Environmental Site Design Criteria for the Maryland Critical Area

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List of Acronyms

CAC	Critical Area Commission
CDA	Contributing Drainage Areas
CIDA	Contributing Impervious Drainage Area
CSN	Chesapeake Stormwater Network
ESC	Erosion and Sediment Control
ESD	Environmental Site Design
EMC	Event Mean Concentration
GIS	Geographic Information System
HSG	Hydrologic Soil Group
IC	Impervious Cover
IDA	Intensely Developed Area
LDA	Limited Development Area
MDE	Maryland Department of Environment
MEP	Maximum Extent Practicable
NRCS	Natural Resources Conservation Service
Pe	ESD Target Volume
RCA	Resource Conservation Area
RCN	Runoff Curve Number
SA	Surface Area
TP	Total Phosphorus
TMDL	Total Maximum Daily Load
WQv	Water Quality Volume

Part 1
Introduction

The Chesapeake Bay Critical Area Protection Act was originally enacted in 1984 by the Maryland General Assembly to help reverse the deterioration of the Chesapeake Bay and the surrounding environment. In 2002, the Act was amended to add the Atlantic Coastal Bays to the area protected by the Critical Area regulations. The Act was amended again in 2008 to strengthen its provisions to protect water quality and habitat. A summary of the new provisions can be found at www.dnr.state.md.us/criticalarea/guidancepubs/052008overviewofhousebill1253.pdf.

The Critical Area Protection Act is designed to promote environmentally sensitive stewardship of land and water resources in the Critical Area. It addresses three principal concerns: minimizing adverse impacts on water quality that result from pollutants that are discharged from structures or conveyances or that have run off from surrounding lands; to conserve fish, wildlife and plant habitat; and to accommodate future growth in the most environmentally protective means possible. More detailed information about the Critical Area Act and the local Critical Area regulations designed to preserve and protect the Chesapeake Bay and the Atlantic Coastal Bays can be found online at: www.dnr.state.md.us/criticalarea.

1.1 The Maryland Critical Area and Buffer

The Maryland Critical Area is defined as all land and water areas within 1,000 feet of the landward boundary of tidal waters or tidal wetlands. It also includes the waters of and the lands under the Chesapeake and Atlantic Coastal Bays. The Critical Area Law and Regulations apply to 16 counties, Baltimore City, and 47 municipalities surrounding Maryland's tidal waters. Each locality must implement a land use and resource protection program that is designed to minimize the damaging impact of water pollution and loss of natural habitat, while also accommodating the jurisdiction's future growth. The Critical Area was created with the recognition that land use immediately adjacent to the Bay and its tributaries has the greatest potential to influence water quality and natural habitats.

Since 1986, Critical Area regulations have required a minimum Buffer of 100 feet of natural vegetation extending landward from the Mean High Water Line of tidal waters or the edge of tidal wetlands and tributary streams. The Buffer is critical for habitat protection and water quality enhancement, and acts as a transition zone between human disturbance and sensitive land and water resources. The Buffer also acts as a filter for the removal or reduction of sediment, nutrients, and toxic substances that enter adjacent waterways in land runoff.

In 2010, the Critical Area Commission issued new regulations for the Critical Area Buffer; a synopsis can be found at www.dnr.state.md.us/criticalarea/pdfs/LGAG_BR0210.pdf. Most notably, the new regulations now specify how Buffers are to be established in forest vegetation and provide clearer rules on Buffer management, mitigation and enforcement. Further, a minimum 200-foot Buffer is now required for all new subdivisions or site plans within the Resource Conservation Area (RCA).

The Critical Area Buffer may be disturbed only for certain activities, such as water-dependent structures, access to the shoreline, and shore erosion control measures. Also, agricultural activities are permitted within the Buffer under special guidelines. In general, cutting or clearing of trees, except those that are diseased or damaged, is not permitted within the Buffer. A Buffer Management Plan, approved by the local government, can be used to allow for reasonable access to the water, for the removal of invasive species, and for enhancement of the Buffer. Overall, the Buffer should be maintained in natural forest vegetation and must be expanded to include adjacent sensitive resources, such as steep slopes, and hydric or highly erodible soils.

No other types of development or other land disturbances are permitted in the Buffer (e.g., swimming pools, tennis courts, structures, stormwater management structures, and septic fields). If such activities are proposed within the Buffer, the property owner is required to request a variance from their local jurisdiction that both demonstrates unwarranted hardship and proves that the project will not have a negative impact to water quality, plant, fish, or wildlife habitat.

1.2 Evolution of Stormwater Management in the Critical Area

The Critical Area has three primary land use overlay zones: Resource Conservation Areas (RCA), Limited Development Areas (LDA), and Intensely Developed Areas (IDA). *Intensely Developed Areas* are dominated by residential, commercial, industrial, and institutional land uses (at the time of the original Critical Area mapping) and possess relatively little natural habitat. IDAs are also considered the preferred locations for future growth through redevelopment and/or new development.

The original criteria developed under the Critical Area Act required that any development within the IDA be accompanied by practices to reduce water quality impacts associated with stormwater runoff. The Criteria further specified that these practices must be capable of reducing stormwater pollutant loads from a development site to a level at least 10% below the load generated by the same site prior to development. This requirement is commonly referred to as the “10% Rule.”

The Critical Area Commission published a guidance document in 1987 to provide a consistent approach to compliance with the 10% Rule (MWCOG, 1987). This document was revised in 1993 and then again in 2003 to reflect changes in stormwater science, treatment technology and state regulations and design manuals (CAC, 2003). The new stormwater criteria presented in this edition apply to all new and redevelopment projects in all three land use overlay zones in the Maryland Critical Area.

The responsibility to review Critical Area stormwater criteria is delegated to each local government for most projects, although there is a subset of projects which must also be submitted to the Critical Area Commission staff.

Over the past decade, stormwater management has evolved dramatically in Maryland, both in terms of the overall strategies to treat stormwater and the most effective types of stormwater Best Management Practices (BMPs). In 2009, the Maryland Department of the Environment (MDE) revised the 2000 Maryland Stormwater Design Manual, Vol. I & II to reflect the use of environmental site design (ESD) practices. The revised Maryland Stormwater Design Manual can be accessed online at: http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp

1.3 Why the New Edition was Created

This new edition replaces the CAC (2003) stormwater guidance manual and Appendix D.4 of MDE (2000). It is intended to streamline and improve compliance with both the phosphorus removal standard and the new environmental site design regulations. Consequently this new edition seeks to integrate compliance with both stormwater requirements in a single spreadsheet compliance tool. This edition also reflects improvement in our scientific and engineering understanding of stormwater management over the last decade. The goal of this edition is to ensure that runoff from development projects in the Critical Area does not represent an additional nutrient load to the Chesapeake Bay, as defined under Maryland's nutrient allocation under the Bay-wide nutrient TMDL (MDE, 2010).

1.4 What's New in the 2011 Edition?

- To be consistent with new state-wide ESD requirements, *the phosphorus removal performance standards apply to all projects with more than 5000 square feet of disturbance in all three overlay zones in the Critical Area -- Resource Conservation Areas (RCA), Limited Development Areas (LDA), and Intensely Developed Areas (IDA).* Any development within these three overlay zones must be accompanied by ESD practices to reduce water quality impacts associated with stormwater runoff.

- The stormwater phosphorus removal performance standard for the Critical Area has been enhanced and refined. *The standard is now expressed in terms of a maximum acceptable annual phosphorus load of 0.3 pounds per acre for new development projects in the Critical Area.* The new performance standard ensures that phosphorus loads from new development in the Critical Area will meet water quality standards in the Maryland portion of the Chesapeake Bay, as derived for the Bay-wide TMDL (MDE, 2010). The new standard also reflects a factor of safety to account for the close proximity of the Critical Area to the waters of the Chesapeake Bay. The technical basis for the new standard is documented in Appendix B. The practical implication for communities is that new development projects that meet the performance standard in the Critical Area will not add to their nutrient reduction liability under their local watershed implementation plans.

- The Critical Area phosphorus removal standard is triggered automatically by the spreadsheet once the proposed impervious cover for a site exceeds 10% (note: sites with less impervious cover are still subject to MDE ESD requirements). Phosphorus removal requirements become progressively more stringent as site impervious increases, with a maximum TP removal requirement of 85% at the most intensively developed sites (i.e., 100% impervious cover --IC).

- This edition also establishes a two-track plan review process that distinguishes between very small projects (250 to 5000 square feet of site disturbance) and the larger projects (5000 or more square feet of site disturbance that trigger the new MDE ESD stormwater requirements). *This edition applies to all development projects above 5000 square feet in the Critical Area.* Another guidance document is currently being developed to streamline the review of very small development projects.

- This edition adopts a definition for redevelopment that is consistent with the more stringent MDE ESD stormwater regulations. *The key change is that the threshold at which a project is classified as redevelopment increases to 40% pre-existing impervious cove*r (compared to the 15% impervious cover threshold proposed in CAC, 2003).

- This edition also integrates the site analysis of predevelopment hydrologic soil groups to better conform to the state-wide methods and equations prescribed for ESD to the MEP compliance (MDE, 2009). The permeability of predevelopment soil types at a development site determines the magnitude of the target volume that must be treated by ESD practices. Soil properties also govern which ESD practices are feasible at a given site, and can strongly influence the phosphorus removal rate they can achieve.

- For the sake of consistency, *this edition uses the same nomenclature and practice names as outlined in the new state-wide ESD regulations and stormwater manual*. New phosphorus removal rates were developed to conform to the new list of ESD practices (see Appendix A). In some cases, designers need to meet criteria that are more stringent than the new MDE stormwater manual in order to achieve the highest removal rate.

- This edition and the accompanying spreadsheet presents “design level” approach for estimating the phosphorus removal capability of certain stormwater practices, based on a two-tiered design approach in the Critical Area. *A practice designed to Level 1 achieves a lower phosphorus removal rate than the more stringent Level 2 designs*.

- In general, Level 1 design equates to the minimum design criteria for ESD practices, as outlined in MDE (2009). Level 2 design includes an enhanced list of design features known to maximizes phosphorus removal, and, consequently, earn a higher phosphorus reduction rate. The technical basis for the two design levels are outlined in CWP and CSN (2008). The specific phosphorus removal rate and required design elements differ for each practice: more detailed Level 1 and 2 design criteria can be found in Section 4.

- This edition presents two new non-structural ESD credits that can be used at Critical Area development sites -- *impervious cover conversion and natural area reforestation*. In addition, several new design criteria are presented for existing MDE ESD credits to ensure they perform effectively in the Critical Area.

- The edition also provides expanded design guidance for alternative surfaces, micro-ESD practices, and ESD practices. *It explicitly recognizes that infiltration, dry swales and regular bioretention areas are acceptable ESD practices to use in the Critical Area*. In addition, this edition treats green roofs and permeable pavements as micro-ESD practices rather than alternative surfaces, which provides greater flexibility in applying these innovative practices. The expanded design guidance also promotes more reliable phosphorus removal, and is specifically adapted to withstand the unique conditions and constraints of the Maryland Coastal Plain (CSN, 2008).

- This edition *is linked to an accompanying spreadsheet tool that simultaneously allows designers to track their environmental site design and phosphorus removal requirements*. The spreadsheet should be used for all development projects that disturb more than 5000 square feet in the Critical Area. The spreadsheet enables designers to quickly find the most cost-effective combination of ESD practices that can comply with both laws.

- The compliance spreadsheet replaces the paper worksheets first introduced in CAC (2003). The spreadsheet automatically computes both the ESD target volume and TP removal requirements, and then shows incremental reductions achieved by various combinations of non-structural ESD credits, alternative surfaces, micro ESD practices and conventional structural practices. Part 3 of this document provides further detail on how to use the spreadsheet, in the context of the Critical Area phosphorus removal performance standard.

- This edition also clarifies *the conditions under which ESD practices can or cannot be used in the 100 foot Critical Area Buffer.*

- The new edition acknowledges that *sea-level rise will affect the location of stormwater infrastructure in the Critical Area,* and proposes several adaptive engineering criteria with respect to the elevation of stormwater outfalls and ESD practices relative to mean high water line.

- Finally, the new edition updates the 2003 CAC guidance for setting offset fees or allowing off-site restoration in the event that full compliance is not possible under the phosphorus removal standard. Part 5 presents *an updated offset fee structure and qualifying criteria for off-site restoration projects.*

Part 2
Standard Critical Area Stormwater Design Review Policies

Over the last 25 years, a series of recurring plan review issues have arisen when local planners evaluate stormwater plan submittals in the Critical Area. This section presents standard design review policies to resolve these issues, which should reduce conflicts between the designer and plan reviewer during the approval process.

2.1 To Whom Do You Submit Your Critical Area Stormwater Plan?

Traditionally, a stormwater plan is either reviewed by the local Critical Area planning authority or the engineering review staff in the Department of Public Works (who is also responsible for ensuring state-wide ESD compliance). Applicants should consult with their local jurisdiction to determine where to submit their Critical Area stormwater plan. It is now possible to consolidate the local stormwater review process within a single review agency that checks for compliance with the "ESD to the MEP" requirement and the Critical Area phosphorus removal standard.

The following table lists those projects which are required to be sent to the Critical Area Commission via the local jurisdiction which will require stormwater calculations. This is not an exhaustive list of required project submittals but rather only those which have a stormwater component. The complete listing of projects required to be submitted to the Commission for review can be found in COMAR 27.01.03.

Table 1
Projects Requiring Stormwater Submittals to the Critical Area Commission

	Type of Application	IDA	LDA	RCA
1.	Variance from Critical Area provisions	Y	Y	Y
2.	Development of less than 5000 square feet of disturbance- (outside of any Habitat Protection Area)	N	N	N
3.	Development of between 5,000 and 15,000 square feet of Disturbance (outside of HPA)	N	N	Y
4.	Development resulting in greater than 15,000 square feet of disturbance	Y	Y	Y
5.	Subdivision of 3 lots or fewer	N	N	Y
6.	Subdivision of 4 to 10 lots	N	Y	Y
7.	Subdivision of greater than 10 lots	Y	Y	Y
8.	Subdivision affecting growth allocation	N/A	Y	Y
9.	Intra-family transfer	N/A	N/A	Y

Under the new ESD regulations, stormwater plans must be submitted for review during three stages of site plan review: the concept plan, the preliminary plan and the final plan. It is strongly recommended that the phosphorus removal spreadsheet computations and ESD plans should be submitted and reviewed concurrently in each stage of local stormwater plan review.

