Tiber Hudson Subwatershed Restoration Action Plan

April 19, 2013

PREPARED FOR:

Patapsco Valley Heritage Greenway

PREPARED BY:

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20 Years 1992-2012
Solutions for Clean Water and Healthy Natural Resources

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EXECUTIVE SUMMARY

E.1 Introduction

The Tiber Hudson subwatershed is one of five major tributaries to the Lower Patapsco and includes a major population center for Howard County, Ellicott City. It is 3 square miles and 27.7% impervious, which classifies it as non-supporting of aquatic life according to the impervious cover model (citation). The County completed biological monitoring for the Lower Patapsco, including the Tiber Hudson, in 2003 and 2008. The studies showed the mean biological condition to be "poor" and the habitat to be "partially supporting" in 2003 and "non-supporting" in 2008. The Tiber Hudson is included in three local Total Maximum Daily Loads (TMDLs), including the North Branch Patapsco for non-tidal bacteria (2009), phosphorus (2009) and sediments (2011). The Tiber Hudson also falls under the Chesapeake Bay TMDL that allocates nutrient and sediment reductions for each Bay state. For Maryland, this equates to a 25% reduction in nitrogen, 24% reduction in phosphorus and 20% reduction in sediment. These reductions were further broken down by county and major river basin. At the state level, Phase I and Phase II Watershed Implementation Plans (WIPs) were developed to determine how each state will help meet pollutant reductions. Downtown Ellicott City has ample history of flooding:
http://www.ellicottcity.net/tourism/history/floods/

Typical watershed restoration strategies for a non-supporting subwatersheds focus on restoration (e.g., stormwater retrofits, reforestation and pollution prevention). Prior to this report, there was no existing information on upland restoration projects in this subwatershed despite its relatively small size. In December, 2012, an upland assessment was completed to quantify pollution severity and identify restoration opportunities in neighborhoods and commercial "hotspots," as well as identify stormwater retrofit opportunities. Development of action plans with specific and prioritized project recommendations is an important first step to getting restoration projects in the ground. The subwatershed assessment intended to fill in watershed planning gaps for the Lower Patapsco as well as define further actions for responsible parties to implement.

The watershed field assessment strategy aimed to identify opportunities to address stream corridor impacts identified in the Lower Patapsco River Watershed Restoration Action Strategy (2006). The WRAS identified 30% of eroded streams and 40% of impacted buffers (includes both banks) on the 6.4 miles of stream in the watershed. Due to the significant amount of in-stream erosion, poor biological rating and non-supporting habitat, the primary field strategy was to 1) identify potential upland pollution sources in residential and commercial areas; 2) identify opportunities to treat uncontrolled stormwater with new storrmwater management facilities; and 3) retrofit existing impervious cover and stormwater management facilities to provide water quality treatment and additional storage where possible.

During these field assessments, the field crew teams, consisting of one Center staff and one or more volunteers from the Patapsco Heritage & Greenway, Howard County Watershed Stewards Academy and other organizations visited over 98 locations in the watershed and used one of three field assessment methodologies to evaluate the feasibility of implementing a management or restoration practice. Approximately 48 potential stormwater retrofit sites, 27 potential hotspot locations and 23 residential neighborhoods were assessed in the Tiber Hudson subwatershed. Table 2.5 provides a summary of general findings from the field assessments.

One key component of the Tiber Hudson Action Plan (Action Plan) was to develop specific watershed protection and restoration objectives and then rank and prioritize the proposed projects identified from the field work according to these watershed objectives. A list of ranked watershed management and restoration projects along with estimated project costs are listed in Appendix A of this Action Plan and are mapped in Appendix B. Further information regarding project ranking can be found in Section 3.2. Project and site ranking differed among assessment types but, generally, the factors included the following:

- *Cost* – The cost associated with project implementation. Project costs represent only planning level estimates and were determined based on guidance provided in Schueler et al. (2007) and Wright et al. (2005).
- *Water Quality Improvement* – Potential for treatment or prevention of pollutants. Treats or eliminates exposure of pollutants to stormwater runoff.
- *Restoration Potential* – Project is feasible with regards to constraints such as space, utilities, etc.
- *Location* – Projects was located adjacent to a stream.
- *Visibility* – Project with high visibility and potential to raise the public's awareness of the watershed (e.g. visible from street or located in public area).

