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MEMORANDUM

Date: April 22, 2010 (revised September, 2011)
To: Meo Curtis, Montgomery County DEP
From: Tom Schueler, Chesapeake Stormwater Network
Biohabitats, Inc.
Project: Montgomery Task Order #7 – Subtask 1
RE: Implementation Plan Guidance Document

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Introduction

The purpose of this Implementation Plan Guidance Document is to provide a common technical road map for the watershed analyses to be conducted over the next year and throughout the Permit cycle. The three specific objectives are to:

1. Detail the recommended approaches, methods, and techniques used in preparing individual watershed-based implementation plans for the County;
2. Meet the following MS4 Permit requirements:
 - Watershed restoration via runoff management;
 - Targeted waste load allocations for EPA-approved Total Maximum Daily Loads (TMDLs);
 - Trash and litter management for a trash-free Potomac;
3. Document the best available science underlying the technical assumptions used in developing the plans to allow the County to make cost-effective implementation decisions and achieve MDE regulatory approval.

The methods and technical assumptions presented in this Implementation Plan Guidance Document have been reviewed and refined by the County and the consultant team. These methods will be used to provide the best possible estimates of runoff and pollutant load reductions, and treated impervious acres based on the bundle of restoration practices proposed for each Implementation Plan.

Establishing a well thought out protocol upfront will not only improve the end result of these Implementation Plans, but will also provide a cost-effective approach to better meet, measure, document, and report achievement of regulatory endpoints. Methods that can specifically measure progress towards meeting County 20% impervious cover treatment and TMDL pollutant reduction targets, as well as showing progress for the Potomac Trash Treaty commitments will be preferred. It is recognized that this Implementation Plan Guidance Document, and more importantly the Implementation Plan Framework (a preliminary step in the development of the full Implementation Plan) must allow, document and account for variations and inconsistencies in available data and varying conditions across watersheds. Furthermore, it is recognized that not all approaches or restoration strategies presented in this Guidance Document will have applicability or be applied in the development of each Implementation Plan.

This memo is organized into six parts as outlined below to provide a unified and standard approach to watershed analysis.

Part 1: General Issues Involved in Implementing the Permit of the memo provides over-arching information on current County watershed management policies and practices that drive the planning effort. These include:

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- 1.1 Key Watershed Management Provisions in the New Stormwater NPDES Permit**
- 1.2 Defining ESD and MEP in the Context of Existing Development and Watershed Restoration**
- 1.3 Current County Watershed Management Classification**
- 1.4 Existing Watershed Plans/Studies and Resources**
- 1.5 Involving and Engaging County Stakeholders in the Watershed Process**

Part 2: Baseline Inventories and Baseline Water Quality Input Data of the memo describes the structure and content of the baseline inventories with the detailed tables provided in Appendix A. This section outlines the watersheds with current EPA-approved TMDL goals and the baseline loads established by MDE, providing a starting point for watershed restoration. In addition, this section begins to outline the process for estimating baseline loads for those watersheds which do not have baseline loads established through modeling associated with EPA approved TMDLs.

Part 3: Pollutant Load Reduction Estimation of the memo includes a unified modeling approach, subject to data variability. This part also presents standard methods for conducting desktop BMP coverage, with a special analysis of BMP performance in the County BMP inventory. It also outlines an alternative method to evaluate the effect of ESD practices on runoff reduction.

Part 4: Restoration Practices of the memo outlines the 13 different restoration practices that will be evaluated for each watershed.

Part 5: Evaluating Impact of Restoration Practice Implementation in Watersheds of the memo outlines how the Watershed Treatment Model (WTM) will be used to evaluate the impact of various levels of restoration implementation, in relation to the baseline load and the treatment and/or load reduction benchmarks for each watershed.

Part 6: Process for Defining Outcomes and Tracking Progress of the memo outlines the process for defining outcomes and tracking progress in each of the implementation plans.

Five appendices are included as follows:

Appendix A - Acronyms, Units Abbreviations and Consolidation References

Appendix B – Modeling Framework

Appendix C - GIS Steps for Processing Montgomery County Data

Appendix D – Baseline Inventory Template

Appendix E – Trash Reduction Strategies

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Part 1: General Issues Involved in Implementing the Permit

1.1 Key Watershed Management Provisions in the New Stormwater NPDES Permit

The Implementation Plan development is geared toward quantitatively demonstrating how the County can meet the requirements of the County's third-round National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit. Specifically, these plans must meet the requirements of the three permit sections described below.

Watershed Restoration (Permit Section III.G)

The permit requires that the County restore an additional 20% of the total untreated impervious acres to the MEP on a countywide basis during the five year permit cycle. Initial estimates supplied by the County indicate that this will involve about 4,100 acres of impervious area Countywide (or about 6.4 square miles) (MS4_Impervious 2009_V2.xls). Some portion of this area is already programmed for retrofitting or other restoration practice in the County CIP budget. The balance will need to be managed by new restoration practices identified through the Implementation Plans.

Each Implementation Plan will seek the 20% implementation rate for uncontrolled impervious surface within that watershed grouping. However it is recognized that the percentage for likely restoration will vary based on feasibility, cost, and existing development intensity. Each Implementation Plan will begin with already programmed retrofit projects in their watershed based on the watershed baseline inventory from Part 2 of this Guidance. The team will then evaluate the need and type of practice(s) necessary to meet any additional impervious acreage, as identified during the desktop analysis of restoration practices and management measures described in Part 5 of this Guidance.

Some projects like reforestation and compost amendments cannot be quantified in terms of impervious acres treated. The proposed solution for these projects is to consider them as equivalent impervious area using correlations and justifications from available literature and studies. More detail on the assumptions used for these correlations is provided in Appendix B.

TMDLs in the Context of the Permit (Permit Section III.J)

The NPDES permit requires that the County reduce non-point pollutant discharge to impaired waters below the waste load allocations (WLAs) to meet water quality standards for watersheds where TMDLs have been developed. The strategy is to control nonpoint source pollution by implementing BMPs through voluntary or mandatory programs for enforcement, technical assistance, financial assistance, education, training, technology transfer, and demonstration projects. A quantitative analysis is used to show reasonable assurance that progress is made towards achieving these WLAs. In addition, each

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Implementation Plan will outline an effective monitoring program for demonstration of compliance with nonpoint source pollutant reduction. In those watersheds for which EPA-approved TMDLs exist, a four-step analysis will be followed, based on EPA 2007 guidance.

- Step 1. Obtain baseline urban (i.e., MS4) stormwater loads from MDE for Pollutant of Concern for the targeted watershed
- Step 2. Provide a specific list of BMPs that will be applied in the listed watershed
- Step 3. Estimate the pollutant removal capability of the individual BMPs applied
- Step 4. Compute the aggregate pollutant reduction achieved under this MS4 process for the watershed

The basic process in each TMDL watershed is to determine/document the mass loading which must be reduced to meet the EPA-approved WLA for the pollutant(s) of concern.

Next, a determination is made of load reductions achieved through projected implementation strategies for that pollutant, beginning with the watershed baseline run (which computes load reductions with existing programmed projects). The model proposed for this process is the Watershed Treatment Model (WTM) developed by the Center for Watershed Protection (CWP). Then the consultant team will evaluate groups of restoration practices that maximize removal of the pollutant of concern and determine whether the WLA can be achieved through targeted treatable areas, based on a reasonable rate of practice delivery over the first five year permit cycle. In the event that the WLA cannot be met, additional analysis will be required to determine additional pollutant reductions that can be achieved in the second permit cycle, and a corresponding implementation schedule will be prepared.

Potomac Trash Treaty (Permit Part III.E.4)

The permit specifies that the County show progress towards the commitments in the Potomac River Watershed Trash Treaty and Watershed Initiative 2006 Action Agreement. The County must develop a baseline trash reduction strategy and work plan with timelines for implementation for the Anacostia watershed within Montgomery County within one year of permit issuance. For the rest of the Potomac watershed, the County must identify trash and litter reduction measures that are being implemented towards the goal of a Trash Free Potomac by the year 2013.

The consultant team will develop a conceptual model for addressing the trash generation, prevention and control issues, using the data available for the Anacostia where deemed applicable to the rest of the Potomac. For the Anacostia, the EPA intends to complete a Trash TMDL by early 2010 which will specify WLAs by source in the watershed. The consultant team will apply a simple trash reduction analysis method as presented in Appendix E to assess trash management strategies in individual watersheds.

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It is likely that many policy responses will be needed to reduce trash generation such as bottle deposits, plastic bag bans, education measures and other practices. The team will consider policy and nonstructural BMPs for inclusion in the trash reduction and tracking model.

1.2 Defining ESD in the Context of Existing Development and Watershed Restoration

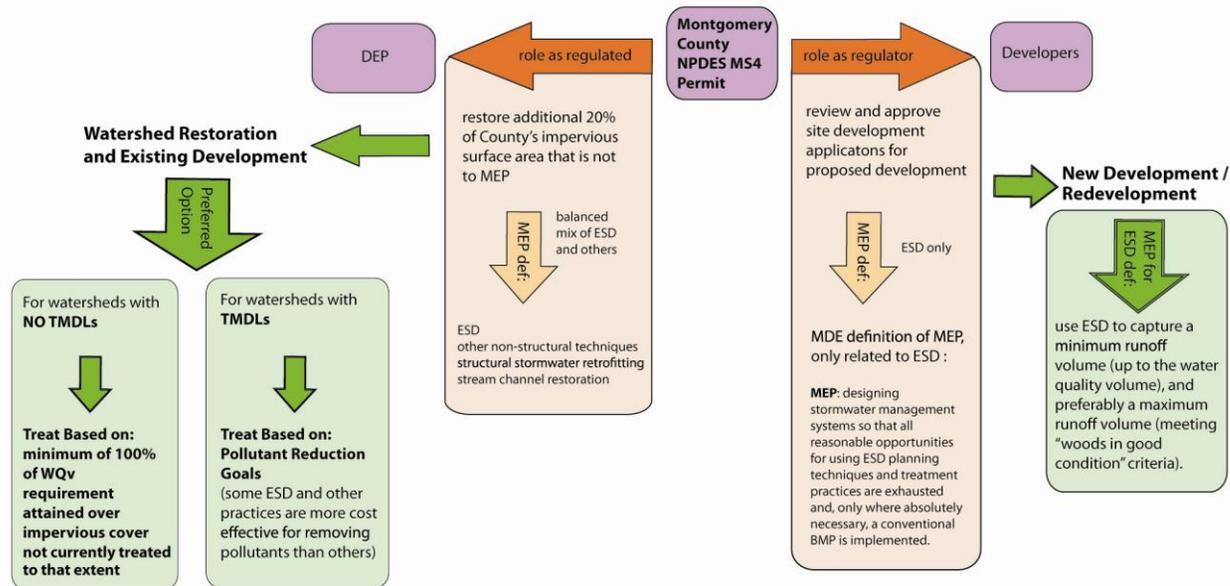
Under the MS4 permit, the County is required to complete the implementation of restoration of a watershed, or combination of watersheds, to restore an additional twenty percent of the County's impervious surface area that is not restored to the MEP. In this context, the County is a *regulated entity*. Figure 1 below provides an overview of the definition and process of MEP and ESD for the Montgomery County NPDES MS4 Permit.

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Figure 1.1 Overview of the definition and process of MEP and ESD for the Montgomery County NPDES MS4 Permit

Definition and Process of Maximum Extent Possible (MEP) and Environmental Site Design (ESD) for the Montgomery County NPDES MS4 Permit



Notes and definitions (from MDE):

Maximum Extent Possible (MEP): definition varies

Environmental Site Design (ESD): using small-scale stormwater management practices, non-structural techniques, and better site planning to mimic natural hydrologic runoff characteristics and minimize the impact on land development on water resources. These include: reducing impervious cover, better site design, green roofs, permeable pavers, reinforced turf, disconnection of rooftop runoff, disconnection of non-rooftop runoff, sheetflow to conservation areas, rainwater harvesting, submerged gravel wetlands, landscape infiltration, infiltration berms, dry wells, micro-bioretenion, rain gardens, swales, and enhanced filters.

Total Maximum Daily Load (TMDL): establishes the maximum amount of an impairing substance or stressor that a waterbody can assimilate and still meet WQSs and allocates that load among pollution contributors. TMDLs are a tool for implementing State water quality standards. They are based on the relationship between pollution sources and in-stream water quality conditions. A TMDL addresses a single pollutant or stressor for each waterbody.

Water Quality Volume (WQv): volume needed to capture and treat the runoff from 90% of the average annual rainfall; equivalent to 1 inch of rainfall x volumetric runoff coefficient (Rv) x site area; minimum volume of 0.2 inches/acre used for sites where imperviousness < 15%; WQv is directly related to site imperviousness; WQv may be reduced using environmentally-friendly nonstructural techniques; WQv is treated using BMPs capable of meeting pollutant removal goals of 80% total suspended solids (TSS) and 40% total phosphorus (TP).

The Environmental Protection Agency's (EPA) National Pollutant Discharge Elimination System (NPDES): first published in 1990, phase I of these regulations required stormwater permits for 11 categories of industrial activity and certain size municipal separate storm sewer systems. The individual five-year permits under Phase I of NPDES require that "large" (populations greater than 250,000) and "medium" (populations greater than 100,000) municipalities establish and maintain comprehensive programs to reduce storm drain system pollution. Phase II municipal stormwater regulations followed in 1999 and established obligations for small storm drain system owners within urbanized areas not covered previously. Phase II in Maryland is addressed through general stormwater discharge permits that specify that basic runoff control programs be implemented.

Municipal Separate Storm Sewer System (MS4): an MS4 is a system of conveyances that include catch basins, curbs, gutters, ditches, man-made channels, pipes, tunnels, or storm drains that discharges into waters of the United States. An MS4 moves water away from an area to a local water body. (Source: Township of Harbor Creek. <http://www.harborcreektownship.org/ms4.htm>).

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Currently, MDE defines ESD as the use of small-scale stormwater management practices, nonstructural techniques, and better site planning to mimic natural hydrologic cycling of rainwater and minimize the impact of land development on water resources. ESD practices include nonstructural techniques such as optimizing conservation of natural resources and minimizing impervious surfaces. The structural practices of ESD are designed as micro-scale controls which capture and treat runoff close to the source. Applicable practices include: alternative surfaces (green roofs, permeable pavements, reinforced turf), non-structural practices (impervious surface disconnection and non-concentrated sheetflow), and micro-scale practices (rainwater harvesting, submerged gravel wetlands, landscape infiltration, infiltration berms, dry wells, micro-bioretenion, rain gardens, swales, and enhanced filters).

The scale of ESD practices are small and site specific, while the goals of the Implementation Plan are countywide. The County has a well established watershed planning and assessment program that has been conducted at a scale to meet MS4 permit requirements. The term watershed is used for major County watershed groupings (Figure 1.2), including Anacostia, Rock Creek, Cabin John, Seneca Creek, Potomac Direct, Lower Monocacy, and Patuxent. The consultant team proposes continued use of the major watershed scale for the purposes of pollutant and stormwater runoff and management modeling.

The County uses the term subwatershed in its stream protection strategy which is typically based on smaller drainage areas (from less than one square mile to 5 square miles) with more homogeneous land uses. The County has begun moving towards developing restoration implementation plans based on smaller watershed scales as required for the watershed restoration assessment element of the MS4 permit. Implementing projects based on restoring smaller drainage areas increases the likelihood of detecting water chemistry and in-stream changes within the MS4 permit cycle. Results can then be extrapolated to larger watershed scales.

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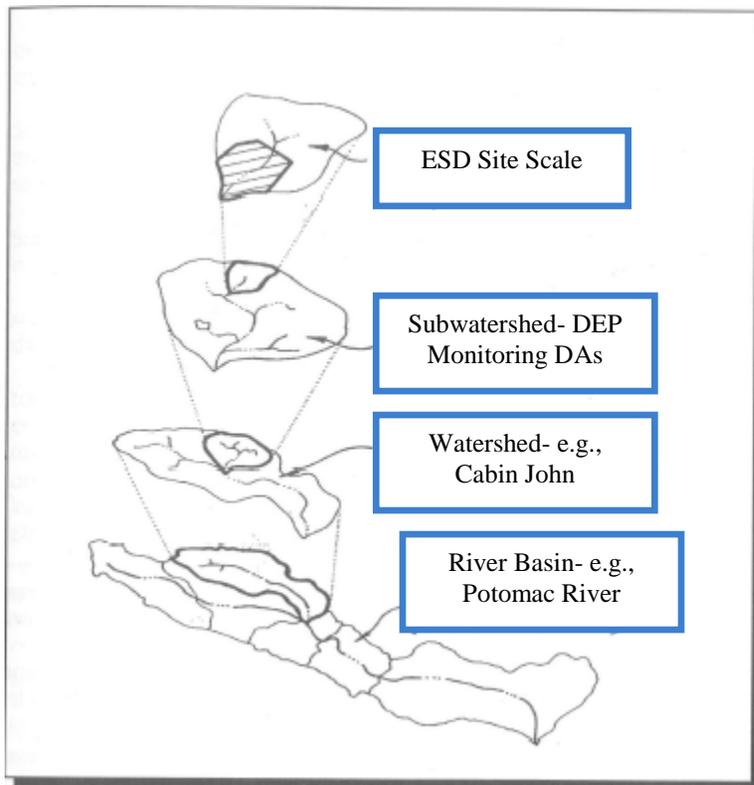


Figure 1.2: Watershed scales- adapted from CWP, 1998. Acronyms stand for Environmental Site Design (ESD), Department of Environmental Protection (DEP), and Drainage Areas (DA).

The framework in this guidance document for the watershed-based implementation plans includes how to identify data needs and set priorities based on nested drainage area scales (large to small) and available data at each scale. The watershed groupings will provide management and restoration priorities based on the MS4 permit requirements. Existing and planned BMPs will be identified and then biological and physical habitat data collected at the smaller drainage area scales will be used to set priorities for implementation outside of areas covered by planned restoration and retrofit BMPs. Some watersheds, like the Anacostia, have well-defined data collection, structural, and ESD project inventories on a subwatershed basis while others, like the Patuxent, lack this level of detail.

Due to the new permit specifically requiring 20% watershed restoration during this permit cycle, there must be more flexibility in the priority placed on using ESD practices in meeting this requirement. The set of available ESD practices is smaller than the set of restoration practices available and usually the impervious acreage treated for retrofit situations is small compared to that treated by more conventional structural practices. Some ESD practices like green roofs and soil compost amendments can significantly reduce runoff volumes but are less effective at reducing pollutant concentrations.

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Traditional retrofit practices have varying flow reduction combined with pollutant reduction capabilities. Bioretention and biofiltration practices are characterized as structural (i.e. non-ESD) by MDE, but should be considered under 'ESD' approaches since vegetated treatment and relatively small drainage areas are treated. In fact, for the purpose of the development of the Implementation Plans, the term ESD has a broader definition than the more narrow MDE definition. Specifically, we present ESD as encompassing practices that are also thought of as Low Impact Development (LID) practices that provide the same distributed treatment using filtering, infiltration, and vegetative uptake processes for water quality treatment. Drainage areas to these practices are still limited but not always to the "micro" extent that MDE specifies in the Stormwater Design Manual.

As presented, some non-ESD restoration practices may prove to be more cost-effective. This is particularly the case when considering that many of the most cost-effective watershed restoration strategies involve retrofitting existing stormwater management facilities to provide enhanced pollutant load reduction capabilities. Consequently, it makes more sense to consider a wider range of restoration practices and a more narrow ESD definition for impaired watersheds or watersheds where trash reduction is the primary management objective.

The County's preferred restoration strategy to treat 20% of the inadequately treated impervious surface consists of a balanced mix of ESD and non-ESD restoration practices, linked to opportunities that are known to exist and building on existing watershed restoration plans (e.g., Sligo Creek, Rock Creek, etc.). Specifically, the County's preferred restoration strategy consists of the following key elements:

- Major repairs to existing stormwater management facilities;
- Construction of retrofits identified as priorities in current County inventories;
- Targeted ESD retrofits of County owned buildings;
- Targeted ESD retrofits of County roads;
- Targeted ESD retrofits of County schools;
- Voluntary programs and educational efforts targeting pollutants of concern (e.g., nutrients, bacteria, and trash).

Based on the above considerations, we recommend the County consider the following approach to defining MEP for meeting watershed restoration requirements under the new County MS4 permit.

1. For watersheds with no EPA-approved TMDLs, the team will place emphasis on restoration of biological impairments, trash removal, and high-quality waters conservation. The following operating design criteria will be applied:

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- First, identify acreages currently controlled or planned for control. The goal for the remaining existing developed land in the County (i.e., existing impervious cover) would be 100% of the WQv (which is more stringent than the MDE requirement for re-development) attained in aggregate over 20% of the impervious cover in the County using both ESD, targeted repairs, and major retrofits. In the event that this requirement cannot be met within a watershed, the consultant team will substitute retrofits, stream restoration, or other practices identified in County watershed studies and restoration management plans.
 - As part of this, the list of ESD practices or acceptable restoration practices can be expanded to include a wider range of appropriate strategies. An equivalency system may be necessary to equate treatment volumes of conventionally sized stormwater BMPs (i.e., practices where accepted sizing is established in design manuals or other literature sources) to other practices such as stream restoration or nutrient education. Restoration goals will target non-TMDL impairments identified and located giving consideration of available information including DEP's biomonitoring studies, illegal dumping and citizen complaint logs, and conservation areas.
2. For watersheds where there are EPA-approved TMDLs, the operating design criteria is to target practices that provide the best cost/benefit in terms of mass loading reduction as priority strategies. Load reductions need to be attached to a design criteria for sizing of practices, and under this approach for TMDL waters, it is proposed that the full WQv (1-inch rainfall) be targeted as required by MDE for new development. This can be done more easily for waters listed for nutrients and sediment. It is more problematic for bacteria and trash. For bacteria and trash impaired waters, a list of acceptable or preferred practices will be identified along with appropriate sizing approaches (see Appendix B).
 3. Results from available monitoring data will be considered in setting target areas for implementation. The countywide monitoring program uses biologically-based indices to track improvements in watershed and stream health over time. However, these indices cannot be directly tied back to nutrient, bacteria, or sediment TMDL wasteload allocation compliance. The Implementation Plans will include recommendations for tracking progress towards meeting TMDL wasteload allocations as well as documenting changes in countywide stream resource conditions. The approach used for countywide watershed management is defined in Section 1.3 below.

