Maryland State Highway Administration
Stormwater Management Site Development Criteria

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MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

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Section 1 - Introduction

1. *Introduction*

The Maryland State Highway Administration (SHA) promotes environmental stewardship and sustainability in many of its efforts. Managing stormwater is a critical component of environmental sustainability to maintain and improve the quality of our watersheds and the Chesapeake Bay. Stormwater Management (SWM) Best Management Practices (BMPs) address both water quantity and quality treatments. The term BMP infers that the facility is designed and constructed in the best possible manner. Making a facility its “best” requires a balanced and organized process from planning through design and construction. These criteria will help to guide engineers and designers to develop the best possible SWM facilities.

1.1 SHA Stormwater Management Design Policy

The Maryland Department of the Environment (MDE) regulates stormwater management practices as outlined in the *2000 Maryland Stormwater Design Manual.* SHA has developed a policy for the engineering of SWM facilities that must adhere to the latest MDE Stormwater Design Manual, Maryland Stormwater Management Guidelines for State and Federal projects, the SHA Stormwater Management Site Development Criteria and all other applicable criteria, details, specifications, and permits.

Project coordination is extremely important because stormwater management is integral in all project aspects. The water resources team must integrate the stormwater management concepts into the overall project design and must justify all design solutions and analyses on every project.

Environmental Site Design - The current MDE Stormwater Design Manual includes a requirement for using an Environmental Site Design (ESD) approach. ESD focuses on mimicking pre-development drainage patterns and treating run-off close to its source. This approach maximizes opportunities for infiltration and evapo-transpiration throughout a site and minimizes the use of impervious surfaces and structural conveyances, such as underground pipes or paved swales. This approach is best accomplished with smaller, non-structural BMPs treating smaller drainage areas located throughout a site. This approach can also help to reduce run-off velocity and reduce impacts to site features and natural resources. It is important to consider ESD in the earliest planning stages of a project to effectively and efficiently incorporate these BMPs into the landscape.

1.2 SHA Stormwater Management Site Development Criteria

Context sensitive solutions are efforts incorporated in the planning, design and construction process that tailors an individual project to address specific needs related to its surroundings. Because each project has a unique situation, a one-size-fits-all approach is not applicable. The site development process includes analysis of unique features and conditions on a project-by-project basis and develops individualized solutions specifically for the given situation. Utilizing context-sensitive solutions serves as measures of stewardship and improves environmental sustainability and aesthetics.

Stormwater Management Site Development Criteria

SHA has developed criteria to address context-sensitive measures for stormwater management facilities. The criteria provided in this document is meant to challenge stormwater design professionals to consider situational factors beyond the standards set forth in the *2000 Maryland Stormwater Design Manual*. This document has been developed to assist stormwater designers to incorporate safety, sustainability, visual, and environmental quality features into stormwater management (SWM) facilities. It is important that SWM facilities fit within the surrounding environmental and community context. It is also important to protect the public from safety hazards associated with the functioning of these facilities and to ensure that these facilities can be properly maintained into the future. The SWM site development criteria have been developed to ensure these concerns are addressed. However, the manner in which an individual project is designed and built should be done with an approach that addresses the project's unique circumstances.

This site development criteria (SDC) includes:

- Safety – includes safety for field inspectors, maintenance personnel, motorists, and the public.
- Sustainability – means that the facility is able to be maintained and is built in a manner to get the longest achievable service life.
- Visual quality – addresses the appearance of the facility and includes grading and landform design, detailing at site structures such as stormwater outfall structures, fencing, riprap, and planting design.
- Environmental quality – looks at the benefits or impacts the facility may have on water quality, critter habitat, thermal reduction, or other environmental conditions.

Section 2 – Stormwater Management Considerations

2. Stormwater Management Considerations

Each SWM facility needs to be designed with unique project requirements and conditions in mind. Facilities should be designed to be effective at treating stormwater and also be safe, easily maintainable, cost-effective, and aesthetically pleasing. In order to determine the appropriate type of facility, location, and design features, the designer must have a full understanding of all factors and considerations that may affect the facility. It is important to understand these considerations at the beginning of the planning process to ensure that stormwater is treated effectively and efficiently. There are a number of factors to consider including the following:

- Clean Water Act
- Appropriateness of BMP Type
- Volume Considerations
- Soil Considerations
- Additional Regulatory Compliance
- Water Quality Bank Balance and Maximizing Treated Impervious Surfaces
- Post-Construction Certifications

2.1 Clean Water Act

A National Pollutant Discharge Elimination System (NPDES) General Permit for Construction Activity is required for projects that disturb one acre or more. The purpose of the permit is to control pollution generated from an active construction site typically in the form of soil erosion, fuel spills, and construction waste. SHA is required to submit Erosion and Sediment Control and Stormwater Management plans along with a Stormwater Pollution Prevention Plan (SWPPP) for approval.

SHA is responsible for maintaining an NPDES Municipal Separate Storm Sewer System (MS4) Permit covering the runoff discharge from all SHA SWM facilities. The permit conditions require SHA to implement and manage programs to control stormwater runoff to the maximum extent practical, inspect the inventory of SWM facilities, and maintain them in a functional state. There is also an annual reporting component of the permit to document how these requirements are being met.

2.2 Appropriateness of BMP Type

The following considerations can affect the type of facility proposed:

Facility Type and Location – Consider watershed, terrain, treatment suitability, physical feasibility, community, environment, and permits. Facilities should be appropriate for their site and should also incorporate the lowest life-cycle costs to the extent practical, which include costs associated with construction, right of way and lifetime maintenance. Additional considerations may include habitat potential, green infrastructure creation or connectivity, and the potential to address TMDL targets.

Refer to *Section 10* herein and the following chapters of the *2000 Maryland Stormwater Design Manual* for more information related to BMP selection

- Chapter 2: Unified Stormwater Sizing Criteria
- Chapter 3: Performance Criteria for Urban BMP Design
- Chapter 4: Guide to BMP Selection and Location in the State of Maryland
- Chapter 5: Environmental Site Design
- Appendix A: Landscaping Guidance for Stormwater BMPs
- Appendix. D.3: Short Cut Method for a Wetland Drawdown Assessment

Facility Retrofits – A project site may include an existing facility or retrofit of an under-performing existing facility may be used to address stormwater management. Consider the age and condition of these facilities and address any deficiencies. Whenever an existing facility is being retrofit, it should be upgraded to meet all current standards. Consider an ESD approach when directing run-off into existing facilities.

Design Exceptions – When any design criteria cannot be met or otherwise merits a design variance or exemption, a written design exception approval must be obtained from the SHA Highway Hydraulics Division Chief. Written justification and all supporting documents must be provided with a design exception request.

Joint Use Facilities – Joint-use SWM facilities are strongly discouraged. Do not consider developing a joint-use SWM facility unless there is a clear and apparent benefit to SHA. A written approval from the SHA Highway Hydraulics Division Chief is required before a joint-use facility may be used.

Surrounding Context – Each project site is unique with its own set of contributing factors. Visual quality can be paramount in certain contexts to ensure that the facility blends with the surroundings and to ensure that SHA remains a good neighbor within the communities we serve. SWM facilities can also have a negative impact on structural foundations and should be placed so that there is no potential to undermine adjacent structures. Furthermore, environmental resources can be either impacted or enhanced depending on how the SWM facility is designed and constructed. The SDC reviewer will help identify projects where the surrounding context necessitates special circumstances and design decisions to address specific concerns.

The following includes a variety of considerations to take into account:

Land Use and Community Character – The character of the surrounding land use should be factored into the design. Highly visible SWM facilities should complement or serve as an enhancement to the surrounding environment. This is particularly important for SWM facilities that are within or visible from residential areas, parks, commercial districts, institutional settings, or other public spaces. Visibility from the roadside should also be considered and factored into the SWM aesthetics.

Utilities – Exercise care in placing SWM facilities in proximity to utilities or utility easements. Utility impacts can be a costly component of facility design and should be avoided when practical. Ensure that utilities are located far enough away so that no soil deposition or facility disturbance would occur should the utility need to be installed, repaired, or replaced and that no utility failure, rupture, or leakage could affect the SWM facility. Neither utilities nor utility easements can be located within a SWM facility.

Mosquito Reduction – Standing water can become a breeding ground for mosquitoes, which can be a nuisance to surrounding neighbors of a SWM facility. Facilities that are designed to have a permanent pool may attract mosquitoes and upset local community members. Mosquito populations can be reduced by using dry facilities that do not have a permanent pool of water or by designing facilities to attract additional wildlife that can eat mosquitoes and their larvae. some plants help to repel mosquitoes such as Pine, Lavender, Rosemary, Catnip, and Marigold.

Open section roadway with narrow, vegetated channels suits the context of this scenic byway. Photo Credit: Flickr.com

Scenic Byways – Refer to the Maryland Scenic Byways map to determine if the site is within a scenic byway corridor and in need of special aesthetic considerations. Scenic byway corridors are loosely defined as the area within the viewshed of a scenic byway route, or within one mile of the right of way if the viewshed is expansive. Local jurisdictions prepare a corridor management plan with specific guidelines and strategies for each scenic byway to preserve and enhance its character.

Wild and Scenic Rivers – The Maryland General Assembly has designated nine rivers as scenic and one river as wild in Maryland. The nine scenic rivers include the Anacostia, Deer Creek, Monocacy, Patuxent, Pocomoke, Potomac (Frederick and Montgomery Counties), Severn, Wicomico - Zekiah, and Youghiogheny Rivers. The section of the Youghiogheny between Millers Run and the southern corporate limits of Friendsville has been officially designated a "Wild" river. The Maryland Department of Natural Resources (DNR) prepares a management plan for each designated river for preservation and management strategies of river related resources. Special attention should be made to context-sensitive design within these watersheds to preserve the character and water quality. For more information, please refer to the following:

Scenic River integrity depends on water quality and volume management as well as aesthetic considerations.

https://dnr.maryland.gov/land/pages/stewardship/scenic-and-wild-rivers.aspx

Stormwater Hotspots – Hotspots are areas producing higher concentrations of pollutants than typically found in urban run-off or that could result in groundwater contamination. It should also be determined if the site is located in a SWM Hotspot as defined in the *2000 Maryland Stormwater Design Manual*. These are usually located in heavily industrialized areas, or other locations with a high potential for pollutant runoff. This may affect the type of facility selected to ensure water quality measures are effectively addressed.

Examples of Stormwater Hotspots may include gas stations, vehicle service and storage facilities, vehicle washing areas, auto recycling facilities, salt storage facilities, golf courses, landscape nurseries, or other locations using high levels of chemicals or fertilizers. Do not use a SWM BMP in hotspot locations unless the facility is approved for hotspot use.

Aircraft bird strikes or other wildlife impacts can cause serious safety concerns; therefore, SWM facilities near airports should not be designed to attract wildlife. Photo Credit: Flickr.com

Proximity to Airports – Elimination of bird strike potential and other wildlife hazards at and in the vicinity of airports affects the choice of stormwater facility type and planting choices. Generally, wet pools, wetlands and wet swales are not permitted in these areas and any plant material that is used must have low wildlife value.

Check proximity to airports, particularly Martin State Airport and BWI-Thurgood Marshall Airport (BWI), which have Airport Zoning Districts. Verify that facility types in these zones meet Maryland Aviation Administration (MAA) restrictions. Furthermore, the same restrictions should be considered at local and military airports. Refer to Section 2.3 of the MAA Planning and Engineering Guidelines for details on bird deterrent systems and Section 2.2 for specifications on landscaping within airport zones.

Federal Aviation Administration (FAA) restrictions apply to other airports such as Andrews Air Force Base and the Patuxent Naval Base. FAA generally requires a 5-mile radius for airport zoning districts. Additional information is found on the FAA website at www.faa.gov including Advisory Circulars and CertAlerts specific to wildlife issues.

Airport considerations should also be given to other county, municipal and private airfields around the State. Limits of the various airport zoning zones within Maryland can be found on the MAA website at the link below:

https://marylandaviation.com/permits-forms/airport-zoning-districts-and-airport-obstruction-zones/

Stream Use Classification – Watershed stream use classifications for use III and IV streams have additional design requirements. These watersheds have shortened extended detention times and require attention to thermal impacts that facilities might impart to receiving waters. Facilities with no permanent pools may be required. Special plantings that provide shade or underground storage may reduce thermal impacts. (See *Appendix D.9* of the *2000 Maryland Stormwater Design Manual* for stream use designations.)

Chesapeake Bay Critical Areas – The Chesapeake Bay Critical Area is defined as all water and submerged lands of the Chesapeake Bay to the head of tide, and all land and water within 1,000 feet of mean high water or within 100 feet of tidal water wetlands (see Appendix D.4 of the *2000 Maryland Stormwater Design Manual* for Stormwater Criteria for Maryland Critical Area IDA Zone). If the project is within the Critical Area, additional project approval and impact mitigation is required by the Critical Areas Commission (CAC). These additional requirements may impact the type of facility proposed and the landscaping requirements. The CAC generally prefers non-structural BMP facilities. Refer to www.dnr.state.md.us/criticalarea/ for more information.

