1.0 Introduction and Purpose of Manual

Title 4, Subtitle 2 of the Environment Article of Annotated Code of Maryland states that "…the management of stormwater runoff is necessary to reduce stream channel erosion, pollution, siltation and sedimentation, and local flooding, all of which have adverse impacts on the water and land resources of Maryland." The program designed in the early 1980s to address this finding of the General Assembly concentrated primarily on controlling runoff increases and mitigating water quality degradation associated with new development. The counties and municipalities in Maryland are responsible for administering effective stormwater management programs that "…maintain after development, as nearly as possible the predevelopment characteristics…" These localities have performed remarkably in establishing Maryland as a national leader in stormwater management technology. Over the last 14 years, tens of thousands of best management practices (BMPs) have been constructed in an attempt to meet program mandates. However, the experience gained since Maryland's stormwater statute was enacted has identified necessary improvements and revealed a need to refocus the approach to fulfill the original intent of this essential water pollution control program.

Recently, increased emphasis on water quality, resource protection needs, increased BMP maintenance costs, and identified shortcomings in Maryland's program have all contributed to basic philosophical changes regarding stormwater management. The "Maryland Stormwater Design Manual" is an effort to incorporate the significant experiences gained by the State's stormwater community and accommodate much needed improvements for managing urban runoff. It is hoped that the design standards and environmental incentives provided below will produce better methods and advance the science of managing stormwater by relying less on single BMPs for all development projects and more on mimicking existing hydrology through total site design policies. Additionally, the inherent philosophical change should produce smaller less obtrusive facilities that are more aesthetic and less burdensome on those responsible for long-term maintenance and performance.

The purpose of this manual is threefold:

❶ to protect the waters of the State from adverse impacts of urban stormwater runoff,

❷ to provide design guidance on the most effective planning techniques, and nonstructural and structural BMPs for development sites, and

❸ to improve the quality of BMPs that are constructed in the State, specifically with regard to performance, longevity, safety, ease of maintenance, community acceptance and environmental benefit.

The BMPs and the required design criteria below represent conventional stormwater management technology for controlling runoff from new development projects. Based upon current available research, the Maryland Department of the Environment, Water Management

Administration (MDE/WMA) has evaluated each BMP group and the associated design variants and has developed standards for each so that all perform similarly. The "General Performance Standards" outlined in this manual (see Section 1.2, page 1.13) specify those criteria that were used to create runoff control options that would perform equally. The BMPs contained in this manual are by no means exclusive. MDE encourages the development of innovative practices that meet the intent of Maryland's stormwater management law and can perform according to the standards in Section 1.2. In the future, should structural or non-structural practices be developed that meet the standards specified below, MDE will approve their use for controlling new development runoff.

MDE encourages wise, environmentally sensitive site designs to reduce the generation of runoff borne pollution. Additionally, Maryland has adopted "Smart Growth" policies that are geared toward concentrating development where it currently exists thereby reducing "suburban sprawl." Therefore, redevelopment is encouraged. A stormwater management policy for redevelopment is established in the Code of Maryland Regulations (COMAR 26.17.02). Additionally, redevelopment is defined in both COMAR and this manual.

The policy required in COMAR for redevelopment basically specifies a 50% reduction in impervious surface area below existing conditions. Because this may be impractical due to site constraints, environmental site design (ESD) practices are to be used to the maximum extent practicable (MEP) to meet the equivalent in water quality control of a 50% decrease in impervious surface area. Various alternative BMPs that do not necessarily meet the performance criteria established in this manual may be implemented for redevelopment projects provided that it is demonstrated that impervious area reduction and ESD have been implemented to the MEP. These alternative BMPs may also be implemented to satisfy the pretreatment volume requirements established in Chapter 3 below. Individual project designers should contact the appropriate approval authority for the specific practices allowed for redevelopment and pretreatment purposes.

The approval of new control technologies, modifications to the practices contained in this manual, and alternative policies regarding stormwater management for new development is the responsibility of MDE. Typically, information is submitted to the WMA that describes the policy or practice. For new BMPs, monitoring data need to be submitted that demonstrate that the performance criteria in this manual can be met. WMA then reviews this material to determine if the proposed practice is appropriate for use on new development projects. Because of local variations in ownership policies, maintenance abilities, cost, design standards, hydrology, etc., information on practices to be used for redevelopment and pretreatment should be submitted to the appropriate authority for approval.

NOTE: The Maryland Stormwater Design Manual has been revised. Changes are identified as Supplements (e.g., Supp. 1) and occur throughout the design manual. When there are conflicts between supplemental and original requirements, the newest shall supersede.

