# MARYLAND CHESAPEAKE AND ATLANTIC COASTAL BAYS
# CRITICAL AREA 10% RULE GUIDANCE MANUAL
## FALL 2003

Prepared for:
Critical Area Commission
For the Chesapeake and Atlantic Coastal Bays
1804 West Street
Suite 100
Annapolis, Maryland 21401

Prepared by:
Center for Watershed Protection
8390 Main Street
2nd Floor
Ellicott City, MD 21043

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CWP Project Team
Ted Brown – Water Resources Engineer
Tom Schueler – Director of Watershed Research and Practice
Tiffany Wright – Research Assistant
Rebecca Winer – Project Manager
Jennifer Zielinski – Watershed Engineer

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# SECTION 1.0 INTRODUCTION

The Chesapeake Bay Critical Area Protection Act (Critical Area Act) was 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 recognizes that the land immediately surrounding the Bays and their tributaries has the greatest potential to affect its water quality and wildlife habitats. The "Critical Area" is designated as all land within 1,000 feet of tidal waters or from the edge of tidal wetlands. The Act is designed to promote environmentally sensitive stewardship of land in the Critical Area. It addresses three principal concerns: the accommodation of future growth and development; sensitive utilization of natural resources; and the preservation of certain resources for future generations. 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.

Within the Critical Area there are three land use classifications or overlay zones: Resource Conservation Areas (RCA), Limited Development Areas (LDA), and Intensely Developed Areas (IDA). Intensely Developed Areas are the areas that were predominated by residential, commercial, industrial, and institutional land uses at the time of the original Critical Area mapping and where relatively little natural habitat occurred. IDAs are also considered the preferred locations for future growth through redevelopment and/or new development.

The criteria set forth in conjunction with the Critical Area Act require that any development within the IDA be accompanied by practices to reduce water quality impacts associated with stormwater runoff. The Criteria further specify 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 responsibility of implementing the Criteria is delegated to each local government. Therefore, each jurisdiction must ensure that the 10% Rule is met for development projects located within the IDA. In order to provide a consistent approach to compliance with the 10% Rule, the Critical Area Commission published a guidance document, "A Framework for Evaluating Compliance with the 10% Rule in the Chesapeake Bay Critical Area" in 1987 (MWCOG, 1987). This document was then revised in 1993, and divided into three guidance manuals: an Applicant's Guide, a Plan Reviewer's Guide, and a Technical Manual.

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 2000, the Maryland Department of the Environment (MDE) developed, promulgated, and adopted the 2000 Maryland Stormwater Design Manual, Vol. I & II. The Stormwater Design Manual reflects up-to-date information on stormwater practices. It includes a brief appendix on the Critical Area 10% Rule, but

does not include all of the information needed to plan, design, and review sites, nor did it resolve all of the inherent differences between the State's stormwater management program and the Critical Area 10% Rule. The Maryland Stormwater Design Manual can be accessed online at:
http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp

The purpose of this Guidance Manual is to update and consolidate the three existing guidance documents. It is important to note that this guidance information applies to development and redevelopment of properties located within the Critical Area and designated as an Intensely Developed Area (IDA). Some of the information and concepts presented in this document may not be applicable to properties designated as Limited Development Area (LDA) or Resource Conservation Area (RCA). The Manual also addresses and clarifies the differences between complying with the 10% Rule and the Maryland Stormwater Design Manual. Other significant changes include:

- the use of a single concentration of 0.3 mg/L to characterize phosphorus concentrations in stormwater runoff for both new development and redevelopment scenarios; and
- detailed information regarding local government offset programs and offset fees.

The Guidance Manual is organized as follows:

Section 2 – Introduces the concept and selection of total phosphorus as the keystone urban pollutant.

Section 3 – Provides an overview of the methods to comply with the 10% Rule and details the approach to 10% Rule compliance.

Section 4 – Shows how to prepare the Standard Application Process and includes sample worksheets.

Section 5 – Describes the shorter process for complying with the 10% Rule for development of an individual single-family lot and includes a sample Residential Water Quality Control Plan.

Section 6 – Provides guidance on how to implement offsets for development sites that cannot meet the 10% Rule.

Section 7 –Contains a series of frequently asked questions about complying with the 10% Rule.

Section 8 – References and Resources

Appendix A – Provides information about urban runoff pollutants.

Appendix B – Provides the criteria and justification for selection of a "keystone pollutant”.

Appendix C – Provides information about the “Simple Method” for estimating pollutant export from urban development and redevelopment sites.

Appendix D – This technical memo provides the justification for the application of a single phosphorus concentration of 0.3 mg/l for both new development and redevelopment.

Appendix E – Provides descriptions, advantages, disadvantages and schematics for stormwater BMPs allowed under the Standard Plan.

Appendix F – Provides descriptions, advantages, disadvantages and schematics for stormwater BMPs allowed under the Residential Water Quality Plan.

Appendix G – This technical memo provides the basis for setting an offset fee that fully recovers the cost to remove phosphorus from one acre of impervious cover

# SECTION 2.0 TOTAL PHOSPHORUS AS THE KEYSTONE POLLUTANT

Urban stormwater runoff contains a diverse array of pollutants that can have an adverse impact on the Chesapeake Bay, Atlantic Coastal Bays and its environs, which are reviewed in Appendix A. Because of the large number and variability of stormwater pollutants, it is neither feasible nor practical to compute pre-development and post-development loads for each to determine if an overall pollutant reduction of 10% has been achieved at a development site.

To simplify matters, a single urban pollutant was selected as a surrogate for all stormwater pollutants. This "keystone" pollutant is 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 (Appendix B provides a discussion on the selection of the keystone pollutant). Based on this review, total phosphorus was recommended as the keystone pollutant to meet the Critical Area 10% Rule. 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 and Atlantic Coastal Bays 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.

# SECTION 3.0 APPROACH

In the Critical Area of Maryland, development and redevelopment activities in IDAs must be designed with appropriate BMPs that must achieve at least a 10% reduction of pre-development pollutant loadings.

This section outlines the six steps to check whether an applicant's development plan has complied with the 10% Rule.

**A** Is the proposed development in the IDA of the Critical Area?

*If yes, then go to Step B.*
*If no, the 10% process does not apply.*

**B** Is the impervious surface proposed for the entire project greater than 250 square feet?

*If yes, then go to Step C.*
*If no, the 10% process does not apply.*

**C** Is the proposed development for an individual residential lot?

*If yes, go to Step D.*
*If no, go to Step E.*

**D** Use the Residential Water Quality Management Process (Section 5).

**E** Use the Standard Application Process (Section 4).

**F** Can the 10% Rule be met?

*If yes, process is complete.*
*If no, explore Offset options (Section 6).*

**Figure 3.1 10% Rule Application Process**

Two application procedures have been developed for 10% Rule compliance based on the type of development that occurs within the Critical Area (Figure 3.1).

- In the Standard Application Process, computations of pre-development and post-development pollutant loadings and pollutant removal efficiencies of BMPs are used to determine compliance with the 10% Rule. Four different pollutant reduction strategies can be used under the Standard Application Process:

    1) Reduce post-development impervious cover to lower levels of pollutants.
    2) Design and install stormwater BMPs to remove pollutants from the Critical Area portion of the site equal to the 10% reduction
    3) Design and install stormwater BMPs to remove pollutants from the Critical Area portion of the site and portions outside of the Critical Area that provide 10% reduction.
    4) Obtain an offset if compliance with the 10% Rule cannot be met with the first three strategies.

- The Residential Water Quality Management Process provides a streamlined process for development on individual residential lots. If the proposed development is eligible, the applicant must submit a Residential Water Quality Management Plan for approval (see Section 5).

# SECTION 4.0 STANDARD APPLICATION PROCESS

The Standard Application Process provides a six-step method for comparing pollutant loads before and after development, and assessing the appropriate stormwater best management practice (BMP) for a given site (Figure 4.1). The pollutant loading methodology is based on relationships between impervious cover and concentrations of pollutants found in urban runoff as defined by the Simple Method (Schueler, 1987). The Simple Method is discussed in detail in Appendix C.

Worksheet A (page 4-11) guides the applicant through Steps 1 to 5 of the Standard Application Process. Worksheet B (page 4-19) guides the applicant through Step 6 of the process and should be completed when an applicant proposes to treat an off-site area with an on-site BMP, proposes to construct a new retrofit BMP, or proposes to convert an existing BMP to achieve higher pollutant removal.

**Step 1: Calculate Existing and Proposed Site Imperviousness**

In this step, the applicant calculates the impervious cover of the predevelopment (existing) and post-development (proposed) site conditions. Next, the applicant adjusts the post-development impervious cover to account for any non-structural stormwater BMPs planned for the site. Lastly, the applicant must determine whether the site should be classified as new development or redevelopment.

Impervious cover is defined as those surfaces on the site that impede the infiltration of rainfall and result in an increased volume of surface runoff. As a simple rule, human-made 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 4.1 identifies which surfaces are typically considered impervious.

<u>Measuring Impervious Cover at the Project Site</u>

- Existing and proposed impervious cover must be measured directly from the most recent and accurate site plan.
- A table of measured values listed specifically for each impervious cover type (roads, rooftops, etc.) must be submitted. The use of a planimeter is recommended (See Worksheet A: Standard Application Process).
- Estimates of impervious cover based on general land use type or hydrologic modeling programs, (e.g., TR-55), are not allowed for submission.
- If land is subdivided prior to construction, it is recommended that the applicant complete the Standard Application Process at the time of initial subdivision, with imperviousness calculated using maximum building envelopes and proposed road layouts.

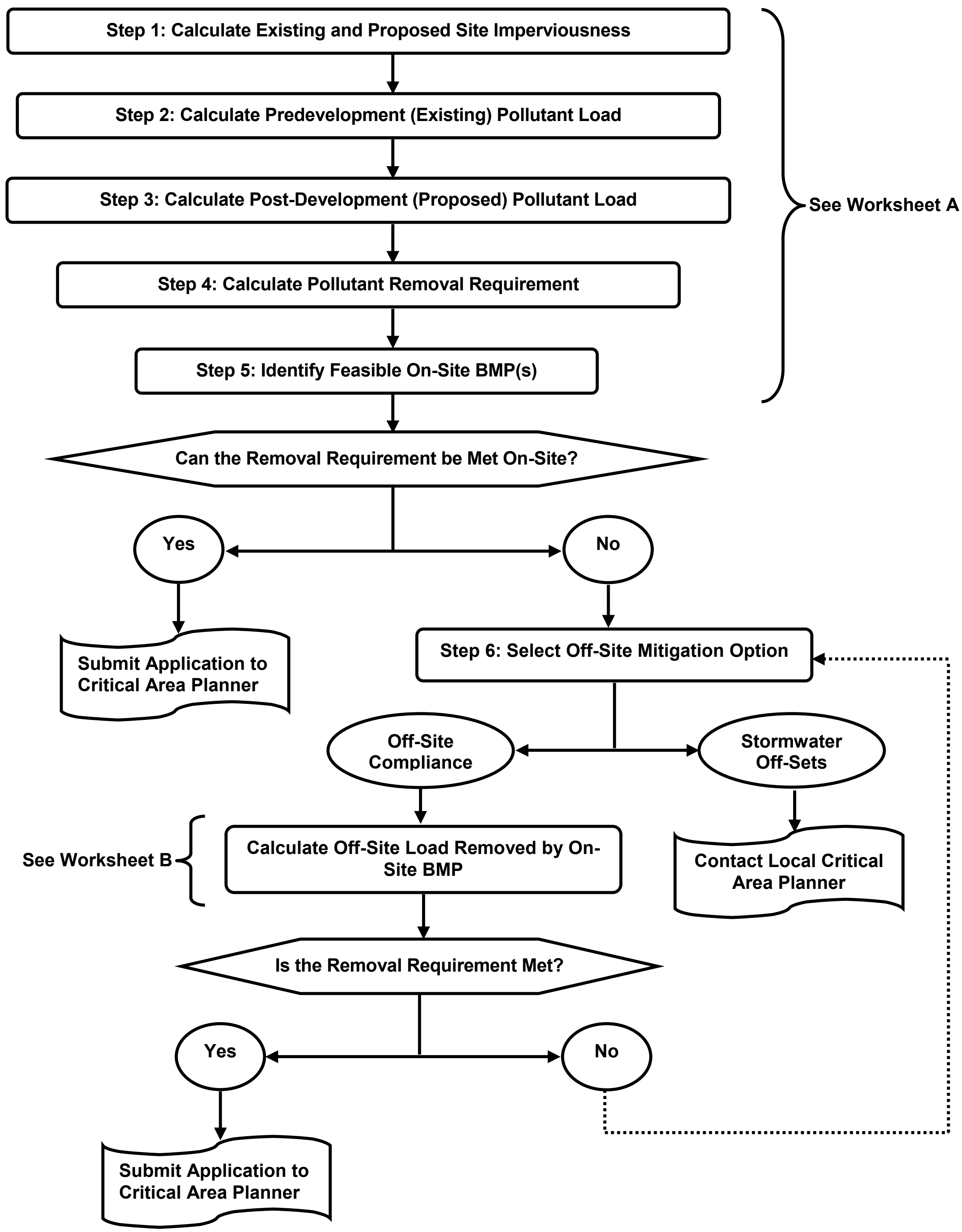


**Figure 4.1 Standard Application Process**

| Table 4.1 Detailed Definitions of Impervious Cover | | |
|---|---|---|
| **Surface** | **Impervious?** | **Design Suggestions** |
| **Roads / Parking Lots** | | |
| paved/concrete<br>gravel<br>dirt | yes | • minimize road width<br>• avoid curb and gutters<br>• use the grass channel non-structural BMP option |
| **Driveways** | | |
| paved<br>gravel/shell<br>dirt | yes | • minimize surface area<br>• use the permeable pavers non-structural BMP option |
| permeable pavers | partial | • perviousness ranges from 10 to 50%, depending on the product<br>• must be installed to the manufactures specifications<br>• applicant should collaborate with the local government to determine exact imperviousness |
| porous pavement | partial | • applicant should collaborate with the local government to determine exact imperviousness |
| **Sidewalks / Paths** | | |
| paved<br>gravel | yes | • minimize surface area<br>• use the permeable pavers non-structural BMP option |
| permeable pavers | partial | • perviousness ranges from 10 to 50%, depending on the product<br>• must be installed to the manufactures specifications<br>• applicant should collaborate with the local government to determine exact imperviousness |
| porous pavement | partial | • applicant should collaborate with the local government to determine exact imperviousness |
| wood chip | no | |
| **Rooftops** | | |
| shingle / asphalt | yes | • use the filter strip or vegetated rooftop non-structural BMP option |
| Vegetated | no | |
| **Decks** | no | • must be designed and constructed per Pervious Deck Design guidance in Appendix F |
| **Swimming Pools / Landscaping Ponds** | yes | |
| **Structural BMPs** | no | |

Accounting for Non-Structural BMPs

The proposed impervious cover for the site can be reduced if certain non-structural BMPs are installed on the site. Non-structural BMPs can reduce the impervious cover of the site in one of two ways:

1. The surface area of the non-structural BMP itself is not considered to be impervious, or is assigned a percent imperviousness.

2. All or a portion of the impervious surface area draining to the non-structural BMP (or the “disconnected impervious area”) is subtracted from the total proposed site impervious area.

Table 4.2 shows how to reduce the proposed impervious cover for each of the non-structural BMP options, along with design criteria.

For most of the non-structural BMPs, design criteria are available from the 2000 Maryland Stormwater Design Manual (MDE Manual). Table 4.3 provides an overview of the relationship between 10% Rule compliance and the MDE Manual stormwater credits.

**Table 4.2 Application of Non-Structural BMP Options**

| Non-Structural BMP Option | Impervious Area Adjustment | Design Criteria Reference |
|---|---|---|
| **Strategies to Disconnect Rooftop Runoff** | | |
| Filter Strip | DA | • *Disconnection of Rooftop Runoff Credit* |
| **Strategies to Store Rooftop Runoff** | | |
| Vegetated Rooftop | SA | • See Appendix E |
| **Strategies to Disconnect Non-Rooftop Runoff** | | |
| Permeable Pavers | SA | • Perviousness ranges from 10 to 50%, depending on the product<br>• See Appendix E |
| Grass Channel | DA | • *Grass Channel Credit* |
| **Approved on a Case-by-Case Basis** | | |
| Porous Pavement | SA | • See Appendix E |
| Cisterns | DA | • See Appendix E |
| DA = Impervious area draining to the non-structural BMP is subtracted from the total impervious cover<br>SA = Surface area of the BMP itself is not considered to be impervious | | |

| Table 4.3 Relationship Between 10% Rule Compliance and the Maryland Stormwater Design Manual Stormwater Credits | |
|---|---|
| **MDE Manual Stormwater Credit** | **How the Credit is Incorporated into the 10% Calculations** |
| 1. Natural Area Conservation | • Application of this credit does not change the way calculations are done for the 10% Rule.<br>• Total site area, including the natural area conservation area, is used in the 10% Rule calculations.<br>• The natural area conserved is not impervious. |
| 2. Disconnection of Rooftop Runoff | • Application of this credit reduces the post-development site imperviousness used to calculate the average annual load of total phosphorus exported from the post-development site.<br>• The disconnected impervious surface area is deducted from total impervious surface area when calculating proposed imperviousness.<br>• See Worksheet A, Step 1. |
| 3. Disconnection of Non Rooftop Runoff | • If the runoff is directed to a grass channel, application of this credit reduces the post-development site imperviousness used to calculate the average annual load of total phosphorus exported from the post-development site.<br>• The disconnected impervious surface area is deducted from total impervious surface area when calculating proposed imperviousness.<br>• See Worksheet A, Step 1. |
| 4. Sheet Flow to Buffers | • Application of this credit does not change the way calculations are done for the 10% Rule.<br>• Total site area, including the 100-foot Critical Area Buffer area on the site, is used in 10% Rule calculations.<br>• Any impervious area draining to the 100-foot Critical Area Buffer is still considered impervious, and is included in impervious cover when calculating the post-development pollutant load. |
| 5. Grass Channel Use | • Application of this credit reduces the post-development site imperviousness used to calculate the average annual load of total phosphorus exported from the post-development site.<br>• The disconnected impervious surface area is deducted from total impervious surface area when calculating proposed imperviousness. |
| 6. Environmentally Sensitive Development | • If the Credit has been applied to a Single Lot Development, the application process outlined in Section 5, Residential Approach, must still be followed.<br>• If the Credit has been applied to a Multiple Lot Development, the 10% Rule calculations must still be completed and the 10% Rule worksheets must still be submitted. |

Define Development Classification

The next step is to classify the proposed development as one of the following: 1) new development, 2) redevelopment or 3) single lot residential. (Classifications 1 and 2 are based on predevelopment impervious cover and lot size):

- New development is defined as a project having a predevelopment impervious cover less than 15%.
- Redevelopment is defined as a project having predevelopment impervious cover of 15% or more.
- Single Lot Residential Development is defined as a project on an individual residential lot.

If the proposed development is classified as Single Lot Residential Development, the Standard Application Process does not apply. The applicant should reference Section 5, Residential Approach, for detailed criteria and requirements.

**Step 2: Calculate Predevelopment Phosphorus Load**

In this step, the applicant calculates stormwater phosphorus loadings from the site prior to development. Depending on the development classification, the applicant will use one of two equations (Table 4.4). The equation to determine phosphorus loading in a redevelopment situation is based on the Simple Method (Appendix C). The equation to determine phosphorus loading in a new development situation utilizes a benchmark load for undeveloped areas, which is based on average phosphorus loadings for a typical mix of undeveloped land uses.

The information needed for these calculations includes:

- the area of the site within the IDA of the Critical Area
- pre-development (existing) site imperviousness

| Table 4.4 Method For Calculating Predevelopment Phosphorus Loading | | |
|---|---|---|
| **New Development Phosphorus Loading, $L_{pre} = 0.5\ (A)$** | | |
| Where: | | |
| $L_{pre}$ | = | Average annual load of total phosphorus exported from the site prior to development (lbs/year) |
| 0.5 | = | Annual total phosphorus load from undeveloped lands (lbs/acre/year) |
| A | = | Area of the site within the IDA Critical Area (acres) |

| Table 4.4 Method For Calculating Predevelopment Phosphorus Loading | | |
|---|---|---|
| **Redevelopment Phosphorus Loading, $L_{pre}$ = ($R_v$) (C) (A) 8.16** | | |
| Where: | | |
| $L_{pre}$ | = | Average annual load of total phosphorus exported from the site prior to development (lbs/year) |
| $R_v$ | = | Runoff coefficient = 0.05 + 0.009 ($I_{pre}$) |
| $I_{pre}$ | = | Predevelopment (existing) site imperviousness (i.e., I = 75 if site is 75% impervious) |
| C | = | Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l |
| A | = | Area of the site within the Critical Area IDA (acres) |
| 8.16 | = | Includes regional constants and unit conversion factors |

**Step 3: Calculate Post-Development Pollutant Load**
In this step, the applicant calculates stormwater phosphorus loadings from the post-development, or proposed, site. Again, an abbreviated version of the Simple Method (Appendix C) is used for the calculations, and the equation is the same for both new development and redevelopment sites (Table 4.5).

| Table 4.5 Method For Calculating Post-Development Phosphorus Loading | | |
|---|---|---|
| **Post-Development Phosphorus Loading, $L_{post}$ = ($R_v$) (C) (A) 8.16** | | |
| Where: | | |
| $L_{post}$ | = | Average annual load of total phosphorus exported from the post-development site (lbs/year) |
| $R_v$ | = | Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff |
| | = | 0.05 + 0.009 (I) |
| $I_{post}$ | = | Post-development (proposed) site imperviousness (i.e., I = 75 if site is 75% impervious) |
| C | = | Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l |
| A | = | Area of the site within the Critical Area IDA (acres) |
| 8.16 | = | Includes regional constants and unit conversion factors |

**Step 4: Calculate the Pollutant Removal Requirement**

The phosphorus load generated from the post-development site must be reduced so that it is at least 10% less than the load generated prior to development. The amount of phosphorus that must be removed through the use of stormwater BMPs is called the Pollutant Removal Requirement (RR). The equation in Table 4.6 expresses this term numerically.

| Table 4.6 Computing Pollutant Removal Requirements | | |
|---|---|---|
| **Pollutant Removal Requirement, RR = $L_{post}$ - 0.9($L_{pre}$)** | | |
| Where: | | |
| RR | = | Pollutant removal requirement (lbs/year) |
| $L_{post}$ | = | Average annual load of total phosphorus exported from the post-development site (lbs/year) |
| $L_{pre}$ | = | Average annual load of total phosphorus exported from the site prior to development (lbs/year) |

**Step 5: Identify Feasible Structural BMPs**

Structural BMPs that may be used to comply with the 10% Rule are described in Appendix E. These BMPs are subject to the performance and design criteria set forth by the 2000 Maryland Stormwater Design Manual.

Structural BMP options must be shown to be feasible for the site both in terms of physical suitability and pollutant removal capabilities. It should be noted that the Structural BMPs which survive the screening procedure still need to undergo more detailed design checks and field tests to confirm that they are actually feasible. Evidence of site feasibility will be required as part of the final submittal package.

Physical Suitability
The 2000 Maryland Stormwater Design Manual outlines a process for selecting the best BMP or group of BMPs for a site and provides guidance on factors to consider when deciding where to locate them. The process guides the designer through six steps that progressively screen the following issues:

- Watershed factors
- Terrain factors
- Stormwater treatment suitability
- Physical feasibility factors
- Community and environmental factors
- Locational and permitting factors

The matrices for this screening process are presented in Chapter 4 of the 2000 Maryland Stormwater Design Manual, which may be accessed online at:

www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp

Pollutant Removal Feasibility
The second step used to determine feasibility relates to the ability of the chosen BMP to meet the pollutant removal requirements of the 10% Rule. The pollutant load removed by each BMP (Table 4.7) is calculated using the BMP removal efficiency (Table 4.8), the computed post-development load, and the drainage area served.

| Table 4.7 Estimate of Pollutant Load Removed by Each BMP | | |
|---|---|---|
| **Load Removed, LR = ($L_{post}$) ($BMP_{RE}$) (% DA Served)** | | |
| Where: | | |
| LR | = | Annual total phosphorus load removed by the proposed BMP (lbs/year) |
| $L_{post}$ | = | Average annual load of total phosphorus exported from the post-development site prior to development (lbs/year) |
| $BMP_{RE}$ | = | BMP removal efficiency for total phosphorus, Table 4.8 (%) |
| % DA Served | = | Fraction of the drainage area served by the BMP (%) |

**Table 4.8 BMP Removal Rates for Total Phosphorus**

| Code | BMP | Total Phosphorus Removal Efficiency (%) |
|---|---|---|
| P-1 | Micropool ED | 40% |
| P-2 | Wet Pond | 50% |
| P-3 | Wet ED Pond | 60% |
| P-4 | Multiple Pond | 65% |
| P-5 | Pocket Pond | 50% |
| W-1 | Shallow Wetland | 40% |
| W-2 | ED Wetland | 40% |
| W-3 | Pond/Wetland | 55% |
| W-4 | Pocket Wetland | 40% |
| I-1 | Infiltration Trench | 65% |
| I-2 | Infiltration Basin | 65% |
| F-1 | Surface Sand Filter | 50% |
| F-2 | Underground Sand Filter | 50% |
| F-3 | Perimeter Sand Filter | 50% |
| F-4 | Organic Filter | 50% |
| F-5 | Pocket Sand Filter | 40% |
| F-6 | Bioretention | 50% |
| O-1 | Dry Swale | 65% |
| O-2 | Wet Swale | 40% |

If the Load Removed is equal to or greater than the Pollutant Removal Requirement computed in Step 4, then the on-site BMP complies with the 10% Rule. If not, the designer must evaluate alternative BMP designs to achieve higher removal efficiencies, add additional BMPs, design the project so that more of the site is treated by the proposed BMPs, or design the BMP to treat runoff from an off-site area.

# Worksheet A: Standard Application Process

## Calculating Pollutant Removal Requirements[1]

**Step 1: Calculate Existing and Proposed Site Imperviousness**

**A. Calculate Percent Imperviousness**

1) Site Area within the Critical Area IDA, A = ____________ acres

2) Site Impervious Surface Area, Existing and Proposed, (See Table 4.1 for details)

| | (a) Existing (acres) | (b) Proposed (acres) |
|---|---|---|
| Roads | ________ | ________ |
| Parking lots | ________ | ________ |
| Driveways | ________ | ________ |
| Sidewalks/paths | ________ | ________ |
| Rooftops | ________ | ________ |
| Decks | ________ | ________ |
| Swimming pools/ponds | ________ | ________ |
| Other | ________ | ________ |
| Impervious Surface Area | ________ | ________ |

3) Imperviousness (I)

Existing Imperviousness, $I_{pre}$ = Impervious Surface Area / Site Area
= (Step 2a) / (Step 1)
= (_____________) / (_____________)
= _____________ %

Proposed Imperviousness, $I_{post}$ = Impervious Surface Area / Site Area
= (Step 2b) / (Step 1)
= (_____________) / (_____________)
= _____________ %

**B. Define Development Category (circle)**

1) New Development: Existing imperviousness less than 15% I *(Go to Step 2A)*

2) Redevelopment: Existing imperviousness of 15% I or more *(Go to Step 2B)*

3) Single Lot Residential Development: Single lot being developed or improved; single family residential development; and more than 250 square feet of impervious area and associated disturbance (Go to Section 5, Residential Approach, for detailed criteria and requirements).

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[1] NOTE: All acreage used in this worksheet refers to areas within the IDA of the Critical Area only.

**Step 2: Calculate the Predevelopment Load ($L_{pre}$)**

**A. New Development**

$L_{pre}$ = (0.5) (A)

= (0.5) (____________)

= ____________ lbs /year of total phosphorus

Where:

$L_{pre}$ = Average annual load of total phosphorus exported from the site prior to development (lbs/year)
0.5 = Annual total phosphorus load from undeveloped lands (lbs/acre/year)
A = Area of the site within the Critical Area IDA (acres)

**B. Redevelopment**

$L_{pre}$ = ($R_v$) (C) (A) (8.16)

$R_v$ = 0.05 + 0.009 ($I_{pre}$)

= 0.05 + 0.009 (____________) = ____________

$L_{pre}$ = (____________) (____________) (____________) (8.16)

= ____________ lbs/year of total phosphorus

Where:

$L_{pre}$ = Average annual load of total phosphorus exported from the site prior to development (lbs/year)
$R_v$ = Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff
$I_{pre}$ = Pre-development (existing) site imperviousness (i.e., I = 75 if site is 75% impervious)
C = Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l
A = Area of the site within the Critical Area IDA (acres)
8.16 = Includes regional constants and unit conversion factors

**Step 3: Calculate the Post-Development Load ($L_{post}$)**

**A. New Development and Redevelopment:**

$L_{post}$ = $(R_v)$ (C) (A) (8.16)

$R_v$ = 0.05 + 0.009 ($I_{post}$)

= 0.05 + 0.009 (____________) = ____________

$L_{post}$ = (____________) (____________) (____________) (8.16)

= ____________ lbs/year of total phosphorus

Where:

$L_{post}$ = Average annual load of total phosphorus exported from the post-development site (lbs/year)
$R_v$ = Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff
$I_{post}$ = Post-development (proposed) site imperviousness (i.e., I = 75 if site is 75% impervious)
C = Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l
A = Area of the site within the Critical Area IDA (acres)
8.16 = Includes regional constants and unit conversion factors

**Step 4: Calculate the Pollutant Removal Requirement (RR)**

RR = $L_{post}$ - (0.9) ($L_{pre}$)

= (____________) - (0.9) (____________)

= ____________ lbs/year of total phosphorus

Where:

RR = Pollutant removal requirement (lbs/year)
$L_{post}$ = Average annual load of total phosphorus exported from the post-development site (lbs/year)
$L_{pre}$ = Average annual load of total phosphorus exported from the site prior to development (lbs/year)

**Step 5: Identify Feasible BMP(s)**

Select BMP Options using the screening matrices provided in the Chapter 4 of the 2000 Maryland Stormwater Design Manual. Calculate the load removed for each option.

| BMP Type | ($L_{post}$) | x | ($BMP_{RE}$) | x | (% DA Served) | = | LR | |
|---|---|---|---|---|---|---|---|---|
| ________ | ________ | x | ________ | x | ________ | = | ________ | lbs/year |
| ________ | ________ | x | ________ | x | ________ | = | ________ | lbs/year |
| ________ | ________ | x | ________ | x | ________ | = | ________ | lbs/year |
| ________ | ________ | x | ________ | x | ________ | = | ________ | lbs/year |

Load Removed, LR (total) = ________ lbs/year

Pollutant Removal Requirement, RR (from Step 4) = ________ lbs/year

Where:

Load Removed, LR = Annual total phosphorus load removed by the proposed BMP (lbs/year)
$L_{post}$ = Average annual load of total phosphorus exported from the post-development site (lbs/year)
$BMP_{RE}$ = BMP removal efficiency for total phosphorus, Table 4.8 (%)
% DA Served = Fraction of the site area within the critical area IDA served by the BMP (%)
RR = Pollutant removal requirement (lbs/year)

If the Load Removed is equal to or greater than the Pollutant Removal Requirement computed in Step 4, then the on-site BMP complies with the 10% Rule.

**Has the RR (pollutant removal requirement) been met?** ☐ **Yes** ☐ **No**

**Step 6: Select Off-Site Mitigation Option**

If the pollutant removal requirement has been met through the application of on-site stormwater BMPs and non-structural BMPs, the Standard Application Process is complete and the application may be submitted to the local Critical Area plan reviewer.

In the event that on-site BMPs cannot fully meet the pollutant removal requirement and on-site design cannot be changed, two options exists for off-site mitigation:

- *Stormwater Offsets.* Compliance achieved by using alternatives to the construction of an on-site or off-site BMP. Examples of offset projects are provided in Table 4.9, and Section 6.0, Offset Program, describes Stormwater Offsets in detail.

- *Off-Site Compliance.* Compliance achieved by treatment of off-site drainage areas with an on-site BMP.

| Table 4.9 Examples of Acceptable Stormwater Offset Projects |
|---|
| Having shown that on-site compliance is not feasible, the applicant may choose from the following offset options (see Section 6, Offset Program for more details):<br>• Construct a new BMP<br>• Convert an existing BMP to achieve higher pollutant removal<br>• Modify the existing conveyance network to enhance pollutant removal<br>• Reduce the imperviousness of an existing property<br>• Restore a degraded tidal or non-tidal wetland<br>• Restore a channelized stream<br>• Daylight a stream<br>• Implement a riparian reforestation project<br>• Install trash interceptors on existing stormwater inlets<br>• Improve existing stormwater ponds by planting forested buffer areas around the facility<br>• Develop and implement a public education program about stormwater management in conjunction with local government<br>• Over-design another pending project |

*Worksheet B: Standard Application Process* must be completed if off-site compliance is proposed for a site. This includes projects where an applicant proposes to treat an off-site area with an on-site BMP, proposes to construct a new retrofit BMP, or proposes to convert an existing BMP to achieve higher pollutant removal. If multiple BMPs are used to treat off-site drainage areas, Worksheet B should be completed for each BMP.

Worksheet B, Step 1
In Step 1, the applicant calculates the impervious cover of the off-site drainage area to be treated by the on-site BMP. The impervious cover should reflect the *ultimate* conditions of the site, or the impervious cover of the site that will be draining to the completed BMP. Table 4.1 describes which surfaces are impervious and which are not.

The applicant then uses the ultimate off-site impervious cover to classify the off-site drainage area as either new development or redevelopment:

- New Development is defined as a site having an impervious cover less than 15%

- Redevelopment is defined as a site having an impervious cover of 15% or more

Worksheet B, Step 2
In this step the applicant calculates storm loadings of phosphorus from the off-site drainage area. Depending on the off-site drainage area classification, the applicant will use one of two equations (Table 4.10).

The information needed for these calculations includes:

- the off-site drainage area to be treated by the on-site BMP
- the ultimate off-site impervious cover

| **Table 4.10 Method For Calculating Post-Development Phosphorus Loading for Off-site Drainage Area** |
|---|
| **When:**<br>Ultimate impervious cover of the off-site drainage area to be treated by the on-site BMP is **less than 15%**<br><br>**Use:**<br>**New Development Phosphorus Loading, $L_{off\text{-}site} = 0.5\ (A_{off\text{-}site})$**<br>Where:<br>$L_{off\text{-}site}$ = Average annual load of total phosphorus exported from the site prior to development (lbs/year)<br>0.5 = Annual total phosphorus load from undeveloped lands (lbs/acre/year)<br>$A_{off\text{-}site}$ = Off-site drainage area to be treated by on-site BMP (acres) |

| Table 4.10 Method For Calculating Post-Development Phosphorus Loading for Off-site Drainage Area | | |
|---|---|---|
| **When:** Ultimate impervious cover of the off-site drainage area to be treated by the on-site BMP is **15% or more** | | |
| **Use:** **Off-site Phosphorus Loading, $L_{off\text{-}site} = (R_v)\ (C)\ (A_{off\text{-}site})\ 8.16$** | | |
| Where: | | |
| $L_{off\text{-}site}$ | = | Average annual load of total phosphorus exported from the off-site drainage area (lbs/year) |
| $R_v$ | = | Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff |
| | = | $0.05 + 0.009\ (I_{off\text{-}site})$ |
| $I_{off\text{-}site}$ | = | Ultimate off-site imperviousness (i.e., I = 75 if site is 75% impervious) |
| C | = | Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l |
| $A_{off\text{-}site}$ | = | Off-site drainage area to be treated by on-site BMP (acres) |
| 8.16 | = | Includes regional constants and unit conversion factors |

Worksheet B, Step 3

In this step, the applicant calculates the load removed from the off-site drainage area by the on-site BMP. It is important to note that the BMP should be designed to provide treatment for the entire area draining to it, both on-site and off-site, per the MDE Manual.

The pollutant load removed is calculated using the BMP removal efficiency (Table 4.8), and the computed off-site load (Table 4.11).

| Table 4.11 Off-Site Pollutant Load Removed by On-Site BMP | | |
|---|---|---|
| **Off-Site Load Removed = $(BMP_{RE})\ (L_{off\text{-}site})$** | | |
| Where: | | |
| $BMP_{RE}$ | = | BMP removal efficiency for total phosphorus, Table 4.8 (%) |
| $L_{off\text{-}site}$ | = | Average annual load of total phosphorus exported from the off-site drainage area (lbs/year) |

Worksheet B, Step 4

In Step 4, the applicant calculates the total load removed by the on-site BMP (Table 4.12).

| Table 4.12 Total Load Removed by On-Site BMP |
|---|
| **Total Load Removed = Load Removed On-Site + Load Removed Off-Site** |

# Worksheet B: Standard Application Process

## Calculating Removal from Off-site Drainage Areas

**Step 1: Project Description**

**A. Calculate Percent Imperviousness**

1) Off-site Drainage Area to be Treated by On-site BMP, $A_{off\text{-}site}$ = _____________ acres

2) Ultimate Off-site Drainage Area Imperviousness

(a) Ultimate Off-site Impervious Area (acres)

| | | |
|---|---|---|
| Roads | _____________ | (acres) |
| Parking Lots | _____________ | (acres) |
| Driveways | _____________ | (acres) |
| Sidewalks/paths | _____________ | (acres) |
| Rooftops | _____________ | (acres) |
| Decks | _____________ | (acres) |
| Swimming pools/ponds | _____________ | (acres) |
| Other | _____________ | (acres) |

Total Off-site Impervious Area (sum of the above) = _____________ (acres)

(b) Ultimate Off-site Imperviousness ($I_{off\text{-}site}$)

Off-site Imperviousness ($I_{off\text{-}site}$) = Total Off-site Impervious Area / $A_{off\text{-}site}$

= (Step 2a) / (Step 1)

= (_____________) / (_____________)

= _____________ %

**B. Define Development Category of Off-site Drainage Area**

1) New Development: Ultimate imperviousness of off-site drainage area less than 15% I *(Go to Step 2A)*

2) Redevelopment: Ultimate imperviousness of off-site drainage area greater than or equal to 15% I *(Go to Step 2B)*

**Step 2: Calculate Post-Development Load for Off-site Drainage Area ($L_{off\text{-}site}$)**

**A. New Development**

$L_{off\text{-}site}$ = 0.5 ($A_{off\text{-}site}$)

= 0.5 (_____________)

= _____________ lbs/year of total phosphorus

Where:
$L_{off\text{-}site}$ = Average annual load of total phosphorus exported from the off-site drainage area (lbs/year)
0.5 = Annual total phosphorus load from undeveloped lands (lbs/acre/year)
$A_{off\text{-}site}$ = Off-site drainage area to be treated by on-site BMP (acres)

**B. Redevelopment**

$L_{off\text{-}site}$ = ($R_v$) (C) ($A_{off\text{-}site}$) 8.16

$R_v$ = 0.05 + 0.009 ($I_{off\text{-}site}$)

= 0.05 + 0.009 (_____________) = _____________

$L_{off\text{-}site}$ = (_____________) (_____________) (_____________) 8.16

= _____________ lbs/year of total phosphorus

Where:
$L_{off\text{-}site}$ = Average annual load of total phosphorus exported from the off-site drainage area (lbs/year)
$R_v$ = Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff
$I_{off\text{-}site}$ = Ultimate off-site imperviousness (i.e. I = 75 if site is 75% impervious)
C = Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l
$A_{off\text{-}site}$ = Off-site drainage area to be treated by on-site BMP (acres)
8.16 = Includes regional constants and unit conversion factors

**Step 3: Calculate the Load Removed from Off-site Drainage Areas by On-site BMP**

Type of BMP: ____________________________________________

Off-site Load Removed = $(BMP_{RE})$ $(L_{off\text{-}site})$

= (____________) (____________)

= ____________ lbs/year of total phosphorus

Where:
$BMP_{RE}$ = BMP removal efficiency for total phosphorus, see Table 4.8 (%)
$L_{off\text{-}site}$ = Average annual load of total phosphorus exported from the off-site drainage area (lbs/year)

**Step 4: Calculate the Total Load Removed by On-site and Off-site BMPs**

Total Load Removed = Load Removed On-site + Load Removed Off-site

= (Worksheet A, Step 5) + (Step 3)

= (____________) + (____________)

= ____________ lbs/year of total phosphorus

Pollutant Removal Requirement (Worksheet A, Step 4) = ____________ lbs/year

If the Load Removed is equal to or greater than the Pollutant Removal Requirement computed in Step 4, then the on-site BMP complies with the 10% Rule.

**Has the Pollutant Removal Requirement been met?** ☐ **Yes** ☐ **No**

**Standard Application for Simple On-Site Compliance – New Development**

The following example presents a step-by-step process for completing the Standard Application Process for a simple new development situation. The existing and proposed site plans are displayed below (Figure 4.2) and the completed "Worksheet A: Standard Application Process."