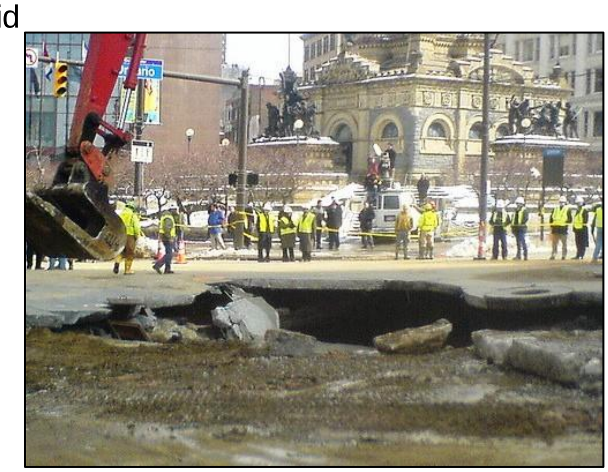
Areas within 1000 feet of tidal waters are a part of the Chesapeake Bay Critical Area where additional requirements apply. Photo Credit: Flickr.com

Coastal Bays Watershed – The Coastal Bays Program protects the land and waters of Assawoman, Isle of Wight, Sinepuxent, Newport, and Chincoteague bays. Refer to www.mdcoastalbays.org for more information. If the project is within this watershed, refer to the latest Coastal Bay Comprehensive Conservation and Management Plan for recommended practices related to stormwater management

Severn River Watershed – Anne Arundel County Soil Conservation District (AASCD) and the Severn River Commission have additional erosion and sediment control guidelines that apply to any project within the Severn River Watershed. This watershed is also designated as a scenic watershed, so aesthetic considerations are also important. Refer to the Severn River Commission website at https://www.aacounty.org/severn-river-commission or the AASCD website at https://www.annearundelscd.org for more information.

Special Protection Areas (SPAs) – A SPA is a geographic area that has high quality or unusually sensitive water resources and environmental features that would be threatened by proposed land development if special water quality protection measures were not applied. SPAs are designed by Montgomery County, and any special stormwater requirements unique to these areas would be imposed by Montgomery County. Additional stormwater controls for these areas are not required by SHA but good environmental stewardship is always encouraged. Refer to https://montgomeryplanning.org/planning/environment/water-and-wetlands/special-protection-areas for more information.

Hazardous Materials – Sites that contain hazardous material contaminants may be found throughout the state. Soil or water testing may confirm the presence of hazardous materials. Stormwater facilities that are designed to infiltrate or have contact with the ground water table should not be used in locations where hazardous materials are found. It is preferable to avoid locations where hazardous materials are found, or to use an impervious pond liner. Pond liners can avoid the transfer of contaminants off site into discharge water or ground water. Coordinate with the SHA Environmental Planning Division (EPLD) to confirm results of an Environmental Assessment and any requirements related to hazardous materials avoidance or mitigation.



Sink hole damage along a major urban thoroughfare. Photo Credit: Flickr.com

Karst Topography - Karst topography is a landscape shaped by the dissolution of soluble bedrock, usually carbonate rock such as limestone or dolomite. Areas with karst topography are prone to sinkholes, which can cause significant property damage or safety concerns. Pooled water from a stormwater management facility may increase bedrock dissolution and cause sinkholes to form. Areas known to have karst topography should be avoided. If they cannot be avoided, they should be designed to be a dry facility or to have an impervious pond liner. Coordinate with the Office of Materials and Technology (OMT) in project areas with Karst topography.

2.3 Volume Considerations

Over-Capacity – The SWM report should document facility sizing requirements to identify the potential for adjusting landforms, shape, and slope steepness if necessary. Capacity computations will note if the facility is oversized. If more water quality volume (WQv) or channel protection volume (CPv) treatment is provided than is required, there may be the potential to make adjustments. Landform adjustments may also be accommodated on sites that do not have over-capacity without reducing size, depending on the site conditions. For computation formulas, refer to Chapter 2 of the MDE *2000 Maryland Stormwater Design Manual*.

Watershed Approach – Reduced stormwater volumes or improved water quality can also be accomplished by considering stormwater management efforts upstream and throughout the watershed. Treating stormwater offsite may be a good substitute if the onsite conditions limit treatment options. By taking a watershed approach, untreated runoff from upstream developments could be affecting the water quality on the project site or downstream from the project area. Treating runoff in areas that have insufficient stormwater management can provide a net improvement in watershed water quality.

These may be areas that predate stormwater regulations (i.e. development built prior to 1982) or areas suitable for stormwater facility retrofits because of structural failures or inadequate treatment. The goal of the watershed approach is to holistically provide a net improvement to water quality in the watershed of the project site rather than focusing only on the project site.

2.4 Soil Considerations

Infiltration Rate – Stormwater soil boring information shows the infiltration rate at facilities proposing wet storage. If infiltration is greater than 1.0 inch per hour, the facility will infiltrate rather than hold water. Either the type of facility should be changed to an infiltration type, or a liner will be required to ensure adequate hydrology for the wet facility. It is preferable to change the design to accommodate infiltration rather than install liners.

Hydrologic Soil Group (HSG) – Pay attention to facilities that are slated to have permanent water but have A or B HSG soil classifications. Evaluating the HSG in combination with the stormwater boring infiltration rate may lead to the determination that the facility should be an infiltration type instead. See discussion above on Infiltration Rate.

2.5 Additional Regulatory Compliance

Stormwater management facilities can cause environmental impacts that require coordination outside of the Highway Hydraulics Division (HHD). The stormwater designer should reduce environmental impacts to the highest extent practical. ***Appendix A*** provides a summary of environmental permits and approvals that may be necessary on SHA projects. The following describes applicable laws and permitting requirements beyond the typical stormwater management and erosion and sediment control permits.

Environmental Documentation – Environmental documentation is required by the National Environmental Policy Act (NEPA) for projects with Federal funding and by the Maryland Environmental Policy Act (MEPA) for projects with State funding. NEPA and MEPA documentation includes an assessment of all environmental impacts as well as avoidance, minimization and mitigation measures. The NEPA process must be successfully completed before the Federal Highway Administration (FHWA) will approve the release of federal funds. Coordinate with EPLD to confirm that right of way and water quality impacts associated with stormwater management facilities are accounted for in the NEPA and MEPA documentation.

Historic Sites, Parkland, Recreation Sites and Wildlife Refuges - In addition to NEPA and MEPA documentation, Section 4(f) of the 1966 US Department of Transportation Act requires that impacts to parkland, recreational areas, wildlife or waterfowl refuges, or historic sites be avoided unless there is no other feasible and prudent alternative. These lands should be avoided for stormwater management practices. In addition to Section 4(f), Section 106 also governs impacts to historic properties (above and below ground) and requires mitigation and coordination with the Maryland Historic Trust to obtain a Memorandum of Agreement (MOA). Coordinate with EPLD to ensure any Section 4(f) and Section 106 considerations are addressed.

SWM Facilities should be designed so that they do not affect the integrity of a historic site.

Archeology - Stormwater management facilities may cross, or coincide with, environmental settings that have a high probability for containing archeological sites. Under MEPA, NEPA, and Section 106, archeological sites are considered a historic property type. Therefore, it is important to recognize that archeological compliance studies would likely be needed to fulfill regulatory requirements, especially for projects that involve large-scale earthmoving activities such as the construction of basins. The purpose of the archeological studies would be to locate and identify any Maryland/National Register listed or eligible archeological sites within the project's archeological Area of Potential Effect (APE) and subsequently analyze project effects on any such sites therein. For most projects, the archeological APE usually coincides with the project's horizontal and vertical limits of disturbance. If study results and interagency project coordination conclude that the project may adversely affect Maryland/National Register listed or eligible archeological sites, avoidance options or treatment measures to minimize and/or mitigate adverse project effects would be developed in consultation with the Maryland Historical Trust. For federally funded projects, a MOA detailing the stipulations for site avoidance or site treatment would be prepared. Coordinate with EPLD to ensure archeological concerns are addressed.

Wetland, Stream and Floodplain Impacts – Identify impacts to environmental features including jurisdictional wetlands and streams (waters of the U.S.), their buffers, and 100-year floodplains. Evaluate whether impacts are necessary or could be avoided through a different design or facility type. Ensure the impacts are accounted for in permit applications. Coordinate with the SHA Environmental Programs Division (EPD) to confirm permitting status.

Forest Conservation - Maryland legislation includes three separate laws pertaining to forest conservation. The Reforestation Law pertains to linear projects that impact over an acre of forest. The Roadside Tree Law pertains to tree impacts totaling less than one acre along a roadside. The Forest Conservation Act pertains to non-linear projects, such as park and ride facilities, stream and wetland mitigation projects, or other site development projects. Coordinate with the SHA LPD to confirm that any impacts to trees are accommodated in the requisite tree removal permits.

Chesapeake Bay Critical Areas – Any construction activities within 1,000 feet of the Chesapeake Bay and its tidal tributaries or within 100 feet of tidal water wetlands requires special considerations and mitigation measures. The CAC considers permanent pools of water to be included as impervious land cover. Coordinate with EPLD, EPD and LOD to confirm that Critical Areas requirements are addressed.

2.6 Water Quality Bank Balance and Maximizing Treated Impervious Surfaces

The HHD maintains an agreement with MDE that allows SHA to obtain credits or debits for water quality requirements on projects. This process is referred to as the water quality (WQ) bank. Allowances are made to debit the bank when water quality treatment cannot be provided either on or offsite. The option to debit the bank is limited to instances where BMP facility installation is not feasible and debits to the WQ bank require HHD and SHA Plan Review Division (PRD) approval.

The SDC reviewer should review instances where the designer is proposing to debit the WQ bank to ensure that the reasons are valid and to verify that the bank balance has not exceeded the maximum debit allowance. The SDC reviewer should also look for opportunities to maximize water quality credits to the water quality bank.

2.7 Post-Construction Certifications

Generally, two types of certifications are required: The Stormwater Management As-Built Certification and the Plant and Turf Establishment Certification.

<u>Stormwater Management As-Built Certification</u> - The SWM facility As-Built Certification is a condition of the SWM permit approval and is required for all SWM facilities. The certification process requires that any facility be inspected during construction and that the final grading and control structures be within specified tolerances. If a facility does not meet the tolerances, computations to verify that it meets the intended function are required. Projects may not be closed out until the As-Built Certification Package has been approved by the HHD and/or SHA PRD. The construction contractor is responsible for preparing the documentation and requesting certification approval.

<u>Plant and Turf Establishment Certification</u> – The Plant and Turf Establishment Certification documents that the plants and permanent seeding or sod are properly established. Plantings and turf are inspected at the completion of construction and at the end of the one year plant establishment period. The LPD is responsible for certifying the Plant and Turf Establishment.

Section 3 - BMP Design




3. *Facility Design*

The design process is a means of integrating multiple goals in an organized manner. A stormwater management designer must understand the goals, develop solutions to address the goals, and find resolution when goals compete. The primary goals of stormwater management design are to address environmental sustainability, safety, maintainability, and aesthetics. Each of the primary goals can have additional facets specific to the project derived from any of the project considerations. Permit conditions, environmental regulations, and contextual features can have a significant effect on how "best" to design a stormwater management facility.

The design process is not one that can be prescribed because each individual project and site will have its own unique set of issues and constraints that will affect how to address the project's goals. The designer may need to prioritize goals, however, a good design is one that will address all goals.

Principles of organization include harmony, variety, balance, dominance, proportion, movement, and economy. In terms of stormwater management, the organization of design must consider landform, water, hardscape, plantings, and site-specific features that must all work together to create a BMP.

3.1 Landform

Grading Patterns - Contour grading at BMP facilities should incorporate natural shapes with minimal use of straight lines or sharp angles. In many instances, geometric or simple shapes appear unnatural and should be avoided. In particular, they become an overly dominant feature that is not in harmony with the surroundings. Landforms should be designed so that they blend seamlessly into the topography. Typically, landform should be characterized by rolling and rounded forms that appear as if they would occur naturally, thus blending with the surrounding landscape.

SWM pond with curvilinear landform creating an attractive landscape feature.

Natural landforms are typically curvilinear with varying widths and gradual transitions. Landforms that are boxy with straight lines and square angles or rounded as a geometric circle or oval are not typically landforms that occur naturally. Furthermore, slopes should gradually change pitch rather than making sharp transitions. The landform should not appear contrived, forced or unnatural.

Effective design of landform can improve the function and water quality treatment of the BMP. Using curvilinear landforms that incorporate a baffle, or peninsula-like feature, can lengthen the flow path of water in the BMP. Longer flow paths allow more time for sediment to settle out of the water. See *Figure 3-1* for examples of curvilinear and natural shapes and *Figure 3-2* for examples of geometric shapes to avoid.

