Recommended Framework for Completing Future Watershed Implementation Plans (Pre-Assessments, Watershed Assessments, and Implementation Planning)

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I. BACKGROUND

Watershed restoration requires identifying watershed problems and developing solutions to address those problems. Montgomery County's program of watershed assessment and implementation planning is designed to achieve restoration within the context of regulatory and programmatic needs.

Montgomery County has a long history of completing watershed assessments, creating restoration project inventories and prioritizations, and then designing and constructing projects based on those project inventories. Completing watershed studies and submitting action plans with schedules for project implementation was a requirement in the County's first MS4 Permit (Permit) issued in 1996. The components and schedule for developing future watershed assessments and implementation plans recommended in this framework were derived from our summary evaluation of the previous county watershed studies (see appendix).

The overall goal of the watershed assessments required under the Permit is to ensure that each county watershed has been thoroughly evaluated and has an implementation plan to maximize water quality improvements. Therefore, these watershed assessments include detailed water quality analyses and the identification of water quality improvement opportunities that lead to the development of implementation plans to control stormwater discharges to the maximum extent practicable (MEP).

The County's second-round Permit was issued in 2001 and included a quantitative restoration goal; this quantitative requirement has been increased in the County's third-round Permit issued in 2010. The 2010 Permit also requires the County to identify sufficient best management practices to (1) provide for loads reductions that meet any EPA approved TMDLs within the county and (2) demonstrate progress in meeting the commitments under the Potomac Trash-Free Treaty. To meet these Permit requirements, the County is developing an overall implementation strategy, which will include completing watershed implementation plans for currently unassessed watersheds and revisiting watersheds with existing assessments if needed.

The watershed analyses and program planning associated with the implementation plans for each county watershed are described in the Guidance Document and the Countywide Coordinated Implementation Strategy and not addressed in detail in this document. Per the Guidance Document, implementation plans are currently being completed for all watersheds that have previously been assessed. There are currently four watersheds in the county where one or more subwatersheds have not yet been assessed. In the Lower Monocacy and Patuxent watersheds, implementation plans have been initiated without conducting a full assessment. For the others, assessments are planned for completion prior to development of implementation plans.

This framework describes the methods being used to complete pre-assessments and full assessments for the unassessed subwatersheds. These methods include (1) describing environmental conditions; (2) conducting desktop analyses to identify candidate restoration areas; (3) conducting field investigations; and (4) developing an action inventory that includes project concepts, costs estimation, and priority setting for implementation. Once assessments are completed, the process of developing implementation plans can move forward. Implementation plans can require more detailed analysis to track pollutant loads and combine restoration strategies (structural and programmatic) to achieve the full restoration potential watershed-wide. Implementation plans also balance other countywide priorities such as funding and phasing. The final section of this framework is the schedule for completing or revisiting watershed implementation plans for all county watersheds, including recommendations for the monitoring needed to track and adapt the performance of the implementation plans.

II. COMPLETION OF PRE-ASSESSMENTS AND FUTURE WATERSHED ASSESSMENTS

As described above, the County needs to complete watershed assessments and implementation plans for unassessed subwatersheds in four watersheds, so that they can ultimately be included in the implementation planning for meeting the MS4 Permit requirements. The approach defined by the County is to complete pre-assessments for these four watershed groupings and identify next steps for completing the full watershed assessments at a later date. The sections below describe the methods to be used to complete these steps.

1. Methodology for Preparing a Pre-Assessment

The “pre-assessment” includes (1) establishing the environmental conditions of the watershed and (2) conducting a desktop analysis to identify potential restoration opportunities without performing field investigations.

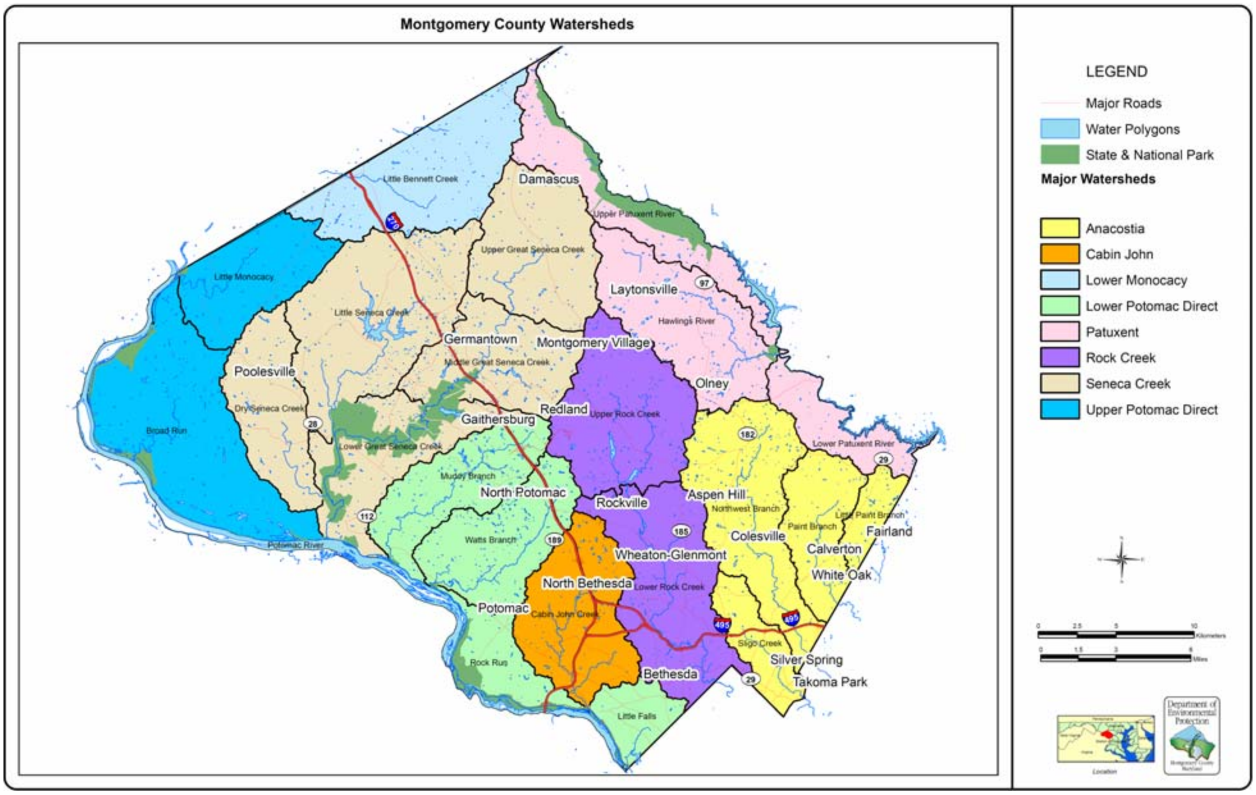
1.1 Pre-Assessment Watersheds

As described in the Guidance Document, Montgomery County must complete watershed assessments for the following four “watershed groupings” (comprising specific subwatersheds) that have not previously been assessed (see map):

- Lower Potomac Direct watershed grouping which includes Rock Run and Little Falls subwatersheds
- Seneca watershed grouping which includes Little Seneca and Dry Seneca subwatersheds
- Upper Potomac Direct watershed grouping which includes Little Monocacy and Broad Run subwatersheds

- Patuxent watershed grouping which includes Triadelphia and Rocky Gorge sub-watersheds

Pre-assessments have been completed using the methodology described below. The pre-assessment for the Patuxent is being carried forward into a draft implementation plan for the Patuxent watershed that includes the watershed assessment for the Hawlings River subwatershed of the Patuxent watershed.