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1.3 County Watershed Management Classification and Objectives

Montgomery County has a long history of watershed management and environmental restoration. The County has outlined key watershed restoration goals in the updated Countywide Stream Protection Strategy (MCDEP, 2003). These goals include:

- Restore County streams damaged by inadequate management practices in the past, by re-establishing the flow regime, chemistry, physical conditions, and biological diversity of natural stream systems as closely as possible.
- Explore opportunities to lessen unintended, adverse environmental impacts of land development on water resources
- Reduce nonpoint runoff sources and air deposition sources of nitrogen impacting local streams and the Chesapeake Bay
- Target and reduce general runoff pollution loadings from runoff draining intensively developed urban/suburban areas, while also providing other important cross-media environmental benefits.
- Promote and support new outreach initiatives that enhance public awareness and increase citizen participation in environmental stewardship
- Develop and implement a comprehensive approach for assessing environmental quality that integrates information on terrestrial, wetland and stream conditions
- Continue producing an enhanced, accurate, understandable, watershed-based assessment of county stream conditions

These goals will be considered as individual watershed implementation plans are developed, particularly the strong focus on stream assessment, restoration and management. Table 1.1 summarizes the management status and impairments by watershed groupings that must be considered during the development of the Implementation Plans.

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Table 1.1. Management Phase and Impairments by Watershed Grouping

Watershed Grouping	Subwatershed	Management Phase (Current in bold)	TMDLs (Approval Date)	Impairments (First Listed)	Conservation
Anacostia		Restoration Plan (2009) Implementation	Bacteria (2007) Sediment (2007) Nutrients (2008) Trash (2010)	Heptachlor Epoxide (2002) PCBs (2002) Biological (2006)	
	Paint Branch	Upper Assessment (1997) Lower Assessment (2006)			Paint Branch SPA
	Little Paint Branch				
	Northwest Branch	Assessment (2000)			
	Sligo Creek	Action Plan (2009)			
Rock Creek		Assessment (2001) Action Plan (2001) Implementation	Bacteria (2007)	Phosphorus (1996) TSS (1996) Biological (2002)	Upper Rock Creek SPA
Cabin John Creek		Assessment (2004) Implementation	Bacteria (2007)	TSS (1996) Phosphorus (1996) Biological (2006)	
Seneca Creek				Phosphorus (1996) TSS (1996) Biological (2006)	

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Watershed Grouping	Subwatershed	Management Phase (Current in bold)	TMDLs (Approval Date)	Impairments (First Listed)	Conservation
	Great Seneca Creek (including Clopper Lake)	Draft Assessment (2009) Implementation	Clopper Lake : Phosphorus and Sediment (2002)		Clarksburg SPA & Tier II Stream Segment (Goshen Run)
	Dry Seneca and Little Seneca	Pre-Assessment			Clarksburg SPA
Lower Monocacy		Implementation	Fecal Bacteria (2009) Sediment (2009)	Nutrients (TMDL 2010) Phosphorus (1996) Biological (2002)	
Upper Potomac Direct		Pre-Assessment		Phosphorus (1996) TSS (1996) Biological (2006) PCBs in Fish Tissue (2008)	
Lower Potomac Direct		Implementation		Phosphorus (1996) TSS (1996) Biological (2006) PCBs in Fish Tissue (2008)	
	Muddy Branch				
	Watts Branch	Assessment (2006)			Piney Branch SPA
	All other subwatersheds	Pre-Assessment			
Patuxent		Pre-Assessment & Draft Implementation		Biological (2004)	

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Watershed Grouping	Subwatershed	Management Phase (Current in bold)	TMDLs (Approval Date)	Impairments (First Listed)	Conservation
	Rocky Gorge Reservoir		Phosphorus (2008)		
	Hawlings River	Assessment (2003) Action Plan (2003) Implementation			
	Triadelphia Reservoir	Pre-Assessment & Draft Implementation	Phosphorus and Sediment (2008)		Tier II Stream Segment
Sources: http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/Sumittals/ http://www.mde.state.md.us/Water/HB1141/Map_WQ_MontgomeryCo.asp MDE 2008 Integrated Report (combined 303(d) List and 305b Report)					

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As a consequence of its long history of stream monitoring, the County has developed extensive data on the relationship between subwatershed metrics, such as impervious cover, and indices of stream health using fish, benthic and habitat. Consequently, each DEP biomonitoring station defines a smaller subwatershed formed by its drainage area. These subwatersheds are assigned to a management category based upon review of stream conditions, existing watershed development, and projected land use changes. The management categories are: *Watershed Preservation Area*, *Watershed Protection Area*, *Watershed Restoration Area*, *Urban Watershed Management Area*, and *Agricultural Watershed Management Area*.

The subwatershed management categories will be considered in setting priorities for implementation within the watershed groupings. The Implementation Plans will require that, in addition to meeting the MS4 permit requirements for restoration and WLAs, stream resources be protected and preserved in higher quality streams. Indeed, trends in stream conditions over time at this smaller scale will be the best environmental indicator of progress made in restoration.

1.4 Existing Watershed Plans/Studies and Resources

Existing watershed plans and available studies will be reviewed to characterize each watershed and to begin to develop baseline inventories. In addition, GIS data review will evaluate available data for each watershed grouping. Particular emphasis to be placed on impervious cover (IC) layers (type), BMPs (type and drainage area, where available), past and future restoration projects, monitoring sites, and land use (public versus private). Available reports identified for each watershed grouping are presented in Table 1.2 below. For each watershed group, a profile as shown in Table 1.3 will be completed. Collectively, the watershed grouping metrics development process will provide for a degree of quality control and comparison across all watersheds. It will also facilitate decisions on how to modify some of the assessment methods and generate some initial concepts on most feasible restoration practices for a given watershed grouping.

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Table 1.2. Reports to be used in the development of baseline inventories by watershed grouping

Watershed Grouping	Report
Anacostia	Anacostia Watershed Restoration Plan Interim Report Framework – November 2008
Rock Creek	Rock Creek Feasibility Study – April, 2001 Rock Creek Watershed Restoration Action Plan – July, 2001
Cabin John Creek	Cabin John Creek (& Minnehaha Branch) Watershed Study – February 2004
Lower Potomac Direct – Muddy Branch	Great Seneca Muddy Branch Read Ahead Materials Report (Feb 2009) and Appendix
Lower Potomac Direct – Watts Branch	2006 Watts Branch Watershed Restoration Study
Seneca Creek – Great Seneca	Great Seneca Muddy Branch Read Ahead Materials Report (Feb 2009) and Appendix
Patuxent- Hawlings River	Hawlings River Watershed Restoration Study (2003) Hawlings River Watershed Restoration Action Plan – February 2003
Lower Monocacy	Lower Monocacy Watershed Restoration Action Strategy – May, 2004 (does not include Montgomery County)
Other:	<p>NPDES Reports: Montgomery County Annual NPDES MS4 Permit Reports (1997-2006) NPDES Water Chemistry Monitoring in Lower Paint Branch Watershed (2008) MDE 2008 Integrated Report (combined 303(d) list and 305b Report)</p> <p>County reports: Countywide Stream Protection Strategy (2003) Infiltration and Filtration Practices: Definition and Nutrient and Sediment Reduction Effectiveness Estimates (2008) Montgomery County DEP Task Order 13- Low Impact Design Inventory of Publicly-owned Facilities (2007) Montgomery County 2007 Resident Survey Final Report of Results (2007)</p> <p>SPA: Special Protection Area Program Annual Reports (1998-2008)</p>

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Table 1.3. County Watershed Profile Example

Watershed Metric	Total
Total Watershed Acres	To Be Determined (TBD)
Impervious Cover (acres & %)	TBD
Non-exempt County Acres¹	TBD
Non-exempt County IC (acres & %)¹	TBD
Previously Identified Project IC Treatment²	TBD
IC Treatment Goal (acres)³	TBD
Forest Cover (acres & %)⁴	TBD
Pervious Cover (acres & %)⁵	TBD
Stream miles⁶	TBD
Stream miles restored⁷	TBD

¹ Excluded areas include Gaithersburg, Rockville, Takoma Park, rural zoning, all MNCPPC parks, Federal and State property, and Federal and State roads from GIS data layer ALLEXCLUSIONwFEDSTATERRD.shp

² Projects include previous watershed restoration plans, action plans, Capital Improvement Projects (CIP)

³ 20% of untreated, non-exempt county IC

⁴ Derived from Forest2008 shapefile (County digitized forest from 2008 aerial photography)

⁵ Remainder of Jurisdictional area minus IC and FC area

⁶ Derived from Hydro_line.shp

⁷ Derived from Restoration_Sites_Export.shp

Table 1.3 data will also be supplemented with additional information such as the following, where available:

- What are primary management objective(s) and regulatory drivers?
- Have load reductions been modeled? Using what model, for which pollutants? What are the practice removal estimates used?
- Where and how many hotspots exist, where hotspots are land uses that exhibit a tendency to have higher pollutant loadings (see Appendix B for more detail)?
- Locations and ownership of publicly owned acres.
- Is there a list of potential restoration projects and have restoration project costs been identified for these projects?
- County IBI scores - expressed by subwatershed or stream miles.
- Brief narrative of past monitoring data and management efforts in watershed.
- Key watershed-specific stakeholders, and some general demographic data.

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1.5 Involving and Engaging County Stakeholders in the Watershed Process

As the Implementation Plans will be derived solely from existing watershed information without field verification, limiting insight into current conditions, this leads to increased reliance on local stakeholder participation/knowledge, which has a strong history in the County. Some of the unique aspects and demographics of County stakeholders are described in Appendix B, part 6. The ensuing section outlines some key stakeholder strategies to keep in mind when preparing individual watershed plans

Montgomery County is a combination of rural, urban, and suburban landscapes. Each landscape offers different outreach opportunities and has unique stewardship challenges. Each landscape also has its own pool of stakeholders. The consultant team will develop implementation plans taking this diversity into consideration both in the method of reaching out to stakeholders and in the stewardship activities stakeholders are encouraged to undertake.

Because of the massive stewardship responsibilities associated with protecting the Potomac and Anacostia watersheds – feeding the two rivers that run through the United States capital -- Montgomery County has a unique pool of approximately 23 “friends of” and watershed protection organizations. Those groups have membership from individuals as well as businesses in the county. In addition, the Montgomery Soil Conservation District maintains contact with farming businesses in the county. Municipal governments and homeowners associations are also well organized in Montgomery County as compared to other Maryland counties. There are also a variety of active business organizations in Montgomery County that serve as the voice of businesses on multiple issues. There are also State and Federal property owners whose involvement in implementation efforts will be encouraged. To target implementation plan stewardship activities for each of these stakeholder groups, the consultant team will conduct quick web-site analyses to list key issues and concerns and to assess awareness of the issues addressed in the implementation plans. The team will actively pursue partnerships for information dissemination through avenues such as Montgomery County’s outstanding school system, multiple higher-learning institutions, and other academic assets such as the National Institutes of Health.

Relying on previous outreach efforts will also guide stakeholder involvement with implementation plan development and application. Where there are existing watershed management plans, previous outreach activities will be taken into consideration so that stakeholder involvement efforts are really “second generation” efforts. The team acknowledges and plans to build upon accomplishments of ongoing outreach. A good example can be found in ongoing efforts such as the Rainscapes program and parks programs targeting tree canopy rebates. The team will further target these programs in the implementation plans and augment by additional stakeholder involvement activities responsive to changes in stewardship behaviors since their implementation.

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In the course of developing Montgomery County's watershed plans in the past, stakeholder involvement activities have identified several repeating stewardship practices that can be used as over-arching themes in stewardship education – thus unifying the individual watershed implementation plans. In addition, recent national trends and the apparent popularity of “going green” drive the likely acceptance of these guiding principles as unifying themes.

- One of these generally accepted principles is that trash should not be left in Montgomery County streams. Multiple well-attended clean up days throughout the year and the Anacostia River Trash Treaty are among the activities that support this principle.
- A second generally accepted principle is that riparian buffer protection and enlargement is necessary. Multiple county watershed plans support that statement. Existing state and county stewardship programs encourage buffer protection and enlargement. Numerous volunteer-led tree plantings throughout the County support it.
- A third generally accepted principle is that stormwater management on individual properties is needed. This is evidenced by the County's implementation of its Rainscapes program and the clear resident demand for and interest in the program.
- A fourth generally accepted principle is that agricultural properties should apply BMPs. Montgomery County is unique not only for its agricultural component but more for its large-lot hobby farms. BMP implementation is widely supported by the agricultural community and is tracked and encouraged by the Soil Conservation District.

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Part 2: Creating Baseline Inventories and Baseline Water Quality Input Data

Baseline inventories are to be populated by available information provided in existing reports, and desktop GIS analysis toward the development of the watershed metrics and water quality model input data. These inventories will generally be comprised of the content presented in Appendix D Baseline Inventory Template of this document and based on Chapter 4 of the Anacostia Interim Report: Sligo Creek Subwatershed Action Plan.

Implementation plan consultant teams will prepare baseline watershed inventories for their respective watershed groupings, compiling all the available pertinent data for modeling. The data will be used to compute a baseline estimate of current pollutant loading and runoff volume. The suggested 12 step process is used to pre-process the County GIS database for each watershed to provide quality inputs to the WTM.

Step 1: Identify watershed and jurisdictional area using County GIS data.

Step 2: Partition land cover and land use by area for each watershed using the Maryland Department of Planning (MDP) 2002 land use/land cover spatial data as displayed in Table 2.1.

Step 3: Partition impervious, forest, and pervious cover per watershed. Develop attribute layers for each watershed impervious cover including roads, parking lots, roofs, driveways, sidewalks; forest, and turf. Partition turf cover in residential land use category using the non-impervious and non-forested areas. Compare with the assumed percentages of turf cover presented in Table B.3 in Appendix B and classify as high input or low input (assume 50% distribution).

Step 4: Partition Commercial and Industrial areas into high and low potential hotspots, based on an analysis of the WQ complaint database and illegal dumping site locations. Use designated property and parcel area land use overlaid with the complaint databases to distribute commercial and industrial areas into hotspot and not.

Step 5: Partition soils data by hydrologic soil group based on 2002 SSURGO Soils data from NRCS.

Step 6: Estimate total stream length using the HYDRO_LINE County Database, with the following expression:

$$TotalStreamLength = SingleLineStream + HiddenHydro + \frac{River / Stream}{2}$$

Step 7: Identify DEP biomonitoring subwatershed areas within the watershed of interest. Partition stream miles per subwatershed by IBI score metrics.

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Step 8: Review current BMP coverage. Partition and map stormwater BMP and retrofit location and storm drainage attributes data, including type of facility, year constructed and drainage area. Code the performance of BMPs following the methods in Appendix B, Section 3.

Step 9: Create summary tables including:

- General watershed land cover/land use and stream length
- Breakdown of impervious cover, turf cover, and forest cover associated with county-owned property

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TABLE 2.1: Land use/land cover partitioning methodology

<u>Primary Source Land Use</u>	<u>Subuse Designation</u>	<u>2002 MdOP Land Use/Land Cover Code</u>	<u>Assumptions</u>
Residential-High and Low Input Turf	Low Density (<1 du/acre)	11 Low Density Residential	Residential split 50/50 into high and low input turf
	Medium Density (1-4 du/acre)	12 Medium Density Residential	
	High Density (>4 du/acre)	13 High Density Residential	
Commercial	HOTSPOT and NOT	14 Commercial	Split based on WQ complaint database
Industrial	HOTSPOT and NOT	15 Industrial and 16 Extractive	Split based on WQ complaint database
Roadway	Curb to Curb	N/A	Roadway spatial data from County Impervious MS4 Database
Forest	Forest	192 Large Lot Subdivision and 40 Forest	
Rural	Rural	191 Large Lot Subdivision and 20 Agriculture	
Municipal/Institutional	Intensive	16 Institutional	Churches, schools, and municipal buildings
	Extensive	18 Open Urban Land	Parks, cemeteries, and golf courses
Open Water		50 Water and 60 Wetlands	
Active Construction	Active Construction	73 Bare Ground	Exposed ground

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Part 3: Pollutant Load Reduction Estimating

Pollutant Reduction Estimation

During the Implementation Plan development, the team will use available GIS and other data in a simple land use and impervious cover model for scenario runs formulating implementation recommendations for the County. Land use and impervious cover have been successfully linked to runoff volume and pollutant loading using the Simple Method (Schueler, 1987). Treatment strategies through best management practices (BMP), restoration, education, and policy changes that result in pollutant removal and runoff reduction have been successfully modeled using a spreadsheet-based modeling tool.

The WTM and other spreadsheet analysis will be used to estimate pollutant sources and treatment options for a watershed. The current publically available version of the WTM is 3.1, but modifications to the model include an additional runoff volume reduction component (Hirschman and Schueler, 2008). The model has been successfully implemented by the US Army Corps of Engineers (USACE) during their Anacostia River Watershed Restoration Plan Interim Report Framework (November 2008). In addition, where TMDLs exist, available Maryland Department of the Environment (MDE) total maximum daily load (TMDL) modeling information will be used for calibration, including event mean concentrations (EMCs) and total load allocations. The calibration process will be similar to that implemented by the ACOE in the Anacostia, whereby the WTM baseline load is compared to the MDE-approved loading. Assuming reasonable agreement, the model will then be used to calculate the required percent reduction in load as defined by MDE (see ACOE Anacostia WRP Interim Report Framework pg B-26, 2008). For each major watershed in the County, the pollutant load analysis will:

- Assign EMCs and runoff volume coefficients (Rvs) for each land use/cover type for computation of an annual pollutant load from primary sources (e.g., high input/low input low density residential):
 - Nitrogen (lbs/year)
 - Phosphorus (lbs/year)
 - Sediment (lbs/year)
 - Fecal Coliforms (billion/year) (a ratio of 0.34 will be used to correlate enterococcus to fecal coliform based on MDE precedent for the Anacostia)
- Calculate the annual land use loading using the simple method and WTM.
- Evaluate necessary secondary sources for use within the watershed.
- Adjust the loads to account for removal by existing BMPs or retrofits within the watershed, with appropriate adjustments for their BMP code.
- Calculate the baseline load and runoff volumes for the watershed.
- Identify management practices suitable for meeting the TMDL requirements and associated pollutant reductions – Appendix B, Table B5 – B15.

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Default EMCs are included in the WTM, but need to be modified to address stormwater hotspots and high input turf using standards developed during the Anacostia River Watershed Restoration Plan (ACOE, 2009), existing TMDLs, and the National Stormwater Quality Database (Pitt, et al. 2007). Appendix B Table B.1 provides representative values to use for these considerations.

Secondary sources can be estimated from available watershed studies or TMDL reports. The selection of secondary sources is based on watershed characteristics; secondary sources might include hobby farms and livestock, failing septic systems, sanitary sewer overflows, and road sanding. Secondary Sources should be addressed only in TMDL watersheds where specific action inventory items warrant the estimate of a current pollutant load. See Section 1.4 of Appendix B for more information on secondary sources.

It is assumed that all future development follows the new MDE stormwater regulations, practicing ESD to the MEP and will result in no net increase in load. The basis for much of the assumed reductions will come from the National Pollutant Removal Performance Database (CWP, 2008), the MDE Stormwater Design Manual (2000), and the Runoff Reduction Method (Hirschman, et al. 2008). The potential pollution prevention strategies are subdivided into identifiable “restoration practice groups” as presented in Table 4.1 and Tables B5 – B15 in Appendix B.

BMP cost will be preferentially based on existing County cost database information but may require supplemental cost information for where the County does not have existing data associated with the proposed practice. Cost, environmental benefit, feasibility, community outreach, existing natural resources, permitting, regulations, and maintenance requirements will all be used to further justify decisions. Section 4 of Appendix B reviews the current assumptions of BMP capital and life cycle costs in the County.

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Part 4: Evaluating Restoration Practices

Table 4.1 introduces the 11 groups of watershed restoration practices that will be evaluated for each watershed implementation plan. The first four groups of restoration practices involve various forms of ESD, which are given priority in the assessment stage. All restoration practices differ in the mode and manner by which they are delivered in each watershed over the next two permit cycles - 10 years (capital budgets, water quality protection charge, regulation, etc.). The basic idea is that multiple delivery mechanisms are needed to implement enough watershed restoration practices to meet the stringent watershed treatment and pollutant reduction targets contained in the County’s MS4 permit.