Figure 3-1. Curvilinear and Natural BMP Shapes

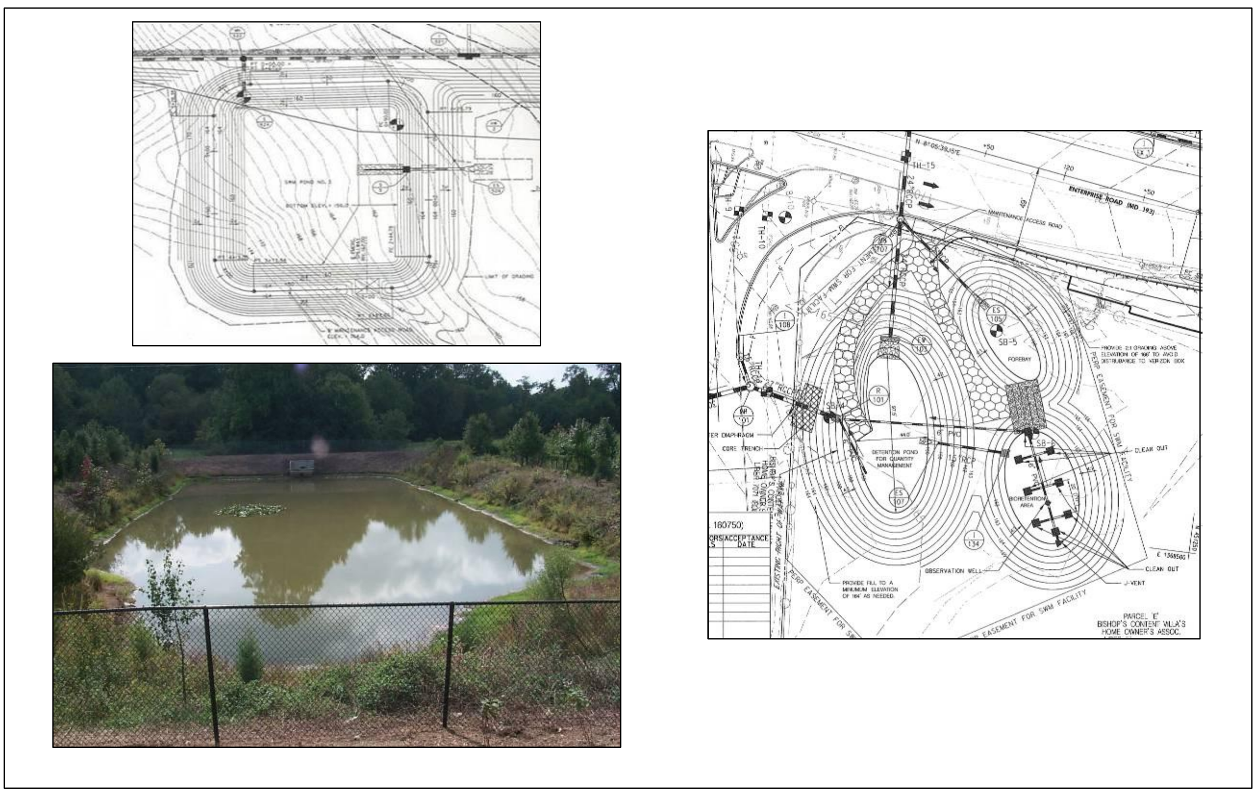


Figure 3-2. Simple and Geometric Shapes to be Avoided

Baffles and Peninsulas – Baffles should be constructed by leaving the baffle material in situ of undisturbed virgin soil and should not be constructed from fill material. Creating baffles from fill material will result in easily eroded baffles that are ineffective at directing flow after several seasons (see *Figure 3-3*). To ensure the contractor leaves the baffle material in place rather than removing it to simplify the grading operation and placing back unconsolidated fill material or common borrow, the minimum width for a baffle landform should be 20 feet. For smaller facilities, it should be proportional to the overall size of the basin, being no less than a quarter of the total width of the facility.

Baffle Constructed In-Situ Holds Form Over Time

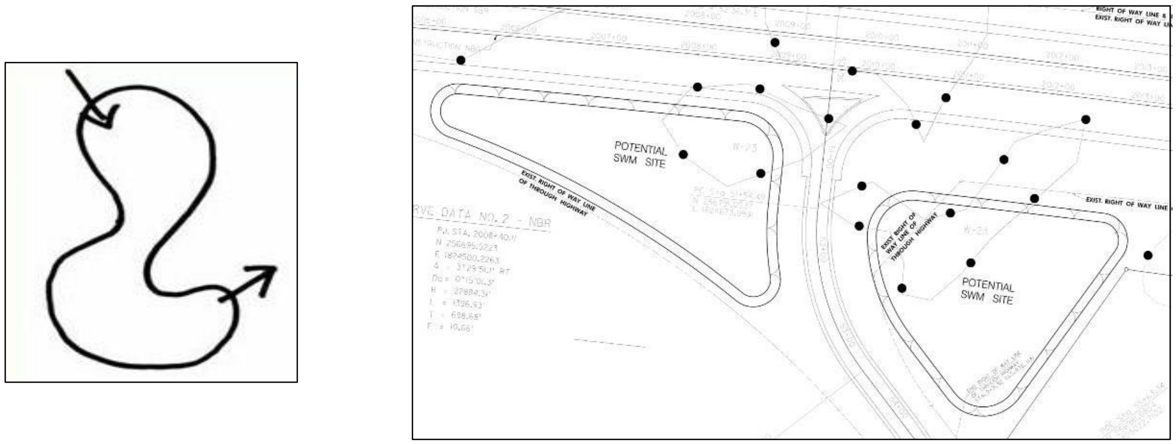
Baffle Constructed from Fill

Baffle Constructed from fill eroded after one year

Figure 3-3. Examples of Baffles (Good and To-Be-Avoided)

Landform Features to Avoid - Landforms can also facilitate ease of or hinder future maintenance. Steep slopes and tight angles are difficult for maintenance crews to navigate. Islands should also be avoided because they are not accessible to maintenance crews.

Establishing Right-of-Way - Landform grading should be considered and provided at the concept development stage. The preliminary grading plans should be developed reflecting the desired landform. This will ensure that enough right-of-way is programmed into the budget to ensure this type of landform is possible in the final design (see *Figure 3-4*).



This **Not This**

Figure 3-4. Concept Stage Should Reflect Natural Shape

The right-of-way should be set at least 15' beyond the toe of an embankment slope. This area is part of the critical woody-free zone that must be maintained by SHA.

3.2 Slope

Slope – The slopes within a BMP that encompass the frequently fluctuating zone (area between the permanent water surface and the 10-year water surface elevation) require special consideration. This area is prone to erosion due to the frequently fluctuating water surface elevation and the tendency of the applied seed to float. To improve the sustainability of these slopes, they should be graded at 4:1 or flatter and should include a combination of seed and herbaceous plantings.

Grade steepness should be dictated by safety and mowability. Maximum steepness is restricted to 4:1 or flatter in certain circumstances as defined in the following sections.

Frequently Fluctuating Zone – The area between the permanent water surface elevation and the projected 10-year storm water surface elevation is known as the frequently fluctuating zone because the surface elevation frequently changes with precipitation events. The slope within the frequently fluctuating zone requires special consideration because it is more prone to erosion with the frequent changes in water elevation. This area should maintain flatter slopes no steeper than 4:1. Refer to the Safety Grading Requirements for safety bench design guidance. Flatter slopes also help to keep seed and mulch in place. This area should include herbaceous and/or woody plantings as appropriate. Geotextile fabric may also be necessary to stabilize soil. Refer to *Section 8* for planting requirements and *Section 9* for soil stabilization requirements.

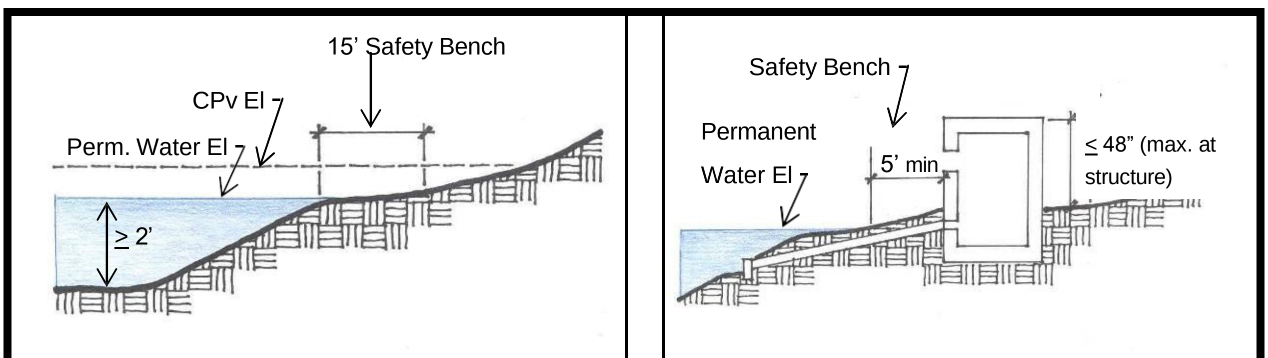
Grading for Mowability - Grading design should facilitate mowing in areas that require routine mowing. Areas that require routine mowing are outlined in *Table 3-1*, and should be 4:1 or flatter in steepness. Access should be provided to all mowing areas from the maintenance access path. Dimensions and turning requirements of standard mowing equipment shall also be considered in the design.

Table 3-1. Areas Requiring Routine Mowing

1. Maintenance Access Path
2. Code 378 SWM Free-Standing and Roadway SWM Embankment (both upstream and downstream faces)
3. 15 ft. Clear Zone at Code 378 SWM Embankment Toe
4. 25 ft. Clear Zone Around SWM outfall structure
5. Emergency Spillway
6. Bottom and Side Slopes of Dry Swales and Surface Sand Filters
7. Filter Strips at Grass Channels, Infiltration Basins, Infiltration Trenches, Dry Swales and Bioretention Areas

Safety Grading Requirements - SHA policy requires that safety features be provided in SWM facilities in lieu of fencing or railings wherever possible. Safety features can include landforms, signs, or plantings. Facilities with 2 ft. deep permanent water or deeper (including forebays) require safety grading. Safety grading features include:

- Side Slopes should be 4:1 or flatter. This includes both stand-alone MD Code 378 SWM embankments and roadway MD Code 378 SWM embankments. Cut slopes with reforestation plantings can be steeper than 4:1 with SHA approval.



Safety Bench at Water Surface **Safety Bench Around Structure**

Figure 3-5. Safety Benches

- Safety benches should be placed around the perimeter of permanent pools that are 2 ft. deep or deeper. The benches should be a minimum 15 ft. wide and centered at the permanent pool elevation with a grade of 12:1 or flatter. (See *Figure 3-5*.)
- MDE requires that a safety railing be placed at endwalls and outfall structures that are 48 in. or greater in height (page 3.15 of the *2000 Maryland Stormwater Design Manual*). SHA policy requires that SWM outfall structures be designed so that they do not exceed this height in order to eliminate the need for railings. This can be accomplished by grading a bench around the structure. This bench should extend a minimum of 5 ft. beyond the structure on all sides. (See *Figure 3-5*.)

- Signs can also be used that state "No Trespassing State Highway Administration", from the Maryland Standard Sign Book, Standard No. R11-2(4).

Requirements for Fencing Approval - If safety grading is not feasible for the facility or outfall structure, the designer must demonstrate this to the SHA Highway Hydraulics Division using grading studies, sketches, computations or other means as appropriate. Fencing around stormwater management facilities should only be used as a last option when other alternatives are not feasible. Please see *Section 5 - Fences and Railings*, for more information.

3.3 Conveyance

Open Conveyance – The ESD Approach favors use of open drainage patterns and stormwater conveyances. This more closely follows natural drainage patterns using vegetated swales that can treat water quality with infiltration. Vegetated swales also offer opportunities for nutrient uptake or phytoremediation of pollutants and can be designed as a landscape amenity or species habitat. Slopes should be relatively flat in open conveyances to reduce water velocity and avoid soil erosion. Check dams, stone riprap, or vegetation can increase channel roughness to help slow water velocity as well.

Examples of Open Conveyance Facilities in Urban and Suburban Settings

Closed Conveyance – Stormwater has traditionally been directed into closed conveyance systems, such as underground pipes, to remove the stormwater from the site as quickly as possible. Closed drainage systems cannot always be avoided, especially in roadway reconstruction projects where much of the existing drainage system is underground. Closed conveyance systems should only be used if there are no feasible and practical opportunities for open conveyance.

3.4 Establishing Right-of-Way

Locate all SWM facilities within SHA right-of-way. If right-of-way is being purchased to accommodate SWM facilities, ensure that the entire facility, including its maintenance access, is within SHA property. The property line should be set at least 15 feet beyond the toe or top of slope on an embankment because this is part of the critical woody-free area that must be maintained.

3.5 Impervious Pond Liners

Impervious pond liners are sometimes necessary in instances where a SWM facility is located in an area with Karst topography or areas with existing soil contamination. The impervious pond liner prevents infiltration that can cause sink holes or cross contaminate stormwater runoff with hazardous materials found on site. The liner must be a single piece so that no water can seep beneath the facility. The liner should either be cut from a single sheet or should be seamed together with an impenetrable seal. The pond liner manufacturer should warranty the liner for a minimum of 20 years or for the foreseeable lifespan of the BMP facility.

<u>Liner Depth</u> - Liners should be placed at least 12 inches beneath the finished surface elevation and extend at least 12 inches beyond the top of slope. Any filtering media or underdrain system must also be placed above the liner. The edge of the liner should be keyed into the top of slope to ensure stability.

<u>Slope Stability with Liners</u> - Slopes over pond liners should be kept to a maximum of 4:1, and flatter is preferred. Depending on the stability characteristics of the topsoil, there may be a need to add a cellular confinement system on the slopes to keep soil from sloughing off into the bottom of the facility. Loamy or sandy soils have a tendency to slough off the sides of the smooth liner surface and become deposited in the facility bottom. The cellular confinement system should either be glued to the liner or sufficiently keyed to the top of slope. It should not be pinned, stapled, or staked in place.

<u>Preventing Punctures</u> – No augers or heavy construction equipment should be used during construction when a liner is in place. Any construction activities, including grading, placement of facility components, or planting installation, should be done by hand or with lightweight equipment.

Pins, staples, or stakes should not be used over pond liners because they may puncture the liner. However, these fasteners may be necessary with a stabilized maintenance access drive or other structural features. If the design requires components with pins, staples, or stakes, ensure that the liner is placed sufficiently below the deepest depth of any fastener that can cause the liner to puncture.

If riprap or gravel is to be placed on top of the liner, care must be taken so that no sharp edges can puncture the liner. This can be prevented either by adding a 4-inch layer of soft soil between the stone or by ensuring that the stone is placed with care.