2.2 What are the Rules for Measuring Impervious Cover?

The degree of phosphorus removal required at a development site is strongly influenced by the amount of post-development impervious cover (IC). Therefore, it is extremely important to accurately measure IC when preparing Critical Area stormwater plans.

Table 2 Defining Impervious Cover in the Maryland Critical Area

Land Cover	Material	Is it Impervious?	Counts Toward Lot Cover?
Roads & Parking Lots	Concrete, asphalt, dirt, gravel or oyster shell	Yes	Yes
Driveways	Concrete, asphalt, dirt, gravel or oyster shell	Yes	Yes
Sidewalks/Path	Concrete, asphalt, dirt, gravel or oyster shell	Yes	Yes
Sidewalks/Path	Woodchip	No	No
Buildings	All Roof Surfaces	Yes	Yes
Rooftop	Green Roof	No [2]	Yes
Permeable Paver	Concrete, Asphalt or Pavers	No [2]	Yes
ESD practices	MDE (2009)	No	No
Conventional Structural Practices	MDE (2000)	No	No
Decks	Pervious Design [1]	No	No
Decks	Impervious Design	Yes	Yes
Swimming Pools and Landscaping Ponds		Yes	Yes
Bridges or marine facilities over open water		Yes	Yes

1. The deck is constructed with gaps between the boards and, instead of a concrete pad, a sloping gravel bed is placed under the deck to allow stormwater to infiltrate into the soil. Sheet flow from deck runoff can be insured and erosion reduced by the placement of a gravel bed with vegetative stabilization
2. It is initially entered as impervious cover in Step 2, but the spreadsheet automatically computes the effect of these alternative surfaces in reducing runoff volumes for the site

Impervious cover is broadly defined as those surfaces in the landscape that impede the infiltration of rainfall and result in an increased volume of surface runoff. As a simple rule, all surfaces that are not vegetated will be considered impervious. Impervious surfaces include roofs, buildings, paved streets and parking areas and any concrete, asphalt, compacted dirt or compacted gravel surface. Table 2 provides more detail on what surfaces are classified as impervious or not.

The following policies pertain to the measurement of impervious cover:

- Existing and proposed impervious cover must be measured directly from the most recent and accurate site plan. The use of a planimeter is recommended.
- In addition, the specific contributing impervious drainage area (CIDA) to each ESD credit and/or practice should be delineated on the ESD concept plan.
- Estimates of impervious cover based on general land use type or hydrologic modeling programs are not allowed for submission (e.g., TR-55).
- If land is subdivided prior to construction, it is recommended that the applicant complete the compliance spreadsheet at the time of initial subdivision for lots with an average density of one acre or less, with imperviousness calculated using maximum building envelopes and proposed road layouts.

2.3 How do Permeable Pavement or Green Roofs Affect Your Site IC Footprint?

Prior to 2008, sites within the Critical Area's Limited Development Area (LDA) and Resource Conservation Area (RCA) were limited to a maximum of 15% impervious cover. Impervious surfaces could generally be defined as those man-made surfaces that do not allow stormwater to be infiltrated into the soil. However, certain types of materials were granted a percentage of pervious cover if they provided some degree of infiltration (e.g., pervious pavers). Often, the use of these types of materials created scenarios where individuals could greatly expand the footprint of development on a site. As a result, in 2008 the Commission amended Natural Resources Article §8-1808 to change the term "impervious surface" to "lot coverage" in order to limit the footprint of development on properties designated as LDA and RCA. Lot coverage is now defined as follows:

"Lot Coverage" means the percentage of a total lot or parcel that is:

1. Occupied by a structure, accessory structure, parking area, driveway, walkway, or roadway; or
2. Covered with gravel, stone, shell, impermeable decking, a paver, permeable pavement, or any manmade material.

Lot coverage does not include:

1. A fence or wall that is less than one foot in width that has not been constructed with a footer;
2. A walkway in the Buffer or expanded Buffer, including a stairway, that provides direct access to a community or private pier (local governments shall ensure that impacts to the Buffer associated with access are minimized);
3. A wood mulch pathway; or

4. A deck with gaps to allow water to pass freely.

The Critical Area commission has also adopted the following definitions to clarify the review process:

> *Impermeable decks* - Lot coverage includes the ground area covered or occupied by an impermeable deck, even when that deck is not directly touching the ground surface.
>
> *Stairways* - Lot coverage does not include walkways or stairways in the Buffer that provide direct access to a community or private pier. All other stairs or walkways count.
>
> *Stormwater management and erosion control measures* - Lot coverage does not include these practices when they are approved only for the specific purpose of performing stormwater management or erosion control.

The 2008 Critical Area amendments specify that lot coverage may not exceed 15% within the Limited Development Area (LDA) and Resource Conservation Area (RCA). Designers frequently ask whether this threshold can be exceeded if alternative surfaces such as green roofs or permeable pavers are used. The policy of the Critical Area Commission is that while these practices are encouraged to meet stormwater requirements, they **cannot** be used to increase the site lot coverage footprint.

2.4 How do you define limits of disturbance for new and redevelopment projects?

The project area subject to both Critical Area and ESD stormwater requirements is defined as the area bounded by the limits of disturbance (i.e., any area subject to clearing, grading, excavation or stockpiling activities during all stages or phases of site development). This definition applies to both new and redevelopment projects.

In general, the Critical Area Buffer and other "down-gradient" natural conservation areas are protected by locating them outside the limits of disturbance. Therefore, the site area devoted to the Critical Area Buffer and related natural areas can be excluded from the analysis of the phosphorus removal standard.

2.5 What are rules for working in the Critical Area Buffer?

The Critical Area Buffer is strictly protected from disturbance to maintain its habitat and water quality functions. Therefore, it can only be disturbed for limited activities such as water-dependent structures, access to the shoreline, and for the installation of shore erosion control measures.

- The general rule is that stormwater treatment practices are not permitted within the 100-foot or expanded Buffer

- Stormwater pipes and outfalls are allowed to cross the Buffer, since they are considered to be water-dependent facilities. Outfalls must discharge to open water but be located at least one foot above the mean high water line to account for extreme tides and future sea level rise. The size and capacity of stormwater pipes should be minimized by using ESD practices to the maximum extent possible. Large diameter stormwater outfall pipes are normally a sign of a poor stormwater plan.
- In limited circumstances, it may be permissible to construct regenerative conveyance wetlands (also known as Coastal Plain Outfalls) for restoration purposes within the Buffer if there is an existing erosion problem around a stormwater outfall or within a stream valley. These proposals are considered on a case-by-case basis.
- The Critical Area Buffer cannot be used for disconnection purposes (rooftop, non-rooftop, or sheet flow to conservation areas) unless there is a minimum 75-foot distance between the closest impervious surface to the landward edge of the 100-foot Buffer.
- In portions of the Buffer which have been designated as Buffer Exemption Areas (also known as Modified Buffer Areas, Buffer Management Areas or Special Buffer Areas), there may be certain ESD practices that are permitted within the Buffer. Generally, acceptable practices must be vegetated (i.e., bioretention areas, rain gardens and landscape infiltration) with a mix of native trees, shrubs and ground covers that replicate natural plant communities while still providing effective runoff reduction and pollutant removal.
- If a Buffer currently lacks forest cover, stormwater credits may be obtained if it meets qualifying conditions for soil restoration and reforestation, as outlined in Section 4.1. The use of native species adapted to the coastal plain is required. A guide to recommended species can be found at http://www.nps.gov/plants/pubs/chesapeake/pdf/chesapeakenatives.pdf.

2.6 Where do you get data on hydrologic soil groups present at your site?

The new ESD regulations require that the hydrologic soil groups present at the site must be mapped to determine the ESD target volume. This information is readily available from the Natural Resources Conservation Service, which publish soil surveys in both hard copy and on-line editions. Please consult the following url to determine the soils data available in your community.

http://soils.usda.gov/survey/printed_surveys/state.asp?state=Maryland&abbr=MD

The most convenient format are the web-based soil surveys that make it easy to analyze soil properties using a GIS format. More information on how to use the web soil survey can be found at:

http://websoilsurvey.nrcs.usda.gov/app/Help/WSS_HomePage_HowTo.pdf
If soils are classified as urban fill or equivalent (e.g., urban land, cut and fills, or made land), they should generally be assigned to hydrological soil group "D", which has the greatest runoff response (CSN, 2011). Designers also have the option of conducting on-

site soil tests to determine the appropriate HSG using the soil testing methods outlined in Appendix E of NJDEP (2009). If testing indicates the soils have acceptable infiltration rates throughout the entire soil profile and there are no signs of suspicious materials, then the site can be considered suitable for infiltration. If the soil tests are negative, then infiltration should be avoided.

Infiltration is prohibited in cases where a site history investigation indicates that the redevelopment site is a brown-field (US EPA, 2008). Contaminated soils should be capped and stormwater practices should treat surface runoff in a "closed" system which does not allow any interaction with groundwater. This typically involves the use of stormwater filtering practices such as sand filters and bioretention that have impermeable bottom liners. Designers should also avoid infiltration at sites that are expected to become severe stormwater hotspots.

2.7 How do you deal with projects that split the Critical Area boundary?

Many development projects cross the boundary of the Critical Area, such that portions of the site are subject to the phosphorus removal performance standard and others are not. In the past, this situation required special paper worksheets to split the site that perplexed designers and reviewers alike.

While it is still a local call, it is now strongly recommended that the phosphorus removal calculations be performed **for the site as a whole.** The rationale is that the entire site must meet the ESD to MEP standard, and in doing so, may be sufficient to also meet the phosphorus removal standard. In the rare cases where this is not possible, the designer may elect to enter site data for the Critical Area portion of the site into the spreadsheet to see if compliance can be achieved in that manner.

2.8 How do you handle off-site runoff to your project from another property?

Some projects receive additional stormwater runoff from off-site properties. In general, applicants are not required to treat this runoff to the meet the phosphorus removal standard, although they should ensure that their drainage system and ESD practices have sufficient capacity to safely convey this upstream runoff during the ten year storm event without erosion.

A designer may elect to treat some or all of the off-site runoff on their property in order to meet their own phosphorus removal requirement. This can be documented by using the spreadsheet to determine their on-site phosphorus removal requirement, and then running the spreadsheet a second time using the inputs for the off-site drainage area (and proposed treatment areas) to calculate the total load reduction. The offsite load reduction can then be compared to the on-site removal requirement to determine if compliance has been achieved.

2.9 What constitutes a direct stormwater discharge to tidal waters, and does it exempt the need for channel protection storage?

The 2000 MDE stormwater manual waives channel protection storage requirements in situations where stormwater directly discharges to tidal waters. The rationale at the time was that the erosive energy of urban stormwater does not come into play in tidal waters. The 2000 manual also specifically exempted Eastern Shore counties from the channel protection requirement (although they are now subject to higher ESD volumes as a result of the new ESD regulations, which provide some form of channel protection).

It is important to note that the Western shore projects are not exempted from the channel protection requirement unless they can demonstrate that the stream channel to which they directly discharge to is tidal in nature.

Direct discharge is defined in the Code of Maryland Regulations 26.17.02.02(12) as "the concentrated release of stormwater to tidal waters or vegetated tidal wetlands from new development or redevelopment projects in the Critical Area." In addition, under COMAR 26.24.01.02 "Filling" (of tidal waters or wetlands) includes "storm drainage projects which flow directly in tidal waters of the State." Thus, a tidal wetland permit must be applied for from MDE's Tidal Wetlands Division for any direct stormwater discharge, unless the peak discharge rate is less than 2.0 cfs for the one year storm event.

Both designers and plan reviewers have struggled with the interpretation of what constitutes a direct discharge and what is the receiving channel. The current policy of the Critical Area Commission is as follows:

- A direct discharge occurs when a storm drain pipe or ESD outflow discharges to a point no more than 50 lateral feet from tidal water, and at an invert elevation no higher than two feet above the mean high tide line.
- All other stormwater discharges on the Western shore must meet the entire calculated P_e volume to satisfy the channel protection requirement
- Projects on the Eastern shore must still treat their entire calculated P_e volume with acceptable ESD practices.

2.10 How close to you need to be to meet the phosphorus removal performance standard?

Full compliance may be hard to achieve at new development sites with high impervious cover or at high intensity redevelopment projects. Plan reviewers often ask how close to the phosphorus load removal requirement a project needs to be in compliance.

Given the inherent uncertainties associated with the spreadsheet, it is not appropriate to rely on them to more than one significant digit. Consequently, if a project is shown to be within 0.1 pounds per acre per year of the removal requirement, the site can be considered to be compliant.

2.11 How does this guide compare to the MDE stormwater manual?

This document expands on the guidance presented in MDE (2009) for the sizing and design of ESD practices. Within the Critical Area, this document supersedes MDE with respect to design criteria for the following practices:

- The design standards for certain ESD credits are more stringent than the MDE manual to assure reliable phosphorus removal.
- Two new ESD credits for reforestation and impervious cover conversion are now available within the Critical Area.
- Design standards have been adopted for ESD micro-practices in the Critical Area that expand on the guidelines proposed in MDE (2009).
- A more flexible design approach has been developed to size green roofs and permeable pavements.
- Due to their proven runoff reduction capability, infiltration, dry swales and bioretention practices are all considered acceptable ESD practices within the Critical Area.
- A new two-tier design standard has been adopted for conventional stormwater practices as outlined by MDE (2000) to assure proper phosphorus removal credit.

Localities may elect to use the Critical Area design criteria throughout their jurisdiction, or wait for the next edition of the MDE stormwater manual.

Part 3
The Critical Area Spreadsheet Tool

The ESD to MEP spreadsheet tool was developed, tested and refined during 2010 to allow designer engineers and local plan reviewers to evaluate compliance with the new ESD regulations and phosphorus removal performance standard. Version 3.0 of the spreadsheet, released in May 2011, enables the user to track phosphorus reductions and ESD volume reductions at new and redevelopment projects within both the State of Maryland and the Critical Area.

These phosphorus calculations have been integrated within the new ESD to MEP framework, which provides, for the first time, a unified basis for addressing both the MDE and Critical Area stormwater regulations in a single tool. This tool should help streamline project review and reduce the need for duplicate submittals. The spreadsheet is only needed for Critical Area projects with a minimum threshold of 5000 square feet or more of disturbed area. The reader should consult the entire user's guide (CSN, 2010, www.chesapeakestormwater.net); the ensuing section describes how to apply it to satisfy the Critical Area phosphorus removal performance standard.