Table 4.1 Restoration Practices to be Evaluated in Watershed implementation Plans
ESD Practices
<i>New ESD Retrofit Practices</i> - These include small scale ESD practices applied to county- owned or privately owned buildings, streets and parking lots and rights of way. Examples include rainwater harvesting, green roofs, upland reforestation, soil compost amendments, rooftop disconnection “green street” retrofits and converting swales to dry swales.
<i>ESD Upgrades</i> - This category includes retrofit ESD practices within existing publicly-owned or privately-owned stormwater infrastructure, so that their hydrologic and pollutant removal performance is upgraded (e.g., installing bioretention in existing dry ponds).
<i>Impervious Cover Reduction</i> - This category involves cases where un-needed impervious cover is removed, soils amended and vegetation restored primarily on County schools, streets and parking lots
<i>Voluntary LID Implementation</i> - ESD practices that are installed as a result of County education and incentive programs (e.g., Rainscapes incentives and Green Roof Subsidies)
Programmatic and Operational Practices
<i>MS4 Programmatic Practices</i> – This category deals with reduced pollutants that can be attributed and quantified through MS4 stormwater education (e.g., lawn care), pollution prevention improvements at municipal hotspots, and better housekeeping on County land and facilities. Also includes any Countywide pollutant reductions due to product substitution, such as imposing restrictions on N or P content in fertilizer, increased pet waste enforcement, trash prevention and control.
<i>Hotspot Pollution Prevention</i> – This category credits enhanced structural and non-structural practices employed at non-publicly owned stormwater hotspots that are identified through land use analysis.
<i>Enhanced County Street Sweeping</i> - This category includes any pollutant removal that can be attributed to more intensive and targeted street sweeping in the watershed conducted by the County.
<i>Trash Prevention and Control</i> - This category includes a wide range of programs and practices specially aimed at reducing trash inputs to stream, including reduce, reuse and recycle campaigns, littering and illegal dumping enforcement, dumpster management, storm drain marking, storm drain inlet devices, stream cleanups, in-stream controls to trap and remove trash, etc. These measures are in addition to any trash trapped and removed by other restoration practices which are computed separately.
Structural Practices
<i>Traditional Retrofits</i> - This is the traditional retrofit scale where large-scale, non-ESD retrofits are constructed on larger parcels of public or private land as discovered through analysis of MCDEP BMP inventory.

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Table 4.1 Restoration Practices to be Evaluated in Watershed implementation Plans

Retrofit of Existing BMPs - Credit for upgrades of failed or inadequate stormwater practices that result in significant improvement in hydraulic function and increased treatment capacity. Credit can only be taken for increased load reduction due to upgrades that significantly rehabilitate BMP function from its installation baseline. (e.g., increase capacity, lengthen flow path, reduce short-circuiting, eliminate design failures).

Habitat Restoration - This category includes any pollutant reduction or volume reduction that can be attributed to specific stream restoration or riparian reforestation projects planned for construction in the watershed for the permit cycle.

The draft technical assumptions for evaluating each restoration practice group in each watershed are provided in a series of 11 tables presented in Appendix B (Table B5 – B15). Each table provides methods for computing runoff reduction and pollutant reduction, unit area treated, where the practices are applied, and what the average unit cost is for installation, maintenance, and life-cycle costs. In addition, the tables outline the recommended way to evaluate each practice group in the context of the WTM or other spreadsheet accounting method. As might be expected, there are some key data gaps and uncertainties associated with evaluating each group of restoration practices.

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Part 5: Evaluating Impact of Restoration Practice Implementation in Watersheds

Process for Evaluating Implementation

The process for evaluating various bundles of restoration practices to meet watershed benchmarks is necessarily iterative in nature. In general, the benchmarks are predefined for each individual watershed, in terms of numeric targets for treated impervious acres, specific load reductions to meet a TMDL or a target flow reduction volume.

The first step is to run the WTM with planned restoration projects in the watershed baseline/action inventories (see Appendix D) and compare to the original baseline condition to determine if the appropriate watershed benchmark can be met. The methods and technical assumptions that are used to define treated area, pollutant removal and runoff reduction for each group of restoration projects can be found in Appendix B. Additional load reductions from practices that are not easily estimated using the WTM will be tracked using a summary spreadsheet for each watershed group.

In addition, a standard watershed cost spreadsheet will be developed using information summarized by practice type in Appendix B to estimate the aggregate implementation cost, based on units of restoration practices multiplied by unit cost data. If the load reduction analysis indicates watershed benchmarks can be met at a reasonable cost, then efforts will be shifted to creating the watershed action plan, and devising an implementation schedule.

It is doubtful that a final solution will result from the first iteration, in which case, the consultant team will develop an expanded list of restoration practices, using the Desktop BMP analysis methods described later in this section. The level of effort expended in investigating new restoration practices will be determined by relative difference from the watershed benchmarks including both the TMDL and imperious restoration goals.

Revisions to the analysis will be addressed on a watershed basis based on ability to meet TMDL and impervious restoration goals. The team will assess the groups of restoration practices and define the maximum treatable area by practice for the watershed, using the indicators defined below. These revised suites of restoration practices will then be incorporated into the watershed baseline/action inventory as the MEP, and the load reduction analysis is then run again, and compared to baseline conditions.

Once the watershed meets benchmarks, the level of implementation will be considered MEP, and the team will proceed to the implementation action plan and implementation schedule where the subset of the most feasible, cost-effective and stakeholder supported projects are identified. Projects will undergo a ranking process according to environmental benefits, feasibility, outreach and community stewardship opportunity,

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impacts to existing natural resources, permitting and regulation, cost, and maintenance requirements and other stake-holder defined factors. The project ranking system would follow the general methods outlined in CWP Manual 2: Methods to Develop Restoration Plans- Chapter 5 and pages 226-230 of CWP Manual 3: Stormwater Retrofit Practices.

The final table of results from the load reduction analysis will be developed and considered under the development of the broader and integrated Countywide watershed restoration strategy.

Desktop Review of BMP Coverage

The desktop review of BMP coverage is needed for several reasons. First, the desktop tool needs to analyze the **existing BMP coverage** within each watershed to determine the impervious acres adequately treated to the MEP. Next, the existing BMPs in the inventory within a watershed must be classified based on their hydrologic and pollutant removal capabilities. This not only helps to identify opportunities for potential ESD upgrades, traditional retrofits and maintenance upgrades within the BMP inventory, but also is needed to compute the most accurate baseline pollutant load for the watershed, based on different levels of treatment. The basic approach would be to analyze the County BMP inventory on a watershed basis, using the following steps.

1. Classify existing BMPs according to the performance codes in Table 5.1 (further described in Section 3 of Appendix B). Compute the total drainage area served by each of the five codes in the watershed. Adjust status as necessary to reflect site specific information that may indicate poor maintenance, design or installation that impair performance
2. Assign a composite pollutant removal, runoff reduction, channel protection and flood control to the treated area in each performance code category (see Table B.17 in Appendix B).
3. Adjust baseline load in WTM load to reflect effects of existing BMP treatment. The output would be impervious acres adequately treated, and the baseline pollutant load and runoff volume for the watershed.
4. Add traditional retrofits that are planned which are contained in retrofit inventories and CIP budgets.
5. Evaluate individual Code 1 and 2 BMPs and BMPs built prior to 1986 within individual watersheds to determine potential for ESD upgrades, traditional retrofits and maintenance upgrades. For economy, the search should be restricted to BMPs with a contributing drainage area of two acres or more in area.
6. Calculate the maximum treatment area in the watershed that could be handled by feasible ESD upgrades, traditional retrofits, and maintenance upgrades.

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Table 5.1 Suggested Primary Classification of Existing County Stormwater Facilities

Performance Code
Code 0: Pretreatment Practices
Code 1: Non-performing BMPs: No runoff reduction and no long term pollutant removal
Code 2: Under-performing BMPs: Limited runoff reduction and low pollutant removal
Code 3: Effective BMPs: No runoff reduction but moderate to high pollutant removal
Code 4: ESD BMPs: high runoff reduction and moderate to high pollutant removal

The next element of the desktop review would evaluate **new opportunities** for retrofit treatment in the watershed using key desktop retrofit identification metrics outlined in CWP Manual 3: Stormwater Retrofit Practices. This is done when the initial WTM run indicates that implementation of the baseline projects cannot meet watershed benchmarks. There are different approaches to identifying new opportunities through a desktop analysis and they will vary by watershed characteristics, but the following locator metrics are suggested as a starting point:

- Large parking lots (>1 acre)
- Large buildings
- Poor riparian coverage
- Roadway improvement projects
- Priority Residential Neighborhoods (e.g., Rainscapes)
- Non-residential tax accounts not currently under the Water Quality Protection Charge (WQPC)

In order to identify the Priority Residential Neighborhoods, the consultant will perform a desktop assessment similar to the basic approach taken in the Anacostia River Restoration Plan to target residential areas suitable for on lot retrofitting. The criteria used for evaluation includes lot size, home ownership, presence or absence of homeowners association (HOA), and presence or absence of existing stormwater management facilities. Neighborhood areas are then broken into tiers of high, medium, and low based on the points assigned to the various criteria:

- SWM Score: Yes = 0; No = 2
- Lot Size Score:
 - > 1.0 acre = 0
 - ≤ 0.25 BUT ≤ 1.0 = 3 (High)
 - ≤ 0.1 BUT <0.25 = 2 (Medium)
 - < 0.1 acre = 1 (Low)

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- Home Ownership Score:
 - > 70% = 3 (High)
 - <= 30 BUT <=70 = 2 (Medium)
 - < 30% = 1 (Low)
- HOA Score: Yes = 2 ; No = 0
- Total Priority Score:
 - >=9 = High
 - >=6 BUT <=8 = Medium
 - <= 5 = Low

These indicators would be assessed in the context of identifying opportunities linked to the practices identified in Table 4.1. Based on the desktop investigation, the consultant team will identify candidate retrofit projects for future investigation, including retrofit type, estimated drainage area, location and preliminary feasibility. The aggregate drainage area that could be treated by new retrofits would then be added to the watershed implementation sheet and considered as the “maximum treatable area” for each group of restoration practices. The maximum treatment area would be the starting point for evaluating the combinations of restoration practices needed to achieve permit limits.

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Part 6: Process for Defining Outcomes and Tracking Progress

Ultimately the watershed implementation strategy needs to evaluate and modify the implementation of restoration projects so that the combined watershed restoration plans meet regulatory and programmatic targets of the County and stakeholders. A process for defining these outcomes and tracking their progress is critical to ensuring watershed restoration success. Specifically, the process should include (1) an implementation schedule for the action inventories and (2) a framework for tracking progress toward meeting regulatory and programmatic targets.

Action Inventory Implementation Schedule

Individual implementation plans will identify the projects that will help the County achieve their watershed restoration targets. The overall implementation strategy should also include an implementation schedule for those projects based on how they will contribute to meeting the targets, i.e., projects and practices that provide the greatest benefit will receive a higher priority for implementation. These priorities should be done both at the watershed scale and Countywide. Implementation schedules should consider project synergies, such that projects that do not rank high by themselves can still receive a high priority if their cost-effective benefit increases when coupled with adjacent or related projects. The output of this implementation schedule process will be an action inventory matrix that identifies priority tiers and time frames for implementation in each watershed and Countywide. Actual implementation dates will be based on expected funding levels, so that they can be accelerated if additional funding is obtained.

Progress Tracking Framework

For tracking progress toward watershed restoration targets, such as TMDL wasteload allocations, a spreadsheet-based approach will be used to document project implementation and associated (projected) load reductions. Tracking key data on the design, construction, and maintenance of watershed restoration practices is both required under the County's MS4 permit and critical to the adaptive management approach needed to ensure successful implementation of the watershed restoration plans and Countywide strategy.

In addition to tracking implementation of restoration projects, this framework should also monitor improvement in stream conditions. Such monitoring is best accomplished through a mix of "sentinel monitoring stations" and performance monitoring of individual practices. Sentinel stations are fixed long-term monitoring stations that track temporal trends, typically targeting selected aquatic indicators to measure progress towards watershed goals. Guidelines for the monitoring strategy are outlined by the Maryland DNR 2010 Trust Fund Water Quality Monitoring Strategy. The principles of the strategy dictate the scale and time period over which realistic stream condition

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improvement could be documented. Generally, stream condition improvement can be observed over a 3-5 year period if the expected reduction in nutrient and sediment loads exceeds 30%. Monitoring the performance of individual restoration practices helps determine whether these practices are working as designed and providing the desired level of treatment. This latter information can then be used to improve design, construction and maintenance aspects of these practices for future implementation and to confirm assumptions regarding pollutant removal capabilities. The sentinel monitoring of aquatic indicators will provide the best confirmation of restoration success.

The existing biological monitoring network in Montgomery County is extensive and can be adapted for monitoring benefits of implementation at the subwatershed scale (approximately 0.5 – 2 square miles). While this or any monitoring network cannot monitor changes in all County streams (except as estimation from probability-based sites), existing monitoring stations can be identified downstream of clusters of projects likely to produce measurable benefits in acceptable timeframes. Each implementation team will consult with County staff once preliminary implementation inventories are developed to identify stations that would be good targets for this kind of monitoring. These targeted areas should have existing data (for baseline comparisons), suitability for future monitoring, and ease of access. The representativeness of selected monitoring areas is critical to extrapolating restoration benefits throughout the watershed and Countywide.

In addition to the County's regular sentinel monitoring stations, the County has a number of special project monitoring stations. For instance, Special Protection Areas, Breewood Tributary, and Bennington Branch are all currently monitored for biological, chemical, and physical stream condition in order to assess the improvement in subwatershed health in response to restoration efforts. An alternative outfall screening strategy whereby smaller impaired or developing drainage areas, such as these special projects, are targeted for intensive investigation of illicit discharges should be considered for progress tracking. Results of these specified investigations could be extrapolated to infer larger watershed impacts. Restoration would be a labor intensive endeavor, requiring a multi-media approach of physical screening, compliance assistance, and outreach and education efforts. Due to competition for County resources, restoration efforts need to be prioritized for specifically allocating staff and resources. The County currently has a fairly comprehensive list of water quality and illegal solid waste dumping complaints over the last five years (2004-2009) in a GIS database. Using the water quality complaint database to prioritize and target problem outfalls for pre- and post- restoration monitoring could also be used to track progress at a subwatershed scale.

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APPENDICES

Appendix A – Acronyms, Units Abbreviations and Consolidation References

Appendix B – Modeling Framework

Appendix C – GIS Steps for Processing Montgomery County Data

Appendix D – Baseline Inventory Template

Appendix E – Trash Reduction Strategies

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Appendix A – Acronyms, Units, Abbreviations and References

Appendix A: Table 1- List of Key Acronyms, Units and Abbreviations Used in Memo			
A	Site Area (acres)	MDE	Maryland Department of the Environment
ACOE	Army Corps of Engineers	MEP	Maximum Extent Practicable
BMP	Best Management Practices	MS4	Municipal Separate Stormwater System
CDA	Contributing Drainage Area	NPDES	National Pollutant Discharge Elimination System
CIP	Capital Improvement Projects	NRCS	Natural Resources Conservation Service
Cpv	Channel Protection Volume	QC	Quality Control
CN	NRCS Curve Number	Rv	Runoff Coefficient
CSN	Chesapeake Stormwater Network	SPA	Special Protection Area
CWP	Center for Watershed Protection	TC	Turf Cover
ED	Extended Detention	TP	Total Phosphorus
EMC	Event Mean Concentration	TN	Total Nitrogen
EPA	Environmental Protection Agency	TSS	Total Suspended Solids
ESD	Environmental Site Design	TMDL	Total Maximum Daily Load
FC	Forest Cover	WLA	Waste Load Allocation
GIS	Geographic Information System	WTM	Watershed Treatment Volume
HSG	Hydrologic Soil Group	WQPC	Water Quality Protection Charge
IA	Impervious Area	WQv	Water Quality Volume
IC	Impervious Cover	WSSC	Washington Suburban Sanitary Commission
MCDEP	County Dept of Environmental Protection		

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Appendix B – Modeling Framework

This appendix details the assumptions and corresponding documentation for standard technical procedures for estimating pollutant loads from various land uses, evaluating the effectiveness and cost of the various BMPs and watershed restoration practices used to reduce them, and various modeling conventions to assure consistency and accuracy within individual watershed implementation plans. As such, this Appendix is organized as follows.

1. Procedures for Estimating Land Cover and Pollutant Loads
 - 1.1 Defining Event Mean Concentrations in WTM
 - 1.2. Recommended Splits for Land Cover within Land Use Categories
 - 1.3 Defining Potential Stormwater Hotspots
 - 1.4 General WTM Modeling Protocols
2. Description and Technical Assumptions for Watershed Restoration Practices
 - New ESD Retrofit Practices (Table B.5)
 - ESD Upgrades (Table B.6)
 - Impervious Cover Reduction (Table B.7)
 - Voluntary ESD Implementation (Table B.8)
 - MS4 Programmatic Practices (Table B.9)
 - Hotspot Pollution Prevention (Table B.10)
 - Enhanced Street Sweeping Operations (Table B.11)
 - Traditional Retrofits (Table B.12)
 - Retrofits of Existing BMPs (Table B.13)
 - Habitat Restoration (Table B.14)
 - Trash Prevention and Control (Table B.15)
3. Desktop BMP Classification and Evaluation
 - 3.1 Basis of Classification of BMP Groups
 - 3.2 Dealing with Multiple BMPs within the Same Drainage Area
 - 3.3 Composite Runoff Reduction and Pollutant Removal Rate per BMP Code
 - 3.4 Removal Rates for Non Retrofit Practices
4. Rationale for Unit Planning Costs for Selected Restoration Practices
5. Special Issues in Watershed Analysis
 - 5.1 Rationale for Alternative Approach for Flow Reduction Analysis
 - 5.2 Documentation of Equivalent Impervious Area Treated
 - 5.3 Method For dealing with Channel Protection in Individual Watersheds
 - 5.4 Handling Bacteria Loads in Individual Watersheds
6. Montgomery County Stakeholder Demographics

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1.0 Procedures for Estimating Land Cover and Pollutant Loads

1.1 Defining Event Mean Concentrations in WTM

Table B.1 presents recommended Event Mean Concentrations (EMCs) for urban land uses in Montgomery County based on Pitt (2008), which has twice the number of storm events than previous versions. These EMCs will be used as default values in WTM modeling for individual Watershed Implementation Plans. In addition, the EMC values have been compared with the non-tidal Anacostia watershed HSPF model that was used for the Anacostia TMDL development (ICPRB, 2008) in addition to data from the Montgomery County NPDES storm sampling from their permit requirements. Note that these storm samples account for only three events from five sites representing the different land uses.

The TMDL EMCs are found to be within the ranges and in close agreement for the nutrient values provided below in Table B.2. For Total Suspended Sediment data, the ICPRB and MC data are approximately a factor of two greater than WTM default data. These data reflect the Anacostia watershed, so for purposes of this analysis the average based on the nationwide compilation of data will be used as the WTM default values for the initial modeling runs. If there is reasonable agreement between the TMDL and WTM baseline loads, no further adjustments will be made. Where agreement is not achieved, adjustments will be considered to take into account TMDL data. Bacteria data are more challenging since the TMDLs are typically for enterococci while the majority of stormwater monitoring data are for fecal coliform. The Maryland Department of the Environment (MDE) has used ratios to convert between fecal and enterococci in the development of TMDLs. These ratios will be used for initial modeling runs to convert fecal coliform loads to enterococci loads, as shown in the following equation.

$$\text{Fecal Coliform (Billion MPN/year)} * 0.34 = \text{Enterococci (Billion MPN/year)}$$

(Macomber and Dalmasy, 2006)

The EMC for residential land uses was split into two categories based on lawn care: high input and low input turf (HI and LO). The EMCs represent the 25th and 75th percentile values, because the distribution of data from residential runoff is approximately a normal distribution. Two estimates of fertilization are available for the area that range between 50% and 65% (Swann, 1999, Law et al, 2004). Making assumptions about past lawn care education and stewardship efforts in the County, it is recommended that the lower 50% rate be used (half of all residential turf cover is high input and the other half is low input). Consequently, the composite EMC for residential land in a watershed would still equate to the ALL value.

Stormwater hotspots were defined using the County property database in conjunction with the water quality complaint database. Only commercial and industrial land uses

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associated with water quality complaints were considered for hotspot designation. The sediment and nutrient EMCs were derived for hotspots and not hotspot areas using approximately the 45th and 95th percentile values from EMCs to characterize them. The historic distribution of data for commercial and industrial EMC's are skewed such that approximately 5% of all sites are hotspots, with the remaining 95% not. This was the rationale for choosing the 45th and 95th percentile values.