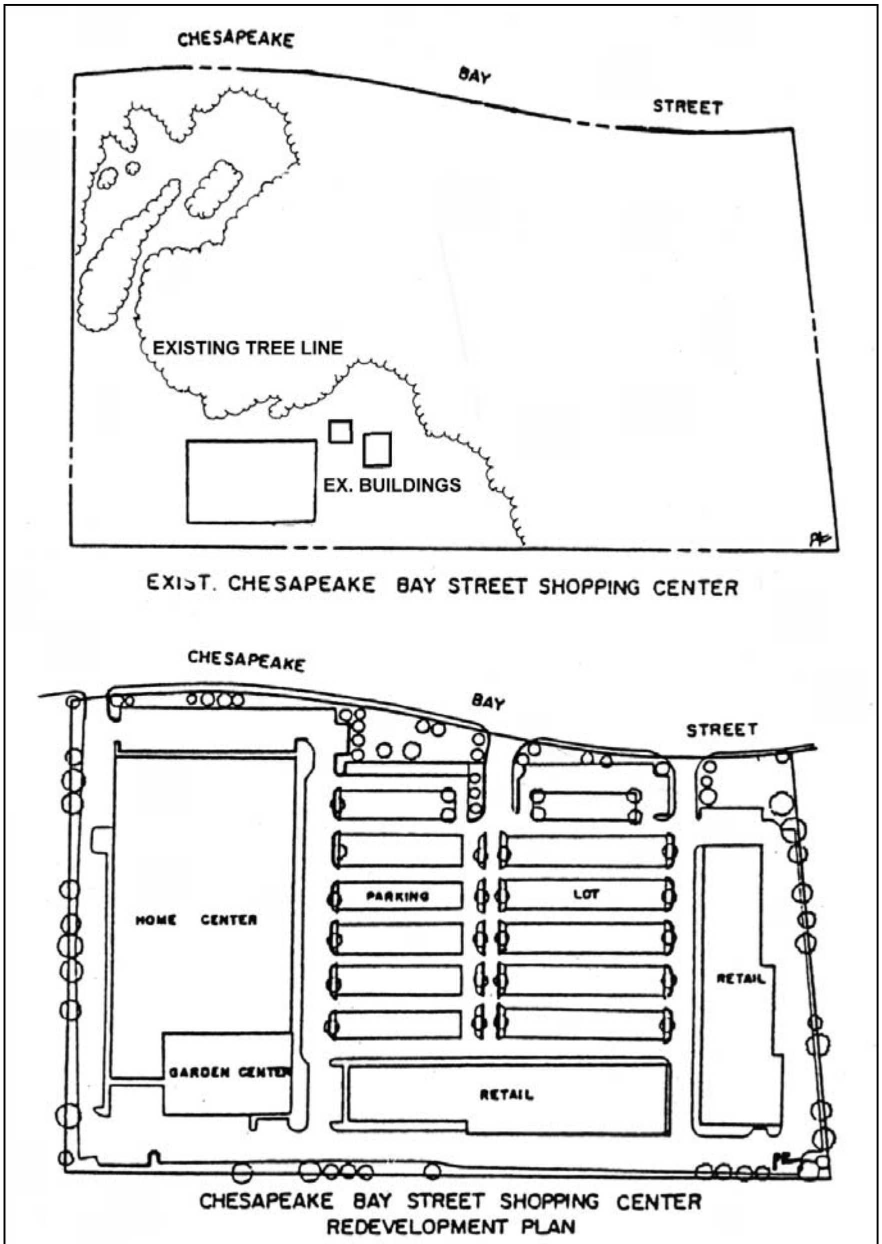



**Figure 4.2 Existing and Proposed Site Plans for Simple On-Site Compliance Example**

# Worksheet A: Standard Application Process

## Calculating Pollutant Removal Requirements[1]

**Step 1: Calculate Existing and Proposed Site Imperviousness**

**A. Calculate Percent Imperviousness**

1) Site Area within the Critical Area IDA, A = **15** acres

2) Site Impervious Surface Area, Existing and Proposed, (See Table 4.1 for details)

| | (a) Existing (acres) | (b) Proposed (acres) |
|---|---|---|
| Roads | | **2.40** |
| Parking lots | | **5.30** |
| Driveways | | |
| Sidewalks/paths | | **0.15** |
| Rooftops | **0.75** | **4.52** |
| Decks | | |
| Swimming pools/ponds | | |
| Other | | |
| Impervious Surface Area | **0.75 acres** | **12.37 acres** |

3) Imperviousness (I)

Existing Imperviousness, $I_{pre}$ = Impervious Surface Area / Site Area
= (Step 2a) / (Step 1)
= ( **0.75** ) / ( **15** )
= **0.05 or 5** %

Proposed Imperviousness, $I_{post}$ = Impervious Surface Area / Site Area
= (Step 2b) / (Step 1)
= ( **12.37** ) / ( **15** )
= **0.8247 or 82** %

**B. Define Development Category (circle)**

1) New Development: Existing imperviousness less than 15% I *(Go to Step 2A)*

2) Redevelopment: Existing imperviousness of 15% I or more *(Go to Step 2B)*

3) Single Lot Residential Development: Single lot being developed or improved; single family residential development; and more than 250 square feet of impervious area and associated disturbance (Go to Section 5, Residential Approach, for detailed criteria and requirements).

[1] NOTE: All acreage used in this worksheet refers to areas within the IDA of the Critical Area only.

**Step 2: Calculate the Predevelopment Load ($L_{pre}$)**

**A. New Development**

$L_{pre}$ = (0.5) (A)

= (0.5) (__**15 acres**__)

= ____**7.5**____ lbs /year of total phosphorus

Where:

$L_{pre}$ = Average annual load of total phosphorus exported from the site prior to development (lbs/year)
0.5 = Annual total phosphorus load from undeveloped lands (lbs/acre/year)
A = Area of the site within the Critical Area IDA (acres)

**B. Redevelopment**

$L_{pre}$ = ($R_v$) (C) (A) (8.16)

$R_v$ = 0.05 + 0.009 ($I_{pre}$)

= 0.05 + 0.009 (____________) = ____________

$L_{pre}$ = (____________) (____________) (____________) (8.16)

= ____________ lbs/year of total phosphorus

Where:

$L_{pre}$ = Average annual load of total phosphorus exported from the site prior to development (lbs/year)
$R_v$ = Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff
$I_{pre}$ = Predevelopment (existing) site imperviousness (i.e., I = 75 if site is 75% impervious)
C = Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l
A = Area of the site within the Critical Area IDA (acres)
8.16 = Includes regional constants and unit conversion factors

**Step 3: Calculate the Post-Development Load ($L_{post}$)**

**A. New Development and Redevelopment:**

$L_{post}$ = $(R_v)$ (C) (A) (8.16)

$R_v$ = 0.05 + 0.009 ($I_{post}$)

= 0.05 + 0.009 (**82**) = **0.79**

$L_{post}$ = (**0.79**) (**0.30**) (**15**) (8.16)

= **29.0** lbs/year of total phosphorus

Where:

| | | |
|---|---|---|
| $L_{post}$ | = | Average annual load of total phosphorus exported from the post-development site (lbs/year) |
| $R_v$ | = | Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff |
| $I_{post}$ | = | Post-development (proposed) site imperviousness (i.e., I = 75 if site is 75% impervious) |
| C | = | Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l |
| A | = | Area of the site within the Critical Area IDA (acres) |
| 8.16 | = | Includes regional constants and unit conversion factors |

**Step 4: Calculate the Pollutant Removal Requirement (RR)**

RR = $L_{post}$ - (0.9) ($L_{pre}$)

= (**29.0**) - (0.9) (**7.5**)

= **22.3** lbs/year of total phosphorus

Where:

| | | |
|---|---|---|
| RR | = | Pollutant removal requirement (lbs/year) |
| $L_{post}$ | = | Average annual load of total phosphorus exported from the post-development site (lbs/year) |
| $L_{pre}$ | = | Average annual load of total phosphorus exported from the site prior to development (lbs/year) |

**Step 5: Identify Feasible BMP(s)**

Select BMP Options using the screening matrices provided in the Chapter 4 of the 2000 Maryland Stormwater Design Manual. Calculate the load removed for each option.

| BMP Type | ($L_{post}$) | x | ($BMP_{RE}$) | x | (% DA Served) | = | LR | |
|---|---|---|---|---|---|---|---|---|
| **bioretention** | **29.0** | x | **50%** | x | **40%** | = | **5.8** | lbs/year |
| **dry swale** | **29.0** | x | **65%** | x | **30%** | = | **5.7** | lbs/year |
| **infiltration trench** | **29.0** | x | **65%** | x | **30%** | = | **5.7** | lbs/year |
| | | x | | x | | = | | lbs/year |

Load Removed, LR (total) = **17.2** lbs/year

Pollutant Removal Requirement, RR (from Step 4) = **22.3** lbs/year

Where:

Load Removed = Annual total phosphorus load removed by the proposed BMP (lbs/year)

$L_{post}$ = Average annual load of total phosphorus exported from the post-development site (lbs/year)

$BMP_{RE}$ = BMP removal efficiency for total phosphorus, Table 4.8 (%)

% DA Served = Fraction of the site area within the critical area IDA served by the BMP (%)

RR = Pollutant removal requirement (lbs/year)

If the Load Removed is equal to or greater than the Pollutant Removal Requirement computed in Step 4, then the on-site BMP complies with the 10% Rule.

**Has the RR (pollutant removal requirement) been met?** ☐ **Yes** ☑ **No**

**NOTE: Alternative off-site mitigation options or off-sets will be required. Applicant will discuss options with local planning department.**

**Standard Application for Simple On-Site Compliance – Redevelopment**

The following example presents a step-by-step process for completing the Standard Application Process for a simple redevelopment situation. The existing and proposed site plans are displayed below (Figure 4.3) and the completed “Worksheet A: Standard Application Process.”

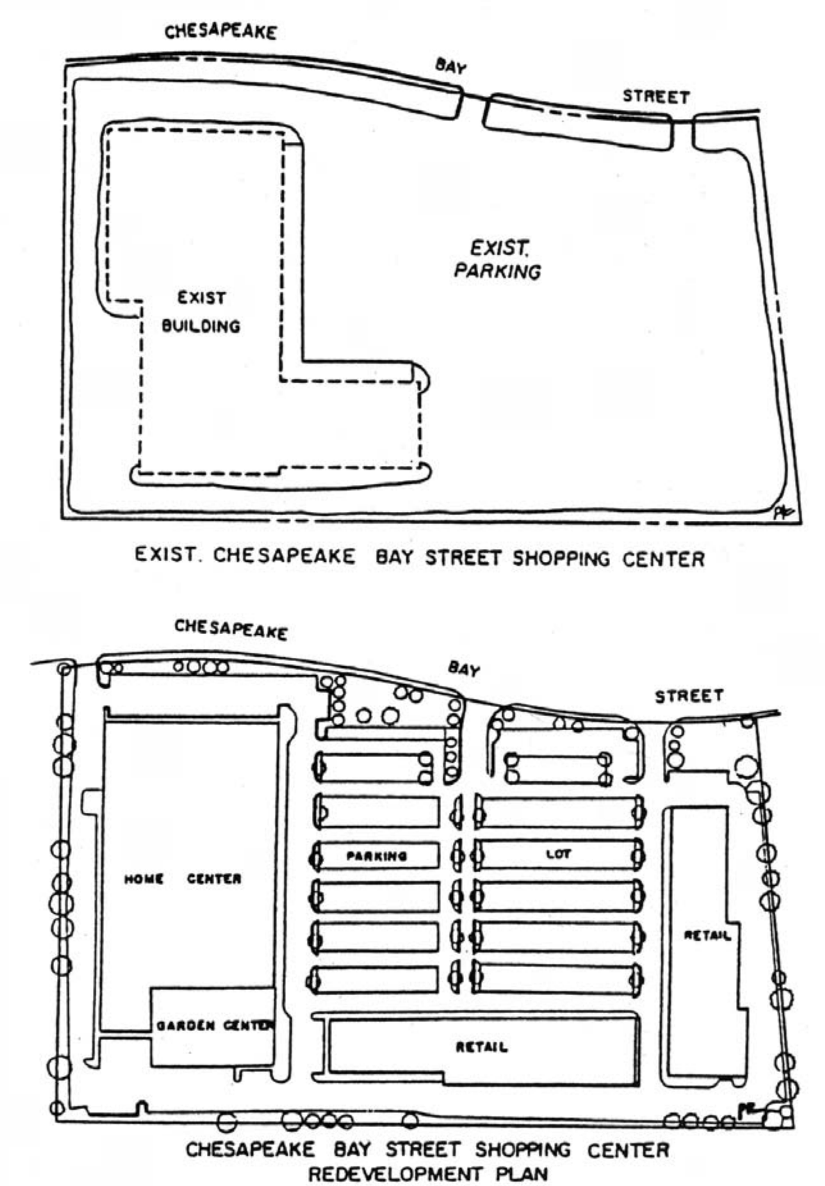



**Figure 4.3 Existing and Proposed Site Plans for Simple On-Site Compliance Example**

# Worksheet A: Standard Application Process

## Calculating Pollutant Removal Requirements[1]

**Step 1: Calculate Existing and Proposed Site Imperviousness**

**A. Calculate Percent Imperviousness**

1) Site Area within the Critical Area IDA, A = **15** acres

2) Site Impervious Surface Area, Existing and Proposed, (See Table 4.1 for details)

| | (a) Existing (acres) | (b) Proposed (acres) |
|---|---|---|
| Roads | **2.20** | **2.40** |
| Parking lots | **6.75** | **5.30** |
| Driveways | | |
| Sidewalks/paths | | **0.15** |
| Rooftops | **3.10** | **4.52** |
| Decks | | |
| Swimming pools/ponds | | |
| Other | | |
| Impervious Surface Area | **12.05 acres** | **12.37 acres** |

3) Imperviousness (I)

Existing Imperviousness, $I_{pre}$ = Impervious Surface Area / Site Area
= (Step 2a) / (Step 1)
= ( **12.05** ) / ( **15** )
= **0.8033 or 80** %

Proposed Imperviousness, $I_{post}$ = Impervious Surface Area / Site Area
= (Step 2b) / (Step 1)
= ( **12.37** ) / ( **15** )
= **0.8247 or 82** %

**B. Define Development Category (circle)**

1) New Development: Existing imperviousness less than 15% I *(Go to Step 2A)*

2) Redevelopment: Existing imperviousness of 15% I or more *(Go to Step 2B)*

3) Single Lot Residential Development: Single lot being developed or improved; single family residential development; and more than 250 square feet of impervious area and associated disturbance (Go to Section 5, Residential Approach, for detailed criteria and requirements).

[1] NOTE: All acreage used in this worksheet refers to areas within the IDA of the Critical Area only.

**Step 2: Calculate the Predevelopment Load ($L_{pre}$)**

**A. New Development**

$L_{pre}$ = (0.5) (A)

= (0.5) (______________)

= ______________ lbs./year of total phosphorus

Where:

$L_{pre}$ = Average annual load of total phosphorus exported from the site prior to development (lbs/year)
0.5 = Annual total phosphorus load from undeveloped lands (lbs/acre/year)
A = Area of the site within the Critical Area IDA (acres)

**B. Redevelopment**

$L_{pre}$ = ($R_v$) (C) (A) (8.16)

$R_v$ = 0.05 + 0.009 ($I_{pre}$)

= 0.05 + 0.009 (**80**) = **0.77**

$L_{pre}$ = (**0.77**) (**0.30**) (**15**) (8.16)

= **28.27** lbs/year of total phosphorus

Where:

$L_{pre}$ = Average annual load of total phosphorus exported from the site prior to development (lbs/year)
$R_v$ = Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff
$I_{pre}$ = Predevelopment (existing) site imperviousness (i.e., I = 75 if site is 75% impervious)
C = Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l
A = Area of the site within the Critical Area IDA (acres)
8.16 = Includes regional constants and unit conversion factors

**Step 3: Calculate the Post-Development Load ($L_{post}$)**

**A. New Development and Redevelopment:**

$L_{post}$ = $(R_v)$ (C) (A) (8.16)

$R_v$ = 0.05 + 0.009 ($I_{post}$)

= 0.05 + 0.009 (**82**) = **0.79**

$L_{post}$ = (**0.79**) (**0.30**) (**15**) (8.16)

= **29.0** lbs/year of total phosphorus

Where:

$L_{post}$ = Average annual load of total phosphorus exported from the post-development site (lbs/year)
$R_v$ = Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff
$I_{post}$ = Post-development (proposed) site imperviousness (i.e., I = 75 if site is 75% impervious)
C = Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l
A = Area of the site within the Critical Area IDA (acres)
8.16 = Includes regional constants and unit conversion factors

**Step 4: Calculate the Pollutant Removal Requirement (RR)**

RR = $L_{post}$ - (0.9) ($L_{pre}$)

= (**29.0**) - (0.9) (**28.27**)

= **3.56** lbs/year of total phosphorus

Where:

RR = Pollutant removal requirement (lbs/year)
$L_{post}$ = Average annual load of total phosphorus exported from the post-development site (lbs/year)
$L_{pre}$ = Average annual load of total phosphorus exported from the site prior to development (lbs/year)

**Step 5: Identify Feasible BMP(s)**

Select BMP Options using the screening matrices provided in the Chapter 4 of the 2000 Maryland Stormwater Design Manual. Calculate the load removed for each option.

| BMP Type | ($L_{post}$) | x | ($BMP_{RE}$) | x | (% DA Served) | = | LR | |
|---|---|---|---|---|---|---|---|---|
| **bioretention** | **29.0** | x | **50%** | x | **20%** | = | **2.90** | lbs/year |
| **perimeter sand filter** | **29.0** | x | **50%** | x | **10%** | = | **1.45** | lbs/year |
| | | x | | x | | = | | lbs/year |
| | | x | | x | | = | | lbs/year |

Load Removed, LR (total) = **4.35** lbs/year

Pollutant Removal Requirement, RR (from Step 4) = **3.56** lbs/year

Where:

Load Removed = Annual total phosphorus load removed by the proposed BMP (lbs/year)
$L_{post}$ = Average annual load of total phosphorus exported from the post-development site (lbs/year)
$BMP_{RE}$ = BMP removal efficiency for total phosphorus, Table 4.8 (%)
% DA Served = Fraction of the site area within the critical area IDA served by the BMP (%)
RR = Pollutant removal requirement (lbs/year)

If the Load Removed is equal to or greater than the Pollutant Removal Requirement computed in Step 4, then the on-site BMP complies with the 10% Rule.

**Has the RR (pollutant removal requirement) been met?** ☑ **Yes** ☐ **No**

**Standard Application for Off-Site Drainage Area Treatment by On-Site BMP**

The following example presents a step-by-step process for completing the Standard Application Process for a redevelopment situation where the pollutant removal requirement is met, in part, by treating runoff from an off-site drainage area with an on-site BMP. In this process, both Worksheets A and B must be used, and are included in this example.

The on-site and the off-site drainage areas to the proposed BMP are displayed in Figure 4.4.

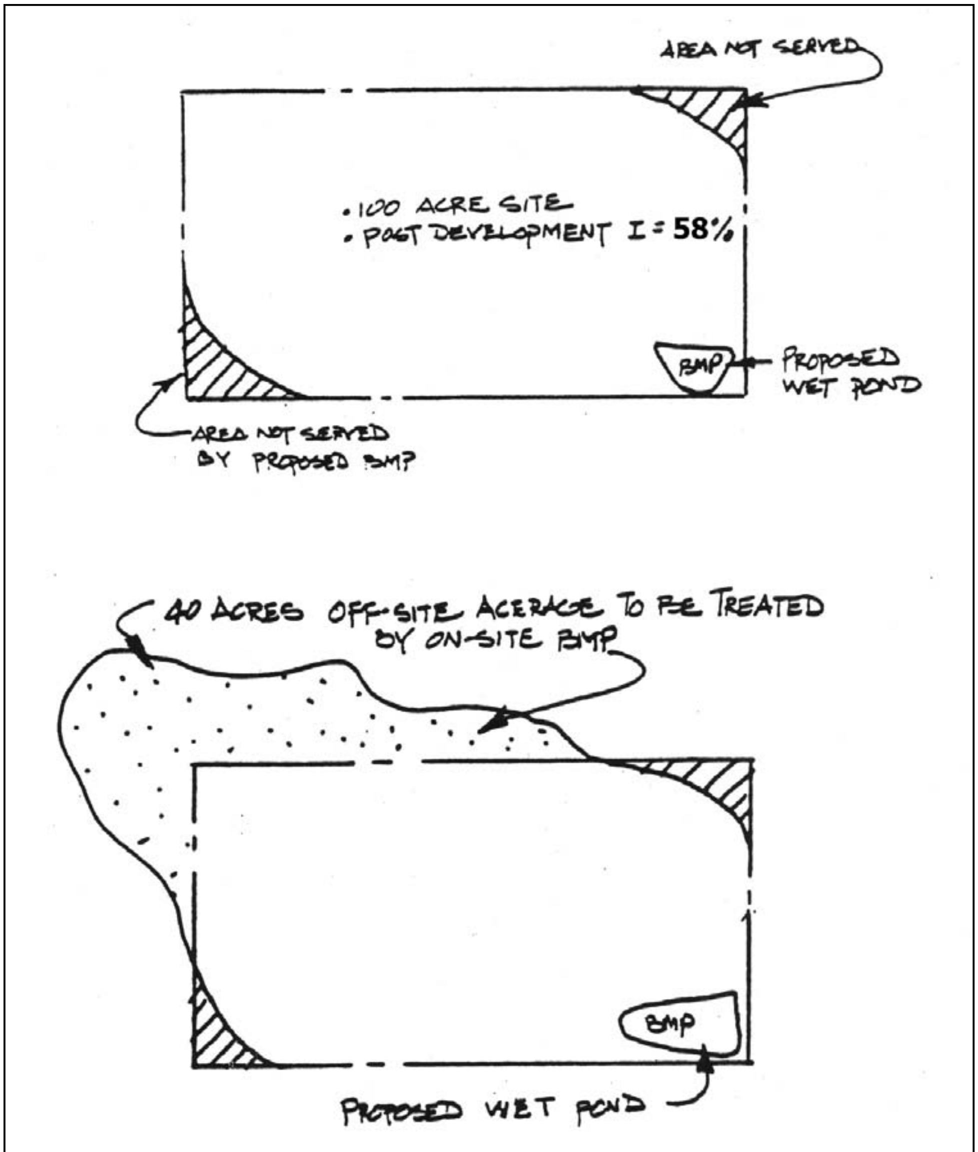



Figure 4.4 Off-Site Drainage Area to Proposed On-Site BMP

# Worksheet A: Standard Application Process

## Calculating Pollutant Removal Requirements[1]

**Step 1: Calculate Existing and Proposed Site Imperviousness**

**A. Calculate Percent Imperviousness**

1) Site Area within the Critical Area IDA, A = **100** acres

2) Site Impervious Surface Area, Existing and Proposed, (See Table 4.1 for details)

| | (a) Existing (acres) | (b) Proposed (acres) |
|---|---|---|
| Roads | **1.5** | **5** |
| Parking lots | **8** | **10** |
| Driveways | | |
| Sidewalks/paths | **0.5** | **0.5** |
| Rooftops | **12** | **42** |
| Decks | | |
| Swimming pools/ponds | | |
| Other | | |
| Impervious Surface Area | **22 acres** | **57.5 acres** |

3) Imperviousness (I)

Existing Imperviousness, $I_{pre}$
= Impervious Surface Area / Site Area
= (Step 2a) / (Step 1)
= ( **22** ) / ( **100** )
= **0.22 or 22** %

Proposed Imperviousness, $I_{post}$
= Impervious Surface Area / Site Area
= (Step 4) / (Step 1)
= ( **57.5** ) / ( **100** )
= **0.58 or 58** %

**B. Define Development Category (circle)**

1) New Development: Existing imperviousness less than 15% I *(Go to Step 2A)*

2) Redevelopment: Existing imperviousness of 15% I or more *(Go to Step 2B)*

3) Single Lot Residential Development: Single lot being developed or improved; single family residential development; and more than 250 square feet of impervious area and associated disturbance (Go to Section 5, Residential Approach, for detailed criteria and requirements.)

[1] NOTE: All acreage used in this worksheet refers to areas within the IDA of the Critical Area only.

**Step 2: Calculate the Predevelopment Load ($L_{pre}$)**

**A. New Development**

$L_{pre}$ = (0.5) (A)

= (0.5) (______________)

= _____________ lbs /year of total phosphorus

Where:

$L_{pre}$ = Average annual load of total phosphorus exported from the site prior to development (lbs/year)
0.5 = Annual total phosphorus load from undeveloped lands (lbs/acre/year)
A = Area of the site within the Critical Area IDA (acres)

**B. Redevelopment**

$L_{pre}$ = ($R_v$) (C) (A) (8.16)

$R_v$ = 0.05 + 0.009 ($I_{pre}$)

= 0.05 + 0.009 (**22**) = **0.25**

$L_{pre}$ = (**0.25**) (**0.30**) (**100**) (8.16)

= **61.2** lbs/year of total phosphorus

Where:

$L_{pre}$ = Average annual load of total phosphorus exported from the site prior to development (lbs/year)
$R_v$ = Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff
$I_{pre}$ = Predevelopment (existing) site imperviousness (i.e., I = 75 if site is 75% impervious)
C = Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l
A = Area of the site within the Critical Area IDA (acres)
8.16 = Includes regional constants and unit conversion factors

**Step 3: Calculate the Post-Development Load ($L_{post}$)**

**A. New Development and Redevelopment:**

$L_{post}$ = $(R_v)$ (C) (A) (8.16)

$R_v$ = 0.05 + 0.009 ($I_{post}$)

= 0.05 + 0.009 (**58**) = **0.57**

$L_{post}$ = (**0.57**) (**0.30**) (**100**) (8.16)

= **139.5** lbs/year of total phosphorus

Where:

$L_{post}$ = Average annual load of total phosphorus exported from the post-development site (lbs/year)
$R_v$ = Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff
$I_{post}$ = Post-development (proposed) site imperviousness (i.e., I = 75 if site is 75% impervious)
C = Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l
A = Area of the site within the Critical Area IDA (acres)
8.16 = Includes regional constants and unit conversion factors

**Step 4: Calculate the Pollutant Removal Requirement (RR)**

RR = $L_{post}$ - (0.9) ($L_{pre}$)

= (**139.5**) - (0.9) (**61.2**)

= **84.4** lbs/year of total phosphorus

Where:

RR = Pollutant removal requirement (lbs/year)
$L_{post}$ = Average annual load of total phosphorus exported from the post-development site (lbs/year)
$L_{pre}$ = Average annual load of total phosphorus exported from the site prior to development (lbs/year)

**Step 5: Identify Feasible BMP(s)**

Select BMP Options using the screening matrices provided in the Chapter 4 of the 2000 Maryland Stormwater Design Manual. Calculate the load removed for each option.

| BMP Type | ($L_{post}$) | x | ($BMP_{RE}$) | x | (% DA Served) | = | LR | |
|---|---|---|---|---|---|---|---|---|
| **wet ED pond** | **139.5** | x | **60%** | x | **80%** | = | **67.0** | lbs/year |
| **bioretention** | **139.5** | x | **50%** | x | **5%** | = | **3.5** | lbs/year |
| **dry swale** | **139.5** | x | **65%** | x | **5%** | = | **4.5** | lbs/year |
| | | x | | x | | = | | lbs/year |

Load Removed, LR (total) = **75.0** lbs/year

Pollutant Removal Requirement, RR (from Step 4) = **84.4** lbs/year

Where:

| | | |
|---|---|---|
| Load Removed | = | Annual total phosphorus load removed by the proposed BMP (lbs/year) |
| $L_{post}$ | = | Average annual load of total phosphorus exported from the post-development site (lbs/year) |
| $BMP_{RE}$ | = | BMP removal efficiency for total phosphorus, Table 4.8 (%) |
| % DA Served | = | Fraction of the site area within the critical area IDA served by the BMP (%) |
| RR | = | Pollutant removal requirement (lbs/year) |

If the Load Removed is equal to or greater than the Pollutant Removal Requirement computed in Step 4, then the on-site BMP complies with the 10% Rule.

**Has the RR (pollutant removal requirement) been met?** ☐ **Yes** ☑ **No**

# Worksheet B: Standard Application Process

## Calculating Removal from Off-site Drainage Areas

**Step 1: Project Description**

**A. Calculate Percent Imperviousness**

1) Off-site Drainage Area to be Treated by On-site BMP, $A_{off\text{-}site}$ = **40** acres

2) Ultimate Off-site Drainage Area Imperviousness

(a) Ultimate Off-site Impervious Area (acres)

| | | |
|---|---|---|
| Roads | **5** | (acres) |
| Parking Lots | **2** | (acres) |
| Driveways | | (acres) |
| Sidewalks/paths | **1** | (acres) |
| Rooftops | **8** | (acres) |
| Decks | | (acres) |
| Swimming pools/ponds | | (acres) |
| Other | | (acres) |

Total Off-site Impervious Area (sum of the above) = **16** (acres)

(b) Ultimate Off-site Imperviousness ($I_{off\text{-}site}$)

Off-site Imperviousness ($I_{off\text{-}site}$) = Total Off-site Impervious Area / $A_{off\text{-}site}$

= (Step 2a) / (Step 1)

= (**16**) / (**40**)

= **0.40 or 40** %

**B. Define Development Category of Off-site Drainage Area**

1) New Development: Ultimate imperviousness of off-site drainage area less than 15% I *(Go to Step 2A)*

2) Redevelopment: Ultimate imperviousness of off-site drainage area greater than or equal to 15% I *(Go to Step 2B)*

**Step 2: Calculate Post-Development Load for Off-site Drainage Area ($L_{off\text{-}site}$)**

**A. New Development**

$L_{off\text{-}site}$ = 0.5 ($A_{off\text{-}site}$)

= 0.5 (____________)

= ____________ lbs/year of total phosphorus

Where:
$L_{off\text{-}site}$ = Average annual load of total phosphorus exported from the off-site drainage area (lbs/year)
0.5 = Annual total phosphorus load from undeveloped lands (lbs/acre/year)
$A_{off\text{-}site}$ = Off-site drainage area to be treated by on-site BMP (acres)

**B. Redevelopment**

$L_{off\text{-}site}$ = ($R_v$) (C) ($A_{off\text{-}site}$) 8.16

$R_v$ = 0.05 + 0.009 ($I_{off\text{-}site}$)

= 0.05 + 0.009 (**40**) = **0.41**

$L_{off\text{-}site}$ = (**0.41**) (**0.30**) (**40**) 8.16

= **40.1** lbs/year of total phosphorus

Where:
$L_{off\text{-}site}$ = Average annual load of total phosphorus exported from the off-site drainage area (lbs/year)
$R_v$ = Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff
$I_{off\text{-}site}$ = Ultimate off-site imperviousness (i.e. I = 75 if site is 75% impervious)
C = Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l
$A_{off\text{-}site}$ = Off-site drainage area to be treated by on-site BMP (acres)
8.16 = Includes regional constants and unit conversion factors

**Step 3:** **Calculate the Load Removed from Off-site Drainage Areas by On-Site BMP**

Type of BMP: **wet ED pond**

Off-site Load Removed = $(BMP_{RE})\ (L_{off\text{-}site})$

= ( **60%** ) ( **40.1** )

= **24.1** lbs/year of total phosphorus

Where:

$BMP_{RE}$ = BMP removal efficiency for total phosphorus, see Table 4.8 (%)

$L_{off\text{-}site}$ = Average annual load of total phosphorus exported from the off-site drainage area (lbs/year)

**Step 4:** **Calculate the Total Load Removed (in pounds) by On-Site BMP**

Total Load Removed = Load Removed On-site + Load Removed Off-site

= (Worksheet A, Step 5) + (Step 3)

= ( **75.0** ) + ( **24.1** )

= **99.1** lbs/year of total phosphorus

Pollutant Removal Requirement (Worksheet A, Step 4) = **84.4** lbs/year

If the Load Removed is equal to or greater than the Pollutant Removal Requirement computed in Step 4, then the on-site BMP complies with the 10% Rule.

**Has the Pollutant Removal Requirement been met?** ☑ **Yes** ☐ **No**

# SECTION 5.0 RESIDENTIAL PROJECTS

This section addresses how to comply with the 10% Rule for construction on individual residential lots. The standard application process and calculation worksheet, presented in Section 4.0, are typically not required for individual residential lot development projects, however, requirements may vary by local jurisdiction. Applicants should check with the appropriate local jurisdiction to ensure compliance.

Residential projects that involve an impervious surface area less than 250 square feet are exempt from the 10% Rule requirements. It is recommended that applicants plant trees and/or shrubs, to compensate for site impacts. Local Critical Area staff will utilize discretion based upon the specific site and the type of project proposed. Construction of BMPs or the payment of offset fees are not required for these exempted projects.

Residential projects taking place on an individual single-family lot (dwelling, garage, shed, etc.) that involve an impervious surface area of 250 square feet or more must comply with the 10% Rule, using one of the three options described below:

Option 1. Submit a Residential Water Quality Management Plan

Option 2. Plant Trees and/or Shrubs on the site

Option 3. Obtain an Offset

**Option 1. Residential Water Quality Management Plan**
The preferred option to comply with the 10% Rule for individual residential lots is to submit a Residential Water Quality Management Plan. This plan shows how non-structural stormwater BMPs will be used at the site. In some cases, structural BMPs may also be used. The process for submitting a Residential Water Quality Management Plan is as follows:

1. Determine if the Site is Eligible
2. Develop a Narrative and Site Plan to Minimize, Disconnect, Store and/or Treat Runoff From Impervious Surfaces
3. Submit Plan to Critical Area Reviewer

Note: Individual residential development projects that disturb an area greater than 5,000 square feet may be required to submit a standard stormwater management plan for a single lot residential construction per Maryland Department of the Environment (MDE) requirements. A model permit has been developed by MDE Water Management Administration. The model is available at: http://www.mde.state.md.us/assets/document/standard_plan_v8.0.pdf. These standard plans outline the minimum requirements for stormwater management and erosion and sediment control practices for residential lots.

Requirements: The applicant must submit a narrative and associated plans and specifications for the proposed development. The narrative will address water quality measures used to prevent or treat stormwater runoff from the proposed development and will describe how various impervious surfaces will be treated using residential stormwater techniques (see Appendix F). The drawings will be at an appropriate scale to depict impervious cover and non-structural techniques to treat stormwater runoff. General guidelines on how to measure impervious surface can be found in Section 4.0.

Narrative: The narrative portion of the plan will indicate what practices will be used on the site. Applicants are encouraged to use any of the non-structural stormwater Best Management Practices (BMPs) described in Appendix F, as they are well suited for individual residential lots. The preferred non-structural BMPs are organized under the following strategies:

- Disconnect Rooftop Runoff
- Store Rooftop Runoff
- Disconnect Non-Rooftop Runoff

The specific techniques that are recommended for individual residential lots are listed in Table 5.1, and more detailed information about these techniques is provided in Appendix F. Applicants are encouraged to utilize a combination of these techniques to disconnect or store all of the stormwater runoff from the lot and essentially "erase" the proposed impervious surfaces for computational purposes. Figure 5.1 illustrates the application of multiple stormwater techniques at a residential site. In addition a sample Residential Water Quality Management Plan is provided at the end of this section.

**Table 5.1 Recommended Techniques for Individual Residential Lots**

| Strategy | Technique |
|---|---|
| Disconnect Rooftop Runoff | Rain Garden |
| | French Drains and Dry Wells |
| Store Rooftop Runoff | Rain Barrels |
| Disconnect Non-Rooftop Runoff | Permeable Pavers |
| | Two-Track Driveway |
| | Pervious Deck Design |

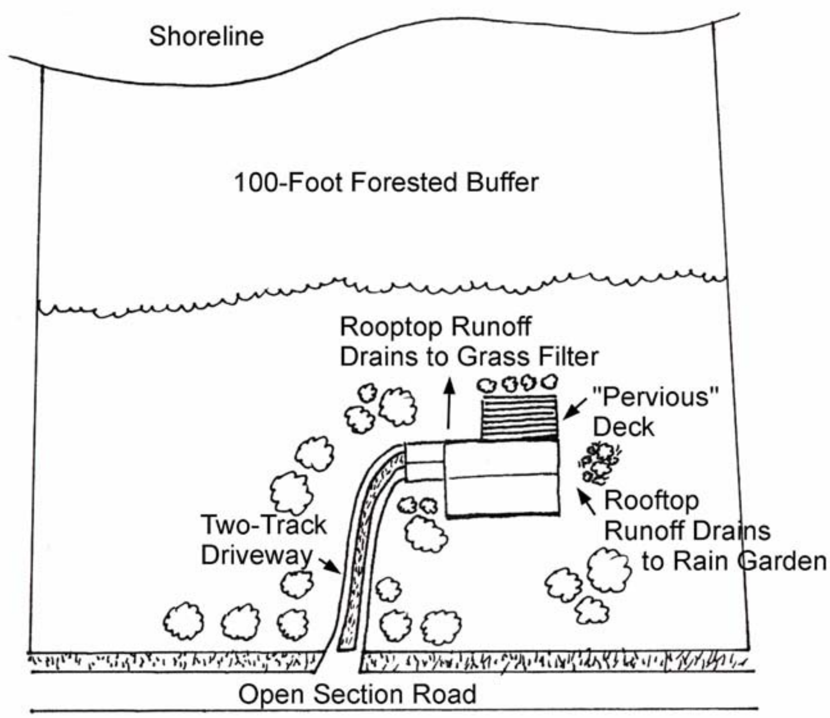



**Figure 5.1 Illustrative Example of How Multiple Non-structural Stormwater Techniques Can be Applied at a Residential Site**

**Option 2. Tree and/or Shrub Plantings**
When local government staff and applicant jointly determine that the nature of the project or site constraints warrant an alternative to the recommended residential BMPs under Option 1, staff may require the applicant to plant native trees and/or shrubs on the residential site. Trees and shrubs planted for stormwater management benefits should be nursery grown containerized or balled and burlap stock. In general, trees should be at least four feet in height and shrubs should be three gallons in size. A listing of native trees and shrubs is available at: http://www.dnr.state.md.us/criticalarea/trees.html.

Plantings should be accomplished at the following ratios:

Buffer and Buffer Exemption Areas: A minimum of three trees or nine shrubs shall be planted for every 100 square feet of the proposed development activity or a portion thereof at the individual lot. A combination planting of trees and shrubs is also acceptable. Please note that this formula satisfies both the 10% Rule and Buffer mitigation requirements. For more information on Buffers and Buffer Exemption Areas, see "Critical Area Buffer" in Section 7.

Non-Buffer Areas: The planting requirement for this area is a minimum of one tree or three shrubs for every 100 square feet (or portion thereof) of new impervious surface created. A combination planting of trees and shrubs is also acceptable.

The applicant should take steps to ensure the plantings are healthy and in good condition after the first growing season. This may entail watering, weeding, mulching, and use of tree shelters and other techniques to reduce deer browsing.

**Option 3. Offsets**

In the rare instance that residential stormwater BMPs and tree plantings are not feasible for the lot, the applicant may pay an offset fee in the localities that offer this option. More details regarding offset fees are provided in Section 6.0.