1.2 Study Area for the Pre-Assessments

The County's Permit only applies to the portion of the county serviced by the municipal separate storm sewer system (MS4) and does not include areas covered under other MS4 permits. Potential restoration sites at Montgomery County Public Schools are already included in the County's project inventory and are not included in the pre-assessments. Areas within the County, but outside the Permit area and therefore not addressed in the pre-assessments, are the following:

- The cities of Rockville, Takoma Park, and Gaithersburg
- The Maryland-National Capital Park and Planning Commission (MNCPPC) properties
- State and federal land, including roads
- Lands with rural zoning.

These are referred to in this methodology as the "Non-MS4 Permit area."

1.3 Describing Environmental Conditions in the Pre-Assessments

The environmental conditions of the pre-assessment watersheds were obtained from existing, countywide geographic information system (GIS) layers (Table 1).

Table 1. Montgomery County data layers used to characterize environmental conditions in the pre-assessments

Condition	Layer
Watershed and subwatershed boundaries	Watersheds
Parks	Parks
Land use/Land cover	Land use/Land cover with inserted Roadways
Impervious cover	Impervious features
County property	Property (polygons) spatially associated with Montgomery County MS4 Permit area (points)
Residential properties	Property (polygons) spatially associated with Maryland Department of Planning data (points) reflecting residential land use types
Hydrologic soils	Soils
Forest cover	Forest stand delineations
Wetlands	Wetlands (subsets may be derived by Cowardin type)
Stream condition ratings (benthic, fish, habitat)	Biological monitoring stations
Stormwater BMPs and drainage areas	BMP facility locations (points) and drainage areas (polygons)
Streams	Hydrography
Riparian buffers	Derived from Streams and Forest

1.4 Conducting the Desktop Analysis to Identify Candidate Restoration Areas

The feasibility of implementing stormwater management retrofits is limited by a host of issues including the following:

- Willingness of property owners to assume responsibility for maintenance
- The budget available for retrofits and labor investment required by the County to implement retrofits in a particular land-use category
- Technical feasibility and complexity of design and installation in particular land uses and in each particular lot
- Desired benefit for a particular watershed or stream reach.

The implementation of stormwater management involves developing engineering designs through site visits, surveying, permitting, negotiations with landowners for easements and maintenance, etc. As such, the smaller the candidate retrofit the less cost-effective each man-hour and dollar spent, per amount of contaminant and volume of water managed. The assignment of priorities in the pre-assessments considers upgrading existing facilities and adding stormwater management to treat currently untreated areas, based on land use, ownership, and residential conditions, to suggest a spectrum of cost-effective solutions.

The desktop analysis for the pre-assessments was specifically designed to combine the information in available GIS layers, including aerial photographs, with institutional knowledge provided by Montgomery County Department of Environmental Protection (DEP) staff. The desktop analysis method was able to address historic land-use changes, planned land-use changes based on current zoning, planned development, existing stormwater management facilities, socio-political priorities, and the feasibility of candidate projects as experienced by DEP staff. The result was the assignment of high, medium, and low priorities for potential stormwater management opportunities. Specifically, (1) high priority areas are already being treated by older, less-efficient stormwater management facilities (known as Best Management Practices, or BMPs) which can be upgraded or retrofit relatively easily; (2) small, distinct non-residential parcels that have one owner also present good opportunities for on-site retrofits; (3) residential areas are generally considered a lower priority with decreasing density; and (4) the lowest priorities are given to specialized lands that would present significant obstacles to BMP design or installation (e.g., golf courses and historic properties) or those which the DEP staff have identified for other purposes. Within a GIS, the parcels and regions considered viable for stormwater BMP retrofits were assigned priority rankings and the total acreage associated with each property and its relative contribution to the County's MS4 Permit area were calculated and summarized.

The priorities for stormwater management retrofit project areas were defined as follows:

High Priority candidate projects are modifications/improvements of *existing BMP facilities*. The Guidance Document recognizes three distinct "design eras," 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 discharge reduction for control of flooding of downstream structures and not for protection of streams from erosion (channel protection) or for treatment of pollutants.

- Era 2a: 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 robust as later designs.

- Era 2b: 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.

Within the pre-assessments, modification of older, existing facilities (Era 1) is listed as a top priority, because stormwater from impervious surfaces is already being concentrated to a particular location, land has been set aside for the treatment facility, and ownership and maintenance of the facility is already formalized. The additional cost to upgrade these facilities for protection of the stream channel and contaminant treatment is very low compared to the acquisition of property rights, and the costs of designing, permitting, and construction of a new BMP. Additionally, these pre-1986 facilities tend to treat large areas, so the return on the dollar invested is high.

Medium Priority for the County is the retrofit of developed, privately owned parcels that have no existing stormwater management, by particular *land-use type*. Land-use types are important because they can influence the following parameters:

- <u>Cost effectiveness of retrofit</u>. In other words, how much pollution control and volume control is provided for every dollar invested.

- <u>Mean imperviousness and even the type of imperviousness</u>. Parcels with high mean imperviousness are higher priority, as are parcels with large ratios of automobile parking surface to total impervious surface. The Guidance Document summarizes findings for imperviousness for various land uses, which are cited below.

Imperviousness varies significantly by land use, ranging as low as 12.5% for low-density residential to as high as 72.2% for commercial properties and 90% for roadways and their rights-of-way, as shown in Table 2 below (modified from the Guidance Document). Forest cover tends to be consistent across land-use types at around 15% with the exception of low-density residential, which has less forest cover (8.5%), and parks, cemeteries, and golf courses, which have more forest cover (36.4%). Percent turf cover by land-use type also varies significantly, from a high of 79% for low-density residential to a low of 13% in commercial land-uses and 3% for roadways.

Table 2. Percent impervious, percent forest, and percent turf cover associated with land use types in the Chesapeake Bay watershed

LAND-USE	Percent Impervious Cover[(a)]	Percent Forest Cover[(b)]	Percent Turf Cover[(c)]
Low Density Residential	12.5	8.5	79.0
Medium Density Residential	24.5	15.0	60.5
High Density Residential	36.8	15.2	48.0
Multifamily Residential (apartments & condominiums)	44.4	14.6	41.0
Commercial	72.2	14.8	13.0
Industrial[(d)]	53.4	14.6	32.0
Roadway[(e)]	90	7.0	3.0
Municipal/Institutional (churches, schools and municipal buildings)[(f)]	35.2	13.8	51.0
Green Municipal/Institutional (parks, cemeteries and golf courses)[(g)]	8.6	36.4	55.0

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

In conjunction with DEP staff input, the following land-use types were placed in order of importance for medium-priority stormwater retrofit projects:

- Commercial and industrial properties, and some churches, tend to have large expanses of impervious surfaces in the form of parking lots and large flat roofs; 72% imperviousness on average with similar parts forest (14.8%) and turf cover (13%). This is the highest imperviousness of any land use with the exception of roadways.

  Parking lots are of particular importance for watershed managers, because of the many contaminants associated with automobiles, such as petroleum products, hydraulic fluids, coolant, dust from brake materials, and car tire materials. Additionally, these lots tend to have fewer owners relative to the total impervious surface, making negotiation of retrofits less complex.

  Public and government buildings are considered top priority for retrofits, both because they tend to have very high percentages of impervious cover and large parking lots, and because they allow governments to demonstrate leadership by example. Montgomery County DEP is already developing an inventory for retrofits on county-owned properties which includes Montgomery County Public Schools.