Liners typically are made from a PVC material that can quickly degrade if exposed to direct sunlight. To ensure the integrity of the liner, care must be taken so that exposure to direct sunlight during construction is limited.

Section 4 - Stormwater Management Structures

4. Stormwater Management Structures

Outfall riser structures, weirs, end walls, and head walls can each serve as an important functional item as part of a BMP, but have potential to be visually obtrusive. These structures should be designed to blend into the surroundings wherever possible. In some contexts the structure may be designed as an architectural feature and in others, it may be designed so that it is less visible. The structures should not present any safety hazards and should be designed to facilitate maintenance.

4.1 Safety Features at Stormwater Management Structures

Outfall Riser Structure Top Dimension – Maintenance crews often need to stand on top of the structure to access the inside and perform routine maintenance. When a structure is over 30" tall, the top dimension should include a minimum 4'-2" space on two consecutive sides adjacent to the manhole cover. This will allow room for a maintenance worker or inspector to safely maneuver the manhole cover from the frame. (See *Figure 4-1*.)

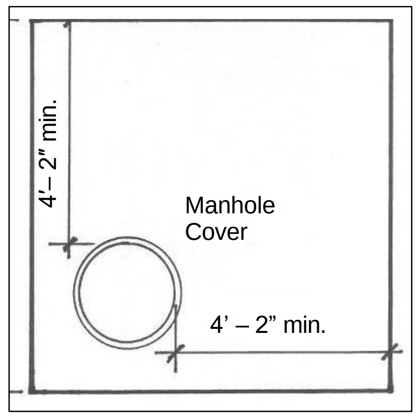
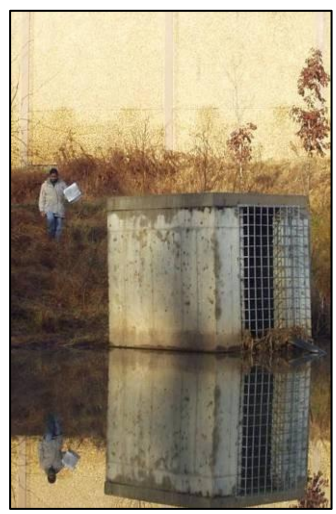


Figure 4-1. Plan at Riser Structure

Height – All outfall structures should be less than 48-inches in height on all sides. Safety grading should be provided around the SWM outfall structures and endwalls. Safety grading, as discussed in *Section 3.2.*, can also be used to reduce the overall height of the structure. If the structure elevation is higher than 48 inches at any point, the designer should grade a 5-foot safety bench around the structure so that the height does not exceed 48-inches on all sides.

Ladder rungs should also be provided on the outside of the riser structure if it is greater than 30-inches high.



This riser does not meet safety criteria because of its excessive height.

4.2 Structure Aesthetics

The structure design should be appropriate and attractive. The structure design should include appropriate details or specifications. These may include:

- Concrete integral coloring concrete to provide a softer structure color tone.
- Use of formline finishes to create a more attractive finish.
- Use of chamfers to soften structure edges and reduce potential for chipping.
- Epoxy coatings or paint for metal components.

Concrete Color - Where concrete stormwater management outfall structures are visible from the roadway and/or adjacent to visually sensitive land uses, the use of integral color pigment in the concrete mix may be used to improve area aesthetics. The color shall meet Federal Standard 595B and shall be chosen from the following choices: 30277, 31219, and 30145 or similar. Concrete staining is not preferred because it does not have the longevity of an integral stain.

The low flow device is visible above the water surface and is unattractive.

Grates - There should be no flat grates on top of the outfall structure. If modified inlet structures are used at bioretention facilities and sand filters, the inlet grate should be modified so it is not flat or has ability to bypass flow if the grate becomes clogged.

Woody vegetation, including ivy, must be kept clear from a riser structure to ensure proper function.

Trash Racks - Trash racks should be provided and should not be flat on the top. Trash racks should be, at a minimum, galvanized, but may also be painted or epoxy-coated black.

Low Flow Device – Low flow device placement and type should be appropriate and there should be adequate measures to prevent clogging. The use of submerged devices is preferable (see *Figure 4-2*). A "T" connection with the device running parallel to the side slope makes the device less visible.

Low Flow Device uses a T-Connection and Runs Parallel to the Side Slopes (Preferred)

Low Flow Device runs perpendicular to structure (Avoid)

Figure 4-2. Low Flow Device Can be Unobtrusive

Section 5 – Fencing and Railings

5. Fences and Railings

5.1 Fence Approval

The use of fences to enclose SWM facilities should be avoided whenever possible so that the facility is accessible for future maintenance activities. Safety grading features discussed in *Section 3.2* alleviate the need for fencing. Furthermore, landscaped hedgerows or a fence along a single side of the facility may be more appropriate depending on the site's context and restrictions.

If the facility faces considerable constraints that make safety grading impossible and it is determined there is a site-specific safety concern, the facility designer may request approval from the HHD Division to use fencing. This approval will only be granted if the designer can prove that safety grading features are impossible to accommodate and that an enclosed fence is the only alternative. This can be done using grading studies, sketched grading plans, computations, or other means as appropriate.

When fences are used, they should be sited to blend into the surroundings as much as possible.

5.2 Fence Requirements and Design

When fencing is required and allowed, it should be designed according to the following criteria. Please note, these requirements and criteria do not apply to SHA right-of-way fencing.

- Fencing should be 42-inch height maximum.
- Use black or brown coated vinyl chain link fencing with a top rail.
- Do not use a top rail if the fence is within the roadway clear zone and parallel to the roadway. Since the top rail of the chain link fence can be a spearing hazard if a vehicle were to run into the fence from the side, the top rail should be eliminated and the standard SHA fence with tension wire at top and bottom should be used instead (see *Figure 5-1*). See *Section 7 – Safety Considerations for discussion on roadside safety at SWM facilities.*

Black Vinyl Coated Chain Link Fence with Top Rail | Black Vinyl Coated with Tension Wire

Figure 5-1. Chain Link Fence Options

Examples of ornamental fencing used for SWM facilities.

- Decorative fencing can be used when the site is highly visible and warrants the added expense, however it is not preferrable due to its shorter lifespan and increased maintenance requirements. The same color choice and detailing should be used throughout the project.
- When fencing is used, provide a 12 ft. wide double gate at the stabilized maintenance access. A method to secure the gate in the closed position should be included in the design detailing
- Visually unobtrusive placement that would typically follow along a contour line or other significant land features (see *Figure 5-2* and *Figure 5-3*).

Fence Steps Up and Down Contours (Avoid)

Fence Follows Contours (Preferred)

Figure 5-2. Fencing Should Follow Contours

Do not suspend fence over outfall openings as shown above. (See photo to right)

Rather than suspend the fence over this weir structure, the fencing is worked into the design of the structure and embankment.

Fencing ditches can be a problem. Refrain from placing the post at the invert of the ditch as shown above. (See photo below)

Avoid blocking wier openings with fence as shown above. (See photo to right)

Rather than block the weir opening (left), the fence could have followed along either side of the riprap channel and tied into the endwall. Crossing a ditch farther downstream is preferable to blocking a weir.

Ditches should be spanned so that debri can flow under the fence , as shown above.

Figure 5-3. Additional Fencing Guidance at Weirs and Ditches

5.3 Temporary Fencing

Temporary fencing is a requirement for sediment basins during the construction process and should be detailed on the approved Erosion and Sediment Control plan. If temporary fencing is used, provisions should also be made to secure it against high winds and unauthorized relocation (see *Figure 5-4*).

Figure 5-4. Footer at Temporary Fencing

Figure 5-5. Chain Link Railing at Endwall

5.4 Verify Railing Requirements and Design at Hydraulic Structures

Safety should be considered in the design of hydraulic structures such as headwalls and endwalls. MDE requires that a safety railing be provided at endwalls and headwalls that are 48-inches or greater in height from the ground surface, including the submerged ground surface (see *Figure 5-5)*. The SHA Office of Bridge Design has fencing standards for structures:

- 42-inch height
- Black or brown vinyl coated chain link with top rail (*see Figure 5-1*)

As noted above in *Section 4.1*, SHA Policy requires that SWM outfall structures be lower than 48-inches from the ground surface (including submerged ground surfaces) on all sides so that no railing is required on top of the outfall structure. Refer to *Section 4, Stormwater Management Structures* for more information regarding structure design. If the structure elevation is higher than 48-inches at any point, the designer should grade a 5-foot wide safety bench around the structure so that the height does not exceed 48-inches on all sides.

Section 6 - Maintenance Access




6. Maintenance Access

Maintenance is an important aspect of the continued functionality and appearance of a stormwater facility. A stabilized maintenance access from a public right-of-way to all SWM facilities should be provided.

6.1 Placement

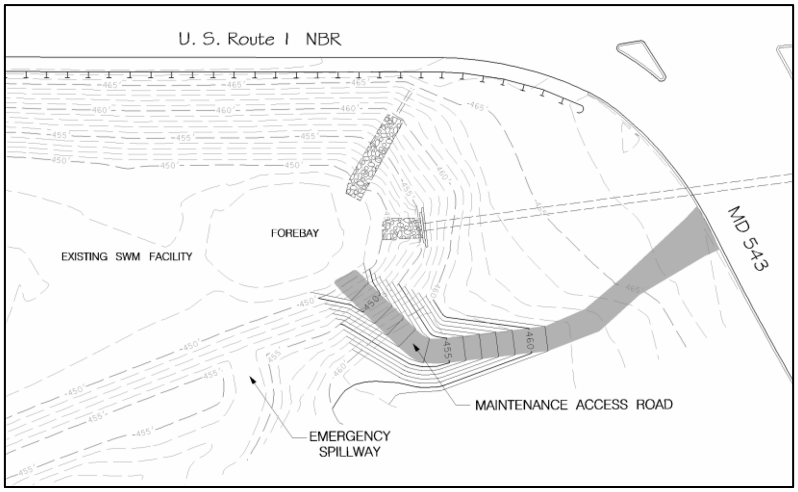
The placement of the maintenance access should be considered at the beginning stages of the facility's design. This will help ensure that the maintenance access is accommodated and properly designed. The following includes a list of placement requirements:

- Connect the maintenance access to a public road where maintenance trucks can pull off
- Ensure the entrance to the maintenance access is unobstructed. Please see *Figure 6-1* for examples of how maintenance access drives have been obstructed, rendering them useless. Common obstructions may include traffic barrier, traffic signs, vertical curb, parked cars, and woody vegetation

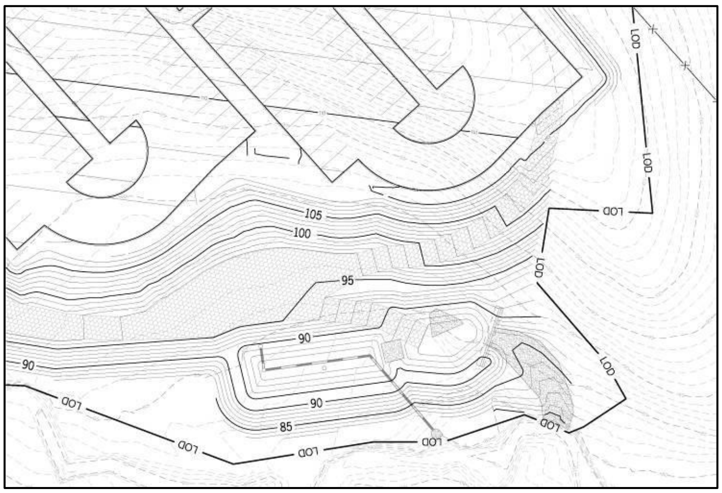
Obstacles blocking the maintenance access gate render the access useless.

Figure 6-1. Obstructed Maintenance Access

- Connect the access road to the forebay, inflow, and outflow structures
- Provide space at the beginning and end of the access to allow large maintenance vehicles to turn completely around. Room should be provided at the entrance for a maintenance truck with trailer to pull completely off the roadway without blocking traffic or access to adjacent properties.
- Design the maintenance access road to be a minimum of 1 foot above any permanent water surface
- Grade the access into the landform by benching the path into side slopes somewhat parallel to contours rather than ramping down side slopes perpendicular to the contours. Benching reduces erosion by breaking runoff travel path at slopes and is also more visually appealing. (See *Figure 6-2*.)



Access Road Ramped (Avoid) into side slope that encourages runoff to flow down road causing erosion



Access Road Benched (Preferred) into Side Slope so Runoff sheets down slope and not down road

Figure 6-2. Benched vs. Ramped Access Roads

6.2 Design Requirements and Detailing

To safely accommodate typical maintenance vehicles, the maintenance access design must follow the following criteria:

- A preferred minimum width of 12-ft should be provided. A 10-ft width may be acceptable only when limited right-of-way, environmental impacts, or other factors require.
- Design the maintenance access to be permeable yet stable enough to withstand the anticipated traffic for occasional heavy maintenance vehicles. It is preferred that the maintenance access be constructed with a 6-inch depth cellular confinement system filled with open graded aggregate, topped with 4 inches of topsoil and seeded and mulched. Contact HHD for the latest access road detail. Other stabilization techniques may be considered.

- The preferred maximum slope at maintenance access is 8:1 (12%). Slopes as steep as 6.6:1 (15%) may be used in extreme conditions but is not preferable.
- The preferred cross slope for benched access road is 2%.
- The maintenance access drive should include a 3-foot clearance area without any barriers that would prohibit opening vehicle doors when parked on the access drive. Potential barriers would include hedgerows, guide rails, fences, sound barriers, etc.
- Provide space at the beginning and end of the access to allow large maintenance vehicles to turn completely around. Room should be provided at the entrance for a maintenance truck with trailer to pull completely off the roadway without blocking traffic or access to adjacent properties. See *Figures 6.4, 6.5* and *6.6* for turn around area details.

