each cubic foot of runoff collected.
While it appears that ESD\textsubscript{V} and sediment reductions (measured per cubic foot and per pound) are significantly higher than those of nitrogen and phosphorus, the percentages in reduction (with exception to ESD\textsubscript{V}) all fall within a fairly close range. What is significant, however, is the cost to achieve those reductions. Removal of nitrogen and phosphorus is exponentially more expensive than that of sediment and ESD\textsubscript{V} capture. The chart below outlines the costs per unit measured for each installation group’s various nutrient reductions.

<table>
<thead>
<tr>
<th></th>
<th>Bio-Swale</th>
<th>Micro-Bioretention</th>
<th>Permeable Pavers</th>
<th>Combined</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESD\textsubscript{V}</td>
<td>$1/cu ft/yr</td>
<td>$1/cu ft/yr</td>
<td>$3/cu ft/yr</td>
<td>$1/cu ft/yr</td>
<td>186%</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>$114,204/lb/yr</td>
<td>$13,604/lb/yr</td>
<td>$3,718/lb/yr</td>
<td>$19,135/lb/yr</td>
<td>16%</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>$50,250/lb/yr</td>
<td>$67,959/lb/yr</td>
<td>$31,544/lb/yr</td>
<td>$25,176/lb/yr</td>
<td>12%</td>
</tr>
<tr>
<td>Sediment</td>
<td>$394/lb/yr</td>
<td>$554/lb/yr *(2 sites)</td>
<td>$77/lb/yr</td>
<td>$767/lb/yr</td>
<td>18%</td>
</tr>
</tbody>
</table>

Knowing that the project cost is significantly high in comparison to the reduction in pollutant loading, one method for assessing the expense is to examine the cost per person receiving the benefit. The Westport project site covers 0.651 square miles, and according to Census 2000 data, the site has a population density of approximately 4,128 persons per square mile.\textsuperscript{81} This yields an approximate population of 2,687 people living in the Westport community. The per capita investment per reduction for the Westport nonpoint source pollution reduction project, while representative of the same overall cost, is far more palatable. In cases where cost is carried partially or entirely by residents (taxes, investments, etc) the per capita cost is an excellent assessment tool for determining financial feasibility of a project. The chart below outlines the per capita investment per unit measured for each installation group’s various nutrient reductions and the total annual per capita investment for each installation group. Note also that Turner’s Westport development will significantly increase the community population, thereby lowering future annual per capita investments.

<table>
<thead>
<tr>
<th></th>
<th>Bio-Swale</th>
<th>Micro-Bioretention</th>
<th>Permeable Pavers</th>
<th>Combined</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESD\textsubscript{V}</td>
<td>$&lt;0.01/ person/ cu ft/yr</td>
<td>$&lt;0.01/ person/ cu ft/yr</td>
<td>$&lt;0.01/ person/ cu ft/yr</td>
<td>$&lt;0.01/ person/ cu ft/yr</td>
<td>$&lt;0.01/ person/ cu ft/yr</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>$42.50/ person/ lb/yr</td>
<td>$5.06/ person/ lb/yr</td>
<td>$1.38/ person/ lb/yr</td>
<td>$7.12/ person/ lb/yr</td>
<td>$4.76/ person/ lb/yr</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>$18.70/ person/ lb/yr</td>
<td>$25.29/ person/ lb/yr</td>
<td>$11.74/ person/ lb/yr</td>
<td>$9.37/ person/ lb/yr</td>
<td>$29.73/ person/ lb/yr</td>
</tr>
<tr>
<td>Sediment</td>
<td>$0.15/ person/ lb/yr</td>
<td>$0.21/ person/ lb/yr *(2 sites)</td>
<td>$0.03/ person/ lb/yr</td>
<td>$0.29/ person/ lb/yr</td>
<td>$0.09/ person/ lb/yr</td>
</tr>
<tr>
<td>Total Investment</td>
<td>$47/ person/yr</td>
<td>$26/ person/yr</td>
<td>$20/ person/yr</td>
<td>$16/ person/yr</td>
<td>$109/ person/year</td>
</tr>
</tbody>
</table>

Project feasibility, however, cannot be determined based solely on capital investment versus nutrient load reductions. Increases in unaccounted elements provide additional rationale for funding that will allow the project to move forward.

While assessing project feasibility in this manner is necessary, it is nonetheless challenging to attach a monetary value to life, health, and nature. For proponents on either side of a project, introducing a price to un-priced things is often subjective, and unfortunately can be inflated or deflated to support or discredit the particular argument.\textsuperscript{82} In pursuit of maintaining accuracy in regards to pricing the un-priced, the Center for Neighborhood Technology’s National Green Values Calculator (GVC) Detailed Benefit Sheet was used to assign costs to the more subjective benefits yielded by the Westport environmental site design (ESD) project.
Bio-swale installations, based on their established widths and planting depths (see Site Plan and Sections), will contain a greater number of shade trees. This will reduce the urban heat island effect and energy consumption. A study listed by the National GVC states, “in the Chicago area, the shade provided by trees also reduces direct energy use at a rate of 5 to 10 percent of urban heating and cooling costs for a 10 percent increase in tree cover.”

For the Westport ESD project, properties bordering bio-swale installations on Waterview Avenue, Hollins Ferry Road, Nevada Street, Kloman Street, Norfolk Street, Westport Street, and Clare Street could see a five to ten percent reduction in heating and cooling costs.

Bio-swale and micro-bioretention facilities all contain a variety of flowering and non-flowering vegetative plantings (see Site Plan and Sections). This increases a property’s aesthetic value which in turn increases a property’s value. According to the National GVC, “studies have shown that trees increase the value of a home by 2 to 30 percent…landscaping can add value to a home as well. Hedges and other landscaping can increase a home value by 3 to 12 percent.” In the Westport community, the average home value was approximately $51,000 in 2009. This represents a gain in property value of $1,020 to $15,300. It is important to ensure however that each installation is properly planted and maintained as ill kept installations will decrease in aesthetic value and detract from property value.

All installations affect street width or permeability in one manner or another. These changes in street structures present opportunities for a number of different savings. The reduction in non permeable street area allows for savings in annual street maintenance including street cleaning and winter salt applications. Permeable pavement installations allow for additional savings, especially in winter salt applications, as salting is not permitted on these installations (see Site Plan and Sections). A study on salt applications in New York City cited by the National GVC states, “reducing paved areas and using porous pavement can reduce the need for salt to de-ice sidewalks, driveways, and roads. Reduced salt use saves money – side walk can cost $0.05 per square foot treated.” For the Westport ESD project, this represents a community wide savings of nearly $12,400 per salt application.