**Sample Residential Water Quality Management Plan**

**NARRATIVE:**
For:
Clifton Cumberland
6902 37th Place
South Hyattsville, MD 20700

Description of work: Erect a single family home
Total Site Area: 8,237 $ft^2$
Total Disturbed Area: 4,588 $ft^2$
Total Forest Area Before Construction: 8 trees; 1,742 $ft^2$
Total Forest Area After Construction: 10 trees; 2,115 $ft^2$
Existing Impervious Area: 0.0
Proposed Impervious Area: 1,512 $ft^2$ (18.3%)

Non-Structural BMPs:
Permeable Pavers (Turfblock) for Driveway
Permeable Pavers (Blockpaver) for Sidewalk
Pervious Deck Design
Dry Well (See sizing information below)

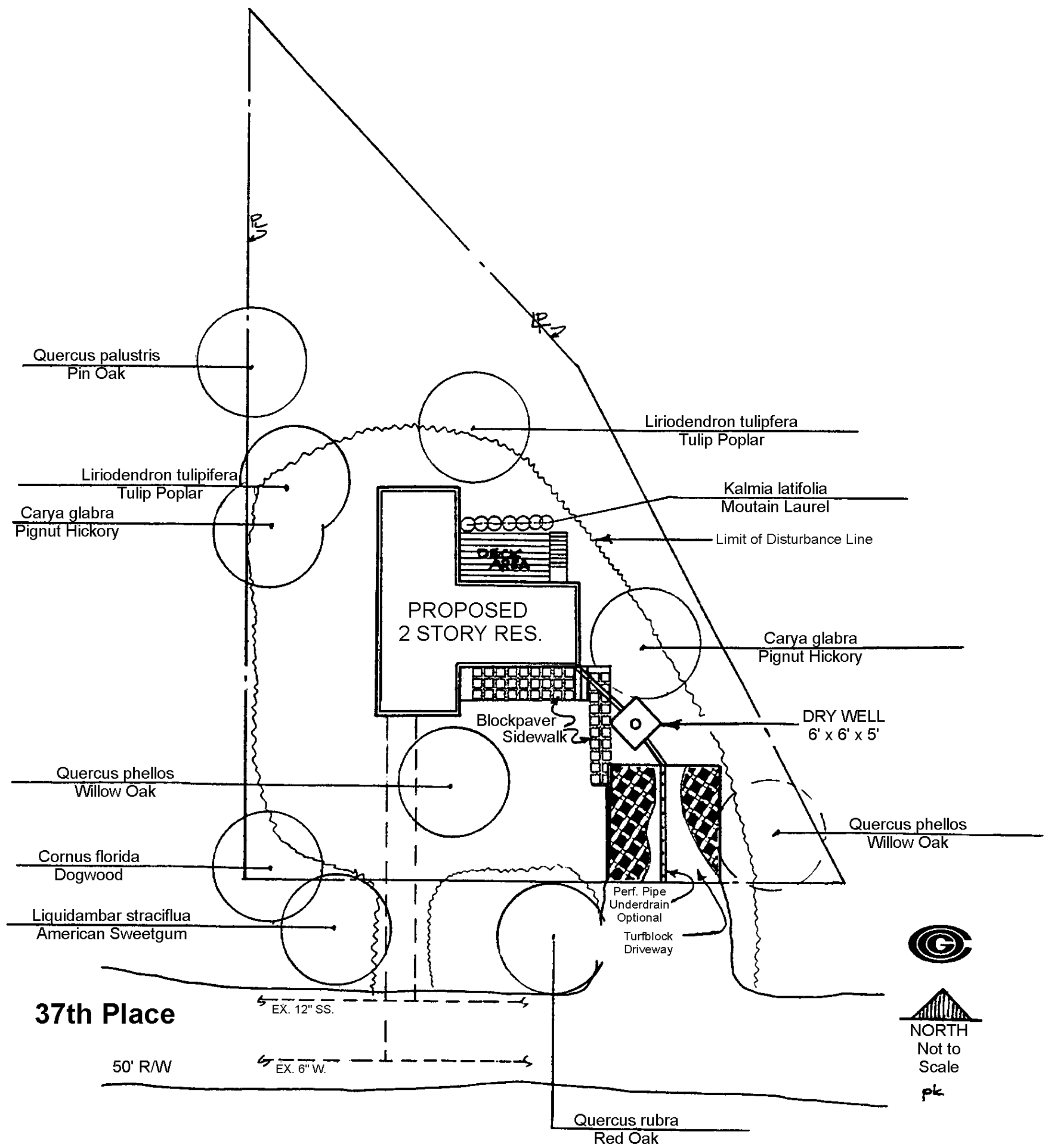
Dry Well Sizing Information
Impervious Area Treated: 756 $ft^2$ (1/2 of rooftop area)
Utilized Following Equation to Determine Dry Well Surface Area (SA): $\frac{(DA)(P)}{12(D)(V)}$

Drainage Area (DA) = 756 $ft^2$
Rainfall Depth (P) = 1”
Depth of Proposed Trench (D) = 5ft
Voids Ratio for Gravel (V) = 0.35

$$SA = \frac{(756)(1)}{12(5)(0.35)} = 36ft^2$$

Trench Dimernsions: 6’ length
6’ wide
5’ deep

**SITE PLAN:**


Quercus palustris
Pin Oak
Liriodendron tulipfera
Tulip Poplar
Liriodendron tulipifera
Tulip Poplar
Carya glabra
Pignut Hickory
Kalmia latifolia
Moutain Laurel
Limit of Disturbance Line
PROPOSED
2 STORY RES.
Carya glabra
Pignut Hickory
DRY WELL
6' x 6' x 5'
Blockpaver
Sidewalk
Quercus phellos
Willow Oak
Quercus phellos
Willow Oak
Cornus florida
Dogwood
Perf. Pipe
Underdrain
Optional
Liquidambar straciflua
American Sweetgum
Turfblock
Driveway
37th Place
EX. 12" SS.
50' R/W
EX. 6" W.
NORTH
Not to
Scale
Quercus rubra
Red Oak

# SECTION 6.0 STORMWATER OFFSETS AND OFFSET FEES

This section outlines some of the offset options available to applicants and provides guidelines to help local jurisdictions administer offset programs. Offsets may be used in the following situations:

- The use of on-site and off-site BMPs cannot meet the pollutant removal requirement of the 10% Rule;
- The use of off-site areas draining to on-site BMPs cannot meet the pollutant reduction requirement; or
- Construction of on-site BMPs is not feasible or practical.

In these situations, a jurisdiction can allow an applicant to provide an offset or pay an offset fee to meet the pollutant reduction requirement. Applicants are strongly encouraged to make every effort to provide at least some stormwater treatment on the project site, and if necessary, comply through a combination of on-site BMPs and offsets.

**What is an Offset?**

The Critical Area Criteria define offsets 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 BMPs are insufficient or impractical. Offsets must remove a pollutant load equal to or greater than the pollutant removal requirement. Offset fees must be equivalent to the cost of planning, designing, constructing, and maintaining a BMP capable of meeting the pollutant removal requirement.

The clear intent of the criteria is to encourage on-site compliance with the 10% Rule wherever possible; therefore, **offsets are to be used only as a last resort**. An applicant must demonstrate that full compliance with the 10% Rule is not feasible or practical at the site using on-site stormwater BMPs. Supporting documentation, including but not limited to, detailed information about current or historic land use, soil borings, or soil contamination analyses, shall be submitted to the local government with the request to use offsets or pay offset fees. The local government must agree that on-site stormwater BMPs are not feasible or practical and the use of offsets is warranted. Factors that may be considered to determine that on-site compliance is not feasible or practical include:

Physical Factors, such as:

- High water table
- Restrictive terrain
- Severely compacted or contaminated soils or fill
- Lack of space
- Location of underground utilities

Other Factors

- Water dependant uses

- Unique land use activities
- Implementation of a comprehensive stormwater management plan with approved offsets

Offsets must be located within reasonable proximity to the Chesapeake Bay, Atlantic Coastal Bays, their tributaries and associated tidal wetlands, and preferably within the Critical Area itself. The criteria state that, at a minimum, "offsets must be in the same watershed." Although the scale of the watershed is not defined in the criteria, it is generally intended that all offsets will take place in the same jurisdiction in which the development project is located.

In addition, any measure or practice that is used for an offset cannot be a measure that would have been required under existing laws, regulations, statutes, or permits. For example, the restoration of a wetland required as mitigation for a non-tidal wetland impact cannot also be used as a stormwater offset. Similarly, any reforestation required under the Maryland Forest Conservation Act cannot also be used as an offset.

**How is an Offset Different from Off-Site Compliance?**
Compliance with the 10% Rule through offsets should be clearly distinguished from compliance achieved by providing treatment of off-site drainage areas with an on-site BMP. Treatment of an off-site drainage area with an on-site BMP is a means of increasing the amount of runoff treated by the on-site BMP and, thereby, increasing the amount of pollutant load removed. An offset, on the other hand, is not located on the project site, and may involve activities other than the construction of a BMP. Offsets are used when on-site practices are either infeasible and/or insufficient to comply with the 10% Rule at the development site.

**Examples of Acceptable Offset Opportunities**
Five offset options or opportunities are described below. However, offset opportunities are not limited to these examples. Jurisdictions and applicants are encouraged to develop innovative ways to comply with the pollutant removal requirement – these will be approved on a case-by-case basis. When identifying offset opportunities, jurisdictions should meet with the appropriate local planning, parks, environmental and public works agencies to identify, review and select the best offset opportunities for the Critical Area. For more information on identifying and implementing offset opportunities, please consult the "Additional Resources" provided in Section 8.

Option 1: Stormwater Retrofits: Constructing a New BMP
One type of commonly used offsets involves stormwater retrofitting to providing treatment in locations where BMPs previously did not exist. This offset option involves constructing a new BMP to serve an existing urbanized area within the Critical Area. New BMPs should be confined to the designs listed in Appendices D and E, and be located in developed areas that are not currently served by stormwater BMPs or are underserved by existing stormwater BMPs. Good candidate sites for new BMP retrofits include public land, such as parks, schools, local government buildings, and recreational areas.

Stormwater retrofits can also be located on private property, such as residential open space, industrial parks and institutional areas. If private lands are used, jurisdictions will need to resolve relevant concerns about ownership, liability, maintenance and compensation. BMPs located on private lands must be maintained as stormwater practices over the long term; therefore, an easement and maintenance agreement must be provided. Jurisdictions or private developers may also acquire the land needed for the retrofit; however, land acquisition costs are likely to be very high in the Critical Area.

The first step in identifying new stormwater retrofit opportunities involves analyzing local land use maps to find publicly-owned land that is undeveloped or in open space. These sites are often the most promising for developing larger regional stormwater facilities, and because they are already publicly owned, this option can be quite cost-effective. Parcels that allow for the construction of a BMP that serves a large drainage area may provide certain economies of scale and opportunities for "banking". However, smaller sites with smaller drainage areas may be suitable for application of infiltration BMPs and off-line structures such as filters and bioretention areas. Although these sites are not as cost-effective as pond systems, they may be easier to locate and build. School grounds, transportation rights-of-way, institutional areas and state/federal land are all good candidate areas.

The pollutant removal associated with the construction of a new BMP should be calculated using Worksheet B and the standard BMP removal efficiency rates (see Section 4). Appropriate plans of the site must be obtained (or developed) in order to calculate existing impervious surface area on the site.

<u>Option 2: Stormwater Retrofits: Converting an Existing BMP to Achieve Higher Pollutant Removal</u>

Improving the efficiency of existing BMPs can be a very attractive retrofit option. Older stormwater BMPs were often designed to control stormwater quantity and not to provide water quality. Some examples include dry detention ponds that were constructed to control floods in the 1970s and 1980s. Consequently, this retrofit option typically involves modifying the existing hydraulic controls in the dry pond to increase detention times, create a permanent pool, form a shallow marsh, or a combination of these. In addition to increasing pollutant removal rates, this retrofit option can also enhance community and landscaping amenities provided by the pond. Generally, the cost associated with retrofitting older BMPs is much lower than constructing a new retrofit BMP.

The most attractive candidates are large dry stormwater management ponds or flood control structures designed to control large design storms (i.e., the 10- and 100-year storm events). The conversion process varies from site to site and typically involves sacrificing a fraction of the total stormwater management storage to detain or retain runoff for pollutant removal. This is done by modifying the riser, excavating the bottom, or by raising the embankment, or some combination thereof. Publicly owned stormwater facilities are probably the best candidates for such retrofits, but private facilities may also be used. In some cases, there may also be strong interest on the part of owners of private stormwater facilities for retrofits, particularly if the existing structure is unattractive, creates nuisance problems, or has chronic maintenance problems.

A second retrofitting approach involves expanding storage capacity or retention times of existing urban lakes and impoundments to improve their pollutant removal performance. Many of these existing impoundments were built for other purposes (e.g., recreation and aesthetics) and are undersized for pollutant removal. Others have lost needed storage capacity because of high rates of sedimentation. The relatively low cost of retrofitting existing impoundments makes this offset option particularly attractive.

To identify old stormwater BMPs that may be retrofit candidates, first contact the local stormwater management authority for information on private and public stormwater management and flood control structures constructed within the jurisdiction. These files usually contain plans and as-built drawings that can be reviewed to identify retrofit opportunities. Ideal facilities are those that are older (generally constructed before 1987), drain a large, heavily developed area, have reasonable construction access, are close to the Critical Area, are not crossed by utility corridors, and control large design storms.

Potential facilities that meet most of the criteria should be checked in the field to determine if a retrofit is feasible. Suitable BMPs should then be referred to the engineering department or consultant to perform the appropriate hydrologic and hydraulic design studies. If a facility for a potential retrofit is privately owned or managed by a third party, it will also be necessary to secure approval from the property owners to install the retrofit. Making residents aware of the benefits of the retrofit and satisfying safety and aesthetic issues during the retrofit design process can generally alleviate citizen concerns.

The pollutant removal associated with the conversion of a new BMP should be calculated using Worksheet B and estimating the removal efficiency rate of the existing BMP. Most likely, the removal efficiency rate of the existing BMP will be somewhat lower than the removal efficiencies in Section 4.0, depending on the age of the BMP. If the existing BMP is a dry pond, applicants should consider using the removal efficiency provided in the National Pollutant Removal Performance Database for Stormwater Treatment Practices (Winer, 2000). This document is available online at: www.stormwatercenter.net. The removal efficiency of other types of existing BMPs can be estimated using the Watershed Treatment Model (Caraco, 2000). To determine the removal efficiency of older facilities, the Watershed Treatment Model takes several factors into account, including design, capture, and maintenance.

Once the applicant has determined the existing pollutant removal rates, a second Worksheet B should be completed to document the ultimate phosphorus removal rate after the BMP is enhanced or retrofitted. The “pollutant removal credit” associated with the improvement of the BMP is the difference between the existing phosphorus removal rate and the final phosphorus removal rate.

Option 3: Stormwater Retrofits: Modifying the Existing Conveyance Network to Enhance Pollutant Removal

The existing conveyance system in a community contains a network of storm drains, swales, ditches and catchbasins, which can provide good opportunities for retrofits. Many jurisdictions have existing stormwater conveyance systems that are purely collection systems with no treatment at the point of collection, discharge point or elsewhere throughout the conveyance. The objective of this retrofit option is to promote greater detention or infiltration within the conveyance system. This can be accomplished by adding extra storage, enhancing exfiltration or employing off-line sedimentation facilities. One typical example is a site where the bottom of a series of catchbasins is removed, excavated and backfilled with stone. This modification allows a portion of the first flush of runoff to be diverted into the soils, rather than through the pipe system. Other engineering solutions involve modifying the storage or release rate of catchbasins to promote settling. Other examples include retrofitting existing residential areas with low-cost dry wells, dry swales, grassed channels with checkdams.

Opportunities to provide treatment at either the collection point or the discharge point should be investigated. In addition, designers can explore whether the storm drain network can be modified to relocate collection points to places where there is adequate land to provide stormwater treatment. The public works department should always be consulted to determine what, if any, possible improvements might be made to the public storm drain system for which it is responsible.

The pollutant removal rate of this offset is likely to be highly specific to the particular site conditions and stormwater conveyance network. Because of the variability of this offset option and innovative systems, the designer and the local jurisdiction working cooperatively with the Commission should determine the phosphorus removal rate.

<u>Option 4: Reducing the Imperviousness of an Existing Property</u>
Some older waterfront areas are so intensely developed that there is no available land for most offset options. As an alternative, these jurisdictions may consider the option of reducing or eliminating impervious cover on publicly or privately owned lands. Some jurisdictions have acquired tax-delinquent properties within the Critical Area. These abandoned properties may be purchased by a developer seeking an offset and can be subsequently converted to vegetated open space and maintained in a perpetual easement. Developers also have the option of purchasing private land for this purpose.

A review of aerial photography and the tax delinquent property rolls can be used to determine if there are any sizeable abandoned parcels. These parcels may be converted to open space within the Critical Area. In some cases, reductions of impervious cover can be accomplished through the reconfiguration of existing parking lots and roads serving schools, government buildings, libraries, and hospitals.

- The pollutant removal credit given for this offset is based on the amount of impervious surface converted to pervious surface. For example, if an applicant removes 2,000 square feet of impervious surface from a property that would satisfy the pollutant removal requirement associated with the construction of a 2,000 square foot building on the project site. Applicants may also reduce imperviousness through the use of permeable pavers. The perviousness of permeable pavers range from 10 to 50%, depending on the product and it must be installed to the manufactures specifications.

The applicant should collaborate with the local government to determine exact imperviousness. An applicant could obtain additional pollutant removal credit by planting the area where impervious surface was removed. Planting native trees and shrubs in the area would result in an additional pollutant credit at a rate of two pounds for every one acre planted. Trees should be planted at a density of 400 trees per acre. Up to 30 percent of the planting may be accomplished with shrubs (one tree equates to three shrubs).

Option 5: Innovative Offset Options

Jurisdictions have considerable latitude to use innovative methods for offsets, as long as they can provide a reasonable estimate of the phosphorus removed. Innovative techniques are encouraged. Several acceptable examples include:

a) *Restore a degraded tidal or non-tidal wetland*
   In urban areas, many floodplain wetlands have been filled or drained to make room for development while increased storm flows and runoff cause streambeds to erode, ultimately disconnecting the stream from its floodplain. Wetland restoration should target degraded tidal or non-tidal wetlands in the Critical Area. Restoration may include removing fill, roads or man-made features; restoring natural water circulation patterns; planting marsh vegetation; and removing bulkheads or other structures. The only requirements would be that the project would need approval by the appropriate State and/or federal permitting agencies and that water quality and habitat benefits generated by the project be documented. A phosphorus reduction of three pounds for each acre of wetland restored can be granted, given that the restored wetlands have considerable ability to reduce phosphorus and other pollutants.

b) *Restore a channelized stream*
   Stream channelization is the practice of straightening stream channels to increase conveyance capacity, eliminate floodplains and drain wetlands. Stream de-channelization is the practice of returning stream channels to as natural a condition as possible, given the constraints, while creating a stable, non-erosive stream channel. The extent that de-channelization can be undertaken is primarily limited by constraints such as adjacent land use, infrastructure, and flood conveyance. Changes in sediment transport within the de-channelized reach can alter erosion and deposition patterns, for better or worse, in downstream waters. Careful hydrologic and hydraulic modeling, as well as careful design is required. A phosphorus reduction of 0.035 pounds for each linear foot of restored stream can be granted (Baltimore County, 2002).

c) *Stream daylighting*
   Stream daylighting is the process of unearthing and re-establishing surface streams that have been enclosed in pipes or culverts. Many of these streams were piped out of convenience to eliminate a floodplain, create additional buildable land, or simply because that was the way things were done. Daylighting can pose significant challenges as a restoration practice. Not only does the practice require the skills and knowledge of channel design, but also buried streams are often constrained by the

lack of available land area, incompatible land uses, infrastructure and utility conflicts, and the fear of negative consequences. Despite these constraints, dozens of urban streams have been successfully daylighted across the country. A phosphorus reduction of 0.035 pounds for each linear foot of restored stream can be granted (Baltimore County, 2002).

d) *Implement a riparian reforestation project*
A riparian forest buffer is a vegetated zone located immediately adjacent to a stream, river or other waterbody, whose vegetation reflects the pre-development riparian plant community, usually a mature forest. Ideally, the minimum buffer width should be 100 feet. Applicants should check with the local buffer requirements and use this as the target width. In some cases, it may be acceptable to establish a non-riparian buffer strip adjacent to other land uses that contribute significant phosphorus pollutant loads (e.g., agricultural and pasture areas). The offset consists of securing a buffer strip easement (if privately owned) and performing the necessary vegetative restoration/reforestation. Ideal sites for riparian reforestation may already be identified through a local watershed plan or Watershed Restoration Action Strategy (WRAS). Local governments and applicants should work cooperatively to select and implement such opportunities.

For this project, a phosphorus reduction of two pounds for each acre planted can be granted.

e) *Install trash interceptors on existing stormwater inlets*
This simple offset opportunity entails the installation of trash interceptors on inlet and outlet pipes to catch the floatable garbage. The local public works agency should be consulted at the planning stages of this project. Based on limited performance monitoring, a phosphorus removal credit of 0.1 pounds per storm drain inlet or outlet treated is appropriate. To get the credit, applicants must demonstrate that a long-term maintenance plan is in place to collect and properly dispose of trapped materials.

f) *Improve existing stormwater ponds by planting forested buffer areas around the facility*
A forested buffer around a stormwater pond has numerous benefits that include improved aesthetics, shade (can lead to reduced water temperatures), additional habitat, and minimized impacts from adjacent land uses. Plantings should comply with state and local dam safety requirements (e.g., no plantings on pond embankment) and should not be located within the maximum design pool elevation. For this project, every acre of forest planting equals two pounds of pollutant removal. Trees should be planted at a density of 400 trees per acres. Up to 30 percent of the planting may be accomplished with shrubs (one tree equates three shrubs).

g) *Develop and implement a public education program about stormwater management*
Structural stormwater practices, while effective, are not capable of removing 100% of pollutants. Stormwater education programs further reduce the likelihood of contamination of stormwater runoff. Two basic types of stormwater education programs are awareness and personal stewardship. Awareness includes raising basic knowledge about stormwater runoff and the Critical Area using signs, storm drain stenciling, and other educational materials. Personal stewardship educates residents about the individual roles they play in the Critical Area and their influence on water quality. Stewardship programs focus on specific messages about positive and negative behaviors that influence phosphorus and stormwater pollution (lawn fertilization, car washing, etc.). It is difficult to assign a specific phosphorus credit for this option, but as a rule of thumb, a reduction rate of one pound of phosphorus per $10,000 invested in education can be assigned. In all cases, education programs must be developed in cooperation with the local government agency responsible for implementing the Critical Area Program. It is difficult to assign a specific phosphorus credit for this option because it is likely to be highly specific to the particular jurisdiction, the proposed program, and the proposed audience. Because of the variability of this offset option, the local jurisdiction working cooperatively with the Commission shall determine the phosphorus removal rate.

h) *Over-designing another pending project*
Under this option, an applicant who is unable to entirely comply with the 10% Rule onsite may over-design another pending project. In this case, over-design is referring to an increase in the amount drainage area treated (more than what is required via the 10% Rule). Over-designing may be accomplished by sizing the BMP to treat a larger drainage area than would normally be required. By over-designing the stormwater management of a pending project, the applicant may receive credit for the additional pounds of phosphorus removed beyond the onsite Critical Area requirements. This option will be considered on a case-by-case basis.

In order to receive credit for this option, the applicant must demonstrate that:
- the over-design is part of the same development parcel as the project not within compliance (i.e., may be phase II of a multi-phased development project)
- built-out plans exist for the entire development project (all phases)
- the over-design meets the State's stormwater regulations
- the over-design meets onsite Critical Area pollutant removal requirements
- the over-design must be in place by the project's completion

For example, a large development site with multiple construction phases is entirely located within the IDA. For phase I of the development site, the applicant is unable to fully meet the pollutant removal requirement. However, the applicant is able to demonstrate that by over-designing the stormwater BMP meant to serve phase II, he/she is not only able to meet the Critical Area pollutant removal requirement for phase II but is also removing enough phosphorus to make up the amount that was not met under phase I. The over-designed BMP must be in place by the completion of phase I.

The pollutant removal associated with the conversion of a new BMP should be calculated using Worksheet B and estimating the pollutant removal requirement for "Phase I". Once the applicant has determined the pollutant removal requirement for the "Phase I", a second Worksheet B should be completed to document the estimated phosphorus removal requirement and the load removed by the over-designed BMP for "Phase II". The "pollutant removal credit" associated with the over-design of the BMP is the difference between the Phase II's pollutant removal requirement and the load removed by the over-designed BMP.

Offset opportunities can be evaluated using a combination of aerial photos, vegetation maps and field verification. These opportunities may already be identified through existing watershed plans, stormwater retrofit and offset inventories, and Maryland Department of Natural Resources' Watershed Restoration Action Strategies (WRAS). Applicants must work cooperatively with the local jurisdiction to select and implement such opportunities.

Other innovative options such as better housekeeping (e.g., street sweeping and storm drain cleanouts) may be approved contingent upon developing a protocol agreed upon by the Commission and local jurisdiction.

<u>Unacceptable Offsets</u>
Any activity or practice that is required under existing statutes, permits, National Pollutant Discharge Elimination System (NPDES) stormwater requirements or regulations may not be used as an offset. For example, a developer cannot take credit for constructing a BMP in a developing area that is already subject to the water quality provisions of the Maryland Stormwater Law. Likewise, a government cannot take offset credits for constructing a regional BMP that is primarily intended to control runoff from new or planned development activities. Additional offsets that are unacceptable include the required mitigation of wetland impacts and required 100-foot buffer plantings (plantings are required when there is a change in land use under Critical Area regulations).

**Administering Offsets**
The primary responsibility for administering an offset program lies with each local jurisdiction. Offset programs are most effective when the local government develops a stormwater management plan, related regulations that identify offset opportunities and clear methods for implementing them. It is strongly recommended that a jurisdiction develop and use a written application to use offsets in order to fully document why an on-site BMP is not feasible and to ensure that offset measures are adequately identified. An offset application would include the information in the two cases discussed below:

1. Physical factors and/or site conditions prevent the use of any urban BMP at the development site. The offset would be equal to the entire pollutant removal requirement calculated for the site.

2. A stormwater BMP is installed, but is not sufficient to meet the entire pollutant removal requirement for the site. The offset would then be equal to the removal requirement for the project site less the load removed by an on-site BMP.

Generally, an offset program would be administered by the agency that implements the Critical Area and stormwater management regulations. If these two programs are administered by different agencies, for example the Planning and Zoning Department and the Public Works Department, it may make sense for them to work cooperatively on an offset program, but to identify a lead agency for the day-to-day implementation. The lead agency would be responsible for reviewing offset applications, identifying and approving acceptable offsets, overseeing implementation of offsets, and tracking offset program effectiveness. Local jurisdictions have considerable latitude concerning their level of involvement in actually implementing offsets. Three possible approaches to implementing local offset programs are described below.

Approach 1:
In this approach, the local jurisdiction's role is largely restricted to reviewing the proposed offset. The developer is responsible for finding an acceptable offset project and for performing all subsequent design, construction and maintenance activities. The local jurisdiction's responsibility is limited to prescribing general guidelines on acceptable offset options, reviewing the developer's offset plan for conformance with all local regulations, holding a performance bond, inspecting construction of the offset, and either monitoring or assuming subsequent maintenance.

Approach 2:
In this approach, local jurisdictions have a more active "brokering" role whereby they become involved in assisting an applicant in implementing the offset. In this situation, the developer is still required to design, construct and maintain the offset, however, the local jurisdiction works closely with the developer to help him/her find a suitable offset option and a site that will meet his/her needs. If the offset site is located on property owned by a third party, the local jurisdiction assists the developer in approaching the property owner and obtaining any necessary easements and maintenance agreements. In short, the local jurisdiction's role is to actively facilitate offsets.

Approach 3:
In this approach, the local jurisdiction takes on responsibility for all phases of the offset program. In contrast to the other approaches, the developer is only responsible for paying an "offset fee." The local jurisdiction then identifies a site and an appropriate BMP, which is constructed using the collected offset fee. This approach works most effectively when a local jurisdiction has conducted a detailed inventory of potential sites and potentially viable stormwater treatment options, from which it selects priority sites. The local jurisdiction then performs preliminary design and cost analyses for the projects, and determines an appropriate fee sufficient to cover the design and construction of the project, as well as any purchase, lease, or easement cost. In some cases, maintenance costs may also be included. The local jurisdiction then contracts for the design and construction of the offset project and constructs the individual offset within two years of the date that the offset fee is collected. In

most cases, the local jurisdiction will maintain the offset projects. The two year provision may be waived if the local jurisdiction is accumulating funds for a larger project (i.e., such as a regional stormwater facility). To receive this waiver, the local government must have a plan in place describing the use of accumulated funds.

Local jurisdictions have the additional responsibility of tracking and reporting the overall performance of the offset program to the Critical Area Commission (CAC) and interested citizens.

The three approaches attempt to recognize the fact that the need for offsets will vary from jurisdiction to jurisdiction. For example, a small municipality that may rarely, if ever, receive an offset application may opt for the first approach in order to reduce its administrative burden. On the other hand, a jurisdiction that receives several applications a year may wish to implement the second or third approach; these reduce possible delays for desirable development projects and provide greater control in which offsets are used and where they are located.

**Elements of a Local Offset Program**

In order to effectively implement a local offset program, a local government must address four elements in its local codes, ordinances, regulations, or policies. These are an inventory of offset opportunities, an implementation mechanism, a financing mechanism, and a tracking system as described below. The level of effort and responsibility for each element varies depending on which offset program approach is selected by a local jurisdiction.

<u>Inventory of Offset Opportunities</u>

The first element necessary to implement an offset program is an inventory of potential offset opportunities within the jurisdiction. The jurisdiction must perform or obtain consultant services to perform a survey to identify the most suitable sites and techniques for offsets. This element is needed for all approaches to implementing offset programs, and the scope of the local jurisdiction's effort and involvement depends on which approach they are using to implementing the offset program. The inventory is important for a number of reasons. First, a list of potential sites/techniques enables the local jurisdiction to quickly respond to an offset application. Without a list of potential sites, it is likely that local jurisdictions may encounter significant delays in processing applications. Second, the inventory helps local jurisdictions set priorities for its offset program and provides a rational basis for selecting the most effective and least expensive offset options. Finally, an offset inventory allows for an accurate determination of offset fees. Without an inventory and associated cost data, it is difficult for local jurisdictions to establish an appropriate offset fee. Costs will vary by location. Cost data specific to conducting a stormwater retrofit inventory is available in Appendix G.

<u>Implementation Mechanism</u>

In order to effectively administer an offset program, a local jurisdiction must have clear and concise criteria specifying how the program works and which agency takes the lead responsibility. These criteria must be reviewed and approved by the Critical Area Commission. This generally involves provisions in local codes or ordinances regarding who will be responsible for each of the four major phases of offset implementation (planning, design, construction, and maintenance) and the time frame in which they will be accomplished. The provisions should also specify how offsets located on properties owned by the local government or a private individual shall be maintained. For example, if a local government allows a riparian buffer planting as an offset, the trees cannot be removed at a later date to accommodate a development project. A description of the four phrases is provided below.

The planning phase involves selecting the most suitable sites from the offset inventory and preparing preliminary concept designs and associated cost estimates for the sites selected. It also includes estimating the amount of pollutant load controlled by the offset projects and calculating the total cost per pound removed. This phase also involves determining whether the offset will be protected by the jurisdiction's ownership of the property or through an easement or similar legal instrument.

The design phase includes the final design of the offset projects, including hydrologic/hydraulic computations, geotechnical engineering, final design of the structure and preparation of construction specifications and bid documents.

The construction phase involves advertising for bids and awarding the contract for the construction of the project as well as oversight and inspection during construction.

The maintenance phase includes defining and assigning maintenance responsibilities over a minimum 20-year period, negotiating maintenance tasks and schedules, and allocating a maintenance budget. Maintenance also includes executing appropriate easements or other legal instruments to ensure that offsets located on properties owned by the local government or a private individual are maintained and not eliminated during subsequent redevelopment efforts. For example, if a local government allows a stream buffer reforestation as an offset, the buffer vegetation cannot be removed at a later date to accommodate a development project.

A Financing Mechanism

An important element of an offset program is the option to collect offset fees when appropriate. It may be appropriate to collect offset fees when the identified offset opportunities are large and costly or when an offset opportunity has been identified but cannot be implemented immediately. The collection of offset fees allows a developer to pay the local jurisdiction a fee to finance public sector implementation of an offset. The amount of the fee is variable and is based on the amount (pounds) of the unmet pollutant removal requirements at the developer's project site. The fee must be established to recover all of the costs incurred by the local jurisdiction in implementing the offset program including planning, design, construction and maintenance.

A Tracking System

A tracking system is needed in all local offset programs, to demonstrate in reasonably quantitative terms, that the program is, in fact, accomplishing its intended objective. Local jurisdictions must keep detailed and accurate records of the pollutant loadings associated with specific projects, of the fees collected, and of the fees expended on the individual and cumulative remedial measures. They must demonstrate that the total amount of phosphorus removed by offset measures is equal to or greater than the total phosphorus load generated by development projects that do not provide treatment on site.

**Offset Fees**

In some jurisdictions, it may be more practical to collect offset fees on a project-by-project basis, rather than implement an overall offset program that may or may not include offset fees. If a jurisdiction opts to collect offset fees, specific provisions relating to the collection and expenditure of the offset fees will be included in the local zoning or Critical Area ordinance. These provisions will ensure that adequate fees are collected, that fees are spent on appropriate water quality improvement projects, and that projects are accomplished in a timely manner. Jurisdictions must show that the fees collected can cover the costs of phosphorus removal or an equivalent water quality improvement.

Because determining an offset fee can be a complex task for local jurisdictions this section provides data on the actual costs of stormwater management and general guidelines for setting a locally appropriate offset fee. Brown and Schueler (1997) evaluated the actual costs for 73 stormwater BMPs in the mid-Atlantic region, and developed cost equations and cost per cubic foot of water quality storage provided. The data from this study can provide the basis for setting an offset fee that fully recovers the cost to remove phosphorus from one acre of impervious cover. Based on this data it was determined that the fee necessary to fully recover the cost to remove phosphorus from one acre of impervious cover ranges from $22,500 to $38,400 per pound of phosphorus removed. These costs (adjusted for inflation) account for several aspects of stormwater BMP implementation including construction costs, design, engineering, permitting, and maintenance. Additional information on this cost estimate can be found in Appendix G.

Costs may vary and jurisdictions are encouraged to develop their own fees utilizing this information and more specific local cost data. However, for many local jurisdictions, very little cost data is available to estimate the costs associated with local offset programs. Costs can vary widely depending on the nature of the offset option(s) used and the availability of suitable sites. As a result, it is not likely that local jurisdictions will be able to accurately assess offset costs until they complete the offset inventory, screen suitable options and conduct preliminary design/cost estimates. Therefore, local jurisdictions may decide to use a fee within the range included herein until additional data is collected in the local jurisdiction based on the implementation of specific projects. Once projects have been accomplished, information regarding the cost of the specific BMPs and the pollutant load removal estimates can be used to determine a per pound cost. The final offset fee for the jurisdiction would then be the total cost of the BMPs divided by the total phosphorus load removed expressed in terms of dollars per pound of phosphorus.

Local jurisdictions may consider waiving or modifying these costs for small property owners (sites of one acre or less), brownfields, or other special infill sites. Local jurisdictions need to include provisions for this fee modification in their critical area or zoning ordinance.

If a local jurisdiction chooses to establish its own offset fees, it must consider all of the costs associated with the offset. The offset fee should reflect the costs associated with the planning, design, construction, and maintenance of offset facilities constructed (see Appendix G).

Planning

Planning costs include the staff time necessary to conduct an inventory of offset opportunities and involve reviewing plans, checking sites in the field, coordinating with various local agency staff, and screening sites. Additional costs may be associated when private lands are used because staff effort would be needed to contact and negotiate with private landowners. In some cases, costs associated with watershed-scale modeling will need to be considered. The planning process can be facilitated if a jurisdiction has previously completed a comprehensive watershed plan with specific information about stormwater management.

Design Costs

Design costs are incurred in preparing and obtaining approval for the offset project plan, in preparing construction specifications and drawings and for construction oversight and inspection services. Design costs for construction of typical offsets run 15 to 25% of the total construction cost. This depends on the complexity of the site characteristics and if concept plans and details are available for the proposed offset.

Construction Costs

Construction costs widely vary depending on the offset project. Estimated costs of stormwater retrofits are provided in Appendix G. Stream restoration costs are highly variable and can range from $10 to $300 per linear foot. These costs do not account for any utility relocations, bridge/culvert replacement, or potential land acquisition.

Local jurisdictions should also take into account the cost of land. Although it is preferable to implement offsets on publicly owned lands, this is often not possible, and the cost of fee-simple acquisition or easement acquisition must be considered.

Maintenance

Maintenance is frequently overlooked, but is necessary to maintain the pollutant removal function of a stormwater BMP and many other potential offset projects. Consequently, a mandatory element of any offset program is the reservation of funds to cover anticipated maintenance costs over a 20-year period. Stormwater BMP annual maintenance costs are estimated to be 3 to 5% of the initial construction cost and cover both routine tasks (e.g., grass mowing, inspection, debris removal) and sediment removal. The incremental maintenance costs associated with offsets that involve retrofitting an existing BMP are largely confined to extra sediment removal expenses, which are estimated to be 1 to 2% of the initial construction cost per year.

# SECTION 7.0 FREQUENTLY ASKED QUESTIONS

This section answers frequently asked questions (FAQs) pertaining to the 10% Rule. These FAQs are organized under the following categories:

- General Information
- Standard Application Process
- Calculating Impervious Cover
- 2000 Maryland Stormwater Design Manual and the 10% Rule
- Best Management Practices (BMPs)
- Residential Lot Development
- Special Development Scenarios
- Critical Areas Buffer
- Offsets

**General Information**

1. *What is the Critical Area?*

   In 1984, the Maryland General Assembly resolved to reverse the deterioration of the Chesapeake Bay's environment by enacting the Chesapeake Bay Protection Act. The Act required 16 counties, Baltimore City, and 44 municipalities surrounding the Bay to implement a land use and resource management program designed to mitigate the damaging impact of water pollution and loss of natural habitat, while also accommodating the jurisdiction's future growth. The General Assembly passed the "Atlantic Coastal Bays Protection Act " in 2002 that added the area surrounding the five Atlantic Coastal Bays and their tributaries to the Critical Area. The Critical Area Act recognizes that the land immediately surrounding the Bay and its tributaries has the greatest potential to affect water quality and wildlife habitat and thus designated all lands within 1,000 feet of tidal waters or adjacent tidal wetlands as the "Critical Area."

2. *Who and what does the Critical Area Act affect and how can I find out if my property is in the Critical Area?*

   The Act affects all those who live or own property within 1,000 feet of the Chesapeake Bay, Atlantic Coastal Bays, and their associated tidal waters and wetlands. All development or use of land located within the Critical Area is affected in some way. Land located in the Critical Area is subject to additional regulations; however, these regulations do not prohibit the land from being developed and used. Counties and municipalities affected by the Critical Area regulations maintain maps showing the extent of the Critical Area. Information about the maps and the Critical Area can be obtained from the local planning and zoning office.

3. *What is the Critical Area Commission for the Chesapeake and Atlantic Coastal Bays and how does it affect me?*

   The 29-member Critical Area Commission for the Chesapeake and Atlantic Coastal Bays was established by the 1984 Chesapeake Bay Protection Act and amendments to the Act in 2002. The Commission designed the Critical Area Criteria which are the basis of 61 local Critical Area Programs. The Commission is a State agency that reviews and approves local jurisdiction's Critical Area Programs and amendments to those programs. The Commission staff review and comment on subdivisions, site plans, variances and other local development proposals within the Critical Area. However, each local jurisdiction maintains sovereignty in creating, adopting, and implementing its local program in accordance with the Commission's Criteria.

4. *Does the Critical Area Commission have to approve all applications to build or develop in the Critical Area?*

   No. The Commission reviews and approves State government projects on State land and some local government projects that involve major development or development that involves approval under specific conditions. Most residential building permits can be reviewed and approved by the local government. If the permit involves a variance or special exception, then Commission staff will review it and provide comments on the proposed project to the local government. Applicants should remember to check with their local planning and zoning office before undertaking any development activity within the Critical Area.

5. *Who should be contacted about a stormwater problem?*

   The local Public Works Department or Planning Department usually handles stormwater management issues, and complaints and questions about stormwater problems should be directed to them. General information about stormwater management is available from the Maryland Department of the Environment, which can be accessed on-line at www.mde.state.md.us

**Standard Application Process**

6. *How does an applicant perform the calculations for a redevelopment site that has an existing BMP that is assumed to be adequately sized and designed to treat the "existing conditions" load?*

   The 10% Rule requires a 10% reduction below pre-development conditions, so a BMP sized to treat the pre-development load will not satisfy the 10% Rule requirements. The applicant must complete the Standard Application Process. If the existing BMP is an approved structural practice, it should be identified in Step 5 of the Standard Application Process. If the existing BMP is not an approved structural practice, or if the BMP does not satisfy the removal requirements, the applicant should examine other opportunities to meet the 10% Rule requirements.

7. *How does an applicant perform the calculations for a redevelopment site that has an existing older BMP that does not meet the current design standard, but may be providing some water quality benefit?*

   The pollutant removal associated with the existing BMP may be estimated based on the best available information about the design and construction of the BMP and its performance. An applicant should work with the local government and the Commission to estimate the removal efficiency rate of the BMP. Most likely, the removal efficiency of the existing BMP will be somewhat lower than the removal efficiencies in Section 4.0 depending on the age and type of the BMP.

8. *How should the calculations be performed when the acreage of the drainage area changes from the pre-development to the post-development conditions because of site grading?*

   The applicant should apply the post-development drainage boundaries to the pre-development site to calculate pre-development loads. The site area should remain the same for all calculations.

9. *How does the "fraction of drainage area served" listed in Step 5 of the Standard Application Process affect the 10% rule requirements?*

   The fraction of the drainage area served by BMPs is rarely 100% of the development site, yet is often reported as so. The plan submittal should clearly delineate the drainage area associated with each proposed BMP (see Figure 7.1 for an example). The drainage area should be measured, and divided by the total site area (or, if the site has been split, divided by each "workable unit") to determine the fraction of drainage area served. The fraction of drainage area served is then used to determine the total load removed.

10. *How should an applicant handle large sites to ease the review process?*

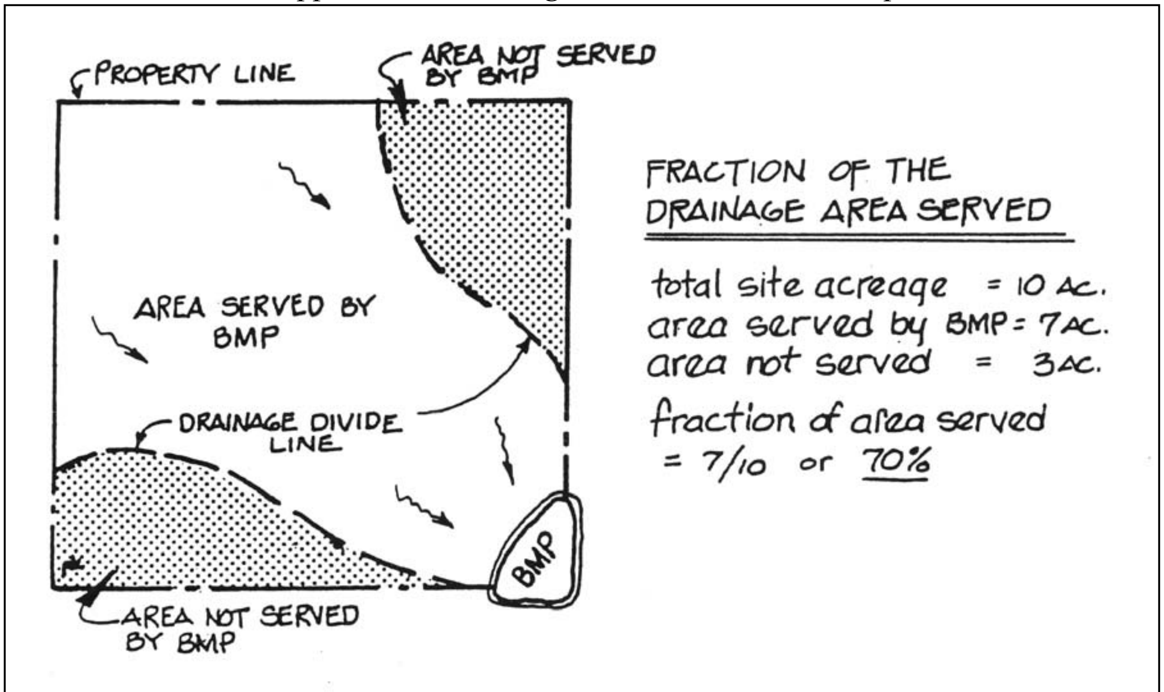



**Figure 7.1 Delineation of Drainage Area Served by the BMP**

Large development sites may be broken up into separate workable units based on drainage divides or type of development (see Figure 7.2 for an example). Separate worksheets for each "unit" must be completed.