3.1 Getting Started

The first step is to consult with your local Critical Area planning authority to determine whether your development project lies in all or part of the 1000 foot Critical Area Zone. A map of the Critical Area for each County can also be found online at the Maryland Environmental Resources and Land Information Network (MERLIN) website (http://mdmerlin.net/). Please note that the maps found on MERLIN are for guidance purposes only. You still must consult with your local Critical Area planning department to officially verify whether your site is located within the Critical Area.

If your project is located within the Critical Area, the next step is find out which local agency to submit your Critical Area stormwater plan. This local agency may not always be the same agency that reviews your ESD stormwater plan. Several tasks should be conducted prior to using the spreadsheet including a site reconnaissance visit and an analysis of environmental mapping features. The minimum environmental and site mapping data needed are outlined on page 5.7 of MDE (2009), and localities often have additional mapping requirements. The importance of early stormwater planning and analysis cannot be over-emphasized, as early decisions about site layout and the development footprint can make it much easier to comply with the phosphorus removal standard.

In particular, designers thoroughly understand the pre-development flow paths, hydrology, soils and environmental features present and work with them to layout the ideal development footprint and locate the best sequence of ESD practices.

As a general rule, designers should split the site up into logical drainage areas of 3 to 5 acres or less, and try to maintain natural flow paths. Designers should focus on the most permeable soils at the site that can be exploited for ESD practices. The product of this effort is a draft site plan that shows the proposed development foot print, impervious cover areas, protected natural areas, pervious areas and basic soils information.

3.2 Users Guide for the ESD to MEP/Critical Area Spreadsheet

The spreadsheet is large and complex and can certainly be intimidating to first time users. In reality, however, there are only a handful of inputs to prepare and enter. With a bit of practice, the spreadsheet is easy to use in the Critical Area, once you understand a few of its key aspects:

- Most of the Critical Area TP reduction calculation outputs are on the extreme right hand side of the spreadsheet, and will not be visible when the spreadsheet is opened. They can be found by scrolling about ten columns to the right.

- Most of the key spreadsheet inputs are located on the left hand side of the spreadsheet, and are clearly shown as blue cells.

- For most projects, designers will need to follow an iterative process and it may take several tries before you successfully comply. The trick is to keep track of your incremental progress in phosphorus reductions at several key cells in the spreadsheet, which are identified later in this section.

- Designers should seek to apply some kind of ESD or credit or practices to all of the impervious cover present at the site.

- The equations in the spreadsheet are locked so they cannot be changed by the user.

The remainder of this section provides a step by step guide on how to analyze ESD practices in the context of the spreadsheet, and provides general advice for designers and plan reviewers on how to most efficiently comply with the phosphorus removal standard.

Step 1: Complete ESD Planning Checklist

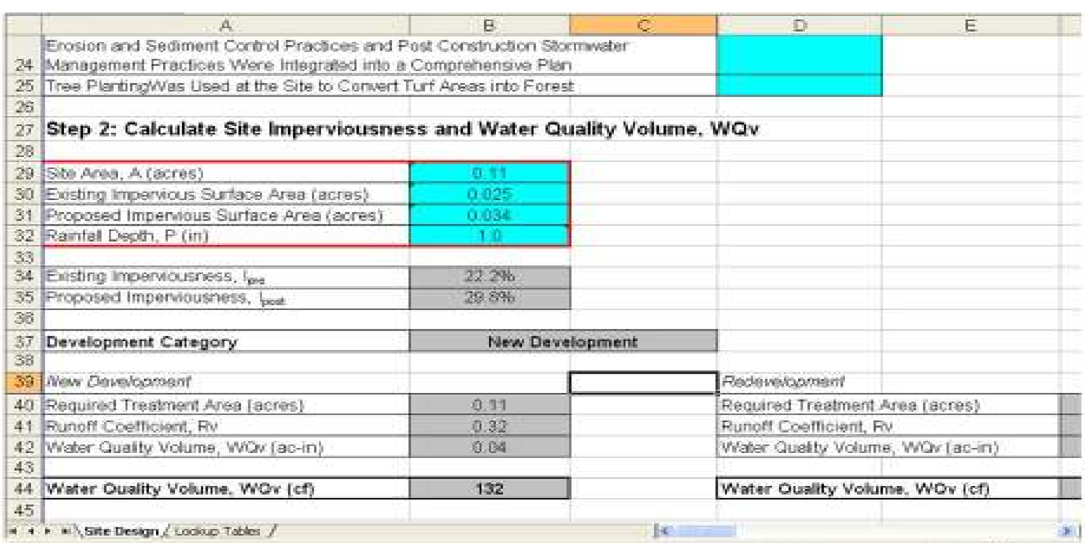
In the first step, designers analyze environmental and soil maps to layout the site and maximize utilization of ESD practices. Designers are asked to answer 12 questions in Table 3 to determine whether they have maximized these early stormwater opportunities. The basic idea is that a compliant concept plan has a “Yes,” or “N/A” selected for each question.

It is recommended that designers clearly show these practices on their stormwater concept plan. In the case that a question is answered “No”, the designers must provide a narrative justification as to why the practice could not be used on the project.

Table 3. ESD Implementation Checklist			
Check all of the Following ESD Practice That Were Implemented at Site	Yes	No	N/A
1. Environmental site mapping was conducted prior to site layout			
2. Natural areas were conserved (e.g., forests, wetlands, steep slopes)			
3. Stream, wetland and shoreline buffers were reserved			
4. Disturbance of permeable soils was minimized			
5. Natural flow paths were maintained across the site			
6. Building layout was fingerprinted to reduce site clearing/grading			
7. Site grading promoted sheet flow from impervious areas to pervious ones			
8. Better site design was used to reduce needless impervious cover			
9. Site Design maximized disconnection of impervious cover			
10. Future site operations evaluated to identify potential stormwater hotspot			
11. Installation of ESC and ESD Practices are integrated together			
12. Tree planting was used at the site to convert turf areas into forest			

Step 2: Input Pre and Post Development Site Variables. The basic inputs for this step are simple: Site Area **(B29)**, Existing Site Impervious Cover Area **(B30)**, and Proposed Site Impervious Cover Area **(B31)**. Figure 1 shows where the input cells are located within the spreadsheet. Designers should directly measure impervious cover from the site plan using the Critical Area definitions for impervious cover outlined in Table 2. The spreadsheet calculates the percentage of impervious cover for both existing and proposed conditions. If the existing site is greater than 40% impervious, redevelopment rules will apply. The designer also needs to indicate the rainfall depth **(B32)** in order to calculate the required water quality volume. For the Maryland Critical Area, the appropriate choice is 1.0 inch. The Site Area input is defined as the post-development limits of disturbance.

Figure 1: The Four Key Spreadsheet Inputs in Step 2



Step 3: Calculate Phosphorous Removal Requirement

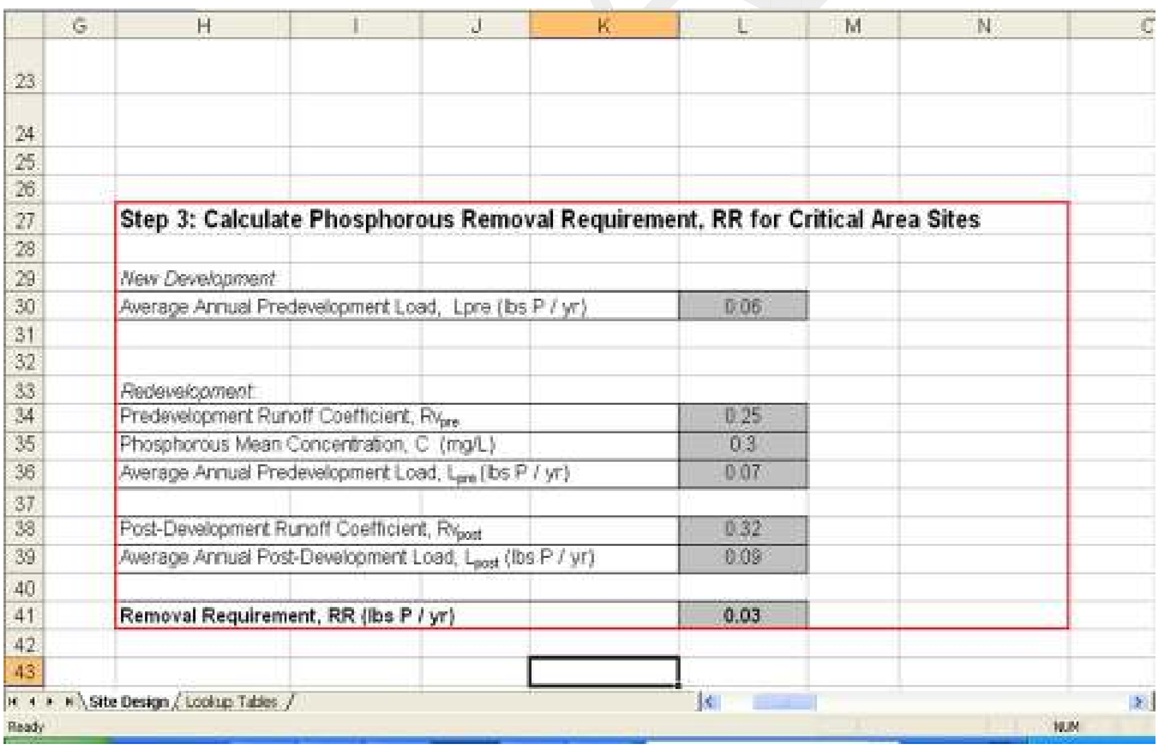
The spreadsheet automatically calculates the average annual predevelopment load based upon whether the project is a new development or redevelopment site. For new development, the predevelopment load for the Critical Area is now defined as an annual load of 0.3 pounds of P per acre.

Redevelopment rules apply if the existing site has more than 40 % impervious cover. In these cases, the predevelopment load is calculated based upon the runoff coefficient and an average runoff concentration of 0.3 mg/L for total phosphorus. The phosphorus removal requirement for redevelopment sites is to reduce the pre-development phosphorous load by 50%.

Figure 2 shows where these phosphorus removal calculations occur within the spreadsheet. The spreadsheet first reports the phosphorus removal requirement for the site in **cell 41-L.** Incremental phosphorus reductions achieved by subsequent ESD practices can be tracked in the following spreadsheet cells:

- Effect of ESD Credits and Micro-Practices: **Cell 133- R**
- Additional Effect of Conventional Structural Practices: **Cell 168-K**

Figure 2: Where the Phosphorus Removal Requirement is Automatically Calculated



Step 3: Calculate Phosphorous Removal Requirement, RR for Critical Area Sites	
New Development	
Average Annual Predevelopment Load, Lpre (lbs P / yr)	0.06
Redevelopment	
Predevelopment Runoff Coefficient, Rv_{pre}	0.25
Phosphorous Mean Concentration, C (mg/L)	0.3
Average Annual Predevelopment Load, L_{pre} (lbs P / yr)	0.07
Post-Development Runoff Coefficient, Rv_{post}	0.32
Average Annual Post-Development Load, L_{post} (lbs P / yr)	0.09
Removal Requirement, RR (lbs P / yr)	**0.03**

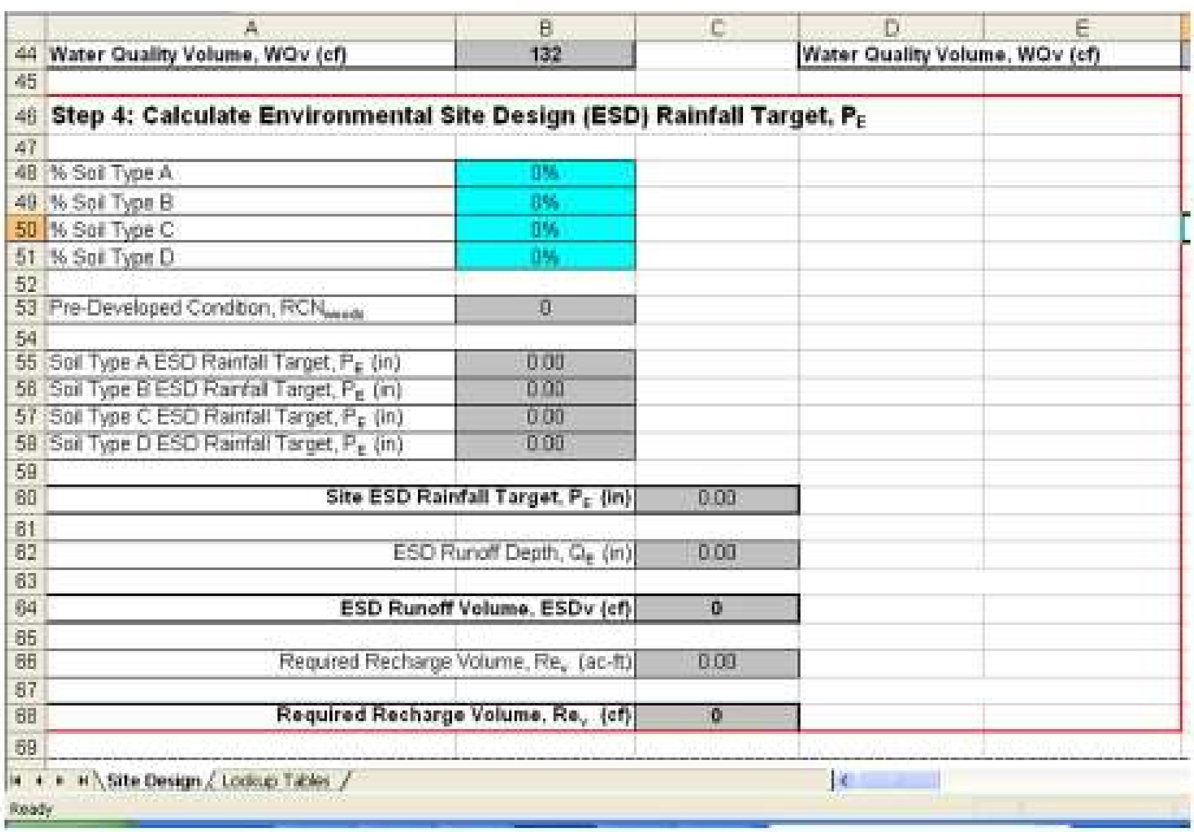
Step 4: Calculate the Environmental Site Design Rainfall Target

In this step, designers need to enter the percentage of the site in each of the four Hydrologic Soil Groups (HSGs) on **rows B48-51**. The soil data is used to calculate a pre-development runoff curve number (RCN), which in turn, is used to compute the ESD Rainfall Target. Figure 3 shows where these soil inputs are located in the spreadsheet.