- Private schools tend to have large parking lots and average 35.2% imperviousness with 50% in turf cover. They are usually owned by only one decision-making entity and have a secondary benefit of offering an opportunity to educate students and others in the community on the stormwater management facilities.

- Apartments and condominiums (Multi-Family Residential). This land-use category also tends to have large parking lots and roofs. Average imperviousness is 44.4%, with only 14.6% forest cover and a significant percentage as turf, 49%. The decision-making authority on these private parcels varies, but tends to be somewhat centralized, allowing retrofits to be implemented with only moderate complexity. This makes them good candidates for stormwater retrofits.

- Townhouses. This category includes townhome developments (physically attached single-family structures). Townhouses belong to the high-density residential land-use type which tends to average 36.8% imperviousness with 48% turf cover. Average imperviousness is slightly lower than that of apartments and condominiums, but the decision-making process usually rests with individual homeowners or a homeowners' association (HOA), making it more difficult to implement retrofits than with apartments and condominiums.

- High- and medium-scoring residential neighborhood assessment areas. These areas were determined by a separate desktop assessment to target residential areas suitable for on-lot retrofitting that would potentially fit into the County Rainscapes program. The evaluation criteria were lot size, home ownership, presence or absence of HOAs, and the presence or absence of existing stormwater management facilities. The evaluation produced tiers of high, medium, and low potential. Areas of high and medium potential, that do not fall in any other category in the priority ranking and do not currently have stormwater BMP treatment, are included in the Medium Priority ranking for the pre-assessment.

Low Priority land-uses have low percentages of imperviousness and therefore are considered the lowest priority for implementation of stormwater management retrofits. They include the following:

- Low-scoring residential neighborhood assessment areas. The areas in the neighborhood assessment (described above) that were evaluated as having a low potential for on-lot retrofit are considered a Low Priority for the pre-assessment.

- Specialized areas that are considered a Low Priority. These areas are unique in each watershed and are considered by the County to have a very low priority for retrofit opportunity. These areas are specifically identified by DEP staff and include golf courses, historic properties, and residential areas intended for special County programs.

1.5 Focus Areas

The desktop analysis for the pre-assessments is augmented by the knowledge of historic land-use changes, planned zoning changes, planned development, status of existing stormwater management devices, socio-political priorities, and other constraints based on best professional judgment by County staff. These factors affect the feasibility of watershed restoration and define county "focus areas." These focus areas are considered the best candidates for restoration, other than existing BMPs, and include a mix of parcel sizes, primarily within the medium-priority groups Focus areas are used to highlight particular regional interests of the county, and do not modify the structured priority assignments of the pre-assessment process.

1.6 Types of Candidate Stormwater Management Projects to Be Considered

The types of stormwater management projects that were considered in the pre-assessments are those described in detail in Appendix B of the Guidance Document, as well as in the 2009 MDE Stormwater Design Manual. Only general categories of projects were evaluated in the pre-assessments, as appropriate to land use types. The specific project types will be identified during the field investigation phase of the watershed assessments to be conducted in the future.

2. Methodology for Completing the Watershed Assessments for the Pre-Assessment Watersheds

Once the pre-assessments for the four unassessed watershed groupings are completed, full watershed assessments will be undertaken. The approach will be to expand on the pre-assessments by updating any environmental condition information and conducting field investigations to identify specific restoration sites. Following the field investigations, concept plans would be developed for candidate restoration sites to serve as the action inventory. Pollutant loading estimates and public involvement may also be conducted to assign priorities and integrate the watershed assessment into the Countywide Coordinated Implementation Strategy.

2.1 Field Investigations

The ideal method for identifying restoration sites is to complete comprehensive stream and upland walks to ground truth the pre-assessment, watershed-wide. Recognizing budget constraints, field investigations should be targeted to the high-priority areas identified by the desktop analysis for the pre-assessments, as well as the medium- and low-priority “focus” areas. The high-priority areas are existing BMPs that can be retrofitted, while the focus areas comprise the best candidate areas of varying land use types based on the institutional knowledge of County staff.

Each of the pre-assessment desktop analyses identified high-, medium-, and low-priority areas, and calculated the potentially treated acres of impervious surface for each. Table 3 shows these potentially treated acres for the high-priority and focus areas in each pre-assessment. Based on these numbers, we anticipate that watershed assessments conducted using this method will produce the information needed to support an implementation plan for each watershed. For example, implementing high-priority and focus area projects in the Lower Potomac Direct and Upper Potomac Direct watershed groupings have the restoration potential to treat up to 20% additional impervious area, which is consistent with the countywide target. In the case of Dry Seneca/Little Seneca and Patuxent watershed groupings, approximately twice this amount (i.e., 40% additional impervious area) would potentially be treated with these projects. Therefore, the following field investigations should be undertaken:

- In the Lower Potomac Direct and Upper Potomac Direct, field investigations should be conducted on all high-priority existing BMP areas and medium- and low-priority "focus areas"
- In the Dry Seneca and Little Seneca, field investigations should be conducted on high-priority existing BMP areas
- In the Patuxent, field investigations should be conducted on all high-priority existing BMP areas and approximately half of the focus areas

Table 3. Potential impervious area (IA) that could be treated by implementation of priority restoration projects identified in the four pre-assessments. Remainder untreated is the IA in the County MS4 Permit area of each watershed that does not have BMPs constructed after 1986. IA in the pre-1986 BMPs (high-priority) and Focus Areas (most feasible medium- and low-priority) are shown as acres and percent of IA remainder untreated.

Lower Potomac Direct (Rock Run and Little Falls)		
Impervious area targets	*Acres*	*Percent of remainder untreated*
County MS4 total impervious cover	1788.3	
Post-1986 BMP treatment	74.9	
Remainder untreated	**1713.4**	
Pre-1986 retrofit treatment	122.7	7
Focus Area projects	207.7	19
Upper Potomac Direct (Little Monocacy and Broad Run)		
Impervious area targets	*Acres*	*Percent of remainder untreated*
County MS4 total impervious cover	223.6	
Post-1986 BMP treatment	29.5	
Remainder untreated	**194.0**	
Pre-1986 retrofit treatment	1.5	1
Focus Area projects	39.3	21

Table 3. (Continued)		
Dry Seneca and Little Seneca		
Impervious area targets	*Acres*	*Percent of remainder untreated*
County MS4 total impervious cover	1520.5	
Post-1986 BMP treatment	681.3	
Remainder untreated	**839.2**	
Pre-1986 retrofit treatment	269.7	32
Focus Area projects	62.8	40
Patuxent (Triadelphia and Rocky Gorge)		
Impervious area targets	*Acres*	*Percent of remainder untreated*
County MS4 total impervious cover	219.0	
Post-1986 BMP treatment	10.1	
Remainder untreated	**208.8**	
Pre-1986 retrofit treatment	1.6	1
Focus Area projects	80.1	39

The specific methods for completing the field investigations of focus areas as part of the watershed assessments would include the following:

- Stream Reconnaissance
- Retrofit Investigations
- Upland Investigations

Stream Reconnaissance. The watershed assessment would include a stream reconnaissance or stream walk similar to the Stream Corridor Assessment (SCA) developed by Maryland DNR targeted to the focus areas. The stream walk identifies specific problems and their locations, as well as qualitatively assessing stream conditions for representative reaches of stream. Problems recorded in these SCAs include stormwater pipe outfalls, inadequately vegetated stream buffers, bank erosion, fish blockages, channelized stream sections, exposed utility pipes, unusual conditions, trash dumping, and active construction near the stream. Ponds and tree blockages are also noted. The location of each problem is photographed to document existing conditions, and problem sites were rated to identify severity, correctibility, and accessibility. In-stream and near-stream habitat conditions are assessed at representative sites spaced at ½- to 1-mile intervals along the stream. Assessments are based on habitat assessment procedures in EPA's RBPs (Barbour et al. 1999). Sites are rated as optimal, suboptimal, marginal, or poor for ten parameters, and stream measurements including wetted width, pool depths, thalweg depths, and bottom sediments are recorded. All data would be incorporated into an ArcView GIS application.