- The pollutant removal requirement can be met through an additive process across the site. This is accomplished by comparing the total load removed for each unit with the sum of the Removal Requirement (RR) for the site.
- All phases of a development should be included in the computations, using conceptual impervious cover estimates for later phases.

11. *How does an applicant handle negative removal requirements?*

Under certain scenarios, the calculations can result in a value less than zero for the pollutant removal requirement. This less-than-zero scenario is referred to as a negative removal requirement, and can happen when a drainage area has less than 17% imperviousness. An applicant must complete calculations for each drainage area and select BMPs to meet the removal requirements for each drainage area. Once this is done, sites with multiple drainage areas are evaluated on a drainage area by drainage area basis and not by the summation of the site's total drainage area.

Negative removal requirements (RR) are not portable to other sites or drainage areas. Negative values for RR must be rounded up to zero for determination of total site compliance.

12. *What if a BMP plan only meets a portion of the Removal Requirement on site?*

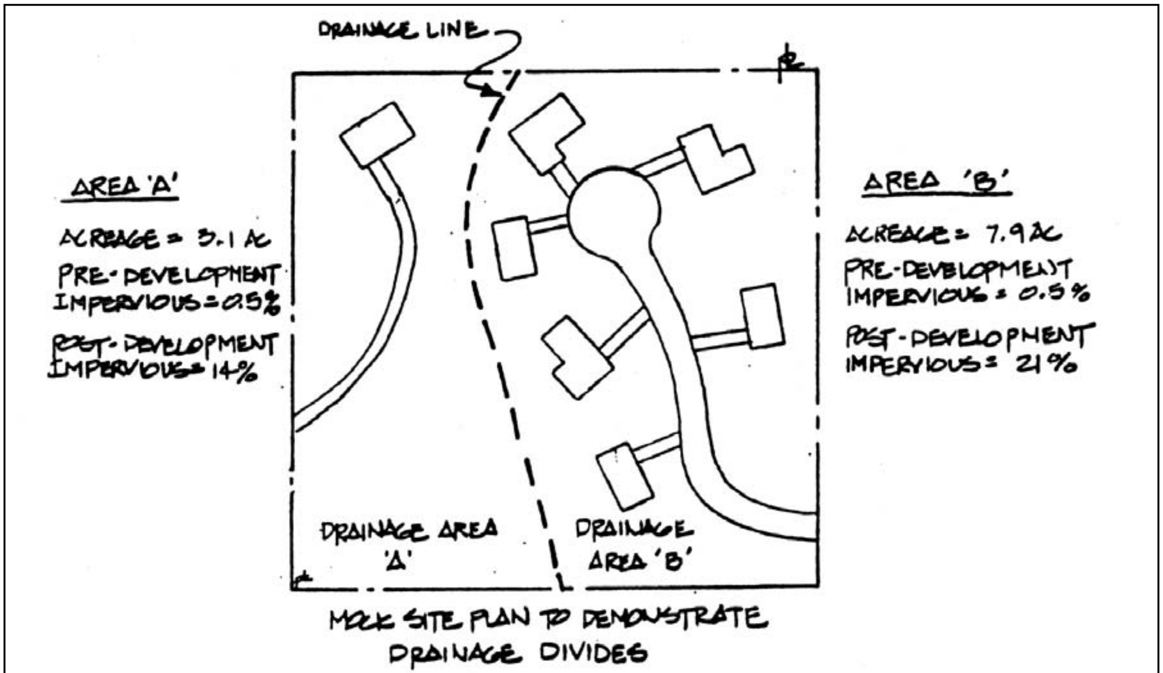



**Figure 7.2 Using Drainage Divides to Break-Up the Site into Workable Units**

If at all possible the applicant should try to improve the BMP design or lower the level of site impervious cover as a means to ensure compliance through an improved design. If changes to the design are proven infeasible, the plan reviewer should choose an appropriate offset project to fully meet pollutant removal requirement. See Section 6.0 for more information on offset options.

13. *Do the calculations for the Standard Application Process have to be completed for portions of the site that will be left undeveloped?*

Yes. Generally, the Standard Application Process must be completed for the entire portion of the site within the Critical Area that is designated IDA. Certain development projects on large sites that are developed over time, such as college campuses or airports, may have some flexibility with addressing stormwater requirements for portions of the site as various projects are completed. The applicant should work with the Commission and appropriate State and local government staff to identify the best method for addressing the pollutant reduction requirement. In some cases, the development of a comprehensive stormwater management plan for the entire site is the most practical and effective way to address large sites that are developed over many years.

**Calculating Impervious Cover**

14. *For purposes of stormwater calculations within the IDA, what is "impervious cover?"*

Impervious cover is 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, human-made 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.

15. *Are certain types of BMPs that "hold water," such as ponds and wetlands, considered impervious?*

No. Although these facilities may technically be all or partially impervious, these facilities do not generally generate or accelerate stormwater flows and they function to collect and treat pollutants rather than generate them. For purposes of performing stormwater calculations, all BMPs are considered pervious unless they are located within or under an impervious structure such as a building or parking lot.

16. *How far back should an applicant go when determining pre-development impervious cover?*

Pre-development impervious cover is defined as the impervious cover at the site at the time that the development planning process begins.

17. *Should wooden decks count as impervious cover?*

Wooden decks are considered impervious unless:

- The deck is constructed with gaps between the boards and, instead of a concrete pad, a sloping 6" 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.

If a concrete pad is placed under a wooden deck, include the square footage of the deck into the total impervious calculation. See Appendix F for more information.

Decks that are not constructed in this manner or that are made of concrete are considered impervious.

18. *Should gravel roads and dirt drives be included in the impervious cover calculation?*

Both gravel roads and dirt drives should be considered as impervious surface areas for the following reasons:

- Compaction of these non-paved surfaces occurs over time with increased use, which prevents infiltration of rainwater into soils.
- Gravel roads and dirt drives become sources of erosion and sediment transport during storm events.

See Appendix F for alternative driveway designs.

19. *Should landscaping ponds and swimming pools be counted as impervious cover?*

    Landscaping ponds and swimming pools should be included as part of the total site impervious cover. Although pools may collect portions of stormwater runoff, they are not designed as a stormwater facility. In addition, they disrupt the natural ability of soils to percolate/filter surface runoff. In the case of landscaping ponds, the same criteria and reasoning applies, regardless of the use of the pond.

20. *Permeable pavers and porous pavement are considered partially pervious. How can the percent of perviousness be determined?*

    The applicant should submit the manufacturer's specifications for the specific product proposed to be used to the local Critical Area Planner ofr review and a determination of perviousness.

**2000 Maryland Stormwater Design Manual and the 10% Rule**

21. *Do local governments and consultants still need to submit 10% Rule Worksheets when stormwater management for a site falls under the requirements of the MDE Manual?*

    Yes. Commission staff and MDE staff think that in most cases compliance with the MDE Manual will meet or exceed the requirements for compliance with the 10% Rule for new development projects. However, until this is verified through actual practice, the worksheets still need to be submitted.

22. *Do these worksheets need to be submitted to the Critical Area Commission?*

    Yes. For projects that require submittal to the Commission as specified in COMAR 27.03.01.03 for review and comment, the applicant must submit the 10% Rule worksheets with the site plan or subdivision plat. For projects that do not require review and comment by the Critical Area Commission, submit the 10% Rule worksheets to the local agency responsible for reviewing them.

23. *Why are there differences between MDE's 2000 Maryland Stormwater Design Manual and the Commission's Urban Stormwater Quality Guidance?*

MDE's 2000 Maryland Stormwater Design Manual addresses stormwater comprehensively and the provisions relate to all aspects of stormwater management including stormwater quantity, stormwater quality, stormwater velocity, groundwater recharge, stream degradation, and overbank flooding. The Commission's guidance relates only to stormwater quality and the provisions in the Critical Area Criteria that require a 10% reduction in pre-development pollutant loadings.

24. *COMAR 26.17.02 defines redevelopment as "Any construction, alteration, or improvement exceeding 5,000 square feet of land disturbance performed on sites where existing land use is commercial, industrial, institutional, or multi-family residential." This definition is different than the one provided in the 10% Rule guidance. Which definition should be used?*

Applicants should use the definition in the 10% Rule guidance for compliance with the Critical Area pollutant reduction requirement. Applicants should use the definition in the 10% Rule guidance that categorizes redevelopment as a development activity that takes place on a site with pre-development imperviousness greater than 15%. New development is defined as a development activity that takes place on a site with pre-development imperviousness less than 15%.

25. *The MDE Manual applies to any construction activity disturbing 5,000 or more square feet of earth, and exempts the following activities:*

- *Additions or modifications to single family structures that do not disturb more than 5,000 square feet of land*
- *Developments that do not disturb more than 5,000 square feet of land*

*Are these activities also exempt from compliance with the 10% Rule?*

No.

Additions or modifications to single family structures that disturb 250 square feet or more of site area must comply with the 10% Rule, using one of the three options described below:

- Option 1. Submit a Residential Water Quality Management Plan
- Option 2. Plant Trees and/or Shrubs on the site
- Option 3. Implement an Offset

Individual residential development projects that disturb an area greater than 5,000 square feet may also be required to submit a standard stormwater management plan for single lot residential construction. See Section 5.0 for more information on individual, single-family residential development requirements.

Developments that disturb less than 250 square feet of land are exempt, but those that disturb between 250 square feet and 5,000 square feet must comply with the 10% Rule. Those that disturb over 5,000 square feet must comply with both the 10% rule and the MDE Manual.

Agricultural activities are exempt from 10% Rule compliance because Best Management Practices on agricultural lands are implemented through Soil Conservation and Water Quality Plans administered by the local Soil Conservation Districts.

26. *Why aren't additions or modifications to single family structures exempt?*

Additions to single family structures and projects that disturb less than 5,000 square feet are not exempt from 10% Rule compliance because the Critical Area Criteria require that for both new development and redevelopment projects, pollutant loadings must be reduced by at least 10% below the level of pollution on site prior to development. The Criteria do not provide for exemptions because for every development activity, some effort should be made to improve water quality. Rather than provide for exemptions, the Criteria do allow for the implementation of alternative measures or offsets that compensate for the undesirable impacts of development on water quality.

27. *The MDE Manual doesn't address BMPs in a series. Can an applicant still use them?*

Yes, an applicant can use BMPs in a series to meet the 10% Rule requirements, per the following conditions:

- Each BMP must be sized to treat the full water quality volume ($WQ_v$) for the area draining to it, per the 2000 Maryland Stormwater Design Manual.

- The pollutant load removed by the first BMP in the series is calculated per Step 5 in the Standard Application Process (see Table 4.7).

- The removal efficiency of the second BMP in the series is one-half of the total phosphorus removal efficiency displayed in Table 4.8. For instance, the total phosphorus removal efficiency for wet ponds is 50%. If the wet pond is the second BMP in a series, a removal efficiency of 25% is used to calculate the phosphorus load removed by the second practice.

- The "$L_{post}$" (see Table 4.7) used to calculate the load removed by the second BMP in the series equals the pollutant load exported from the first BMP in the series, *not* the average annual load of total phosphorus exported from the post-development site.

  Load Removed, $LR = (LR_{BMP1}) + (LR_{BMP2}) + (LR_{BMP3})$

Where $(LR_{BMP1}) = (L_{post})\ (BMP_{1RE})$ (% DA Served)

$(LR_{BMP2}) = (L_{post} - LR_{BMP1})\ (0.5)\ (BMP_{2RE})$ (% DA Served)

$(LR_{BMP3}) = (L_{post} - LR_{BMP2})\ (0.5)\ (BMP_{3RE})$ (% DA Served)

28. *Can vegetated rooftops be used to obtain a stormwater management benefit?*

Yes. Buildings with a vegetated roof system, approved by a local government, the Critical Area Commission, or MDE, will not be considered as an impervious surface. This means that when calculating the post-development area of impervious surface, the applicant should not include the area of a building or buildings with a vegetated roof. CAC and MDE both consider vegetated rooftops as 100% pervious. Section 4.0 discusses the inclusion of vegetated rooftops in the Standard Application Process.

29. *The MDE Manual gives stormwater credits for the following site planning techniques: natural area conservation, disconnection of rooftop runoff, disconnection of non-rooftop runoff, sheet flow to buffers, grass channel use, and environmentally sensitive development. How do these credits relate to 10% Rule compliance?*

The Critical Area Criteria allows the application of non-structural BMPs to meet the 10% pollutant reduction requirements. Several of these non-structural BMPs align with options presented in the MDE Manual under the stormwater credits. Some of the stormwater credits in the MDE Manual apply to reductions in the required recharge volumes, water quality storage volumes, channel protection storage volumes, and overbank flood protection volumes. These credits do not apply directly to phosphorus removal; however, some of the planning techniques will have the effect of reducing pollutant loadings and ultimately reducing the phosphorus removal requirement. See Section 4.0 for more information.

30. *The MDE Manual encourages avoiding structural facilities for stormwater management and using more natural methods. How will this new strategy be coordinated with 10% Rule compliance?*

The application of non-structural BMPs allows for a more natural method for managing stormwater. The Commission is willing to coordinate stormwater planning and design with applicants and MDE to identify the most appropriate stormwater management measures for each site. In cases where nonstructural approaches will achieve the 10% pollutant reduction requirement, they will be strongly encouraged.

Appendix E provides information on non-structural BMPs that may be used to comply with the 10% Rule. The non-structural BMPs include filter strips, vegetated rooftops, permeable pavers, and grass channels. Porous pavement and cisterns may be approved on a case-by-case basis. Some non-structural BMPs may not be appropriate for certain sites. Section 4.0 and Appendix E provide additional specific information about BMPs. For the purposes of this Guidance Manual, these BMPs have not been assigned phosphorus removal efficiencies but should be used from the perspective of "reducing the area" of proposed impervious cover. Implementing non-structural BMPs first at a site can help reduce or eliminate the need for costly structural BMPs. See Section 4.0 for guidance on incorporating non-structural BMPs in the Standard Application Process.

The 10% Rule Guidance also allows for compliance with the pollutant removal requirement using offsets. Section 6.0 provides additional information about offset options. Many of the offset options involve nonstructural approaches. In general, the "credit" given for these offsets is determined on a case- by-case basis.

31. *The MDE Manual provides a "sheetflow to buffer" credit. When an applicant establishes the buffer on a new development project, can they get a phosphorus removal credit for compliance with the 10% Rule?*

On any site where the 100-foot Buffer is required to be established by the Critical Area Criteria, a phosphorus removal credit for planting a forested buffer within 100 feet of tidal waters, tidal wetlands, and tributary streams (the 100-foot Buffer) is not permitted. On a case-by-case basis, an applicant may receive phosphorus removal credit of up to two pounds per acre for planting a forested buffer on a site where buffer establishment is not required (a grandfathered lot that is not part of the project) or planting offsite in an area approved by the local government (see Section 6.0).

**Best Management Practices (BMPs)**

32. *Can BMPs that are not listed as structural BMPs in this guidance be used to meet the 10% Rule Requirements?*

The Maryland Department of the Environment (MDE) periodically reviews new structural BMPs and determines whether they may be used to meet the management requirements per the 2000 Maryland Manual. If a structural BMP not included in this guidance has been reviewed by MDE, the recommendation of MDE should be followed.

If a proposed structural BMP has not been reviewed by MDE, it may be used to treat runoff from no more than 10% of the development site for redevelopment projects only. The total phosphorus removal efficiency used in the Standard Application Process must be the BMP efficiency as reported by an independent source (i.e., not associated with the manufacturer of the proprietary device).

Only MDE-approved BMPs may be used to provide stand-alone water quality treatment for new development.

Alternatively, some BMPs may be applied as non-structural practices instead. This will be applied on a case-by-case basis.

33. *Can an applicant obtain credit for BMPs that may not be designed in accordance with the specifications included in the MDE Manual (i.e., a bioretention area with less than the specified depth of controlled soil medium)?*

Yes. On a case-by-case basis, an applicant may obtain some credit for alternative BMP designs based on recommendations from the Maryland Department of the Environment (MDE). Applicants proposing modifications to the design standards in the MDE Manual should coordinate with Commission staff and MDE staff early in the design process in order to allow sufficient time to review the proposal.

34. *What kinds of BMPs can be used in linear road rights-of-way (ROWs)?*

Several of the structural BMP options are linear in nature and well suited to ROWs, including:

- Infiltration trenches
- Perimeter sand filters
- Bioretention
- Dry swales
- Wet swales

Alternatively, stormwater runoff may be conveyed in an grass channel to a structural BMP. More detail on these BMP options is provided in Appendix E.

35. *How should the calculations be handled for a BMP that is located outside the Critical Area on a project site?*

The applicant should complete Worksheet A to calculate the removal requirement for the Critical Area portion of the site as they would for a typical on-site compliance project. The applicant should include the proposed BMP located outside the Critical Area in Step 5. The post-development load and drainage area served used in Step 5 should be based on the Critical Area portion of the site, even if the BMP is located outside the Critical Area. The applicant should ensure that the BMP is adequately sized to treat any run-off draining to it from portions of the site outside the Critical Area in addition to treating the run-off from within the Critical Area.

36. *Can an applicant meet the pollutant removal requirement by treating portions of a site that are located outside the Critical Area? How should the calculations be handled for this situation?*

In most cases, if an applicant cannot meet the pollutant removal requirement by treating stormwater run-off within the Critical Area, then treatment of areas outside the Critical Area may be considered at the local government's discretion. This situation would be considered an off-site compliance situation, and the applicant would complete Worksheet B.

37. *How should the calculations be handled for a BMP that treats an on-site pollutant load, but the BMP itself is located off-site?*

The applicant should complete Worksheet A to calculate the removal requirement for the site as they would for a typical on-site compliance project. The applicant should include the proposed off-site BMP in Step 5. The post-development load and drainage area served used in Step 5 should be based on the project site, even if the BMP is off-site. The applicant should ensure that the BMP is adequately sized to treat any run-off draining to it from off-site in addition to treating the run-off from within the Critical Area.

38. *How is an offset different from off-site compliance?*

Compliance with the 10% Rule through offsets should be clearly distinguished from compliance achieved by providing treatment of off-site drainage areas with an on-site BMP. Treatment of an off-site drainage area with an on-site BMP is a means of increasing the amount of runoff treated by the on-site BMP and, thereby, increasing the amount of pollutant load removed. An offset, on the other hand, is not located on the project site, and may involve activities other than the construction of a BMP. Offsets are used when on-site practices are either infeasible and/or insufficient to comply with the 10% Rule at the development site. Applicants can calculate pollutant loads removed in off-site compliance situations using Worksheet B. In situations where offsets are used, Worksheet B may be applicable if the offset involves the construction, conversion, or retrofitting of a BMP. For other types of offsets, applicants should refer to Section 6 and consult with the local Critical Area Planner and the staff of the Critical Area Commission for guidance.

**Residential Lot Development**

39. *How should an applicant treat residential lots in a subdivision that has a community stormwater facility? What if there is little or no information about the design of the facility?*

An applicant should assume that the facility is not designed to accommodate runoff from additional development. Development of individual residential lots that involve construction and associated disturbance of 250 square feet or more of site area must comply with the 10% Rule, using one of three options:

- Option 1. Submit a Residential Water Quality Management Plan
- Option 2. Plant Trees and/or Shrubs on the site
- Option 3. Obtain an Offset

See Section 5.0 for more information on residential project compliance.

**Special Development Scenarios**

40. *How should an applicant address the treatment of stormwater on new or widened bridges or on berthing facilities that are constructed over open water?*

The site area will include the project site plus any areas of open water that will be covered by post-development impervious surfaces such as a bridge or berth structure. The pre-development load associated with any open water areas of the project site will be 0 (zero) pounds per acre per year because open water areas will be considered the same as a "pervious area" of the project site. The post-development load will be calculated per the standard application process with the bridge surface or berth structure considered as impervious.

41. *Can the removal of piles of debris and garbage obtain some sort of stormwater credit?*

No. The removal of debris and garbage from a site is done as part of the normal construction process and may not receive a credit.

**Critical Area Buffer**

42. *What is the 100-foot Buffer and how does it differ from the rest of the Critical Area?*

A crucial part of habitat protection and water quality improvement is the establishment of a naturally vegetated, forested Buffer between human disturbances and sensitive land and water resources. A forested Buffer acts as a filter for the removal or reduction of sediment, nutrients, and toxic substances that enter adjacent waterways in land runoff. The Buffer also minimizes the adverse impact of human activities on habitat within the Critical Area. The Critical Area Act requires the establishment of a minimum Buffer of 100 feet of natural vegetation landward from the Mean High Water Line of tidal waters or the edge of tidal wetlands and tributary streams. In general, in order to develop within the Buffer, an applicant must obtain a variance by demonstrating unwarranted hardship and proving the project will not have a negative impact to water quality, plant, fish, or wildlife habitat. Shore erosion control measures, water access and water-dependent facilities may be permitted in the Buffer without a variance. Any clearing that occurs for access or water-dependent facilities must be mitigated through a Buffer Management Plan approved by the local jurisdiction.

43. *Exactly what is and isn't permitted in the Critical Area Buffer? Who should be contacted if a violation is suspected?*

The Buffer may be disturbed only for certain activities such as water-dependent structures, access to the shoreline, and shore erosion control measures. Agricultural activities within the Buffer are permitted under special guidelines. In general, the cutting or clearing of trees, except those that are diseased or damaged, is not allowed in the Buffer. A Buffer Management Plan, approved by the local government, can be used to allow for reasonable access to the water, the removal of invasive species and overall enhancement of the Buffer. No other development (e.g., swimming pools, tennis courts, structures, stormwater management structures, and septic fields) or other land disturbances are permitted in the Buffer. The Buffer should be maintained in natural vegetation (e.g., forested) and must be expanded to include adjacent sensitive resources, such as steep slopes, hydric or highly erodible soils. Trees and other vegetation may be planted in the Buffer, and the use of native species such as Sycamore, Flowering Dogwood, Mountain Laurel and American Holly is strongly recommended. A more complete list of native species recommended by the Critical Area Commission can be found on-line at www.dnr.state.md.us/criticalarea/trees.html.

44. *Can BMPs be located within the 100-foot Buffer?*

No. The CAC considers BMPs a development activity, and they may not be located within the 100-foot Buffer.

45. *Are outfalls allowed in the 100-foot Buffer?*

Yes, outfalls that are considered to be water-dependent facilities are allowed to pass through the 100-foot Buffer, but they must discharge into open water.

## Offsets

46. *What is an Offset?*

The Critical Area Criteria define offsets 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 BMPs are insufficient or impractical. Offsets must remove a pollutant load equal to or greater than the pollutant removal requirement. Offset fees must be equivalent to the cost of planning, designing, constructing, and maintaining a BMP capable of meeting the pollutant removal requirement.

# SECTION 8.0 REFERENCES AND ADDITIONAL RESOURCES

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# Appendix A. Review of Urban Runoff Pollutants

The following is an excerpt from Section 1.1.1 of the Maryland Stormwater Design Manual. Typical pollutant concentrations found in stormwater are provided in Table A.1.

*Nutrients*. Urban runoff has elevated concentrations of both phosphorus and nitrogen, which can enrich streams, lakes, reservoirs and estuaries (known as eutrophication). In particular, excess nutrients have been documented to be a major factor in the decline of Chesapeake Bay. Excess nutrients promote algal growth that blocks sunlight from reaching underwater grasses and depletes oxygen in bottom waters. Urban runoff has been identified as a key and controllable source. Maryland has committed to reducing tributary nutrient loadings by 40% as part of the Chesapeake Bay restoration effort.

*Suspended solids*. Sources of sediment include washoff of particles that are deposited on impervious surfaces and the erosion of streambanks and construction sites. Both suspended and deposited sediments can have adverse effects on aquatic life in streams, lakes and estuaries. Sediments also transport other attached pollutants.

*Organic Carbon*. Organic matter, washed from impervious surfaces during storms, can present a problem in slower moving downstream waters. As organic matter decomposes, it can deplete dissolved oxygen in lakes and tidal waters. Low levels of oxygen in the water can have an adverse impact on aquatic life.

*Bacteria*. Bacteria levels in stormwater runoff routinely exceed public health standards for water contact recreation. Stormwater runoff can also lead to the closure of adjacent shellfish beds and swimming beaches and may increase the cost of treating drinking water at water supply reservoirs.

*Hydrocarbons*. Vehicles leak oil and grease, which contain a wide array of hydrocarbon compounds, some of which can be toxic at low concentrations to aquatic life.

*Trace Metals*. Cadmium, copper, lead and zinc are routinely found in stormwater runoff. These metals can be toxic to aquatic life at certain concentrations, and can also accumulate in the sediments of streams, lakes and the Chesapeake Bay.

*Pesticides*. A modest number of currently used and recently banned insecticides and herbicides have been detected in urban streamflow at concentrations that approach or exceed toxicity thresholds for aquatic life.

*Chlorides*. Salts that are applied to roads and parking lots in the winter months appear in stormwater runoff and meltwater at much higher concentrations than many freshwater organisms can tolerate.

*Thermal Impacts*. Impervious surfaces may increase temperature in receiving waters, adversely impacting aquatic life that requires cold and cool water conditions (e.g., trout).

*Trash and Debris*. Considerable quantities of trash and debris are washed through the storm drain networks. The trash and debris accumulate in streams and lakes and detract from their natural beauty.

**Table A.1 Typical Pollutant Concentrations Found in Urban Stormwater**

| Typical Pollutants Found in Stormwater Runoff (Data source) | Units | Average Concentration (1) |
|---|---|---|
| Total Suspended Solids (a) | mg/l | 80 |
| Total Phosphorus (b) | mg/l | 0.30 |
| Total Nitrogen (a) | mg/l | 2.0 |
| Total organic Carbon (d) | mg/l | 12.7 |
| Fecal Coliform Bacteria (c) | MPN/100 ml | 3600 |
| E. coli Bacteria (c) | MPN/100 ml | 1450 |
| Petroleum Hydrocarbons (d) | mg/l | 3.5 |
| Cadmium (e) | ug/l | 2 |
| Copper (a) | ug/l | 10 |
| Lead (a) | ug/l | 18 |
| Zinc (e) | ug/l | 140 |
| Chlorides (f) (winter only) | mg/l | 230 |
| Insecticides (g) | ug/l | 0.1 to 2.0 |
| Herbicides (g) | ug/l | 1 to 5.0 |

(1) these concentrations represent *mean or median* storm concentrations measured at typical sites, and may be greater during individual storms. Also note that mean or median runoff concentrations from *stormwater hotspots* are 2 to 10 times higher than those shown here. Units = mg/l = milligrams/liter, µg/l = micrograms/liter.

Data Sources: (a) Schueler (1987) , (b) Schueler (1995a), (c) Schueler (1997), (d) Rabanal and Grizzard (1995), (e) USEPA (1983), (f) Oberts (1995), (g) Schueler (1995b)

# APPENDIX B. SELECTION CRITERIA FOR THE KEYSTONE POLLUTANT

The following describes the criteria used in the selection of a keystone pollutant. To serve as a good surrogate for other urban pollutants, a keystone pollutant should have the following characteristics:

1) It should have well defined adverse impacts on the Chesapeake Bay. In particular, the pollutant should have an impact on the shorelines and coves adjacent to the Critical Area where stormwater runoff can be expected to exert the greatest impact on water quality.

2) The form and behavior of the keystone pollutant should be a composite of most stormwater pollutants. That is, the pollutant should exist in both the particulate and soluble phase. For our purposes, these terms are defined in an operational rather than a strict physical/chemical manner. Thus, any pollutant that can pass through a 45 micron filter is considered soluble; whereas, any pollutant that cannot is considered to be particulate. A few stormwater pollutants are normally found in soluble form, some are in particulate form, and still others are a mixture of both. The form of a pollutant has a strong bearing on how easily it can be controlled by a best management practice (BMP), and also on how it may impact the Chesapeake Bay.

   Generally, particulate forms are easier to remove by conventional BMPs than soluble forms. However, soluble forms typically have a greater and more immediate impact on aquatic life than particulate forms. Therefore, if a particulate pollutant were to be selected as the keystone pollutant, it would be relatively easier to achieve compliance under the 10% Rule, but it would not necessarily result in adequate protection of water quality. Selection of a soluble pollutant as the keystone may result in substantially better water quality, but also would make compliance with the 10% Rule very difficult, since most current BMPs are not capable of achieving highly soluble pollutant removal.

   As a compromise, it is recommended that the keystone pollutant should be present as a roughly equal mix of both particulate and soluble forms.

3) Enough research must be available to provide a reasonable basis for estimating how keystone pollutant loads change in response to development and to current stormwater control measures. Specifically, enough data must exist to confidently predict:

   - Pre-development keystone pollutant loads.
   - Post-development keystone pollutant loads.
   - How much of the keystone pollutant load is removed by urban BMPs.
   - How much of other stormwater pollutants are removed when the keystone pollutant is removed.

The only stormwater pollutants that meet all three criteria for suitability as a keystone pollutant are: total phosphorus, total nitrogen and zinc (see Table B.1). Of these three, total phosphorus is the only one that exists in particulate and soluble forms in roughly equivalent proportions, (40/60, compared to 20/80 and 25/75, for nitrogen and zinc, respectively).

Because of its composite form, total phosphorus is a good surrogate for all stormwater pollutants. Removal of total phosphorus usually produces an equal or greater level of removal for most other pollutants, except total nitrogen. High removal rates of total nitrogen cannot be achieved with current techniques because much of the nitrogen is present in soluble forms. Consequently, the selection of nitrogen as the keystone pollutant would make widespread on-site compliance with the 10% Rule very difficult.

These data, when combined with the excellent database available for estimating the response of phosphorus to changes in development and control practices, make it the best candidate for the keystone pollutant.

**Table B.1 Selection Criteria of the Keystone Pollutant**

| Pollutant | Well-Defined Impact on the Bay | Composite Form | Adequate Data |
|---|---|---|---|
| Sediment | yes | no | no |
| Total Phosphorus | yes | yes | yes |
| Total Nitrogen | yes | yes | yes |
| Coliform Bacteria | yes | no | no |
| BOD/ COD | yes | yes | no |
| Oil/ Grease | yes | no | no |
| Zinc | yes | yes | yes |
| Lead | yes | no | yes |
| Toxins | no | no | no |

# APPENDIX C. COMPUTING POLLUTANT LOAD EXPORT

## SIMPLE METHOD FOR CALCULATING PHOSPHORUS EXPORT

The Simple Method is a technique used for estimating storm pollutant export delivered from urban development sites. The method was developed to provide an easy yet reasonably accurate means of predicting the change in pollutant loadings in response to development. This information is needed by planners and engineers to make rational non-point source pollution decisions at the site level.

The Simple Method Calculation, Table C.1, is intended for use on development sites less than a square mile in area. As with any simple model, the method to some degree sacrifices precision for the sake of simplicity and generality. Even so, the Simple Method is still reliable enough to use as a basis for making non-point pollution management decisions at the site level.

Phosphorus pollutant loading (L, in pounds per year) from a development site can be determined by solving the equation displayed in Table C.1.

**Table C.1 Phosphorus Pollutant Export Calculation**

**Pollutant Loading, $L = [(P)(P_j)(R_v)/12]\ (C)\ (A)\ (2.72)$**

Where:

- $P$ = Rainfall depth over the desired time interval (inches)
- $P_j$ = Fraction of rainfall events that produce runoff
- $R_v$ = Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff. $R_v = 0.05 + 0.009(I)$
- $C$ = Flow-weighted mean concentration of the pollutant in urban runoff (mg/l)
- $A$ = Area of the development site (acres)

12 and 2.72 are unit conversion factors

### P, Depth of Rainfall

The value of P represents the number of inches of precipitation that falls during the course of a normal year of rainfall. Long-term weather records around the state of Maryland suggest that the average annual rainfall depth is about 40 inches. This can be used to estimate P or a user can substitute the average annual rainfall depth from the closest National Weather Service long-term weather station or other suitable locations for which a reliable record can be demonstrated (> 10 years).

### $P_j$, Correction Factor

The $P_j$ factor is used to account for the fraction of the annual rainfall that does not produce any measurable runoff. Many of the storms that occur during the year are so minor that all of the rainfall is stored in surface depressions and eventually evaporates. As a consequence, no runoff is produced. An analysis of regional rainfall/runoff patterns indicates that only 90% of the annual rainfall volume produces any runoff at all. Therefore, $P_j$ should be set at 0.9.

**$R_v$, Runoff coefficient**

The $R_v$ is a measure of the site response to rainfall events, and in theory is calculated as:

> $R_v = r/p$, where r and p are the volume of storm runoff and storm rainfall, respectively, expressed as inches.

The $R_v$ for the site depends on the nature of the soils, topography, and cover. However, the primary influence on the $R_v$ in urban areas is the amount of imperviousness of the site. Impervious area is defined as those surfaces in the landscape that cannot infiltrate rainfall consisting of building rooftops, pavement, sidewalks, driveways, etc. In the equation $R_v = 0.05 + 0.009(I)$, "I" represents the percentage of impervious cover expressed as a whole number. A site that is 75% impervious would use I = 75 for the purposes of calculating $R_v$.

**A, Site Area**

The total area of the site located in the Critical Area IDA (in acres) can be directly obtained from site plans. If the total area of the site is greater than one square mile (640 acres), the Simple Method is may not be appropriate and applicants should consider utilizing other approaches, such as modeling or monitoring.

**C, Pollutant Concentration**

Statistical analysis of several urban runoff monitoring datasets has shown that the average storm concentrations for the keystone pollutant phosphorus do not significantly differ between new and existing development sites (see Appendix D for a summary of current data). Therefore, a pollutant concentration, C, of 0.30 mg/l should be used in this equation.

The Simple Method equation listed in Table C.1 can be simplified to the equation shown in Table C.2. Applicants with verified data indicating alternative values may choose to use the original Simple Method equation as represented in Table C.1; otherwise, Table C.2 represents the revised Simple Method equation and associated values.

| Table C.2 Simplified Pollutant Loading Calculation | | |
|---|---|---|
| **Pollutant Loading, L = ($R_v$) (C) (A) (8.16)** | | |
| Where: | | |
| $R_v$ | = | Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff.<br>$R_v = 0.05 + 0.009(I)$ |
| I | = | Site imperviousness (i.e., I = 75 if site is 75% impervious) |
| C | = | Flow-weighted mean concentration of the pollutant in urban runoff (mg/l).<br>C = 0.30 mg/l |
| A | = | Area of the development site (acres) |
| 8.16 | = | Regional constant and unit conversion factor |

## PROPER USE OF THE SIMPLE METHOD

The Simple Method should provide reasonable estimates of changes in pollutant export resulting from development activity. However, several caveats should be kept in mind when using the method, and these are discussed below.

The Simple Method only estimates pollutant loads generated during storms. It does not consider baseflow runoff and associated pollutant loads. Typically, baseflow is negligible or nonexistent at the scale of a small development site, will not change appreciably before or after development or redevelopment, and can be safely neglected. Pollutant levels in baseflow were generally low and seldom can be distinguished from the natural background as based on a 1978 study that evaluated land-use runoff relationships in the Washington, DC metropolitan area (NVPDC, 1978). Consequently, baseflow pollutant loads normally constitute only a small fraction of the total load delivered from a site.

However, if the level of watershed development is quite low (less than 5 % impervious), the Simple Method may not accurately estimate the total annual load, although it should be reasonably good at estimating annual storm loads for the site (which is the focus of the 10% Rule). For example, in large low-density residential watersheds, as little as 25% of the annual runoff volume may occur as stormflow. In this case, the annual baseflow nutrient load may be equivalent to the annual stormflow nutrient load.

The Simple Method provides a general planning estimate of likely storm pollutant export from development sites less than one square mile (640 acres) in size. More sophisticated methods, such as simulation modeling may be needed to analyze large and complex watersheds.

Finally, the Simple Method does not accurately estimate pollutant loadings under certain special conditions. These include site disturbances during actual construction and prior to land stabilization, heavily industrialized areas, heavily traveled highways, and undeveloped areas, such as croplands.

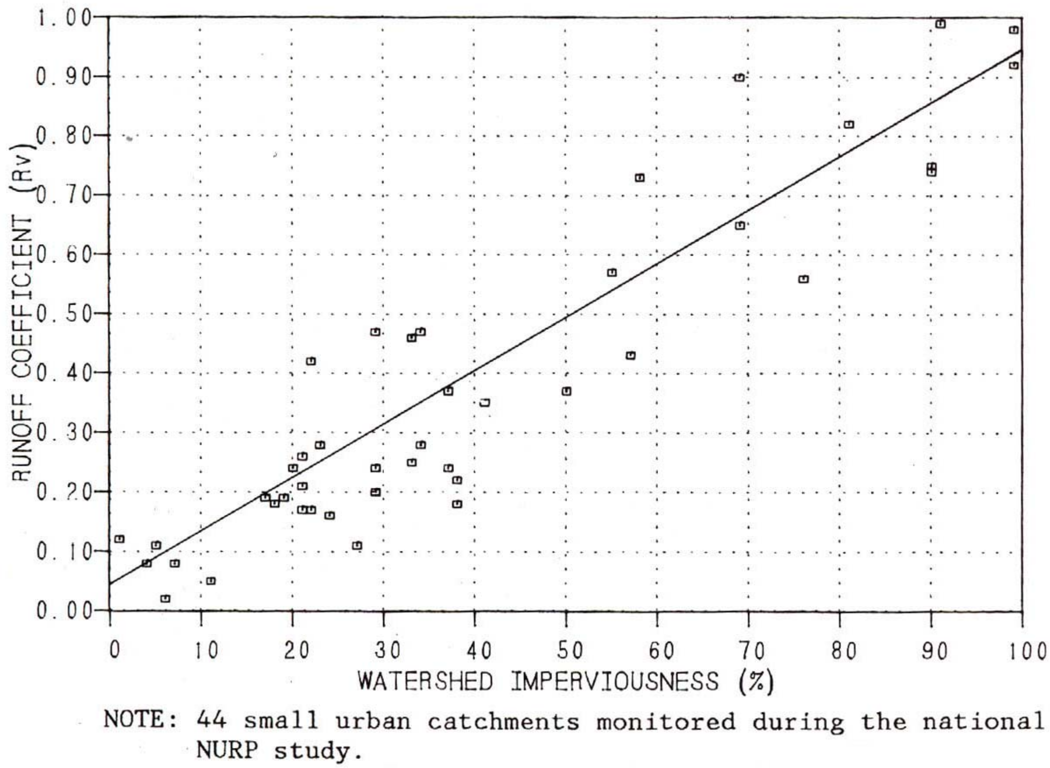


**Figure C.1 Relationship Between Watershed Imperviousness and Runoff Coefficient**

**PHOSPHORUS LOADS FROM UNDEVELOPED SITES**

Numerous difficulties arise when computing phosphorus loads from undeveloped areas. First, the variability in phosphorus export from undeveloped areas is enormous even for the same kind of land use. Some undeveloped land uses (e.g., cropland) export more phosphorus than even the most intensive new development while others (e.g., forests) generate much less phosphorus than the least intensive new development.

Second, the Simple Method is not a reliable tool for predicting pollutant export from undeveloped land uses. The method was developed for use on urban areas where annual stormwater runoff can be predicted by a runoff coefficient ($R_v$) that is a simple function of watershed imperviousness. No such relationships exist for undeveloped areas. Factors such as soils, slope, and vegetative cover exert a much stronger and more variable influence on annual storm runoff in these areas. As an example, the agricultural areas can produce 60% more runoff annually than forested areas in the coastal plain (Lomax *et al.*, 1982), despite the fact that both land uses have essentially no impervious cover. The Simple Method is not sensitive enough to account for these important differences between undeveloped land uses.

## BENCHMARK LOADS FROM UNDEVELOPED LAND

To avoid unnecessary confusion and to promote a consistent and reliable approach for computing loads from undeveloped land uses, it is recommended that local jurisdictions adopt a single, fixed benchmark load for all undeveloped areas. The benchmark should represent an average load measured for a typical mix of undeveloped land uses (i.e., forests, fields, crops, pastures, meadow, etc.), and is exclusively used as the basis for estimating pollutant removal requirements for new development sites only.