All installations are designed as infiltration practices (except Manokin St). Infiltration of runoff provides a number of different benefits including flood protection for property owners and reduced water treatment costs for municipalities. The benefit in reductions in insurance claims for properties in the south eastern area of the project site where slopes are steeper and runoff velocity higher can be significant. The National GVC cites an Illinois study in which over a 20 year period, insurance claims averaged over $15,000. The National GVC states, “a modest benefit for flood reduction can probably be assumed for green infrastructure alternatives. For the calculator, this benefit is valued at $1000 per acre-foot of reduced flow from the total site during the 100-year storm.”

The city of Baltimore Department of Public Works also stands to receive a benefit in the collection and treatment of stormwater runoff. Reduced inflow and reduced incidences of combined sewer overflows represent a savings in regards to the volume of water requiring treatment. The City of Chicago reported, in 2004, a savings of $29.94 in treatment costs per each acre foot of runoff reduced. The Westport ESD project collects 5.76 acre feet of runoff annually; this represents a potential treatment savings of nearly $175 annually. While this is a modest annual savings, the greater benefit is in the reduction in water volume entering the stormwater sewer system. The reduced volume lowers system stress, maintenance costs, and potential damages due to overflows.
Though other benefits have yet to be quantified, they do deserve mentioning as they may have an impact in the future. Two potential benefits that could have direct impact on the Westport community include increases in public health and in habitat quality.

A rise in public health quality has been tied to increases in green spaces. Reduced illness, increased educational performance, and reduced instances of depression and anxiety have all been linked to an increase in well maintained green spaces. A 2005 Dutch study cited by Reuters Health states:

- Researchers found that among more than 300,000 Dutch adults and children, those living near more “green spaces” tended to have lower rates of 15 different health conditions. The link was especially strong when it came to depression and anxiety, suggesting, the researchers say, that respite from stress and the hustle and bustle of urban life may be an important reason for the benefits of green…Overall the study found, greater amounts of green space within one kilometer of people’s homes was related to small reductions in the risks of health problems like heart disease, diabetes, chronic neck and back pain, asthma and migraines…The study also found that the relationship between green space and health was particularly strong among children and lower-income groups, which, researchers speculate could be because they tend to spend much of their time close to home.\(^{89}\)

While this has not been quantified as a dollar savings, potential savings could be estimated per capita based on reductions in income loss or health care expenses due to illness.

Habitat quality can also be linked to potential increases in property value. Increases in wildlife areas, plant and species diversity, and physical area quality are largely considered desirable by potential homeowners. Home sellers in these areas have the potential to demand greater purchase prices, thereby increasing seller revenue and property value. A study by the Agricultural and Applied Economics Association states:

- The results of a hedonic analysis of houses that sold within 0.2 miles of 51 stratified-random selected riparian survey sites in Tucson, Arizona reveals that homebuyers significantly value habitat quality and negatively value manmade park-like features. Homebuyers are willing to pay twenty percent more to live near a riparian corridor that is densely vegetated and contains more shrub and tree species, particularly species that are dependent on perennial water flow. These environmental premiums are significant, outweighing structural factors such as an additional garage or swimming pool. Likewise, proximity to a riparian habitat with low biological quality or to a golf course lowers property values.\(^{90}\)

Increases in property value have already been linked to property aesthetics by a similar percentage. Further investigation is required to determine if property aesthetics and habitat quality combined will provide additional property value and by what percentage.
In light of current economic conditions, financing options for the Westport nonpoint source pollution reduction project must be selected based on the criteria that they provide the least financial burden to the City of Baltimore and to the residents of the Westport community while still generating significant funds. Establishing tax increment finance districts is one financial mechanism that generates project funding without increasing the financial burden on the resident tax base.

Tax increment financing (TIF) originated in California in 1952 as a means to provide local matching funds for federal grants. According to contributing authors Klačik and Nunn in the book *Tax Increment Financing: Uses, Structures and Impacts*:

TIF has been viewed as a mechanism to distribute the cost of local development incentives among the various taxing units benefiting from a long term increase in the local tax base. Without the use of TIFs, the general tax base of the city alone would bear the cost of providing the local incentives necessary to obtain certain economic development projects…Nationally, the use of TIF has expanded in reaction to the decreased availability of federal funds for economic development projects and infrastructure improvements.\(^9\)

TIF Financing was established in the State of Maryland in 1980 under Maryland Economic Development Act, Title 12 Local Development Authorities and Resources, Subtitle 2 Tax Increment Financing Act (modified 2008). This allows county and city municipalities to establish special financing districts for the purpose of borrowing money by issuing and selling bonds for financing development or redevelopment projects.\(^9\) The City of Baltimore, in 1994, under Article II General Provisions, Section 62 Tax Increment Financing, of the City Charter approved the use of TIF financing “to borrow money by issuing and selling bonds, at any time and from time to time, for the purpose of financing and refinancing the development of an industrial, commercial, or residential area in Baltimore City.”\(^9\)

The funds generated from the establishment of a TIF district may only be used for specific development or redevelopment activities. These include, as listed in the City Charter: \(^5\)

- The cost of purchasing, leasing, condemning, or otherwise acquiring land or other property, or an interest in them…or as necessary for a right-of-way or other easement to or from the development district area;
- Site removal;
- Surveys and studies;
- Relocation of businesses or residents;
- Installation of utilities, construction of parks and playgrounds, and other necessary improvements including streets and roads to, from, or within the development district, lighting, and other facilities;
- Construction or rehabilitation of buildings provided that such buildings are to be donated to a governmental use, are abandoned property, are distressed property, or will provide units of affordable housing;
- Reserves and capitalized interest on the bonds;
- Necessary costs of issuing bonds;
• Structured and parking facilities that are publicly owned or privately owned but serve a public purpose, and;
• Payment of the principal and interest on loans, money advanced, or indebtedness incurred by the Mayor and the City Council of Baltimore for any of the purposes set out in this section.

TIFs are primarily used to finance infrastructure related projects, however the city, through local ordinance, can designate alternative projects. The city predominantly uses TIFs to finance public infrastructure relating to land acquisition, utilities and planning costs, sewer expansion and repair, curb and sidewalk work, storm drainage, street construction and expansion, environmental remediation, landscaping, park improvements and public lighting, etc.