Retrofit Investigations. The Retrofit Reconnaissance Investigations (RRI) procedure of the Center for Watershed Protection (CWP) is an example of how to conduct field investigations to identify specific restoration projects. The essence of this procedure is to confirm the feasibility of a restoration project at the site and to develop a concept design for the project. An RRI would be conducted at each high-priority or focus area site by linking the following four components: (1) stream problems from the stream walk, (2) stormwater source areas, (3) stormwater drainage, and (4) property ownership and use. The field team would carry into the field a map and log with the preliminary expectations for the site from the desktop analysis. These expectations would be confirmed and revised, and the concept plan developed. For example, the field team might first confirm the severity of erosion in a length of stream and then trace the contributing flow from a nearby parking lot through a specific storm drain outlet. A concept design for constructing a bioretention facility would be developed given the assessment of the topography, sizing needed, or the contributing impervious area, and site constraints such as property boundaries, nearby trees, and utility lines. The concept design would be sketched on a topographic or other map and preliminary calculations performed.

Upland Investigations. Two kinds of upland investigations would also be conducted in the focus areas: contamination hotspot investigations (similar to the HSIs of CWP) and pervious area assessments focusing on reforestation (similar to the PAAs of CWP).

- The hotspot investigations identify enhancements to stormwater management and landscaping at specific facilities or neighborhoods. The objective is to review current practices and develop specific recommendations to prevent pollution and improve stormwater management at facilities and neighborhoods as a whole.

- The pervious area assessments identify significant opportunities for restoration of undeveloped land (specifically reforestation) within the watershed, including riparian areas. The primary objective is to identify candidates for reforestation that are greater than 1 acre, especially the largest available unforested areas and areas bordering the longest length of stream. Specific opportunities would be based on (1) planting viability by evaluating vegetation, soils, slopes, and site hydrology; (2) site constraints owing to access, utilities, wetlands, required set backs, and aesthetics issues; and (3) potential benefits evidenced by wildlife, invasive species, and total area available for forest planting. Other opportunities to restore wetlands and other natural habitats would be identified.

The level of effort to complete these stream and upland investigations will vary with the number of sites visited and the methods used. In general standard site investigations may cost $500 per site (inclusive of travel, field time, data management, and reporting), while more detailed investigations (e.g., complex hotspot investigations) may cost $1000 per site. Assuming a minimal stream reconnaissance is needed and about 40 each of the RRIs and upland investigations are needed a level of effort between $50,000 and $100,000 could be expected.

Electronic entry of field data should be used where possible and a geodatabase employed that links all field results with standard design and costing criteria to produce cost-effective mapping and project development.

2.2 Action Inventory

Following the field investigations, completion of the watershed assessment for each pre-assessment watershed grouping would involve completing the Action Inventory using the following steps:

- Concept Plans for Restoration Projects
- Community Education and Stakeholder Involvement
- Pollutant Loads and Anticipated Load Reductions
- Priorities for Proposed Projects

Concept Plans for Restoration Projects would be prepared using the retrofit reconnaissance results, GIS maps, aerial photos, and county soil surveys. The designs would address the following site conditions and constraints:

- Upstream existing stormwater management facilities
- Drainage area and amount of impervious cover
- Site topography/slope
- Tree/vegetation impacts
- Streams, seeps, and wetlands impacts
- Utility/storm drain impacts
- Site accessibility for construction and maintenance

The restoration project (retrofit) designs would follow the 2009 Maryland Stormwater Design Manual and address treatment of water quality and water quantity, providing stream channel protection as appropriate. Assuming an action inventory of 50 restoration projects, the level of effort might be $200,000.

Community Education and Stakeholder Involvement would be an extension of the Public Outreach and Stewardship Work Plan developed as part of the County MS4 Permit implementation effort. The level of effort would depend on the demographics of the stakeholder audience, and number of meetings held and amount of materials prepared, but might be approximately $30,000.

Pollutant Loads and Anticipated Load Reductions would be determined using the modeling approach defined in the Guidance Document. Substantial GIS analysis to attribute the watershed area with existing impervious surface, treated impervious surface, and project treated area under the action plan would be needed prior to implementing the Watershed Treatment Model (WTM) to calculate projected pollutant loadings and expected reductions from restoration practices. The level of effort for this simple modeling effort might be $20,000.

Priorities for Proposed Projects would be developed using a scoring and ranking system that reflects County priorities and is conducive to implementation planning. The quantitative scoring method would be used to rank projects in order of total benefit and feasibility. This method should be modified to address the implementation strategy for meeting the Permit requirements. For example, watersheds with TMDLs or trash reduction agreements would assign priorities to projects most likely to meet these requirements. Overall, the designation of high-, medium-, and low-priority areas in each pre-assessment provides the baseline ranking of projects identified in each. In general, all of the high-priority (BMP retrofits) and focus areas projects would be expected to be constructed to meet the Permit requirements. A quantitative scoring method for assigning priorities to possible restoration projects might include the following factors:

- Environmental Benefits
- Attainment of Programmatic Goals
- Feasibility of Implementation and Maintenance
- Outreach and Community Connection
- Impacts to the Existing Environment
- Regulatory and Programmatic Changes or Permitting Required
- Estimated Cost of Implementation

Preliminary Action Inventory. As described in Table 3, there should be sufficient projects within the existing BMP retrofits and focus areas to be consistent with the County MS4 Permit requirement of treating an additional 20% of impervious area. Whether additional projects will be needed to meet TMDL or trash reduction targets will be determined by the modeling to be conducted as part of the full watershed assessments, but an action inventory of 50 to 100 restoration projects might be expected.

III. COMPONENTS OF IMPLEMENTATION PLANS

Implementation plans for each of the Montgomery County watersheds (or watershed groupings) must be completed to meet the requirements of the Permit for watershed assessment (permit section III.F), watershed restoration (section III.G), addressing any total maximum daily loads or TMDLs (section III.J), and, for the Potomac River tributaries, controlling trash (section III.E.4). These implementation plans incorporate the information in the pre-assessments and watershed assessments. The pre-assessments provide the introduction, existing conditions, and desktop analysis of the action inventory. The full watershed assessments augment the pre-assessments with field investigations and the project concept plans, costs, and priorities of the action inventory.

Watershed implementation plans should also include the nine minimum elements required for Clean Water Act 319 funding from EPA (www.epa.gov/owow/nps/cwact.html). The following components should be developed for each watershed implementation plan to meet these requirements:

- Introduction (for regulatory and programmatic context)
- Environmental Conditions (focusing on water quality conditions)
- Action Inventory (of possible restoration projects)
- Implementation Planning (to meet regulatory and programmatic targets)

The following subsections describe the contents of each of these components, i.e., the chapters of the overall watershed implementation plan. These components are present in most previously completed county watershed studies and reflect the current approach to planning undertaken in the recent Anacostia watershed restoration plan in partnership with the U.S. Army Corps of Engineers.