A number of monitoring studies have been conducted on experimental watersheds in the Maryland coastal plain that can be used to derive a representative benchmark phosphorus load. For example, seven small, mixed-use catchments were monitored over a three year interval in the Rhode River watershed on slightly rolling topography of the Western Shore of the Chesapeake Bay in Maryland (Correll *et al.*, 1977a and Correll *et al.*, 1977b ). The seven Rhode River watersheds contained a wide diversity of land use, all of which had at least six of the following seven land use types: row crops, hay, upland wetlands, forest, old fields, pasture and rural residential. Moreover, the distribution of land use types within individual watersheds was quite heterogeneous.

Annual storm phosphorus export (lbs/acre) was derived for each of the Rhode River watersheds by subtracting the baseflow component from the total annual load reported by Correll *et al.* (1977b). When computed in this manner, annual storm phosphorus export averaged 0.65 lbs/acre/year over 12 watershed years, and ranged from 0.2 to 1.5 lbs/acre/year.

In addition, two test watersheds were monitored over two years on the flatter terrain of Horn Point on the Eastern Shore of the Chesapeake Bay in Maryland (Lomax *et al.*, 1982). One 212 acre watershed was devoted to agriculture, and was cropped in the common two year corn/soybean/small grain rotation. A smaller 75 acre forested watershed was also monitored. Although accurate estimates of storm export could not be derived from the reported data, it was evident that the storm phosphorus concentrations on both of the Eastern Shore watersheds were considerably lower than those reported for Rhode River. In addition, the authors noted that storm runoff in the two watersheds was also very low, presumably due to the sandy soils and flat topography. Based on the reported data, it is likely that phosphorus export on the flatter Eastern Shore is lower than that of the more rolling Western Shore. Future monitoring data derived from the Wye River experimental watersheds should help to clarify this matter.

Until better data become available, it is recommended that local jurisdictions adopt a fixed benchmark load of 0.5 lbs/acre/year from undeveloped areas. It is felt that this interim value best represents an average phosphorus load that might be expected for undeveloped lands throughout the Critical Area. However, local jurisdictions may wish to adjust the value if better, more localized monitoring data are available.

Some of the consequences of the benchmark load on the pollutant removal requirement computed for new development sites are shown in Figures C.2 and C3. As can be seen, new development sites that are less than 17% impervious will not be subject to the keystone pollutant removal requirement under the 10% Rule. However, these sites will still be subject to local stormwater management regulations and the State best management practice (BMP) preference list.

It can also be noted that as new development on a previously undeveloped site becomes very intense (60% or more impervious), on-site BMP options are not likely to achieve full compliance with the 10% Rule (unless additional off-site areas drain to and are served by the BMP at the site). Therefore, it is likely that intensive new developments may require the implementation of offsets or the collection of offset fees.

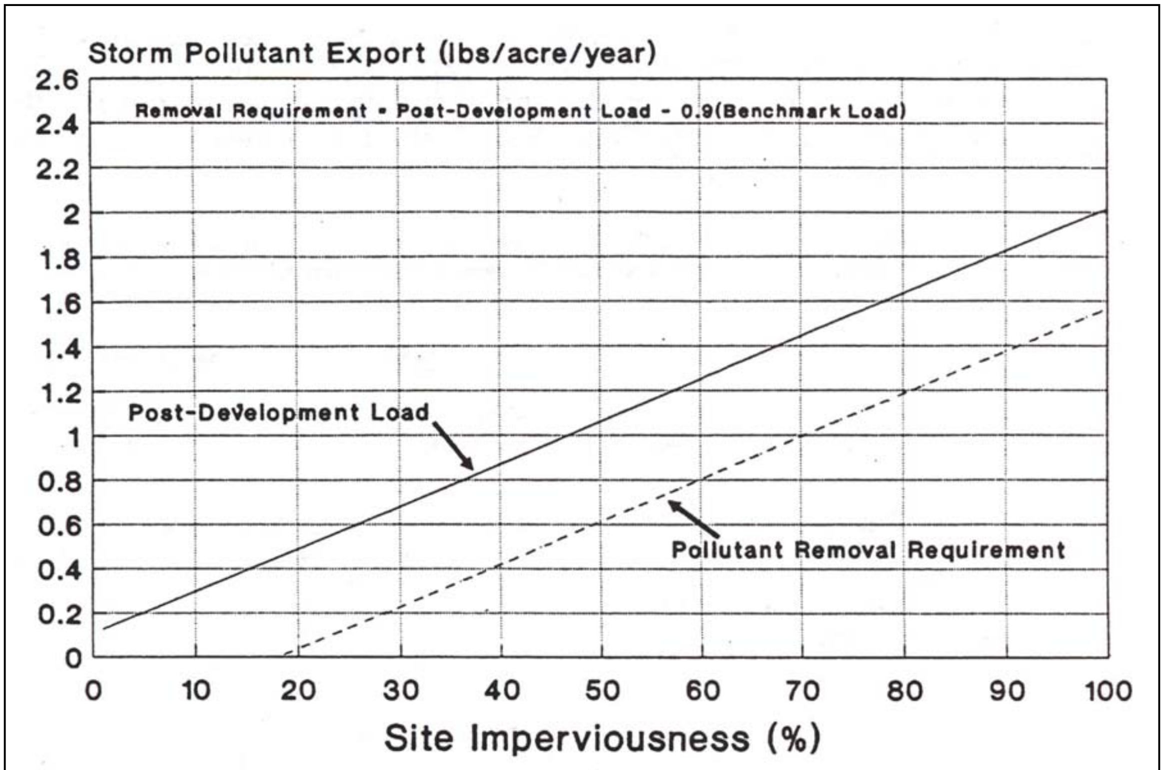


**Figure C.2 Pollutant Removal Necessary at New Development Sites as a Function of Imperviousness**

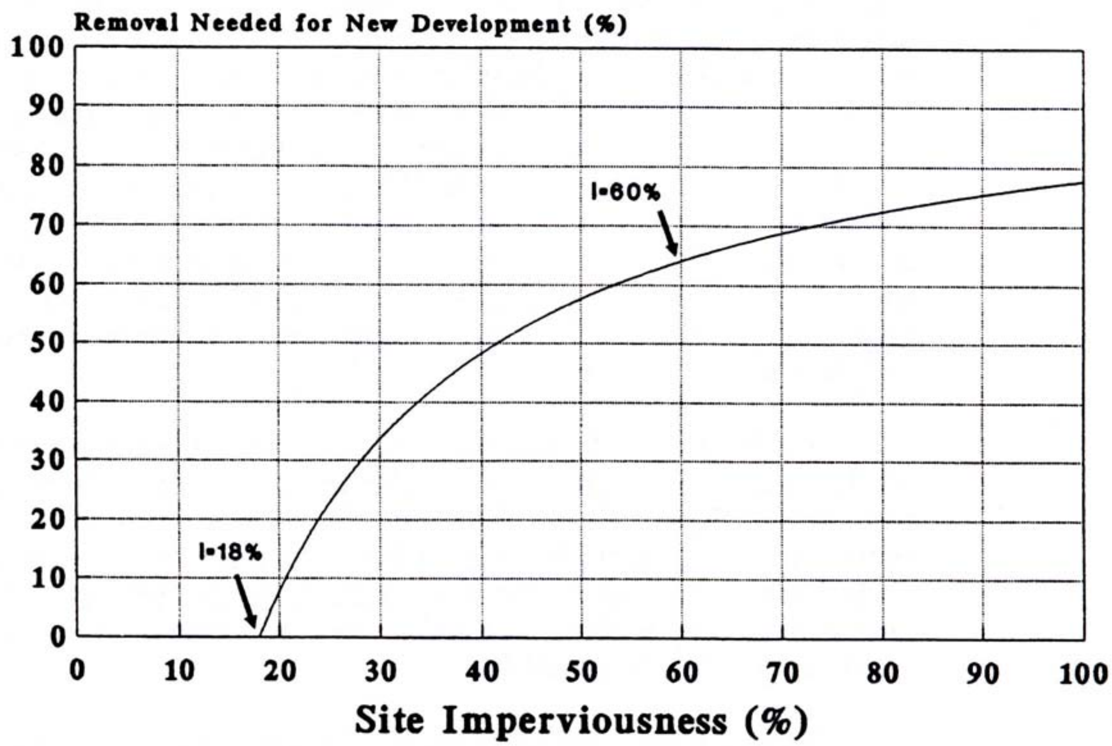


**Figure C.3 The Effect of Benchmark Loads on Pollutant Removal Requirements**

# APPENDIX D. REVISION OF PHOSPHORUS CONCENTRATIONS IN STORMWATER RUNOFF

## TECHNICAL MEMO

To: Critical Area Commission
From: Center for Watershed Protection

Re: Proposed Simplification of the 10% Method

**Recommendation**: Apply a Single "C" value of 0.3 mg/l for both new development and redevelopment to characterize total phosphorus (TP) concentrations in stormwater runoff from the Maryland Critical Area.

**Background**
When the first 10% rule guidance was published in 1987, we had limited monitoring data to define phosphorus (P) concentrations. The major source was the Washington, D.C. area NURP study, which involved about 300 stormwater samples at about 12 suburban single land use catchments. The group mean concentration was 0.26 mg/l of total P, and no statistically significant difference was found among the catchments. This concentration value was then used to characterize TP levels from new development.

Baltimore also conducted a NURP study in the early 1980s that sampled stormwater quality from much more urban catchments. The study reported much higher TP concentrations than in the Washington area, but these were found to be elevated by the almost chronic sewage overflows in the small watersheds they sampled (and which are still experienced today). The tricky part is that the authors could not tell how much of the elevated TP concentration was due to stormwater and how much to overflows. The prevailing view at the time was that highly urban catchments probably did have higher TP concentrations, but the Baltimore data could not be used to define the redevelopment TP concentration.

To fill the gap, we used a study conducted in DC from a catchment in its downtown business district that had a 1.08 TP concentration, which was intermediate between the Baltimore and Washington data. The unpublished study has apparently disappeared; I could not find it when we were doing the revision in 1992. As I recall it was done for DC government, used older time-compositing sampling techniques that have since been found to elevate TP concentrations, and had less than ten storm events sampled. It was the best we had at the time, so we went with it.

The use of the 1.08 mg/l value for redevelopment has had unintended consequences over the last 15 years. First, it made compliance with the 10% rule harder at redevelopment sites than new development sites, which is contrary to Maryland's smart growth policies developed in the late 1990s. On the operational side, it has frustrated plan reviewers and consultants alike, since they had to classify the site as to whether it was new or redevelopment, based on impervious cover thresholds of 15 and 20%, respectively. It also added additional worksheets and steps to the process. But like a lot of things, the higher redevelopment TP concentration was used because of the prevailing but untested assumption that highly urban sites probably did produce more TP than suburban ones.

**Current TP Monitoring Data**

Quite a bit of stormwater monitoring has taken place both in Maryland and across the nation in the last decade since the 10% revision was completed in 1992. The data clearly do not support the continued use of 1.08 ppm to define redevelopment TP concentrations, and suggest that the 0.26 mg/l to define new development may be a shade low. Let me quickly review the findings from the three most intensive data reviews available on phosphorus levels in urban stormwater runoff.

The first is Schueler (1999) which reviewed TP concentrations from 37 residential catchments that collectively represented about 500 individual storm event samples. The group mean for TP was 0.3 mg/l with a range from 0.1 to 0.66 mg/L. This suggests that a higher TP might be used for new development, and also suggests that an average concentration of 1.08 mg/l did not occur anywhere else in the country.

The next evidence is from MDE Water Management Administration which did a statistical review in 1997 of all the municipal monitoring data generated by the Phase I stormwater communities in the State. The review at the time included 107 storm events collected from Anne Arundel, Baltimore, Howard, Montgomery, and Prince Georges County, as well as the City of Baltimore. The overall results for TP concentrations are shown below:

| | |
|---|---|
| Residential Sites | 0.37 mg/l of TP |
| Commercial Sites | 0.22 |
| Industrial | 0.33 |
| All Sites | 0.31 |

Note: sample n is not 107 for each land use

Again evidence for a higher TP for new development, and no evidence to support the 1.08 ppm. Also, evidence of some land use differences, although not dramatic ones.

The final nail in the coffin is a national database that we have produced in association with Dr. Robert Pitt of the University of Alabama. Preliminary findings from this database, which contains more than 3,783 storm event samples for TP, are shown below:

| | |
|---|---|
| Residential | 0.31 mg/l of TP |
| Commercial | 0.23 |
| Industrial | 0.27 |
| Freeway | 0.25 |
| All Sites | 0.27 |

Once again the pattern is confirmed: TP of 0.3 mg/l or so characterizes much of new and existing development. Some of the land use differences were found to be statistically significant, but they are pretty minor. Most of all, the new database gives us an opportunity to analyze how often a 1.08 mg/l concentration is found in urban stormwater runoff nationally. My quick look indicated less than 1% of all samples. I think it is a good thing the unpublished DC study is lost to history, because it was such an outlier.

**Suggested Revision**

We believe that a single TP concentration value of 0.3 mg/l should be used for the 10% rule. This would greatly simplify the calculations and is based on the best science available.

# APPENDIX E. STANDARD PLAN: ALLOWABLE BMP OPTIONS

The following section provides descriptions, advantages, limitations, and schematics of allowable best management practices (BMPs) for use under the Critical Area Standard Plan. This section is divided into two main parts:

- Non-Structural BMPs
- Structural BMPs

For the purposes of this Manual, non-structural BMPs are not given a phosphorus removal rate but are used to reduce or erase proposed impervious cover at the site. Use of non-structural BMPs can reduce or eliminate the need for costly structural BMPs.

The second part of this section describes structural BMPs that are outlined within the Maryland Stormwater Design Manual. These BMPs are subject to the performance and design criteria set forth by the 2000 Maryland Stormwater Design Manual, which is available online:
http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp.

## NON-STRUCTURAL BMPS

Non-structural BMPs are mainly used within the Critical Area to disconnect impervious cover. These BMPs are organized by several non-structural strategies to reduce the amount of stormwater runoff:

- Strategies to Disconnect Rooftop Runoff
- Strategies to Store Rooftop Runoff
- Strategies to Disconnect Non-Rooftop Runoff
- Approved on a Case-by-Case Basis

The majority of non-structural BMPs do not require numerical sizing to meet drainage needs. However, limited sizing criteria are available for grass channel and filter strip sizing in the Maryland Stormwater Design Manual:
http://www.mde.state.md.us/assets/document/chapter5.pdf

## Strategies to Disconnect Rooftop Runoff

Filter Strips

A filter strip is a vegetated area that is intended to treat sheet flow from adjacent impervious areas (Figure E.1). Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants and providing some infiltration to underlying soils. Filter strips are best suited to treat runoff from roads and highways, roof downspouts, very small parking lots, and pervious surfaces.

*Advantages*

- Ideal as pretreatment to another stormwater treatment practice
- Can be applied in most regions of the state

*Limitations*

- There is not much monitoring data to suggest that the practice can achieve high pollutant removal
- Require a large amount of space in relation to the impervious area they treat
- If poorly designed, filter strips can cause soil erosion and become a mosquito breeding ground
- Require regular mowing

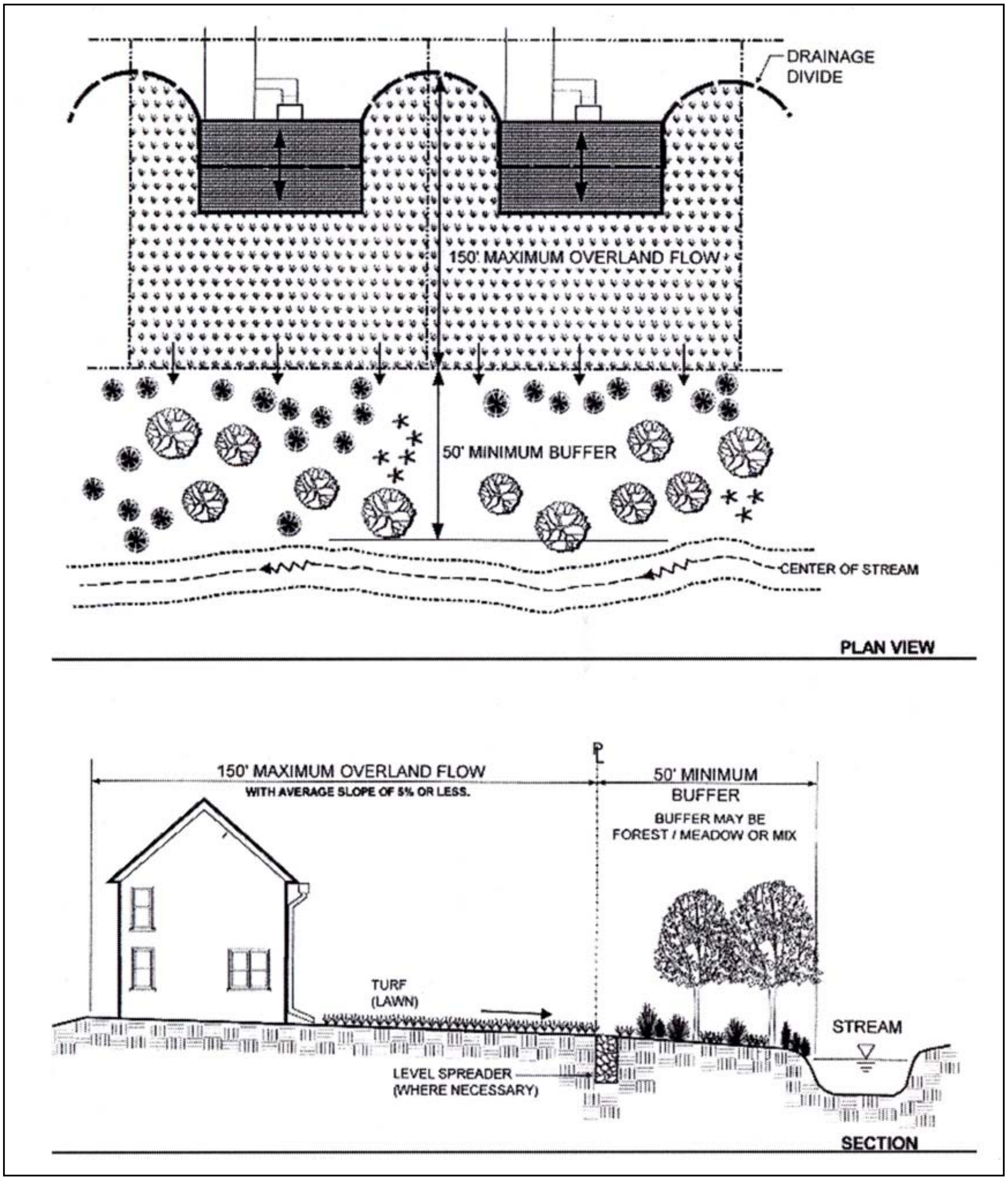


**Figure E.1 Schematic of a Filter Strip**
(Source: Maryland Stormwater Design Manual, 2000)

## Strategies to Store Rooftop Runoff

Vegetated Rooftops
A vegetated rooftop, also called a green rooftop, is a thin layer of soil and vegetation installed on top of a conventional flat or sloped roof (Figure E.2). In the summer, vegetated rooftops retain 70 to 100% of the precipitation that falls on them; in the winter they retain 40 to 50% (Green Roofs for Healthy Cities). Vegetated rooftops can reduce the total annual runoff volume by 50 to 60% (Roofscapes, Inc.). Rooftop vegetation can range from turf and grass to shrubs or even trees, depending on the climate and the load-bearing capacity of the roof. The turf-dominated, or "extensive green roof" is lighter, less expensive, and has limited space for people, while the rooftop garden, or "intensive green roof" is heavier, requires more management/maintenance, and can accommodate people.

*Advantages*
- Reduce runoff volume and peak flow rate
- Increase property values
- Provide green open space
- Provide habitat
- Conserve space that would otherwise be used for stormwater treatment
- May be best choice for stormwater management in redevelopment projects due to lack of space and pervious cover

*Limitations*
- May need maintenance in first few years of growing
- May require watering depending on type of vegetation, climate, and season.
- May be difficult to implement on existing structures without providing structural reinforcement
- Professional/contractor installation fees can be expensive
- Local building codes may require mechanical fastening of the drainage and insulation layers
- More difficult to use on pitched roofs

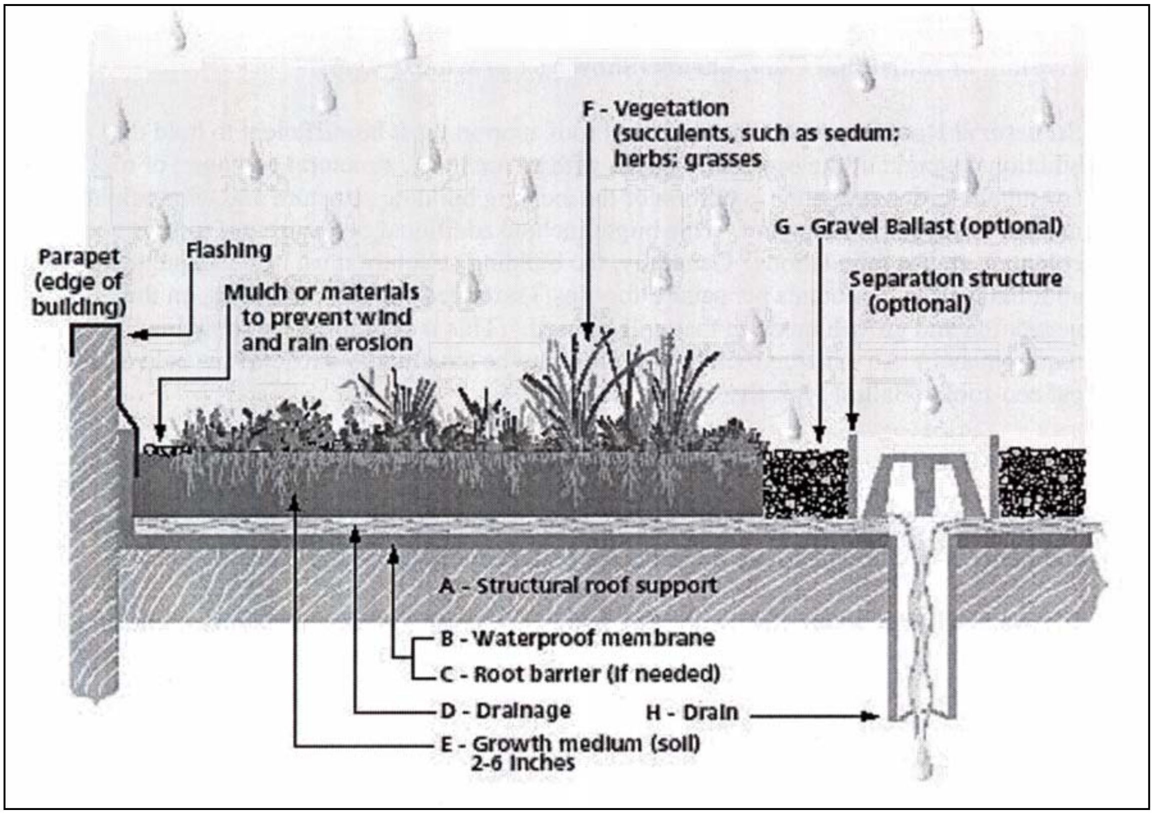


**Figure E.2 Schematic of Vegetated Rooftop**
(Source: Portland, OR Stormwater Management Manual, 2002)

## Strategies to Disconnect Non-Rooftop Runoff

Permeable Pavers

Permeable pavers are permeable surfaces that can replace asphalt and concrete and can be used for driveways (Figure E.3), parking lots and walkways. From a stormwater perspective, this is important because permeable pavers can replace impervious surfaces, creating less stormwater runoff. For the purposes of the 10% Rule, the perviousness of permeable pavers ranges from 10 to 50%, depending on the product. Permeable pavers must be installed to the manufactures specifications. Utilizing the manufacturer's specifications, the applicant should collaborate with the local government to determine exact imperviousness.

*Advantages*

- Can replace conventional asphalt or concrete in parking lots, driveways, and walkways
- Can abate overall stormwater management costs by reducing or eliminating the need of other stormwater management techniques
- Reduces pavement ponding

*Limitations*

- Slight to moderate risk of groundwater contamination depending on soil conditions and aquifer susceptibility
- High failure rate potential
- Requires regular maintenance
- No sanding for de-icing permitted
- Only feasible where soil is permeable, there is sufficient depth to bedrock and water table, and there are gentle slopes
- Not suitable for areas with high traffic volume
- More expensive than traditional paving surfaces

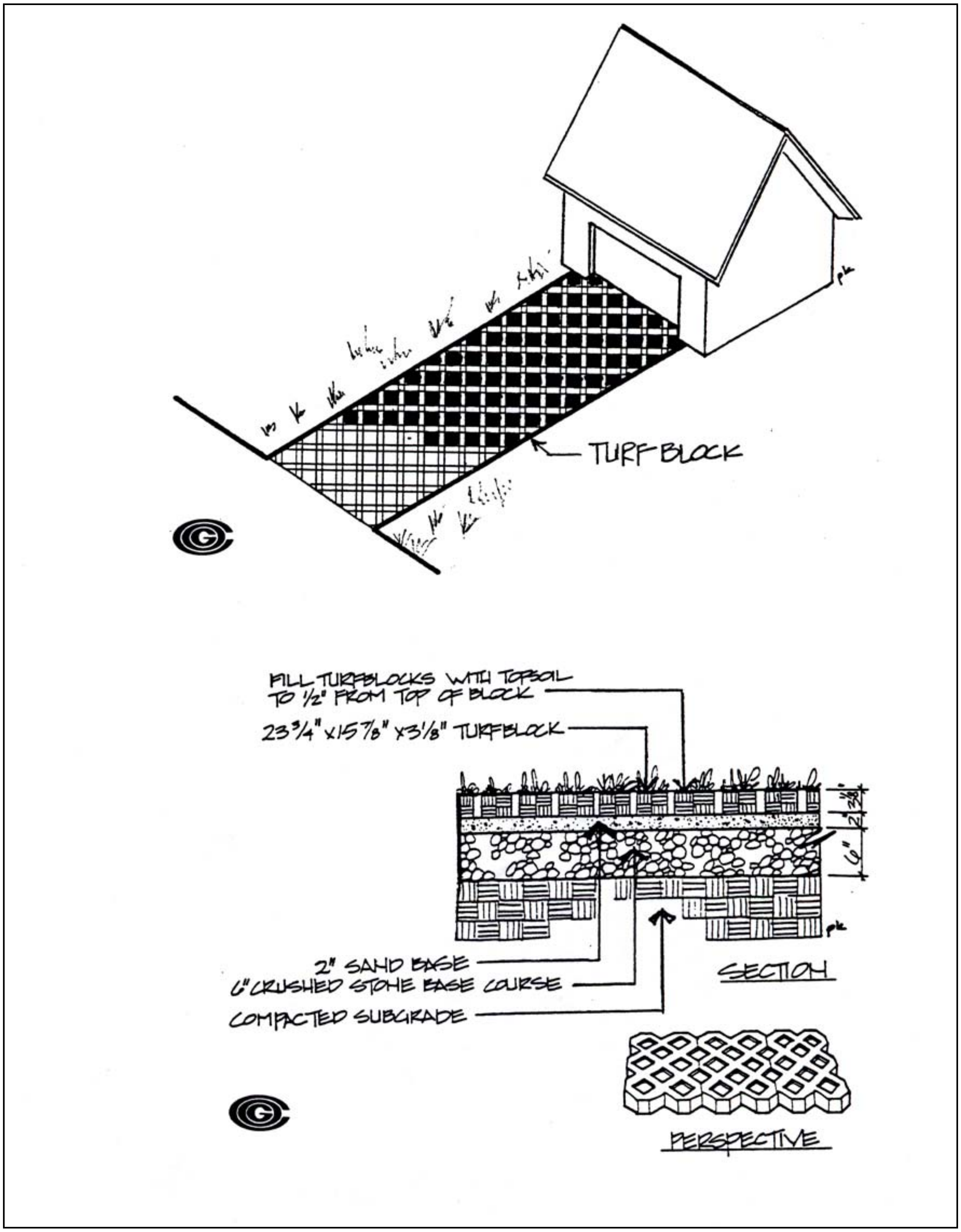


**Figure E.3 Schematic of Permeable Pavers**
(Source: Metropolitan Washington Council of Governments, 1993)

Grass Channels

Grass channels are typically designed to meet runoff velocity targets for the water quality design storm (Figure E.4). Runoff velocity should not exceed 1.0 foot per second during the peak discharge associated with the water quality design rainfall event, and the total length of the channel should provide at least five minutes of residence time. In some regions of the country, grass channels are termed “biofilters.” To meet the water quality criteria, grass channels must have broader bottoms, lower slopes and denser vegetation than most drainage channels. Nominal pretreatment is created by placing checkdams across the channel below pipe inflows, and at various other points along the channel. The filter bed area in a grass channel is usually confined to the top inch of soil and thatch, since most runoff events will traverse the length of channel in ten minutes or less. Grass channels must be designed per the Stormwater Design Manual’s Grass Channel Credit specifications (http://www.mde.state.md.us/assets/document/chapter5.pdf).

*Advantages*

- Generally result in reduced impervious cover compared with curb and gutter designs
- Can act to partially infiltrate runoff from small storm events if underlying soils are adequate
- Can be used as part of the runoff conveyance system to provide pretreatment
- If designed well, can provide moderate pollutant removal of particulate pollutants
- Can be an easy retrofit on traditional drainage channels

*Limitations*

- Possible impact on local groundwater quality
- Standing water in residential channels will not be popular with adjacent residents for aesthetic reasons and because of potential safety, odor, and mosquito problems
- Potential for bottom erosion and resuspension
- Lower pollutant removal rates (may actually be a source for some pollutants like bacteria associated with pet wastes)
- Ineffective unless carefully designed to achieve slow flow rates in the channel
- Ineffective if a dense vegetative cover cannot be established

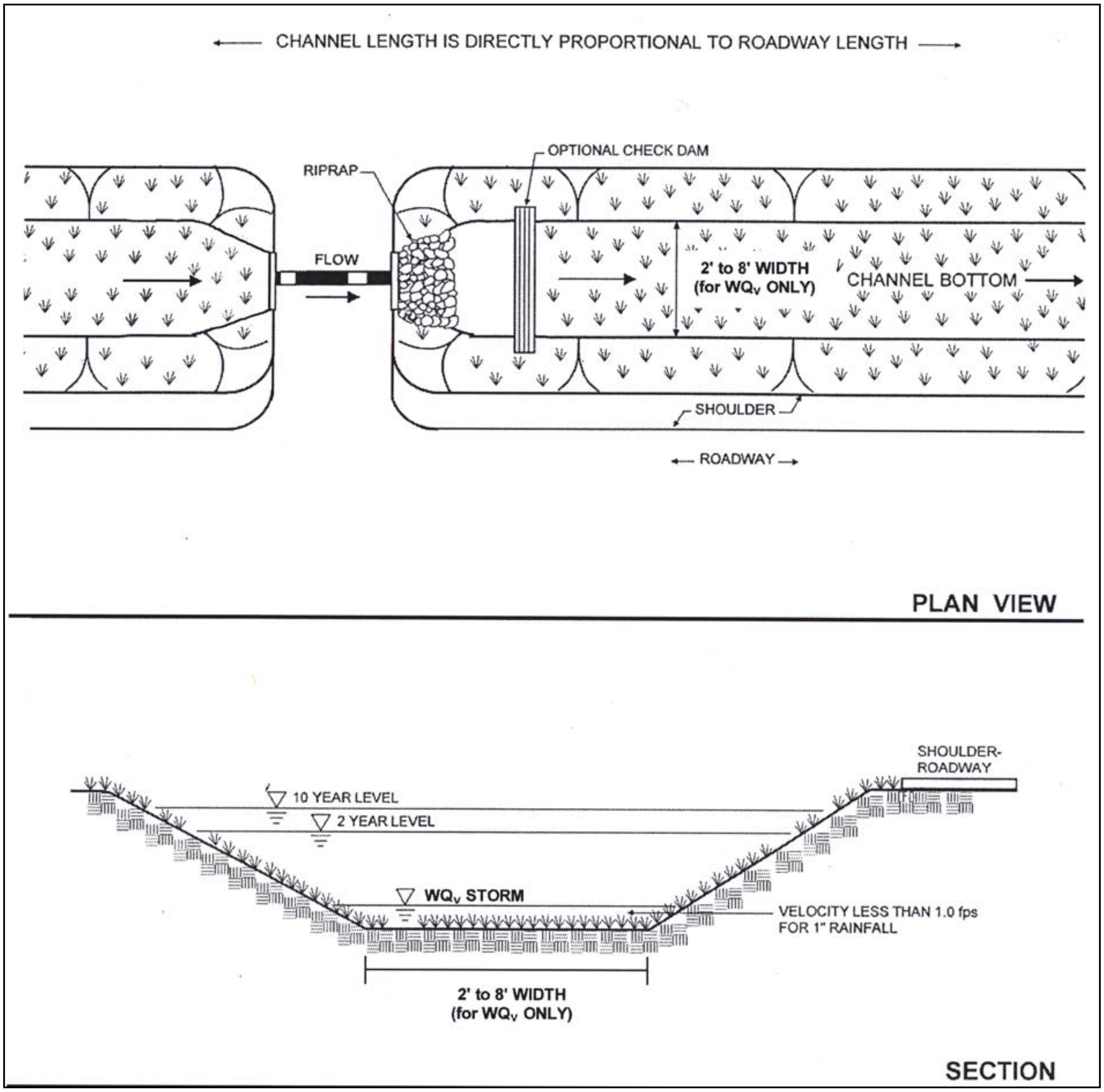


**Figure E.4 Schematic of Grass Channels**
(Source: Maryland Stormwater Design Manual, 2000)

## Approved on a Case-by-Case Basis

Porous Pavement

These systems are designed to infiltrate water through the porous upper layer into a storage reservoir of stone aggregate below (Figure E.5). The runoff eventually either percolates into the ground or runs out of the stone reservoir through an underdrain collection system. Use of porous pavement is typically limited to light traffic roads, parking lot overflow areas, and driveways.

*Advantages*

- Diverts surface runoff to groundwater recharge and, in some cases, provides even greater recharge than pre-development conditions
- Can provide stormwater quantity and quality treatment on-site
- Reduces pavement ponding
- Fair to good removal rates for sediment nutrients, organic matter, and trace metals

*Limitations*

- Slight to moderate risk of groundwater contamination depending on soil conditions and aquifer susceptibility
- Possible transport of hydrocarbons from vehicles and leaching of toxic chemicals from asphalt surface
- High failure rate potential
- Extended rain can reduce the pavement's load bearing capacity
- Requires sophisticated level of construction and regular maintenance
- No sanding for de-icing permitted
- Possible cracking in freezing weather conditions
- Only feasible where soil is permeable, there is sufficient depth to bedrock and water table, and there are gentle slopes
- Not suitable for areas with high traffic volume
- More expensive than traditional paving surfaces

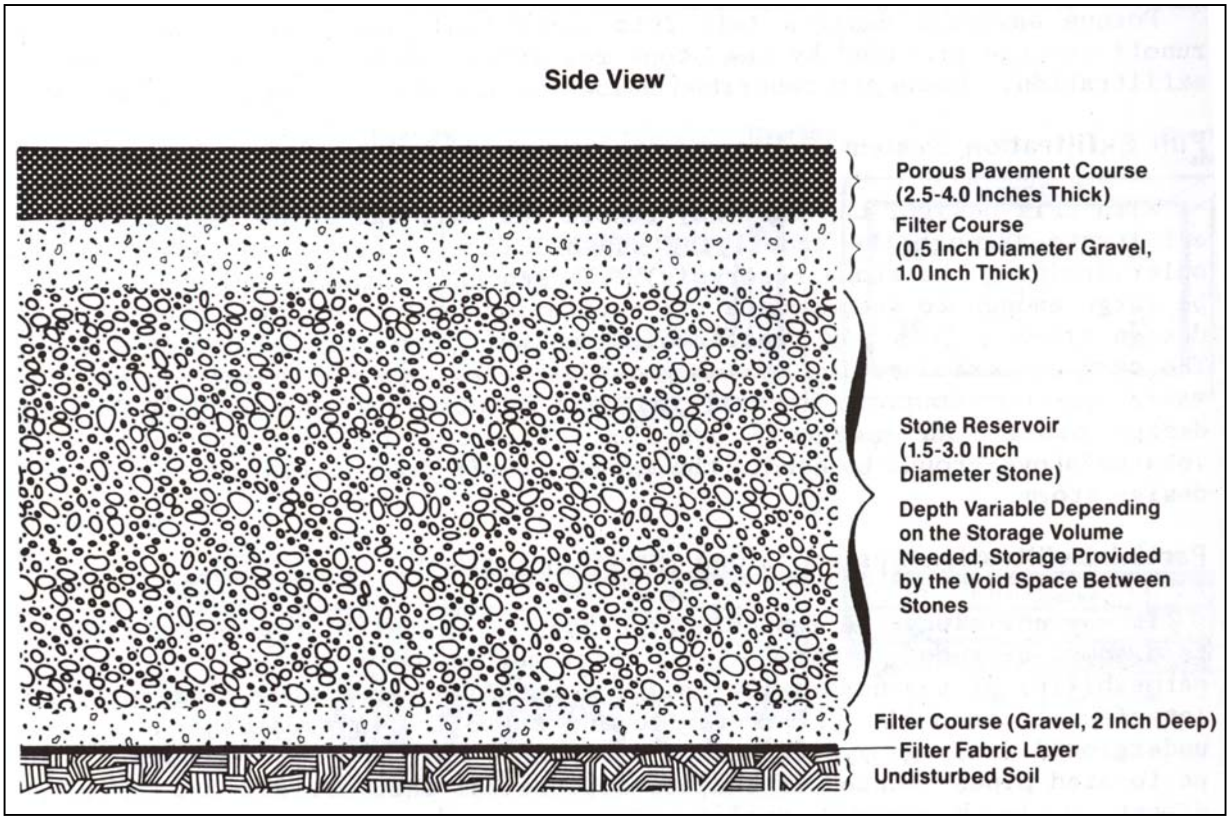


**Figure E.5 Schematic of Porous Pavement**
(Source: City of Rockville, MD, 1984)

<u>Cisterns</u>
Cisterns are roof water collection devices that provide retention storage volume in above-ground or underground storage tanks (Figure E.6). The water collected can be used for lawn and garden watering, household graywater needs or drinking water supply. Cisterns are generally larger than rain barrels, with some underground cisterns having capacities of 10,000 gallons. Storing rainwater on-site for later re-use also provides an opportunity for water conservation and the possibility of reducing water utility costs (LID Center, 2003).

*Advantages*
- Cisterns can reduce the volume of water entering public systems through rooftop storage of large amounts of rainfall
- Promotes water conservation and increased public awareness and
- Reduces water utility bills
- Can be retrofit into existing communities
- Requires little space

*Disadvantages*
- Requires strong landowner buy-in
- Can be relatively expensive compared to rain barrels
- If collected water is used for drinking, expensive filtration and treatment systems may be required

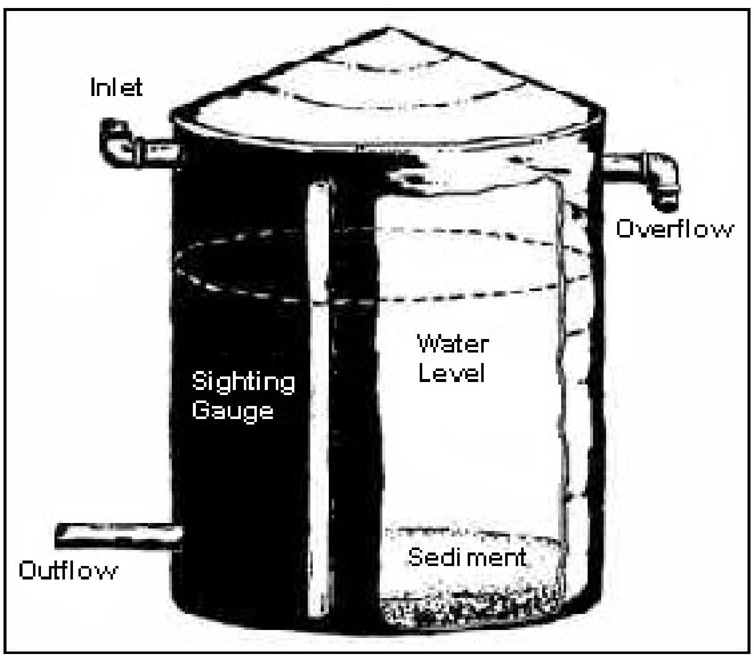


**Figure E.6 Cistern**
(Source: Texas Guide to Rainwater Harvesting, 2003)

## STRUCTURAL BMPS

Structural BMPs are grouped into six general categories:

- Stormwater Ponds
- Stormwater Wetlands
- Infiltration Practices
- Filtering Practices
- Grass Channel Practices

Much of the information and schematics presented in this section were directly taken from the Maryland Stormwater Design Manual. Additional information regarding the design and sizing of structural BMPs can be found in the Maryland Stormwater Design Manual at: http://www.mde.state.md.us/assets/document/chapter3.pdf

## Stormwater Ponds

Micropool Extended Detention (ED) Pond
Micropool extended detention ponds are variations of wet ED ponds where a small "micropool" is maintained at the outlet to the pond that prevents resuspension of previously settled sediments and also prevents clogging of the low flow orifice (Figure E.7). The rest of the facility's remaining storage above the permanent pool drains down.