Section 1.2 General Performance Standards for Stormwater Management in Maryland

To prevent adverse impacts of stormwater runoff, the State of Maryland has developed fourteen performance standards that must be met at development sites. These standards apply to any construction activity disturbing 5,000 or more square feet of earth. The following development activities are exempt from these performance standards in Maryland:

1. Additions or modifications to existing single family structures;
2. Developments that do not disturb more than 5000 square feet of land; or
3. Agricultural land management activities.

The following performance standards shall be addressed at all sites where stormwater management is required:

*Standard No. **1*** *Site designs shall minimize the generation of stormwater and maximize pervious areas for stormwater treatment.*

*Standard No. **2*** *Stormwater runoff generated from development and discharged directly into a jurisdictional wetland or waters of the State of Maryland shall be adequately treated.*

*Standard No. **3*** *Annual groundwater recharge rates shall be maintained by promoting infiltration through the use of structural and non-structural methods. At a minimum, the annual recharge from post development site conditions shall mimic the annual recharge from pre development site conditions.*

*Standard No. **4*** *Water quality management shall be provided through the use of ennvironmental site design practices.*

*Standard No. **5*** *Structural BMPs used for new development shall be designed to remove 80% of the average annual post development total suspended solids load (TSS) and 40% of the average annual post development total phosphorous load (TP). It is presumed that a BMP complies with this performance standard if it is:*

- *sized to capture the prescribed water quality volume (WQ_v),*
- *designed according to the specific performance criteria outlined in this manual,*
- *constructed properly, and*
- *maintained regularly.*

Standard No. ***6*** *Control of the two-year and ten-year frequency storm events is required if the local authority determines that additional stormwater management is necessary because historical flooding problems exist and downstream floodplain development and conveyance system design cannot be controlled. In addition, safe conveyance of the 100-year storm event through stormwater management practices shall be provided.*

Standard No. ***7*** *To protect stream channels from degradation, the channel protection storage volume (Cp_v) shall be based on the runoff from the one-year frequency storm event. Environmental site design practices shall be used to the maximum extent practicable to address Cp_v. Any remaining Cpv requirements shall be addressed using stormwater practices described in Chapter 3.*

Standard No. ***8*** *Stormwater discharges to critical areas with sensitive resources [e.g., cold water fisheries, shellfish beds, swimming beaches, recharge areas, water supply reservoirs, Chesapeake and Atlantic Coastal Bays Critical Area (see Appendix D.4)] may be subject to additional performance criteria or may need to utilize or restrict certain BMPs.*

Standard No. ***9*** *All stormwater management practices shall have an enforceable operation and maintenance agreement to ensure the system functions as designed.*

Standard No. ***10*** *Every BMP shall have an acceptable form of water quality pretreatment.*

Standard No. ***11*** *Redevelopment, defined as any construction, alteration or improvement on sites where existing land use is commercial, industrial, institutional or multi-family residential and site impervious area exceeds 40%, is governed by special stormwater sizing criteria depending on the amount of increase or decrease in impervious area created by the redevelopment.*

Standard No. ***12*** *Certain industrial sites are required to prepare and implement a stormwater pollution prevention plan and file a notice of intent (NOI) under the provisions of Maryland's Stormwater Industrial National Pollutant Discharge Elimination System (NPDES) general permit (a list of industrial categories subject to the pollution prevention requirement can be found in Appendix D.6). The requirements for preparing and implementing a stormwater pollution prevention plan are described in the general discharge permit available from MDE and guidance can be found in the United States Environmental Protection Agency's (EPA) document entitled, "Storm Water Management for Industrial Activities, Developing Pollution Prevention Plans and Best Management Practices" (1992). The stormwater pollution prevention plan requirement applies to both existing and new industrial sites.*

Standard No. ***13*** *Stormwater discharges from land uses or activities with higher potential for pollutant loadings, defined as hotspots in Chapter 2, may require the use of specific structural BMPs and pollution prevention practices. In addition, stormwater from a hotspot land use may not be infiltrated without proper pretreatment.*

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Standard No. ***14*** *In Maryland, local governments are usually responsible for most stormwater management review authority. Therefore, prior to design, applicants should always consult with their local reviewing agency to determine if they are subject to additional stormwater design requirements. In addition, certain earth disturbances may require NPDES construction general permit coverage from MDE (see Appendix D.7).*

Section 1.3 How to Use the Manual

The Maryland Stormwater Design Manual is provided in two volumes. This *first volume* provides designers a general overview on how to size, design, select and locate BMPs at a new development site to comply with State stormwater performance standards. The *second volume* contains appendices with more detailed information on landscaping, BMP construction specifications, step-by-step BMP design examples and other assorted design tools.