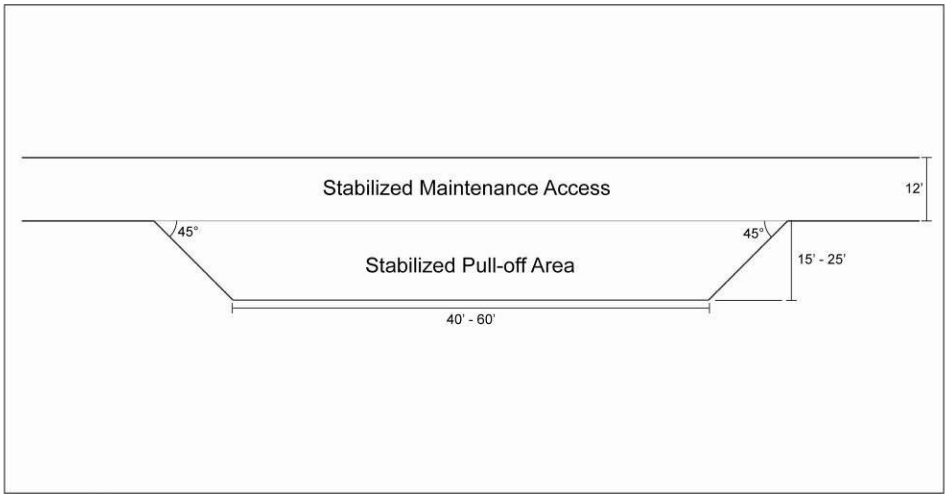


Figure 6-3. Pull-Off Area Dimensions for Maintenance Vehicles

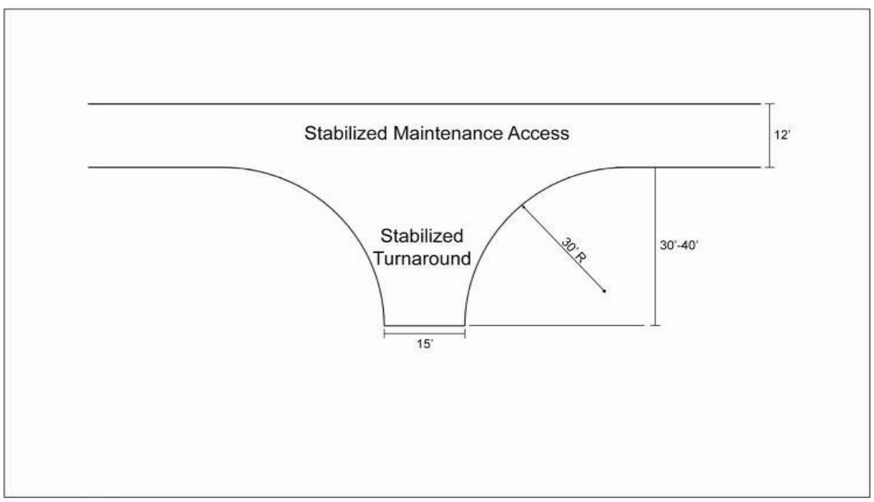


Figure 6-4. Turnaround Dimensions for Maintenance Vehicles

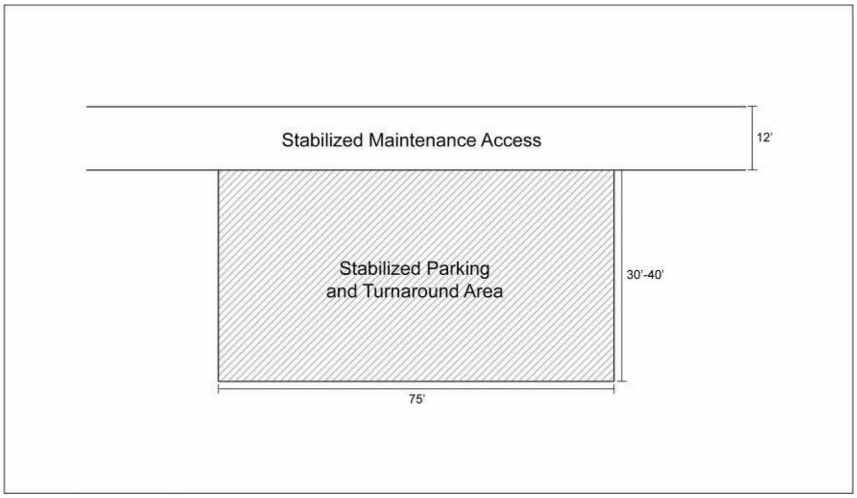


Figure 6-5. Combination Parking Area and Turnaround Dimensions for Maintenance Vehicles

6.3 Entrance Requirements

Pull off – Access should be provided from a public roadway right-of-way. If the roadway is a high speed, limited access facility, consideration should be given to the safety of maintenance vehicles, including trailers and other necessary equipment for slowing and pulling off the roadway. For instance, a widened, stabilized shoulder may be needed. Consider both entering and exiting the facility when reviewing the facility design for this requirement.

Figure 6-6. Concrete Apron and Depressed Curb Provided at Maintenance Access

Concrete Apron/Depressed Curb – If the roadway is closed section with curb and gutter, a concrete apron should be provided with depressed curb (See *Figure 6-6*). A depressed curb alone may be acceptable at SWM facilities when speeds of 10 mph can be obtained. If the facility entrance is also along a sidewalk, ensure that the apron meets all current standards for compliance with the Americans with Disabilities Act (ADA). Coordinate with the SHA ADA Coordinator to ensure compliance and receive approval for ADA accessibility standards.

Turning Radius – A turning radius should be included at the maintenance access entrance to accommodate turning vehicles from the main line.

Barrier Placement – If a traffic barrier is used along the roadway, an opening should be provided to accommodate the maintenance access entrance. End treatments and opening configurations at traffic barrier should adhere to the *AASHTO Roadside Design Guide, 3rd Edition* and SHA *Guidelines for Traffic Barrier Placement and End Treatment Design*.

Section 7 – Safety Considerations


7. Safety Considerations

Oftentimes, SHA's stormwater management facilities are located along roadways. Safety considerations are of paramount importance, especially in the public right-of-way.

7.1 Traffic Barriers

The need for traffic barriers should be evaluated using the *AASHTO Roadside Design Guide* and SHA *Guidelines for Traffic Barrier Placement and End Treatment Design*. Factors that can affect the roadside safety in stormwater management design are based upon the placement of a facility within the clear zone, placement of outfall structures and embankments, steep slopes, and permanent pools. The use of traffic barrier may be warranted and if so, it should be included in the roadway plans.

If a traffic barrier is used along the roadway, an opening should be provided to accommodate the maintenance access entrance. End treatments and opening configurations at traffic barrier should be provided and adhere to the design requirements outlined in *Section 6* mentioned above.

Be aware that the top rail at the chain link fence can be a spearing hazard if a vehicle were to run into a fence parallel to the road. If the fence is placed in a location where this may be the case, such as just outside the clear zone, then the top rail should be eliminated and the standard SHA fence with tension wire at top and bottom should be used instead.

7.2 Clear Zone

The facility plan should accommodate clear zones along the roadway. Clear Zones are areas where obstructions along the roadside present a safety hazard for errant vehicles. Clear Zone distances vary depending on the road type and vehicle speeds. Roadsides with curb or traffic barrier railings have a reduced clear zone. Please refer to the *AASHTO Policy on Geometric Design of Highways and Streets* for more information on clear zone width and constraints.

7.3 Sight Distance

The facility plan should accommodate all necessary sight distance requirements for safety. Unobstructed sight lines are necessary for vehicular turning movements at intersections, ramps, driveways, and maintenance access drives. Plant material, fences, signs, guide rail, and other visual obstructions can cause safety hazards. A sight triangle should be considered as an area without visual obstructions. Objects should be less than 2-ft tall within sight distance triangles. Tree canopies and signage should be at least 7-ft above ground, depending on topographic features, with careful placement of poles and trunks to reduce sight distance blockages. Sight distance calculations vary depending on the road type and vehicle speeds. Please refer to the *AASHTO Policy on Geometric Design of Highways and Streets* for more information on sight distance stopping requirements.

Section 8 - Planting

8. Planting

Plantings can provide visual enhancement to stormwater facilities, as well as other important benefits. Plants provide nutrient removal, particulate pollutant removal, shade, wildlife habitat, and natural heritage continuation. Plantings are also important for maintaining or building green infrastructure hubs and corridors, which are undeveloped lands most critical to Maryland's long-term ecological health. Hubs are typically unfragmented areas, hundreds or thousands of acres in size, while corridors are linear remnants of natural lands such as stream valleys and mountain ridges. Stormwater management facilities are oftentimes located in or adjacent to green infrastructure hubs and corridors and help expand the green infrastructure network.

It is important to utilize native vegetation when selecting plants for a site. This avoids the accidental introduction of invasive species, ensures greater likelihood of plant survival and adaptability, and allows the facility to merge into the adjacent landscape.

Plantings should take on a natural appearance. Groups of a single species should be placed in loose drifts interspersed with individual plants of different species to improve visual quality.

8.1 Pollutant Removal Capabilities

Vegetation within SWM facilities help to remediate water pollutants, such as nitrogen, phosphorous, and suspended solids. It is encouraged to maximize landscaping within SWM facilities to provide nutrient uptake of nitrogen and phosphorous and to stabilize soils preventing erosion and sedimentation.

Seasonal differences in pollutant removal performance can be important in addressing TMDL targets. Vegetation dormancy will result in reduced pollutant and nutrient uptake and may remove an important mechanism for flow reduction. Decomposition in the autumn and absence of vegetative cover in the winter can even produce an outwelling of nutrients and expose the soil to erosion. Woody vegetation is more resistant to seasonal differences because the plant structure and root zone remain intact year-round.

Care should be taken to reduce the likelihood of leaf litter or clippings accumulating in the SWM facility. In late autumn, fallen leaves and herbaceous material that has died back should be removed to ensure that nutrients are not released back into the watershed and do not clog control structures. Herbaceous material should be clipped back, not pulled out, to ensure that the roots remain intact.

Example of stormwater facility with trees planted along the embankment. This can cause damage to the embankment and ultimately cause embankment failure.

8.2 Woody Plant Restrictions and Buffer Zones

Planting of woody species, including live fascines, should adhere to MD Pond Code 378 restrictions at SWM embankments and SWM outfall structures. The following should also apply:

- No woody material should be planted on the SWM embankment (roadway and non-roadway), within 15 feet of the toe of SWM embankment fill or within 25 feet of the SWM control structure. This woody free area should be labeled on the plan sheets.
- A 15-foot buffer zone within SHA right-of-way should be provided at the toe of SWM embankments (roadway and non-roadway) that should be maintained free of woody vegetation (see *Figure 8-1*).

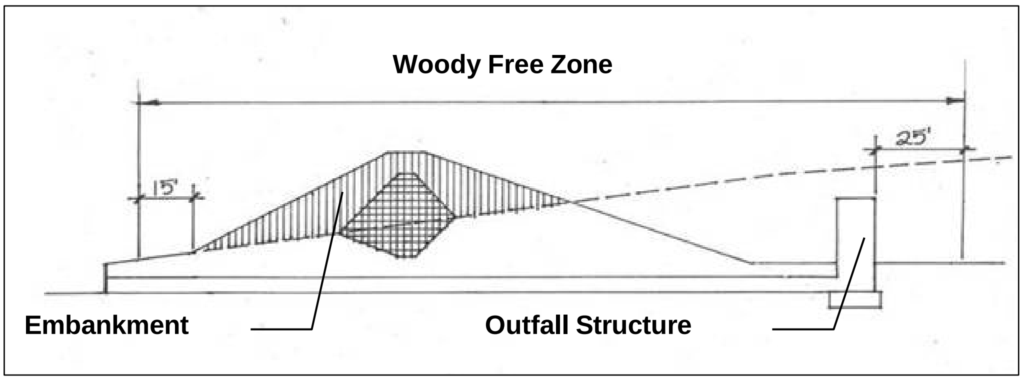


Figure 8-1. Woody Plant Restriction Area at Code 378 SWM Embankment

8.3 Plantings within Airport Zones

Plantings within Airport Zoning Districts should comply with the most recent MAA requirements. Generally, MAA and FAA regulations require that stormwater management facilities within a five mile radius of an airport be planted with vegetation that has low-wildlife value. (Refer also to *Section 2 – Stormwater Management Considerations* regarding airport planting restrictions.)

8.4 Planting Requirements

The planting design should account for the varying water levels within a facility, depending on the facility type there may be deep or shallow pools that are permanently submerged, areas that have frequently fluctuating water levels, temporary ponding, and other cases. The design should include varying plant types that will be best suited to each location and provide the best odds for establishment and survival. *Figure 8-2* graphically depicts the various planting zones. The Landscape Programs Division (LPD) can provide guidance on the best plantings for individual stormwater facilities and planting zones.