1. Introduction

This section provides the context for

- Previous studies for the county's watersheds
- Progress to date in meeting regulatory and programmatic needs
- Goals for this watershed implementation plan
- Methods used to develop this plan
- Process for involving and engaging county stakeholders

Each plan should meet the water quality goals defined in the County's Chapter 19, Article IV. Water Quality Control, adopted in 1994.

- Protect, maintain, and restore high quality chemical, physical, and biological conditions in the waters of the state in the county

- Reverse past trends of stream deterioration through improved water management practices

- Maintain physical, chemical, biological, and stream habitat conditions in county streams that support aquatic life along with appropriate recreational, water supply, and other water uses

- Restore county streams damaged by inadequate water management practices of the past, by reestablishing the flow regime, chemistry, physical conditions, and biological diversity of natural stream systems as closely as possible

- Help fulfill interjurisdictional commitments to restore and maintain the integrity of the Anacostia River, the Potomac River, the Patuxent River, and the Chesapeake Bay

- Promote and support educational and volunteer initiatives that enhance public awareness and increase direct participation in stream stewardship and the reduction of water pollution.

2. Existing Conditions

This section describes the physical, chemical, and biological conditions of the watershed, focusing on the effects of stormwater on water quality. However, an ecosystem approach to watershed conditions should be used to address the full range of public concerns (i.e., all ecological effects of upland, riparian, and aquatic habitat management should be considered). This section should also include all existing stormwater management (SWM) facilities, non-structural best management practices (BMPs), and other restoration projects. Information on all of these factors should be mapped to provide the geographic specificity needed to identify and address significant problem areas within the watershed.

Much of this information will be obtained from the following countywide geographic information system (GIS) layers that are regularly updated:

- Watershed and subwatershed boundaries
- Public lands
- Impervious cover
- Hydrologic soils
- Forest cover
- Wetlands
- Stream physical habitat ratings at stream monitoring sites
- Benthic invertebrate condition ratings (BIBI) at sampling sites
- Fish condition ratings (FIBI) at sampling sites

Some of the data will have been collected during previous studies. Both field work (e.g., targeted stream visits to assess conditions) and baseline Watershed Treatment Model (WTM) modeling (e.g., pollutant loadings) should be performed, if not previously conducted or sufficient.

The output of this chapter is the problem summary for the watershed. The list of problem areas should be geographically specific and include the following:

- Severely disrupted hydrologic regime
- Excessive stormwater runoff
- Excessive soil erosion and/or deposition of sediment
- Low or no base flow in perennial streams
- Sanitary sewer system leakage
- Illegal connections to storm drains or streams
- Permitted point sources
- Fish blockages
- Poor or no instream aquatic habitat
- Poor quality or non-functional wetlands
- Loss of riparian habitat (usually within 100 feet of the streambank)
- Loss of upland forest habitat (beyond the riparian zone)

- Lack of tree canopy
- Invasive non-native species
- Excessive dumping or trash

3. Action Inventory

This section develops the inventory of restoration actions for the watershed, i.e., environmental site design (ESD) practices, new SWM facilities and retrofits, stream restoration, wetland creation/restoration, fish blockage removal/modification, riparian buffer restoration, invasive plant management, wildlife habitat improvement, land preservation, and programmatic BMPs such as street sweeping and pollution or trash control policies and education. ESD practices include the suite of practices described in the new Maryland Department of Environment (MDE) regulations and encompass practices frequently referred to as low impact development (LID), as well as reduced site disturbance and other practices to reduce imperviousness and mimic pre-development hydrology. The basic categories of non-ESD and ESD practices are as follows:

Structural Practices:

- Traditional Retrofits, i.e., large-scale, non-ESD retrofits, constructed on larger parcels of public or private lands within county stormwater facility (BMP) inventory

- BMP Maintenance Upgrades of failed stormwater practices, such as increasing capacity, lengthening the flow path, reducing short-circuiting, eliminating design failures, and incorporating proper maintenance

- Habitat Restoration resulting in pollutant reductions or volume reductions from specific stream rehabilitation, wetland restoration, or riparian reforestation projects

ESD Practices:

- New ESD Practices, such as rainwater harvesting, green roofs, green street retrofits, converting swales to dry swales, upland reforestation, soil compost amendments, and rooftop disconnection

- ESD Upgrades to existing stormwater infrastructure, such installing bioretention in dry ponds
- Impervious Cover Reduction ESD by removing un-needed impervious surfaces and amending soils or restoring vegetation

- Voluntary LID Implementation ESD installed as a result of county education and incentive programs (e.g., Rainscapes incentives and Green Roof Subsidies)

Programmatic and Operational Practices:

- MS4 Programmatic Practices to reduce polluted runoff through stormwater education (e.g., lawn care), improvements at municipal hotspots, better housekeeping on county land and facilities, and countywide controls on product content, pet waste enforcement, and trash

- Hotspot Pollution Prevention through enhanced structural and non-structural practices employed at non-publicly owned stormwater hotspots that are identified through land use analysis

- Enhanced County Street Sweeping to remove pollutants through more intensive and targeted street sweeping and storm drain cleanouts

- Trash Prevention and Control, such as reduce, reuse and recycle campaigns; littering and illegal dumping enforcement; dumpster management; storm drain marking; storm drain inlet devices; stream cleanups; and in-stream controls to trap and remove trash

The action inventory follows from the problem summary developed under Environmental Conditions. The challenge is to identify restoration projects that are appropriate for the kind of problem and feasible given site and other constraints.

When the number of candidate projects is very large, or exceeds restoration targets, a screening or priority-setting process should be employed. This screening can be based on a general understanding of where the likely benefits are greatest or on quantitative estimates of benefits generated by WTM modeling.

The first step in selecting candidate projects is to develop a method to evaluate the restoration potential for each type of problem area. The focus is on identifying specific locations for structural solutions, but programmatic BMPs should also be identified at whatever geographic scale is appropriate. The most accurate, but also the most time and labor intensive, method is to conduct a site reconnaissance of each problem area. At some point, a site visit will be required for any restoration project carried forward, but a desktop analysis is a more efficient method for identifying candidate projects. Ideally, there will be comprehensive stream characterization information from stream walks that can be analyzed. More often there will be stream sampling data that only provides information on certain reaches, or by extrapolation to the watershed scale. In these cases, evaluation of problem sites must be done using GIS data for land cover and stormwater infrastructure. Development of GIS databases is an essential and non-trivial first step for conducting desktop analysis, and subsequent interpretation of field investigations.

The final inventory of possible restoration projects should provide all the information needed to complete WTM modeling and incorporate the inventory into the watershed implementation plan. Specifically, the drainage area (and contributing impervious cover), location on the storm drainage network, type of project or practice (capture, design, and maintenance), standard performance values and discounts, and year constructed should be described in table or fact sheet for each project. Ideally, this information will be incorporated into a geodatabase. The watershed implementation planning process will be most efficient if the project specific information available at this stage is sufficient for bidding design and construction.

The possible restoration projects in the inventory can be assigned priority values at this stage, or later, when they are incorporated in the implementation plans. Priority setting can take many forms, but should include quantitative measures (at least high, medium, or low) of the environmental benefits, construction and maintenance costs, and feasibility of implementation. The metrics used should relate directly to the restoration goals for the watershed, specifically the legal requirements and public interest concerns.

4. Implementation Planning

Implementation planning is the final step where the environmental conditions of the watershed (e.g., the current amount of untreated impervious cover and the current loads of pollutants) are evaluated against the projected benefits of implementing the candidate restoration projects in the action inventory. When the projects in the inventory fall short of County needs, the watershed implementation plan provides an iterative process for identifying more candidate projects.