<i>Land Use</i>	<i>TSS (mg/L)</i>	<i>TP (mg/L)</i>	<i>TN (mg/L)</i>	<i>Bacteria¹ (MPN/100mL)</i>
Residential	59 mg/l	ALL: 0.3	ALL 2.0	4200
		HI: 0.4	HI: 2.5	
		LO: 0.2	LO: 1.5	
Commercial	ALL: 55 HOT: 150 NOT: 50	ALL: 0.22	ALL:2.2	3000
		HOT: 0.60	HOT: 6.00	
		NOT: 0.20	NOT: 2.00	
Highway	53	0.3	2.3	2000
Industrial	ALL: 73 HOT: 230 NOT: 65	ALL: 0.26	ALL: 2.1	2850
		HOT: 0.60	HOT: 6.00	
		NOT: 0.24	NOT: 1.9	
Municipal	18	0.22	1.8	3400
All Land Uses	62	0.27	2.0	4000
Source: Pitt, R. 2008. National Stormwater Quality Database Version 3. University of Alabama and CWP (2003) for TN ALL: Median for all land uses HI: High input turf, assumed to be 50% of all residential turf LO: Low input turf, assumed to be 50% of all residential turf HOT: Stormwater hotspot, area defined by Property database features selected by commercial/industrial land use and water quality complaint database. NOT: Not a stormwater hotspot, all areas not defined as HOT ¹ Concentrations shown are for fecal coliform bacteria as no stormwater monitoring data is available for enterococci (see Section 5.4)				

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<i>Landuse Designation</i>	<i>TN (mg/L)</i>	<i>TP (mg/L)</i>	<i>TSS (mg/L)</i>	<i>SOURCE</i>
Residential	2.3	0.35	139	MC & PG Anacostia
	1.90	0.24	116.94	MC NPDES Sampling
	2	0.3	59	Table B.1; Pitt, 2008
Commercial	3.5	0.20	132	MC & PG Anacostia
	3.64	0.17	55.35	MC NPDES Sampling
	2.2	0.22	55	Table B.1; Pitt, 2008
Industrial	2.1	0.24	218	MC & PG Anacostia
	2.21	0.21	256.63	MC NPDES Sampling
	2.1	0.26	73	Table B.1; Pitt, 2008
Municipal	1.3	0.11	125	MC in-stream Anacostia
	-	-	-	MC NPDES Sampling
	1.8	0.22	18	Table B.1; Pitt, 2008

1.2. Recommended Splits for Land Cover within Land Use Categories

Table B.3 presents the recommended splits for defining the three types of land cover within a land use. The impervious cover values were directly measured from GIS data and aerial photography from jurisdictions across the Chesapeake Bay in MD, PA, and VA (Cappiella and Brown, 2001). An adjustment was made for the institutional category, where it was split into two categories, intensive and extensive. The intensive category includes churches, schools and municipal facilities, as reported in Cappiella and Brown (2001). The extensive category includes greener institutional areas, such as park, cemeteries and golf courses.

Average forest cover was derived for each land use based on the estimated forest cover coefficients in Cappiella, et. al. (2005). These estimates are not directly measured, but are consistent with forest cover (not canopy) measurements from urban forestry models. Turf cover was obtained by subtraction from the total acreage after impervious cover and forest cover were added together, but represents a mix of pervious surfaces including turf, meadow, and fields.

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Table B.3 Recommended Splits for Land Cover within Land Use Categories

<i>LAND USE</i>	<i>Impervious cover</i> ¹	<i>Forest Cover</i> ²	<i>Turf Cover</i> ³
Low Density Resid	12.5	8.5	79.0
Medium Density Resid	24.5	15.0	60.5
High Density Resid	36.8	15.2	48.0
Multifamily Resid	44.4	14.6	41.0
Commercial	72.2	14.8	13.0
Industrial ⁴	53.4	14.6	32.0
Roadway ⁶	90	7.0	3.0
Intensive Muni/Instit ⁷	35.2	13.8	51.0
Extensive Muni/Instit ⁸	8.6	36.4	55.0

¹ average values as reported in Capiella and Brown (2001), if more than two zoning categories were present with residential categories, they were averaged
² average forest cover values estimated for indirect forest conservation in Table 5 of Capiella et al (2005), if more than two zoning categories were present with residential categories, they were averaged
³ turf cover, as determined by residual of IC and FC
⁴ light industrial only
⁶ Measured as curb to curb in the GIS database.
⁷ Intensive: Sum of Institutional land use (churches, schools and municipal buildings)
⁸ Extensive Sum of open urban land and bare rock land uses (parks, cemeteries and golf courses)

1.3. Defining Potential Stormwater Hotspots

The desktop retrofit analysis requires that potential stormwater hotspots be identified within the watershed. Hotspots are defined in a two step process. First, the consultant team will select from the County GIS database of Properties in the commercial and industrial categories (CZ and IZ) to screen for land uses shown in Table B.4. On the second step, sites or operations where water quality problems or citizen complaints have been historically recorded will automatically be considered hotspots. These will be identified using the County supplied GIS layer showing them in each watershed (WQCases2004_2009_locations shapefile). The focus of this analysis is to estimate the number and potential area within the watershed that is classified as a potential hotspot (HOT), and to define the spatial extent of potential hotspot inspection needed in the restoration analysis.

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IZ Designated Zoning ¹	Industrial Facilities
CZ Designated Zoning ¹	Commercial Facilities
Historic pollution reports and citizen complaints to MCDEP ²	Pollutant discharge
	Chemical discoloration/unknown
	Petroleum Product in Water
	Sewage
¹ County GIS Properties Geodatabase	
² County GIS WQCases2004_2009_locations shapefile	

1.4 General WTM Modeling Protocols

The following WTM modeling protocols will be used to make decisions on how to effectively model individual watersheds in the County:

Protocol 1: Be consistent with existing TMDLs and past watershed studies. The consultant team will check pollutant load calculations from the WTM against MDE TMDL or other watershed study results. If results deviate by greater than 25%, the estimated reduction goal will be scaled to the TMDL or other reduction goal to retain consistency in loading sources and rates (see Anacostia Watershed Restoration Plan, Interim Report Framework, 2008, pg. B-26).

Protocol 2: Select a common baseline year against which all reductions will be measured, where possible. For TMDL watersheds, the baseline year against which reductions will be measured against will likely be the year(s) used in the TMDL development modeling (i.e., for Anacostia it was 1995 - 1997 “typical flow conditions” (wet year 1996, dry year 1995, and an average year 1997). For non-TMDL specified watersheds, the baseline year will be 2002 since this is the most recent year for which MDP land use data is available.

Protocol 3: Use discretion in defining secondary pollutant sources in each watershed. Secondary sources in WTM include a long list of pollutant point and nonpoint sources. The use of secondary sources in the model will be based on individual watershed characteristics, and will not be calculated (a) if they are a minor source in the County (e.g., CSOs, marinas, etc.) or (b) are not a source term in TMDL for the watershed in question. The following general recommendations are made to determine if any secondary sources need to be modeled in individual watershed plans:

- Pet Waste is an important contribution of bacteria in highly residential watersheds, and the consultant team will evaluate pet waste as a fraction of residential dwelling units and literature supported loading rates per pet.

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- While Channel Erosion is an important term in the watershed sediment budgets, the unsophisticated WTM computational approach is not likely to give accurate load estimates given the complex geomorphology of County streams. Instead, it is recommended that the proportion of each watershed that is effectively treated with the channel protection be tracked in each watershed, in order to track gradual improvement in stream condition over time. The proposed analysis method is described in Section 5.3.

Protocol 4. Tracking loads from new development. The consultant team will set up the loading models to enable MCDEP to account for future land use change in future permit cycles by showing how the actual IC created by new development and redevelopment can be tracked in each watershed. For example, for future projects where ESD to the MEP is achieved these areas would be considered effectively treated, and no additional load would be added to the watershed baseline at the end of the permit cycle. On the other hand, until the new ordinances are fully adopted and implemented in the county, new development would be treated as an additional pollutant load to the baseline in future years.

Protocol 5. Minimum WTM outputs to handle flow volumes and multiple pollutants in individual watersheds. Several watersheds have TMDLs set for multiple pollutants (bacteria, nutrients, and sediment). An inventory of TMDL modeling results will be collected for baseline and calibration purposes. Biological impairments due to stormwater runoff to surface waters may also be a contributing factor in the restoration decisions. Therefore, the following outputs will be prepared for each watershed: impervious acres adequately treated; baseline load of sediment, nitrogen and phosphorus; and the baseline load of any pollutant listed in the watershed TMDL.

Protocol 6. Trash will not be modeled in the WTM except for the Anacostia. Since trash cannot be effectively modeled in the context of the WTM for all watersheds, the analysis will be limited to discussion of prevention and control options. For the Anacostia, where a TMDL with unit loads by land use exist, a modified application of the WTM can be used as outlined in Appendix E.

Protocol 7. Link tabular WTM output into a GIS-compatible form. The output from WTM is currently in table form, and should be linked to GIS so that update queries can be run to update the model. Direct real-time linkage to GIS will not be an output of this effort and would require substantially more effort.

Protocol 8. Restoration costs to be determined using simple spreadsheet, based on aggregate implementation units of restoration practices. Since cost will inevitably be a very important factor in determining the recommended watershed implementation strategies, tracking implementation cost is important. The consultant team will use a common spreadsheet, based on the number of units of implementation of restoration

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practices multiplied by a unit cost (or actual project cost) if available, using the technical assumptions outlined in Section 4 for each restoration practice group.

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2.0 Description and Technical Assumptions for Watershed Restoration Practices

This section describes the 11 different groups of watershed restoration practices that can be evaluated in the watershed implementation plans, and outlines technical assumptions to be used in load reduction modeling, costs, and special considerations.

Table B.5	
New ESD Retrofit Practices	
Description: These include small scale ESD practices applied to county- owned or privately owned buildings, streets and parking lots and rights of way. Examples include rainwater harvesting, green roofs, upland reforestation, soil compost amendments, rooftop disconnection “green street” retrofits and converting swales to dry swales.	
<i>Runoff Reduction Capability?</i> High <i>Pollutant Removal Capability?</i> Moderate, except for nutrients <i>Derivation:</i> Use unit runoff and load reduction for “aggregate” ESD practice (Table B.17).	
<i>Unit Area Treated :</i> 0.1 to 0.5 Impervious Acres (IA) <i>Where Applied:</i> County buildings, streets and parking lots (including schools and parks), and larger privately owned parking lots in subwatersheds that are not currently treated	
<i>Mode of Delivery :</i> capital budget	<i>Average Delivery Time:</i> 1 to 2 years
<i>Other Benefits :</i> Provide additional points in comparative practice ranking to account for hydrologic, demonstration and community benefits afforded by ESD practice	
<i>Unit Costs:</i> Variable depending on existing development density and ESD retrofit type, as shown in Table B.21	
<i>How is it Modeled:</i> Maximum treatment assumption is 10% of all IA associated with schools and parks in watershed, and 50% of county buildings and parking lots. Determine load and volume reduction for total IA treated by this practice in WTM.	

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Table B.6	
ESD Upgrades	
<i>Description</i> : This category includes retrofit ESD practices within existing publicly-owned or privately-owned stormwater infrastructure, so that their hydrologic and pollutant removal performance is upgraded (e.g., modified outlet to existing dry ponds).	
<i>Runoff Reduction Capability?</i> High <i>Pollutant Removal Capability?</i> High <i>Derivation:</i> Use unit runoff reduction and load reduction rates for an “aggregate” bioretention practice, see table B.17.	
<i>Unit Area Treated</i> : 2 acres of IA <i>Where Applied:</i> To underperforming BMPs on county stormwater inventory with DA between 2 and 10 acres	
<i>Mode of Delivery</i> : Capital budget	<i>Average Delivery Time:</i> 2 to 3 years
<i>Other Benefits:</i> Provide additional points in comparative practice ranking to account for hydrologic, demonstration and community benefits afforded by ESD practice	
<i>Unit Costs</i> : \$57K per IA treated	
<i>How is it Modeled:</i> Analyze code 1 and 2 BMPs in stormwater inventory from Design Eras 1 and 2 with CDA of 2 to 10 acres for potential retrofit, with priority on publicly owned facilities. Determine load and volume reduction for total IA treated by this practice in WTM.	
Note: The installation of ESD practices such as bioretention in dry ponds is currently discouraged due to recurring maintenance problems, but it is proposed that it be considered an experimental retrofit to see if such problems can be eliminated	

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Table B.7	
Impervious Cover Reduction	
<i>Description:</i> This ESD category involves cases where un-needed impervious cover is removed, soils amended and vegetation restored primarily on County land.	
<i>Runoff Reduction Capability?</i> High <i>Pollutant Removal Capability?</i> High <i>Derivation:</i> Change the impervious cover to either un-compacted turf or forest in WTM	
<i>Unit Area Treated:</i> 0.5 acre, or about 10% max of each municipal property with car habitat <i>Where Applied:</i> Delivery is primarily by county agencies (DOT-road abandonment, MCPS-green schools, MNCCPC parking lot reductions).	
<i>Mode of Delivery:</i> Capital budget and highway budget.	<i>Average Delivery Time:</i> 1 to 2 years
<i>Other Benefits:</i> Provide additional points in comparative practice ranking to account for hydrologic, demonstration and community benefits afforded by ESD practice	
<i>Unit Costs:</i> \$72,600 per IA converted	
<i>How is it Modeled:</i> Determine combined treatable area for municipal land in each watershed and then change the acres of impervious cover to either un-compacted turf or forest in WTM, based on degree of practice implementation (maximum 10%)	

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Table B.8
Voluntary ESD Implementation
<i>Description:</i> ESD practices that are installed as a result of County education and incentive programs in Priority Residential Neighborhoods and Non-residential Properties (e.g., Rainscapes incentives and Green Roof Subsidies)
<i>Runoff Reduction Capability?</i> High <i>Pollutant Removal Capability?</i> Moderate <i>Derivation:</i> Use unit runoff reduction and load reduction rates from CWP 2009 for an “aggregate” ESD practice (Table B.17)
<i>Unit Area Treated :</i> 0.1 acres <i>Where Applied:</i> priority residential neighborhoods and CBD areas in target subwatersheds.
<i>Mode of Delivery :</i> County Incentives and Education through special funding <i>Average Delivery Time:</i> one year
<i>Other Benefits :</i> Provide additional points in comparative practice ranking to account for hydrologic, demonstration and community benefits afforded by ESD practice
<i>Unit Costs :</i> Assume an equal mix of ESD practices
<i>How is it Modeled:</i> Determine the total impervious area within the Priority Neighborhoods and Non-residential properties by a desktop assessment similar to the basic approach taken in the Anacostia River Restoration Plan to target residential areas suitable for on lot retrofitting. The criteria used for evaluation includes lot size, home ownership, presence or absence of homeowners association (HOA), and presence or absence of existing stormwater management facilities. Neighborhood areas are then broken into tiers of high, medium, and low based on the points assigned to the various criteria. Non-residential properties not currently draining to a storm water management facility are also prioritized. Assume the areas are treated with ESD practices for pollutant load reduction estimation within the WTM.
<i>Special Issues to Address:</i> Assume a maximum of 30% implementation of ESD within the targeted voluntary areas could be implemented in each watershed based on expansions to current Rainscapes Program

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Table B.9
MS4 Programmatic Practices
Description:: This category deals with reduced pollutants that can be attributed and quantified through MS4 stormwater education (e.g., lawn care), improvements at municipal hotspots, and better housekeeping on County land and facilities (see Manual 9, CWP, 2009).
<i>Runoff Reduction Capability?</i> No <i>Pollutant Removal Capability?</i> Moderate to High <i>Derivation:</i> For municipal operations (MO) designated as hotspots, adjust EMC for pollutant load baseline (pre-source control) and adjust to normal range after source controls are implemented. For residential lawn care education (LCE), create hi input and low input EMCs for pervious cover, and adjust EMCs based on projected changes in lawn care behavior based level of outreach and education employed. For municipal good housekeeping (MGH), assume that no fertilizers are used (see MCDEP 2006 Table III-E7).
<i>Where Applied:</i> Municipal Operation: ID IC associated with municipal facilities from GIS, including MCDOT, MCPS, MNCCPC Lawn Care Education: Targeted residential neighborhoods in watershed, based on lot size, income and neighborhood age. Municipal Good Housekeeping: ID TC associated with municipal facilities from GIS, including MCDOT, MCPS, MNCCPC
<i>Mode of Delivery:</i> Existing operating Budget and WQPC <i>Average Delivery Time:</i> 6 months to 1 year
<i>Unit Costs:</i> Use cost data for hotspot technical assistance and retail or wholesale nutrient management shown in table B.21
<i>How is it Modeled:</i> Adjust land cover EMCs to reflect reduced hotspot or high input turf cover in the watershed, assuming that 25% of each land cover area is effectively treated.

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Table B.10	
Hotspot Pollution Prevention	
<i>Description:</i> This category credits enhanced structural and non-structural practices employed at non-public owned stormwater hotspots that are identified through land use analysis.	
<i>Runoff Reduction Capability?</i> No <i>Pollutant Removal Capability?</i> Yes	
<i>Derivation.</i> For commercial and industrial sites classified as hotspots, increase EMC for pollutant of concern in baseline (pre-source control) per the method outlined in Section 1.1 and then adjust to normal range after source controls are implemented.	
<i>Where Applied:</i> all designated land uses and historical water quality complaints in GIS layer supplied by MCDEP from Table B.4.	
<i>Mode of Delivery :</i> Inspections and Technical Assistance <i>Average Delivery Time:</i> 3 to 6 months	
<i>Unit Costs :</i> Assume 2.5K per hotspot site for staffing to conduct inspections and provide technical assistance at private hotspots.	
<i>How is it Modeled:</i> Create a new IC land cover within various land uses designated as hotspots, and then adjust EMCs to reflect hotspot load in the baseline watershed load, and then reduce to reflect implementation of pollution prevention source controls.	

Table B.11	
Enhanced Street Sweeping Operations	
<i>Description.</i> This category includes any pollutant removal that can be attributed to more intensive and targeted street sweeping and storm drain cleanouts ¹ in the watershed conducted by the County.	
<i>Runoff Reduction Capability?</i> No <i>Pollutant Removal Capability?</i> Yes	
<i>Derivation:</i> Based on frequency of street sweeping. Residential street sweeping only qualifies for sediment reduction at one ton/mile swept/yr (MCDEP, 2006). Nutrient reductions for enhanced street sweeping are provided in Table B.20	
<i>Unit Area Treated :</i> IC for qualifying street lengths <i>Where Applied:</i> Commercial and CBD Streets in the watershed that could be swept	
<i>Mode of Delivery:</i> Operating Budget	<i>Average Delivery Time:</i> Continuous
<i>Unit Costs :</i> \$657mi/yr for commercial and CBD streets swept twice a month . Source: MCDEP Cost spreadsheet .	
<i>How is it Modeled:</i> Take load reductions for total area of swept commercial and CBD streets in the watershed as a back-end reduction to WTM	
¹ Based on data in MCDEP (2006), there is currently no concerted effort by county to clean out storm drains at a frequency capable of achieving meaning sediment or pollutant reduction	

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Table B.12	
Traditional Retrofits	
<i>Description:</i> This is the traditional retrofit scale where large-scale, non-ESD retrofits are constructed on larger parcels of public or private land. These may exist in prior County retrofit inventories are identified in desktop BMP analysis in this study.	
<i>Runoff Reduction Capability?</i> Low <i>Pollutant Removal Capability?</i> High <i>Derivation:</i> Pollutant and runoff reduction for Individual retrofit projects with CDA more than 25 acres using the retrofit design point method (Appendix B of Schueler et al, 2007), otherwise use Code 3 pollutant removal rates (Table B.17).	
<i>Unit Area Treated:</i> varies, based on individual project <i>Where Applied:</i> Planned retrofits in the watershed contained in existing 2006-2013 CIP retrofit budget and additional code 1 and 2 BMPs investigated in the desktop retrofit analysis	
<i>Mode of Delivery:</i> Capital budget and grants	<i>Average Delivery Time:</i> 3 years
<i>Unit Costs:</i> \$15K per IA for new pond retrofits	
<i>How is it Modeled:</i> Deduct pollutant loads reduced by each individual retrofit practice through appropriate land use in WTM	

Table B.13	
Retrofits of Existing BMPs	
<i>Description:</i> Credit for upgrades of failed or inadequate stormwater practices that result in significant improvement in hydraulic function and increased treatment capacity. Credit can only be taken for increased load reduction due to upgrades that significantly rehabilitate BMP function from its installation baseline. (e.g., increase capacity, lengthen flow path, reduce short-circuiting, eliminate design failures).	
<i>Runoff Reduction Capability?</i> Low <i>Pollutant Removal Capability?</i> Moderate to High <i>Derivation:</i> Apply Code 3 removal rates to Code 2 practice as shown in Table B.17	
<i>Unit Area Treated:</i> Varies based on BMP CDA <i>Where Applied:</i> Code 2 BMPs in the watershed's stormwater BMP inventory suitable for upgrade through desktop retrofit inventory, particularly those constructed in Design Era 1 and 2.	
<i>Mode of Delivery :</i> WQPC <i>Average Delivery Time:</i> one year	
<i>Unit Costs:</i> 12K per IA treated	
<i>How is it Modeled:</i> Deduct pollutant loads reduced by each individual retrofit practice through appropriate land use in WTM	

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Table B.14	
Habitat Restoration	
<i>Description:</i> This category includes any pollutant reduction or volume reduction that can be attributed to specific stream rehabilitation, wetland restoration and or riparian reforestation projects planned for construction in the watershed for the permit cycle.	
<i>Runoff Reduction Capability?</i> Yes, for reforestation <i>Pollutant Removal Capability?</i> Yes <i>Derivation:</i> For riparian reforestation (RR), change land cover classification from grass to forest to compute flow and load reduction estimates. For stream rehabilitation (SR), use Baltimore City numbers of in-stream and bank sediment and nutrient reduction per stream mile.	
<i>Unit Area Treated:</i> varies <i>Where Applied:</i> RR: priority on MNCCPC stream valley parks and county- owned land SR: Existing and expanded CIP projects	
<i>Mode of Delivery:</i> capital budget and grants <i>Average Delivery Time:</i> RR: one year SR/WR 2 to 3 years	
<i>Unit Costs:</i> RR: 7.5K per acre reforested. SR: \$200 per linear foot of stream (or actual project cost data for planned CIP projects)	
<i>How is it Modeled :</i> Estimate number and extent of RR and SR projects expected to be implemented in each watershed in each permit cycle, and take resulting load and volume reduction at the back end of the WTM calculation	

Table B.15	
Trash Prevention and Control	
<i>Description:</i> This category includes a wide range of programs and practices specially aimed at reducing trash inputs to stream, including reduce, reuse and recycle campaigns, littering and illegal dumping enforcement, dumpster management, storm drain marking, storm drain inlet devices, stream cleanups, in-stream controls to trap and remove trash, etc. These measures are in addition to any trash trapped and removed by other restoration practices which are computed separately.	
<i>Runoff Reduction Capability?</i> No <i>Pollutant Removal Capability?</i> Limited <i>Derivation:</i> See Appendix E of this memo on the conceptual model for targeting implementation of trash controls on watershed basis	
<i>Unit Area Treated:</i> various	<i>Where Applied:</i> various scales
<i>Mode of Delivery:</i> various	<i>Average Delivery Time:</i> ?
<i>Unit Costs:</i> not currently available at watershed scale	
<i>How it is Modeled:</i> cannot presently be modeled in WTM, so requires a separate analysis. See Appendix E for recommended approach	

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3.0 Desktop BMP Classification and Evaluation

3.1. Basis of Classification of BMP Groups

The initial classification of BMPs was performed based on an evaluation of the practice type, using the coding system outlined in Table B.16. The relative performance of each practice type was based on national comparative reviews of pollutant removal and runoff reduction performance of practices (CWP, 2007; and CWP and CSN, 2008) or performance studies on individual practices (Schueler, 1998).