For new development, the ESD rainfall target is defined as the depth of rainfall that must be treated to reduce the site's post-development RCN to the pre-development RCN (i.e., woods in good condition). Required recharge volume is also calculated based upon specific recharge rates for each soil type.

For redevelopment sites, the spreadsheet calculates the required water quality treatment volume, based on the net change in proposed site impervious cover relative to existing site impervious cover.

Figure 3 Where HSG Soil Data is Entered in the Spreadsheet



	A	B	C	D	E
44	Water Quality Volume, WQv (cf)	132		Water Quality Volume, WQv (cf)	
45					
46	Step 4: Calculate Environmental Site Design (ESD) Rainfall Target, P_E				
47					
48	% Soil Type A	0%			
49	% Soil Type B	0%			
50	% Soil Type C	0%			
51	% Soil Type D	0%			
52					
53	Pre-Developed Condition, RCN_{woods}	0			
54					
55	Soil Type A ESD Rainfall Target, P_E (in)	0.00			
56	Soil Type B ESD Rainfall Target, P_E (in)	0.00			
57	Soil Type C ESD Rainfall Target, P_E (in)	0.00			
58	Soil Type D ESD Rainfall Target, P_E (in)	0.00			
59					
60		Site ESD Rainfall Target, P_E (in)	0.00		
61					
62		ESD Runoff Depth, Q_E (in)	0.00		
63					
64		ESD Runoff Volume, ESDv (cf)	0		
65					
66		Required Recharge Volume, Re_v (ac-ft)	0.00		
67					
68		Required Recharge Volume, Re_v (cf)	0		
69					

Site Design / Lookup Tables /
Ready

If the proposed impervious cover at a redevelopment site exceeds existing impervious cover, the spreadsheet also computes the incremental recharge and channel protection volume for the site. Since most redevelopment sites will be on urban fill soils (CSN, 2010), designers should generally assume that 100% of site area will behave as HSG "D" unless they have an on-site soil test to the contrary.

Designers should always look for the most permeable soils present at the site in order to locate the best ESD practices that possess the highest possible phosphorus reductions.

Step 5: Evaluate Effect of Non-structural ESD Credits

In this step, designers can apply for credits for non-structural practices that effectively disconnect impervious cover. The five credits include:

1. Impervious Cover Conversion
2. Reforestation and Soil Restoration
3. Rooftop Disconnection
4. Non-Rooftop Disconnection
5. Sheet flow to Conservation Area

The designer enters the contributing impervious drainage area **(Column D)**, as well as site-specific design parameters that are needed to receive each credit **(Column G & H).** Based on this information, the spreadsheet automatically computes an ESD runoff volume credit (P_E) that is used to reduce the site ESD rainfall target volume. The credits are calculated based upon the following MDE relationships:

Disconnection of Rooftop Runoff						
	Disconnection Flow Path Length (ft)					
Western Shore	0	15	30	45	60	75
Eastern Shore	0	12	24	36	48	60
P_E Credit	0	0.2	0.4	0.6	0.8	1

Disconnection of Non-Rooftop Runoff						
Ratio of Disconnection Length to Contributing Length	0	0.2	0.4	0.6	0.8	1
P_E Credit	0	0.2	0.4	0.6	0.8	1

Sheet Flow to Conservation Areas				
Minimum Conservation Area Width	0	50	75	100
P_E Credit	0	0.6	0.8	1

The technical basis for the reforestation and impervious cover conversion credits are documented in Part 4.

To obtain the credits, designers must input the predominant predevelopment HSG over the filter path or reforestation areas (i.e., A/B or C/D). The soils data is needed to determine the specific phosphorus removal rates for each hydrological soil group. Designers should always double check the actual distances and slopes of the contributing impervious areas and filter path on the site plan to ensure they conform to the minimum qualifying criteria outlined in Part 4 of this document.

Step 6: Evaluate Effect of ESD Micro-Practices

The spreadsheet presents a somewhat simplified approach to handling ESD micro-practices, which include:

- Green Roof
- Permeable Pavements
- Rainwater Harvesting
- Submerged Gravel Wetlands
- Micro-infiltration (or Dry Wells)
- Rain Gardens
- Micro-Bioretention
- Landscape Infiltration
- Grass Swales
- Bioswales
- Wet Swales

Designers can optimize the types of ESD micro-practices that are most suitable for their site by analyzing the predevelopment HSG as shown in Table 4.

Table 4 Acceptable Soils for ESD Micro-Practices

ESD PRACTICE	HSG A	HSG B	HSG C	HSG D
Green Roof	**X**	**X**	**X**	X
Permeable Pavement	**X**	**X**	**X**	
Rainwater Harvesting	**X**	**X**	**X**	**X**
Submerged Gravel Wetlands			**X**	**X**
Infiltration	**X**	**X**		
Rain Garden		**X**	**X**	**X**
Bioretention		**X**	**X**	**X**
Landscape Infiltration	**X**	**X**		
Grass Swales	**X**	**X**	**X**	
Bioswales	**X**	**X**	**X**	**X**
Wet Swales			**X**	**X**

X= may be suitable depending on depth to water table, bedrock and slope

In addition, designers should consult Table 5 to identify the most effective micro-ESD practices, based on their contributing drainage area, higher phosphorus removal or capacity to be "upgraded" to a Chapter 3 ESD practice (MDE, 2000).

Enhanced filters can be added as a supplemental design option to the appropriate ESD practices in **Column L.** Infiltration berms are only considered a design element to improve the effectiveness of various disconnection credits in Step 5.

The appropriate hydrologic soil group associated with several ESD micro-practices must be entered into the spreadsheet; this is done to compute differential phosphorus removal rates for the Critical Area computation, as well as to clearly show the most appropriate soil conditions where they can be effectively used.

Table 5 Comparing the ESD Micro-Practices

ESD PRACTICE	Removal tied to HSG?	Max CIDA [2] (sf)	Upgrade? [3]
Green Roof	No	**None**	**No**
Permeable Pavements	Yes	**Varies**	**Yes**
Rainwater Harvesting	No	**~20,000**	**Yes**
Gravel Wetlands	No	**< 1 acre**	**No**
Infiltration	Yes	**500**	**Yes**
Rain Garden	Yes	**2,000**	**No**
Bioretention	Yes	**20,000**	**Yes**
Landscape Infiltration	Yes	**20,000**	**No**
Grass Swales	Yes	**< 1 acre**	**No**
Bioswales	Yes	**< 1 acre**	**Yes**
Wet Swales	No	**< 1 acre**	**No**
Enhanced Filters	No	**n/a**	**No**

[1] Practice has a higher phosphorus removal rate when situated on permeable A or B soils
[2] The contributing drainage area limits, as prescribed in MDE, Chapter 5
[3] The practice be "upgraded" to a Chapter 3 practice that also meets the ESD criterion (e.g., micro-bioretention upgraded to a regular bioretention area)

This step begins with an overlay of the site layout, pervious areas and soil conditions. Designers should work to direct contiguous impervious areas to pervious areas, and draw the approximate drainage areas to each micro-practice. The spreadsheet assumes that 100% of the impervious area is treated by the individual micro-practice. The designer then estimates the surface area of the micro-practice. The designer can then aggregate the total contributing impervious drainage area (CIDA) and surface area for each category of micro-practice for the drainage area as a whole.

The designer enters the CIDA into **Column D**, as well as any practice-specific design parameters in **Column G & H** for each set of ESD micro-practices planned for the site. One of the new features in this version of the spreadsheet constrains the practice design parameters so they do not exceed reasonable combinations of surface area to CIDA.

The combined phosphorus reductions achieved by ESD micro-practices can be tracked in spreadsheet cell **133-R.**

Dealing with ESD Credits and Practices in Series.

Designers can select a down-gradient ESD practice to which runoff from an up-gradient ESD practice will be directed from the dropdown box in **Column N** (e.g., bioretention to a bioswale). The spreadsheet allows for proper accounting of ESD practices in series, and produces the aggregate ESD rainfall target credit and the increment of phosphorus load reduction for the entire system of ESD micro-practices at the site.

Important Note: When practices are to be used in series, select the down-gradient practice from the pull-down menu in Column N, but DO NOT input the same drainage area into Column D of the down-gradient practice. The spreadsheet automatically directs the proper runoff volume to the down-gradient practice. The only time Column D would be filled in for the down-gradient practice would be if the practice receives runoff from additional impervious cover that was not treated by the up-gradient practice.

Step 7: Check for Site Compliance with Phosphorous Reduction Requirement

The spreadsheet summarizes the total phosphorous load reduced by the ESD practices at **cell 133-R.** This load is then compared to the site reduction requirement to determine whether the site has complied with the phosphorus removal standard. Operationally, this requirement is satisfied when sufficient ESD practices are used to meet the entire ESD rainfall target volume and the entire phosphorus load reduction requirement for the project.

If full compliance with the phosphorus removal performance standard cannot be demonstrated, the designer must re-evaluate the site to achieve greater phosphorus reductions. This involves an iterative process to investigate more ESD options, using the spreadsheet. Some useful strategies include:

Run the Spreadsheet Just For the Critical Area Portion of the Site: If your project contains portions inside and outside the Critical Area boundary, you may want to run the spreadsheet twice, once for the entire site and a second time just using the portion of total site area within the Critical Area. If either run indicates compliance, you are done (see Part 3.6).

Evaluate Whether Off-site Treatment Helps: You may also want to investigate whether it is possible to treat off-site stormwater on your site and credit this towards your on-site phosphorus removal requirement, using the protocols outlined in Part 3.7

Go Back to Step 1 and Adjust Site Layout to Reduce Impervious Cover or Increase Forest Cover. Designers should particularly focus on any of the ESD planning practices that were not used in the ESD implementation checklist.

Go Back to Step 5 and Expand Site Area Subject to Credits. The site plan should be reexamined to determine if more impervious cover could be treated through disconnection and filter strips, either by additional disconnection, or improving the soil and slope conditions within the filter strip, using infiltration berms (p. 5.87 of MDE, 2009), compost amendments, grading, or engineered level spreaders or other measures so that a greater CIDA can be treated.

Go Back to Step 6 and Apply More Effective ESD Practices For Phosphorus Removal. Designers have a number of options to improve the aggregate ESD performance for the site in this step. Consult Table 6 to see whether a different ESD practice or design level could boost the phosphorus removal rates.

1. Add more micro-ESD practices to pick-up additional untreated CIDA
2. Over-control at individual micro-ESD practices by treating the entire target ESD volume
3. Change the mix of micro-ESD practices to increase runoff reduction (shift from grass swale to bio-swale, or from rain garden to micro-bioretention, etc.)
4. Add Enhanced Filters to the bottom of select ESD micro-practices (MDE, 2009, see page 5.113)
5. Use ESD practices such as infiltration trenches, bioretention and dry swales that serve a larger CIDA and/or have a greater phosphorus removal capability (these can be entered directly into the micro-ESD spreadsheet)

Go forward to Step 9 to see if Conventional Stormwater Practices are capable of removing your remaining phosphorus load (e.g., sand filters, wetlands and ponds).

If you still cannot fully comply, then you should build the maximum system of ESD practices, and apply for an offset with the local Critical Area planning authority to handle the remaining untreated phosphorus load (see Part 5).

Step 8: Compute Reduced RCN for the Channel Protection Volume

If your site is subject to the Channel Protection requirement, you can use this step to determine whether the volume can be reduced due to the ESD volume that you have already provided on the site. The spreadsheet automatically calculates a reduced RCN based upon the ESD rainfall depth treated in prior steps. If the required ESD rainfall depth has not been completely treated through acceptable ESD practices, this revised and reduced RCN is used to calculate the Channel Protection Volume that must be treated through structural practices, such as ponds or wetlands.

The reduced RCN values **should not be used** for the larger design storms used for flood control analysis (e.g., the 10 or 100 year design event).

Step 9: Select Structural Practices to Meet Remaining Phosphorus Load

This step is only performed when the system of ESD practices cannot meet the phosphorus removal standard. Designers can then consider traditional structural stormwater practices such as ponds, wetlands, and filtering systems to obtain the remaining phosphorus reduction.

Designers will need to design the structural practice (or practices) at the most downstream point in the project drainage area, and then independently calculate the treatment volume. These values should then be imported into the respective entry fields for contributing impervious drainage area (**column B**) and the design treatment volume (**column E**). The spreadsheet then recalculates the phosphorous load reduction achieved by the additional structural practices utilized (**cell 168-K**).

The spreadsheet shows two levels of design for structural stormwater practices, which are used to estimate their phosphorus removal capability for the Critical Area requirement. Level 1 is a baseline design using the minimum criteria for the practice as outlined in MDE (2000), whereas Level 2 is an enhanced design that maximizes phosphorus removal. The technical basis for the two design levels are outlined in CWP and CSN (2008). More detailed Level 1 and 2 design criteria can be found in Part 4.

Step 10: Evaluate Feasibility of the Stormwater Plan

Your local review authority may require additional information to evaluate the feasibility of your ESD plan (beyond the spreadsheet result). Several important elements are needed to finalize the concept plan, as follows:

- A detailed stormwater site plan should be drafted to show the spatial distribution of ESD practices in such a manner that plan reviewers can verify spreadsheet areas related to CIDA and ESD practice surface area.

- The designer should also analyze the site to confirm the feasibility of individual ESD practices (e.g., depth to water table, depth to bedrock, contributing slopes, sheet flow distances, minimum practice surface area) as described in Part 4 of this document.

- Designers must also solve the tricky problem of how to sequence installation of ESD practices in the context of plans for grading and erosion and sediment control (ESC).

- Many ESD practices must be protected from disturbance during construction and/or installed after the site has been permanently stabilized. At the same time, the ESC plan must provide effective controls during construction to prevent the discharge of sediments.

- Soil borings and infiltration testing may also be needed to confirm infiltration rates and underlying soil conditions at the site.

- Designers should also carefully review the plan to ensure safe and non-erosive conveyance of large storms through the sequence of ESD practices across the site. This analysis dictates the consequent need for overflows, flow splitters, channel stability and other measures to protect ESD practices from larger storms events, such as peak discharges from the 2 or 10 year storm design event.

- Lastly, the concept plan must meet the minimum submittal requirements established by the State (i.e., pages 5.15-16 of MDE, 2009), in addition to any requirements established by the local stormwater review authority.