E.2 Watershed Strategies

Based on preliminary background research and field findings, nine key strategies were developed that are presented below. These strategies focus on a range of activities from source control and education, the treatment of polluted runoff, establishment of a coordinating body to manage implementation and more.

1. **Establish a watershed restoration coordinating body.**
2. **Educate and engage the watershed community in the restoration process.**
3. **Minimize the creation of impervious surfaces during the development review process.**
4. **Manage uncontrolled stormwater runoff in neighborhoods, commercial areas and from other impervious surfaces.**
5. **Implement pollution prevention measures at private sites and BMPs at public sites.**
6. **Encourage pollution prevention practices, tree planting and on-site stormwater management in residential neighborhoods.**
7. **Update County WRAS for streams.**
8. **Fill data gaps for unidentified stream impairments.**
9. **Track and monitor the implementation progress.**

These strategies are detailed in Section 4 of this Action Plan. Section 4 also details recommended short-term and long-term actions to support these strategies.

E.3 Implementation Planning

Implementation is by far the longest and most expensive step in the watershed management process. In fact, restoration and protection costs for a single suburban subwatershed can easily range in the millions of dollars depending on the extent of restoration and protection activities, number of jurisdictions involved, land costs, and other factors. Section 4 and Appendix A of this Action Plan presents information on planning partners, planning level costs, and phasing and resources for implementing watershed strategies. Table E.1 below provides a draft implementation schedule for implementing each short term and long term action.

E.4 Pollutant load reductions

Pollution load reductions were estimated for stormwater retrofit projects based on assumptions detailed in Schueler et al. (2007) and Hirschman, et al. (2008). Using these assumptions, the identified projects have the potential to reduce nitrogen by 167 lb/yr, phosphorus by 23 lb/yr, total suspended sediment by 8,340 lb/yr. as well as reduce runoff by over 5 million gallons per year. These pollutant load reduction estimates do not include actions that were identified in neighborhoods or at hotspots.

Table E.1. Implementation Plan

Strategy	Responsible Parties	Short-Term Action (year 1-3)	Long-Term Action (year 3-10)[1]
1. Establish a watershed restoration coordinating body	Patapsco Heritage Greenway Ellicott City Flood Solution Howard County Government Local businesses and HOAs	4-6 meetings to establish goals and structure	Monitor progress towards meeting watershed restoration goals and implementation of Action Plan items Update Action Plan to reflect new data and priorities
2. Educate and engage the watershed community in the restoration process	Coordinating Body	Hold 1-2 open to the public watershed-related events Stencil storm drains and provide other highly "visible" indicators to heighten awareness Develop web-based maps with priority locations and actions for the public to use	Conduct targeted outreach to high and medium priority neighborhoods and hotspot sites Conduct targeted outreach to private property owners regarding stormwater retrofit opportunities, particularly churches and BGE and areas with high impervious coverage Evaluate outreach effectiveness and adjust accordingly
3. Minimize the creation of impervious surfaces during the development review process.	Howard County	Review the City and County development codes using the Codes and Ordinances Worksheet (COW)	Implemented needed code revisions as determined by the COW
4. Manage uncontrolled stormwater runoff in neighborhoods, commercial areas and from other impervious surfaces	Coordinating Body Private landowners Howard County	Identify grant and foundation funding sources for stormwater improvement projects Modify, repair, and/or maintain existing stormwater management facilities to improve water quality performance Begin design and installation of high priority stormwater projects on public land and road rights-of-way projects	Begin design and installation of high priority stormwater projects on private properties Continue to identify retrofit opportunities at schools, neighborhoods, commercial areas, and outfalls that do not have existing BMPs