The second screen was based on County approval date for the BMP, which reflects the design era under which the BMPs were designed and installed. Three broad design eras were defined, as follows:

- **Era 1: Pre-1986.** BMPs installed prior to full implementation of the Maryland Stormwater law of 1984, which typically focused on detention and peak shaving.
- **Era 2: 1986 to 2002.** These practices reflect a design era where water quality was an important part of design, although water quality sizing and design standards were not as great.
- **Era 3: 2002 to 2009.** These practices were built to the more stringent water quality and channel protection sizing requirements and BMP design standards contained in the 2000 edition of the Maryland Stormwater Manual

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Table B.16 General BMP Coding of Montgomery County BMP Database

Performance Code	Structure Type¹
Code 0: Pretreatment BMPs² Not intended to provide runoff reduction or significant pollutant removal	Baysaver (BAYSAV), Interceptor (INT), Vortechinics (VORTEC), Oil/grit separator (SEP), Stormcepter (STC), Flowsplitter (FS), Plunge Pool (PP), V2B1 (V2B1), Vegetated Pool (VP), Aquaswirl (AQSW)
Code 1: Non-performing BMPs Detention or other practices with no runoff reduction and no long term pollutant removal	Control Structure underground (CS), Pond-dry quantity control (PDQN), Underground detention (UG), Underground with stone bottom (UGINF), Pond-dry quantity control and extended detention (PDQNED)
Code 2: Under-performing BMPs Limited runoff reduction and low pollutant removal	Pond-dry quantity control and sand filter base (PDQNSF), Pond-infiltration basin quality control (PDIB), Pond-infiltration basin with extended detention (PDIBED), Pond-infiltration basin quantity control (PDIBQN), Stormfilter (STFIL), Aquafilter (AQFIL)
Code 3: Effective BMPs³ Limited runoff reduction but moderate to high pollutant removal	Pond-wet quantity control and extended detention (PDWTED), Pond-wet quantity control and extended detention (PDWTQNE), Pond-infiltration basin quantity control and extended detention (PDIBQNE), Sand filter (SF), Sand filter quantity control (SFQN), Oil/grit separator and sand filter (SEPSF), Sand filter underground (SFU), Pond-wetland (PDWD), Pond-wetland with extended detention (PDWDED), Pond-wetland quantity control and extended detention (PDWTQN), Pond-wet quality and quantity control (PDWT),
Code 4: ESD BMPs High runoff reduction and moderate to high pollutant removal	Dry swale (DS), Bioretention quality control (BR), Bioretention quantity control (BRQN), Infiltration trench quality control (INF), Infiltrator (INFIL), Infiltration trench quality and quantity control (INFQN), Infiltration trench quality control underground (INFU), Infiltration trench quality and quantity control buried non-surface fed (INFUQN), Level Spreader (LS), Peat sand filter (PSF), and Vegetated Swale (VS).

¹ Structure type codes as reported in MCDEP 2005-06

² Stand-alone practices are given Code 2 pollutant removal efficiency.

³ Structure may not always achieve these rates due to poor design, installation and maintenance, and may be down-graded to under-performing based on inspection reports and hydrologic assessment of practice.

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Code 0. Pretreatment Practices: This class of BMPs includes pretreatment BMPs that were never intended to provide full pollutant removal or runoff reduction, but were used to protect the function of a downstream practice. Typically, these pretreatment BMPs were installed in commercial areas and have a small contributing drainage area. They are often designed based on rate of flow and not the full water quality volume. The most numerous practices in this class are oil grit separators that have been shown to have little or no pollutant removal (e.g., see Schueler, 1998). This class also includes flow structures that split, redirect or dissipate flows, such as flow splitters, underground control structures, and plunge pools.

Pretreatment practices and flow structures that are located upstream of primary stormwater practices are not assumed to provide any additional runoff reduction, channel protection or flood control volume or produce any additional pollutant removal, which is consistent with published studies of their performance (see Table B-18). This class of BMPs is also considered to have low or no retrofit potential since most practices are undersized (relative to WQv), underground and located in densely developed areas where little or no surface area is available for retrofits. Consequently, Code 0 practices that are clearly pretreatment practices to another BMP are excluded from further desktop BMP analysis.

In some instances, code 0 practices were installed as a stand-alone practice (i.e., no downstream BMP). Given that the County has an aggressive maintenance and cleanout program for these facilities, the pollutant removal rate for their contributing impervious areas will be considered to be code 2 (underperforming, as shown in Table B-17).

Code 1: Non-performing: This class of BMPs primarily comprises structures built in Design Era 1 (Pre 1986) that intended to provide detention and peak discharge control, such as dry detention ponds, dry extended detention pond and underground detention structures. In some cases, these structures were also built in other design eras, although there often was a water quality practice upstream. Research has shown that detention or extended detention alone provides low or marginal pollutant or runoff volume reduction. These detention BMPs typically serve larger drainage areas, and are ideal candidates for retrofits.

Code 2: Under-performing: This class of BMPs includes various structures built primarily in Design Era 2 such infiltration basins that have limited runoff reduction capacity (either by design or by clogging after construction), and low to moderate pollutant removal capability, based on the National Pollutant Removal Database (2007 and earlier versions). Generally speaking most of these practices have moderate to large drainage areas. Their current hydrologic performance may be diminished due to the limited design requirements of that era, and their age. This class of BMPs has the significant potential for ESD upgrades, traditional retrofits or existing BMP retrofits. The

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composite runoff reduction and pollutant removal rates are consistent with reported performance values in the NPRD (CWP, 2007) and the most recent runoff reduction values in CWP and CSN (2008).

Code 3: Effective: This class includes a series of ponds with various combinations (or cells) of wet pools, extended detention, wetlands, sand filters and infiltration practices. The BMPs tend to have larger drainage area, and some of them are County regional ponds or retrofits, or special practices used in Special Protection watersheds. Based on past performance research, this group is assumed to have limited runoff reduction capability, but moderate to high pollutant removal. In addition, most BMPs in this class also provide channel protection if they were built in Design Era 3.

Code 4: ESD Practices: This class includes the practices that will be classified as ESD as a result of Task 7b. It is currently populated with bioretention, dry swales, working infiltration and vegetated swales. New practices will be added to this group when the County adopts ESD to the MEP. Most practices are applied to relatively small drainage areas. This is the most effective class of BMPs in that it maximizes both runoff reduction and pollutant mass reduction. To derive a composite estimate for runoff reduction and pollutant removal, we assumed the average reduction values for a group of six ESD practices, as reported in CWP and CSN (2008) and Schueler (2009). The approach is presented in Table B.18, and assumes an equal split between Level 1 and Level 2 design used by VA DCR. This is a reasonable split since the effectiveness of ESD practices differs based on soil type and design features.

3.2 Dealing with Multiple BMPs Within the Same Drainage Area

In early testing, it was evident that two or more BMPs were often present within the same drainage area. These situations are created for a number of reasons, including pretreatment practices prior to a stormwater treatment practice, the existence of a treatment train of multiple stormwater practices within a site, or a water quality practice located above a downstream channel protection or quantity control pond. Multiple BMPs within the same drainage area are quite common, occurring in as many as 50% of all drainage areas within some County watersheds. This situation complicates the BMP coding process, and the following decision sequence was made.

1. Where stand-alone Code 0 BMPs can be isolated in the GIS layer, they will be assigned a Code 2 pollutant removal rate for their contributing impervious drainage area.
2. If multiple BMPs still exist in the DA, the BMP type with the higher code will be considered the primary BMP.

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3.3 Composite Runoff Reduction and Pollutant Removal Rates for Each BMP Code.

Once a final BMP code has been assigned for a drainage area, its runoff volume and/or pollutant load are adjusted to reflect the projected pollutant removal capability of the BMP class. Table B.17 outlines these rates for key pollutants to be investigated in the watershed implementation plans. The pollutant removal rates were derived from the National Pollutant Removal Database (Version 3.0, CWP, 2007). For ESD practices, the pollutant removal and runoff reduction rates were derived using a composite blend of runoff reduction practices, as shown in Table B.18.

Table B.17 Composite Runoff Reduction, Impervious Treated and Pollutant Removal by BMP Code									
<i>Code</i>	<i>Description</i>	<i>RR¹</i> (%)	<i>IAET²</i> (%)	<i>TSS³</i> (%)	<i>TN⁴</i> (%)	<i>TP⁵</i> (%)	<i>F Coli⁶</i> (%)	<i>CPv⁷</i> (%)	<i>QN⁸</i>
1	Non-performing	0	0.05	5	0	0	0	0	No
2	Under-performing	5	0.15	20	5	5	10	100	If QN
3	Effective	10	0.75	80	40	50	65	100	If QN
4	ESD Practices	60	1.0	90	65	65	75	100	Varies

¹ RR: percent annual reduction in post development runoff volume for storms
² IAET: Fraction of contributing impervious acres effectively treated to the Water Quality Volume, and is multiplied by contributing impervious area to track IC acres treated in the watershed
³ TSS: Sediment Removal rate
⁴ TN: Total Nitrogen Removal Rate (Mass)
⁵ TP: Total Phosphorus Removal Rate (Mass)
⁶ Fecal coliform reduction, see rationale in section 5.4 for why enterococci could not be used.
⁷ CPv: Facilities with a ED in their descriptor and were built in ERA 3 are assumed to provide channel protection, and the contributing drainage area of the BMP is considered so treated.
⁸ QN: Facilities with a QN in their descriptor are assumed to provide flood control.

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Table B.18 Composite Annual Runoff Reduction and Nutrient Mass Loadings for ESD Practices ¹			
<i>Type</i>	<i>Runoff Reduction²</i> (%)	<i>Total Phosphorus²</i> (%)	<i>Total Nitrogen²</i> (%)
Bioretention	60	72	77
Dry Swale	50	65	65
Infiltration	70	78	75
Permeable Pavers	60	70	70
Green Roofs	52.5	52.5	52.5
Rain Tanks (cisterns)	52.5	52.5	52.5
Average ESD	60	65	65

¹ Source: Schueler 2009. Introduction to VA DCR Stormwater Practices, Table 1
² Reflects the average of Level 1 and Level 2 ESD shown in Table 1

The composite runoff reduction and pollutant removal effectiveness was further compared against recent research values from Collins, et al. (2008) and assumptions used in the ACOE Anacostia Model (2008), Chesapeake Bay Program (2008), and MDE load reduction calculator (2008). A summary of the comparison is shown in Table B.19, which includes the average values from the Schueler (2009), ACOE, CBP, and MDE sources, as well as a comparison to the proposed MDE Chesapeake Bay TMDL model (2009). The purpose of the comparison is to justify the proposed BMP coding efficiencies with concurrent studies and show the relationship to the MDE Chesapeake Bay TMDL model, which groups practices according to approval date (Figure B.1). In principle, the systems are comparable, and the additional detail in the approach proposed in this guidance is consistent with the more complex permit compliance numbers that the County must develop.

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Table B.19 Comparison of Average Runoff Reduction and Pollutant Removal Methodologies

<i>Category</i>	<i>RR%</i>	<i>TN%</i>	<i>TP%</i>	<i>TSS%</i>	<i>FC%</i>	<i>Source</i>
Code 4: ESD Practices ¹	60	65	65	90	75	Table B.17; Schueler, 2009
Code 3: Effective ¹	7.5	30	38	60	48.75	Table B.17; CWP, 2007
Code 2: Under-performing ¹	0.75	0.8	0.8	3	1.5	Table B.17; CWP, 2007
Code 1: Non-performing ¹	0	0	0	0.25	0	Table B.17; CWP, 2007
Average, ESD Practices	52	51	54	78	76	ACOE, 2008; CBP, 2008; Collins, 2008; MDE, 2008; Schueler, 2009
Average, Effective Practices		26	38	73	59	ACOE, 2008; CBP, 2008; MDE, 2008
Average, Under-performing Practices		5	10	10	0	ACOE, 2008; CBP, 2008; MDE, 2008
MDE: 2002-2010 Era		30	40	80		Figure B.1; MDE, 2008
MDE: Retrofits		25	35	65		Figure B.1; MDE, 2008
MDE: 1985-2001 Era		20	30	50		Figure B.1; MDE, 2008
MDE: Prior to 1985 Era		0	0	0		Figure B.1; MDE, 2008

¹ The BMP Code performance values presented here are adjusted according to the IAET Factor (1.0 for Code 4, 0.75 for Code 3, 0.15 for Code 2, and 0.05 for Code 1)

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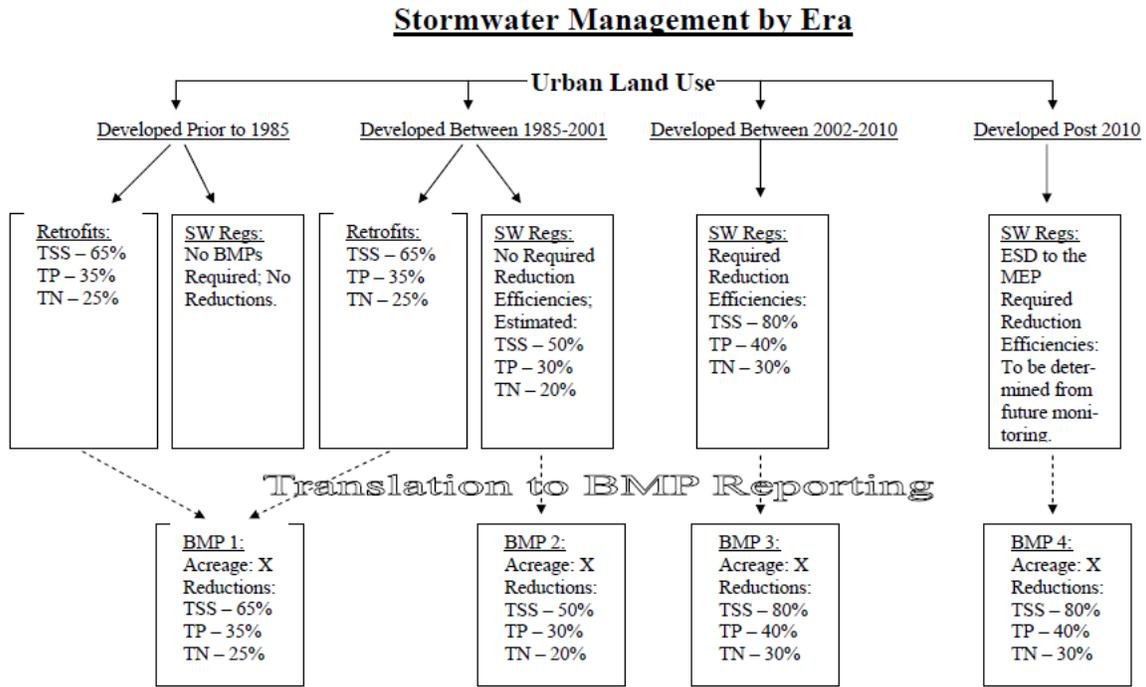


Figure B.1: MDE Chesapeake Bay TMDL modeling approach

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3.4 Removal Rates for Non Retrofit Practices.

This section presents the rationale for selecting pollutant removal rates for various non-retrofit watershed restoration practices that may be analyzed within the individual watershed implementation plans.

Practice	TN Removal	TP Removal	TSS Removal	Reporting Units
Riparian Forest Planting	25%	50%	50%	Acres
Upland Planting (on Turf)	A	A	A	Acres
Septic Denitrification	55	0	0	Systems
Septic Pumping	5	0	0	Systems
Septic connections/hookups	55	0	0	Systems
Emergent marsh restoration	42	55	75	Acres
Palustrine Forest wetland restoration	43	58	75	Acres
Stream restoration	0.20 lbs	0.068 lbs	310 lbs	Linear Ft.
Riparian forest buffers (ag)	60	70	75	Acre treated
Stream fencing and off-stream watering	60	60	75	Acres treated
Residential Nutrient Management	B	B	B	Acres
Hotspot Management	C	C	C	Acres
Enhanced Street Sweeping	5	15	20	Acres
Note A: Shift from turf to forest cover in WTM and change EMC to forest (from turf)				
Note B: Shift from hi input EMC to low input turf EMC within WTM				
Note C: Shift from hotspot EMC to not hotspot EMC within WTM				
Source: CWP. 2005. <i>Maryland Watershed Planning Users Guide</i> . Maryland Department of Natural Resources. Annapolis, MD except for stream restoration which is taken from BDPW (2006) - see Section 5.2 for how it is derived.				

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4.0 Rationale for Unit Planning Costs for Selected Restoration projects

This section outlines the technical assumptions for deriving unit costs for delivering various restoration practices to be considered in the individual watershed implementation plans (Table B.21). Two primary sources were utilized during the evaluations. The first data source were County-derived cost data spreadsheets for restoration projects based on historical costs, which were always considered defaults, since they reflect actual cost of delivery within the County.

The second data source involved retrofit and restoration practice cost surveys and estimates contained in Schueler et al (2007) and (2008). These cost data were used to check the reasonableness of County cost data (if available) and to establish interim cost estimates when County data was not available. No cost data were available for several non-structural practices (e.g., such as hotspot inspections/technical assistance), and the assumptions for making these projections is outlined in a succeeding section.

The consultant met with County staff to review data sources and agree on standard cost assumptions, as follows:

- Base construction costs were increased by a factor of 1.5 to reflect the additional costs for design, engineering, permitting, neighborhood consultation and contingencies for all restoration practices. This reflects the historical experience of MCDEP in bidding restoration practices and is consistent with national cost surveys reported in both CWP (2008) and CWP (2007).
- While maintenance costs are important to consider for every restoration practice, they are already considered in the operating budget impact analysis when CIP projects are approved. Therefore, maintenance costs were not explicitly considered in the analysis. Table B.22 summarizes the implicit maintenance costs per BMP type that comprise the total life cycle costs.
- Costs for restoration practices such as hotspot education/technical assistance or residential nutrient management were developed based on estimated MCDEP staff or consultant costs, assuming a loaded rate of \$100,000 year for salary, benefits and direct program costs, and reasonable assumptions for how many inspections, technical assistance or public outreach events could be conducted by a single worker per year.
- Watershed specific costs could not be developed for several groups of restoration practices: wetland restoration, municipal turf management, County wide policy, and trash prevention and controls.

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- Lastly, it should clearly be recognized that the cost data presented here is for general watershed planning purposes only, and that individual project costs may markedly depart from these averages. Also, since the cost data are based on historical experience, costs may decline in the future as contractors gain more construction experience and can attain economies of scale by batching multiple projects together.