Baltimore, by city council ordinance, designates TIF Development Districts. A TIF is issued to finance specific public improvements that will enable economic development by installing infrastructure that makes a particular project possible. The assumption is that the ensuing development will generate new private investment which will in turn generate an increase in property tax revenues which are then used to pay for the debt. Basically, the project pays for itself.95

Stephen Kraus, chief of the Bureau of Treasury Management for the City of Baltimore, outlined five steps that must be followed prior to the issuance of debt:96

1. Development of the TIF plan and proposal by the appropriate city coordinating agency, such as the Baltimore Development Corporation or the Department of Housing and Community Development.
2. Presentation of the proposed TIF to the Board of Finance for conceptual approval. The purpose of this step is for the board of finance to confirm that the proposed TIF will be consistent with the city’s policies regarding TIFs early in the process before significant city efforts are expended preparing legislation and moving the TIF forward.
3. Present the proposed legislative package creating the TIF to the board of finance for approval.
4. Presenting the proposed legislative package creating the TIF to the city council, and if required, the Board of Estimates (BOE).
5. The final step (following city council and BOE approval) shall be the submission for approval of documents authorizing the proposed issuance of bonds to the board of finance.

The creation of a TIF district to finance the Westport nonpoint source pollution reduction project would be ideal for a number of reasons. First, it puts little to no pressure on already strained financial resources. The sale of bonds to finance the project means that public funds are not required in order for the project to move forward into construction, relieving pressure on municipal financial resources. Secondly, resident tax payers do not have to worry about paying new or increased taxes; the additional tax revenue is generated from an increase in new assessed property values from development and redevelopment activities. According to a 2011 presentation entitled Tax Increment Financing by Abby Ferretti for the Maryland Sustainable Growth Commission, at the beginning of the project when the TIF boundary is defined, “the base value of existing property is established and frozen; the jurisdiction continues to receive all taxes generated from the existing assessed property value.”97 Development activities then increase new assessed property values. As per Ferretti’s presentation, “future taxes generated by increased ‘incremental’ property values are directed to a dedicated TIF fund account...when the bonds are repaid, TIF revenues revert to the jurisdiction as part of regular taxes.”98 This solution is ideal for the Westport community, as the resident tax base will not be required to pay an increase in taxes. However, this does pose a challenge to new low income residents who would be required to pay the increase in taxes due to the increase in property value. It is therefore suggested that a waiver be supplied for new low income residents.
to allow them to pay taxes based on the lots predevelopment assessed property value as opposed to the newly developed lots assessed property value.

The designation of a TIF district should be approached with caution. According to editors Johnson and Mann in the book *Tax Increment Financing: Uses, Structures and Impacts*:

"The layering of numerous TIF districts over a local jurisdiction in order to promote economic development and enable specific public-private deals, municipal authorities are segmenting the local fiscal structure and restructuring how the revenue associated with new assessed value can be used to pay for general public services and facilities." 99

This could lead to issues associated with overlapping taxation and may make local fiscal management and planning more of a challenge. In 2008 Turner’s Westport Waterfront was designated as a TIF district. $160 million dollars in tax-exempt bonds were sold for the purpose of extending sewer and power lines, road and sidewalk construction, and tree planting in order to prepare for the erection of buildings on the site. 100 While the designation of a TIF district in the Westport community for the purpose of financing the nonpoint source pollution reduction project is an ideal solution, it should be done carefully in order to avoid overlapping or multiple taxation, fracturing of the fiscal structure, and default of the loan due to an attempt to finance multiple projects with only one projected tax base to pay for it.
Poorer countries, communities, and individuals are likely to express less “willingness to pay” to avoid environmental harms, simply because they have fewer financial resources. Considering the huge financial strain the Westport nonpoint source pollution reduction project could place on Baltimore City and community residents, financing options feasible in low-income communities must be considered. The Nonpoint Source Management Program is one mechanism that generates project funding without increasing financial burdens.

Amendments to the Clean Water Act (CWA) in 1987 established the Section 319 Nonpoint Source Management Program. The Nonpoint Source Management Program requires states to (1) assess the extent to which nonpoint sources of pollution are responsible for the continued impairment of local water systems, and (2) develop management plans to address these sources of pollution. According to the U.S. Environmental Protection Agency (EPA), “under Section 319, states, territories, and tribes receive grant money that supports a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of specific nonpoint source implementation projects.”

Grant funding from the EPA is provided to states on an annual basis following submittal and acceptance of an application package whose form and contents the administrator of the program requires. Section 319 Nonpoint Source Management Programs, Subsection h Grants Program, Part 2 Applications, of the Clean Water Act outlines what is required from the states for each application package:

An application for a grant under this subsection in any fiscal year shall be in such form and shall contain such other information as the Administrator may require, including an identification and description of the best management practices and measures which the State proposes to assist, encourage, or require in such ear with the Federal assistance to be provided under the grant.

Grant funding is disbursed to the states based on a formula created by the EPA in consultation with the states. Note however that an individual state may not receive more than 15 percent of the amount appropriated to the EPA for the purpose of carrying out the Nonpoint Source Management Program. Funds are then allocated to various projects as determined by the states.

In Maryland the Department of Environment Nonpoint Source Program administers the Section 319(h) Nonpoint Source Management Grant Program. Grant funds can be used for a number of projects by state and local entities including planning, design, construction, research, and monitoring. Maryland Department of the Environment (MDE) indicates:

The Majority of Section 319(h) Grant funding in Maryland is intended for implementation of projects that will (1) reduce or eliminate water quality impairments in the Maryland’s List of Impaired Water (303(d) List), particularly in watersheds where Total Maximum Daily Loads (TMDLs) have been approved; and (2) result in quantifiable or measurable improvements in water quality and habitat, including, pollutant load reductions for impairments addressed in TMDLs or identified in the 303(d) List.

Applications for Section 319(h) funds are submitted to the Chesapeake and Atlantic Coastal Bays Trust Fund through its annual Request for Proposals (RFP). Response to open RFPs allows a project to be eligible for a number of different funding sources including the Section 319(h) Grants. In instances where a project does not match with open RFPs, applicants are invited to submit a Letter of Intent (LOI). According to the
Chesapeake and Coastal Program, “while funding is not guaranteed, your LOI will help CCP staff try to match you with an appropriate funding source or recommend other sources that may be available.”

Funding of the Westport nonpoint source pollution reduction project through the Nonpoint Source Management Program is a viable source of funding, but should be approached with caution for a number of reasons.