Table E.1. Implementation Plan			
Strategy	**Responsible Parties**	**Short-Term Action (year 1-3)**	**Long-Term Action (year 3-10)[1]**
5. Implement pollution prevention measures at private sites and BMPs at public sites	Howard County	Ensure that an enforceable stormwater ordinance for preventing illicit discharges to the storm drain system is in place Provide education on pollution prevention to targeted businesses and implement pollution source control measures Implement BMPs at County facility on Ridge Rd	Develop a *Business Stewardship Outreach Program* that engages the business community in watershed restoration Implement BMPS at private sites
6. Encourage pollution prevention practices, tree planting and on-site stormwater management in residential neighborhoods	Coordinating Body Watershed Stewards Academy HOAs	See items from Strategy 2 regarding outreach Identify neighborhoods and neighborhood leaders to lead efforts Stencil storm drains in high priority neighborhoods Begin implementation of small-scale on-site practices such as downspout disconnection and rain gardens Restore nature buffers, particularly in high priority neighborhoods Conduct residential workshops	Develop and implement widespread downspout disconnection Encourage widespread tree planting and conservation landscaping in residential neighborhoods
7. Update County WRAS for streams	Howard County	Update - 2006 stream corridor assessment to reflect current conditions Engage local residents in the process	New upland actions may need to be integrated into this Action Plan as a result of updating the stream corridor assessment
8. Fill data gaps for unidentified stream impairments	Coordinating Body	Conduct period sampling throughout the watershed for chloride and conductivity	Determine additional action strategies needed as a result of monitoring

Table E.1. Implementation Plan			
Strategy	**Responsible Parties**	**Short-Term Action (year 1-3)**	**Long-Term Action (year 3-10)[1]**
		Conduct illicit discharge assessment	
9. Track and monitor the implementation progress	Coordinating body	Develop project tracking database in GIS and spreadsheets Establish sentinel monitoring stations Provide a web-based forum for displaying project status and sentinel monitoring station results on an annual basis	Revise this plan as needed based on monitored conditions, changes in watershed conditions and new priorities

SECTION 1. INTRODUCTION

1.1 Process for Developing the Tiber Hudson Action Plan

The Tiber Hudson Action Plan (Action Plan) is the culmination of approximately six months of desktop analyses, field assessments, and one stakeholder meeting conducted by the Center for Watershed Protection (the Center) and project partners. The work was completed under contract with Patapsco Heritage Greenway (PHG) under a Chesapeake Bay Trust grant. The tasks identified within the scope of work with PHG included:

1. Prioritize Sites for Restoration and Assessment;
2. Conduct an Upland Assessment; and
3. Develop the Tiber Hudson Subwatershed Action Plan.

Although not included in the scope of work, an initial public stakeholder meeting was held in partnership with Howard County on 11/27/2012 as it was determined that engaging the public will be an integral part of the overall success of the project.

Typically, the watershed planning process begins with developing an understanding of the baseline, or current, conditions in the watershed. This task was completed in 2006 by the County during which the County also conducted a stream corridor assessment of all Lower Pataspco streams (Howard County, 2006). Because initial work was already completed, the goal of this project was to fill data gaps for the watershed restoration plan, namely to identify opportunities for restoration in the upland portions of the watershed.

To identify stormwater retrofit and pollution prevention opportunities in the watershed, the Center conducted field assessments in December, 2012. During these field assessments, the field crew teams, consisting of one Center staff and one or more volunteers from the Patapsco Heritage & Greenway, Howard County Watershed Stewards Academy and other organizations visited over 98 locations in the watershed and used one of three field assessment methodologies to evaluate the feasibility of implementing a management or restoration practice. Approximately 48 potential stormwater retrofit sites, 27 potential hotspot locations and 23 residential neighborhoods were assessed in the Tiber Hudson subwatershed. Table 2.5 provides a summary of general findings from the field assessments. The findings of the fieldwork are summarized in Section 3 of this Action Plan.