Section 1.3.1 VOLUME ONE: STORMWATER MANAGEMENT CRITERIA

The first volume of the manual is organized as follows:

Chapter 1. Introduction to the Manual.

Chapter 2. Unified Stormwater Sizing Criteria. This chapter explains the five new sizing criteria for water quality, recharge, channel protection, overbank flood control, and extreme flood management in the State of Maryland. The chapter also outlines the basis for design calculations. Three step-by-step design examples are provided to familiarize the reader with the new procedures for computing storage volumes under the five sizing criteria. The chapter also briefly outlines the six groups of acceptable BMPs that can be used to meet recharge and water quality volume sizing criteria. Acceptable BMP groups are:

- Stormwater Ponds
- Stormwater Wetlands
- Infiltration Practices
- Filtering Systems
- Open Channel Practices
- Non-structural Practices

Lastly, the chapter presents a list of land uses or site activities that have been designated as "stormwater hotspots." If a development site is considered a "hotspot," it may have special requirements for pollution prevention and groundwater protection.

Chapter 3. Performance Criteria for Urban BMP Design. The third chapter presents specific performance criteria and guidelines for the design of five groups of structural BMPs. The performance criteria for each group of BMPs are based on six factors:

- General Feasibility
- Conveyance
- Pretreatment
- Treatment Geometry
- Landscaping
- Maintenance

In addition, Chapter 3 presents a series of schematic drawings to illustrate typical BMP designs.

Chapter 4. Guide to BMP Selection and Location in the State of Maryland

This chapter presents guidance on how to select the best BMP or group of practices at a new development site, as well as environmental and other factors to consider when actually locating each BMP. The chapter contains six comparative tables that evaluate BMPs from the standpoint of the following factors:

- Watershed Factors
- Terrain Factors
- Stormwater Treatment Suitability
- Physical Feasibility Factors
- Community and Environmental Factors
- Location and Permitting Factors

Chapter 4 is designed so that the reader can use the tables in a step-wise fashion to identify the most appropriate BMP or group of practices to use at a site.

Chapter 5. Environmental Site Design

The Stormwater Management Act of 2007 requires establishing a comprehensive process for stormwater management approval, implementing ESD to the MEP, and ensuring structural practices (Chapter 3) are used only where absolutely necessary. Implementing ESD not only reduces the impact of development on the environment, but also reduces the size and cost of stormwater practices needed at the site. The Chapter includes:

- Design Process and Planning Techniques
- ESD Sizing Criteria
- Alternative Surfaces
- Nonstructural and Micro-Scale Practices
- Redevelopment Design Process
- Special Criteria for Sensitive Waters

The chapter defines ESD and describes planning techniques and design requirements that are used to implement ESD and treat runoff at the source.

Section 1.3.2 VOLUME TWO: STORMWATER DESIGN APPENDICES

The second volume is provided separately and contains the technical information needed to actually design, landscape and construct a BMP. Volume Two is divided into four appendices, including:

Appendix A. Landscaping Guidance for Stormwater BMPs. Good landscaping can often be an important factor in the performance and community acceptance of many stormwater BMPs. The Landscaping Guide provides general background on how to determine the appropriate landscaping region and hydrologic zone in Maryland. Appendix A also includes tips on how to establish more functional landscapes within stormwater BMPs and contains an extensive list of trees, shrubs, ground covers, and wetland plants that can be used to develop an effective and diverse planting plan.

Appendix B. BMP Construction Specifications. Good designs only work if careful attention is paid to proper construction techniques and materials. Appendix B contains detailed specifications for constructing infiltration practices, filters, bioretention areas and open channels. In addition, Appendix B includes a copy of the NRCS Code 378 Standards and Specifications for Ponds.

Appendix C. Step-by-Step Design Examples. A series of design examples are provided in this appendix to help designers and plan reviewers better understand the new stormwater sizing criteria and design procedures. Step-by-step design examples are provided for a pond, a sand filter, an infiltration trench, a dry swale, and a bioretention area.

Appendix D. Assorted Design Tools. This appendix contains an assortment of design tools for stormwater management, including guidance on geotechnical testing, calculating water balance, documenting whether a site complies with the Chesapeake Bay Critical Area "10% Rule," NPDES stormwater permits, pollution prevention, design details, State Water Use Designations and other useful design information.