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Table B.21 Common Assumptions for Costs of Restoration Practices			
<i>Practices</i>	<i>Application</i>	<i>Cost per Unit</i>	<i>Sources</i>
New ESD Retrofits in Street Right of Way:	Central Business Dist	250K per IA **	*MCDEP LID and Retrofit Cost Spreadsheets, and **Schueler, 2008 (Appendix E)
	Suburban w/Curbs	200K per IA *	
	Suburban w/o Curbs	137K per IA *	
New ESD Retrofits for Larger Parking Lots and Rooftops	Green Roofs/Tanks	817K per IA **	
	Permeable Pavers	435K per IA **	
	Bioretention	200K per IA *	
ESD Upgrades	Experimental ¹	57K per IA **	Large bioretention retrofits **
Redevelopment ESD	Not a direct cost to county		
Impervious Cover Reduction	Pavement removal, topsoiling and vegetation	\$72,600 per IA	Schueler, 2008 (Appendix E)
Voluntary LID Projects	Rain gardens, rain barrels, disconnects	298K per IA	From MCDEP Rainscapes
Traditional Retrofit	New Pond Retrofit	15K per IA	MCDEP Retrofit Cost Spreadsheets
Retrofits of Existing BMPs	Retrofit of Hydrologic Function	12K per IA	MCDEP spreadsheets ²
Hotspot Inspection/tech Assistance	One Site per week	2.5K per site	40 sites/year
Retail Public Outreach	One Event per Week	2.5K per event	40 events per year//watershed
Wholesale Public Outreach (Lawn Care Stewardship)	Media Campaign	\$15 per household	Schueler (2007)
Site Reforestation	From turf	20K per Ac ³	Schueler (2007)
Stream Restoration	Beyond simple stream repairs	\$ 200 per lf	Both MCDEP spreadsheets and Schueler (2007)
Enhanced Street Sweeping	Two Week Intervals	\$658/mile/yr	MCDEP staff
Notes:			
¹ The installation of ESD practices such as bioretention in dry ponds is currently discouraged due to recurring maintenance problems, but it is proposed that it be considered an experimental retrofit to see if such problems can be eliminated.			
² Typical MCDEP practice for existing BMPs is to do a full pond retrofit			
³ Includes one inch caliper trees, soil prep, tree protection and maintenance			

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Table B.22 County Annual Maintenance Cost Assumptions for Restoration Practices For Life Cycle Cost Estimates
New ESD Retrofit Practices – 5% of Construction Cost
ESD Upgrades –5% of Construction Cost
Redevelopment ESD. 0% of Construction Cost, since the maintenance is performed by the property owner and not the County. If ESD occurs on redevelopment projects on County, MNCCPC or MCPS land, then the 5% of construction cost number will still apply
Impervious Cover Reduction- 0% of Construction Cost, since the restored soil and vegetation requires no additional maintenance to sustain the performance
Voluntary LID Implementation - 0% of Construction Cost, since the maintenance is performed by the property owner and not the County.
Traditional Retrofits - 3% of Construction Cost
Retrofits to Existing BMPs – 0% of the Upgrade Cost, since the upgrade to existing practices will not increase future maintenance costs, and may in fact reduce them
Hotspot Pollution Prevention – 0% of Initial Cost, since ongoing pollution prevention and training is incurred by the hotspot owner and not the County
Retail Public Outreach - 50% of the First Year Cost since the effort must be repeated every two years to assure changes in watershed behavior and stewardship are maintained
Wholesale Public Outreach - 25% of the First Year Cost since the effort must be repeated on an approximately four year cycle to assure changes in watershed behavior and stewardship are maintained
Site Reforestation – 0.5% of Initial Planting Cost for high intensity maintenance in first three years, followed by less intensive maintenance as the forest matures
Stream Restoration - 2% of Construction Costs
Enhanced County Street Sweeping – 100% of Implementation Cost since the sweeping is conducted every year at the same cost
Note: for purposes of this life cycle analysis, the time-frame is four permit cycles or 20 years.
References and Sources: The maintenance cost assumptions were derived from three primary sources: Personal communication with Dan Harper of MCDEP on actual budgeted costs for maintenance within Montgomery County, MD and prior cost on BMP maintenance research from Schueler (1987), Controlling Urban Runoff: a practical manual for planning and designing urban best management practices. Metropolitan Washington Council of Governments, Washington, D.C. and Schueler (2007). Stormwater Retrofit Practices. Manual 3 in Small Watershed Restoration Manual Series. Appendix D. Center for Watershed Protection. Ellicott City, MD.

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5.0 Special Issues in Watershed Analysis

5.1 Rationale for Alternative Approach for Flow Reduction Analysis

The original scope calls for evaluating flow reduction scenarios in each watershed, relative to six-month, one-year, two-year, five-year, and ten year 24-hour precipitation events. The goal of this analysis was to determine how past and future implementation of LID/ESD practices affect flow reductions, compared to conventional stormwater practices. The team initially sought to use the peak flow reduction potential analysis regression equations cited in Appendix E of the ACOE Anacostia River Watershed Restoration Plan Interim Report Framework (November 2008), for storm events from the 2 year storm to the 10 year storm. However, this approach was dropped from further consideration because the equations did not cover the smaller storm events (e.g., six-month and one-year) with the greatest potential to show runoff volume improvements. Furthermore, review of recent research indicates that peak flow reduction can be extremely hard to detect at the watershed level due to the coincident peak issue, even with larger storm detention measures in place, and the inundation effect of large flood events (Emerson, et. al., 2005; Goff and Gentry, 2006). However, ESD practices can contribute to peak flow reduction depending on their runoff reduction volume and placement in the watershed (Gilroy and McCuen, 2009).

Consequently, the team elected to conduct an alternative approach to model the effect of ESD practices focusing on annual runoff volume within the seven watersheds modeled using the WTM. Table B.17 outlines the percent annual runoff volume reduction for the four BMP groups investigated in the watershed implementation plans. The reduction rates were derived from the National Pollutant Removal Database (Version 3.0, CWP, 2007). For ESD practices, the pollutant removal and runoff reduction rates were derived using a composite blend of runoff reduction practices, as shown in Table B.18.

The team will estimate a countywide benefit from the modeling effort in order to look at the relative benefits of ESD application compared to no controls and conventional controls (Figure B.2). The modeling results can be further used to explore relationships between annual runoff reduction and other watershed metrics indicative of channel protection such peak runoff control and watershed imperviousness to assess the relative benefits of ESD at the watershed and countywide scale. In addition, the relative cost/benefit of the various strategies will be explored in terms of their effectiveness from a volume reduction standpoint.

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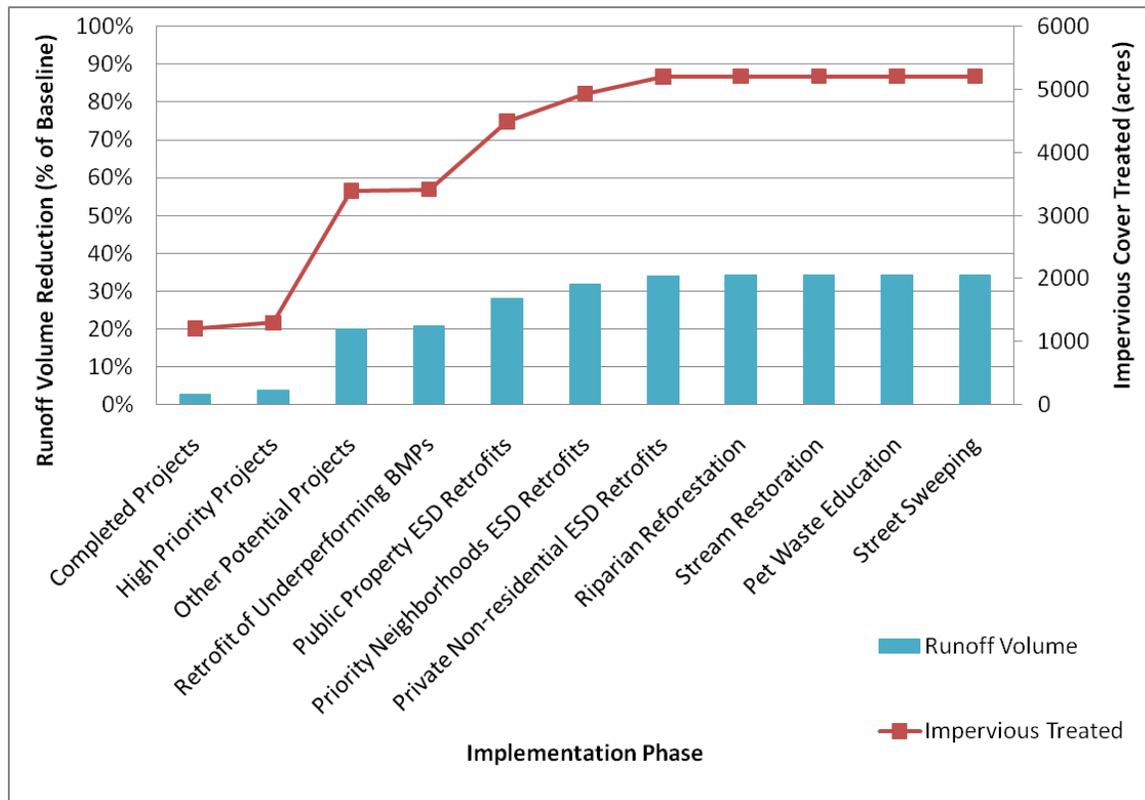


Figure B.2. Volume reduction estimated using the WTM for the Anacostia watershed using a range of potential treatment scenarios

5.2 Documentation of Equivalent Impervious Area Treated

Some projects like reforestation and compost amendments cannot be quantified in terms of impervious acres treated. The proposed solution for these projects is to consider them as equivalent impervious area, from a hydrologic standpoint using the compacted soil runoff coefficients presented in CWP (2009) (Table B.23). Under this approach, ten acres of these practices installed on pervious land would be hydrologically equivalent to one impervious acre treated.

Runoff Coefficient Approach

The R_v for a one acre of impervious cover is 0.95 [$R_v = 0.05 + 0.009 (100)$]

Average Runoff Coefficient for Forest Cover, BCD soil types is 0.04

Average Runoff Coefficient for Disturbed Soils, BCD soil types is 0.223

Differential Runoff Coefficient of 0.183.

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Assume ESD measures (reforestation, compost amendments, etc) are capable of reducing the differential by half (0.091). This is due to the fact that it takes many years for planted trees to achieve enough overhead canopy to function hydrologically as forest. Similarly, there is not enough data yet to show that compost amendments can shift disturbed soils fully to a forest cover runoff coefficient.

Then, it would take ten acres of these ESD measures to be equivalent to one acre of impervious cover of runoff reduction: $(10 \text{ acres}) \times (0.091) + 0.04 = 0.95$

Soil Condition	Runoff Coefficient
Forest Cover	0.02 to 0.05*
Disturbed Soils/Managed Turf	0.15 to 0.25*
Impervious Cover	0.95
*Range dependent on original Hydrologic Soil Group (HSG)	
Forest	A: 0.02 B: 0.03 C: 0.04 D: 0.05
Disturbed Soils	A: 0.15 B: 0.20 C: 0.22 D: 0.25

Note: The effect of these ESD practices is different if they are used to boost runoff reduction by treating runoff from adjacent impervious areas (e.g., filter strip, grass channel, enhanced rooftop connection, etc).

A slightly different approach was used to create an equivalency between stream restoration projects and impervious acres treated. The phosphorus reduction rates for stream restoration provided in Table B.20 were multiplied by a unit reach of 100 feet to obtain a total phosphorus reduction of 6.8 lbs/yr (BDPW, 2006). This value was then divided by the unit phosphorus load for an acre of impervious cover using the Simple Method (2.0 lbs, Schueler, 1987). Based on this analysis, each 100 feet of stream restoration can be considered equivalent to fully treating 3.4 acres of impervious cover.

5.3 Method for Dealing with Channel Protection in Individual Watersheds

Most Montgomery County watersheds have drainage channels and streams that are actively eroding. This is common in watersheds that were developed without stormwater treatment practices. Trimble (1997) attributed up to 70% of the total sediment load in developed watersheds to in-stream channel erosion.

The effect of retrofitting existing impervious cover by providing channel protection controls can contribute to reducing the load by reducing stream channel erosion. In order to estimate this potential reduction in load, a unit load reduction estimate per linear foot of stream channel is proposed. The method is briefly described as follows:

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Method: Unit Stream Loading Reduction

This method simply applies a load reduction as a function of the length of channel influenced by the channel protection measures.

To derive this number a practitioner must use a starting number from the literature of average loading from channel erosion for alluvial stream in the Piedmont. The Chesapeake Bay Program has historically presented monitoring data from Spring Hill Branch in Baltimore County that estimated a value of 2.5lbs/lf as the reduction in load from urban Piedmont Streams associated with the implementation of stream restoration practices. However, more recent data from Baltimore City and State Highway Administration suggests reduction rates of 310 lbs/lf/yr.

The data associated with stream restoration are variable, and therefore, may be subject to refinement or revisions as better and more information is collected, compiled and analyzed. For the purposes of this guidance, we have assumed a sediment reduction benefit associated with stream restoration to be 310 lbs/lf/yr.

5.4 Handling Bacteria Loads in Individual Watersheds

Analyzing bacteria loads, sources and removal mechanisms at the watershed level can be problematic. While bacteria EMCs from various land uses are well documented in the National Pollutant Removal Database (Pitt, 2008), they tend to be quite high and extremely variable and make it difficult to isolate controllable source areas (Schueler, 1999). In addition, while limited information exists on the fecal coliform bacteria removal capability of structural stormwater practices, such as ponds, bioretention and sand filters (CWP, 2007, Hunt et al, 2008 and Barrett et al 2003), there is little or no data on bacteria removal rates for non-structural stormwater practices, education or restoration practices.

Another complicating factor is that nearly all of the bacteria monitoring data that exists for urban watersheds use fecal coliform as a pathogen indicator, yet several of the bacteria TMDLs are based on enterococci, for which there is virtually no data. A review of the National Stormwater Quality Database (Pitt et al, 2004) indicated that while there were more than 2000 storm samples for fecal coliform bacteria, only 67 samples for *e. coli* were recorded, and none for enterococci. Therefore, the consultant team can only evaluate fecal coliform in the watershed implementation plans, and then look to apply correlation ratios that have been used by MDE in the development of the Anacostia bacteria TMDL.

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Given this technical background, the consultant team developed an alternative modeling approach for the County watersheds that are listed for bacteria and have TMDLs. The basic approach involves three steps.

The first step involves WTM modeling of fecal coliform at the watershed level, using default fecal coliform EMCs, and converting the results to the E coli or enterococci for TMDL watersheds accordingly. This conversion is not necessary for non-TMDL watersheds. The conversion process was based on an MDE study of paired enterococci and fecal coliform water samples from the Anacostia River and is previously described in Section 1.1 of this Appendix.

In order to normalize the watershed load to within reasonable agreement of the TMDL baseline, the landuse EMC's were directly adjusted.

The second step requires estimating the degree of fecal coliform reduction achieved by existing stormwater practices and proposed retrofits (using average removal rates as shown in Table B.18). This step is used to define how much of the bacteria load can be controlled by structural stormwater practices alone, and is not expected to show that these reductions are sufficient to meet the TMDL limits in most watersheds.

The third step involves a watershed screening to identify potentially controllable bacteria hotspots using metrics (in the same basic manner as was done for trash). Two primary metrics are used to define subwatersheds with high bacteria loadings to be targeted for specific management practices.

1. *Poor Riparian Buffer Metrics.* These metrics will identify reaches of open channel in the County without an adequate 100-foot buffer of either side of the channel. These areas could be targeted for land use conversion to forested buffer and reduced bacterial loading. The accounting for this conversion is handled in the WTM under the land reclamation subroutine.
2. *Residential Pet Waste Metrics.* These metrics will identify watershed areas with high residential land use that could be targeted for intensive educational outreach to pick up pet waste. The recommended metrics are: fraction of households with a dog, owners who walk their dogs, owners who clean up, fraction willing to change behavior, and awareness of message. The last metric (awareness of message) could be adjusted according to the proposed outreach effort, but 80% awareness is recommended based on an aggressive education and enforcement program.

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6.0 Montgomery County Stakeholder Demographics

Understanding of the county's demographics will also be used to target stakeholder involvement in implementation plan development and application. By and large, Montgomery County has well educated residents. Census data indicates that only 10% of adult individuals have failed to receive a 12th grade education. Over 60% of residents have received a post-secondary degree, of some kind. Communication with such well educated stakeholders will allow the implementation plans to assume greater cognitive capabilities among stakeholders than is found on the national average (where an 8th grade education can only be assumed) making stakeholder comprehension of the complex issues associated with watershed protection more likely.

Implementation plans can rely on census information that the profound majority of county residents own the property they reside on (nearly 70%) and thus have control over that property. Also, nearly 70% of the residences are single unit homes. Moreover, the average household income is roughly \$90,000 making the likelihood of financial capability to install BMPs an appropriate assumption. Both of these statistics make advocacy of BMPs on residential properties an imperative for all implementation plans.

Implementation plans can also rely on census information that the majority of Montgomery County residents speak English well. Spanish translations of stakeholder involvement opportunities will be required in select watersheds to accommodate the 13% of county residents that indicate their preferred language as Spanish. Implementation plans will take multi-lingual requirements into consideration for signage and other educational tools as well.

The relative "youth" of Montgomery County should inform the "look and feel" of outreach communications prescribed in implementation plans. The county includes a fairly even split of males and females. Majority of residents, nearly 50%, fall between the ages of 25 and 55. Only 15% of the population is aged 60 and above. Appropriate application of this knowledge should inform content and design of outreach communications by relying on images and phrases readily recognizable by this age bracket. In certain watersheds it may also be appropriate to allow ethnicity to inform the "look and feel" of outreach communications prescribed in implementation plans. Census data indicates that 11% of the county's population is Asian (Korean and Vietnamese). Consideration of this unique characteristic of Montgomery as compared to other Maryland counties will be included in implementation plan development.

Stakeholder involvement in implementation plan development and application will be framed in reliance on previous MDEP stakeholder surveys. Through those past survey efforts, it is already known that majority of Montgomery County residents, nearly half, prefer newspapers, (*Washington Post* and *Gazette*) as their primary source of information; The *Washington Post* being the more prominently read. Internet media providers rank

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second, among preferred sources. More than half of residents surveyed have, at some point, visited the county website. Residents who claimed to rely primarily on television numbered slightly under one quarter of all surveyed. Far below all, stands radio. From these surveys we also know that county residents who believe that issues affecting the environment directly affect themselves, rely most heavily upon *The Washington Post*. The same is true for those who see water management as the most important environmental concern. Lower income brackets prefer television, while higher income brackets prefer mostly newspapers, but also the internet. Given a choice, most residents, nearly half, claim that they would prefer to receive information from the county government from email or direct mailing. Notable totals also exist for both television and the county website. Although this data was gathered before the current popularity of social media had evolved, reliance on the preferred outreach tools will be strongly considered. For example, jurisdictions in Virginia have recently run public service announcements on local radio stations suggesting stewardship behaviors in relation to storm drains. Given the low reliance on radio in Montgomery County similar PSAs will not likely be a part of outreach in the implementation plans.

Montgomery County's robust business economy will also be considered in implementation plan development. Unique among Maryland counties, Montgomery has a large number of businesses thriving in the current economic downturn. While other parts of the state are plagued by manufacturing facilities and warehouses closing and ceasing to improve their properties, Montgomery County's business community is still profitable and still maintaining and improving existing facilities. Moreover, the construction of the inter-county-connector through much of Montgomery County will provide opportunities to install demonstration BMPs on newly developing properties for replication throughout stakeholder groups. Also, the presence of communication industry leaders (i.e., Discovery Channel) in the county creates unique stewardship education partnership possibilities with businesses. Implementation plans will include these stakeholder involvement opportunities to best harness the power of Montgomery County's healthy business economy.

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Appendix C - GIS Steps for Processing Montgomery County Data

Step 1: Create jurisdictional watershed file

Union watershed to “ALLEXCLUSIONwFEDSTATERD.”

Call it “gs_wtshd_ctyjurisd” (for great Seneca)
Delete features from “allexclusionwfedstaterd”

Step 2A: Batch Clip the following to gs_wtshd_ctyjurisd:

- IMPERVIOUS_RECRE
- LULCwRoads_Final_HW
- WQCases2004_2009_Location
- SWCases2004_2009_Location
- soilmu_a_md031 joined with “muaggatt”
- County_wetlands
- forest2008
- sens_areas_all
- special_protection_areas_2005
- PROPERTY
- MDP_points
- County_points
- pubsch
- Restoration_Sites_Export

****note, do NOT clip the BMP files (SW_DA, BMP_all_with_codes) or HYDRO_line file**

Add “gs” (whatever abbr. for your watershed) to name of each file. Shorten the name for the impervious file to “gs_ic”.

Step 2B: Clip Impervious RECRE and HYDRO LINE to whole watershed

Call it “gs_ic_totalwatershed” and “gs_HYDRO_totalwatershed”

Step 3: Quantify and analyze County Impervious, Forest, Turf, and stream miles

Total Watershed IC

Update shape_area field for “gs_ic_totalwatershed” using calculate geometry, and sum for total watershed IC

Non-exempt County and Non-exempt County IC

Update shape_area fields for “gs_wtshd_ctyjurisd” and “gs_ic” using calculate geometry, and sum for total area and IC.

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Existing IC Treatment/Previously Identified Project IC Treatment

Based on BMP Tables (listed below)

Determine FC/TC

Update shape_area field of “gs_ic” using calculate geometry to get IC

Add field called “imp” to “gs_ic.” Use Field calculator to add “1” to all features, and dissolve by “imp.”

Add field called “forest” to “gs_forest2008.” Use Field calculator to add “1” to all features, and dissolve by “forest.”

Union “gs_ic_dslve” and “gs_forest2008_dslve.”

Add field to gs_imp_forest_union for acres, and calculate geometry.

Only the feature that has no “1” in the “imp” field should be counted for forest cover (FC).

Turf cover is total jurisdiction area – IC – FC.

Determining stream miles

Update shape_length field using calculate geometry

Add field (double) named “strmlth_ft”

Select by attributes – FTR_Code = 0500413 and 0500415

Field calculator “strmlth_ft” = “shape_length” for selected features

Select by attributes – FTR_Code = 0500412

Field calculator “strmlth_ft” = “shape_length” / 2 for selected features

Sum values in “strmlth_ft” to determine total ft and then miles for watershed

****note – some of 0500415 (hidden hydro) are doubled up, i.e., continuations of 0500412 river/streams.**

Step 4: Quantify and Analyze county land use/land cover

Determine land use/cover values

Dissolve gs_LULCwRoads_final_HW by “LULCNAME”

Add field “area_acres” (double) and calculate using calculate geometry

Hotspots

- Quantified and analyzed in Step 8.