First, Section 319(h) grants are not a guaranteed funding source; numerous projects may submit applications, but not all applications may be selected for funding. Furthermore, changes in budget allocations (cuts, appropriation changes, etc) may alter funding which has the potential to increase financial burdens (due to necessity in seeking additional financial assistance) and may altogether slow or halt project implementation.

Second, annual funding for Section 319(h) grants must be obligated by the state within that fiscal year; otherwise the state may loose that funding. Section 319 Nonpoint Source Management Programs, Subsection h Grants Program, Part 6 Availability for Obligation, of the Clean Water Act states, “the funds granted to each State…in a fiscal year shall remain available for obligation by such State for the fiscal year for which it was appropriated. The amount of any such funds not obligated by the end of such fiscal year shall be available to the Administrator for granting to other States…in the next fiscal year.” This has the potential to limit funding for projects, as those that receive funding may be limited to installations that are “shovel ready”. Further, installations that have had funding obligated but have not commenced by the end of the fiscal year may altogether loose their funding.

Third, funding provided by Section 319(h) grants are prohibited from covering more than 60 percent of a state’s management program. Section 319 Nonpoint Source Management Programs, Subsection h Grants Program, Part 3 Federal Share, of the Clean Water Act states, “the Federal share of the cost of each management program…in any fiscal year shall not exceed 60 percent of the cost incurred by the State in implementing such management program and shall be made on condition that the non-Federal share is provided from non-Federal sources.” For project funding this poses a potential financial strain in that additional non-federal funding (no less than 40 percent) will have to be acquired in order for the project to move forward. The projected construction cost is $8.7 million (see Project Cost). Over the past 20 years MDE has been allocated an annual average of $2.1 million in Section 319(h) Grants ($2.6 million in 2009). Clearly this yearly allocation cannot cover the project cost, and will not likely be used in its entirety to cover a single project. If only a portion of Section 319(h) grants may be used to cover project construction cost, this leaves an exceptionally large portion of the project construction cost that will have to be covered from other sources (taxes, donations, other grants, etc). Funding from Section 319(h) grants should, instead, be used to cover annual maintenance costs ($54,000, see Project Cost) as that cost is significantly lower and is more likely to be covered, if not in its entirety, then by a percentage where the remaining costs to be covered are less of a financial burden and likely far more feasible to achieve.

These points of caution aside, the Nonpoint Source Management Program is a viable financial resource, but it should not be relied upon for full guaranteed project funding. For the Westport nonpoint source pollution reduction project Section 319(h) grants should always be treated as supplementary funding and should never be relied upon as a full source of funding. Further it is recommended that application for Section 319(h) grants should be limited to the funding of annual maintenance projects as these costs are lower, are more likely to be covered, and will require a smaller public contribution.
Considering the immense overall cost of the Westport nonpoint source pollution reduction project, this project requires that financing options be limited to those that provide funding without passing on the cost to the City of Baltimore and community residents. The Clean Water State Revolving Fund provides full project funding with flexible loan repayment terms thereby decreasing the potential financial burden of the city and Westport residents.

Established under Title VI of the Clean Water Act, The Clean Water State Revolving Fund (CWSRF) is a loan program used to fund water quality projects covering nonpoint source pollution, watershed protection and restoration, municipal wastewater treatment projects and estuary management projects.\textsuperscript{110} The CWSRF offers low to no interest rates, flexible terms and partnerships with other funding sources.

Funds to capitalize state CWSRF programs are provided through grants from the federal government, covering approximately 80 percent of the cost, and state matching funds equal to 20 percent of the federal grants. The U.S. Environmental Protection Agency (EPA) reported in 2010 that since the program’s inception in 1987, total funds available to the program exceed $77 billion; the state of Maryland alone received $49.3 million dollars in 2010 for its CWSRF.\textsuperscript{111} According to the EPA:

\begin{quote}
CWSRF programs operate much like environmental infrastructure banks that are capitalized with federal and state contributions. CWSRF monies are loaned to communities and loan repayments are recycled back into the program to fund additional water quality protection projects. The revolving nature of these programs provides for an ongoing funding source that will last far into the future.\textsuperscript{112}
\end{quote}

The CWSRF also provides greater flexibility to the states than other federal funding sources. States may use funds from the CWSRF for a number of different options including loans, purchases, debt guarantees, bond insurances, and refinancing programs. Funding is usually available for 100 percent of the project cost, and the individual states set the terms covering interest (0 percent to an average of 2.3 percent) and repayment (up to 20 years).\textsuperscript{113} Additional flexibility in terms is also considered for smaller communities or communities experiencing financial hardship. According to the EPA, states also “have the ability to target resources to their particular environmental needs, including contaminated runoff from urban and agricultural areas, wetlands restoration, groundwater protection, brownfield remediation, estuary management, and wastewater treatment.”\textsuperscript{114}

In Maryland, the CWSRF is managed by Maryland Department of the Environment’s Water Quality Financing Administration (WQFA). The stated mission of the WQFA is to “provide financial assistance in the form of low interest rate loans and/or grant funding for clean water and drinking water capital projects across the State. Eligible types of projects include water quality point source projects, drinking water projects, nonpoint source pollution projects, and septic system upgrade projects.”\textsuperscript{115} The WQFA administers a number of different grant and loan programs including the Water Quality Revolving Loan Fund (WQRLF). The WQRLF provides low-interest loans to local governments to finance nonpoint source projects, wastewater treatment plant upgrades, and other water quality improvement projects.

Current WQRLF loan terms establish interest rates at a standard of 2.3 percent, however, if the service area is classified as a disadvantaged community the rate falls to 1.1 percent. The loan is repaid over a period no longer
than 20 years. An administrative fee is also attached to the loan for the purpose of covering program expenses. The administrative fee is 5 percent of the aggregate debt divided by the number of fee payments paid annually over the life of the loan; this amounts to an increase in the interest rate by 0.47 percent.\textsuperscript{116}

Applicants for WQRLF funds must provide information regarding project specifics beyond the requirements of a traditional loan application. Additional information required in the loan package includes explanations of:

1. Why the project is needed and the problem being corrected
2. Alternative solutions explored and selected
3. Rationale regarding project selection as best alternative for problem resolution
4. Assurances for long term maintenance

The loan package must also include data and calculations covering project cost, nutrient load reductions, and costs per pound reduction.\textsuperscript{117}

For the Westport nonpoint source pollution reduction project, the use of WQRLF funds provides the option of full project funding at low to no interest rates paid over an extended period of time. While this is a simple and ideal solution (single funding source, low interest, negotiable terms, etc) details regarding repayment of loan funds should be decided before acceptance and disbursement of funds to the City of Baltimore. Loan repayment plans should look beyond traditional revenue sources (taxes, fees, etc) and should involve innovative mechanisms to generate the necessary funds.
In speculating on the Maryland General Assembly’s 2011 session, the *Baltimore Sun* indicates environmental advocates intent to revive a bill that would require Maryland counties and municipalities to raise funds for management of local stormwater. In light of today’s economic woes and significant gaps in state and municipal operating budgets, innovative financing options that do not place additional financial stress on municipalities or residents must be explored.