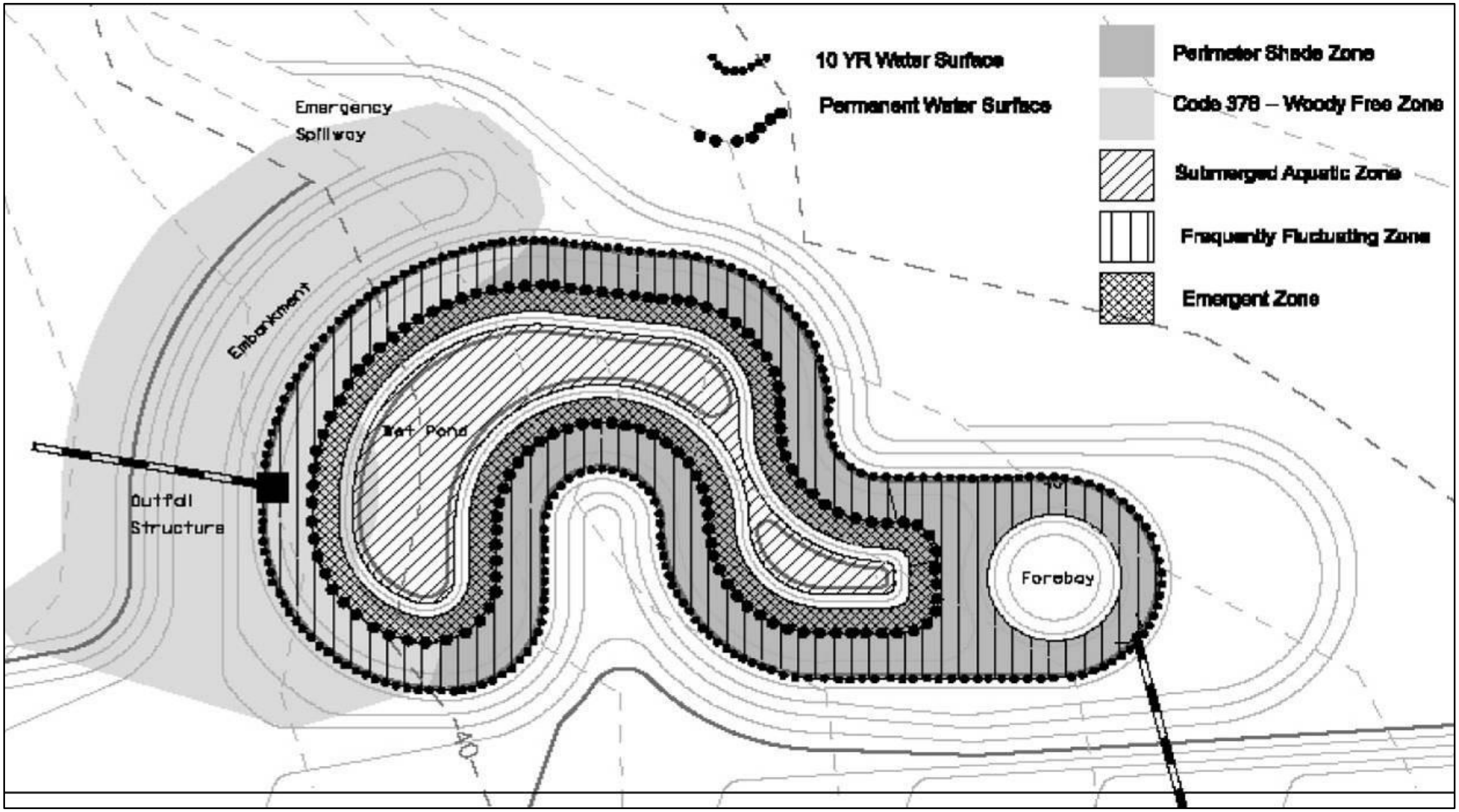


Figure 8-2 Stormwater Management Planting Zones

8.5 General Planting Guidelines

- Woody trees and shrubs should not be planted where a pond liner is used. Shrubs may be used if there is sufficient planting soil. Herbaceous species may be allowed depending upon the depth of cover at the liner, but installation procedures should involve hand digging rather than augers.
- Organic filters and bioretention facilities have subdrains. Plants should be selected so that their roots do not grow deep enough to clog the subdrain. Generally, trees should not be planted within the filter media of a facility.
- Mowability should be addressed in the planting zones so that planting does not inhibit equipment accessing critical areas to be maintained.
- The sight distance at intersections, ramps, and driveways should be checked to ensure plantings to not inhibit site distances.
- Aquatic benches are an excellent opportunity for landscape plantings.
- The limits of no woody vegetation should be shown on the planting plan to ensure that no woody vegetation is planted on the pond embankment.
- Edge of liners should be shown on the planting plan to ensure that no plantings are placed over the liner that would cause risk of puncturing the liner.

Section 9 - Soil Stabilization

9. Soil Stabilization

Soil stabilization is necessary in certain circumstances, particularly with steep slopes and/or erodible soils. Vegetative soil stabilization is the preferred and is suitable for most areas within a stormwater management facility. In some cases, additional measures may be necessary to ensure vegetative cover and stable soils. Soil stabilization matting should be considered first. Riprap should only be used when vegetation and soil stabilization matting will not adequately protect soil from erosion.

9.1 Soil Stabilization Matting

Soil Stabilization Matting (SSM) is used as a mulch to enhance seed germination and establishment, to reduce soil erosion, and to reinforce the root zone of turfgrass or other groundcover vegetation after establishment. Different types of SSM are used for these purposes in level areas, on slopes, and in channels as specified in *Section 709* of the *SHA Standard Specifications for Construction Materials, July 2008*.

Approved types of SSM include the following:

Example of a facility with Type A Matting used on side slopes.
Photo Credit: EPA

- Type A: A degradable, non-permanent matting composed of excelsior (non-woven, shaved wood) that is rolled out directly over prepared and seeded soil. It has a lifespan of about 12-24 months and is best used for the following:
  - In lieu of straw mulch to avoid the mulch floating away
  - On slopes or channels where straw mulch or wood cellulose mulch binders could wash away
  - In areas where rapid establishment is desirable

- Type B: A non-degradable, permanent matting composed of non-woven synthetic fibers that is rolled out directly over prepared and seeded soil. It is best used for the following:
  - In channel bottoms where established turfgrass alone will not be able to withstand erosive forces from water velocity
  - In areas with moderate risk of erosion

- Type C: A non-degradable, permanent matting composed of a synthetic fiber lattice that is rolled out directly over prepared and seeded soil or used on top of soil infill. It is best used for the following:
  - In channel bottoms where established turfgrass along with Type B matting will not be able to withstand erosive forces from stronger water velocity
  - In areas with high traffic to provide resistance to rutting

- Type D: A degradable, non-permanent matting composed of woven coconut fibers that is rolled out directly over prepared soil. It has a lifespan of 24 to 36 months and is best used for the following:
    - In areas where specified vegetation is able to withstand erosive force of water velocities after the plants are established, such as along stream banks, wetlands, or along moderate to steep slopes

- Type E: A degradable, non-permanent matting composed of non-woven straw or coconut fibers that is rolled out directly over prepared soil. It has a lifespan of 6 to 12 months and is best used for the following:
    - Flat areas with low risk of erosion and where straw mulch is objectionable, such as near SWM facilities where straw mulch could wash away
    - In areas with small disturbances
    - In areas where rapid establishment is desirable

9.2 Riprap Aprons, Channel Lining, Check Dams and Outfall Stabilization

Riprap stone used at SWM facilities that are visible from the roadway and/or adjacent properties shall be dark brown or gray in color. No white or light grey riprap should be used in those instances.

Example of dark grey riprap used for check dams in a bioswale

Section 10 - Facility Types and Best Management Practices

10. Facility Types and Best Management Practices

The 2000 MDE Stormwater Management Design Manual includes a summary of both structural and non-structural best management practices.

BMPs for the following categories are summarized in this section:

- Environmental Site Design (ESD) Facilities
- Structural Facilities for Urban Best Management Practices
- Alternative Stormwater Management Measures
- Non-Highway Facilities

10.1 Environmental Site Design Facilities

The practices of ESD should be incorporated to the greatest extent practicable before other structural facility types are considered. Incorporating ESD addresses stormwater management with more non-structural facilities and helps reduce the demands on structural facilities. ESD facilities should use enhanced infiltration whenever feasible and appropriate, and must use enhanced infiltration to provide recharge beneath facilities with sub-drains. Furthermore, ESD facilities should not be used for erosion and sediment (E&S) control or in areas used for E&S control. The following ESD facility types are often used on SHA projects, please refer to Chapter 5 of the *2000 MDE Stormwater Management Design Manual* for more detailed information about each facility type:

- Swales (MDE # M-8)
- Micro-Bioretention (MDE # M-6)
- Rain Garden (MDE # M-7)
- Disconnection of Non-Rooftop Runoff (MDE # N-2)
- Landscape Infiltration (MDE # M-3)
- Infiltration Berm (MDE # M-4)
- Submerged Gravel Wetland (MDE # M-2)

Swales (MDE # M-8):

Description and Suitability:
Vegetated, open channels designed to convey stormwater runoff at a non-erosive velocity and to enhance water quality with infiltration. Swales may include a layer of filtering media, such as BSM, along the bottom. Swales may also include an subdrain if necessary. Suitable for entire ESD_V (Environmental Site Design Volume) & full P_E required, but may be limited to an ESD_V with a P_E = 1". Can provide water quantity and quality when the entire ESD_V is accommodated.

Grass Swale Example

Design Criteria:

- Receives sheet flow on slopes up to 5%
- Pre-treatment is optional
- Certain soils have specific swale designs
- Convey a 10-yr storm with at least 9" of freeboard below shoulder edge
- Manning's roughness coefficient value is 0.15

Maintenance Requirements:

- Maintenance is minimal
- Routine landscape maintenance
- Periodic removal of accumulated debris
- Periodic observation

Benefits:

- Linear design can reduce right-of-way (ROW) impacts

Limitations:

- Proper design is necessary for sediment and pollutant removal
- Only can accommodate a drainage area up to 1 acre, but may accommodate larger areas with treatment train layouts
- Can not be used on slopes ≥ 5%
- Wet swales may have a negative public opinion due to standing water

Micro-Bioretention (MDE # M-6)

Description and Suitability: Smaller scale bioretention facility designed to capture and treat runoff in a landscaped basin. Water filters and infiltrates through a mixture of sand, soil, and bioretention soil mix. Filtered water discharges at a non-erosive velocity either through a subdrain or is infiltrated into the soil. When designed to hold 100% of the ESD_V, it meets the required P_E. It provides both water quality and quantity management.

Micro-Bioretention Basin Example

Design Criteria:

- Drainage area should be less than 20,000 square feet
- Concentrated flows require pre-treatment
- Diffuse larger storm flows to prevent erosion
- Maximum ponding depth = 12"
- HSG Type C & D soils require subdrain & enhanced filtration

Maintenance Requirements:

- Routine landscape maintenance
- Annual or bi-annual mulching
- Periodic removal of accumulated debris
- Periodic observation

Benefits:

- Provides some groundwater recharge
- Multi-use benefits, and good candidate for retrofit projects
- Can be designed as a landscape amenity
- Serves as green infrastructure

Limitations:

- Limited drainage area (Maximum of 20,000 sq. ft.)
- Requires routine landscape maintenance, which can be more intensive than typical turf applications
- Cannot be used in permanently wet conditions or high groundwater table areas
- Large woody plant material should not be used if the facility includes a subdrain.
- Landscaping must be tolerant of both inundation and drought

Rain Garden (MDE # M-7)

Description and Suitability: A shallow, landscaped depression. Rain gardens should only be used in soil with high infiltration rates and therefore do not require an subdrain. Rain garden soil is typically composed of BSM and includes a layer of mulch on the surface with landscaping, which can be woody material, herbaceous material, or a combination of both. It captures run off from curb openings, swales, pipes, downspouts, etc. and allows water to slowly infiltrate in a 24 to 48 hour period. The facility remains dry all other times. When designed to hold 100% of the ESD_V it meets the required P_E and provides both water quality and quantity management.

Rain Garden Examples

Design Criteria:

- Drainage area should typically be less than 2,000 square feet with a maximum of 10,000 square feet
- The bottom should be flat or concave with a maximum ponding depth of 12”
- Minimum depth of BSM is 12”
- 3” depth of mulch and landscaping should be incorporated into the design

Maintenance Requirements:

- Routine landscape maintenance
- Periodic removal of accumulated debris
- Periodic observation

Benefits:

- Promotes infiltration and groundwater recharge
- Treats both water quality and quantity
- Can be designed as a landscape amenity
- Serves as green infrastructure
- No underground drainage system

- *Limitations:*
- Limited drainage area
- Limited to HSG A & B soils only
- Cannot be used in permanently wet conditions or high groundwater table areas
- Can be more maintenance intensive
- Landscaping must be tolerant of both inundation and drought

Disconnection of Non-Rooftop Runoff (MDE # N-2)

Description and Suitability: Direct drainage from impervious surfaces to vegetated, pervious areas where it can infiltrate into the ground. This helps to reduce quantity demands on the storm drain system and addresses water quality. It is only suitable for small and narrow pavement areas such as sidewalks, driveways, or small parking areas, and it requires an open section for sheet flow run off. It addresses water quality for P_E = 1”, and may provide groundwater recharge. Not suitable for quantity management or constrained areas, but it is suitable for pretreatment practices.

Design Criteria:

- Requires sheet flow run-off
- Slopes no greater than 5%
- P_E = 1”
- Maximum flow paths: Impervious 75’; Pervious 150’
- Drainage area should be no greater than 1,000 sq. ft.
- Recharge must meet the soil specific factor or exceed the P_E

Maintenance Requirements:

- Routine mowing or landscape maintenance

Benefits:

- Can be used with any soil type
- Provides groundwater recharge
- Reduces quantity demands on the storm drain system
- Possible to use the space for other purposes

Limitations:

- Does not treat over 1" of rainfall
- No quantity management
- Limited slope, drainage areas and flow paths

Landscape Infiltration (MDE # M-3)

Description and Suitability: On site landscaping helps to capture, store, and treat stormwater runoff. Storage may be provided with constructed features made of stone, brick, concrete, etc., or in excavated areas. These features are then backfilled with stone and topsoil and landscaped. These are suitable to hold 100% of the ESD_V and meets the required P_E. Restricted from use in HSG C & D soils.