WTM Designations

- Institutional is considered Intensive
- Open Urban Land and Bare Exposed Rock are considered Extensive
- Residential is split 50/50 between high input and low input turf.

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Table C.1: 2002 MdOP LULC to WTM Designations

Land Use in WTM	LULC Classification
Residential	Low-density residential
	Medium-density residential
	High-density residential
Commercial	Commercial
Roadway	Roadway
Industrial	Extractive
	Industrial
Forest	Mixed forest
	Brush
	Deciduous forest
	Evergreen forest
Rural	Orchards/vineyards/horticulture
	Feeding operations
	Cropland
	Pasture
	Agricultural buildings
Municipal/ Institutional	Institutional
	Open urban land
	Bare exposed rock
Open Water	Water
	Wetlands
Active Construction	Bare ground

Step 5: Quantify and Analyze County Impervious and Maximum Treatable Area

Determine Roads breakdown

Select by location the “gs_Roads_HW” that intersect low density residential roads, using RE2 and R200 road shapefiles provided by the County. Update shape_area field. Record as total area of open-section roads using summary statistics.

Determine Parking Lot breakdown

Add field to “gs_Parking_final” for “Area_acres.” Calculate geometry. Add field (text) “over_1acre.” Select by attributes features “Area_acres” >= 1, and use field calculator to add “yes” to selected features.

Select by location the “gs_PROPERTY” polygons that contain the “gs_COUNTY_PNTS” – create “gs_County_Property” shapefile.

Add field (text) “cnty_prop.” Select by location the “gs_Parking_final” polygons that have their centroid within “gs_County_Property” polygons. Spot check. Use field calculator to add “yes” to

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“cnty_prop” for selected features. Sum area for county lots \geq 1 acre, $<$ then 1 acre, and subtract both from total for “Private.”

Determine Roof Breakdown

Spatial Join the “gs_PROPERTY” polygons (as target) with the “gs_MDP_PNTS” – “gs_MDP_Property” shapefile. Select by attribute “DESCDWEL” = “split foyer, 2-level” OR “split foyer, 3-level” OR “standard single family unit 1, 2, or 3 story.” Create shapfile “gs_singlefamily_parcel.”

Add fields (text) to “gs_Building_final” named “cnty_prop” and “sngl_fam.”

Select by location the “gs_Building_final” polygons that have their centroid within “gs_County_Property” polygons. Use Field Calculator to enter “yes” in the “cnty_prop” field for selected features.

Select by location the “gs_Building_final” polygons that have their centroid within “gs_singlefamily_parcel” polygons. Use Field Calculator to enter “yes” in the “sngl_fam” field for selected features.

Calculate Sidewalks

Update shape_area field using calculate geometry.

Calculate Recreational Impervious

Update shape_area field using calculate geometry.

Determine “Other” Breakdown

Schools

Select by location the “gs_PROPERTY” polygons that contain the “pubsch” shapefile from LOCATIONS geodatabase – create “gs_pubsch_Property” shapefile.

Add field (text) to “gs_ic” for “pubsch_prop.” Select by location the “gs_ic” polygons that have their centroid within “gs_pubsch_Property” polygons. Spot check. Use field calculator to add “yes” to “pubsch_prop” field for selected features. Sum areas.

NOTE: REPEAT STEP 5 FOR UNTREATED AREAS. UNION IMPERVIOUS FILES WITH SW_DA, AND DELETE IMPERVIOUS AREAS CURRENTLY WITHIN A SW_DA.

Step 6A: Create and populate county existing BMP drainage area layer

Select by location “SW_DA ASSOIN” that intersect “gs_wtshd_ctyjurisd.”
Export to file “gs_SW_DA.” This selects DAs with any portion inside the County’s jurisdiction.

Intersect “gs_SW_DA” and “gs_ic”, save to “gs_IC_DA.” Dissolve the file based on SEQNO and

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update area using calculate geometry. This yields the acres of impervious by DA sequence number.

Join “gs_IC_DA” to “gs_SW_DA” based on SEQNO field. Export to shapefile called “gs_SW_DAwIC.” This gives you a shapefile of DAs by SEQNO with calculated total drainage areas and jurisdictional-only impervious areas.

Step 6B: Quantify and Analyze Existing BMP coverage

Select by location “BMP_all_with_codes” that intersect “gs_SW_DAwIC.” Export to file “gs_BMP.”

Spatially join “gs_BMP” as Target with “gs_SW_DAwIC” as Join Feature with Match Option set to “is_within”. Save as “gs_BMP_final.”

Summarize based on SEQNO_1 (SEQNO of the DA, NOT SEQNO of the BMP) the maximum of the Perf_Code field, the max of the drainage area, and the max of the ic_area, and save output table as “gs_aggregate_BMPcode.”

Summarize “gs_aggregate_BMPcode” based on “Maximum of Perf_Code” field, the “sum” of the drainage area, and the “sum” of the ic_area. Save output table as “gs_agg_BMPcode_final.”

Select by location “gs_SW_DAwIC” that intersect “gs_BMP_final.” Switch selection (selects drainage areas that had no BMPs). Use summary statistics to find sum of drainage area and ic_area. Use these values for “Pretreatment & Unknown” row in table.

Step 7: Quantify and Analyze Existing Stream Restoration coverage

1. Select by location points in the “Restoration_Sites_Export” shapefile that intersect “gs_wtshd_ctyjurisd”
2. Summarize selection based on Project_St
3. Record number of sites Stream Restoration Completed
4. Summarize the total stream restoration project length**.
5. Use IC treatment equivalency (Appendix B-3.4 acres/100 ft of stream) to apply equivalent impervious cover treatment per watershed.

**County Database reports stream restoration project length, derived by the actual final project length or averaging previous reported project length in watershed assessments, action plans, or COST_DATA spreadsheet.

Step 8: Quantify and Analyze WQ Complaints and Illegal Dump Sites

Water Quality Complaints

1. Re-calculate Area field in “gs_Property”
2. Select by location all polygons from “gs_Property” that intersect

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“gs_WQCase2004_2009_locations”

3. Summarize by GENLZONE field with sum of area field. Record sum of area in CZ zoning as commercial hotspot area. Record sum of area in IZ zoning as industrial hotspot area.
4. Also include summary table of number/count of water quality complaints by jurisdiction.

Illegal Dump Sites

5. Select by location all polygons from “gs_Property” that intersect “gs_SWCase2004_2009_locations”
6. Summarize by GENLZONE field with sum of area field.
7. Include summary table of number/count of trash complaints by jurisdiction and sum of area by zoning use.

Step 9: Summarize DEP Biomonitoring Sites

A. Creating a shapefile of Biological Monitoring Drainage Areas with average IBI scores:
THIS STEP HAS BEEN PERFORMED BY MCDEP STAFF. SEE “BIOHABITATS INSTRUCTIONS.doc” dated 01/27/2010.

Table C.2: Metadata for DEP Biological Monitoring Data

FIELDS IN "Bug Narrative Summary"

Narrative	<i>Excellent (36-40(Channery Silt Loam); 35-40(Silt Loam)), Good (26-35); Fair (17-25); Poor (8-16)</i>
SummaryScore	<i>Calculated from metrics: Total number of taxa; Biotic index; Ratio of scrapers (scrapers + filtering collectors); Proportion of hydropsycha and cheumatopsycha/total EPT individuals; Proportion of dominant taxa; Total number of EPT taxa; Proportion of total EPT individuals; Proportion of shredders</i>

FIELDS IN "Fish Narrative Summary"

Narrative	<i>Excellent (4.5-5.0), Good (3.3-4.4), Fair (2.2-3.2), Poor (1.0-2.1)</i>
SummaryScore	<i>Calculated from metrics: Total # spp., total # riffle benthic insectivores; total # minnow spp., total # intolerant spp., proportion of tolerant indiv, prop omnivores/generalists; prop pioneering spp., total # individuals (excluding tolerants); proportion w/disease or anomalies</i>

FIELDS IN "Habitat Narrative Summary"

Narrative	<i>Optimal (166-200); Suboptimal (113-153); Marginal (60-100); Poor (0-47)</i>
SummaryScore	<i>Total Score (maximum 200) from Barbour and Stribling, Visual-Based Habitat Assessment in Riffle/Run Prevalent Streams.</i>

NOTE THAT THE NEW DATASOURCE HAS BEEN GIVEN AN AVERAGE STREAM CONDITIONS NARRATIVE ON A DIFFERENT SCALE THAN OUTLINED ABOVE.

B. Assigning IBI scores per stream mile:

1. Open the gs_HYDRO_totalwatershed shapefile, clipped to your targeted watershed.
2. Intersect the HYDRO_LINE and MC_BaselineStreamCond.shp shapefiles. Export to HYDRO_BASELINE shapefile

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3. Calculate the SHAPE_Length field in HYDRO_BASELINE geometry in miles.
4. Select by attribute in HYDRO_BASELINE from the FTR_CODE field, records with FTR_CODE = 0500412. Summarize by IBI Narrative including the sum of SHAPE_Length. Divide the sum by 2 to get the total length of “river/stream” miles.
5. Repeat step 4 by selecting by attribute FTR_CODE = 0500413 OR FTR_CODE = 0500415. Summarize by IBI Narrative including the sum of SHAPE_Length. The sum equals the total length of “single line stream” or “hidden hydro” miles.
6. Sum “river/stream”, “single line stream” and “hidden hydro” miles by narrative score to obtain the total length of stream per watershed with associated IBI score.
7. Repeat Process 2-6 for the MC_StreamCond_SPA.shp shapefile to obtain the HYDRO_SPA shapefile and summarized stream segment lengths.

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Appendix D- Watershed Baseline Conditions Template

D1. VISION AND EXISTING CONDITIONS

1.1. (Watershed Name) Vision

- 1.1.1. Vision
- 1.1.2. Management Status
 - 1.1.2.1. Inventory of Completed Studies

1.2. Watershed Profile

- 1.2.1. Drainage Area

Figure 1.1: Map of Watershed (highlighted on map of whole county)

- 1.2.2. Location/Watershed

Table A.1: Watershed Profile¹

	Watershed Total
Total Watershed Acres	
Impervious Cover (acres & %)	
Non-exempt County Acres¹	
Non-exempt County IC (acres & %)¹	
Previously Identified Project IC Treatment²	
IC Treatment Goal (acres)³	
Forest Cover (acres & %)⁴	
Turf Cover (acres & %)⁵	
Stream miles⁶	
Stream miles restored⁷	

¹ Excluded areas include Gaithersburg, Rockville, Takoma Park, rural zoning, all MNCPP parks, Federal and State property, and Federal and State roads from GIS data layer ALLEXCLUSIONwFEDSTATARD.shp

² Projects include previous watershed restoration plans, action plans, Capital Improvement Projects (CIP)

³ 20% of untreated, non-exempt county IC

⁴ Derived from Forest2008 shapefile (County digitized forest from 2008 aerial photography).

⁵ Remainder of Jurisdictional area minus IC and FC area

⁶ Derived from Hydro_line.shp.

⁷ Derived from Restoration_Sites11_09_2009.shp

- 1.2.3. Land Use Types (Parks, Agriculture, Forested, etc., with percent of watershed they occupy)
- 1.2.4. Stream conditions and structures
- 1.2.5. Population Density

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Table D.2: Non-exempt County Land Use Breakdown

MdOP 2002 Land Cover/Land Use	Watershed Acres	Percent of Total (%)
Low Density Residential (<1 du/acre)		
Medium Density Residential (1-4 du/acre)		
High Density Residential (>4 du/acre)		
Commercial- Hot ¹		
Commercial- Not		
Industrial- Hot ²		
Industrial- Not		
Municipal/Institutional- Intensive ³		
Municipal/Institutional- Extensive ⁴		
Roadway ⁵		
Rural ⁶		
Forest		
Open Water		
Bare Ground		
Total Watershed		

¹ Identified by intersection of commercial zoning in PROPERTIES.shp and WQCases2004_2009_Locations.shp

² Identified by intersection of industrial zoning in PROPERTIES.shp and WQCases2004_2009_Locations.shp

³ Institutional land use

⁴ Open Urban Land and Bare Rock land use

⁵ Combined County and private roads (excludes Federal and State roads)

⁶ Orchards, Vineyards, Horticulture, Feeding Operations, Cropland, Pasture, and Agricultural Buildings land use

1.2.6. Impervious Surfaces (% of watershed)

Table D.3: Non-exempt County Impervious Cover Breakdown

Impervious Cover Type	Impervious Acres	Watershed (%)
1. Roads		
a. Low Density Residential ¹		
b. Other ²		
2. Parking Lot		
a. County Small Lots (<1 acre) ³		
b. County Large Lots (>=1 acre) ³		
c. Private		

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Impervious Cover Type	Impervious Acres	Watershed (%)
3. Roofs		
a. County ⁴		
b. Single Family Homes ⁵		
c. Other		
4. Sidewalks⁶		
5. Other		
a. Schools ⁷		
b. Recreational ⁸		
Total Impervious Acres from GIS⁹		

¹All roads in RE2 or R200 property zoning.

²Includes county and private roads.

³Parking lots located in County-owned parcels, derived using County_pnts from the County's PROPERTY geodatabase.

⁴Buildings located in County-owned parcels, derived using County_pnts from the County's PROPERTY geodatabase.

⁵Buildings located on single family home parcels, derived using MDP_pnts from the County's PROPERTY geodatabase and selecting only single-family dwelling types.

⁶Sidewalks in jurisdiction. Does not include all residential sidewalks or driveways.

⁷Impervious cover located in public school parcels, derived using pubsch points from the County's LOCATIONS geodatabase. Some overlap with other impervious.

⁸Impervious cover identified as Recreational in geodatabase. Some overlap with other impervious.

⁹Sum of all GIS impervious. Excludes overlaps in schools and recreational.

- 1.2.7. Forested Areas (% of watershed)
 - 1.2.7.1.SPAs, Conservation areas, etc.
- 1.2.8. Stormwater Controls and BMPs

Figure 1.2: Map of Stream Conditions

Figure 1.3: Map of watershed Planning Units (ex: Watershed Preservation Area, Watershed Protection Area, Watershed Restoration Area, Urban Watershed Management Area, and Agricultural Watershed Management Area)

Figure 1.4: Map of watershed BMPs

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Table D.4: Non-exempt County IC: Existing Stormwater Management

BMP Performance Code ¹	Acres of Impervious Treatment				
	Drainage Area Treated	Total IC in DA	IAET Factor ²	IC Treated	% of Total IC
(4) ESD BMPs			1.0		
(3) Effective BMPs			0.75		
(2) Under-performing BMPs			0.15		
(1) Non-performing BMPs			0.05		
(0) Pretreatment & Unknown ³			0.0		
Total IC Treated			-		
Existing IC	-	-	-		
Remaining Untreated	-	-	-		

¹For drainage areas with more than one BMP, the maximum performance code was taken after deleting pretreatment BMPs (Code 0).

²Impervious Area Effective Treatment

³DA not associated with a specific BMP type

“In addition to the structural stormwater management facilities listed above, there are 4 completed stream restoration sites within the County jurisdictional area of Rock Creek. Given the historical average restoration length of 3,500 linear feet, the completed projects have restored a total length of stream equal to 14,000 linear feet, with a treated impervious cover equivalency of 476 acres (7.2% of the total county impervious cover).”

1.3. Biological and Water Quality Conditions

1.3.1. Stream Health Assessment

1.3.1.1. IBI Scores

Table D.5: Watershed Fish and Benthic Invertebrate IBI Scores¹

Score	Fish (Stream Miles)	Benthic (Stream Miles)
Excellent		
Good		
Fair		
Poor		
No Score		
Overall		

¹ DEP Biological Monitoring GIS Database

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Table D.6: Watershed Habitat IBI Scores¹

Score	Fish (Stream Miles)	Benthic (Stream Miles)
Optimal		
Optimal/Suboptimal		
Suboptimal		
Suboptimal/Marginal		
Marginal		
No Score		
Overall		

¹ DEP Biological Monitoring GIS Database

1.3.2. Water Quality and Trash Issues

Figure 1.5: WQCases and SWCases

Table D.7: Solid Waste Trash Dumping Sites¹

#/SW Type				
Total # of cases	Farm Land	Residential	Public Land	Dumpster

¹ From SWCases2004_2009_locations.shp

Table D.7: Solid Waste Trash Dumping Sites by Zoning¹

General Zoning Type ²	Acres	Total # of Properties
Agricultural		
Commercial		
Industrial		
Residential		
Unzoned		

¹ From SWCases2004_2009_locations.shp

² From County PROPERTIES.shp

Table D.8: Recorded WQ complaints¹

#/WQ Type				
Total # of cases	Stormwater- Pollutant Discharge	Surface Water- Chemical Discoloration/ Unknown	Surface Water- Sewage	Surface Water- Petroleum Product in Water

¹ From WQCases2004_2009_Locations.shp

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Table D.7: Water Quality Complaint by Zoning¹

General Zoning Type ²	Acres	Total # of Properties
Agricultural		
Commercial		
Industrial		
NonConforming		
Residential		
Unzoned		

¹ From SWCases2004_2009_locations.shp

² From County PROPERTIES.shp

1.3.3. Other Impairments

1.3.3.1.MDE Impairments

1.3.3.2.Brownfields

1.4. Existing Pollutant Loads

1.4.1. Pollutant Loading rate

1.4.2. TMDLs

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Table D.9: Sediment/Nutrient/Bacteria Baseline Loading Estimates for (Watershed Name) Watershed and Comparison Values from MDE

Parameter	Date	Waterbody Name	Baseline Montgomery County MS4 load	Montgomery County WLAsw % Reduction	Target Montgomery County MS4 load	% of Overall TMDL
Sediment						

D2. INVENTORY OF THE PROVISIONAL RESTORATION CANDIDATES

2.1. Inventory of the Provisional Restoration Candidates

2.1.1. Restoration Objectives

Table D.10: Level of Stormwater Control after Implementation of All Previously Proposed Stormwater Projects

County Jurisdictional Impervious Acres	Existing Stormwater Control		Stormwater Control With Identified Projects		Total Stormwater Control
	Acres	% of Total	Acres	% of Total	% of Total

2.1.1.1. Inventory of Previously Identified Projects

Table D.11: Inventory of Previously Identified Stormwater Management Projects in the Watershed¹

Proposed Site	Cost	Drainage Area (acres)	% Impervious Area	Impervious Acres
TOTAL				

¹ Includes projects identified in Watershed Action Plan (200x) and County Data (Dan Harper, 2009)

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Table D.12: Inventory of Previously Identified Stream Restoration Projects in the Watershed

Proposed Site	Project Type	Cost	Length (miles)
TOTAL			

From County Data (Capital Improvement Project Status, 08/03/09), (Cost Data, 2009), and Watershed Restoration Plan (200x)

NOTE: Given impervious treatment at a ratio of 3.4 acres per 100 linear feet of restoration

Table D.13: Inventory of Previously Identified Other Projects in the Watershed

Proposed Site	Project Type	Cost	Acreage (acres)
TOTAL			

From Watershed Restoration Plan (200x)

NOTE: Given impervious treatment at a ratio of 1 acre per 10 acres of restoration

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Appendix E – Trash Reduction Strategies

Appendix E details the assumptions and corresponding documentation for standard technical procedures for estimating trash loads from various land uses, evaluating the effectiveness and cost of the various BMPs and watershed restoration practices used to reduce trash, and various modeling conventions to assure consistency and accuracy within individual watershed implementation plans. As such, this Appendix E is organized as follows.

1. Procedures for Estimating Trash Loads

- 1.1 Load Allocations versus Waste Load Allocations
- 1.2 Defining Baseline Loading Rates

2. Description and Technical Assumptions for Watershed Restoration Practices

- 2.1 Educational
 - School Based Programs
 - County Employee/Staff Based Programs
- 2.2 Municipal
 - Potential Solid Waste Services Initiatives
- 2.3 Enforcement
- 2.4 Cost Estimates and Efficiencies

3. Special Issues in Watershed Analysis

- 3.1 Handling Trash Control in Individual Watersheds
- 3.2 Spatial Distribution of Watershed Trash Loads

4. References

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1.0 Procedures for Estimating Trash Loads

1.1 Load Allocations versus Wasteload Allocations

Sources of trash include point and non-point sources. MDE defines point sources as materials that are small enough to travel through a sewer system, such as glass bottles, aluminum cans, and plastic bags. Trash and debris from non-point sources are defined as items too large to travel through the sewer system, such as construction materials, appliances, and carpet (MDE, 2010). Montgomery County, as part of their NPDES MS4 permit is responsible for point sources of trash to their receiving waters. They are also a responsible party in the Trash Free Potomac Treaty

In addition, the Anacostia River has a Trash TMDL in development and expected to be approved by EPA in 2010. The TMDL is made up of the sum of load allocations (LA) and wasteload allocations (WLA) within the watershed. The LA is the portion of the TMDL that is allocated to nonpoint sources and background levels. WLAs include the point sources within the watershed, and for the Anacostia, include the District's CSO and MS4 system, the Montgomery and Prince George's Counties' MS4 systems, the Takoma Park MS4 system, the Maryland State Highway Administration, federal facilities, and other smaller point sources. For the Anacostia Trash TMDL, the WLA requires 100 percent removal of the baseline load, which was calculated using conservative assumptions.