Step 11: Final ESD Design Plan and Verification After Installation

The compliance spreadsheet should be run again to verify that the final ESD plan meets the ESD to MEP criterion. At this point, the CIDA, surface areas, design parameters and treatment volume for individual ESD practices can be more accurately measured and defined. The revised values should be entered into the spreadsheet to ensure that the results from the concept plan can be verified or exceeded. The spreadsheet can be submitted as part of the final ESD design package. The package must meet the minimum submittal requirements established by the State (i.e., Page 5.11 of MDE, 2009), in addition to any requirements established by the local stormwater review authority.

Several steps are crucial after the final plan is approved to ensure ESD practices are properly installed. Inspections are needed to ensure ESD areas are protected from disturbance during the construction stage, and when the site has been adequately stabilized to permit the installation of ESD practices. Post-construction inspections are needed to verify that ESD practices have been properly installed, are functioning as intended, and meet any vegetative cover requirements.

Part 4
Enhanced Design Criteria for ESD Practices in the Critical Area

This section documents the phosphorus removal rates for various design levels for stormwater practices installed within the Critical Area (Table 6).

Table 6. Summary of TP Removal Rates For ESD Credits and Practices and Conventional Stormwater Practices in the Maryland Critical Area

ESD Practices	**TP Removal Rates (%)**		**Where is entered on the spreadsheet**
	A & B Soils	**C & D Soils**	
Impervious Cover Conversion	Varies	Varies	Row 31 B2
Simple Rooftop Disconnection	50	25	Rows 80 to 83
Non-Rooftop Disconnection	50	25 *	Rows 84 to 87
Sheet-flow to Conservation Area	50	25 *	Rows 88 to 91
Reforestation/Soil Restoration	Varies	Varies	Rows 76 to 79
Green Roof	Level 1: 45 Level 2: 60		Rows 96 to 99
Permeable Pavements	80	60	Rows 100 to 103
Rainwater Harvesting	45		Rows 104 to 105
Submerged Gravel Wetlands	60		Rows 106 to 107
Landscape Infiltration	75	NA	Rows 118 to 119
Micro-infiltration (Dry Well)	65	NA	Rows 108 to 109
Infiltration	90	60	Rows 165 to166
Rain Gardens	50	25	Rows 110 to 113
Micro and Regular Bioretention	75	50	Rows 114 to 117
Urban Bioretention	50	25	Rows 110 to 113
Grass Channels	40	20*	Rows 120 to 123
Bio Swales and Dry Swales	75	50	Rows 124 to 127
Wet Swales	40		Rows 128 to 129
Sand Filters	Level 1: 60 Level 2: 65		Rows 163 to 164
Wet Ponds and Wet ED Ponds	Level 1: 50 Level 2: 75		Rows 159 to 160
Constructed Wetlands	Level 1: 50 Level 2: 75		Rows 161 to 162

See Appendix A for how these removal values were derived
NA = not applicable * higher rates possible if soils are restored

4.1 Non-structural ESD Practices and Credits

Impervious Cover Conversion

Applicability: Impervious cover conversion involves the removal of existing impervious cover at a redevelopment site, followed by soil restoration such that the new pervious area performs hydrologically as if it were un-compacted grass, and filters runoff from adjacent hard surfaces. This practice primarily applies to redevelopment projects which seek to reduce their required water quality volume. The practice may also apply to new development projects that have some pre-existing impervious cover.

MDE Reference: No specific design criteria are provided.

TP Removal Rate: Computed internally by the spreadsheet, based on how much predevelopment impervious cover is being reduced. The reduced TP removal requirement associated with the impervious cover conversion can be found in cell **41-L.**

Additional Design Criteria for Critical Area

The following design standards apply to impervious cover conversion:

- The minimum surface area for the impervious cover conversion credit is 250 square feet.
- Site plans shall show the specific areas where concrete or asphalt will be removed and recycled.
- Underlying compacted soils shall be deep tilled and amended with compost to restore porosity, using the methods outlined in the most current edition of the Bay-wide soil restoration design specification.
- The new pervious area can be graded to accept runoff from adjacent hard surfaces.
- A project is eligible for additional phosphorus removal credit for the pervious area if it is designed to provide further infiltration or bioretention.
- The pervious area must be planted with an acceptable vegetative cover, which reflects landscaping objectives and anticipated future uses at the redevelopment site.
- The conversion shall be permanent, and accompanied by a deed or covenant that specifies that the area cannot be rebuilt in the future (unless it is adequately mitigated).
- The maintenance plan shall specify that the vegetative condition of the pervious area shall be regularly inspected and must be regularly maintained to ensure no soil erosion occurs.

Where it is Entered in the Compliance Spreadsheet: Go to Row 31, Col B and enter the lower proposed existing impervious area.

Simple Rooftop Disconnection

Applicability: Works best at low to moderate density residential dwellings on individual roof leaders, although it can also be used for very small parking lots. The maximum contributing impervious area that can drain to a single disconnection is limited to 500 square feet for residential projects, and 1000 square feet for all other projects. Disconnections are acceptable for soils in HSG A, B and C; soil restoration is usually needed for disconnections on D soils or urban fill soils.

MDE Reference: Page 5.57 in MDE (2009)

Key MDE Design Criteria:

- The disconnection filter path must be at least 15 ft in length, although performance is maximized when the filter path extends to 75 ft, at which point there is no further phosphorus reduction credit.
- There must be a 10 feet lateral setback from the filter path to any adjacent impervious cover (i.e., driveways or sidewalks).
- The filter path cannot have a slope greater than 5%. Infiltration berms can be used to break up slopes.
- Flow velocities in the filter path shall be non-erosive for two year storm.

Critical Area TP Removal Rate

- 50% for qualifying disconnections on HSG A and B Soils
- 25% for qualifying disconnections on HSG C and D Soils (see Table 7).

Table 7 Simple Disconnection	
Level 1 Design TP:25%	**Level 2 Design TP: 50%**
C and D Soils	A and B Soils, OR Restored C and D Soils *
Filter path is 15 to 50 feet long	Filter path exceeds 50 feet *
Slope of filter path is more than 3%	Slope of filter path is less than 3% *
*All three criteria must be met to qualify for Level 2	

Additional Design Criteria for Critical Area

- The filter path shall have a minimum slope of 1% and a maximum slope of 3%.
- Steeper slopes can be broken up with infiltration berms or site grading to meet these limits.
- The depth between the filter path surface and the seasonally high water table cannot be less than two feet in the coastal plain.
- The lateral distance between any two individual disconnections must exceed 25 feet.

Where it is Entered in the Compliance Spreadsheet. Go to Row 80 to 83 and select the row that corresponds to the predevelopment HSG for your practice, and then enter the acreage of contributing impervious cover, the flow path length (in feet) and its geographic location (Eastern or Western shore).

Non-rooftop Disconnection (Filter Strip)

Applicability: This option works best for commercial sites with sidewalks, driveways and very small parking lots (approximately 6 to 10 spaces). The maximum contributing impervious area that can drain to a single disconnection is limited to 1000 square feet. This disconnection is designed as a filter strip to ensure phosphorus removal.

MDE Reference: page 5.61 in Chapter 5 of MDE (2009)

Key MDE Design Criteria: The basic design criteria are very similar to simple rooftop disconnection:
- The disconnection filter path must be at least 15 ft in length, although performance is maximized when the filter path extends to 75 ft, at which point there is no further phosphorus reduction credit.
- There must be a 10 feet lateral setback from the filter path to any adjacent impervious cover (i.e., driveways or sidewalk).
- The filter path cannot have a slope greater than 5%. Infiltration berms can be used to break up slopes.
- Flow velocities across the filter strip shall be non-erosive for two year storm.

Critical Area TP Removal Rate:
- 50% for qualifying disconnections on HSG A and B Soils
- 25% for qualifying disconnections on HSG C and D Soils (see Table 8)
- Performance can be increased when C and D soils are restored.

Table 8 Non-Rooftop Disconnection (aka filter strip)	
Level 1 Design TP:25%	**Level 2 Design TP:50%**
C and D Soils	A and B Soils OR Restored C and D Soils *
Filter path is 15 to 50 feet long	Filter path exceeds 50 feet *
Slope of filter path is more than 3%	Slope of filter path is less than 3% *
*All three criteria must be met to qualify for Level 2	

Additional Design Criteria for Critical Area
- A gravel diaphragm shall be installed at top of filter strip and an infiltration berm at the toe.
- Heavy equipment must be kept out of the filter strip area during construction, unless the soils are restored.
- The depth between the filter path surface and the seasonally high water table cannot be less than two feet in the coastal plain.
- The lateral distance between any two individual disconnections must exceed 25 feet.

Where it is Entered in the Compliance Spreadsheet: Go to Row 84 to 87 and select the row that corresponds to the predevelopment HSG for your practice, and then enter the acreage of contributing impervious cover, the disconnection length (in feet) and the contributing length of impervious cover (in feet).

Sheet flow to Conservation Area

Applicability: This credit is a good option at the boundary of the Critical Area Buffer, or adjacent to other stream or wetland buffer or other natural areas that must be conserved at the site. The credit cannot be used if stormwater runoff is directed to a buffer that protects a wetland of special state concern.

MDE Reference: page 5.66 in Chapter 5 of MDE (2009)

Key MDE Design Criteria:
- The maximum permissible slope within the Conservation Area is 5%.
- The maximum distance from impervious cover to the conservation area is 75 ft.
- The conservation area must be at least 20,000 square feet in area and have a minimum width of 50 feet.
- The conservation area cannot have managed turf.

Critical Area TP Removal Rate (Table 9)
- 50% for qualifying conservation areas on HSG A and B Soils
- 25% for qualifying conservation areas on HSG C and D Soils

Table 9 Sheet flow to Conservation Area	
Level 1 Design TP:25%	**Level 2 Design TP: 50%**
C and D Soils	A and B Soils OR restored C and D Soils *
Filter path is 15 to 50 feet long	Filter path exceeds 50 feet *
Slope of filter path is more than 3%	Slope of filter path is less than 3% *
*All three criteria must be met to qualify for Level 2	

Additional Design Criteria for Critical Area
- If runoff is directed to the Critical Area Buffer, a grass filter strip must extend at least 75 feet from the nearest contributing impervious cover.
- A grass filter strip with compost amended soils may be suitable to treat small areas of impervious cover, up to a maximum of 5000 square feet.
- The filter strip needs to be equipped with a gravel diaphragm, infiltration berm or engineered level spreader to spread flows.
- The water table must be at least 18 inches below surface the surface of the strip.
- Designers must perform a site reconnaissance to confirm topography, slope, and soil conditions prior to design.
- The boundary zone shall consist of ten feet of level grass, and have a maximum entrance slope of less than 3% in the first ten feet of filter.
- The conservation area must be located outside the limits of disturbance and be protected by ESC perimeter controls.

Where it is Entered in the Compliance Spreadsheet: Go to Row 88 to 91 and select the row that corresponds to the predevelopment HSG for your practice, and then enter the acreage of contributing impervious cover, the width of the conservation area (feet) and the contributing length of impervious cover (feet).

Soil Restoration/Reforestation Credit

Applicability: This practice is used to improve the hydrologic capacity of open areas by restoring soils and planting trees to achieve forest cover. The proposed reforestation must be for the purpose of reducing runoff. Reforestation required under the Maryland Forest Conservation Act or the CAC Forest and Woodland Protection Criteria are not eligible for the credit. Even small units of soil reforestation and reforestation in urban watersheds can help meet local forest canopy goals and provide effective stormwater treatment at the same time.

MDE Reference: No specific design criteria are provided in MDE (2009).

Critical Area TP Removal Rate: Variable. On projects with HSG A or B soils, for each five square feet of soil restoration and reforestation, one square foot of impervious cover can be deducted from the site. On project with HSG C or D soils, for each ten square feet of soil restoration and reforestation, one square foot of impervious cover can be deducted for the site. The credit is further increased if the restored area is graded to receive runoff from adjacent areas of impervious cover.

Additional Design Criteria for Critical Area

- Additional phosphorus removal credit for treatment of adjacent impervious cover directed to restoration areas using the sheetflow to conservation area credit
- The practice must be subject to a long term reforestation plan that is capable of creating 75% forest canopy in 10 years
- Soil restoration is a required component of the reforestation credit.
- The planting plan must be approved by the appropriate local forestry or conservation authority, including any special site preparation needs. It must contain a long term vegetation management plan to maintain the reforestation area in a healthy forest condition.
- After 10 years, the required density of native trees is 300 stems per acre.
- Planting plans must include at least 5 different native tree species.
- Under urban conditions, planting plans should emphasize balled and burlapped native tree stock from 1 to 4 inches in diameter. The primary reason is to quickly achieve the desired tree canopy and ensure that the individual trees are visible enough so they are not disturbed, mowed or otherwise damaged as they grow.
- In rural or suburban settings, planting plans should include at least a minimum 10% of larger stock (1" caliper or more).
- The reforestation area must be protected by a perpetual stormwater easement or deed restriction which stipulates that no future development or disturbance may occur within the area, unless it is fully mitigated.
- The construction contract should contain a care and replacement warranty extending at least 3 growing seasons, to ensure adequate growth and survival of the plant community. Control of invasive tree species should be a major part of the initial maintenance plan.
- The reforestation area shall be shown on all construction drawings and erosion and sediment control plans during construction.

Where it is Entered in the Compliance Spreadsheet: Go to Row 76 to79 and select the row that corresponds to the predevelopment HSG for your restoration area, and then enter the acreage of contributing impervious cover and the surface area of the reforestation area (square feet).

Note on Soil Restoration

Applicability: The phosphorus removal capability of disconnections, filter strips and grass channels can be boosted when soils are restored to increase their permeability. The soil restoration process involves deep tilling, grading and soil compost amendments using the methods outlined in the Bay-wide soil restoration specification. There are a few limits on the use of soil restoration, as they are not feasible when:

- Existing soils have high infiltration rates (e.g., HSG "A" soils)
- The water table or bedrock is located within 1.5 feet of the soil surface.
- Slopes exceed 10%.
- Existing soils are saturated or seasonally wet
- They would harm roots of existing trees (stay outside the tree drip line)
- The downhill slope runs toward an existing or proposed building foundation

Soil Amendment: The depth of compost amendment is based on the relationship of the surface area of the soil amendment to the contributing area of impervious cover that it receives. Table 10 presents some guidance on the required depth to which the compost must be incorporated.