*Advantages*
- Less expensive pond option
- High pollutant removal efficiency and downstream channel protection when properly designed and maintained
- Can be designed for combined flood control and stormwater quality control

*Limitations*
- Inability to vegetate banks and bottom above permanent pool may result in erosion and resuspension of sediments
- Limitation of the water quality orifice diameter may preclude use in small watersheds
- May create mosquito breeding conditions and other nuisances

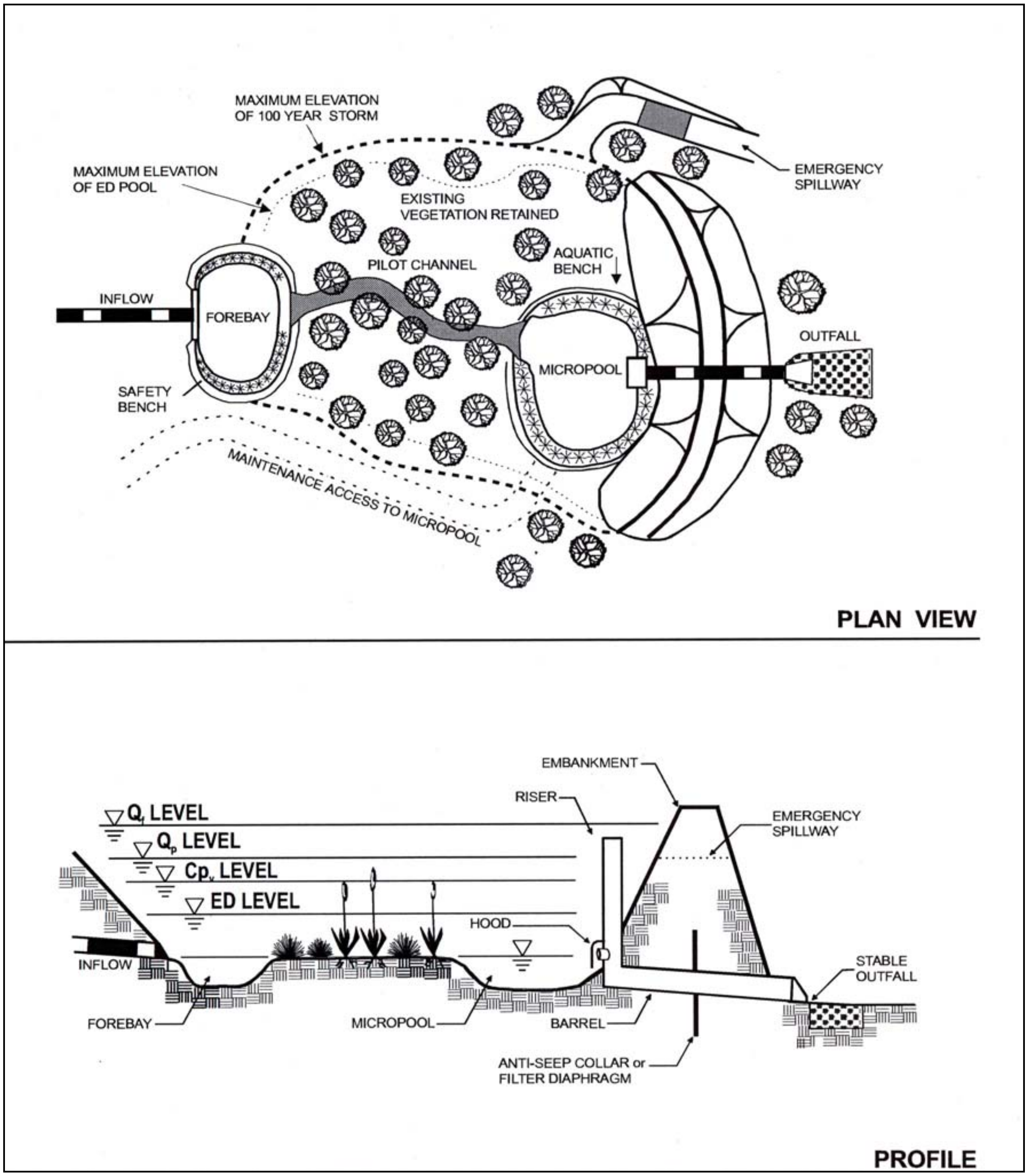


**Figure E.7 Schematic of Micropool Extended Detention Pond**
(Source: Maryland Stormwater Design Manual, 2000)

Wet Pond

Wet ponds are constructed facilities with a permanent pool of water (dead storage) throughout most of the year that treats incoming stormwater runoff through gravitational settling and other means. Wet ponds typically provide additional temporary storage (live storage) for runoff control of the water quantity design storms. Water levels and stormwater controls are managed by the use of risers, orifices, and/or other outlet control structures (Figure E.8).

*Advantages*

- Creation of aquatic and terrestrial habitat (particularly for waterfowl)
- High community acceptance, landscaping, and amenity potential
- High pollutant removal efficiency and downstream channel protection when properly designed and maintained
- Permanent pool helps to prevent scour and resuspension of sediments
- Can be designed for combined flood control and stormwater quality control
- Limited risk of groundwater quality impacts over the long term
- Can provide uptake of soluble pollutants such as phosphorus, through biological activity
- Can be used as a regional facility

*Limitations*

- Cannot be placed on steep unstable slopes
- Need base flow or supplemental water if water level is to be maintained
- Often infeasible in very dense urban areas due to space requirements
- Downstream warming can shift trophic status
- Upstream channels can be heavily impacted when wet ponds are "on line" and serve large drainage areas (> 250 acres)
- Potential loss of wetlands, forest and floodplain habitat associated with poor site selection for the pool
- Potential safety hazard for public
- May need liner in highly permeable soils
- Require a large drainage area (> 10 acres) to retain the permanent pool
- Depth limitations will apply in coastal areas (low relief usually requires facilities to be fully excavated) and karst regions (head build-up can cause piping)

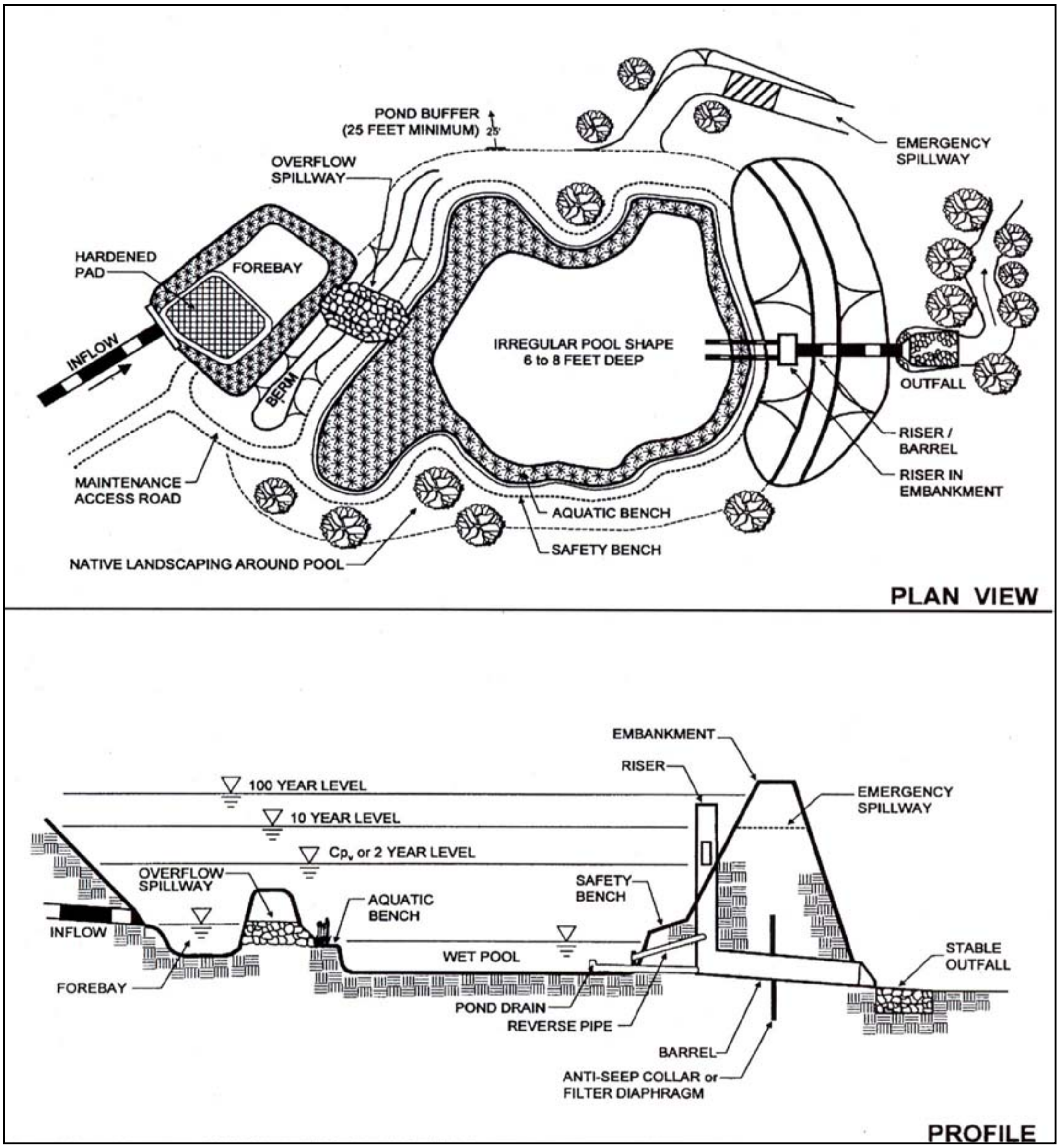


**Figure E.8 Schematic of Wet Pond**
(Source: Maryland Stormwater Design Manual, 2000)

Wet Extended Detention (ED) Pond

Wet ED ponds are constructed facilities that incorporate both a permanent pool and extended detention storage above the permanent pool of a water quality design storm for some minimum time (e.g., 24 hours) to allow for settling of particles and associated pollutants (Figure E.9). These ponds can also be utilized for flood control by including additional temporary storage for larger storm peak flows (e.g., 10-year return frequency).

*Advantages*

- Can create both terrestrial and aquatic wildlife habitat with appropriate pondscaping and vegetation management
- Small permanent pool allows sedimentation to occur in confined location; maintenance is relatively easier
- Can be designed for combined flood control and stormwater quality control
- High pollutant removal efficiency and downstream channel protection when properly designed and maintained
- Can provide uptake of soluble pollutants such as phosphorus, through plant uptake and other biological processes
- Less hazardous than other stormwater ponds with deeper permanent pools

*Limitations*

- Improper site selection can create wetland, forest and habitat conflicts
- May need liner in highly permeable soils
- Possible thermal and oxygen depleted discharge can impact downstream aquatic life
- Need base flow or supplemental water if water level is to be maintained
- May be inappropriate in dense urban areas due to space concerns
- Requires a large drainage area (> 25 acres) to retain the permanent pool

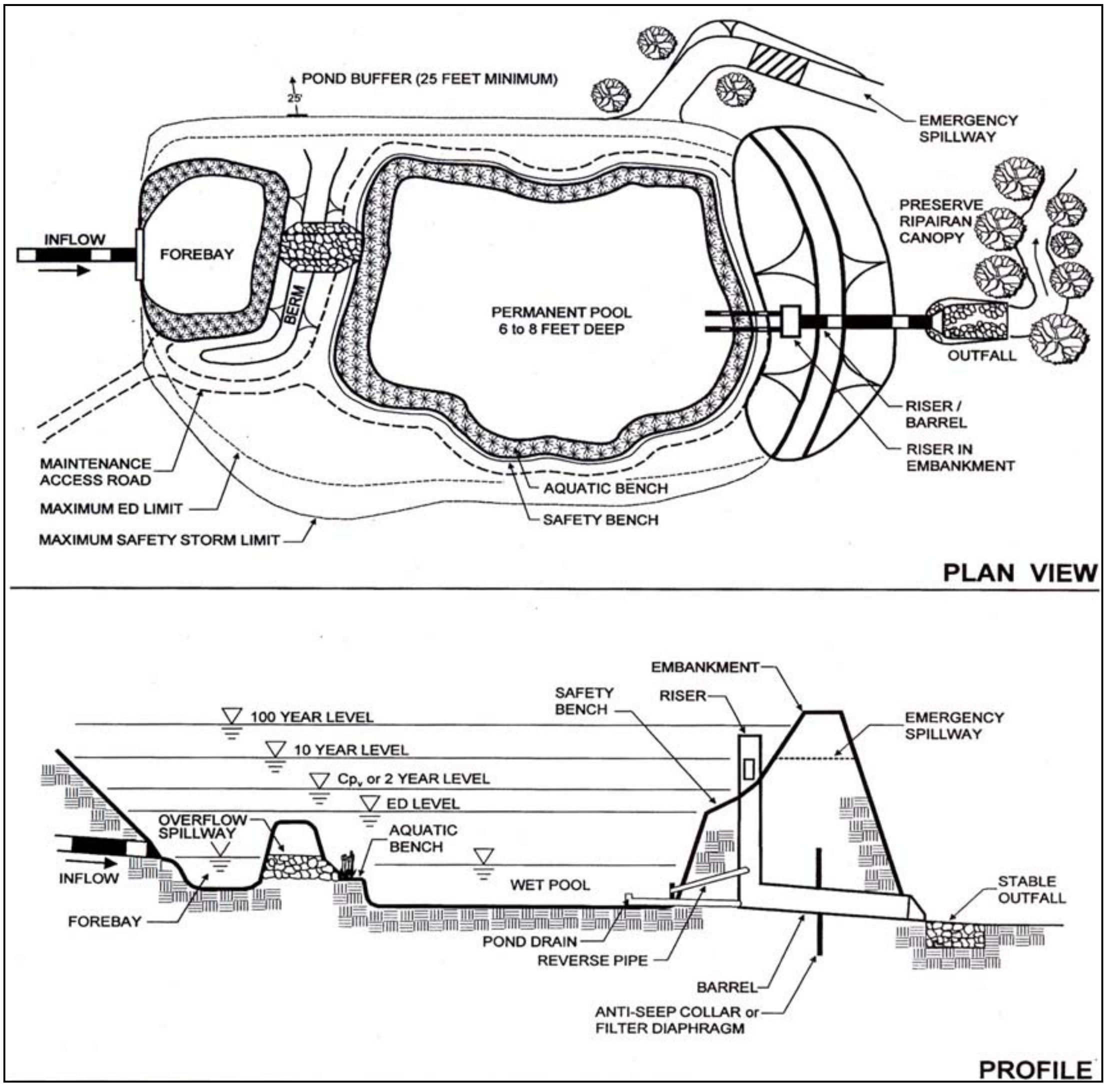


**Figure E.9 Schematic of Wet Extended Detention Pond**
(Source: Maryland Stormwater Design Manual, 2000)

Multiple Pond Systems

Multiple pond systems consist of constructed facilities that provide water quality and quantity volume storage in two or more cells. The additional cells create longer pollutant removal pathways in stormwater discharge (Figure E.10).

*Advantages*

- Provide higher and more consistent levels of urban pollutant removal than a single treatment system due to longer flow paths and increased retention time
- Enhance habitat value
- High pollutant removal efficiency and downstream channel protection when properly designed and maintained
- Can be designed for combined flood control and stormwater quality control

*Limitations*

- Most expensive pond option due to complex design
- Large land requirement
- May need liner in highly permeable soils

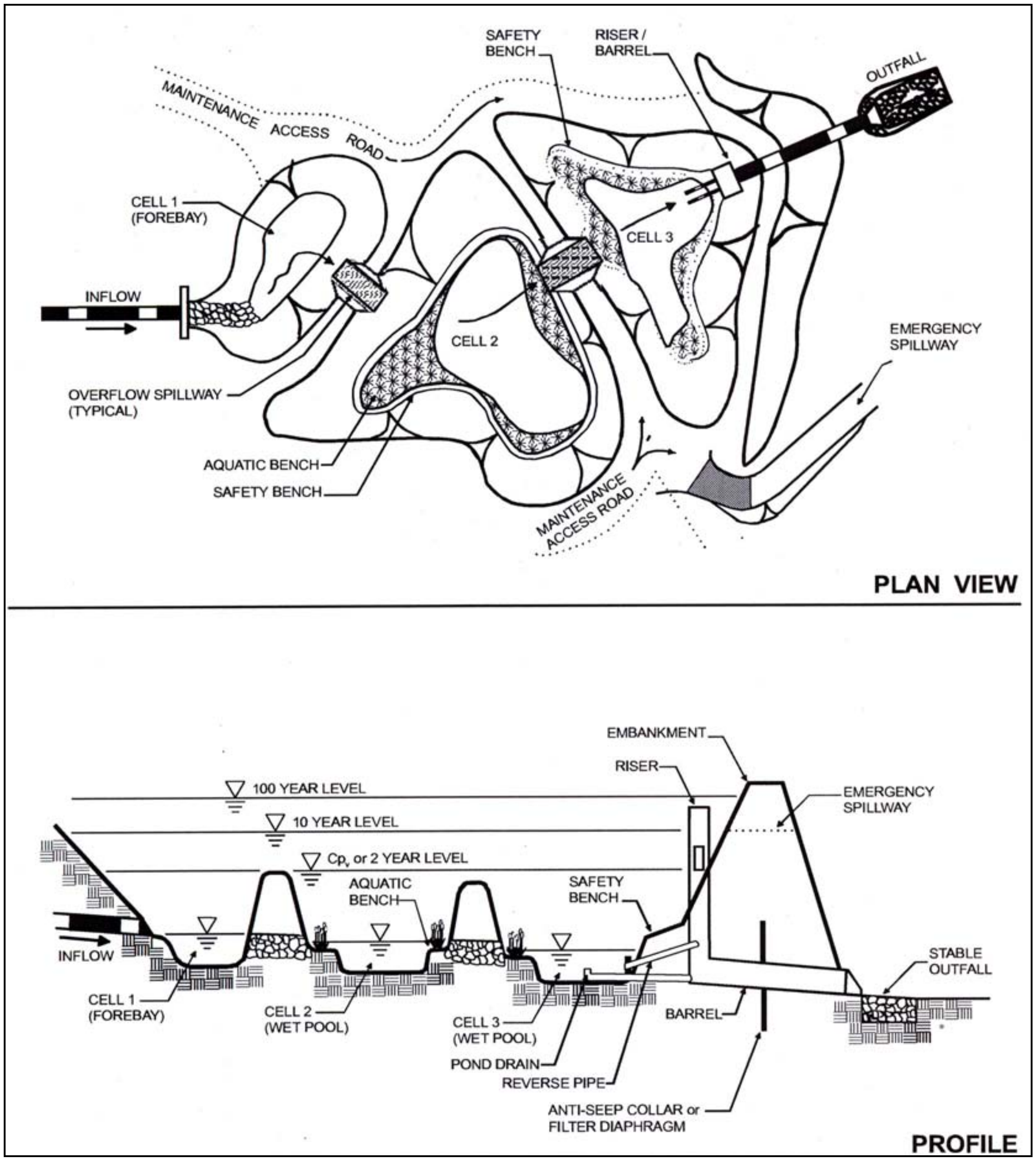


**Figure E.10 Schematic of Multiple Pond System**
(Source: Maryland Stormwater Design Manual, 2000)

<u>Pocket Pond</u>

The pocket pond is a stormwater pond design adapted for the treatment of runoff from small drainage areas that has little or no baseflow available to maintain water elevations (Figure E.11). While this design achieves less pollutant removal than a traditional wet pond, it may be an acceptable alternative on sites where space is at a premium, or in a retrofit situation. Excavation to groundwater interception should be avoided where the land uses draining to the pond may contaminate drinking water supplies.

*Advantages*

- Can be used on site where space is at a premium, or in a retrofit situation

*Limitations*

- Somewhat high maintenance requirements
- Wet ground adjacent to the pond may provide a breeding ground for mosquitoes
- Low habitat and amenity value

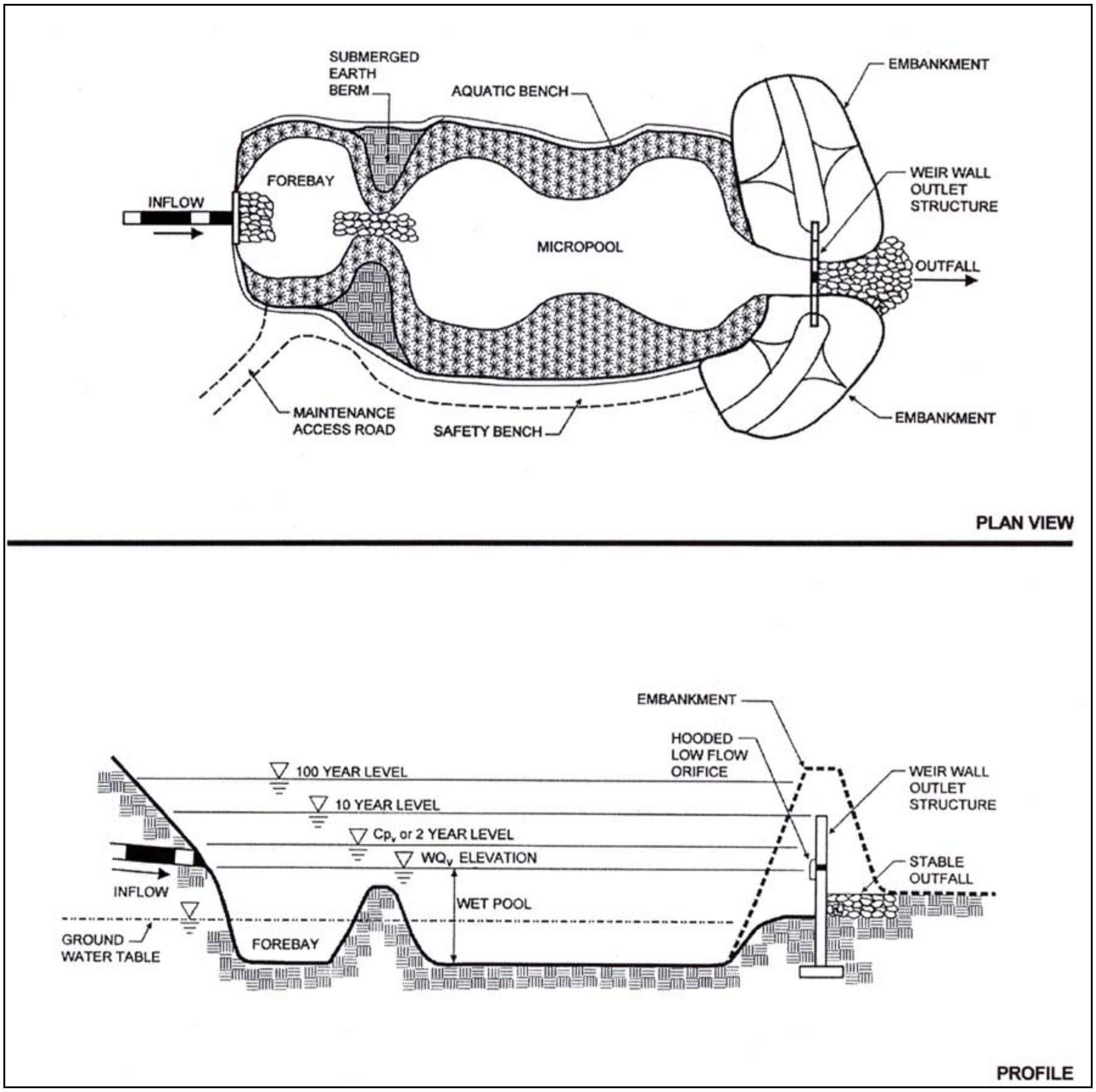


**Figure E.11 Schematic of Pocket Pond**
(Source: Maryland Stormwater Design Manual, 2000)

## Stormwater Wetlands

Shallow Wetland

The shallow wetland is a constructed system that temporarily stores stormwater runoff in shallow pools, creating growing conditions suitable for emergent and riparian wetland plants (Figure E.12). The shallow wetland design has a large surface area, and requires a reliable source of baseflow or groundwater supply to maintain the desired water elevations to support emergent wetland plants. Typically, the shallow system requires a lot of space and a sizeable contributing watershed area (often in excess of 25 acres) to support the shallow permanent pool.

*Advantages*

- Can provide an excellent urban habitat for wildlife and waterfowl, particularly if they are surrounded by a buffer and have some deeper water areas
- Good removal of sediments and nutrients, and can provide uptake of soluble pollutants through plant uptake
- Can be designed for combined flood and stormwater quality control

*Limitations*

- Inappropriate in highly urban areas due to space concern
- Best used with large drainage areas (> 25 acres) to ensure a water balance
- Construction may adversely impact existing wetland or forest areas
- Possible takeover by invasive aquatic nuisance plants
- Possible bacteria contamination if waterfowl populations become very dense
- Cannot be placed on steep unstable slopes
- Need base flow to maintain water level
- Nutrient release may occur during dormant period

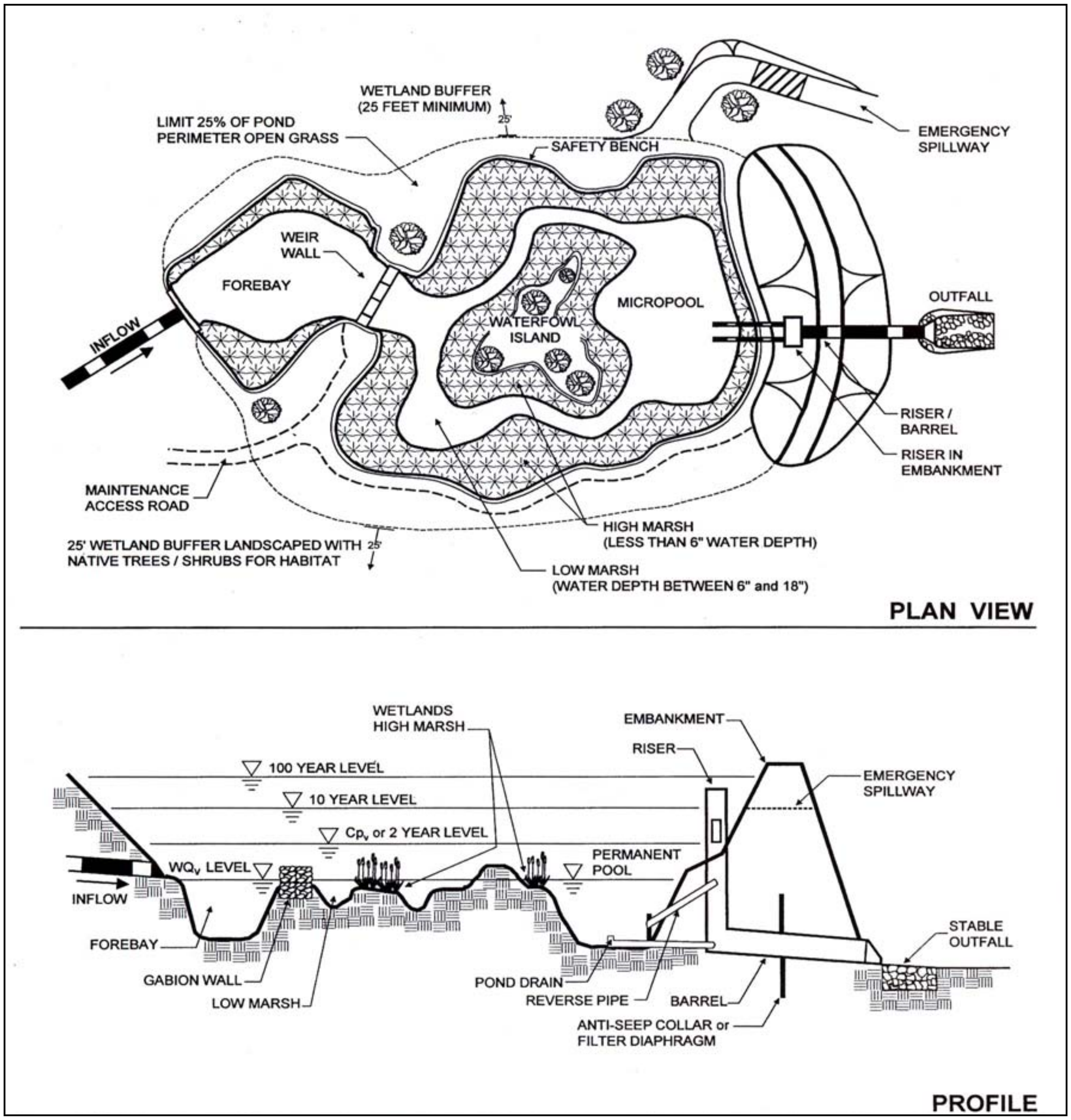


**Figure E.12 Schematic of Shallow Wetland**
(Source: Maryland Stormwater Design Manual, 2000)

Extended Detention (ED) Shallow Wetland

In ED shallow wetlands, extra storage is created above the shallow marsh by temporary detention of runoff (Figure E.13). The ED feature enables the wetland to consume less space, as temporary vertical storage is partially substituted for shallow wetland storage. Along the side-slopes of ED wetlands, a new growing zone is created that extends from the normal pool elevation to the maximum ED water surface elevation.

*Advantages*

- Can provide an excellent urban habitat for wildlife and waterfowl, particularly if they are surrounded by a buffer and have some deeper water area
- Good removal of sediments and nutrients, and can provide uptake of soluble pollutants through plant uptake and biological activity
- Can be designed for combined flood and stormwater quality control
- Can be used as a regional facility

*Limitations*

- Inappropriate in highly urban areas due to space concerns
- Best used with large drainage areas (> 25 acres) to ensure a water balance
- Construction may adversely impact existing wetland or forest areas
- Overgrowth can lead to reduced hydraulic capacity
- Possible takeover by invasive aquatic nuisance plants
- Possible bacteria contamination if waterfowl populations become very dense
- Cannot be placed on steep unstable slopes
- Need base flow to maintain water level
- Nutrient release may occur during dormant season

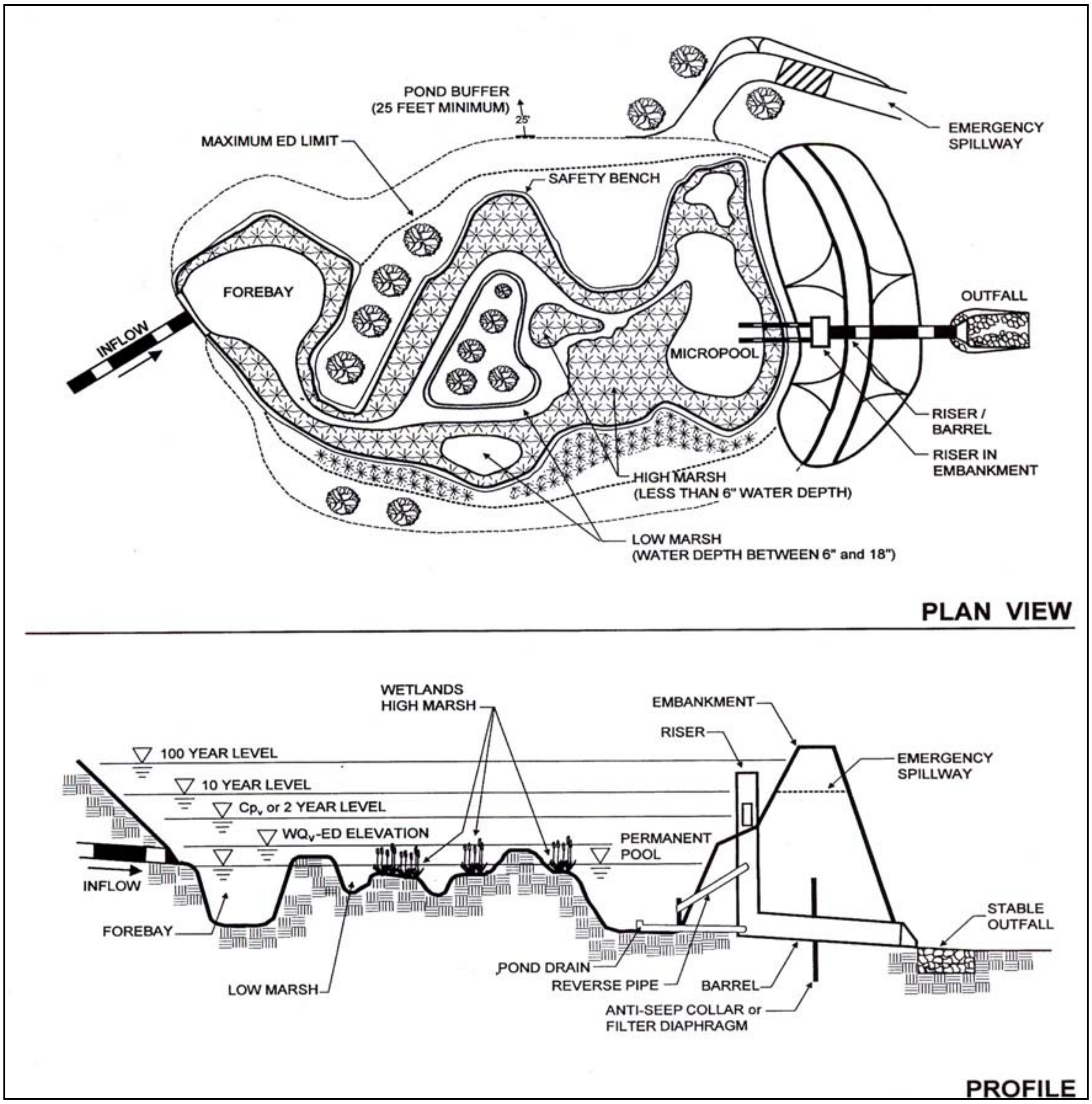


**Figure E.13 Schematic of Shallow ED Wetland**
(Source: Maryland Stormwater Design Manual, 2000)

Pond/Wetland System

The pond/wetland system combines the wet pond design with a shallow wetland (Figure E.14). Stormwater runoff flows through the wet pond and into the shallow marsh. Like the extended detention wetland, this design requires less surface area than the shallow marsh because some of the volume of the practice is in the relatively deep (i.e., six to eight feet) pond.

*Advantages*

- High community acceptance rate
- Requires little maintenance
- Can provide an excellent urban habitat for wildlife and waterfowl, particularly if they are surrounded by a buffer and have some deeper water area
- Good removal of sediments and nutrients, and can provide uptake of soluble pollutants through plant uptake and biological activity
- Can be designed for combined flood and stormwater quality control

*Limitations*

- Inappropriate in highly urban areas due to space concerns
- Best used with large drainage areas (> 25 acres) to ensure a water balance
- Construction may adversely impact existing wetland or forest areas
- Overgrowth can lead to reduced hydraulic capacity
- Possible takeover by invasive aquatic nuisance plants
- Possible bacteria contamination if waterfowl populations become very dense
- Concern for mosquitoes
- Cannot be placed on steep unstable slopes
- Need base flow to maintain water level
- Nutrient release may occur during dormant season

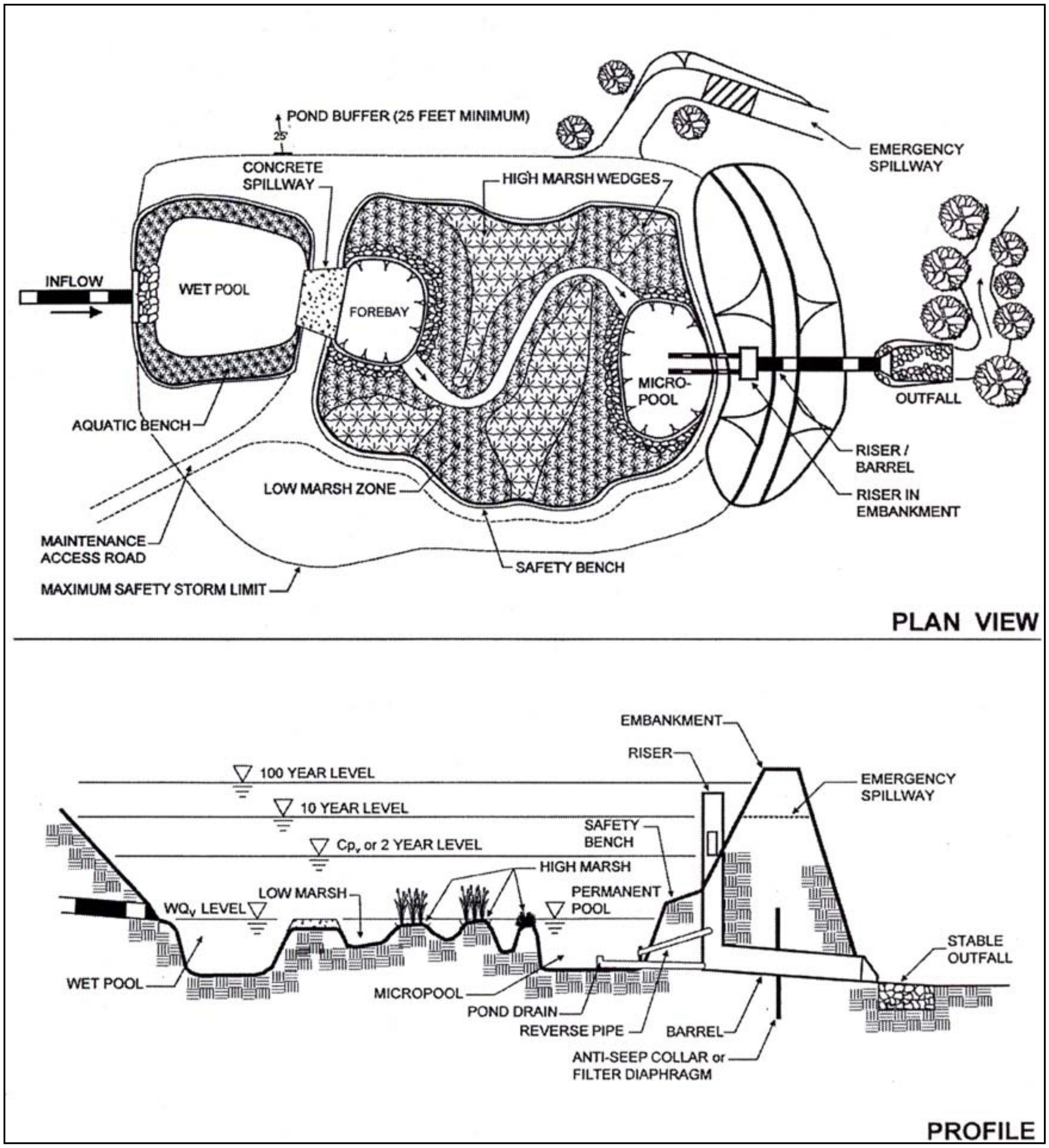


**Figure E.14 Schematic of Pond/Wetland System**
(Source: Maryland Stormwater Design Manual, 2000)

Pocket Wetland

Pocket wetlands (Figure E.15) are adapted to serve smaller sites from one to ten acres in size. Because of their small drainage areas, pocket wetlands usually do not have a reliable source of baseflow, and therefore exhibit widely fluctuating water levels. In most cases, water levels in the wetland are supported by excavating down to the water table. During extended periods of dry weather, the wetland may not have a shallow pool at all (only saturated soils). Due to their small size and fluctuating water levels, pocket wetlands often have low plant diversity and poor wildlife habitat value.