Stormwater utility fees are user fees attached to utility bills, and are used to pay for a city’s stormwater management program. Traditionally, cities pay for stormwater management activities from a number of different resources including taxes, state and federal loans and grants, and municipal general funds. However, these resources are often strained and are increasingly unable to cover the full costs of all stormwater management activities.

For Baltimore to adopt a stormwater utility fee, the Baltimore City Council and the Mayor would have to create, vote on, and approve a monthly or annual stormwater utility charge to be attached to each property’s utility bill. Unlike a property tax, the burden of funding stormwater management activities will fall on all property owners who receive city stormwater services, not just residential homeowners. Assessing a fee to all property owners, as opposed to just residential homeowners equitably spreads the cost of stormwater management activities across all entities that contribute to the problem of increased stormwater runoff. This ensures that all contributors pay for the activities and lowers the potential assessed payments as all contributors are paying for stormwater management activities. The City of Rockville, MD initiated its stormwater utility fee in July of 2009. Financial analysis indicated that payment of a utility fee could save homeowners nearly half the cost of paying taxes to fund stormwater management activities. According to the City of Rockville:

If property taxes were used, the greater burden of funding SWM (storm water management) falls on residential homeowners. The utility fee shifts the burden to property owners who contribute the most runoff…By using the SWM utility fee that is based on a property’s impervious area, residential properties pay only about one-third of the dollars needed…As of November, 2008, the SWM fee is estimated to cost $61.85 the first year for a single family lot…If the costs of the SWM program were funded using the general fund instead of the utility fee, a $507,000 home would pay extra property taxes of about $122 in the first year…

To ensure that revenue generated from the stormwater utility fee is not applied to other city projects, the legislation enacting the fee must include a provision that all revenue be deposited into an enterprise fund that will only be used to pay for the stormwater management program. Money generated from Baltimore’s stormwater utility fee will be used to finance construction projects, maintenance and inspections, public information and education, and increasing development of stormwater regulations and design standards. Revenue generated from this fee could also potentially be used to fulfill other financial obligations tied to stormwater management. The City of Bend, OR uses its stormwater management fee to pay for practices similar to those outlined above. It also uses revenue generated from the fee to pay for stormwater services including loan repayment, water quality management, capital improvement projects, operation and maintenance, and engineering management.
For the Baltimore stormwater utility fee, the fee structure should be established similarly to the City of Lewiston, ME. Lewiston establishes a flat rate up to a certain amount of impervious area. If the property has a greater impervious area, then the bill increases by a set amount per square foot. According to the City of Lewiston:

If your property is a single family home or a residential duplex building, you do not need to calculate your stormwater utility fee as there have been flat rates established for both of these types of uses (Single Family Home $44.00/year, Duplex Residential Building $66.00/year). Other properties, depends on the amount of impervious surface on the property.\(^{123}\)

Lewiston requires properties with less than 2,900 square feet of impervious area (including buildings, patios, porches, driveways, roads, parking areas, sidewalks and walkways) to pay the flat fee. Any property with more than 2,900 square feet of impervious area must pay an additional $0.0484 per square foot.\(^{124}\)

Reductions in fees should be allocated to owners who install management practices on their properties to effectively manage stormwater on site. This should be done on a sliding scale depending upon the treatment practice installed. Management practices that treat only volume or quality would receive a reduction in fees and management practices that treat both would receive an even greater reduction. The City of Bend has a similar credit system for its stormwater management fee. According to the City of Bend:

In summary, maximum allowable credits for stormwater quantity and quality are (1) water quantity only – up to 36% if the service charge; (2) water quality only – up to 23% of the service charge; (3) water quantity plus water quality – up to 59% of the service charge. Credits are only available when on-site stormwater systems go beyond the basic requirements described in the Central Oregon Stormwater Manual.\(^{125}\)

If Baltimore chooses to follow this model, projects treating only water quality should be given a larger credit than those treating only volume. This stems from the Chesapeake Bay’s water quality impairment issues. Projects that treat both quality and volume simultaneously should be given the largest credit of all.

Exemptions should be limited. All properties contribute to stormwater runoff and therefore should contribute to the cost of management activities. This should include properties that are normally exempt, such as churches, schools, and other municipal properties. The City of Bend assesses a stormwater management fee on all property owners, including churches, schools, and public facilities. According to the City of Bend, “All developed property within the City will pay the stormwater service fee. That includes houses, schools, public facilities, and businesses…churches and schools contribute a significant amount of runoff to the City because of their size and amount of hard surface. They will be treated like all other customers under the rate structure,”\(^{126}\)

The City of Bend does provide an exemption for city streets, as many are already designed to manage stormwater runoff. For Baltimore, this exemption is inappropriate as city streets account for a significant portion of impervious area, and very few (if any) are designed to effectively deal with stormwater runoff on site. In this instance, Baltimore should approach the exemption of certain entities like the City of Rockville. Rockville does not allow for any exemptions to the stormwater utility fee; churches, schools, and governments are all considered in the same manner as all other customers under its utility fee structure.\(^{127}\)
In light of current economic conditions, financing options for the Westport nonpoint source reduction project must look beyond traditional revenue sources (taxes, fees, etc). Innovative mechanisms that do not place additional financial strain on the City of Baltimore and Westport residents must be used to generate project funding.

Adopted by the Portland Oregon City Council in 2007 to pay for green street facilities, the One Percent for Green Fund collects one percent of the construction budget of any development, redevelopment, or enhancement project that requires a street opening permit or occurs within the city's right-of-way.128

Like the stormwater utility charge, Baltimore’s One Percent for Green Fund would have to be created, voted upon, and approved by the city council and the mayor. However, unlike the stormwater utility charge, the one percent for green charge would only be assessed to construction, development, and redevelopment activities taking place within the city limits. Collecting funds to finance stormwater management activities in this manner reduces financial strain on residents and the municipality itself, as the developers and construction firms would be the responsible paying party.