The watershed implementation plan is evaluated within a Countywide Coordinated Implementation Strategy, so that the most efficient scenarios are pursued for meeting county needs. In general, the County's preferred restoration strategy consists of the following key elements:

- Major repairs to existing stormwater management facilities
- Construction of SWM facilities and retrofits indentified 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).

The technical process for developing the implementation plan is described in the Guidance Document. It includes the following steps:

1. Resolve general issues associated with plan implementation, such as the requirements of the Permit and definitions of ESD and MEP in the context of this Permit.

2. Create baseline inventories and baseline water quality input data for modeling the restoration benefit of the plan.

3. Conduct baseline pollutant load reduction estimating using the Watershed Treatment Model (WTM) and modifications as needed.

4. Evaluate restoration practices that could be implemented in each watershed.

5. Evaluate the impact of restoration practice implementation in the watershed by comparing the WTM estimates to the baseline load and the treatment and/or load reduction benchmarks for the watershed.

6. Define outcomes and track progress of implementing the plan.

The watershed implementation plan allows the County to schedule, evaluate, and modify the implementation of selected restoration projects, so that the plan meets regulatory and programmatic targets of the County and stakeholders. The implementation planning should be revisited, along with other pertinent parts of the plan, on a regular schedule such every 5 to 10 years.

IV. SCHEDULE FOR COMPLETING WATERSHED IMPLEMENTATION PLANS

To successfully meet its regulatory requirements and environmental goals, Montgomery County must complete and revise watershed implementation plans (as described in Section III above) on a continuing and regular basis. New plans will address changing watershed conditions, apply new restoration technologies, and refine implementation strategies, as needed to achieve watershed restoration success.

Table 4 lists the watershed groupings in Montgomery County with the date their watershed study was completed. By the end of 2010, all watersheds will have completed watershed implementation plans (associated with watershed studies of different ages), except for

- Dry Seneca and Little Seneca within Seneca Creek

- Upper Potomac Direct

- Lower Potomac Direct (Rock Run and Little Falls only, Muddy Branch and Watts Branch will have implementation plans)

- Patuxent (Triadelphia and Rocky Gorge only, but these subwatersheds will be combined with Hawlings into a draft implementation plan)

Therefore, these watershed groupings should be scheduled for final watershed implementation plans within the next three years, or as soon as possible.

1. Criteria for Scheduling Future Watershed Implementation Plans

After plans have been completed for the four remaining watershed groupings in the first round, the next round of watershed implementation plans should be scheduled to occur over a 10-year period, with approximately one watershed grouping per year. Because complete watershed implementation plans will have been completed for the entire county, this next round of plans should be simplified, needing only to reflect changing environmental and regulatory conditions. The criteria for scheduling the next round of revised plans should be as follows:

- <u>MDE timeline for developing TMDLs</u>. The County can expect to see additional TMDLs approved within the next 5- and 10-year permit cycles. In addition, the Chesapeake Bay TMDL and associated Watershed Implementation Plans (WIPs) will include new targets for nutrients and sediment in all watersheds. MDE has a process for preparing TMDLs for Category 5 impaired waters on the 303d list. Therefore, the County can review the current list of impairments without TMDLs to begin its planning. It should be noted, however, that MDE is now applying their new biological stressor identification (BSID) framework and reevaluating many existing TMDLs, leading to some impairments being removed (MDE 2009). It is possible that other impairments will be identified through this process but the pollutants may differ. MDE is also investigating how to address biological impairments and determine whether TMDLs will be developed directly for biology or for related stressors, such as stormwater flow or impervious surface.

  <u>Current TMDL Priorities</u>: Among watersheds groupings without implementation plans, Patuxent (Triadelphia and Rocky Gorge) has 3 TMDLs; the others have no TMDLs.

- <u>Results from the watershed monitoring.</u> The completion of implementation plans for all watersheds in the county will include monitoring, both for meeting the impervious cover controls and TMDL targets (monitoring may be a regional or state responsibility), as well as for local stream conditions. The County should plan to review the results of monitoring as implementation proceeds and for instream condition at least by 2015. Those watersheds that are failing to meet their targets should be revised first. It is also likely that the 4th generation permit will include additional requirements that must be incorporated into this scheduling.

Current Impairment Priorities: The Upper Potomac Direct and Lower Potomac Direct each have 4 impairments; the Patuxent has 1 impairment; and the Dry Seneca and Little Seneca have no impairments.

- Sensitive waters threatened by pending development or land management. Stream protection is almost always more effective and cost-efficient than stream restoration. Therefore, the County should schedule plan revisions to expedite those watersheds under threat from land cover changes. Specifically, the County has designated Special Protection Areas (SPAs) and MDE has designated Tier II waters, as shown in Table 4. In the absence of specific development plans, those watersheds with SPAs and Tier II waters (expanded to include other high quality waters not yet designated) should be revised first.

  Current SPA and Tier II Priorities: Dry Seneca and Little Seneca include the Clarksburg SPA; the Patuxent (Triadelphia) includes a Tier II segment.

- Watershed assessments that are out-of-date or do not adequately support implementation plans. While the goal of the County is to have effective implementation plans for all county watersheds, after completing the Countywide Coordinated Implementation Strategy, some watershed assessments are less rigorous than others. The appendix provides an evaluation and comparison of existing watershed studies. Based on this review, and the outcome of the implementation strategy process, the least effective watershed implementation plans should be revised first. In general, the plans based on the oldest studies have the greatest amount of new development not considered, as well as the least consideration of ESD practices.

- Significant number of stream segments with poor water quality not directly attributable to land uses in the contributing drainage areas. Even though the implementation strategy will be a state-of-the-art process for restoring watersheds through stormwater control and other techniques, degraded watershed conditions will doubtless continue. This includes degraded streams for which atmospheric, legacy, or other stressors separate from land development and management are responsible. Revision of these watershed implementation plans should be focused on improving our understanding of these causes of degradation and implementing new solutions as they are identified.

Table 4. Management phase, TMDLs, impairments, and conservation designation by watershed grouping in Montgomery County

Watershed Grouping	Subwatershed	Current Management Phase (bold)	TMDLs	Impairments	Conservation
Anacostia		Restoration Plan (2009) **Implementation**	Phosphorus (1996) Bacteria (2002) Sediment (2007) Nutrients (2008) Trash (2010)	Heptaclor Epoxide (2002) PCBs (2002) Biological (2006) Trash (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 (2002)	Phosphorus (1996) TSS (1996) Biological (2002)	Upper Rock Creek SPA
Cabin John Creek		Assessment (2004) **Implementation**	Bacteria (2002)	TSS (1996) Phosphorus (1996) Biological (2006)	
Seneca Creek				Phosphorus (1996) TSS (1996) Biological (2006)	
	Great Seneca Creek (including Clopper Lake)	Draft Assessment (2009) **Implementation**	Clopper Lake : Phosphorus and Sediment (1998)		Clarksburg SPA
	Dry Seneca and Little Seneca	**Pre-Assessment**			Clarksburg SPA
Lower Monocacy		**Implementation**	Sediment (2009) Bacteria (2009)	Phosphorus (1996) Biological (2002)	

Table 4. (Continued)

Watershed Grouping	Subwatershed	Current Management Phase (bold)	TMDLs	Impairments	Conservation
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)	
	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/
MDE 2008 Integrated Report (combined 303(d) List and 305b Report)

2. Recommended Schedule and Cost Estimates for Completing Watershed Assessments for Pre-Assessment Watershed Groupings

As stated above, the first watershed implementation plans to be completed should be for the pre-assessment watersheds for which no plans have been prepared. A preliminary schedule and general estimates of costs to complete these plans, as well as future revised plans for the second round, are provided below. Cost estimates are based on past experience in Montgomery County and other jurisdictions to produce similar watershed assessments (considering the area of untreated impervious surface), with additional effort included to address the needs for implementation planning.