*Advantages*

- Can be located in space limited sites (i.e., ultra urban settings)
- Can be effective stormwater retrofit practice
- Good pollutant removal for both particulate and soluble pollutants
- Can provide quantity control as well

*Limitations*

- Cost relative to drainage area served is comparatively high
- Need base flow or high water table to maintain water level
- Possible takeover by invasive aquatic nuisance plants
- Overgrowth can lead to reduced hydraulic capacity

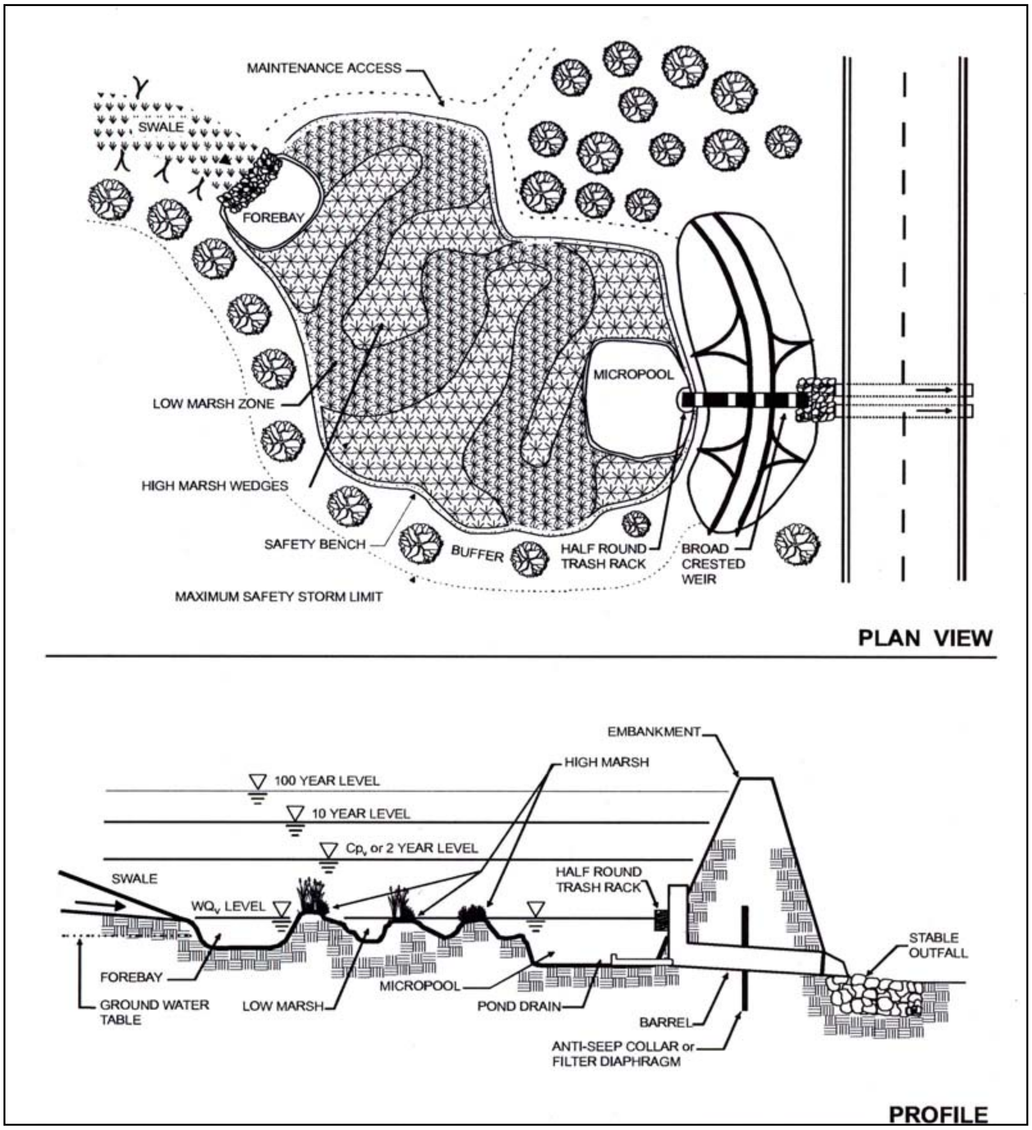


**Figure E.15 Schematic of Pocket Wetland System**
(Source: Maryland Stormwater Design Manual, 2000)

## Stormwater Infiltration Practices

Infiltration Trench

Infiltration trenches are shallow (two to ten feet deep) trenches in relatively permeable soils that are lined with filter fabric and backfilled with a sand filter and coarse stone. The trench surface can be covered with grating and/or consist of stone, gabion, sand, or a grass covered area with a surface inlet. Depending on the design, trenches allow for the partial or total infiltration of stormwater runoff into the underlying soil (Figure E.16). Infiltration trenches can be quality and quantity facilities.

*Advantages*

- Provides groundwater recharge
- Can minimize increases in runoff volume
- Can serve small drainage areas
- Can fit into medians, perimeters, and other unused areas of a development site
- Helps replicate predevelopment hydrology and increases dry weather baseflow
- Good pollutant removal capabilities

*Limitations*

- Slight to moderate risk of groundwater contamination depending on soil conditions
- Metals and petroleum hydrocarbons could accumulate in soils to potentially toxic levels
- No habitat is created
- High failure rates of conventional trenches and high maintenance burden
- Only feasible where soil is permeable and there is sufficient depth to bedrock and water table
- Since not as visible as other BMPs, less likely to be maintained
- Not recommended for discharge to a sole source aquifer
- Should not be used if upstream sediment load cannot be controlled prior to entry into the trench
- Should only be applied on small (< 5 acre) sites

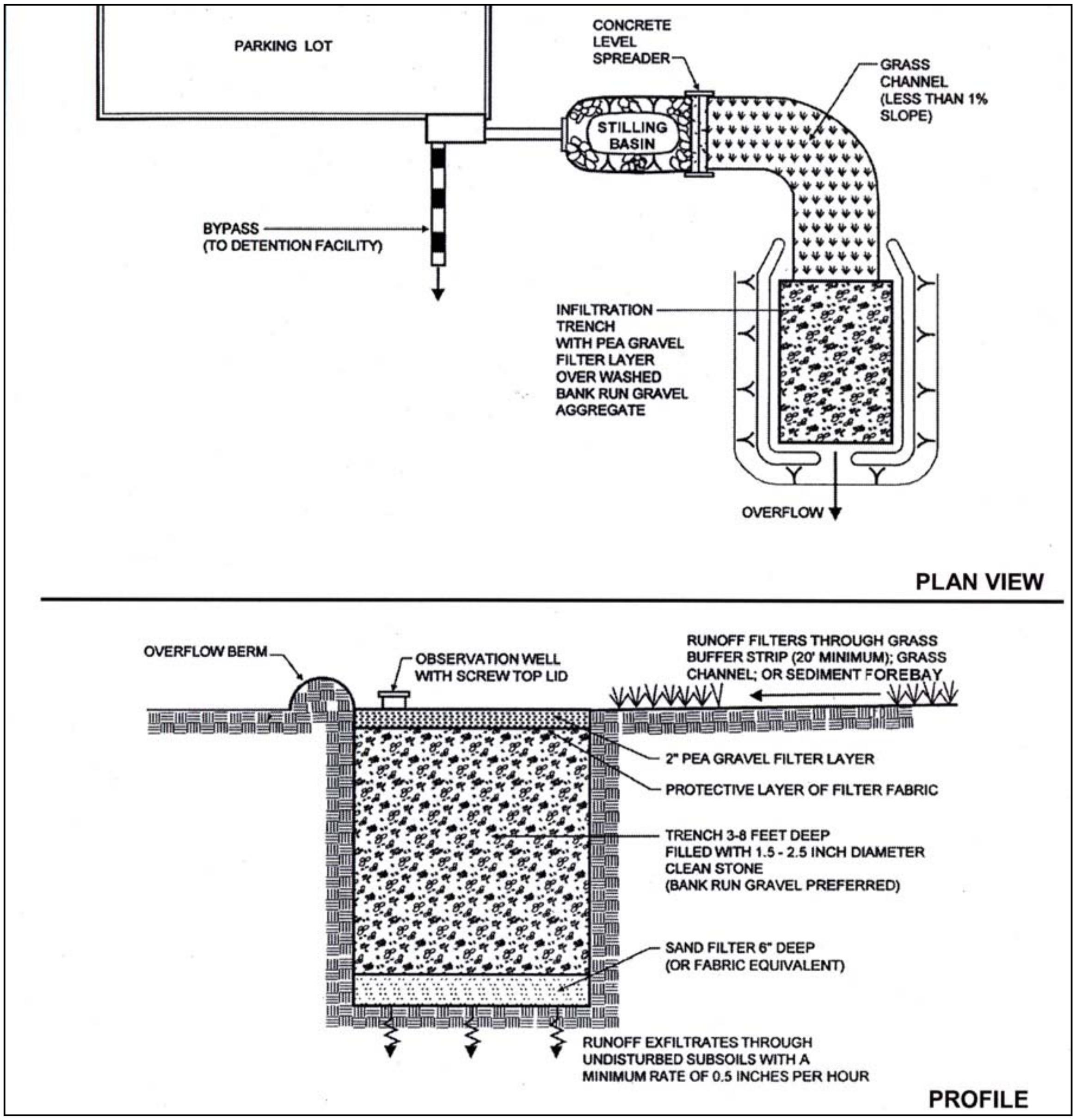


**Figure E.16 Schematic of Infiltration Trench**
(Source: Maryland Stormwater Design Manual, 2000)

Infiltration Basin

Infiltration basins are depressions created by excavation, berms, or small dams to provide short-term ponding of surface runoff until it percolates into the soil (Figure E.17). Infiltration basins can be sized for both water quality and water quantity design storms; however, use of this practice should be restricted to areas with permeable soils (i.e., Hydrologic Soil Groups A and B).

*Advantages*

- Groundwater recharge helps to maintain dry-weather flows in streams
- Can minimize increases in runoff volume
- High removal capability for particulate pollutants and moderate removal for soluble pollutants
- When properly designed and maintained, it can replicate predevelopment hydrology more closely than other BMP options
- Basins provide more habitat value than other infiltration systems

*Limitations*

- Slight to moderate risk of local groundwater contamination (particularly if contributing watershed is industrial or has heavy vehicular petroleum washoff).
- Metal and petroleum hydrocarbons could accumulate in soils to potentially toxic levels
- Relatively large land requirement
- High failure rate due to clogging and high maintenance burden
- Only feasible where soil is permeable and there is sufficient depth to bedrock and water table
- Not recommended for discharge to a sole source aquifer
- Should not be used if significant upstream sediment load exists

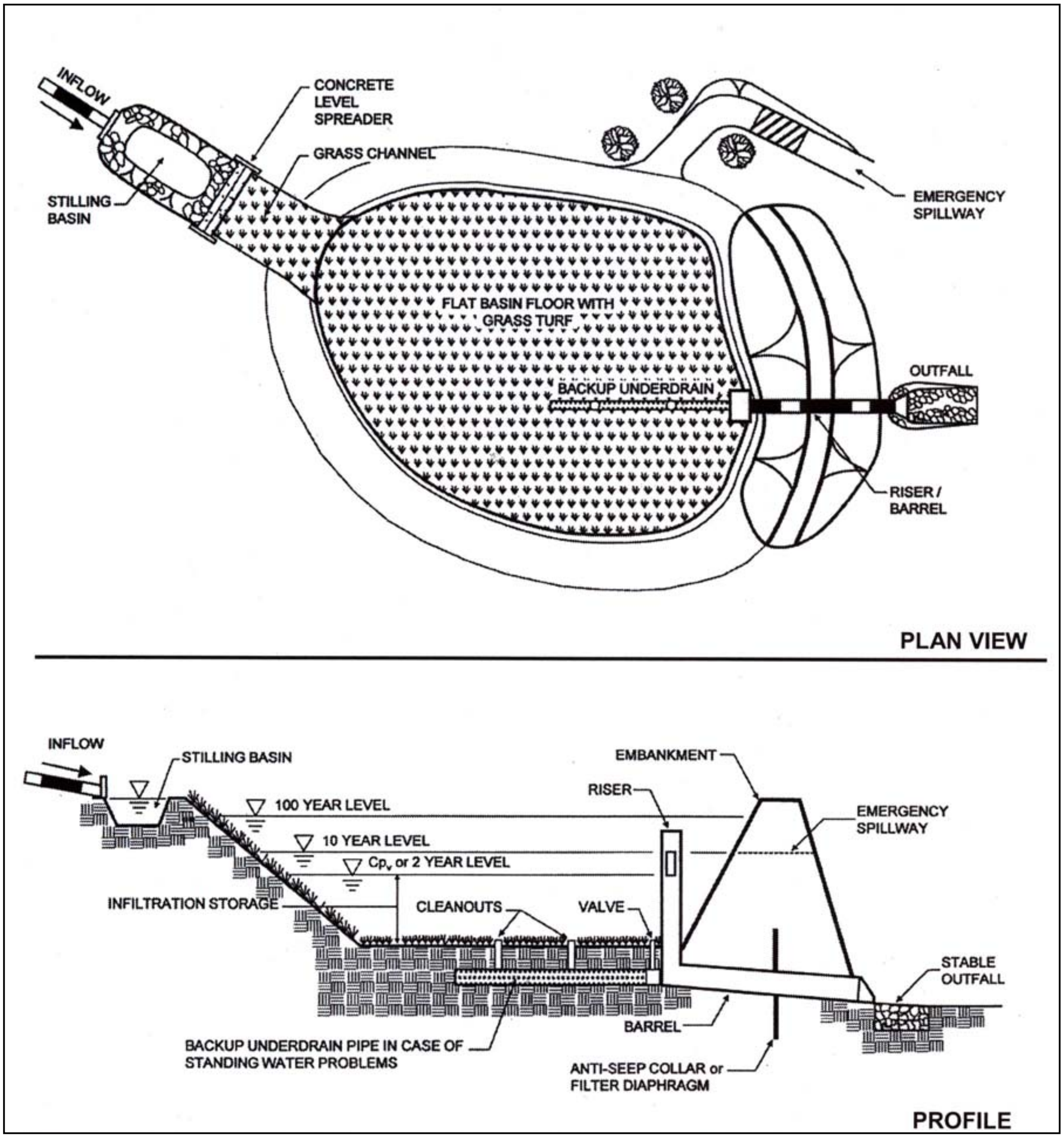


**Figure E.17 Schematic of Infiltration Basin**
(Source: Maryland Stormwater Design Manual, 2000)

**Stormwater Filtering Practices**

Surface Sand Filter

In the surface sand filter, a flow splitter is used to divert the first flush of runoff into an off-line sedimentation chamber. The chamber may be either wet or dry, and is used for pretreatment. Runoff is then distributed into the second chamber, which consists of a sand filter bed (±18") and temporary runoff storage above the bed (Figure E.18). Pollutants are trapped or strained out at the surface of the filter bed. The filter bed surface may have a sand or grass cover. A series of perforated pipes located in a gravel bed collect the runoff passing through the filter bed, and return it to the stream or channel at a downstream point. If underlying soils are permeable, and groundwater contamination unlikely, the bottom of the filter bed may have no lining, and the filtered runoff may be allowed to exfiltrate.

*Advantages*

- Useful in watersheds where concerns over groundwater quality or site conditions prevent use of infiltration
- High pollutant removal capability
- Can be used in highly urbanized settings
- Can be designed for a variety of soils
- Ideal for aquifer regions

*Limitations*

- Requires frequent maintenance to prevent clogging
- Available head to meet design criteria
- Dissolved pollutants are not captured by sand
- Larger sand filter designs, without grass cover, may be unattractive and generate odors
- Concrete walls that surround the sand filter can represent a safety hazard
- If the filter drains pervious surfaces, or large drainage areas, potential clogging by sediment is increased
- Generally best if limited to relatively small drainage areas (< 10 acres)

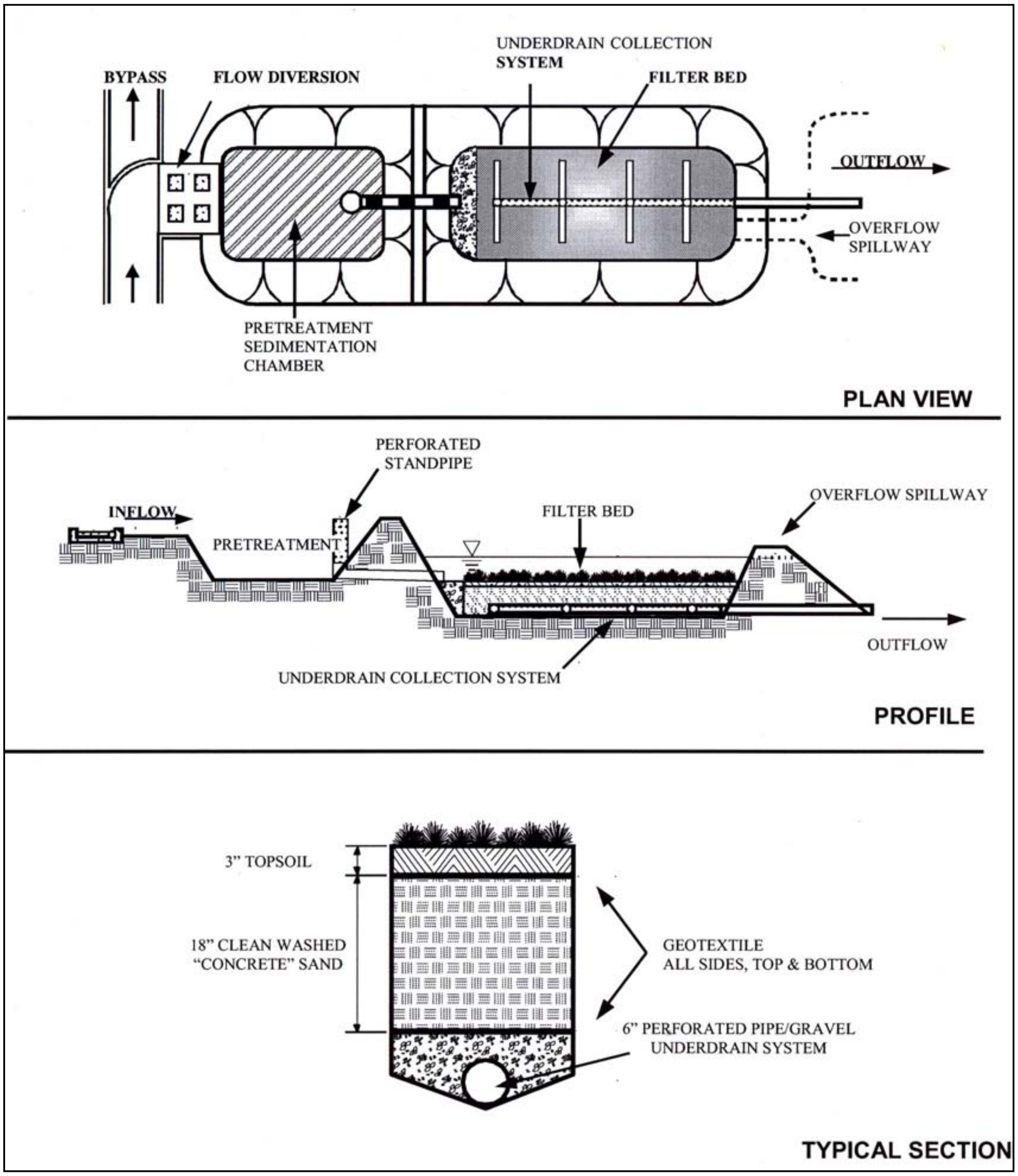


**Figure E.18 Schematic of Surface Sand Filter**
(Source: Maryland Stormwater Design Manual, 2000)

Underground Sand Filter

The underground sand filter was adapted for sites where space is at a premium. In this design, the sand filter is placed in a three chamber underground vault accessible by manholes or grate openings. The vault can be either on-line or off-line in the storm drain system. The first chamber is used for pretreatment and relies on a wet pool, as well as temporary runoff storage. It is connected to the second sand filter chamber by an inverted elbow, which keeps the filter surface free from trash and oil. The filter bed is 18 inches deep and may have a protective screen of gravel or permeable geotextile to limit clogging (Figure E.19). During a storm, the water quality volume is temporarily stored in both the first and second chambers. Flows in excess of the filter's capacity are diverted through an overflow weir. Filtered runoff is collected, using perforated underdrains that extend into the third “overflow” chamber.

*Advantages*

- Useful in watersheds where concerns over groundwater quality prevent use of infiltration
- High pollutant removal capability
- Do not take up surface area
- Can be used in highly urbanized settings
- Can be designed for a variety of soils
- Ideal for aquifer regions

*Limitations*

- Requires frequent maintenance to prevent clogging
- Available head to meet design criteria
- Dissolved pollutants are not captured by sand
- Generally function only as a stormwater quality practice and do not provide detention for downstream areas
- If the filter drains pervious surfaces, or large drainage areas, potential clogging by sediment is increased
- Inspection needs to be vigilant because this BMP is “out of sight”
- Generally best if limited to small drainage areas (< 2 acres)

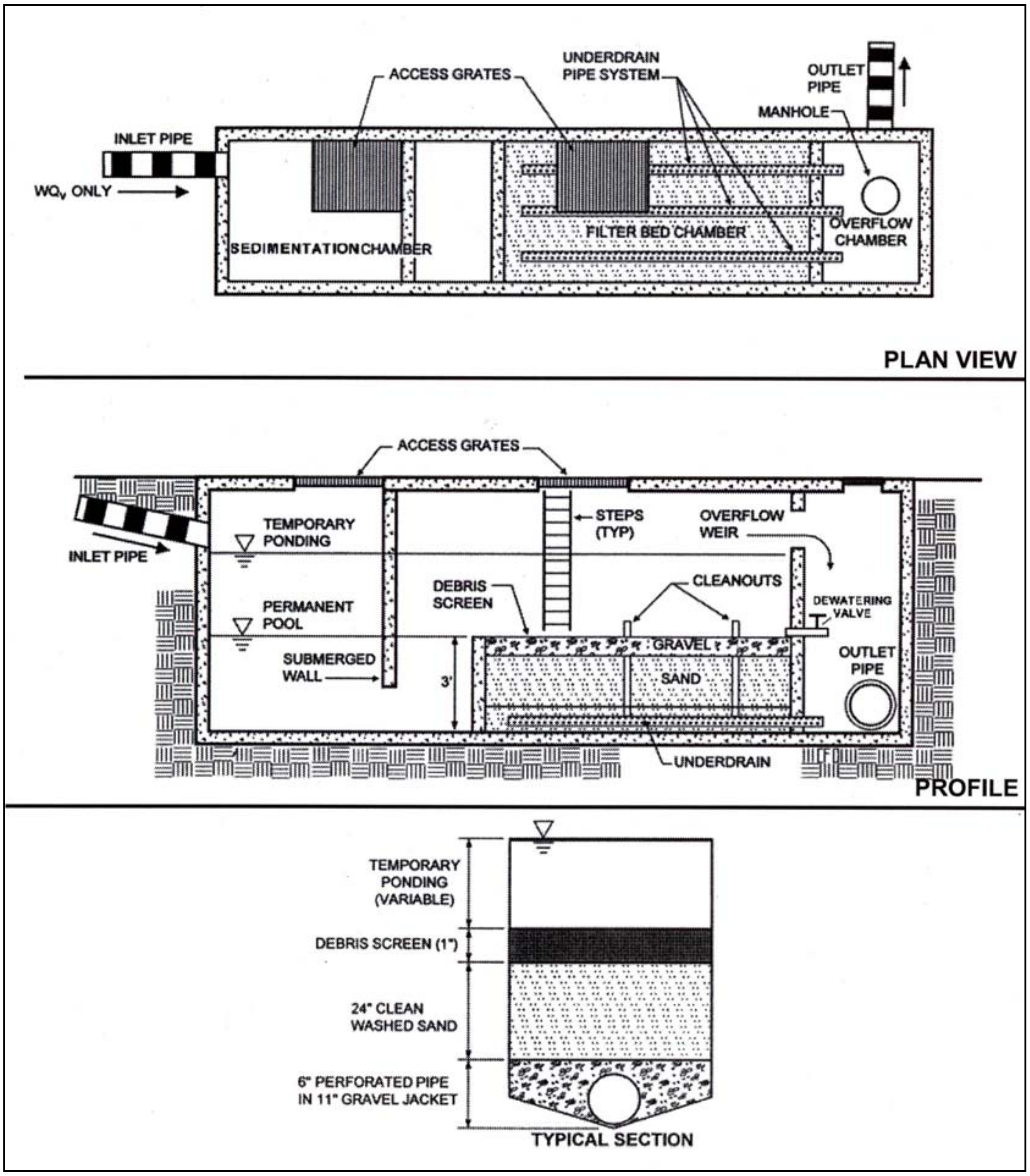


**Figure E.19 Schematic of Underground Sand Filter**
(Source: Maryland Stormwater Design Manual, 2000)

Perimeter Sand Filter

The perimeter sand filter consists of two parallel trench-like chambers that are typically installed along the perimeter of a parking lot. Parking lot runoff enters the first chamber, which has a shallow permanent pool of water (Figure E.20). The first trench provides pretreatment before the runoff spills into the second trench, which consists of a sand layer (±18"). During a storm event, runoff is temporarily ponded above the normal pool and sand layer, respectively. When both chambers fill up to capacity, excess parking lot runoff is routed to a bypass drop inlet. The remaining runoff is filtered through the sand, and collected by underdrains and delivered to a protected outflow point.

*Advantages*

- Sand filters are useful in watersheds where concerns over groundwater quality prevent use of infiltration
- High pollutant removal capability
- Do not take up surface area
- Can be used in highly urbanized settings
- Can be designed for a variety of soils
- Can be used in relatively flat terrain

*Limitations*

- Requires frequent maintenance to prevent clogging
- Available head to meet design criteria
- Dissolved pollutants are not captured by sand
- Generally function only as a stormwater quality practice and do not provide detention for downstream areas
- If the filter drains pervious surfaces, or large drainage areas, potential clogging by sediment is increased
- Inspection/maintenance needs to be vigilant because this BMP is "out of sight"
- Generally best if limited to small drainage areas (< 2 acres)

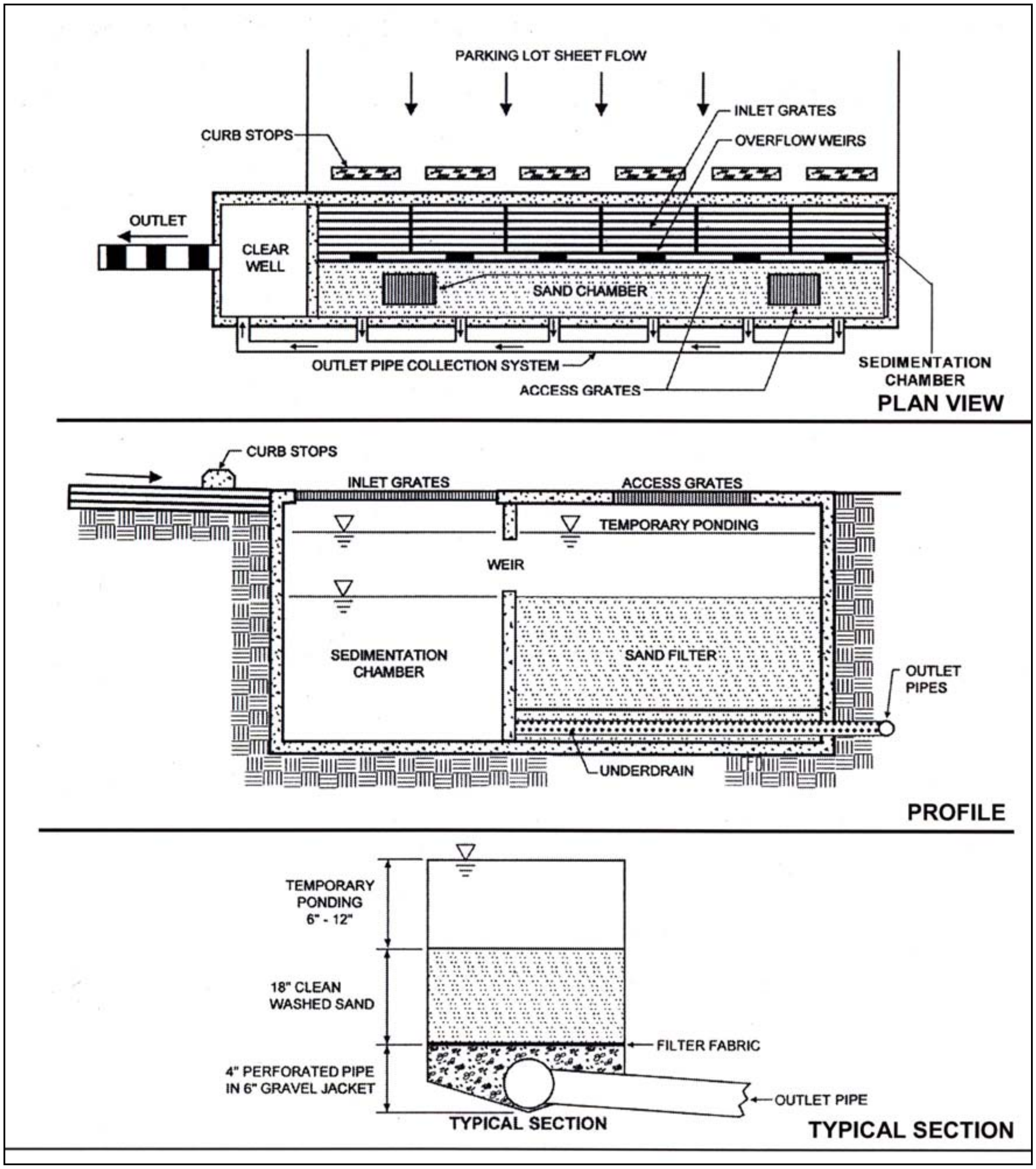


**Figure E.20 Schematic of Perimeter Sand Filter**
(Source: Maryland Stormwater Design Manual, 2000)

Organic Filter

The organic filter functions the same as a surface sand filter design, with the exception that it uses leaf compost or a peat/sand mixture as the filter media. The organic material enhances pollutant removal by providing adsorption of contaminants such as heavy metals. The organic filter consists of a flow splitter, which diverts runoff into a pretreatment chamber, and then passes into one or more filter cells (Figure E.21). Each filter bed contains a layer of leaf compost or the peat/sand mixture, followed by a filter fabric, and perforated pipe and gravel. Runoff filters through the organic media to the perforated pipe and ultimately to the outlet. The filter bed and subsoils can be separated by an impermeable polyliner to prevent movement into groundwater.

*Advantages*
- Organic filters are useful in watersheds where concerns over groundwater quality prevent use of infiltration
- High pollutant removal capability
- Removal of dissolved pollutants is greater than sand filters due to cation exchange capacity

*Limitations*
- Filter may require more frequent maintenance than most of the other BMPs
- Available head to meet design criteria
- Severe clogging potential if exposed soil surfaces exist upstream
- Larger organic filter designs, without grass cover, may not be attractive in residential areas and may cause odors
- Organic material for filter media may be difficult to obtain (especially for peat varieties)

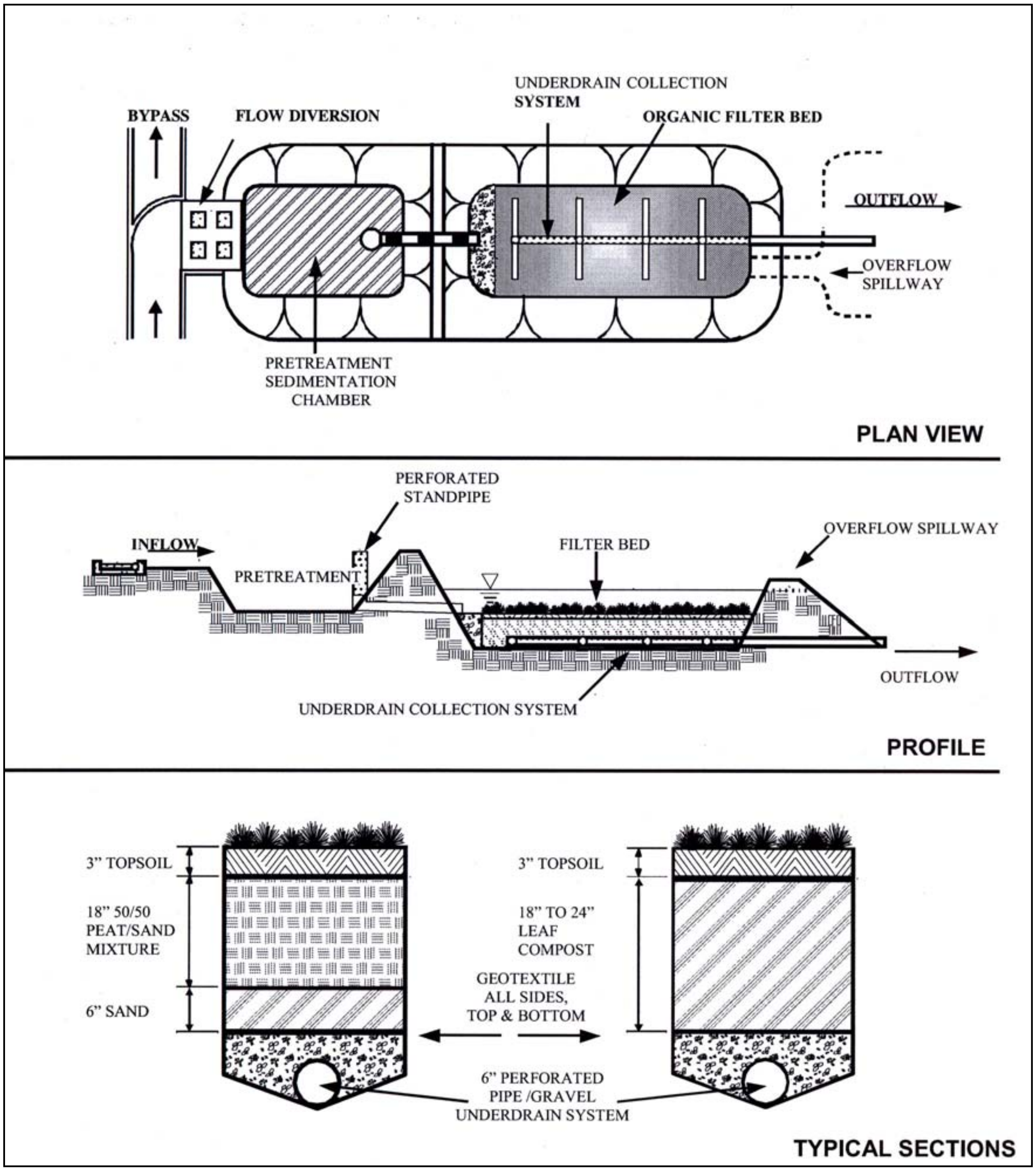


**Figure E.21 Schematic of Organic Filter**
(Source: Maryland Stormwater Design Manual, 2000)

Pocket Sand Filter

The pocket sand filter is a simplified and low cost design that may be used on smaller sites. Runoff is usually diverted within a manhole. A bypass pipe sends excess runoff along the storm drain system, and a flow diversion pipe routes the water quality volume into the system. Pretreatment is provided by a concrete flow spreader, a grass filter strip and a plunge pool (Figure E.22). For the filter bed, a shallow basin is excavated, and contains the sand filter layer. Most of the water quality volume is temporarily stored above the filter bed. The surface of the filter bed contains a soil layer and grass cover crop. In the event of clogging, the pocket sand filter has a pea gravel "window" to direct runoff into the sand, as well as a cleanout and observation well. In most cases, the filtered runoff is allowed to exfiltrate into the underlying soils, although underdrains may be needed if the soils are not suitably permeable.

*Advantages*

- Useful in watersheds where concerns over groundwater quality or site conditions prevent use of infiltration
- High pollutant removal capability
- Can be used in highly urbanized settings
- Can be designed for a variety of soils
- Ideal for aquifer regions

*Limitations*

- Requires frequent maintenance to prevent clogging
- Available head to meet design criteria
- Dissolved pollutants are not captured by sand
- Larger sand filter designs, without grass cover, may be unattractive and generate odors
- Concrete walls that surround the sand filter can represent a safety hazard
- If the filter drains pervious surfaces, or large drainage areas, potential clogging by sediment is increased
- Generally best if limited to a drainage area less than 2 acres

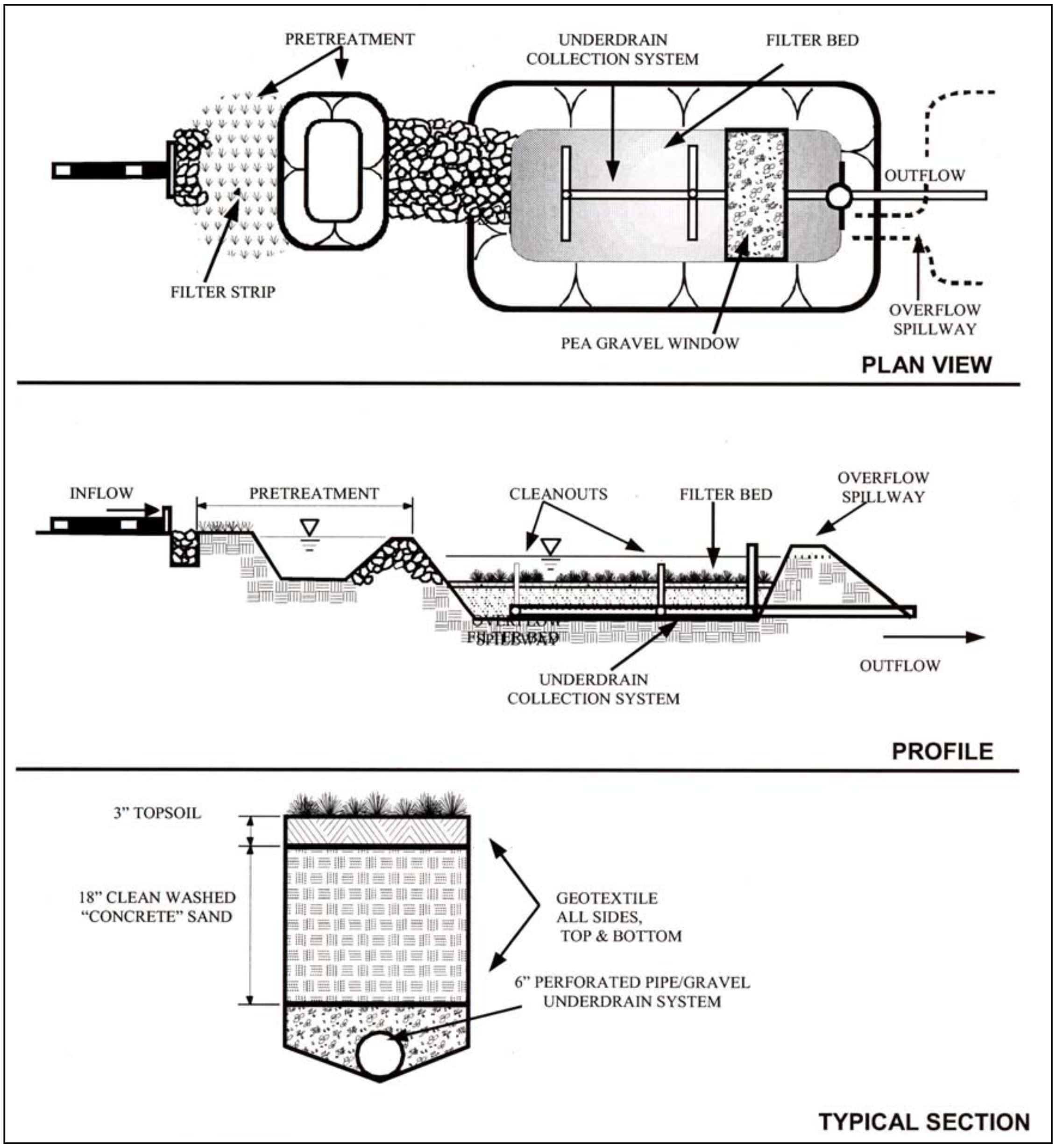


**Figure E.22 Schematic of Pocket Sand Filter**
(Maryland Stormwater Design Manual, 2000)

Bioretention

Bioretention filtering systems are adapted landscaping features used for on-site treatment of the water quality volume. They are commonly located in parking lot islands or within small pockets in residential land uses. Surface runoff is directed into shallow, landscaped depressions. These depressions are designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. During storms, the water quality volume is ponded up to nine inches above the mulch. Runoff in excess of the water quality volume rises to a higher elevation, but is then diverted into a standard drop inlet connected to the storm drain system. The remaining runoff filters through the mulch and prepared soil mix, which is about four feet deep (Figure E.23). Typically, the filtered runoff is collected in a perforated underdrain and returned to the storm drain system. If underlying soils are permeable, and groundwater contamination unlikely, the bottom of the filter bed may have no lining, and the filtered runoff may be allowed to exfiltrate.