Just as funds for the stormwater utility fee are directed into an enterprise fund, so would funds generated from the one percent for green charge. Because fewer payees are contributing to the One Percent for Green charge, and the revenue collected is therefore likely to be less, the funds generated should be targeted towards specific stormwater management projects. Portland targets its One Percent for Green Fund in this manner. According to the City of Portland:

> The Portland City Council created the One Percent for Green fund in April 2007 to support construction of green street facilities that manage stormwater runoff from public rights-of-way…Eligible projects include green street swales, curb extensions, planters, vegetated infiltration basins, porous paving or other types of stormwater management facilities defined by Portland’s Sustainable Stormwater Management Program. Funds may not be used on projects to meet Stormwater Management Manual requirements, but they may be used to go beyond the requirements.129

Baltimore’s One Percent for Green Fund should similarly target specific projects. As city streets account for a significant portion of impervious area, and very few (if any) are designed to effectively manage stormwater runoff on site, revenue from Baltimore’s One Percent for Green Fund should be allocated specifically for activities that create stormwater management facilities on Baltimore’s streets. To prevent users from simply using the fund to meet stormwater management requirements, a stipulation similar to that of Portland’s will require that funds are used for projects that go above and beyond stormwater management requirements.

Due to the fact that revenue collected from the One Percent for Green Fund are likely to be limited, funds should be allocated to applicants whose projects demonstrate a number of different qualities. Qualities to be considered should include those that (1) target and effectively reduce a specific watersheds pollution load, (2) provide multiple benefits including environmental and community benefits, and (3) employs innovative design solutions.
Portland’s One Percent for Green Fund selects projects based on their ability to meet not only the qualities listed above but other criteria as well. Portland also advises applicants that project selection is greatly increased if multiple criteria are met. According to the City of Portland:

Successful projects will achieve a significant number of criteria listed below… (1) projects that address an identified watershed or infrastructure system need; (2) projects with multiple environmental benefits; (3) projects with multiple community benefits; (4) projects with multiple partners, matching dollars, and other resources; (5) innovative projects that test new designs and technology; and (6) projects with high visibility or educational value.

For the Westport nonpoint source pollution reduction project, revenue from Baltimore’s One Percent for Green Fund should be used to finance the projects construction. However, this should not be relied upon as a full funding source for the project. The number of selected projects and the fluctuating nature of the fund (dependent upon the number of construction projects and the value of each project) creates variability in available funds and therefore should always be treated as a source of supplementary funding and never a source for full funding.
This project illustrates that not only are broad applications of environmental site design (ESD) practices effective in reducing pollution loading, but they can be financed in a manner that does not put additional pressure on strained resources. This project also brings to light several issues that need to be addressed if municipalities intend to use ESD as the primary method for managing stormwater runoff and pollution loading.

A distinction must be made that restoring a site’s predevelopment groundwater recharge and runoff characteristics does not necessarily mean that pollution loading has been effectively managed.

The Maryland Stormwater Management Act of 2007 requires that ESD, through the use of nonstructural best management practices and other innovative site design techniques, be implemented to the maximum extent practicable. In May 2009, the Maryland State Legislature updated the Code of Regulations for stormwater management with the intent to “maintain after development, as nearly as possible, the predevelopment runoff characteristics, and to reduce stream channel erosion, pollution, siltation and sedimentation, and local flooding by implementing environmental site design to the maximum extent practicable.” The code requires that in fulfilling the goals and objectives of the Stormwater Management Act that all new development and redevelopment projects must be designed using sizing, recharge volume, water quality volume, and channel protection storage volume criteria set forth in the state’s Stormwater Design Manual (manual).

The manual uses the United States Department of Agriculture’s Natural Resources Conservation Services runoff curve number (RCN) hydrology method to guide the sizing of ESD practices. The RCN coefficient (a coefficient that reduces total precipitation to runoff potential) is used to determine target rainfall which is in turn used to calculate volume capture targets for the sizing of ESD practices. According to the supplemental document to the manual, Environmental Site Design Process and Computations, “when soil type and proposed site imperviousness is known, Table 5.3 (Rainfall Targets/Runoff Curve Number Reductions used for ESD) is used to determine the amount of rainfall required to be captured and treated in ESD practices to mimic wooded conditions.” In calculating the size and assessing the performance of selected ESD practices, if the runoff volume capture target is provided for in all practices then ESD has been implemented to the maximum extent practicable.

Designing ESD practices in this manner assumes that if a practice is effectively designed for the volume capture target, then the maximum extent practicable standards is satisfied without the need for structural or alternative stormwater management practices. In regards to the minimization of nonpoint source pollution loading, this assumption is false. The Westport nonpoint source pollution reduction project has demonstrated that implementation of ESD practices, sized to the manual’s specifications, are exceptionally effective for capturing rainfall but not equally effective for reducing nonpoint source pollution loading. The chart below illustrates the effectiveness of the ESD practices in comparison to the loads they are expected to take. Note the project collects 186.17 percent of the rainfall volume load, but only collects 16.11 percent, 12.14 percent, and 18.42 percent of the nitrogen, phosphorus, and sediment loads, respectively.
A review of the current approach to designing ESD practices needs to be conducted. If the intent is merely to restore a site's predevelopment groundwater recharge and runoff characteristics, then the design guidance, as it stands, is more than sufficient. However, the State of Maryland and City of Baltimore require that the reduction of pollution, siltation, and sedimentation also be taken into account. In this respect, the current design guidance is insufficient. A greater understanding is needed regarding how nutrients are removed through natural processes, if that process can be enhanced, and how that informs and is implemented into the design of ESD practices.

As the goal is not only to restore a site's predevelopment groundwater recharge and runoff characteristics, but also to reduce pollution loading, ESD practices must continue to be improved upon to increase pollution reduction efficiency.

This project used the Environmental Protection Agency's (EPA) Spreadsheet Tool for the Estimation of Pollutant Load (STEPPL) to estimate the nutrient load reduction of each ESD installation. STEPPL calculates nutrient and sediment loads from different land uses and the associated load reductions that would result from the installation of various best management practices (BMPs). Pollution and sediment loads are calculated based on known runoff volumes, pollutant concentrations, the USLE and sediment delivery ratios. The pollution load reductions resulting from the implementation of various BMPs are calculated from the known efficiencies of the selected practices. The chart below lists pollution reduction efficiencies for some of the more popular urban best management practices available in STEPPL.