A ranking system was developed to prioritize identified management and restoration practice opportunities. Using best professional judgment, each project was assigned points and ranked according to several factors including: cost, water quality improvement, visibility, restoration potential and location. Using information gathered from the field and a review of background materials, the Center developed nine watershed action strategies. These strategies are the core of this Action Plan. They provide a framework for implementing the numerous management and restoration practices identified through field assessments as well as program and education related recommendations.

Recommended short-term and long-term actions to support the nine watershed strategies are presented in Section 4. An implementation plan was compiled that outlines the key watershed actions and information on individuals responsible for implementation and an implementation timeline. Cost information can be found in appendix A.

1.2 U.S. EPA Watershed Planning "A-I Criteria"

In 2003, the U.S. Environmental Protection Agency (EPA) began to require that all watershed restoration projects funded under Section 319 of the federal Clean Water Act to be supported by a watershed plan that includes the following nine minimum elements, known as the "a-i criteria":

a. Identification of the causes and sources that will need to be controlled to achieve the load reductions estimated in the watershed plan
b. Estimates of pollutant load reductions expected through implementation of proposed nonpoint source (NPS) management measures
c. A description of the NPS management measures that will need to be implemented
d. An estimate of the amount of technical and financial assistance needed to implement the plan
e. An information/education component that will be used to enhance public understanding and encourage participation
f. A schedule for implementing the NPS management measures
g. A description of interim, measurable milestones
h. A set of criteria to determine load reductions and track substantial progress towards attaining water quality standards
i. A monitoring component to determine whether the watershed plan is being implemented

This Action Plan, in combination with the original WRAS developed by the County, meets the a-i criteria. Table 1. 1 shows where these criteria are addressed throughout these documents.

Table 1. 1. U.S. EPA Watershed Planning "A-I" Criteria

Section of the report	A	B	C	D	E	F	G	H	I
Lower Patapsco WRAS (Howard County, 2006)	X								
Section 1. Introduction									
Section 2. Watershed Assessment Protocols									
Section 3. Watershed Assessment Findings		X	X						
Section 4. Action Strategies			X	X	X	X	X	X	X
Appendix A. Summary of Projects			X	X				X	
Appendix B. Site Location Maps			X						
Appendix C. Potential Funding Sources				X					
Appendix D. Best Management Practice Profile Sheets			X		X				

1.3 Plan Organization

The *Plan* is organized as follows:

Section 1. Introduction – provides an introduction to the Tiber Hudson Action Plan.

Section 2. Watershed Assessment Protocols – provides an overview of retrofit and upland assessment methodologies.

Section 3. Findings – provides key findings from the field assessment.

Section 4. Action Strategies – presents the nine key watershed management strategies based on watershed assessments and brief literature review; describes actions that support the key strategies, along with information on planning partners, project phasing, and resources for implementing watershed strategies. Planning level costs for identified projects can be found in Appendix A.

1.4 Caveats

It is important to keep in mind that this Plan is limited in scope and should be updated as more information on the watershed is acquired. Recommendations are based on desktop analysis and observations made during targeted upland assessments. While representative sites from across the watershed were assessed, all areas were not assessed. In the future, additional assessments should be conducted in areas of concern and this Plan updated to reflect watershed changes and developments.

SECTION 2. WATERSHED ASSESSMENT PROTOCOLS

2.1 Introduction to the Watershed Assessment

The watershed assessment protocols used during this study are based on a series of manuals written by the Center to restore small urban watersheds and compiled into a format that can easily be accessed by watershed groups, municipal staff, environmental consultants and other users. The manuals outline a practical, step-by-step approach to develop, adopt and implement a subwatershed plan. The manuals provide specific guidance on how to identify, design, and construct the watershed restoration practices, describe the range of techniques used to implement each practice, and provide detailed guidance on subwatershed assessment methods to find, evaluate and rank candidate sites.