1.2 Defining Baseline Loading Rates

To determine the point source baseline loading rates for land uses in the Maryland portion of the Anacostia, MDE used the weights of trash collected from storm drain outfall trash traps (fences) and trash nets. The total number of captured trash items was recorded, cataloged according to type of trash, and weighed. Organic matter collected as part of their study was not counted as part of the trash load. Table E.1 presents recommended baseline loading rates for urban land uses in Montgomery County based on the MDE (2010) study. These rates will be used as default values in a landuse-based loading calculation model similar to the Watershed Treatment Model (WTM). The model could be applied to individual Watershed Implementation Plans, or for a County-wide calculation of trash loading.

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Table E.1 Montgomery County Point Source Baseline Loading Rates for Trash	
<i>Land Use</i>	<i>Loading Rate (lbs/ac/yr)</i>
Low-density residential ¹	1.19
Medium-density residential ¹	19.26
High-density residential ¹	7.88
Commercial ¹	2.22
Industrial ¹	2.22
Institutional ¹	2.22
Extractive ¹	2.22
Parkland ¹	0.32
Roadway ²	2.22
Agricultural ¹	0.32
Forest ¹	0.32
Water ¹	0.00
Bare Ground ¹	2.22
¹ Montgomery County Trash Loading Rates from Table 18 in <i>Draft Total Maximum Daily Loads of Trash for the Anacostia River Watershed, Montgomery and Prince George's Counties, Maryland and The District of Columbia, 2010</i>	
² Prince George's County Trash Loading Rates from Table 19 in <i>Draft Total Maximum Daily Loads of Trash for the Anacostia River Watershed, Montgomery and Prince George's Counties, Maryland and The District of Columbia, 2010</i>	

In addition to the point source loading from the MS4 system, the Anacostia TMDL reports an LA nonpoint source load of trash from large items:

Quart size oil containers; Tires; Wooden pallets; Oil filters; Bricks; Concrete; Shopping carts; Metal; Antifreeze containers; Large auto body parts; Small auto body parts; Batteries; Lumber; Miscellaneous construction materials; Appliances; Sporting goods; Cloth/clothing/carpeting; and miscellaneous items.

According to the MS4 permit, the County is not responsible for the LA nonpoint source load, and these items are considered background loading. It is reasonable to assume that these items are too large to be transported by erosive forces to the Potomac, thus should be exempt from the Trash Free Potomac Treaty. However, it is recommended the County make a reasonable effort to promote clean up of non-point source trash items for purposes of beautification and restoration. These efforts could include the Adopt-a-Road program or stream cleanup projects that are detailed in Section 3.0 that target both bulk trash and smaller items from the MS4 system.

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The summary of Montgomery County trash management and level of effort for 2009 is shown in Table E.2.

Table E. 2 Montgomery County 2009 Trash Management Level of Effort			
Trash Management Programs	Coverage	Budget FY09	Funding Agency
Solid Waste Management			
Waste Reduction		\$ 378,430	DSWS
Recycling, Single-family	210,000 households	\$ 357,460	DSWS
Recycling, Multi-family	112,000 households	\$ 717,890	DSWS
Recycling, Commercial	35,000 businesses	\$ 1,688,940	DSWS
Household Hazardous Waste (HHW) Program: Residential		\$ 1,050,550	DSWS
Hazardous Waste Program: Business small quantity generators		\$ 40,560	DSWS
Recycling Volunteer Program		\$ 198,870	DSWS
Subtotal		\$ 4,432,700	
Enforcement Programs			
	Entire county except for Town of Barnesville, Chevy Chase Village, Chevy Chase Section 3, City of Gaithersburg, Town of Garrett Park, Village of Martin's Additions, City of Rockville, Town of Somerset		
Illegal Dumping/Litter/Chapter 48 enforcement		\$ 319,250	DSWS
Weeds/Rubbish/Chapter 48 enforcement		\$ 735,990	DHCA
Solid Waste (Chapter 48) Enforcement: Collections inspectors		\$ 251,640	DSWS
Solid Waste (Chapter 48) Enforcement: Collections inspectors		\$ 878,600	DSWS
Subtotal		\$ 2,185,480	
Street Litter/Trash			
Streetsweeping: Annual Countywide	3630 miles	\$ 265,000	DOT
Streetsweeping: Arterial Route 1,2,3,5 (4 * per year)	189.56 miles (*4)	\$ 27,676	DEP
Streetsweeping: Priority Routes/spring/summer/fall	3737.63 miles	\$ 272,847	DEP
Streetsweeping: Arterial Route 4 (11 * per year)	39.83 miles (*11)	\$ 15,992	DEP
Adopt-A-Road	245 miles (countywide)	\$ 4,000	DOT
Transit Stop Trash Management	600 bus stops countywide	\$ 466,306	DOT
Alternative Community Services Litter Collection	Selected roadways	\$ 32,000	DOT
Subtotal		\$ 1,083,821	
Stormwater ponds			
Pond maintenance and trash clearing	8 ponds	\$ 20,009	DEP
Public Outreach			
Regional Litter Campaign for Trash-free Potomac		\$ 50,000	DEP/DOT
Stormdrain Marking	countywide	\$ 1,000	DOT
Subtotal		\$ 51,000	
Municipal Operations			
Depot Sweeping	6 facilities each swept 6 times/year	\$ 15,000	DGS
Total		\$ 7,788,010	

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2.0 Description and Technical Assumptions for Watershed Restoration Practices

In general, trash reduction strategies fall into four categories: (1) Structural; (2) Educational; (3) Municipal; and (4) Enforcement. Structural stormwater BMPs will be assigned 95% removal credit for trash from the contributing drainage area. BMPs, while not specifically designed to capture trash, are also not very good at passing trash, and debris is prone to build up in forebays, around plants and interior elements, and around the outlet structures. In-stream controls from trash nets or traps are assumed to have 90% capture efficiency if maintained periodically (SCVURPPP, 2007).

In addition to trash removal by structural stormwater BMPs, Table E.3 describes programmatic practices from the other three categories (i.e., educational, municipal, and enforcement) for trash prevention and control.

Table E.3	
Trash Prevention and Control	
<i>Description:</i> Includes a wide range of programs and practices specially aimed at reducing trash inputs to roads and streams, including educationally focused and difficult to measure programs such as reduce, reuse and recycle campaigns; dumpster management and storm drain marking and more measurable programs tied to operations such as littering and illegal dumping enforcement; stream cleanups; and street sweeping. These measures are in addition to any trash trapped and removed by structural practices which are computed using the WTM.	
<i>Runoff Reduction Capability?</i> No <i>Pollutant Removal Capability?</i> Limited <i>Derivation:</i> See Section 3.0 of this appendix on the conceptual model for targeting implementation of trash controls on watershed basis	
<i>Unit Area Treated:</i> various	<i>Where Applied:</i> various scales
<i>Mode of Delivery:</i> various	<i>Average Delivery Time:</i> ?
<i>Unit Costs:</i> not currently available at watershed scale	
<i>How it is Modeled:</i> cannot presently be modeled in WTM, so requires a separate analysis.	

2.1 Educational

Educational trash reduction strategies are aimed at the public at large, businesses (e.g. through the Chamber of Commerce), students, and county employees. Broad based anti-litter campaigns aimed at the public should consist of internet, print (e.g., direct mail) and broadcast (e.g., radio and cable) media messages, signs located near hotspots, transit stops, transit vehicles, and other County and State communications (e.g., driver's license manual and applications, property tax bills, etc.). In addition, use of social media tools such as blogs, facebook, and twitter should be applied and tailored to specific audiences. These messages should convey an appeal to civic pride and warn of the penalties for littering, and emphasize that most of the trash in the Potomac River and Chesapeake Bay originates on their streets, sidewalks, and parking lots.

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Partnerships with intergovernmental departments as well as public and private corporations should be pursued to utilize their connections with the specific audiences and media outlets that they typically use. Ultimately, to effectively expand the reach of an outreach campaign it will be necessary to find ways to spend time where the target audience is comfortable – in other words, go to them instead of them coming to you. Examples include having a presence, delivering messages, and networking at various community group festivals and activities.

Recently the County has been involved in a multi-year marketing research effort in association with the Alice Ferguson Foundation's PROACT Campaign to identify which groups of people are more likely to litter in the Potomac Watershed (Opinion Works, 2008). Montgomery County has spent \$150K on this effort with the goal of creating an effective public outreach campaign to prevent litter/trash behaviors that cause pollution in the Potomac River. This financial investment was pursuant to the County being a signatory to the Trash Free Potomac Treaty. Key findings from the study include:

1. There is a surprisingly large citizen base (50-60%) bothered and concerned about trash and these citizens are ready to do something about it (66%).
2. Littering is a widespread problem. People of all races and socio-economic groups litter. However, the problem is especially acute among young men, where the numbers rise to surprising levels.
3. While litterers make clear that enforcement would deter them, very few people think there is a chance of getting caught (only 6%).
4. There is a tremendous lack of knowledge about what a watershed is and what role stormwater plays in carrying trash to area waterways.
5. The most important reason people say they litter is simple "laziness" or "convenience." Other reasons can be surprising, revealing that traditional media and messages will not reach them.
6. Media that is focused and has the right message can reach confirmed litterers and make an impact on them.

The market research can be used to better understand the littering population and shape the education and messaging campaign to this population. The messages will emphasize the causes of littering and significant connections made by the littering population.

School Based Programs

School-based programs and partnerships targeting Montgomery County Public School (MCPS) and private school students can help to educate the harmful effects of trash on the community and environment, and emphasize the students' personal responsibility and citizenship. Studies have shown that the tendency to litter varies inversely with age (Alice Ferguson Foundation, 2008). Therefore, targeting youth on trash reduction education is critically important. Outreach to youth (especially boys and young men)

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with incentives such as contests that convey anti-litter messages and community service projects should be encouraged.

County Employee/Staff Based Programs

There should be expanded anti-litter training to all County employees and contract staff with an emphasis on the importance of enforcement for police, solid waste and housing inspectors, and collection personnel. There should be an increased priority for education to employees and the general public about enforcement, about the harmful effects of litter on the community, and proper use of trash and recycling bins. This includes a renewed emphasis to collection personnel to clean up any spillage during collection and to properly secure the load on the collection vehicle before moving it.

2.2 Municipal

Municipal programs include funding anti-litter campaigns, zoning districts, and pledges from stake holders. Programs for non-violent offenders to increase the use of youth offenders and prison crews for road clean-ups and litter pickups should be promoted. A ban on plastic bags in the District is in place and has proven to be very effective. Estimates of the effectiveness of such a program range from 20 - 40% (Anacostia Watershed Society, 2008). A green-fund could be started using bottle and can deposits (this may require state legislation), and fees on businesses based on physical litter source tracking such as carry out and fast food restaurants. The fees and deposits could be used to fund litter prevention and removal programs, or grants for community and civic organizations for litter abatement programs. Agreements with commercial property owners and tenants could be worked out whereby they pledge to keep sidewalks, street curbs, and gutters adjacent to their properties litter free. The names of cooperative businesses could be publicized on the county website or by window decals. Similar pledges from community, homeowner or civic organizations could be obtained to educate their members about the ways to minimize litter such as canceling the delivery of unwanted newspapers, recycling, and clean up days. Even individuals should be encouraged to pledge, and similar advertising or publication of the individual names or organizations could be provided.

Potential Solid Waste Services Initiatives

The Division of Solid Waste Services (DSWS) is also considering how to use existing resources to better target litter reduction, although the amount of reduction is not known at this time. Ideas that are being considered include:

1. Step up tarping enforcement
2. Reduce over flowing dumpsters through stepped up dumpster management enforcement
3. Emphasize litter collection at County facilities
4. Tout new requirements in new collection contracts for more contractor accountability. Effective May 2010, new collection service contracts with private

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- sector haulers impose fines if litter is created during and after collection. Code Enforcement Inspectors are assigned to each service area to monitor and assure post-collection littering does not occur.
5. Enforce rigid container for set out instead of plastic bags and reduce early set out, which both make trash susceptible to vermin.
 6. Consider requirements on private haulers in Subdistrict B. Private refuse collectors are not under contract with the County in Subdistrict B; therefore, DSWS is reviewing the option of imposing regulations and fines for litter created by collectors in these areas.
 7. Use displays on compressed natural gas (CNG) trucks in select areas. All County-contracted collection vehicles are equipped with frames to hold billboards. An anti-litter campaign can be developed and displayed on the sides of the 102 collection vehicles that traverse County streets each day.

2.3 Enforcement

The final trash reduction strategy is enforcement. Enforcement should be employed through police, solid waste inspectors, the public, and other authorized County staff. Encourage the police to enforce littering citations under MD Criminal Code section 10-110 and MD transportation code 21-111(d). Surveillance cameras placed at trash hotspots could also be used to track offenders. Leadership within the department should also emphasize the link between litter and more serious crime, lower property values, discouraged business and tourism, pedestrian determent, and health and safety concerns. Furthermore, retail areas should be required to provide a minimum number of trash cans based on retail space square footage. Authorized enforcers (e.g., DHCA, DSWS) should also be encouraged to enforce Montgomery County Code sections 26-10 (D) Maintenance of Nonresidential property and 48-24(b)(3) Responsibility of Owners and Occupants of Commercial and Industrial Property regarding Storage and Removal of Solid Wastes. The public should also be encouraged to report violations of these codes using a hotline or 311 service. Such a service is not currently in place for citizens in the County, but having the ability to respond to citizen complaints about loose litter would complement current programs associated with illegal dumping and should be explored further for feasibility. The County departments should collect and regularly report data on citations, including publicizing the names of repeat offenders. Civil penalties assessed under this legislation could be paid into a fund dedicated to litter abatement and removal, similar to VA Code section 10.1-1418.1 Improper Disposal of Solid Waste; Civil Penalties.

2.4 Cost Estimates and Efficiencies

The cost numbers in Table E.3 provide a good basis to plan and budget for future strategies throughout the County. There are other studies documented in the literature that report costs over a variety of trash management strategies. These costs are often reported using different assumptions or are based on different target populations or areas, making

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comparison to the County experience difficult. Nevertheless, Table E.4 provides some summary costs from other national trash management experiences.

<i>Program Type</i>	<i>Cost</i>	<i>Source</i>
Streetsweeping	\$35-\$70/hr of sweeping	California Coastal Commission
Streetsweeping	\$100 - \$170 per curb mile (2005 \$ and based on quarterly sweeping)	SCVURPPP, 2007
Education and outreach	\$850K per year statewide	Washington State Department of Ecology, 2008
Education and outreach	\$5 Million statewide for Erase the Waste campaign	SWRCB, 2006
Education and outreach	\$0.35-\$1.22 per capita for advertising	New Jersey Clean Community Council, 2005
Volunteer Programs – Adopt-a-Highway	\$14.5 Million per year savings	Caltrans, 2007
Solid Waste Management – increased trash cans	\$600 per bin plus \$750/bin/year for maintenance	City of Los Angeles, 2002
Enforcement	\$1.3 Million, FY2003-04 budget	City of San Francisco, 2003

The Draft Anacostia Trash TMDL was released in late spring 2010 for public review. The document contains trash loading rates according to land use, but there is very little data on littering behaviors by demographics, the effectiveness of various trash reduction techniques, and their cost per unit of trash reduced. The Anacostia loading rate data will be used to model trash loadings and reduction in the context of the WTM. An analytical approach has been developed to evaluate various trash reduction and control measures at the watershed level using programmatic practices.

Table E.5 summarizes the assumed efficiencies of these trash reduction programs. The assumptions and reference information used to derive these reduction efficiencies are indicated in the footnotes to Table E.5. They include:

- Assumptions in the WTM associated with “discount factors” such as target population, effectiveness of messaging, and willingness to participate. Much of the outreach and education information summarized and presented in the WTM is based on a Center for Watershed Protection study conducted for the Chesapeake Research Consortium entitled: A Survey of Residential Nutrient Behavior in the Chesapeake Bay (1999). While the focus of the 1999 study was nutrients, it was assumed that the same effectiveness would be applicable for trash-based messaging and outreach.

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- Literature review and findings from experience in California and South Africa, where more substantial monitoring and research has been conducted. Limited information is also provided by the Anacostia Watershed Society related to effectiveness of various anti-litter campaigns and policies.

Table E.5. Programmatic Trash Reduction Efficiencies

<i>Program Type</i>	<i>Category</i>	<i>Unit Reduction Efficiency</i>
Structural BMPs; Trash Nets; Trash Traps	Structural	90-95% of Load from Drainage Area
Anti-litter Campaign; School-Based Programs	Educational	12% of Residential Land Use ¹
Continued Waste Reduction, Reuse, and Recycling Education and Investigations	Educational; Municipal; Enforcement	25% of Total Load off of areas that have recycling services. ²
Adopt-a-Stream Cleanups	Educational; Municipal	30% of Total Load ³
Plastic Bag Ban	Educational; Municipal; Enforcement	30% of Total Load ³
Littering and Illegal Dumping Enforcement; Dumpster Management	Enforcement	5% of Industrial and Commercial “Hot” Land Use ⁴
Storm drain marking; Catch Basin Cleanouts; Adopt-a-Road Cleanups; Street Sweeping	Educational; Municipal	5% of Roadway Load ⁵
Notes: ¹ Based on assumptions in WTM (CWP, 2001) associated with other outreach and education programs. Assumes half of residential land use is influenced by school age kids, effectiveness of messaging is 40% and willingness to participate is 60% or $.5 \times .4 \times .6 = .12$. ² Based on California state-wide target of 50% diversion of waste from landfills. Assumed half of target (CA Coastal Commission, unknown date). ³ Based on Anacostia Watershed Trash Reduction Plan, 2008. ⁴ Based on assumptions in WTM (CWP, 2001) associated with other outreach and education programs. Assumes 100% of industrial and commercial hot areas are targeted and 8% awareness and 60% effectiveness, or $1.0 \times .08 \times .6 = .05$. ⁵ Limited data are available to that look at this, but unless frequencies are daily to weekly, street sweeping will have limited effectiveness (Marais and Armitage, 2004).		

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3.0 Special Issues in Watershed Analysis

3.1 Handling Trash Control in Individual Watersheds

Several Watershed Implementation Plans will need to address trash loadings to address requirements of the Potomac Trash Treaty that is referenced in the permit. In addition, the Anacostia Trash TMDL is expected to be accepted by MDE and the EPA in 2010. According to the Anacostia TMDL, there is reasonable assurance that the goals of the Treaty and TMDL can be met with proper watershed planning, implementing pollution-reduction BMPs, and using strong political and financial mechanisms.

Currently, the County has a number of activities which target trash reduction. They include the following:

- Adopt-a-Road Program through DOT, which focuses on public awareness and involvement in trash management. There are 205 participants who adopted road segments and agreed to six major road cleanups per year;
- Storm Drain Marking through DOT
- Support for illegal dumping enforcement, outreach, and research and monitoring.
- Partnership with DOT to conduct street sweeping covering about 2,500 curb miles and occurring once a year;
- Partnership with the Park Police to monitor illegal dumping, which combined enforces 300-400 actions a year.
- Non-residential and residential recycling programs through Solid Waste Services (SWS).
- Transit stop trash management program at 600 bus stops countywide supported by DOT Transit Services.

Increasing funding and monitoring of these efforts would greatly reduce the trash load. MDE also recommends implementing six high-priority trash-reduction objectives:

1. Significantly increase funding for trash reduction programs
2. Create and enhance regional partnerships and coordination among businesses, environmental groups, individual citizens, and government at all levels and in all jurisdictions
3. Improve people's awareness, knowledge, and behavior relating to littering and illegal dumping
4. Promote the greater introduction and use of effective trash-reduction technologies and approaches
5. Improve enactment and enforcement of laws to reduce trash
6. Increase trash monitoring-related data collection, generation, and dissemination efforts

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A combination of these efforts is necessary to reduce the trash loading to the Potomac.

3.2 Spatial Distribution of Watershed Trash Loads

In order to track progress toward the commitments in the Potomac Watershed Trash Free Treaty and for the Anacostia TMDL, the implementation plans will default to the baseline loading rates from the MDE analysis. The County complaint database could be used to target trash hotspots spatially. First, the consultant team will select from the County GIS database of Properties to screen for land uses shown in Table E.6. On the second step, sites or operations where citizen complaints of trash have been historically recorded will be used to overlay hotspot areas with Property data. These will be identified using the County supplied GIS layer showing them in each watershed (WQCases2004_2009_locations shapefile). The focus of this analysis is to estimate the relative number and potential area within the watershed that is classified as a potential trash hotspot, and to define the spatial extent of potential hotspot inspection needed in the restoration analysis.

The TMDL baseline loads were found to be in close agreement with the data collected by the County for illegal dumping provided below in Table E.6. These data reflect the trash load as measured by the County in the Anacostia watershed for purposes of validation and comparison. Similar data exists for all the watersheds in the County, and could be used to identify illegal trash dumping hotspots.

Table E.6: Solid Waste Trash Dumping Sites by Zoning for the Anacostia Watershed

<i>Land Use</i>	<i>General Zoning Type¹</i>	<i>Total # of Properties²</i>	<i>Proportion of Complaints (%)</i>	<i>Proportion of Annual Load (%)³</i>
High-density residential	Apartments	22	9.5	6.5
Medium and low-density residential	Residential	180	77.6	87.8
Commercial	Commercial	21	9.1	1.0
Forest	Unzoned	9	3.9	0.9

¹ From County PROPERTIES.shp

² From SWCases2004_2009_locations.shp

³ From Draft Anacostia Trash TMDL, 2010

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