<table>
<thead>
<tr>
<th>STREET</th>
<th>PRACTICE</th>
<th>TARGET ESD</th>
<th>ACTUAL ESD</th>
<th>NUTRIENT LOAD (LBS/YS)</th>
<th>NUTRIENT REDUCTION (LBS/YS)</th>
<th>NITROGEN PHOSPHORUS SEDIMENT</th>
<th>NITROGEN PHOSPHORUS SEDIMENT</th>
<th>NITROGEN PHOSPHORUS SEDIMENT</th>
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<tbody>
<tr>
<td>Watermeir Ave</td>
<td>BD</td>
<td>20,246.01</td>
<td>20,418.92</td>
<td>21.44%</td>
<td>22.88</td>
<td>0.03</td>
<td>0.05</td>
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<tr>
<td>Holme-Fry Pl</td>
<td>ES</td>
<td>15,020.41</td>
<td>15,354.31</td>
<td>21.54%</td>
<td>23.75</td>
<td>0.33</td>
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<td>Novak St</td>
<td>ES, MI</td>
<td>5,687.26</td>
<td>15,504.27</td>
<td>70.48%</td>
<td>74.75</td>
<td>5.12</td>
<td>6.07</td>
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<td>Miller St</td>
<td>MI</td>
<td>7,739.72</td>
<td>12,963.72</td>
<td>41.42%</td>
<td>45.42</td>
<td>3.69</td>
<td>4.52</td>
<td>4.52</td>
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<tr>
<td>corning Ave N</td>
<td>MI</td>
<td>7,754.50</td>
<td>7,610.00</td>
<td>13.90%</td>
<td>11.13</td>
<td>0.60</td>
<td>0.80</td>
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<tr>
<td>Helmst St</td>
<td>BS</td>
<td>6,652.91</td>
<td>25,561.04</td>
<td>73.81%</td>
<td>79.51</td>
<td>1.16</td>
<td>1.36</td>
<td>1.36</td>
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<tr>
<td>Norwalk St</td>
<td>ES, BS</td>
<td>7,296.02</td>
<td>12,853.55</td>
<td>77.37%</td>
<td>82.76</td>
<td>4.15</td>
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<td>Kenne St</td>
<td>MI</td>
<td>8,468.91</td>
<td>8,980.46</td>
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<td>60.74</td>
<td>8.00</td>
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<tr>
<td>Marian St</td>
<td>MI, BS</td>
<td>5,732.72</td>
<td>7,573.10</td>
<td>25.48%</td>
<td>28.75</td>
<td>5.48</td>
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<tr>
<td>Eddy St</td>
<td>MI</td>
<td>4,814.04</td>
<td>16,865.52</td>
<td>25.54%</td>
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<td>Carle St</td>
<td>MI</td>
<td>4,679.92</td>
<td>15,286.71</td>
<td>62.26%</td>
<td>66.18</td>
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<td>Amore Cr (W)</td>
<td>PP</td>
<td>4,581.57</td>
<td>4,302.91</td>
<td>95.82%</td>
<td>95.46</td>
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<td>5,485.30</td>
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<td>Maumela St</td>
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<td>6,962.51</td>
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<td>Anoka Cr (W)</td>
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<td>5,126.50</td>
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<td>57.56</td>
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<td>Kenne St N</td>
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<td>2,569.46</td>
<td>5,802.71</td>
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<td>74.13</td>
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<td>Aspina St</td>
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<td>2,742.55</td>
<td>11.42%</td>
<td>11.42</td>
<td>0.71</td>
<td>0.80</td>
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<tr>
<td>pumber St</td>
<td>MI</td>
<td>2,269.00</td>
<td>2,415.90</td>
<td>15.96%</td>
<td>16.49</td>
<td>1.24</td>
<td>1.34</td>
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<td>Salmon Pl</td>
<td>PP</td>
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<td>2,958.01</td>
<td>58.30%</td>
<td>64.55</td>
<td>1.16</td>
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<tr>
<td>Ameri Cr (W)</td>
<td>PP</td>
<td>2,006.01</td>
<td>1,694.01</td>
<td>35.30%</td>
<td>35.61</td>
<td>1.16</td>
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<td>Dunkirk Cr</td>
<td>MI</td>
<td>5,240.32</td>
<td>1,748.73</td>
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<td>70.75</td>
<td>1.54</td>
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<tr>
<td>Doran Cr (W)</td>
<td>PP</td>
<td>1,635.50</td>
<td>1,578.42</td>
<td>53.00%</td>
<td>56.30</td>
<td>0.89</td>
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<td>Illinois Ave</td>
<td>MI</td>
<td>1,215.06</td>
<td>1,507.67</td>
<td>28.91%</td>
<td>30.56</td>
<td>1.93</td>
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<td>2.19</td>
</tr>
<tr>
<td>wicott Cr (W)</td>
<td>PP</td>
<td>1,169.61</td>
<td>844.25</td>
<td>25.00%</td>
<td>26.92</td>
<td>1.41</td>
<td>1.56</td>
<td>1.56</td>
</tr>
<tr>
<td>Galena Ave S</td>
<td>MI</td>
<td>590.00</td>
<td>852.77</td>
<td>50.65%</td>
<td>52.50</td>
<td>0.77</td>
<td>0.85</td>
<td>0.85</td>
</tr>
<tr>
<td>Eagan St</td>
<td>MI</td>
<td>187.00</td>
<td>5,247.01</td>
<td>44.50%</td>
<td>47.71</td>
<td>0.59</td>
<td>0.68</td>
<td>0.68</td>
</tr>
<tr>
<td>Bennett Cr (W)</td>
<td>PP</td>
<td>700.75</td>
<td>700.25</td>
<td>50.00%</td>
<td>50.00</td>
<td>0.75</td>
<td>0.85</td>
<td>0.85</td>
</tr>
</tbody>
</table>

TOTAL 134,654.21 290,696.48 186.17% 161.82 30.07 6,408.82 22.82 3.5% 1,399.82 16.18% 12.34% 18.42%

<table>
<thead>
<tr>
<th>STREET</th>
<th>NITROGEN</th>
<th>PHOSPHORUS</th>
<th>SEDIMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetated Swale</td>
<td>7.5%</td>
<td>17.5%</td>
<td>47.5%</td>
</tr>
<tr>
<td>Vegetated Filter Strip</td>
<td>40%</td>
<td>45.3%</td>
<td>73%</td>
</tr>
<tr>
<td>Bioretention Facility</td>
<td>63%</td>
<td>80%</td>
<td>0%</td>
</tr>
<tr>
<td>Porous Pavement</td>
<td>85%</td>
<td>65%</td>
<td>90%</td>
</tr>
<tr>
<td>Concrete Grid Pavement</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
</tr>
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</table>
It is interesting to note that some of the available practices have remarkably low pollution reduction efficiencies. What is of greater concern, however, is that these listed reduction efficiencies are “ideal” efficiencies, meaning that the efficiency is fully realized at 100 percent drainage area coverage. Full coverage of the entire drainage area is rare in many instances, which means that performance efficiency is rarely fully realized. The Westport nonpoint source pollution reduction project demonstrates that these efficiencies are directly related to the proportion of practice size to drainage area, and that has a dramatic effect on performance efficiency. The chart below outlines known, actual, and performance efficiencies of the ESD installations.