Year 1 (2012) – Patuxent

The Patuxent (Triadelphia and Rocky Gorge) watershed grouping has 3 current TMDLs, 1 biological impairment, and a Tier II segment, and therefore should be the first priority for preparing a watershed implementation plan. Because a draft implementation plan is being prepared in 2010, the cost of completing the final plan will be less than for other plans. The Triadelphia and Rocky Gorge subwatersheds comprise about 200 acres of untreated impervious area.

Estimated cost = $200,000

Year 1 (2012) – Dry Seneca and Little Seneca

Dry Seneca and Little Seneca have no current TMDLs or impairments but are part of the Seneca Watershed, for which MDE submitted a draft sediment TMDL to EPA in 2010. Since this watershed grouping includes tributaries to the Potomac River, trash reduction and management practices must also be identified for inclusion within the countywide plan. The Clarksburg SPA is included in this watershed grouping. These subwatersheds have more than twice the pre-1986 BMP retrofit potential of the other pre-assessment subwatersheds. Implementing these high-priority projects has the potential to treat an additional 270 acres or 32% of the impervious area in the watershed.

Estimated cost = $585,000

Year 2 (2013) – Lower Monocacy

Lower Monocacy has two current TMDLs, and as a tributary to the Potomac River requires that trash reduction and management practices be identified and included within the countywide plan. The watershed has little total area within the County MS4 area, so many of the restoration opportunities will likely be on private property. With low population density and fewer stream resource problems than other watersheds, completing the restoration assessment and project inventory is deferred to Year 2.

Estimated cost = $100,000

Year 2 (2013) – Lower Potomac Direct (exclusive of Muddy Branch and Watts Branch)

Lower Potomac Direct has no current TMDLs, but 4 impairments for which TMDLs will be developed. Since this watershed grouping includes tributaries to the Potomac River, trash reduction and management practices must also be identified for inclusion within the countywide plan. This watershed grouping has twice the amount of untreated impervious areas of the other unassessed watersheds and includes substantial pre-1986 retrofit potential. Implementing these retrofits and projects in the focus areas has the potential to treat 339 acres or 19% of untreated impervious area in the watershed.

Estimated cost = $320,000

Year 3 (2014) – Upper Potomac Direct

The Upper Potomac Direct has no current TMDLs, but 4 impairments for which TMDLs will be developed. Since this watershed grouping includes tributaries to the Potomac River, trash reduction and management practices must also be identified for inclusion within the countywide plan. This watershed grouping comprises about 200 acres of untreated impervious area.

Estimated cost = $200,000

Future Years – Revisit and Revise Completed Plans

At the end of 2010, each of the watersheds with completed watershed assessments will have newly established watershed implementation plans. These implementation plans will determine how far each plan is from meeting Permit and TMDL/trash goals. To the extent that one or more of these plans could be revised to meet countywide goals, they should be high priority for revision. In addition, older plans, in which more environmental changes are likely to have occurred, should be revised first. The following list combines all the criteria for revisiting watershed implementation plans into a strawman schedule for future watershed planning:

- Rock Creek – Year 4 (revise 2001 plan)
- Cabin John – Year 5 (revise 2004 plan)
- Anacostia – Year 6 (revise 2009 plan)

Subsequently, each watershed would be revisited every 10 years.

3. Monitoring Component of Watershed Implementation Plan Framework

As described in the Guidance Document for the Implementation Strategy, the approach for tracking progress toward meeting regulatory and programmatic targets should include both (1) a spreadsheet-based method to track project implementation and (2) monitoring of the reductions in stressors and improvements in stream conditions that result from project implementation. This approach reflects the realities of monitoring restoration (Southerland and Roth 2009), wherein monitoring the design, construction, and maintenance of BMPs or other restoration projects is relatively easy, while monitoring the performance of these projects, in terms of reducing stressors, is harder (owing to technical and cost factors) and, in terms of stream condition, often much harder (owing to confounding factors and time lags). The proposed monitoring framework will not readily capture water quality improvements associated with programmatic restoration measures, such as increased outreach, enhanced enforcement, or adopting new legislation or regulation. Documenting improvements associated with these types of approaches will be addressed as part of the Public Outreach and Stewardship Work Plan.

Similarly, the recent 2010 Trust Fund Water Quality Monitoring Strategy (Trust Fund Evaluation Workgroup 2010) recognizes that intensive monitoring of BMP performance, while effective, is not practical on a large scale. The Strategy further recommends that sampling of larger receiving waters be done only when a 30% reduction in nutrient or sediment loads from one or more BMPs are expected; otherwise, monitoring should be done as close to the implementation site as possible. Lastly, the Strategy concludes that these monitoring challenges underscore the need for an adaptive management approach that draws upon existing sampling networks and institutional partnerships and recognizes issues related to the local budget and funding cycle.

The challenge for Montgomery County, therefore, is to augment its spreadsheet tracking of restoration project implementation with

- Stream condition monitoring on a time scale where improvements are likely to occur (including biological community metrics beyond narratives of excellent, good, fair, and poor)

- BMP performance monitoring on the spatial scale where changes in stressors are expected to be measurable

The County has a long history of both extensive and intensive monitoring to address stream condition and BMP performance. It is not practical to expand this monitoring effort commensurate with the many-fold increase in project implementation. The County should evaluate their existing monitoring effort and consider reallocation and augmentation to most efficiently track progress toward meeting the targets of the County MS4 Permit. In anticipation of this need, in 2009, the DEP modified its stream monitoring approach to focus on stations with smaller drainage areas to better track changes in stream resource conditions over shorter time intervals.

Where appropriate, monitoring by the State or others (including volunteer citizens) may contribute to providing a more complete picture of restoration progress (e.g., toward Chesapeake Bay TMDL targets). Lastly, it is important not to encourage unrealistic expectations for observing stream condition improvements over large scales or over short time periods.

3.1 Current Montgomery County Monitoring

The County currently conducts monitoring in the following six areas:

1. Countywide stream resource monitoring. Since 1994, Montgomery County has been sampling about 250 stream sites on a five-year rotation (20% of sites per year) for biological, physical/chemical, and habitat components. These sites were originally selected with a probabilistic sample design. From the original station population, stations within first-, second-, and some third-order streams have been selected to show changes as a result of County watershed project implementation. Biological sampling results are converted into fish and benthic macroinvertebrate indices of biotic integrity which are benchmarked to local reference conditions. Biological community characteristics measuring functional and structural responses to land use changes are also used. This provides an excellent baseline for stream conditions that should improve with the implementation of restoration projects. This monitoring is ongoing.

2. Discharge characterization monitoring. Montgomery County is intensively monitoring the water chemistry, biology, and stream physical condition in the Breewood Tributary to evaluate the effectiveness of implementing the full range of restoration practices in this small urban catchment currently lacking stormwater management. This monitoring was initiated before restoration was begun and will provide good evidence of the reduction in stressors from the projects that are implemented. The monitoring began in May 2009 and will continue until after all of the restoration activities are completed and assessed.