Design Criteria:

- Maximum ponding depth = 12"
- Maximum drainage area size is 10,000 sq ft, unless soil tests confirm capacity for additional space and forebays are installed for pretreatment.
- Should be constructed without a slope

Maintenance Requirements:

- Routine mowing or landscape maintenance
- Periodic removal of accumulated debris
- Periodic observation

Benefits:

- May meet the entire P_E requirement
- Provides groundwater recharge
- Can serve as green infrastructure
- Possible to use the space as a landscaped amenity

Limitations:

- Concentrated flows require pretreatment
- Limited to HSG Type A & B soils only
- Not compatible with sloped landscapes
- Should not be used adjacent to areas where there may be concern of basement flooding or damage to subsurface structures.

Infiltration Berm (MDE # M-4)

Description and Suitability: A linear mound made of earth and stone placed parallel to contour lines along a relatively gentle slope. It may be constructed from borrowed or furnished material. Stormwater sheet flows towards and through the berm, which helps to promote infiltration and dissipate stormwater velocities. It works well in combination with other ESD approaches, such as Sheet Flow to Conservation Areas, Disconnection of Non-Rooftop Drainage, and Landscape Infiltration. It may also serve as a pre-treatment option for other stormwater practices.

Design Criteria:

- Requires sheet flow run-off
- Slopes must be less than 10%
- Design must follow contour lines
- Limited to HSG A & B soils only

Maintenance Requirements:

- Routine mowing or landscape maintenance

Benefits:

- Promotes sheet flow and dissipates runoff velocities
- Optional pretreatment
- May be designed as a landscape amenity

Limitations:

- Requires more space and therefore may create larger footprint or ROW needs
- Has a limited storage capacity
- Limited amounts of ESD_V and P_E
- Restricted from HSG Type C & D soils

Submerged Gravel Wetland (MDE # M-2)

Description and Suitability: A small-scale treatment option using wetland plants placed in a gravel medium with a thin layer of planting media above the gravel layer. Runoff drains into the lowest elevations of the facility. Water fills up from beneath and discharges through the surface to an outflow control structure. The gravel layer becomes saturated and anaerobic, promoting growth of algae and wetland plant species that can provide nutrient uptake. This BMP works well in areas with high ground water tables or with poorly drained soils. When designed to hold 100% of the ESD_V, it meets the required P_E.

Design Criteria:

- Forebay must treat 10% of ESD_V
- Requires observation well
- Requires a large drainage area to maintain submerged flow conditions (preferably at least one acre) or a high groundwater table to maintain wetland conditions.
- Liners are a last resort for maintaining a saturated condition
- Surrounding areas should be relatively flat, but the facility should maintain an elevation drop sufficient enough to maintain drainage through the filtering media.
- Groundwater table volume does not count towards ESD_V

Maintenance Requirements:

- Close observation to ensure plant establishment
- Routine landscape maintenance

Benefits:

- Supports a permanent wet condition in areas with poorly drained soils or high ground water elevations

Limitations:

- Requires pretreatment to prevent sediment or debris from entering the gravel layer
- Limited to HSG Type C & D soils or areas with high groundwater only
- Exposed gravel areas may have a poor public perception, and placement may be restricted from residential and highly visible areas

Submerged Gravel Wetland Example

10.2 Structural Facilities for Urban Best Management Practice

The following facility types should only be used after ESD measures have been considered to the greatest extent practicable. The following facility types described below are often used on SHA projects, please refer to Chapter 3 of the *2000 MDE Stormwater Management Design Manual* for more detailed information about each facility type:

- Open Channel Systems (MDE # O-1 for Dry Swale and O-2 for Wet Swale)
- Bioretention (MDE # F-6)
- Sand Filters (MDE # F-1, 3 and 5)
- Stormwater Detention Ponds (MDE # P-1 through 5)
- Stormwater Wetlands (MDE # W-1 through 4)

Open Channel Systems (MDE # O-1 for Dry Swale and O-2 for Wet Swale)

Description and Suitability: Open channel systems are similar to Swales (MDE # M-8 as noted above) except that they have a larger drainage area up to 5 acres. See above for design criteria, maintenance requirements, benefits, and limitations.

Bioretention (MDE # F-6)

Description and Suitability: Bioretention systems are similar to Micro-Bioretention (MDE # M-6 as noted above) except that it may have a drainage area larger than 20,000 square feet but less than 10 acres. The maximum ponding depth is 12”, and the maximum depth of bioretention soil mix is 48”. Bioretention does not meet CP_V alone and requires pretreatment. See above for design criteria, maintenance requirements, benefits, and limitations.

Bioretention Basin Example

Sand Filters (MDE # F-1, 3 and 5)

Description and Suitability: Sand filters are similar to other filtering facilities except that there is no layer of organic filtering media. Sand filters include a shallow layer of topsoil over a layer of clean sand at a depth of at least 18 inches. See above for maintenance requirements, benefits, limitations, and pollution removal capabilities.

Design Criteria:

- Maximum drainage area of 10 acres
- Requires pretreatment
- A subdrain set in a gravel layer is required below the sand layer

Sand Filter Facility Example

Maintenance Requirements:

- Removal of accumulated debris
- Periodic clean out of pretreatment areas
- Routine landscape maintenance of planted vegetation

Benefits:

- Ideal for hotspot treatment where salt may prevent vegetation establishment
- Ideal for pond retrofits to allow both quality and quantity control
- Allows for shallower media layers compared to other filtering facilities

Limitations:

- Cannot be used in areas with permanently wet conditions or high groundwater
- Limited landscaping options may not be aesthetically pleasing and limit use in residential or areas with high foot traffic

Stormwater Ponds (MDE # P-1 through 5)

Description and Suitability: A basin with a permanent pool that is equal to the total WQ_V required, and may also treat CP_V, Q_P and/or Q_f above the permanent pool elevation. Pools are typically deeper than 2 feet, but vary depending on the design of benches and micropools. Flowpaths should be maximized with baffles and landform features as appropriate, but islands should be avoided. Water will fluctuate above the permanent pool elevation after storm events and slowly draw down through an orifice or spillway or with some infiltration and evaporation. High water tables may help to maintain a permanent pool, but should not be considered for WQ_V. Dry basins are not considered to treat WQ_V.

Wet Pond Facility Example

Design Criteria:

- Forebays and micropools help to prevent resuspension of sediment previously settled
- Safety benches are required at the permanent surface elevation and around the riser structure
- If an embankment is used for impounding water, the embankment must adhere to NRCS-MD Pond Code 378 standards.
- Instream ponds should be avoided and existing instream facilities should be taken offline where feasible

Maintenance Requirements:

- Periodic inspection of structural elements
- Routine landscape maintenance
- Maintaining woody-free zones
- Periodic dredging of accumulated sediment

Benefits:

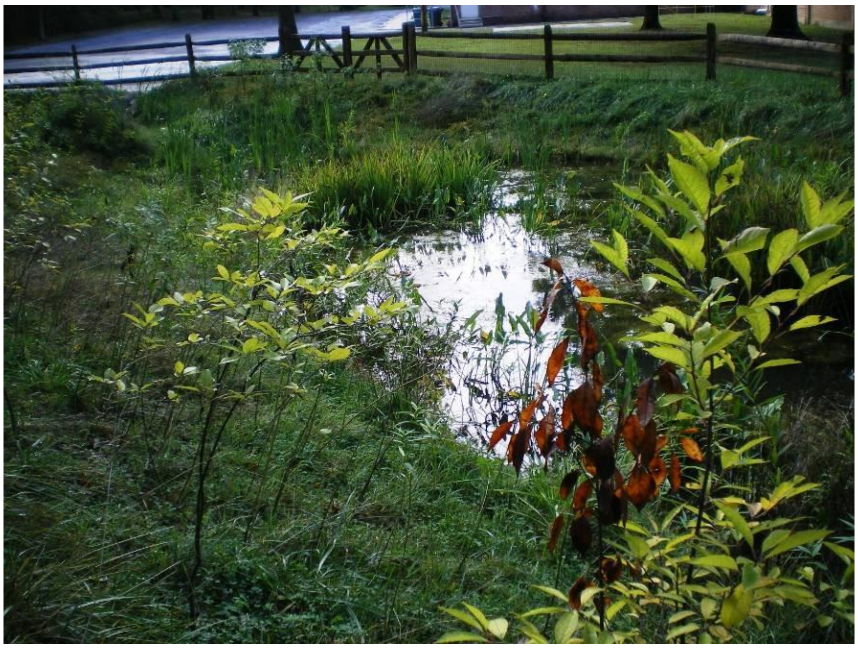
- Provides habitat for aquatic species and water fowl

Limitations:

- Standing water may be considered a nuisance or safety hazard in certain contexts
- Require large amounts of space and more ROW

Stormwater Wetlands (MDE # W-1 through 4)

Description and Suitability: Shallow depressions that collect stormwater runoff and maintain a permanent pool. Stormwater wetlands differ from detention ponds (MDE # P-1 through 5) in that they typically maintain shallow depths of less than 2 feet. Flowpaths should be maximized with curvilinear contour grading and a series of micropools. Otherwise, similar to detention ponds, shallow wetlands maintain a permanent pool that is equal to the total WQ_V required. They may also treat CP_V, Q_P and/or Q_f above the permanent pool elevation. See the description for Stormwater Detention Ponds above for design criteria, maintenance requirements, benefits, and limitations.



Stormwater Wetland Facility Example

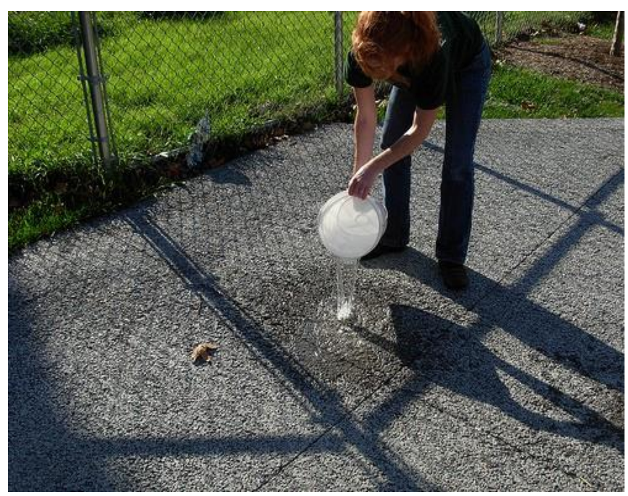
10.3 Alternative Stormwater Management Measures

Depending upon the project's individual needs, there may be an appropriate use for alternative measures when the other methods do not suffice or are not appropriate. The following facility types are generally only acceptable for use as a BMP in special circumstances.

- Permeable Pavement (MDE # A-2)
- Regenerative Conveyance
- Stream Restoration
- Proprietary Filtering Devices
- Underground Systems

Permeable Pavement (MDE # A-2)

Description and Suitability: Permeable pavement is not a stormwater management facility in itself, but rather a substitute for impervious pavement that would otherwise require stormwater management. It is a hardscape paving that allows water to infiltrate, and may be constructed of porous bituminous asphalt, pervious concrete, or permeable interlocking pavers. Water drains through the pavement and infiltrates into the ground. Permeable pavement has different structural characteristics than regular roadway pavement, so use must also be approved by the Office of Highway Development (OHD) and the Office of Materials and Technology (OMT). It is typically not suitable for roadway traffic, but it may be suitable for sidewalks, plazas, trails, parking bays, or lightly traveled driveways. It should be used with well drained soils of HSG type A or B only, and should not be used where there is a high water table or over compacted subgrades.



Pervious pavement examples with interlocking pavers and porous bituminous asphalt

Design Criteria:

- Appropriate for HSG type A and B soils only
- The 10-year, 24 hour storm event volume must be contained beneath the pavement
- Grades should be no greater than 5%
- Should not be designed to receive conveyance from adjacent areas

Maintenance Requirements:

- Regular vacuuming is needed to remove sedimentation from the pavement pores. Pervious pavement receiving any runoff typically will become silted more quickly and no longer function as pervious until the pores are cleared

Benefits:

- Provides a pervious surface in areas that would otherwise be impervious
- Because the pavement takes on ambient air temperatures, it typically drains quickly and often does not require salt or other de-icing chemicals to remain passable

Limitations:

- Not structurally appropriate for roadways or heavy traffic areas
- Not appropriate for HSG type C or D soils or in areas with a high water table
- Not appropriate for on-line conveyance areas
- May require extensive maintenance depending on level of siltation that occurs
- Should not be salted during frozen precipitation events, and plowing should be done with care

Regenerative Conveyance

Description and Suitability: Regenerative conveyance utilizes stream restoration principles for high-velocity stormwater conveyance channels with bioengineered soil stabilization and a series of filtration pools. Berms, rock weirs, and other features can be used to create step pools, which in turn promotes infiltration. It should only be used in soils with high infiltration rates.