Table 10 Short-Cut Method to Determine Compost and Incorporation Depths				
	Contributing Impervious Cover to Soil Amendment Area Ratio [1]			
	IC/SA = 0 [2]	**IC/SA = 0.5**	**IC/SA = 0.75**	**IC/SA = 1.0** [3]
Compost (in) [4]	2 to 4 [5]	3 to 6 [5]	4 to 8 [5]	6 to 10 [5]
Incorporation Depth (in)	6 to 10 [5]	8 to 12 [5]	15 to 18 [5]	18 to 24 [5]
Incorporation Method	Rototiller	Tiller	Subsoiler	Subsoiler

Notes:

[1] IC = contrib. impervious cover (sq. ft.) and SA = surface area of compost amendment (sq. ft.)
[2] For amendment of compacted lawns that do not receive off-site runoff
[3] In general, IC/SA ratios greater than 1 should be avoided
[4] Average depth of compost added
[5] Lower end for B soils, higher end for C/D soils

More information on the design, construction, and inspection of the soil restoration practice can be accessed at www.chesapeakestormwater.net

4.2 Environmental Site Design Practices

Green Roof

Applicability: Green Roofs (also known as *vegetated roofs, living roofs* or *eco-roofs*) are alternative roof surfaces that typically consist of waterproofing, drainage materials and an engineered growing media that is designed to support plant growth. Green roofs capture and temporarily store stormwater runoff in the growing media before it is conveyed into the storm drain system. A portion of the captured stormwater evaporates or is taken up by plants, which helps reduce runoff volumes, peak runoff rates, and pollutant loads on development sites.

The most common design is the *extensive* green roof system which have a shallow growing media (4 to 8 inches), planted with carefully selected drought tolerant vegetation. Green roofs are preferred because they incorporate stormwater treatment directly into the architecture of the building, which eliminates the need to consume surface land. They provide modest levels of runoff reduction, and can be major compliance element at many high intensity redevelopment sites. Their high installation cost is compensated by long term savings in energy consumption and roof longevity.

MDE Reference and Design Criteria: page 5.42 in Chapter 5 of MDE (2009)

Critical Area TP Removal Rate:
- Design Level 1: 45%
- Design Level 2: 60%
- The requirements for each design level are outlined in Table 12

Table 12 Design Levels for Green Roof	
Level 1 Design TP: 45%	**Level 2 Design TP: 60%**
Depth of media up to 4 inches	Media depth 4 to 8 inches
Drainage mats	2-inch stone drainage layer
No more than 20% organic matter in media	No more than 10% organic matter in media
*All three criteria must be met to qualify for Level 2	

Additional Design Criteria for Critical Area

- Select species that can tolerate both drought and salt spray
- Further guidance on green roof design and installation can be found in CSN Bay-wide Design Specification No. 4.

Where it is Entered in the Compliance Spreadsheet: Go to Rows 96 to 99, and select the row that corresponds to the predevelopment HSG for the project site. Next, enter the acreage of contributing impervious cover to the green roof, and the estimated thickness of the media layer (in inches).

Permeable Pavements

Applicability: Permeable pavements are alternative paving surfaces that allow stormwater runoff to filter through voids in the pavement surface into an underlying stone reservoir, where it is temporarily stored and/or infiltrated. Permeable pavement is an attractive option to treat runoff from driveways, plazas, sidewalks, and parking lots, particularly when soils are in HSG A, B and C. Permeable pavement should be avoided if they are located close to sand dunes, due to the risk of blowing sand, at sites where water table is close to the soil surface, and for some HSG D soils.

MDE Reference and Design Criteria: page 5.42 in Chapter 5 of MDE (2009)

Critical Area TP Removal Rate (see Table 11)

Table 11 Permeable Pavement Design Criteria	
Level 1 Design TP: 60%	**Level 2 Design TP: 80%**
Store and treats the entire WQv	Storage exceeds the one-inch WQv *
C or D Soils with infiltration rates less than 0.5 in./hr	A, B or C soils with infiltration rate exceeding 0.5 in./hr *
Under drain required	Under drain not required; ***OR*** if an under drain is used, a 12-inch stone sump must be provided below the under drain invert *
The ratio of external contributing area to permeable pavement does not exceed 2:1.	The ratio of external contributing area to permeable pavement does not exceed 1. *
*All four criteria must be met to qualify for Level 2	

Additional Design Criteria for Critical Area

- Permeable pavers with acceptable storage may be constructed on D soils if the facility can achieve a 48 hour drain time. The design volume and contributing drainage area should be entered as a design level 1 filtering system (Row 164).
- A minimum separation distance of two feet from the bottom of the storage reservoir to the seasonally high water table must be maintained for Level 2 designs.
- This separation distance can be reduced to a foot if the reservoir is equipped with a stone sump and under drain.
- A minimum slope of 0.5% shall be maintained in the under drain system.
- CSN released a Bay-wide design specification in 2010 for permeable pavers which can be accessed at www.chesapeakestormwater.net

Where it is Entered in the Compliance Spreadsheet: Go to Rows 100 to 103, and select the row that corresponds to the predevelopment HSG for under the pavers. Next, enter the acreage of contributing impervious cover to the paver and estimated thickness of the paver bed in feet. If an enhanced filter is added to the facility, the cubic feet of additional storage should be entered.

Rainwater Harvesting

Rainwater Harvesting systems intercept, divert, store and release rainfall for future use. Rainwater harvesting is also known as cisterns or rain tank. Rainwater that falls on a rooftop is collected and conveyed into an above or below ground storage tank where it can be used for non-potable water uses and on-site stormwater disposal/infiltration. Non-potable uses may include flushing of toilets and urinals inside buildings, landscape irrigation, exterior washing, fire suppression systems, water cooling towers, water fountains, and laundry, if approved by the local authority.

Applicability: Rain tanks or cisterns are useful for treating rooftop runoff from low density residential homes, and hi-intensity redevelopment projects. High redevelopment intensity often generates higher demand for both indoor non-potable water and outdoor landscape irrigation water, which means that substantial runoff volumes can be reused throughout the year.

MDE Reference: page 5.91 of Chapter 5 of MDE (2009)

Key MDE Design Criteria:

- Rain barrels and cisterns shall be designed to capture at least 0.2 inches of rainfall from the contributing rooftop area.
- A P_E credit based on the fraction of the ESDv captured and re-used shall be applied to the contributing rooftop area.

Critical Area TP Removal Rate: default of 45%, but may be greater depending on how much rainfall is reused.

Additional Design Criteria for Critical Area

- A spreadsheet available to determine the ESD volume actually captured based on indoor and outdoor demand at www.chesapeakestormwater.net
- Designers should consult Bay-wide Design Specification No. 6 for Rainwater Harvesting.

Where it is Entered in the Compliance Spreadsheet: Go to Rows 104 and 105 and enter the acreage of contributing impervious cover and the design volume of the rainwater harvesting practice (cubic feet).

Submerged Gravel Wetlands

Applicability: This practice is recommended for development projects located on the Eastern Shore that have high water tables. The best soils are in HSG C and D, although they can be used on HSG A and B Soils if the water table is within three feet or less from the land surface.

MDE Reference: page 5.77 of Chapter 5 of MDE (2009)

Key MDE Design Criteria:

- The submerged gravel wetland must have a minimum CDA of one acre.
- The wetland gravel bed should be no shallower than 18 inches and no deeper than 48 inches.
- A pretreatment forebay sized at a minimum of 10% of the incoming ESD volume is required to keep sediments from accumulating in the gravel.

***Critical Area TP Removal Rate*:** 60%

Additional Design Criteria for Critical Area

- More detailed guidance on the design, installation and maintenance of submerged gravel wetlands can be found in UNHSC (2009).

Where it is Entered in the Compliance Spreadsheet: Go to Rows 106 and 107 and enter the acreage of contributing impervious cover to the wetland and the depth of the submerged gravel wetland (in feet).

Landscape Infiltration

Applicability. This is a good option for small residential and commercial projects that are located on highly permeable soils. The maximum contributing drainage area to an individual landscape infiltration practice cannot exceed 10,000 square feet, and is not feasible for projects that have HSG C and D soils.

MDE Reference: page 5.82 of Chapter 5 of MDE (2009)

Key MDE Design Criteria:
- The facility should be designed to fully dewater in 48 hours.
- The typical cross-section from top to bottom includes 6 to 9 inches of surface ponding, 12 to 18 inches of soil media, 12 inches of gravel and 12 inches of sand
- Practice restricted to HSG A and B soils.
- The maximum CDA to an individual practice is 10,000 square feet.
- A larger CDA is permissible with on-site soil testing and pretreatment measures.
- Standard setbacks to building foundations and septic systems must be maintained.

Critical Area TP Removal Rate: 75% (for A and B soils only)

Additional Design Criteria for Critical Area

- Designers may wish to upgrade to an infiltration or bioretention practice to serve a larger drainage area, as long as they conduct soil testing to confirm infiltration capability and install pretreatment measures.

Where it is Entered in the Compliance Spreadsheet: Go to Rows 118 and 119 and enter the acreage of contributing impervious cover, surface area (square feet) and the depth of the landscape infiltration practice (feet).

Dry Well and Micro-infiltration

Applicability: This is a good option for small residential and commercial projects that are located on highly permeable HSG A and B soils. The maximum contributing drainage area to an individual dry well cannot exceed 500 square feet. Dry wells are not feasible for projects with HSG C and D soils.

MDE Reference: page 5.91 of Chapter 5 of MDE (2009)

Key MDE Design Criteria:

- Pretreatment is required in gutters or using grass filter strip.
- A 6 to 12 inch bottom sand layer must be provided below stone reservoir.
- Standard setbacks to building foundations and septic systems must be maintained.
- Dry wells are restricted to slopes of 2% or less.
- The facility should be designed to fully dewater in 48 hours.

Critical Area TP Removal Rate: 65%

Additional Design Criteria for Critical Area

- The modified dry well design presented on page 45 of CCBRM (2010) is strongly recommended for use in the Critical Area. The improved design includes a simple but more effective pretreatment system, and standardized “plumbing” components that are readily available from most hardware stores and can be assembled together easily.
- Designers may wish to upgrade to an infiltration practice to serve a larger drainage area, as long as they conduct soil testing to confirm infiltration capability and install pretreatment measures. These larger infiltration systems are classified as ESD practices in the Critical Area, and also possess a higher phosphorus removal rate.
- If soils are extremely permeable (infiltration rates exceed 4 inches per hour), landscape infiltration or rain gardens are preferred since they provide more treatment before reaching groundwater.
- It is recommended that the depth of stone reservoir be kept to two or three feet to maximize surface area.
- A minimum separation distance of two feet from the bottom of the dry well and the seasonally high water table must be maintained.

Where it is Entered in the Compliance Spreadsheet: Go to Rows 108 and 109 and enter the acreage of contributing impervious cover, the surface area of the micro-infiltration practice (in square feet) and its depth (feet).

Infiltration

Applicability. Infiltration is considered a good option on most HSG A and B soils, and some HSG C soils. It is considered a preferred environmental site design practice in the Critical Area due to its higher runoff reduction and phosphorus removal capability. Infiltration practices are restricted or prohibited at development projects that are expected to become stormwater hotspots in the future (i.e., Table 2.6 in MDE 2000).

MDE Reference and Design Criteria: Page3.38 in Chapter 3 of MDE (2000)

Critical Area TP Removal Rate:
- Design Level 1: 60%
- Design Level 2: 90%
- The requirements for each design level are outlined in Table 13.

Table 13 Infiltration Design Levels	
Level 1 Design TP:60%	**Level 2 Design TP:90%**
Infiltrates the entire WQv	Infiltrates at least 75% of the ESD Target Volume *
At least one pre-treatment device	At least two forms of pre-treatment*
Soil infiltration rate 1/2 to 1 inch/hr.	Soil infiltration rates of 1.0 to 4.0 inch/hr *
Treatment volume infiltrates in less than 36 hours	Treatment volume infiltrates within 36 hours or more *
*All four criteria must be met to qualify for Level 2	

Additional Design Criteria for Critical Area

- The New Jersey soil testing protocols are strongly recommended to evaluate soil infiltration rates (NJDEP, 2009, Appendix E).

- A minimum separation distance of two feet from the bottom of the infiltration practice and the seasonally high water table must be maintained for all designs.

Where it is Entered in the Compliance Spreadsheet

Go to Rows 165 and 166 and enter the acreage of contributing impervious cover and the design treatment volume of the infiltration practice (in cubic feet).

Rain Gardens

Applicability: Rain gardens are an option to treat rooftop runoff at individual homes or small commercial projects. They are effective on A and B soils, but are restricted on C soils. The contributing drainage area (CDA) to an individual rain garden should not exceed 2,000 square feet (sf) for residential applications and 10,000 sf for non-residential projects.

MDE Reference: page 5.104 of Chapter 5 of MDE (2009)

Key MDE Design Criteria:

- The maximum depth of temporary ponding in the rain garden is 6 inches.
- The filter bed in the rain garden can range from 12 and 18 inches deep.
- The basic rain garden design uses soil infiltration to dispose of stormwater, so no under drain is used.

Critical Area TP Removal Rate:

- Design Level 1 25% (HSG C Soils)
- Design Level 2: 50% (HSG A and B Soils)
- The requirements for each design level are outlined in Table 14

Table 14 Rain Garden Design Levels	
Level 1 Design TP 25%	**Level 2 Design TP 50%**
HSG C Soils	HSG A and B Soils

Additional Design Criteria for Critical Area

- Rain gardens will generally be located on individual roof leaders for detached single family homes.

- To ensure proper homeowner maintenance, the builder must disclose their location, purpose and function when property is sold. The GPS coordinates of the rain garden must be recorded, and some form of easement, covenant or right of way be provided to ensure they are not filled in.

Where it is Entered in the Compliance Spreadsheet

Go to Rows 110 to 113 and select the row that corresponds to the predevelopment HSG for the rain garden, and then enter the acreage of contributing impervious cover and the surface area of the rain garden (in square feet).

Micro-Bioretention

Applicability: Micro-Bioretention is a versatile ESD practice that can be applied to all soil types and most development conditions.

MDE Reference: page 5.96 of Chapter 5 of MDE (2009)

Key MDE Design Criteria:

- The CDA for micro-bioretention should not exceed 0.5 acres.
- The maximum depth of ponding in the bioretention area is 12 inches.
- The filter bed should range from 2 and 4 feet in depth.