While some practices have remarkably low efficiencies, others have exceptionally high ones. Porous pavement and concrete grid pavement systems have excellent efficiencies, however, their biggest drawback lies in their load carrying ability. The manuals guidance stated that they have a maximum load bearing capacity lower than conventional paving systems and should therefore be limited to lower weight travel areas such as side walks, driveways, access roads, and small parking lots.  

It is therefore recommended that for ESD installations to be truly effective for both rainfall volume capture and nutrient load reduction, the following actions be taken.

1. More research and financial resources need to be expended on enhancing the strength of permeable paving systems in order to enable them to handle a greater load carrying capacity. Permeable paving systems already have established high pollution reduction efficiencies. As urban areas continue to grow, it would be easy to substitute permeable pavers into repair and replace schedules. But the permeable pavers must have an increased load carrying capacity to fully cover impervious areas, effectively carry road loads, and still provide exceptional pollution load reduction.

2. In the immediate future, ESD installations should be “chained” to ensure maximum volume capture and nutrient reduction. ESD installations must be linked so that if one installation cannot handle all the volume and pollution load, an adjacent installation can capture the excess. The Westport

<table>
<thead>
<tr>
<th>STREET</th>
<th>DRAINAGE AREA ACRES</th>
<th>PRACTICE</th>
<th>PRACTICE SIZE ACRES</th>
<th>PRACTICE BZ. V. DRAINAGE</th>
<th>KNOWN EFFICIENCIES</th>
<th>ACTUAL EFFICIENCY</th>
<th>PERFORMANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wetland Detention</td>
<td>55%</td>
<td>68.5%</td>
<td>86%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infiltration Basins</td>
<td>60%</td>
<td>65%</td>
<td>75%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
nonpoint source pollution reduction project does this for permeable pavement installations. Since the permeable pavers only capture 95 percent of the volume target, the remaining 5 percent is passed on to adjacent bio-swales. ESD installations with low load impervious areas (parking, sidewalks, etc) should be replaced with permeable pavers, street widths should be reduced to accommodate road center bio-swales or micro-bioretention cells, and where applicable, road sides should be replaced with micro-bioretention cells or vegetated filter strips. Approaching ESD installations in this manner will provide for the greatest efficiency in volume capture and pollution load reduction.

3. Municipalities must assess the efficiency of installed ESD practices in order to determine recommendations for future installations. Knowing that certain practices have significantly lower pollution reduction efficiencies, municipalities must assess whether or not their installations have similar efficiencies, and in turn determine if they can be improved upon, supplemented or chained, or if they should be eliminated as an installation option. Municipalities (such as Portland, OR, and Seattle, WA) currently installing low efficiency micro-bioretention cells or vegetated swales with minimum nutrient reductions, at significant cost to the city and the tax payers, must revisit their policies regarding ESD practices. Practices yielding higher nutrient reduction should be implemented instead or the existing installations should be improved upon.

Assessing project cost in relation to benefits gained must include quantifiable elements beyond the immediate pollution reduction gain. Traditionally, project feasibility is determined based on capital investment versus immediate return, or in this case nutrient load reductions. Assessing an ESD installation’s feasibility in this manner does not give a clear picture of the immediate and long term benefits, making it impossible to properly assess the project’s viability. The Westport nonpoint source pollution reduction project assessed project feasibility not only in terms of cost per pound, but also in terms of value gains to life, health, and nature. Assessing feasibility in this manner showed a number of additional financial benefits to ESD installations including:

- Reduced heat island effect and energy consumption
- Increased property value
- Decreased street maintenance costs
- Increased groundwater recharge
- Reduced flood insurance costs
- Reduced water treatment costs
- Increase in public health
- Increase in habitat

Long-term gains also must be assessed to provide a full picture of a project’s ultimate feasibility. Today, these gains are still somewhat subjective and municipalities and researchers will have to spend a considerable amount of energy investigating the connection between the ESD installation and the long-term realized benefit. Municipalities should partner with research groups and colleges and universities to investigate the realized long-term benefits of ESD installations. Long-term benefits linked to ESD installations may include enhanced carbon sequestration, reduced air pollutants, and increased sound absorption. Long-term socio-economic benefits linked to ESD installations also need to be assessed. These benefits may include improved attention span, increased educational attainment, increased health due to recreational opportunities, and a decrease in violent incidents.137

The Westport nonpoint source pollution reduction project illustrates that ESD practices can be effective for rainwater volume capture and pollution load reduction. More importantly, it illustrates that as ESD practices
continue to move forward, key improvements in policy, installation effectiveness, and cost assessment must be made in order for this groundbreaking approach to be truly effective, broadly applied, and publicly embraced.
Citations


6. Baltimore City Code Article 7, Division II, Section 21-1-b-1 {2010}

7. Baltimore City Code Article 7, Division II, Section 21-4 {2010}

8. Baltimore City Code Article 7, Division II, Section 21-6 {2010}

9. Baltimore City Code Article 7, Division II, Section 22-3-b-2 {2010}

10. Baltimore City Code Article 7, Division II, Section 23-1 {2010}

11. Baltimore City Code Article 7, Division II, Section 23-2 {2010}

12. Baltimore City Code Article 7, Division II, Section 23-7-b {2010}

13. Baltimore City Code Article 7, Division II, Section 23-7-c {2010}

14. Baltimore City Code Article 7, Division II, Section 23-7-e-4 {2010}


51 Baltimore City Code Article 7, Division II, Section 23-7-c {2010}

52 Baltimore City Code Article 7, Division II, Section 23-7-c {2010}


Baltimore City Charter Article II, Section 62-a-1

Baltimore City Charter Article II, Section 62-c-1thru10


132 Code of Maryland Regulations. 26.17.02.01.A&B {2009}