Design Criteria:

- Appropriate for HSG type A and B soils only

Maintenance Requirements:

- Periodic observation
- Routine landscape maintenance
- Clearing accumulated debris

Benefits:

- Flexible shape and design can be used with limited ROW applications
- Can be designed as a landscape amenity and provide natural habitat
- High pollution removal efficiencies

Limitations:

- Not suitable for HSG Type C or D soils
- Tends to fail after the filtration pools become filled with sediments and debris

Stream Restoration

Description and Suitability: Stream restoration includes a variety of measures that promote naturally endemic, healthy stream systems with stabilized stream banks and habitat enhancement. These measures can enhance water quality with reduced pollutant loads and increased dissolved oxygen for aquatic species. Stream restoration may be accomplished through channel modification or various bank treatment techniques. Design features should be determined on a site specific basis and may include rock vanes, step pools, log jams, imbricated stone, or vegetative bio-engineering. Stream restoration ideally achieves a self-sustaining system with minimal or no maintenance requirements.

Design Criteria:

- Design should be developed on a case-by-case basis to target site specific issues, such as bank stabilization.

Maintenance Requirements:

- Periodic inspection and monitoring

Benefits:

- Improved aesthetics, ecologic habitat, and property values

Limitations:

- Dependent on individual site conditions

A completed stream restoration project using riffle grade control with stone toe protection

Proprietary Filtering Devices

Description and Suitability: Various manufacturers have developed, and in some cases patented, devices to aid in stormwater management. They are often hardware that can be added to the storm drain system. Filtering devices have been designed to filter out targeted pollutants such as oil, grit, sediment, and debris from entering the storm drain system. Some devices are also designed to deflect or restrict flow in cases where small ESD approaches have a limited capacity to absorb run off from large storm events.

Design Criteria and Maintenance Requirements:

- Based on manufacturer's recommendations

Benefits:

- Often are compact and invisible devices to aid in stormwater management

Limitations:

- Often are proprietary items

Underground Systems

Description and Suitability: Underground systems are useful when space is limited to address WQ_V or quantity control beneath pavement, but are difficult to monitor and maintain. An example of an underground system is a subsurface sand filter (MDE # F-2), which includes a series of chambers for stormwater to pass through before entering the storm drain system. First, the runoff enters an inlet pipe and is directed to a sedimentation chamber. Then, the water is directed through a debris screen towards a sand filter chamber, which also includes a subdrain to the storm drain system. Above the sand filter is a weir wall for any overflows into the storm drain system.

Design Criteria:

- Only suitable in extremely restrictive environments
- Requires manhole access for subsurface maintenance

Maintenance Requirements:

- Periodic observation
- Clearing accumulated debris

- *Benefits:*
- Reduces ROW required
- Reduces thermal impacts on runoff

Limitations:

- Difficult to access and maintain
- Enclosed chambers do not offer any infiltration
- Tends to fail after chambers become filled with sediments and debris

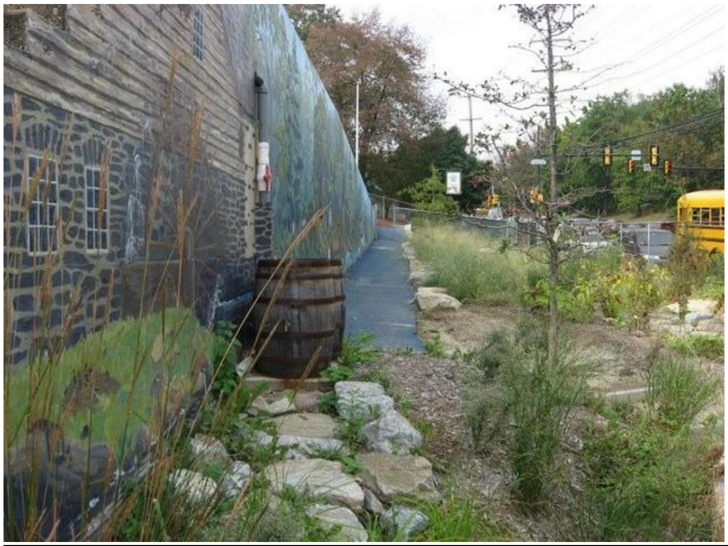
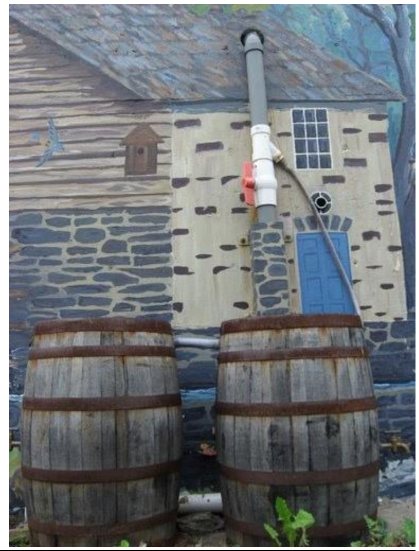
Non-Highway Facilities

The following facility types are not typically acceptable for use in roadway applications but may be applicable to site development projects such as salt barns or other vertical construction type projects. Facility types are summarized below:

- Rainwater Harvesting (MDE # M-1)
- Disconnection of Rooftop Runoff (MDE # N-1)
- Dry Wells (MDE # M-5)

Rainwater Harvesting (MDE # M-1)

Description and Suitability: Runoff from building downspouts or other drainage areas is collected in a rain barrel or cistern for later use with landscape irrigation or other non-potable water needs.

Rain Barrels collecting rooftop drainage

Design Criteria:

- Should be sized to hold at least a 1" storm event entirely within the container.
- A spillway with stabilized outflow should be added for large storm events or in instances when the container is not emptied before the next storm event.
- Install per manufacturer's recommendations

Maintenance Requirements:

- Regular emptying into pervious areas offline

Benefits:

- Reduces stormwater volumes
- Harvests water for beneficial purposes and reduces the demand on potable water sources

Limitations:

- Limited sizes often do not have capacity for large storm events or large drainage areas
- Can not be considered a reliable source of water in times of drought
- May attract birds or mosquitoes that can become a nuisance or further pollute the water
- Is susceptible to freezing, and once frozen, may not provide any attenuation of stormwater
- Overflow or spillways may become erosive if not properly maintained, used, or stabilized.

Disconnection of Rooftop Runoff (MDE # N-1)

Description and Suitability: Building rooftop drainage is collected in a downspout and often connected to the storm drain system. Disconnection of the downspout to outflow into a vegetated, pervious area reduces demands on the storm drain system and reduces pollutants entering receiving waters. Rooftop disconnection can be designed into new construction projects and retrofit projects to redirect rooftop drainage into landscaped areas or swales where it can infiltrate or dissipate. A permeable, vegetated area equal to the flow path length must be provided in the design, or additional microscale treatment measures may be required to meet the P_E requirements.

Design Criteria:

- Landscaped receiving areas should not exceed 5% slopes
- Runoff should be designed to sheetflow or be directed into other BMP treatment facilities
- Runoff should not flow with erosive force

Maintenance Requirements:

- Routine landscape maintenance
- Periodic inspection and clearing of debris

Benefits:

- Reduces stormwater volumes

- *Limitations:*
- Level spreaders may be required to dissipate flow
- Soil amendments may be needed to promote infiltration in compacted or clayey soils
- E&S controls should not be located in vegetated areas receiving runoff
- Foot traffic should be discouraged to deter future compaction

Dry Wells (MDE # M-5)

Description and Suitability: Runoff from a rooftop or small paved area is directed to an excavated pit or chamber filled with gravel where water is collected and allowed to infiltrate into the ground after storm events. The well is covered with a minimum of 12" of topsoil with vegetation and is typically not visible. The size of the well is proportional to the drainage area and infiltration capacity of the soils. Dry wells are not appropriate for large drainage areas and should be designed to capture and store the ESD_V.

Design Criteria:

- Use with HSG Type A or B soils only
- Include an observation well
- Requires setbacks from building foundations, septic systems, and water supply wells.

Maintenance Requirements:

- Periodic inspection

Benefits:

- Inconspicuous design blends into the landscape

Limitations:

- Not appropriate for HSG Type C or D soils
- Setback requirements limit applications in dense, urban environments
- Siltation within the well can cause ponding and structural failure

Appendix A - Glossary of Terms

GLOSSARY OF TERMS

Airport Zoning District: Area within which land uses, obstructions, and wildlife attractants that are incompatible with airport operations are prohibited.
Baffle: A peninsula-like land feature used to extend water flow within a pond facility
Bench: A flat area along a slope following contour lines
Bioretention Areas: Shallow depression filled with sandy soil, topped with a thick layer of mulch, and planted with dense vegetation that uses soil, plants and microbes to treat stormwater before it is infiltrated or discharged.
Best Management Practices (BMP): Control measures taken to mitigate changes to both quantity and quality of urban runoff caused through changes to land use.
Cellular Confinement System: A honeycomb-like structure that is filled with sand, soil, rock or concrete for erosion control, soil stabilization, flexible channel linings, load support and earth retention.
Channel Protection Volume (CPv): The volume used to design structural management practices to control stream channel erosion.
Coastal Bay: Assawoman, Isle of Wight, Sinepuxent, Newport, and Chincoteague bays.
Dry Swales: An open structure of moderate width and gentle side slopes that removes pollutants while also conveying stormwater.
Emergency Spillway: An open channel that is constructed beside an embankment to convey flows that are greater than the principal spillway's design discharge at a non-erosive velocity to an adequate channel.
Environmental Site Design (ESD): A land planning and engineering design approach to managing stormwater runoff that emphasizes use of on-site natural features and a watershed approach to protect water quality.
Environmental Site Design Volume (ESDv): A calculation for runoff volume used with ESD practices encompassing both water quality, quantity, and recharge volume.
Environmental Stewardship: Activities undertaken to improve the quality of the existing environment.
Evapotranspiration: A term used to describe the sum of evaporation and plant transpiration from the Earth's land surface to atmosphere.
Filter Strips: Vegetated areas situated between surface water bodies and cropland, grazing land, forestland, or disturbed land where sediment, organic material, nutrients and chemicals can be filtered from runoff.
Flow Path: The direction of water moving through a wet basin from the forebay to the outfall.
Forebays: A small pool located near the inlet of a storm basin or other stormwater management facility designed as an initial storage area to trap and settle out sediment and heavy pollutants before they reach the main basin.
Frequently Fluctuating Zone: The area between the permanent water surface and the 10-year water surface elevation.
Grass Channels: Vegetated open channels designed to filter stormwater runoff.
Green Infrastructure: Strategically planned and managed networks of natural lands, working landscapes and other open spaces that conserve ecosystem values and functions and provide associated benefits to human populations.

Head/Endwalls: The vertical wall face of a culvert.
Herbaceous Plantings: Plantings that have leaves and stems that die down at the end of the growing season to the soil level. They have no persistent woody stem above ground.
Hydrologic Soil Group (HSG): A group of soils having similar runoff potential under similar storm and cover conditions.
Hydrology: The movement, distribution, and quality of water throughout Earth.
IFB: Invitation for Bids, a book advertising a construction project
Infiltration Basin: A shallow artificial pond that is designed to infiltrate stormwater though permeable soils into the groundwater aquifer.
Infiltration Rate: A measure of the rate at which soil is able to absorb rainfall.
Infiltration Trench: An excavated trench backfilled with a stone aggregate, and lined with filter fabric used to remove suspended solids, particulate pollutants, coliform bacteria, organics, and some soluble forms of metals and nutrients from storm water runoff.
Inlet Structure: The structure that empties storm water into the stormwater management facility.
Liner: An impervious layer provided in a stormwater management facility to inhibit ground water infiltration. Liners are typically used in locations with contaminated soil or karst topography.
Low-Impact Development (LID): A land planning and engineering design approach to managing stormwater runoff that emphasizes conservation and use of on-site natural features to protect water quality.
Offline: An area outside the direct flowpath of channelized water flow.
Online: The area within the direct flowpath of channelized water flow.
Outfall Riser: A box-like structure that controls water level and has an opening above the permanent water surface elevation to serve as an emergency overflow device during heavy storm events.
P_E: A precipitation or rainfall target used in various facility sizing calculations.
Permanent Pool Elevation: The anticipated water level in a wet stormwater management pond under typical conditions.
Rain Garden: A common name for a bioretention facility, often without a subdrain system.
Riprap: Rock or other material used to armor shorelines, streambeds, bridge abutments, pilings and other shoreline structures against scour, water or ice erosion.
Scenic Byways: Roads recognized by the State of Maryland as Scenic Byways based on significant archaeological, cultural, historic, natural, recreational, and/or scenic qualities.
Sediment Basins: A temporary pond built on a construction site to capture eroded or disturbed soil that is washed off during rainstorms, and protect the water quality of a nearby stream, river, lake, or bay.
Soil Stabilization Matting: A geotextile fabric laid down on the ground surface to prevent run-off from eroding soils.
Stormwater Outfall Structures: Any structure (man-made or natural) where stormwater from highways is conveyed off of the right-of-way into receiving waters.
Surface Sand Filter: A filtration system for runoff that consists of a pretreatment basin, a water storage reservoir, flow spreader, sand, and subdrain piping that is

intended to address the spatial constraints that can be found in intensely developed urban areas where the drainage areas are highly impervious.

Subdrain: A drain, installed in porous fill, for drawing off surface water or water from the soil, as under the slab of a structure.

Water Quality Volume (WQv): Calculation of the total treated volume required to achieve the remediation of post development pollutant loads, particularly for sediment or suspended solids.

Watershed Approach: An approach for making sound infrastructure and growth decisions within the context of how water flows through a watershed. Water quality improvements are targeted for areas where they will provide the greatest benefit within the watershed.

Weir Structure: A small overflow-type dam commonly used to raise the level of a river or stream.

Wet Swales: A grassed open channel consisting of a broad open channel capable of temporarily storing water.