Appendix E. Archived Material and Supplemental Design Guidance. The last appendix contains material removed from Volume I of the Design Manual for historical purposes. The appendix also includes guidance material for associated with Design Manual supplements.

Section 1.4 Revising the Design Manual

The Maryland Stormwater Design Manual establishes minimum performance criteria that should be met by all techniques and devices used for stormwater management in Maryland. On occasion, variations or other techniques and devices may be found to function better or be more desirable for stormwater management by plan approval authorities. As stated above, MDE is responsible for approving the use of new techniques for controlling runoff from new development. If an approval authority decides it would like to utilize a revised technique or device on a regular basis, it needs to prepare a Standard and accompanying Specifications with a cover letter to be submitted to the MDE/WMA.

A subcommittee consisting of MDE technical personnel will review the revised technique or device and any supporting data submitted. When the technique or device is approved by the technical subcommittee, an approval authorization from the Director of WMA and the technical representative of the local approval authority will be issued. Once the revised or new technique or device has received approval it can be used on a regular basis within the jurisdiction. If other jurisdictions desire to utilize the same technique or device then they must seek approval from the technical subcommittee. A great amount of deviation from the methods within this design manual is not anticipated, but when better stormwater management can be achieved, revisions will generally be looked upon favorably.

Section 1.5 What's New?

This section highlights some of the new stormwater design requirements that are being introduced in the manual. It is provided to help designers understand how the new manual may affect how they prepare stormwater plans and practices. At most sites, designers shall now:

- Measure the amount of impervious cover created by the development.
- Determine if the proposed land use or activity at the site is designated as a "stormwater hotspot."
- Determine the Use Designation of the receiving water and the condition of the watershed.
- Provide a volume that mimics the natural rate of groundwater recharge using structural and/or nonstructural BMPs (Re_v).
- Implement ESD to the MEP to mimic predevelopment conditions.
- Follow a specific design process to implement a comprehensive site development plan.
- Provide water quality and recharge volume storage using approved ESD practices.
- Use ESD practices to the MEP to provide Cp_v storage. Any remaining Cp_v storage requirements must be addressed using approved BMP options that can meet pollutant removal targets.
- Ensure that the BMP selected meets specific performance criteria with respect to feasibility, conveyance, pretreatment, treatment, landscaping and maintenance.
- Follow new geotechnical testing procedures and provide the contractor with formal construction specifications.

- Consider where the BMP is located in relation to natural features and development infrastructure.
- Consider innovative site planning techniques that can reduce both the size and cost of stormwater practices.
- Include operation and maintenance information on approved stormwater management plans.

Section 1.6 Symbols and Acronyms

As an aid to the reader, the following table outlines the symbols and acronyms that are used throughout the text. In addition, a glossary is provided at the end of this volume that defines the terminology used in the text.

Table 1.3 Key Symbols and Acronyms Cited in Manual

A	drainage area	q_i	peak inflow discharge
A_f	filter bed area	q_o	peak outflow discharge
A_{sf}	surface area, sedimentation basin full	Q_p	overbank flood protection volume
A_{sp}	surface area, sedimentation basin partial	q_u	unit peak discharge
BMP	best management practice	q_p	water quality peak discharge
cfs	cubic feet per second	Re_v	recharge volume
Cp_v	channel protection storage volume (extended detention of the 1-year post development runoff)	R_v	volumetric runoff coefficient
CMP	corrugated metal pipe	R/W	right of way
CN	curve number	S	soil specific recharge factor
d_f	depth of filter bed	SD	separation distance
du	dwelling units	t_c	time of concentration
ED	24 hour drawdown of the water quality volume	t_f	time to drain filter bed
ESD	environmental site design	TP	total phosphorous
ESD_v	environmental site design storage volume	t_t	time of travel
f	soil infiltration rate	TR-20	Technical Release No. 20 Project Formulation-Hydrology, computer program
fps	feet per second	TR-55	Technical Release No. 55 Urban Unit Hydrology for Small Watersheds
h_f	head above filter bed	TSS	total suspended solids
HSG	hydrologic soil group	V_f	filter bed volume
Ia	initial abstraction	V_r	volume of runoff
I	percent impervious cover	V_s	volume of storage
k	coefficient of permeability	V_t	total volume
MEP	Maximum extent practicable	V_v	volume of voids
P_E	ESD rainfall target	WQ_v	water quality storage volume
P	precipitation depth	WSE	water surface elevation
Q_e	ESD runoff depth		
Q_f	extreme flood protection volume		