2.2 Stormwater Retrofit Inventory

Stormwater retrofits are structural stormwater management practices that can be used to address existing stormwater management problems within a watershed. These practices are installed in upland areas to capture and treat stormwater runoff before it is delivered to the storm drainage system, and ultimately, local streams and rivers. They are an essential element of a holistic watershed restoration program because they can help improve water quality, increase groundwater recharge, provide channel protection, and control overbank flooding. Without using stormwater retrofits to address existing problems and to help establish a stable, predictable hydrologic regime by regulating the volume, duration, frequency, and rate of stormwater runoff, the success of many other watershed restoration strategies -- such as stream stabilization, reduced erosion, and aquatic habitat enhancement -- will be threatened. In addition to the stormwater management benefits they offer, stormwater retrofits can be used as demonstration projects, forming visual centerpieces that can be used to help educate residents and build additional interest in watershed restoration.

Assessment Protocol

Potential stormwater retrofit opportunities at a number of candidate project sites in the Tiber Hudson subwatershed were assessed during the retrofit inventory. A Retrofit Reconnaissance Inventory (RRI) field form was used to evaluate retrofit opportunities at candidate sites. Field crews look specifically at drainage patterns, the amount of impervious cover, available space, and other site constraints when developing concepts for a site. Candidate retrofit sites identified for the assessment generally had one or more of the following characteristics:

- Situated on publicly-owned or publically-operated lands or open spaces (e.g. school sites, parks)
- Located on commercial and industrial sites with large areas of impervious cover
- Could serve as a demonstration project; and

- Located at existing stormwater management facilities

It should be noted that the pre-identified sites represent only a portion of the potential retrofit opportunities in the subwatershed. A more thorough search will likely yield more retrofit opportunities.

Water Quality and Pollutant Removal Calculations

A water quality volume (WQv), or the storage needed to capture and treat the runoff volume for 90% of the average annual rainfall, was calculated for each retrofit drainage area. This volume captures high pollutant loads in the "first-flush" of stormwater runoff from all rainfall events. The WQv was calculated for each proposed retrofit as follows:

$$WQ_v = [(P)(R_v)(A)] / 12$$

Where WQ_v = water quality volume (acre-feet)
P = design storm runoff depth (1 inch)
$R_v = 0.05 + 0.009(I)$, where (I) is the percent impervious cover of the site
A = site drainage area (acres)

This volume reflects the water quality design volume defined in Chapter 2 of the Maryland Stormwater Design Manual (MDE, 2009), and is used to assess each retrofit's sizing and pollutant removal potential.

Nutrient load reductions for nitrogen, phosphorus, and total suspended solids (TSS), were calculated based upon several factors:

- The expected nutrient loading to the practice, which is derived from event mean concentrations (EMCs) for nitrogen (2.0 mg/L), phosphorus (0.27 mg/L), and total suspended solids (59 mg/L) (Schueler, et al. 2007)
- Estimated pollutant removal percentages for full-sized practices (designed to treat the WQv) (Hirschman, et al. 2008)
- Adjustments to the pollutant removal percentages based upon the % of the WQv that a proposed retrofit treats. (An undersized practice will treat less of the annual rainfall, and therefore provide a smaller nutrient load reduction. However, the relationship is not linear due to rainfall variability; smaller rain events happen more frequently, so even "undersized" practices can treat a significant portion of annual rainfall.)

Cost Estimates

Planning level cost estimates were developed for each proposed retrofit. The per cubic foot cost estimates for each type of practice were adapted mainly from *Costs of Stormwater Management Practices in Maryland Counties* (King and Hagan, 2011), although information from CWP's *Urban Stormwater Retrofit Practices Manual* (Schueler et al. 2007) and professional judgment were utilized as well to refine the estimates for certain proposed retrofits.

2.3 Unified Subwatershed and Site Reconnaissance

The Center conducted the Unified Subwatershed and Site Reconnaissance (USSR) to evaluate pollution-producing behaviors and restoration potential in upland areas of the watershed. The USSR is a "windshield survey" where field crews drive watershed roads to determine specific pollution sources and identify areas outside the stream corridor where pollution prevention possibilities exist. The USSR can be a powerful tool in shaping initial subwatershed restoration strategies and locating potential stormwater retrofit or restoration opportunities. The goal of the USSR is to quickly identify source areas that are contributing pollutants to the stream, and reduce these pollutant loads through source controls, outreach and change in current practice, and improved municipal maintenance operations. Additional information on the USSR is found in Wright et al. (2005).