*Advantages*

- Generally requires low land consumption, and can fit within the area that is typically devoted to landscaping
- Regular maintenance can be provided by commercial landscaping companies
- Removal of dissolved pollutants is more likely due to cation exchange capacity
- Can be used in highly urbanized settings
- Aesthetically pleasing

*Limitations*

- Available head to meet design criteria
- Requires frequent maintenance to prevent clogging, maintain landscaping, and remove litter
- Generally best if limited to small drainage areas (< 5 acres)

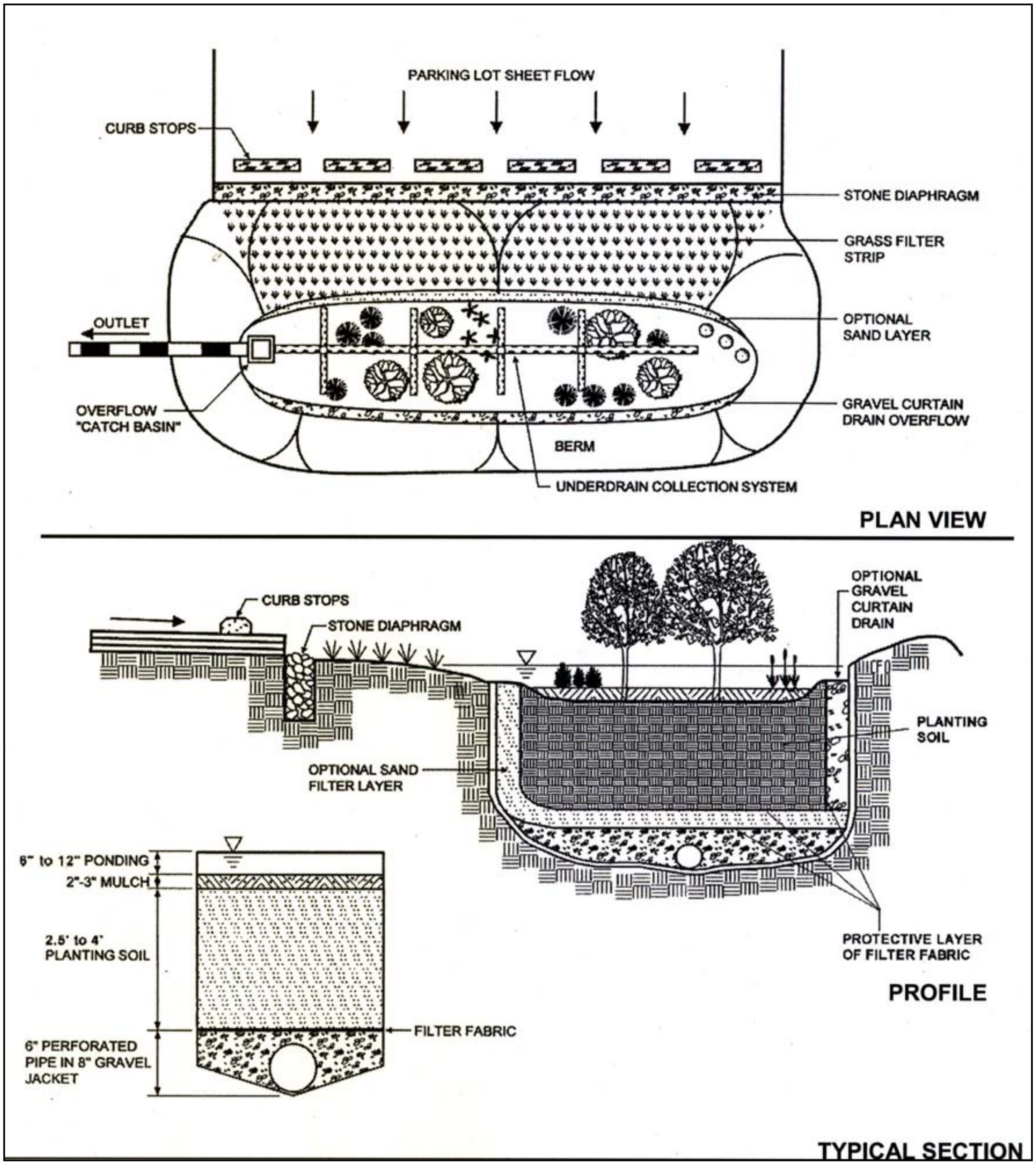


**Figure E.23 Schematic of Bioretention**
(Source: Maryland Stormwater Design Manual, 2000)

## Open Channel Practices

Dry Swale
In a dry swale, the entire water quality volume is temporarily retained by checkdams during each storm. A dry swale also has a filter bed consisting of about 30 inches of prepared soil (sandy loam) that is then collected by an underdrain pipe. The swale is designed to rapidly dewater, thereby allowing swale to be more easily mowed. Pretreatment is provided through check dams and by keeping side slopes gentle if they are adjacent to impervious areas (Figure E.24). A dry swale is often the preferred grass channel option in residential settings since it is designed to prevent standing water that makes mowing difficult and generates complaints.

*Advantages*
- Generally results in reduced impervious cover compared with curb and gutter designs
- Good pollutant removal capabilities
- Can be used as conveyance system to provide pretreatment
- Ideal for low density residential and highway land uses
- Lower construction costs than curb and gutter

*Limitations*
- Can be difficult to avoid channelization in swales
- Cannot be placed on steep slopes
- Proper maintenance required to maintain health and density of vegetation
- Inappropriate in highly urbanized setting, due to space consumption

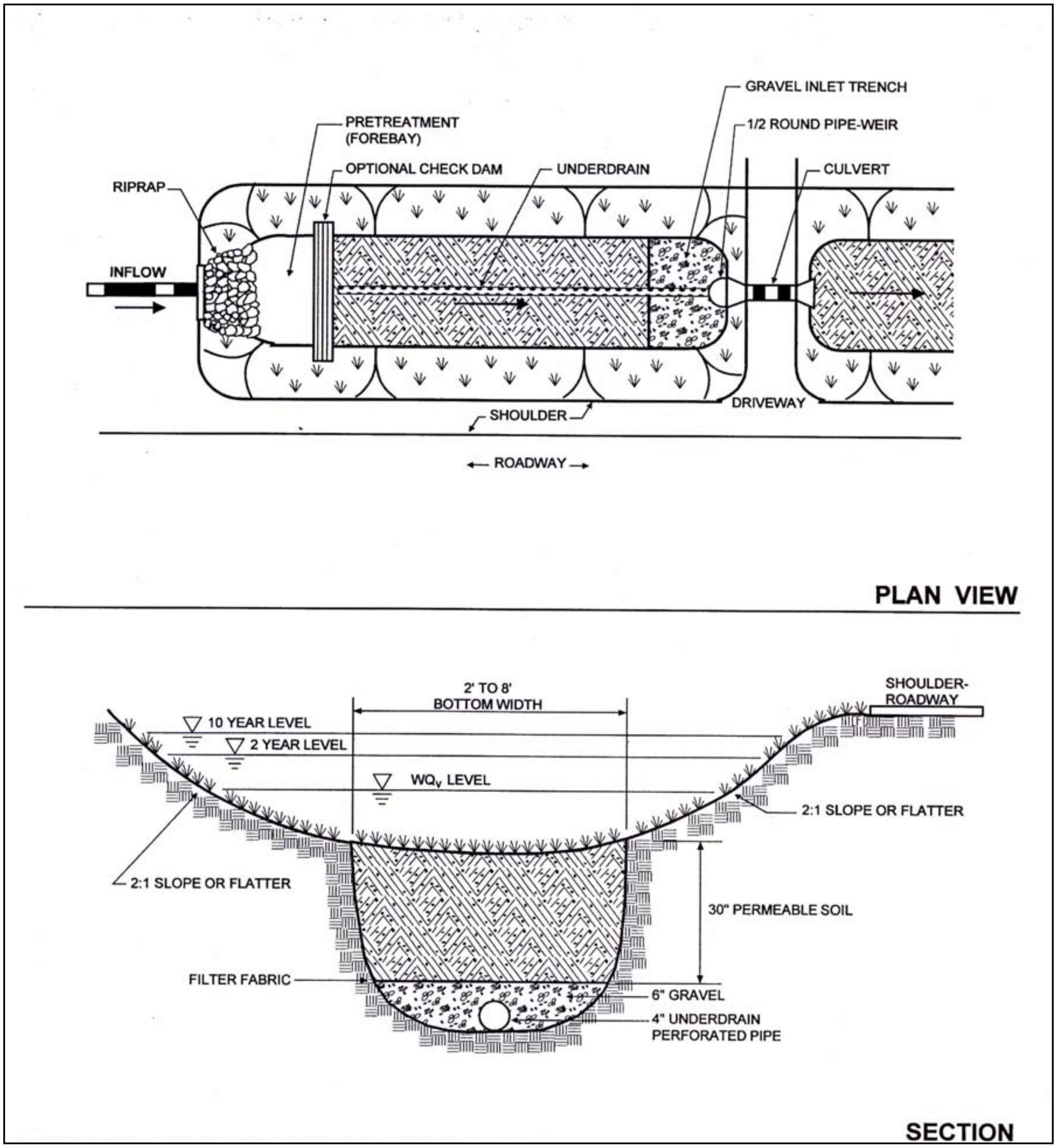


**Figure E.24 Schematic of Dry Swale**
(Source: Maryland Stormwater Design Manual, 2000)

Wet Swale

A wet swale is an grass channel design that occurs when the water table is located very close to the surface. As a result, swale soils often become fully saturated, or have standing water all or part of the year. The wet swale essentially acts as a linear shallow wetland treatment system. Like the dry swale, the entire water quality treatment volume is stored and retained within a series of cells in the channel, formed by berms or checkdams (Figure E.25). The notched checkdams are set so that the invert creates the pool level when the water table is high. In some cases, the cells may be planted with emergent wetland plant species to improve removal rates. If land is available, some wetland cells can be placed off-line.

*Advantages*

- Generally results in reduced impervious cover compared with curb and gutter designs
- Good pollutant removal capabilities
- Can be used as part of the runoff conveyance system to provide pretreatment
- Lower construction costs than curb and gutter

*Limitations*

- Requires high water table
- Can be difficult to avoid channelization
- Cannot be placed on steep slopes
- Not recommended for residential or more urban land uses

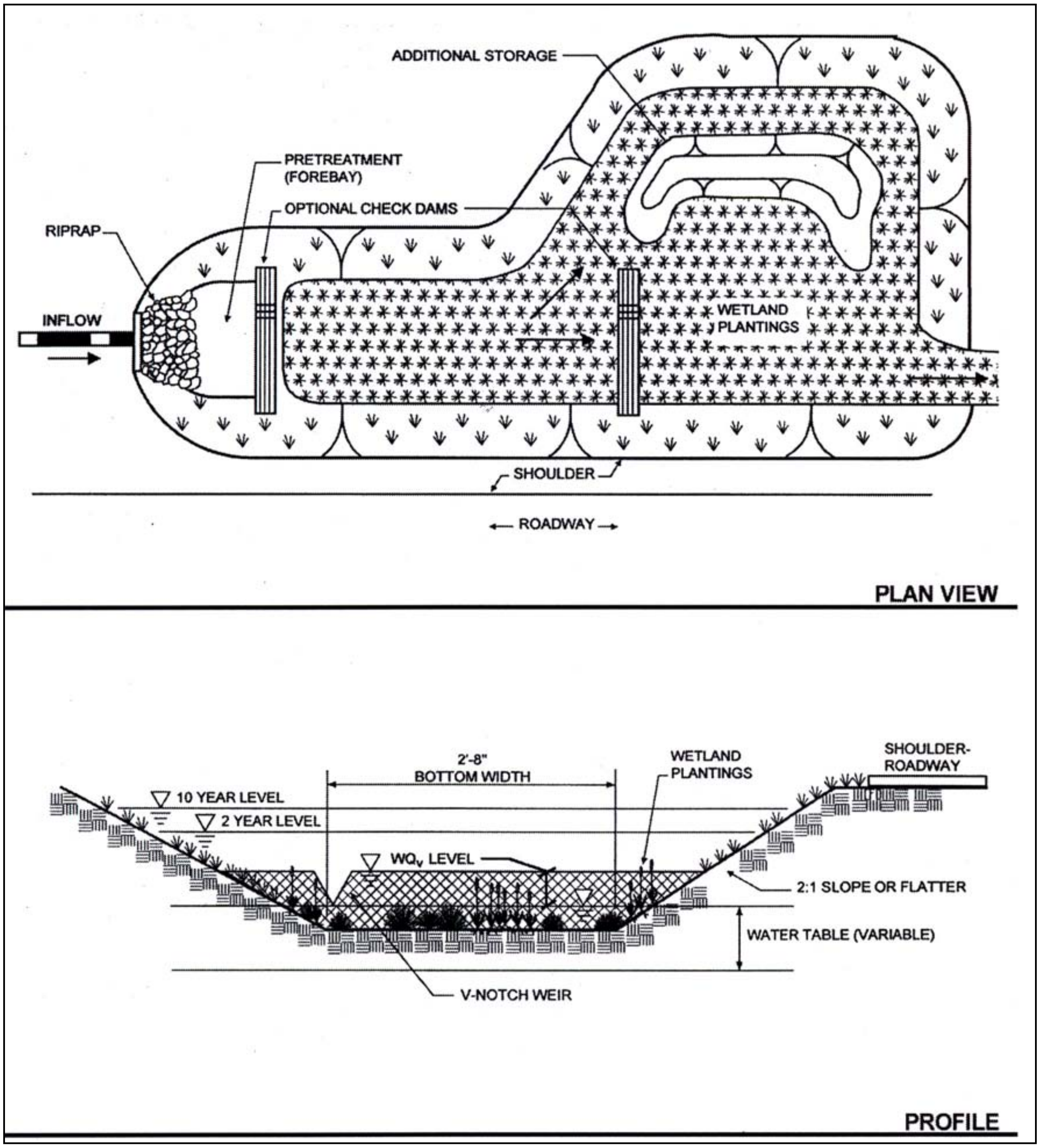


**Figure E.25 Schematic of Wet Swale**
(Source: Maryland Stormwater Design Manual, 2000)

# APPENDIX F. RESIDENTIAL WATER QUALITY PLAN: ALLOWABLE BMP OPTIONS

The following section provides descriptions, advantages, limitations, and schematics of allowable best management practices (BMPs) for use under the Critical Area Residential Water Quality Plan. All of the BMPs allowed under individual residential lot scenarios are considered non-structural BMPs.

For the purposes of this Manual, non-structural BMPs are not given a phosphorus removal rate but are used to reduce or erase proposed impervious cover at the site. These BMPs are organized by several non-structural strategies to reduce the amount of stormwater runoff:

- Strategies to Disconnect Rooftop Runoff
- Strategies to Store Rooftop Runoff
- Strategies to Disconnect Non-Rooftop Runoff

The majority of non-structural BMPs do not require numerical sizing to meet drainage needs. However, to properly function and prevent clogging and nuisance ponding, sizing guidance is provided for french drains, dry wells, and rain gardens.

## Strategies to Disconnect Rooftop Runoff

Rain Gardens

Rain gardens are small, vegetated depressions that are used to capture and infiltrate stormwater runoff. Rain gardens are essentially less engineered versions of a bioretention area (see Appendix E). Runoff usually enters rain gardens by sheet flow or from a rooftop downspout. Rain gardens are excavated six to 18 inches deep and are filled with an appropriate soil mixture and planted with shrubs, grasses, or herbaceous, perennial plants (Figure F.1). The surface of the rain garden should be between 20% and 30% of the roof area that will drain into the rain garden (use 20% for very sandy soils). This will ensure that the garden will temporarily hold water from a 1-inch rainstorm. Water is detained in the ponding area until it either infiltrates or evaporates (usually no more than 24 hours). Rain gardens can be applied to both new and existing developments. Due to space requirements, they are most applicable for residential uses. Sizing examples are shown in Table F.1. They work best in areas with well-drained soils (University of Wisconsin-Extension Office). For more information on how to install a rain garden, step-by-step instructions are provided online at: www.cwp.org/Community_Watersheds/brochure.pdf (CWP and SRF, 2003).

| Table F.1 Rain Garden Sizing Example |
|---|
| 30’ x 30’ house footprint |
| ¼ of this area drains to one downspout |
| 15’ x 15’ = 225 $ft^2$ |
| 20% of 225$ft^2$ = 45$ft^2$ |
| 30% of 225$ft^2$ = 67.5 $ft^2$ |
| The rain garden area should be between 45 and 67.5 square feet, depending on the soil type |

*Advantages*

- Increased public awareness and involvement in stormwater management
- Rain gardens can reduce runoff volume and peak discharge
- Add an appealing landscaping feature to neighborhoods
- Help to disconnect impervious cover

*Limitations*

- Can create flooding and visual nuisance if not properly designed and maintained
- Require strong owner and community buy-in

**Figure F.1 Picture of Rain Garden**
(Source: Roger Bannerman)

French Drains and Dry Wells

French drains and dry wells are gravel filled trenches designed to control runoff from rooftops and other impervious areas through infiltration. Runoff is directed to the trench via a downspout or swale, is temporarily stored in the voids of the stone-filled trench, and ultimately percolates into the ground. The terms *french drain* and *dry well* are often used interchangeably since they perform the same function; however, the design and applicability of each will differ slightly. A french drain is an underground, horizontal trench with perforated pipes that run along the bottom of the trench (Figure F.2). A typical sizing example for a french drain is provided in Table F.2. A typical dry well is a vertical excavated trench with perforated pipes that run both vertically and horizontally through the aggregate (Figure F.3). Larger runoff storage capacity can be realized by using larger diameter perforated pipes.

| Table F.2 French Drain Sizing Example |
|---|
| French Drain Surface Area = $\frac{(DA)(P)}{12(D)(V)}$ |
| 30’ x 30’ house footprint |
| ¼ of this area drains to downspout |
| Drainage Area (DA) = 15’x 15’ = 225ft$^2$ |
| Rainfall Depth (P) = 1” |
| Depth of Proposed Trench (D) = 2ft |
| Voids Ratio for Gravel (V) = 0.35 |
| $\frac{(225)(1)}{12(2)(0.35)} = 26.8$ ft$^2$ |
| Trench dimensions: 13’ length<br>2’ wide<br>2’ deep |
| Notes:<br>Depth (D) can vary depending on site constraints<br>Rainfall Depth (P) can vary; should reflect retrofit water quality target volume or local water quality criteria |

*Advantages*

- Provide groundwater recharge
- Can serve small impervious areas like rooftops
- Helps to disconnect impervious surfaces

*Limitations*

- Loss of infiltrative capacity and high maintenance cost in fine soils
- Low removal of dissolved pollutants in very coarse soils
- Not suitable on fill sites or steep slopes

- Risk of groundwater contamination in very coarse soils, may require groundwater monitoring
- Lack of pretreatment may cause clogging over time
- Soils must be permeable

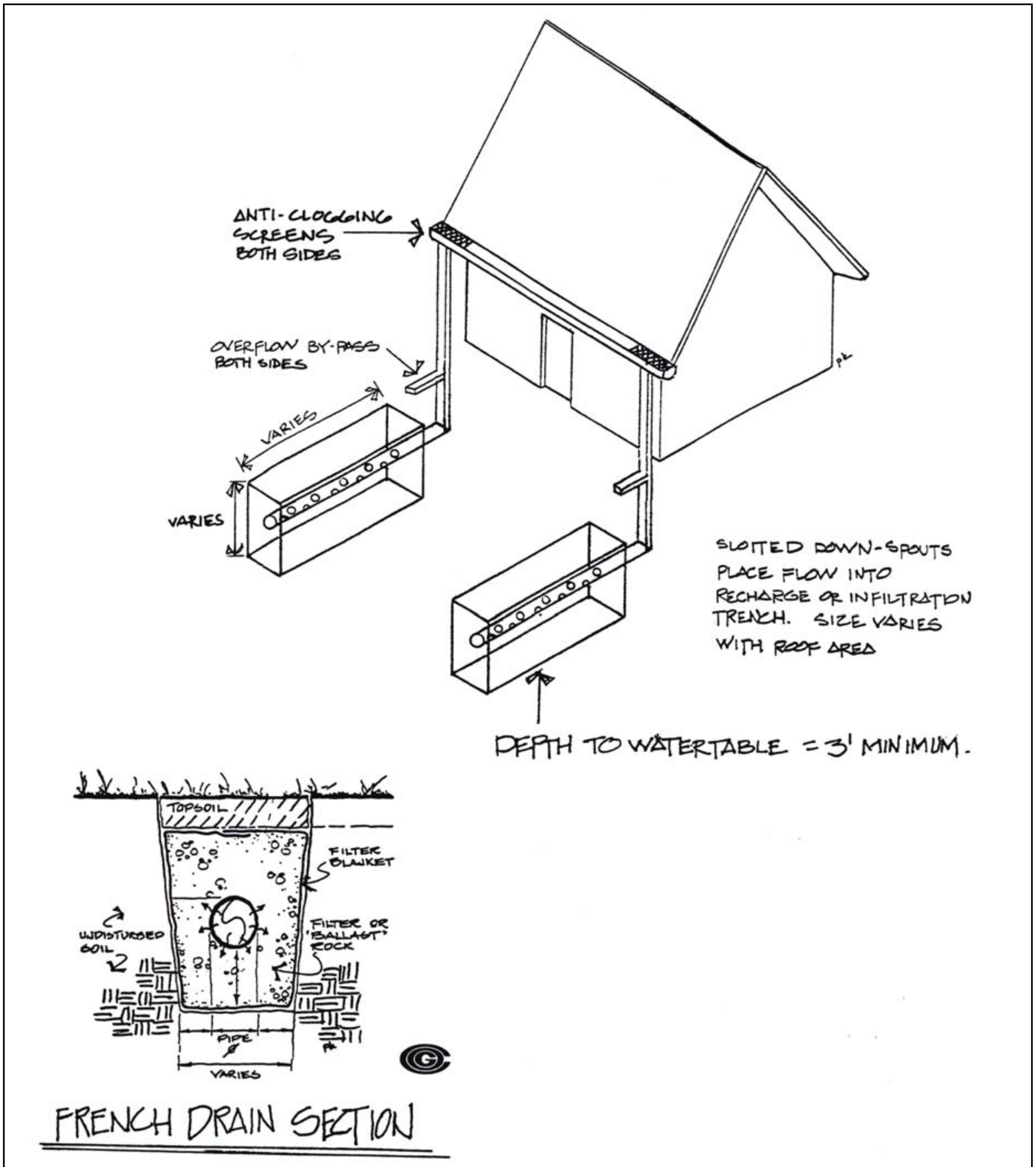


**Figure F.2 Schematic of French Drain**

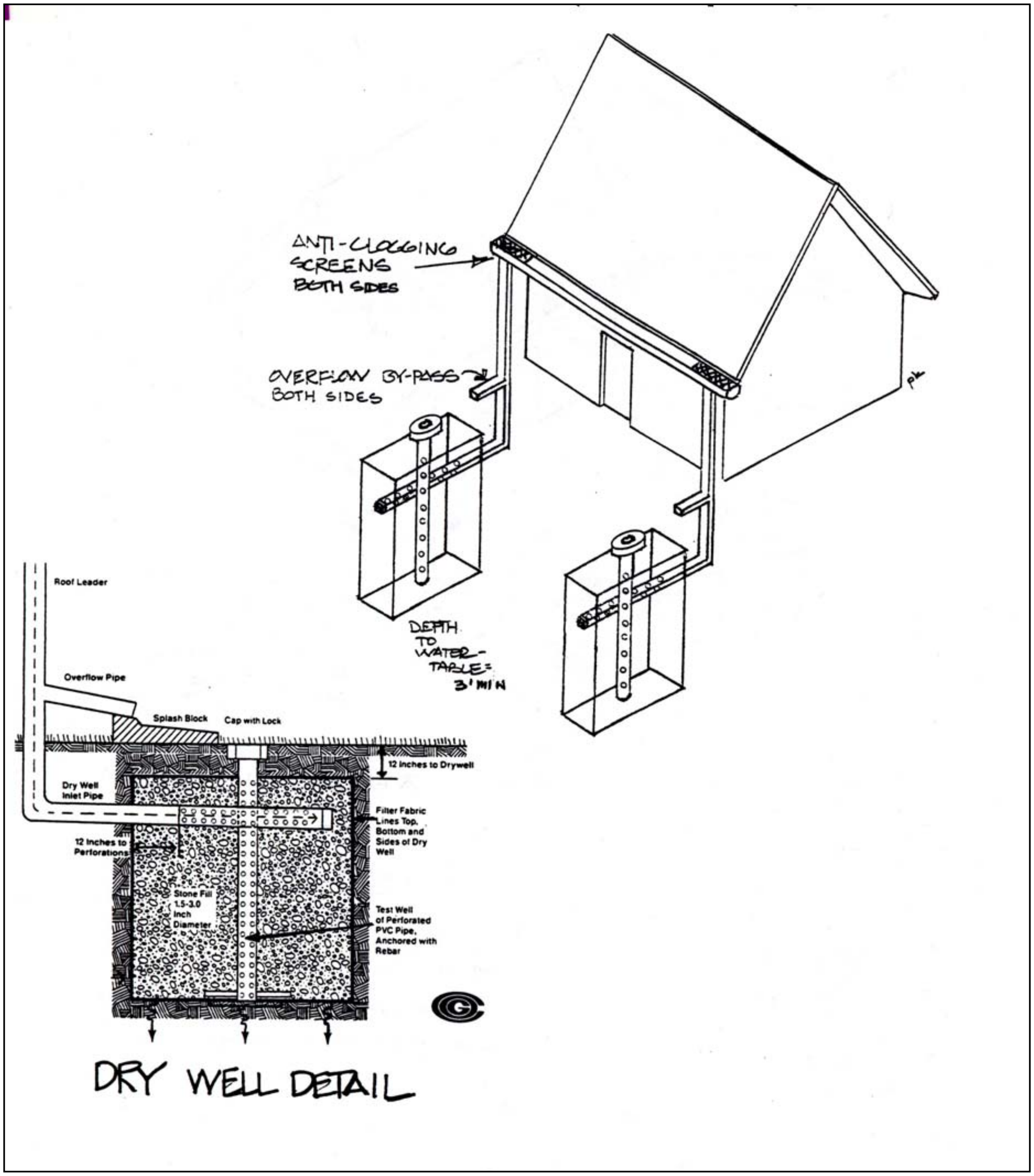


**Figure F.3 Schematic of Dry Well**

## Strategies to Store Rooftop Runoff

Rain Barrels
A rain barrel is a collection device that stores rainwater from rooftops (Figure F.4). This stored water is typically used by homeowners to wash cars or water lawns and gardens. Rooftop runoff stored in a rain barrel would normally flow through the downspout, onto a paved surface, and eventually into a storm drain. Rain barrels are designed to hold between 50 and 100 gallons of water each. For more information on how to install a rain barrel, step-by-step instructions are provided online at: www.cwp.org/Community_Watersheds/brochure.pdf (CWP and SRF, 2003).

*Advantages*
- Reduce water utility bills
- Promote water conservation and increases public awareness
- Require little space

*Disadvantages*
- Require strong homeowner maintenance
- Must have on-site infiltration capacity for rain barrel overflow for larger storm events
- Limited effectiveness in cold winters
- Can create foundation and mosquito problems if not maintained properly

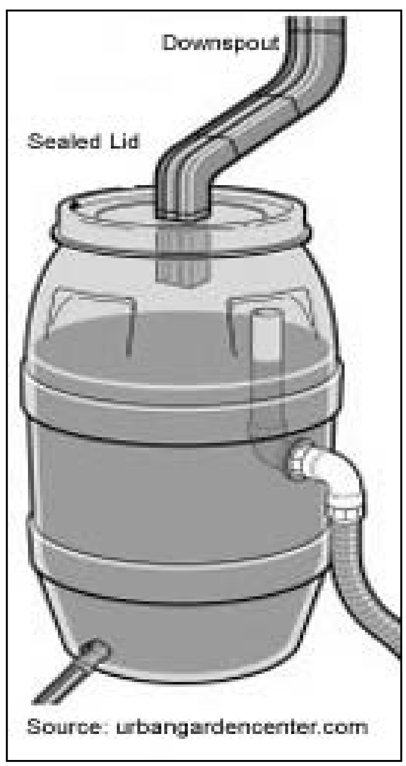


**Figure F.4 Schematic of Rain Barrel**
(Source: www.urbangardencenter.com)

## Strategies to Disconnect Non-Rooftop Runoff

Permeable Pavers

Permeable pavers are permeable surfaces that can replace asphalt and concrete and can be used for driveways (Figure F.5), parking lots and walkways. From a stormwater perspective, this is important because permeable pavers can replace impervious surfaces, creating less stormwater runoff. The two broad categories of alternative pavers are paving blocks and other surfaces including gravel, cobbles, wood, mulch, brick, and natural stone.

*Advantages*

- Can replace conventional asphalt or concrete in parking lots, driveways, and walkways
- Can abate overall stormwater management costs by reducing or eliminating the need of other stormwater management techniques
- Reduces pavement ponding

*Limitations*

- Slight to moderate risk of groundwater contamination depending on soil conditions and aquifer susceptibility
- High failure rate potential
- Requires regular maintenance
- No sanding for de-icing permitted
- Only feasible where soil is permeable, there is sufficient depth to bedrock and water table, and there are gentle slopes
- Not suitable for areas with high traffic volume
- More expensive than traditional paving surfaces

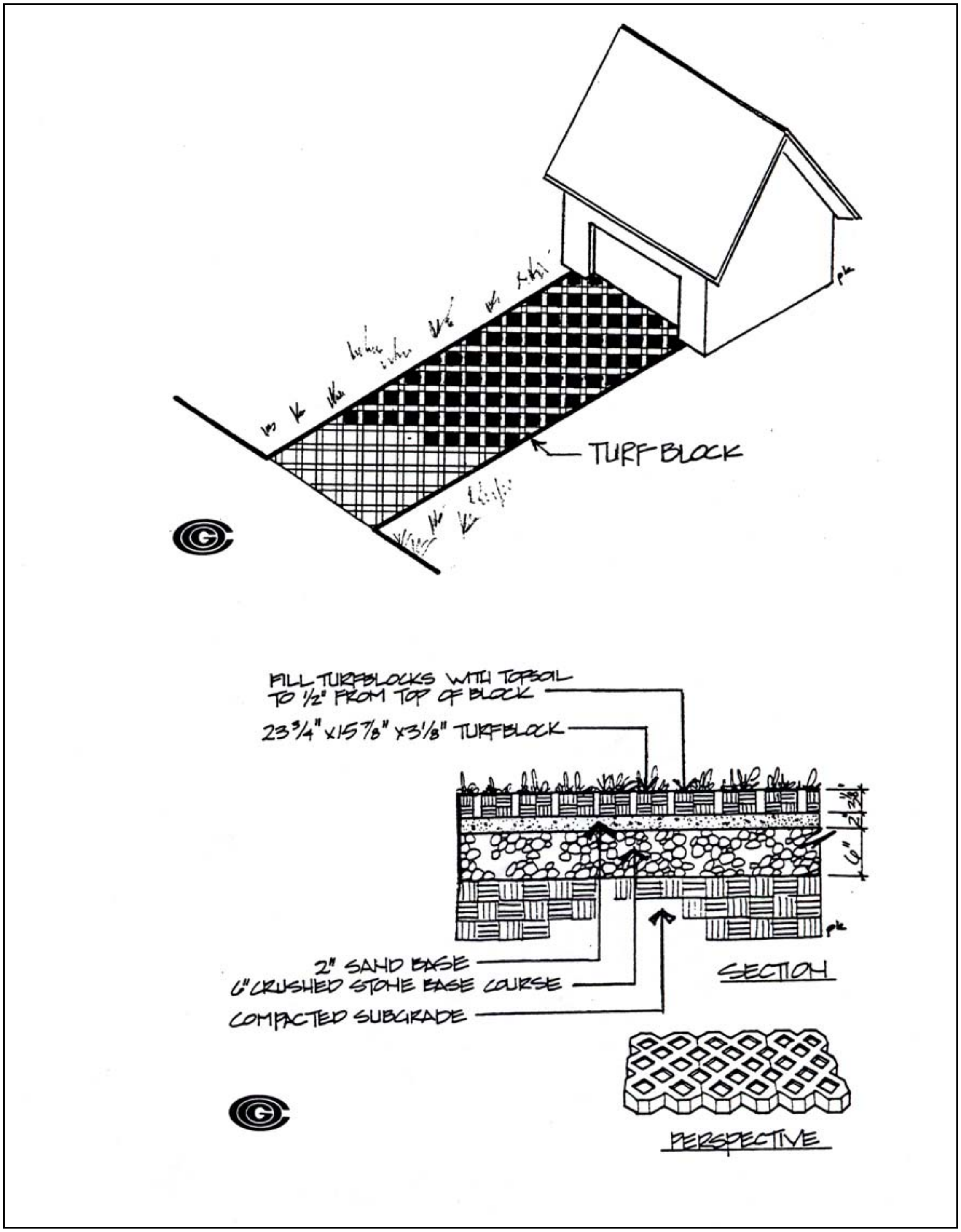


**Figure F.5 Schematic of Permeable Pavers**
(Source: Metropolitan Washington Council of Governments)

Two-Track Driveway

A two-track driveway (Figure F.6) consists of a grassy strip down the center of the driveway, with pavement on either side to accommodate traffic.

*Advantages*

- Simple application
- Reduces the amount of impervious cover

*Limitations*

- May require small amounts of maintenance including mowing

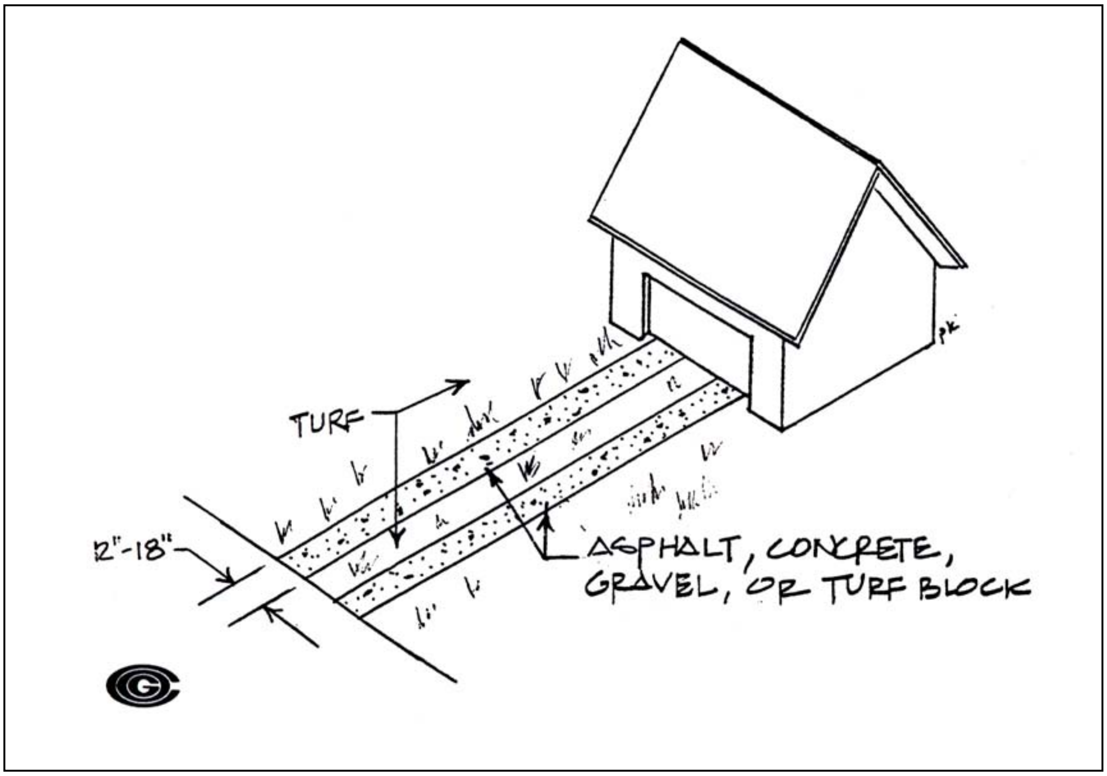


**Figure F.6 Schematic of Two-Track Driveway**

<u>Pervious Deck Design</u>
A deck can be constructed with gaps between the boards to achieve perviousness (Figure F.7). Additional elements to minimize subsequent runoff include 6 inches of gravel beneath the deck and plantings.

*Advantages*
- Simple application
- Reduces the amount of impervious cover

*Limitations*
- Plantings may require limited maintenance

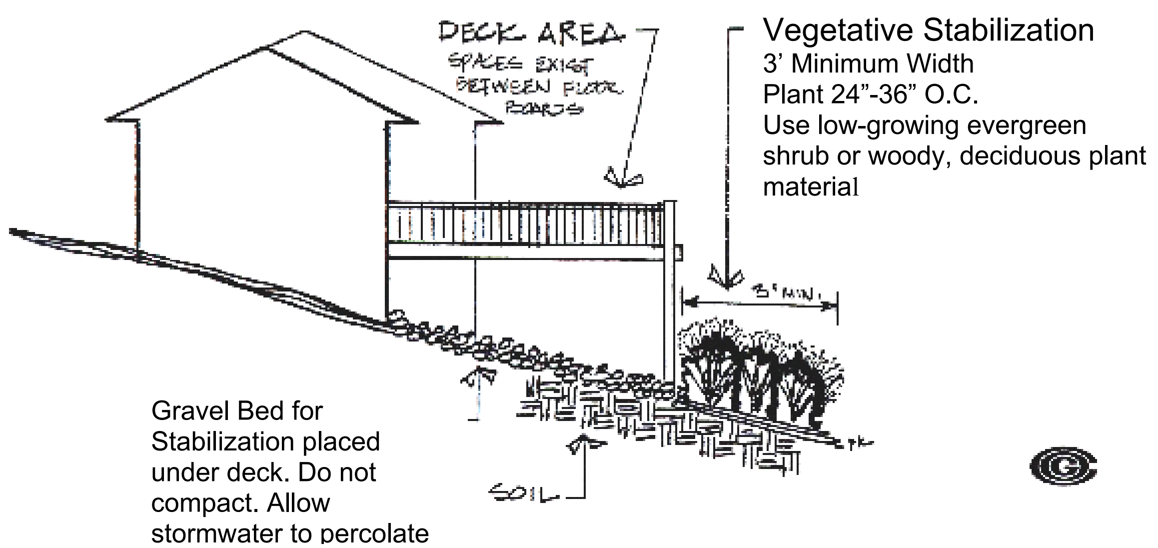


**Figure F.7 Schematic of Pervious Deck Design**

# APPENDIX G. ESTABLISHING AN OFFSET FEE BASED ON THE COST OF STORMWATER MANAGEMENT

## TECHNICAL MEMO

To: Critical Areas Commission
From: Center for Watershed Protection

Re: Establishment of an Offset Fee for a Pound of Total Phosphorus Removed

**Recommendation:** Local governments should set an offset fee to fully recover the costs of stormwater management. Estimates of the cost of stormwater management are detailed within this memo and are based on either the equivalent cost method or the stormwater retrofit method, and escalate each year based on the construction cost index provided by Engineering News Record (2003).

**Background:** Until recently, there has been limited cost data available to estimate stormwater treatment costs. Brown and Schueler (1997) evaluated actual costs for 73 stormwater facilities in the mid-Atlantic region, and developed cost equations and cost per cubic foot of water quality storage provided. This study found that the costs to construct stormwater treatment at small sites (less than five acres) were dramatically greater than larger sites. This is an important finding since our initial research indicates that the vast majority of critical area stormwater applications consist of these smaller sites.

**Developing an Offset Fee:** We provide the basis for setting an offset fee that fully recovers the cost to remove phosphorus from a one acre of impervious cover, using two different methods to estimate costs. The first method calculates the equivalent cost to construct a stormwater treatment practice on the same site, whereas the second method calculates the cost to local government to construct a stormwater retrofit on a large site elsewhere in the Critical Area.

Basic Assumptions in Both Methods

1. P loading rate for one acre of impervious cover with C= 0.3 mg/l = 2.33 pounds/year

2. Assume 45% TP removal rate for BMP applied = 1.05 pound removed per year.

*Equivalent Cost Method.* Two estimates were prepared to compute the cost of constructing an equivalent stormwater practice on the existing site.

The first estimate uses Schueler (1997) overall construction cost equations for small sites which yields a median value of $20,000 per acre of impervious area treated. This cost must be updated to account for construction cost inflation since 1996, as measured by change in

Engineering News Record's construction cost index between December 1996 and July 2003. As a result the base construction cost must be multiplied by a factor of 1.19.

Next the costs for design, engineering and permitting (DEP) must be factored in. For these costs, we rely on cost surveys by Brown and Schueler (1997), which indicate that base construction cost must be multiplied by 1.32 to account for DEP related costs.

Thus, under this estimation method, the total cost to treat one acre of impervious cover would be $31,416.00. If we divide this by the 1.05 pounds of phosphorus removed by the practice, **we get a cost of about $29,920 per pound of phosphorus removed.**

The second method used to derive the equivalent cost of stormwater treatment is to use the cost equations for actual bioretention and filter practices, which are presented in Schueler and Brown (1997). These indicate the cost for bioretention to be $6.40 per cubic foot treated and for other filters $5.00 per cubic foot treated. Using an average of the two, we get $5.70 per cubic foot of stormwater treated as construction cost. After this cost is adjusted for construction cost inflation and DEP costs (per the same methods), we get a final cost of $8.95 per cubic foot treated.

This unit cost must then be multiplied by the 3267 cubic feet of stormwater that are produced from one acre of impervious cover, per the Maryland water quality sizing criteria. This yields a total cost of about $29,234 per acre of impervious area treated. If we divide this by the 1.05 pounds of phosphorus removed by the practice, **we get a cost of about $27,842 per pound of phosphorus removed.**

Based on these two methods, **the equivalent cost of constructing stormwater practices is estimated to be about $ 29,000 per pound of phosphorus removed, exclusive of maintenance.**

*Stormwater Retrofit Cost Method*. The second way to look at offset fees is to estimate the cost to a local government to remove the same pound of phosphorus using a larger stormwater retrofit elsewhere in the community. This approach takes advantage of the economies of scale inherent when treating larger sites (e.g., 5 to 100 acres in size). Local governments who construct stormwater retrofits want to ensure that all their costs are recovered: base construction, design and engineering, retrofit inventories and construction management. For these costs, we have recent unit cost data for retrofits from Brown (2003), as follows:

| | Cost | Description |
|---|---|---|
| a | $ 1,400.00 | Pro-rated cost for subwatershed analysis/retrofit inventory cost to find candidate site |
| b | $ 3,140.00 | Design, engineering and permitting cost |
| c | $12,550.00 | Cost per impervious acre treated: average of new facility and pond modification |

| | | |
|---|---|---|
| d | $ 1,300.00 | local government cost to administer and bid retrofit assessment, design and construction (7.5% of a+b+c) |

Total: $18,390 per impervious acre treated. When divided by the 1.05 pounds of phosphorus removed by the retrofit, we get **$17,500 per pound of removed, excluding maintenance.**

**Maintenance Costs:** Both methods have neglected the cost of maintaining stormwater practices. Several municipalities suggest that any offset fee should fully recover future maintenance costs. Estimated maintenance costs are estimated to be 3 to 5% of base construction cost per year (Brown and Schueler, 1997). Using a midpoint value of 4%, and assuming the present value of a ten year stream of maintenance costs could capitalize future maintenance costs, suggests that the following additional costs should be captured in the offset fee.

*Equivalent Cost Method:*
$29,000 + 9,400 for maintenance = **$38,400 per pound of P removed**

*Stormwater Retrofit Method*
$17,500 + 5,000 for maintenance = **$22,500 per pound of P removed**