Critical Area TP Removal Rate: See Table 15

Table 15 Micro-Bioretention Design Levels	
Level 1 Design TP:50%	**Level 2 Design TP: 75%**
HSG C and D Soils and/or under drain	HSG A and B Soils, OR has full ESD to MEP storage, OR has 12 inch stone sump below under drain invert.*
Filter Media Depth less than 36 inches	Filter Media depth 36 inches or more *
One cell	Two cells, if CDA is more than 10,000 sf *
*All three criteria must be met to qualify for Level 2	

Additional Design Criteria for Critical Area

- The minimum depth of the filter bed shall be no less than 18 inches.
- The minimum depth from the bottom of the bioretention area and the seasonally high water table can be one foot, if an under drain is used. Otherwise, a minimum separation distance of two feet is needed to groundwater.
- The recipe for the filter media is to consist of 85%-88% sand, 8%-12% soil fines and 3%-5% organic matter in the form of leaf compost.
- The soil fines be supplied by vendor must be tested to ensure that soils have a phosphorus index (P-Index) between 10 and 30, or a test to show soil media has between 7 and 21 mg/kg of P in the soil media.
- The design shall include a landscaping planting plan that includes herbaceous vegetation, shrubs, and/or trees to achieve surface area coverage of at least 75% within 2 years.
- Plant species selected should reflect coastal plain ecosystems and be salt tolerant. A bioretention plant list can be found in CSN Bayside Design Spec No. 8.
- In residential areas, it is acceptable to use turf as an alternative surface cover in lieu of mulch.
- Maintain at least a 0.5% slope in the under drain to ensure drainage.
- The following building setbacks apply to bioretention: 10 feet if down-gradient from building or level (coastal plain); 50 feet if up-gradient.

Where it is Entered in the Compliance Spreadsheet: Go to Rows 114 to 117 and select the row that corresponds to the predevelopment HSG for the bioretention area, and then enter the acreage of contributing impervious cover and the surface area of the bioretention area (in square feet).

Regular Bioretention

Applicability: Regular bioretention is considered a preferred ESD practice in the Critical Area due to its high runoff reduction and phosphorus removal capability. It can be applied to all soil types and most development conditions.

MDE References: Page 3.38 in Chapter 3 of MDE (2000)

Critical Area TP Removal Rate: (see Table 16)

Table 16 Regular Bioretention Design Levels	
Level 1 Design TP:50%	**Level 2 Design TP: 75%**
HSG C and D Soils and/or under drain	HSG A and B Soils *OR* has full ESD to MEP storage *OR* has 12 inch stone sump below under drain invert*
Filter Media Depth less than 36 inches	Filter Media Depth 36 inches or more *
One cell	Two Cells, if CDA is more than 10,000 sf *
*All three criteria must be met to qualify for Level 2	

Additional Design Criteria for Critical Area

- Meet all of the design criteria for micro-bioretention, plus:
- Sub-soil infiltration testing: one infiltration test per 1,000 sq. ft. of filter surface; Min infiltration rate > 1/2 inch/hour in order to remove the under drain requirement. Soil infiltration testing is not needed if an under drain is used.
- A pretreatment cell *plus* one of the following: a grass filter strip, gravel/stone diaphragm, gravel/stone flow spreader, or another approved (manufactured) pre-treatment structure. Ideally, bioretention will be provided in a series of cells leading to a ditch system or stream.
- To prevent short-circuiting, the ratio of the length of shortest flow path to the overall average length of the practice must exceed 0.5. If this ratio cannot be attained, shift to a multiple cell design.
- The maximum contributing drainage area to an individual bioretention area shall not exceed 2.5 acres.

Where it is Entered in the Compliance Spreadsheet: Go to Rows 114 to 117 and select the row that corresponds to the predevelopment HSG for the bioretention area, and then enter the acreage of contributing impervious cover and the surface area of the bioretention area (in square feet). If an enhanced filter is added, enter the cubic feet of additional storage provided.

Note on Urban Bioretention: Urban bioretention includes expanded tree pits, street bioretention and foundation planters that are used to treat runoff at high intensity redevelopment projects (CSN, 2011). Due to redevelopment constraints, most urban bioretention practices do not fully meet ESD sizing criteria, and therefore have less phosphorus removal capability. Therefore, they should be entered in the spreadsheet as if they are a rain garden (Row 110 to 113).

Grass Channels

Applicability: Grass channels are a good option along open section roads at low density development projects. They require permeable soils in HSG A , B or C. They **are not** allowed for use on parking lots or rooftops. A bio-swale or dry swale is more effective in TP removal. If the water table is within a foot of the surface, wet swales or linear wetlands are a preferred alternative.

MDE Reference: Page 5.108 in MDE (2009) and described as a credit in MDE (2000).

Key MDE Design Criteria:

- The length of the grass channel must be at least the length of the contributing impervious cover to it.
- The maximum slope of a grass channel cannot exceed 4%, and check dams or infiltration berms should be installed to break up slopes.
- The maximum depth of the flow during the ESD storm shall not exceed 4 inches
- The surface area of the bottom of the grass channel shall be at least 2% of the contributing drainage area.
- The maximum contributing drainage area to an individual grass channel shall not exceed one acre.
- Flow velocities through the channel shall be non-erosive during the two year design storm, and the channel should have sufficient hydraulic capacity to safely convey the 10 year storm.

Critical Area TP Removal Rate (see Table 17)

Table 17 Design Levels for Grass Channels	
Level 1 Design TP:20%	**Level 2 Design TP:40%**
C and D Soils	A or B Soils OR restored C and D Soils *
Slopes from 2 and 4%	Slopes less than 2% *
* Both criteria must be met to qualify for Level 2	

Additional Design Criteria for Critical Area

- The minimum width of the grass channel is 4 feet.
- The water table must be at least 12 inches below the channel bottom.
- The grass channel must provide at least 10 minutes of residence time for the water quality storm event prior to any discharge to an inlet, pipe or stream.
- One foot of restored soil along channel bottom is required for C and D soils and mass graded B soils.
- No more than 3% slope is permitted in any 50 foot grass channel segment (e.g., low check dams).
- A minimum slope of 0.5% must be maintained in the grass channel to ensure positive drainage.

Where it is Entered in the Compliance Spreadsheet: Go to Rows 120 to 123 and select the row that corresponds to the predevelopment HSG for the grass channel and then enter the acreage of contributing impervious cover and the surface area of the channel bottom (in square feet).

Bioswales and Dry Swales

Applicability: Bioswales and dry swales are a versatile practice for low to moderate density development projects over the entire range of soil conditions.

MDE Reference:
- Bioswales: page 5.108 in Chapter 5 of MDE (2009)
- Dry Swales: page 3.45 of MDE (2000)

Key MDE Design Criteria: The geometric design criteria for bioswales are identical to the preceding criteria for grass channels.

Critical Area TP Removal Rate
- Design Level 2: 75% (HSG A and B Soils)
- Design Level 1: 50% (HSG C and D Soils)

Table 18 Design Levels for Bio-swales and Dry Swales	
Level 1 Design TP:50%	**Level 2 Design TP:75%**
Treats the WQv	Filters at least 75% of the ESD Target Volume *
Bioswale design	Dry Swale OR bioswale with stone sump *
C and D Soils	A and B Soils, OR C soils with enhanced filter *
Effective swale slope ≤ 2%	Effective swale slope less than 2% *
Media Depth of 18 inches or less	Media Depth of 24 inches or more *
* All five criteria must be met to qualify for Level 2	

Additional Design Criteria for Critical Area

- The minimum depth of the swale filter bed is 18 inches.
- The recipe for the swale filter media are the same as for regular bioretention
- It is acceptable to use turf as an alternative surface cover in lieu of mulch.
- The minimum depth from the bottom of the swale and the seasonally high water table can be one foot, if an under drain is used. Otherwise, a separation distance of two feet is needed to the seasonally high water table. In cases where the water table is close to the surface, consider shifting to a wet swale or linear wetland.
- Maintain at least a 0.5% slope in the under drain to ensure drainage.
- Sub-soil testing: one per 200 linear feet of filter surface; min. infiltration rate must be > 1/2 inch/hour to remove the under drain requirement. Testing is not required if an under drain is used.
- The following residential road setbacks apply to bio swales and dry swales: five feet down-gradient and one foot below road grade.

Where it is Entered in the Compliance Spreadsheet: Go to Rows 124 to 127 and select the row that corresponds to the predevelopment HSG for the bioswale (or dry swale), and then enter the acreage of contributing impervious cover and the surface area of the swale bottom (in square feet).

Wet Swales

Applicability: Wet swales are most feasible on flat terrain with a high water table and HSG C and D soils. They are not recommended for HSG A and B soils, unless the seasonally high water table is within three feet of the land surface. They are primarily applied in non-residential settings.

MDE Reference: Page 3.45 of MDE (2000) and page 5.108 in Chapter 5 of MDE (2009)

Key MDE Design Criteria:

- Check dams or infiltration berms should be installed to break up slopes.
- The maximum depth of the flow during the ESD storm shall not exceed 4 inches.
- The surface area of the bottom of the wet swale shall be at least 2% of the contributing drainage area.
- The maximum contributing drainage area to an individual wet swale shall not exceed one acre.
- Flow velocities through the swale shall be non-erosive during the two year design storm, and the swale should have sufficient hydraulic capacity to safely convey the 10 year storm.

Critical Area TP Removal Rate: 40%

Additional Design Criteria for Critical Area

- The maximum slope of a wet swale shall not exceed 2%
- The average dry weather ponding depth in the wet swale shall not exceed 6 inches.
- The wet-weather ponding depth may not exceed 18 inches. The basic idea is to design for saturated soils and not a permanent pool of standing water.
- Wet swales work best when designed as a series of on-line or off-line cells in the ditch system, with individual cells that are 50 to 75 feet long. Cells may be formed by check dams, infiltration berms or earthen berms.
- A planting plan must be provided on how emergent wetland species will grow in the swale, although it is acceptable to use wetland seed mixes to establish the plant community.

Where it is Entered in the Compliance Spreadsheet: Go to Rows 128 to 129 and enter the acreage of contributing impervious cover to the wet swale, the surface area of the bioswale (in square feet) and the depth of the swale (in feet).

4.3 Conventional Stormwater Practices

Sand Filters

Applicability: Sand filters are an effective treatment option when there is a groundwater contamination risk, such as at stormwater hotspots and brown-fields, or at redevelopment sites located on urban fill soils. Sand filters are suitable for all soil types. There are many different sand filter design variations that can work in difficult site conditions.

MDE Reference and Design Criteria: Page 3.38 in MDE (2000)

Critical Area TP Removal Rate:
- Design Level 1: 60%
- Design Level 2: 65%
- The requirements for each design level are outlined in Table 19

Table 19 Design Levels for Sand Filters	
Level 1 Design TP: 60%	**Level 2 Design TP: 65%**
Filters the WQv	Filters at least 75% of the ESD Target Volume*
One cell design	Two cell design, with one cell for pretreatment*
Contributing Drainage Area (CDA) contains more than 10% pervious area	CDA is nearly 100% impervious*
* All three criteria must be met to qualify for Level 2	

Additional Design Criteria for Critical Area:

- The perimeter or non-structural design variants are the most feasible sand filter option under most coastal plain conditions.
- The combined depth of the sand filter bed and under drain layer can be reduced to a minimum of 24 inches if site conditions are problematic.
- The minimum depth between the water table and the bottom of the sand filter can be reduced to one foot, if it is equipped with an under drain.

Where it is Entered in the Compliance Spreadsheet: Go to Rows 163 and 164 and select the row that corresponds to the design level achieved by the sand filter. Next, enter the acreage of contributing impervious cover to the filter and the water quality treatment volume (in cubic feet).

Shallow Constructed Wetlands

Applicability: While constructed wetlands are technically not classified as an ESD practice, they are an effective biological treatment practice for the Critical Area (particularly when the water table is close to the surface). New wetland designs that emphasize shallow, linear, multi-cell configurations, and seek to replicate forested wetland conditions are recommended for the Critical Area (Flores et al, 2009 and Cappiella et al, 2008).

MDE Reference and Design Criteria: page 3.8 in MDE (2000)

Critical Area TP Removal Rate (see Table 20)

Table 20 Design Levels for Constructed Wetlands	
Level 1 Design TP:50%	**Level 2 Design TP:75%**
Pool volume treats the one- inch WQv	Pool volume treats 1.25WQv or more *
Single cell (with a forebay)	Multiple cells **
Uniform wetland depth	Diverse microtopography with varying depths **
Mean wetland depth is *more* than 1 foot	Mean wetland depth is *less* than 1 foot **
The surface area of the wetland is *less* than 3% of the contributing drainage area (CDA).	The surface area of the wetland is *more* than 3% of the CDA. **
Length/Width ratio *OR* Flow path = 1:1 or more	Length/Width ratio *OR* Flow path = 2:1 or more **
Length of shortest flow path/overall length = 0.5 or more	Length of shortest flow path/overall length = 0.8 or more**
Emergent wetland plant community	Mixed of forested wetland community **
* Mandatory to qualify for Level 2 ** Must meet at least 4 of 7 of these criteria to qualify for Level 2	

Additional Design Criteria for Critical Area

- It is acceptable to excavate up to 6 inches below water table to create a wetland, and dig pools up to 3 feet to control mosquitoes. The wetland volume is equal to the water quality volume, if the basic geometric criteria in Table 20 are met.
- Flashboard risers are recommended for constructed wetlands in flat terrain.
- The creation of forested stormwater wetland plant communities is strongly encouraged, (e.g., cypress, tupelo, Atlantic white cedar and other wet-footed tree species).
- The Regenerative Conveyance System is recommended in the Critical Area, particularly when there is significant gradient across the site (Flores et al, 2009).

Where it is Entered in the Compliance Spreadsheet: Go to Rows 161 and 162 and select the row that corresponds to the design level achieved by the constructed wetland. Next, enter the acreage of contributing impervious cover to the wetland and the water quality treatment volume provided (in cubic feet).

Wet Ponds

Applicability: The use of wet ponds in the Critical Areas is not encouraged, since they are not considered an ESD practice, and recent research indicates their nutrient removal performance is limited under coastal plain conditions (Appendix A, CSN, 2009). In general, shallow constructed wetlands are a preferred alternative to wet ponds.

MDE Reference and Design Criteria: page 3.8 in MDE (2000)

Critical Area TP Removal Rate:

- Design Level 1: 50%
- Design Level 2: 75%
- The requirements for each design level are outlined in Table 21.