3. Stormwater Design Manual monitoring. Since 2002 (two years before development began in the first test watershed), Montgomery County has been monitoring the effectiveness of the Maryland 2000 Stormwater Management Design Manual in protecting stream channels and biota from new development. It uses a paired watershed design comparing primarily forested parkland and a nearby developing watershed. Stream hydrology, morphology, and biology are being monitored and tracked alongside changes in the landscape. Additional monitoring is done by a collaborative team from USGS and EPA to augment the information the County collects. Information from another test watershed that is now going through the development process will be combined with the first test watershed to better address land use changes and the effectiveness of the 2000 Manual. A sixth gauge will be installed in the Ten Mile Creek watershed in 2010. This gauge and accompanying monitoring will address the effectiveness of the new 2010 stormwater regulations and designs.

4. Special Protection Area (SPA) monitoring. This monitoring evaluates the effectiveness of additional requirements on development in SPAs created to protect sensitive stream resources in the county. One component monitors changes in stream biota as an indicator of stream condition; the other involves BMP monitoring of pollutant loads and water quality at more than 20 development sites. BMP monitoring typically begins one year before construction and continues up to five years afterwards. This monitoring will also improve our understanding of stream changes likely to result from future development.

5. Restoration project monitoring. Since 2001, Montgomery County has been monitoring its stream restoration and stormwater retrofit projects to measure progress toward project-specific restoration goals (e.g., fish population increases). Projects are monitored before construction begins and 1, 3, and 5 years afterwards, providing an opportunity for adaptive management. In 2010, eight projects across half of the county watersheds were being monitored.

6. Water quality and flow monitoring at USGS gauges. Additional funding from the County helped establish a network of 10 stream gauge stations to provide flow and enhanced water quality monitoring. These stations monitor (1) pollutant loadings being carried to other jurisdictions, (2) changes associated with stream restoration and stormwater retrofits, and (3) effects of development in upstream watersheds. This supports other monitoring by providing information on both upstream contributing and downstream cumulative conditions.

3.2 Recommended Monitoring to Track Implementation Progress

Montgomery County DEP should consider how to reallocate and augment its current monitoring program to incorporate the following four components:

- Maintain stream resource sampling of stream benthic macroinvertebrates, fish or salamanders, physical/chemical water quality, and physical habitat at 3 or more fixed, representative sites in each of the eight watersheds (minimum of 24 sites). Sample these stations annually, analyze annually for large changes, and analyze for change in ecological condition every 5 years. Compare sites to results from the countywide stream resource monitoring, as well as the random Maryland Biological Stream Survey conducted by the State, to control for weather or other confounding factors.

These 3 sites per watershed would be selected as follows:

- Headwaters site downstream of restoration efforts
- Mid-watershed site downstream of largest cluster of restoration efforts
- Down-watershed site downstream of 80% of restoration efforts

These sites would be existing fixed sites in the countywide stream resource monitoring network, thus providing a longer time series of sampling results. In the worst case, annual sampling of 24 new sites would increase the work effort by 50% over the 50 sites currently sampled per year.

Significant changes in the composite stream condition scores (based on indices of biotic integrity or more sensitive community-based analyses) would be the ultimate measure of restoration success. Select measures of changes in both biological communities and physical habitat would be evaluated to detect more immediate changes related to reductions in specific stressors. For the headwaters site, the selected monitoring parameters should directly represent the project goals and anticipated environmental benefits. For example, the Maryland Biological Stressor Identification Process (MDE 2009, Southerland et al. 2007) has identified the following variables as significantly correlated with sediment (flow/sediment) and nutrient (energy) stressors to be addressed with restoration projects:

- <u>Flow/Sediment effects</u>: Benthic Tolerant Species, Bank Stability Index, Embeddedness, Epifaunal Substrate Condition, Instream Habitat Condition

- <u>Energy (Nutrient) effects</u>: Hilsenhoff Biotic Index, Shading, Dissolved Oxygen, Dissolved Organic Carbon, Total Nitrogen, Ammonia-NH3, Total Phosphorus

Specifically, each of these metric scores or other measures of community change should be evaluated in addition to the composite stream condition scores to potentially track improvements resulting from reductions in sediment and nutrients, respectively. The biological metrics, Benthic Tolerant Species and Hilsenhoff Biotic Index, alone may prove to be useful surrogates. Additional biological metrics taken from the literature (e.g., specific intolerant taxa) should also be considered.

- <u>Enhance the utility of the flow and water quality monitoring at USGS gauges</u> by focusing the first round of restoration projects upstream of these gauges in Lower Rock Creek and the Anacostia. These are priority watersheds because of the number of pending or approved TMDLs and need for water quality improvement. This would leverage the investment of the County and USGS to address the primary stressor of stormwater flow. MDE, like EPA (in New England and Accotink Creek, VA), is already exploring creating TMDLs for flow (or surrogates such as impervious cover). Using these monitoring stations would also help address the success of ESD practices in infiltrating storm flows as a means of increasing base flows.

- Conduct intensive BMP performance monitoring of flow and pollutant transport in small subwatersheds in the county that represent 3 or more different land use and restoration strategy types, preferably in priority watersheds. These would be before-and-after and/or paired watershed designs in subwatersheds where the maximum number of restoration projects will be implemented. GIS data collected from these subwatersheds would be benchmarked to the monitoring results and the performance extrapolated to similar areas throughout the county. The before-and-after discharge characterization monitoring of water chemistry, biology, and stream physical condition in the Breewood Tributary meets these criteria for an older, small residential subwatershed without stormwater management.

  Watershed restoration monitoring should also provide opportunities for additional BMP performance monitoring in small watersheds. Monitoring may need to be expanded or enhanced to capture the effects of additional restoration efforts getting underway in the contributing drainage area. To the extent possible, the maximum number and variety of restoration projects should be implemented in each land-use-type watershed. Specifically, monitoring should be continued or initiated in the following neighborhood types:

  - Industrial/commercial
  - Residential with lot size greater than 0.25 ac but less than 1.0 ac
  - Residential with lot size less than 0.25 ac but greater than 0.1 ac

  The creation of two new performance monitoring efforts in addition to the Breewood Tributary monitoring would require additional effort. It might be possible to convert the effort used for monitoring the 2000 Stormwater Manual into this restoration performance monitoring. The MDE might be amenable to replacing the 2000 Stormwater Manual monitoring with monitoring future development (not necessarily within the SPAs) that more closely match the new 2010 stormwater regulations. Current BMP monitoring occurs in the SPAs, where monitoring is required for new development and are therefore not priority areas for restoration.

- Consider modifying the current recording of physical and chemical conditions in streams to better capture transient water chemistry conditions. Equipment that can continuously record information on water chemistry is now affordable. For example, optical dissolved oxygen probes do not need regular calibration and can easily be installed in streams to provide information on diurnal changes. Unexplained low dissolved oxygen conditions may reflect high algal or microbial levels related to nutrient enrichment. Initially the County could sample a small number of sites associated with restoration efforts, moving the equipment periodically to increase coverage.

In summary, the County monitoring efforts to document stream changes associated with restoration efforts should

- Continue to use sentinel (fixed) sites for trend monitoring of stream conditions

- Use existing monitoring networks (such as the countywide and MBSS stream resource monitoring) to provide baselines and adjust for confounding effects such as precipitation and unusual weather

- Identify the best sites to conduct BMP-specific monitoring as part of watershed-based restoration

- Use statistically robust before-and-after or paired watershed designs for BMP monitoring associated with restoration efforts

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