Table 21 Design Levels for Wet Ponds	
Level 1 Design TP: 50%	**Level 2 Design TP: 75%**
Pool volume treats the one- inch WQv	Pool volume treats 1.25 WQv or more *
Single Pond Cell (with forebay)	Multiple Cell Design **
Length/Width ratio OR Flow path = 1:1 or more	Length/Width ratio OR Flow path = 2:1 or more**
Length of shortest flow path / overall length = 0.5 or more	Length of shortest flow path/overall length = 0.8 or more**
Standard aquatic benches	Wetlands more than 10% of pond surface area **
* Mandatory to qualify for Level 2 ** Must meet at least 3 of 4 of these criteria to qualify for Level 2	

Additional Design Criteria for Critical Area

- A pond landscaping plan is required to achieve a natural ground cover of native perennials, shrubs and trees in the buffer zone.
- Ponds that are dugout below the water table are poor performers, and no WQv credit is given for any storage below the seasonally water table.
- Fountains may prevent stagnation and sediment release in summer.

Where it is Entered in the Compliance Spreadsheet: Go to Rows 159 and 160 and select the row that corresponds to the design level achieved by the wet pond. Next, enter the acreage of contributing impervious cover to the pond and its water quality treatment volume (in cubic feet).

Part 5
Stormwater Offset Fees and Offsite Compliance

5.1 Updated Stormwater Offset Fee Schedule

Offsets are defined as “structures or actions that compensate for undesirable impacts.” Offsets address the impacts associated with uncontrolled stormwater runoff generated from a development site by providing alternative ways to reduce pollutants when on-site ESD practices are insufficient or impractical. Offsets must remove a phosphorus load equal to or greater than the phosphorus removal requirement. Offset fees must be equivalent to the cost of planning, designing, constructing, and maintaining stormwater retrofits or other restoration practices capable of reducing an equivalent load of phosphorus.

Recent cost data suggests that stormwater offset fees need to be increased to fully recover the public sector cost to build retrofits that can remove an equivalent amount of phosphorus (CSN, 2011). The new recommended offset fee is $32,500 per pound of phosphorus that must be mitigated. The fee assumes that the phosphorus removal will occur in storage retrofits and/or stream restoration practices located on larger public or parcels within the same watershed. This option works best in larger counties with moderate development intensity, abundant retrofit opportunities and past experience in delivering watershed retrofits.

A higher offset fee may be warranted in larger cities that are already intensively developed, since they often lack the abundant and less expensive storage retrofit opportunities of their suburban counterparts. Setting the price for offsets should always be a local decision, given that each is unique with respect to its existing development intensity, expected redevelopment activity, retrofit opportunities, staff capability, business climate and future nutrient reduction liability.

5.2 Basic Principles for Critical Area Stormwater Offset Programs

The following principles are offered to develop effective and accountable programs to handle stormwater offsets for Critical Area projects.

> *Offsets Should be Simple to Administer and Verify***.** The offset fee should be expressed in simple unit terms that can be directly computed from redevelopment site data and/or stormwater spreadsheet computations. In the Maryland Critical Area, this common unit will be pounds of phosphorus load remaining at the site above the phosphorus removal standard.
>
> *Offsets Must Occur Within the Same Sub-Watershed,* which is operationally defined as the scale associated with the USGS 12 digit hydrologic unit code mapping systems. These subwatersheds normally range from about 15 to 65 square miles in area in the Bay watershed. For smaller cities, this scale means the offset project can occur pretty much anywhere in their jurisdiction. In a larger

county, this scale ensures that there is a linkage between where the impact occurs and where it is mitigated.

*Offsets Should Require Some On-Site ESD Treatment***.** Offsets are only allowed if a designer can demonstrate that a reasonable effort has been made to install ESD practices at the site. The basic idea is that you can't just write a check to avoid the entire cost of ESD implementation. Some ESD practices can always be implemented to some degree at nearly every development site, except for certain brown-field sites.

The Off-site Compliance Option: Another way to get to compliance is for the developer to find an off-site retrofit or restoration project that can achieve an equivalent degree of phosphorus removal. This situation may occur when the developer has a large property that extends across the Critical Area boundary. Off-site compliance is only allowed for retrofits of existing impervious cover, and not new impervious cover. The local Critical Area review authority makes the final decision as to whether the off-site compliance option is acceptable.

Local Stormwater Offset Programs Should Be Accountable. It is critically important to craft a stormwater offset program that is transparent and can quantitatively demonstrate that it is providing the desired load reduction under the phosphorus removal performance standard. Therefore, a good local phosphorus offset program has the following accountability elements:

> *Dedicated Account*. All funds collected from offset fees should be parked in a dedicated fund for the sole purpose of constructing qualifying offset projects. The fund should be restricted so that it cannot be tapped to meet other municipal needs.
>
> *Fiscal Accountability*. A locality should track offset fees collected and funds disbursed for offset projects over time, and provide the annual balance and financial status on an annual basis.
>
> *Reversion Clause*. If the locality accumulates offset fees but does not expend them within a five year time period, the funds should automatically revert to a pre-defined state agency, foundation or watershed group with capacity to expend them on restoration projects.
>
> *Watershed Restoration Inventory*. The program should have a current watershed restoration inventory that identifies priority retrofit and restoration projects for offset implementation. Most localities in the Critical Area have conducted watershed restoration plans in the past.
>
> *Retrofit Registry*. The locality should develop and maintain a retrofit registry that tracks the status of offset project implementation and the estimated phosphorus load reduced. The registry should also track the cumulative acres of impervious cover for which offsets have been granted.

The registry can be configured to show whether there is a surplus or deficit in offset treatment, and should be prominently displayed on their local websites. Localities are also advised to link their retrofit registry with their overall nutrient accounting system to meet their phosphorus load reduction requirements under their Bay-wide nutrient TMDL allocation for Maryland.

Offset Fees Should be Indexed for Inflation. One of the most common mistakes is to include a fixed offset fee schedule in a local stormwater ordinance that cannot be increased unless the statute is re-enacted. Within a few short years, revenues collected from offset fees can no longer recover the full cost to the public sector to build the projects. Therefore, the offset fee schedule should be indexed for construction inflation so that it can keep up with the true cost of retrofit implementation over the years. The accepted industry index to cite is the annual construction inflation index published by the *Engineering News Record*.

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Appendix A
Standardized TP Removal Rates for the Critical Area

Tables A-1 and A-2 provide updated total phosphorus removal rates for new ESD practices and traditional stormwater practices in order to integrate the ESD approach with the Critical Area phosphorus removal performance standard. These values are used in the ESD to the MEP compliance spreadsheet in order to track the progressive phosphorus reduction by ESD practices at a development site. The values reflect the mass removal rate for each practice, using the VA DCR technical memo. The mass removal rate reflects the relative contribution from runoff reduction and the change in phosphorus concentration as it flows through the practice. In most cases, the mass removal rate differs based on the hydrologic soils group of the underlying soils. In some cases, an enhanced level of design is possible to increase the TP mass removal rate.

Table A-1 Adjusted Removal Rates for Critical Area Stormwater Practices

ESD Practices	**Old CA P Rate/ Credit**	**New Data Source**	**Recommended New Rates**		**Rationale and Documentation**
			A & B Soils	**C & D Soils**	
Green Roof	Credit[1]	VA DCR	Less than 6: 45 More Than 6 : 60		Depth of vegetated roof. High runoff reduction but no change in TP EMC
Permeable Paver	Credit[2]	VADCR	80	60	Research has shown high rates of both runoff reduction and TP removal, depending on degree of soil infiltration.
Rooftop Disconnect	Credit[4]	VADCR	50	25	The 25% removal rate for C/D soils can be increased to 50% if it conforms to more stringent design criteria
Non- Rooftop Disconnect (Filter Strip)	None [5]	VADCR	50	25	The 25% removal rate for C/D soils can be increased to 50% if soils are restored
Sheet flow to Conservatn Area	None[6]	VADCR	50	25	Subject to Critical Area buffer restriction.

Impervious Cover Conversion and Reforestation Credit are taken by reducing post development IC

Notes

[1] Credit is for surface area of the rooftop is not considered impervious
[2] Credit is for surface area of pavers which are considered 50 to 90% imperviousness, depending on product
[4] Credit is for all contributing impervious area which is excluded from total site impervious cover
[5] Non-rooftop disconnection to a filter strip is allowed as MDE credit but is not directly called out in the 10% guidance
[6] This MDE credit is specifically disallowed within the Critical Area 100 foot buffer

Table A-2
Adjusted Removal Rates for Critical Area Stormwater Practices

ESD Practices	Old CA P Rate/ Credit	New Data Source	Recommended New Rates		Rationale and Documentation
			A & B Soils	C & D Soils	
Rainwater Harvesting	None[7]	VA DCR	45%		TP rates are based on default volume of runoff reused
Landscape Infiltration	None [7]	VADCR	75%	Not Allowed	This a hybrid of both infiltration and bioretention
Sub Gravel Wetlands	None [7]	UNH	Not Allowed	60%	Based on recent research from New Hampshire
Infiltration Berm	None [7]	None	0%	0%	This is not a stand-alone practice, but can help enhance NRD filter strip and grass channel performance
Dry Well	65% [8]	63% NPRD	65%	Not Allowed	Retain same rate as for infiltration practices
Infiltration	65%	VADCR	90%	60%	See Table A-3
Rain Gardens	None [7]	VADCR	50%	25%	Several key design elements that contribute to P removal of this form of bioretention are absent
Micro-bioretention	50% [9]	VADCR	75%	50%	Performance related to degree of soil infiltration achieved
Grass Channels	Credit [10]	VADCR	40%	20%	The 25% removal rate for C/D soils can be increased to 50% if soils are restored
Wet Swales	40%	VADCR	Not Allowed	40	
Bio swales [11]	65	VADCR	75%	50%	Performance related to degree of soil infiltration achieved

Notes

[7] There was no removal rate provided for this practice in the 2003 10% guidance manual
[8] Assumed to be comparable to rates for infiltration practices
[9] Assumed to be comparable to rates for bioretention practices
[10] Credit is for all contributing impervious area which is excluded from total site impervious cover, although parking lots are excluded
[11] Bio-swales are comparable to dry swales

Table A-3
Adjusted Removal Rates for Critical Area Stormwater Practices

ESD Practices	Old CA P Rate/ Credit	New Data Source	Recommended New Rates		Rationale and Documentation
			A & B Soils	C & D Soils	
Infiltration Systems [12]	65%	VADCR	Level 1: 60% Level 2: 90%		Level 1 is the base removal rates for the practice using standard design criteria in MDE (2000). Level 2 are include additional design elements that enhance TP removal rate, following the VADCR approach
Filtering Systems [12]	50%	VADCR	Level 1: 60% Level 2: 65%		
Ponds [12]	50-65	VADCR	Level 1: 50% Level 2: 75%		
Wetlands[12]	40-55	VADCR	Level 1: 50% Level 2: 75%		

Notes
[12] TP removal rates for multiple design variants are provided in Table 4.8 of the 10% Guide.

Appendix B

Documentation of the Revised Phosphorus Removal Performance Standard of 0.30 lb/ac/yr

Background

A single urban pollutant was selected as a surrogate for all stormwater pollutants. This "keystone" pollutant was used as the basis for computing pre-development and post-development pollutant loads at a site and ultimately, the necessary pollutant removal requirement. As part of the original guidance, each major stormwater pollutant was evaluated for suitability as a potential keystone pollutant. Based on this review, total phosphorus was recommended as the keystone pollutant to meet the Critical Area 10% Rule (MWCOG, 1987). Total phosphorus was selected as the keystone pollutant because it has the following characteristics:

- The adverse impacts of total phosphorus on the water quality of the Chesapeake Bay are well documented.
- Total phosphorus exists in both soluble and particulate forms, which means that a variety of removal mechanisms such as settling and biological uptake is needed for effective treatment.
- Abundant data exists to characterize total phosphorus concentrations and pollutant removal performance. This enables reviewers to more accurately compute post development stormwater loads and choose an effective stormwater BMP

The original performance standard was to treat post development runoff to achieve a predevelopment background load of no greater than 0.45 lbs of TP per acre per year. This was established in 1987 using the limited runoff monitoring data then available to characterize nutrient loads from Maryland watersheds. The baseline load was 0.5 lbs/ac/year, which represented a composite of the annual phosphorus load from a mixed watershed of forest, crop and pasture land uses.

Over the last two decades, better data has become available to characterize the acceptable post-development phosphorus load from new development projects. The primary data source is the Maryland nutrient loadings from the Chesapeake Bay Basin Model developed by the EPA to support the Bay-wide TMDL, as reported in MDE (2010), and reprised in Table B-1.

Table B-1
Total Phosphorus Loads, By Sector in Maryland Portion of Bay Watershed

Loading Sector	**2009 Load**	**Target Load**	**% Reduction Needed to Meet Target**
	Million pounds per year		
Forest Runoff	0.35	0.35	0
Atmospheric Deposition	0.04	0.04	0
Wastewater [1]	0.87	0.69	34%
Urban and Suburban Runoff	0.67	0.44	36%
Agricultural Runoff [2]	1.44	1.25	12%
RUNOFF SOURCES	2.46	1.99 [3]	
TOTAL	**3.3**	**2.72**	**12%**

Source: MDE (2010)
[1] includes combined sewer overflows
[2] includes confined animal feedlots
[3] excludes CAFO portion of agricultural runoff

The acceptable P TP target load from Bay-wide TMDL from all land-based sources of phosphorus pollution is 1.99 million/lbs/yr. Land sources of phosphorus pollution included runoff from forest, agricultural (excluding CAFOs) and urban and suburban land uses. Wastewater and CSO loads were excluded from the calculation, since they are not runoff-related, as was atmospheric deposition over open waters of the Bay.

The land-based TP target load was then divided by the total land area in Maryland's portion of the Chesapeake Bay watershed (5.866 million acres) to arrive at an average per acre phosphorus load of 0.34 pounds per acre per year.

Given the direct proximity of the Critical Area to the Bay, and to be consistent with the original Critical Area criteria (i.e., 10% reduction from the predevelopment load), the 0.34 lb target TP load was reduced by another 10%, to yield a final value of 0.30 lbs/ac/year.

The Critical Area Phosphorus removal standard is consistent with the proposed phosphorus baseline load for new development projects in Virginia discharging to the Chesapeake Bay, which has ranged between 0.28 to 0.45 lbs/acre/year.

For redevelopment projects, a lower phosphorus removal standard was developed to be consistent with MD ESD requirements. The target load reduction for redevelopment projects is the removal of one pound of phosphorus per impervious acre, or fraction thereof, by an acceptable treatment facility, or a 50% total P removal rate for the site.