2.3.1 Hotspot Investigations

Pollution source control includes the management of potential "hotspots" which are certain commercial, industrial, institutional, municipal, and transport-related operations in the watershed. These hotspots tend to produce higher concentrations of polluted stormwater runoff than other land uses and also have a higher risk for spills. They include auto repair shops, department of public works yards, restaurants, etc. Specific on-site operations and maintenance combined with pollution prevention practices can significantly reduce the occurrence of "hotspot" pollution problems. After evaluating each hotspot site for pollution producing problems, each site was evaluated for retrofit opportunities as indicated above under the retrofit reconnaissance inventory.

Assessment Protocol

The Hotspot Site Investigation (HSI) is used to evaluate commercial, industrial, municipal or transport-related sites that have a high potential to contribute contaminated runoff to the storm drain system or directly to receiving waters. At hotspot sites, field crews look specifically at vehicle operations, outdoor materials storage, waste management, building conditions, turf and landscaping, and stormwater infrastructure to evaluate potential pollution sources (Table 2. 1). Based on observations at the site, field crews may recommend enforcement measures, follow-up inspections, illicit discharge investigations, retrofits, or pollution prevention control and education.

The overall pollution prevention potential for each hotspot site is assessed based on observed sources of pollution and the potential of the site to generate pollutants that would likely enter the storm drain network. A hotspot designation criterion set forth in Wright et al. (2005) was used to determine the status of each site based on field crew observations. Sites are classified into four initial hotspot status categories:

- Not a hotspot – no observed pollutant; few to no potential sources
- Potential hotspot – no observed pollution; some potential sources present
- Confirmed hotspot – pollution observed; many potential sources
- Severe hotspot – multiple polluting activities directly observed

Table 2. 1. Potential Hotspot Pollution Sources		
Type	**Description**	**Examples**
Vehicle Operations	Routine vehicle maintenance and storage practices, as well as vehicle fueling and washing operations	• Vehicle storage and repair • Fueling areas • Vehicle washing practices
Outdoor Materials	Exposure of outdoor materials stored at the site	• Loading and unloading • Outdoor materials • Secondary containment
Waste Management	Housekeeping practices for waste materials generated at the site	• Dumpster practices
Stormwater Infrastructure	Practices used to convey or treat stormwater, including the curb and gutter, catch basins, and any stormwater treatment practices	• Catch basins • Stormwater treatment practices

2.3.2 Neighborhood Source Assessment

Residents engage in behaviors and activities that can influence water quality. Some behaviors that negatively influence water quality include over-fertilizing lawns, using excessive amounts of pesticides, and poor housekeeping practices such as inappropriate trash disposal or storage. Alternatively, positive behaviors such as tree planting and using native plants, disconnecting rooftops, and picking up pet waste can help improve water quality.

Assessment Protocol

The Neighborhood Source Assessment (NSA) was conducted to evaluate pollution source areas, stewardship behaviors, and restoration opportunities within individual residential areas. The assessments focus specifically on yards and lawns, rooftops, driveways and sidewalks, curbs, and common areas. Table 2. 2 provides examples of the types of restoration opportunities that were evaluated for each site.

An NSA field form was used to assess neighborhoods in terms of age, lot size, tree cover, drainage, lawn size, general upkeep, evidence of pollution sources, and evidence of resident stewardship (i.e., storm drain stenciling, pet waste management signage, etc.). Each site was assigned a pollution severity rating of “severe,” “high,” “moderate,” or “low,” using a set of benchmarks set forth in Wright et al. (2005). Pollution severity is an index of the amount of non-point source pollution a neighborhood is likely generating based on easily observable features (i.e., lawn care practices, drainage patterns, oil stains, etc.). A restoration potential rating of “high,” “moderate,” or “low” was also assigned to each neighborhood. Restoration potential is a measure of how feasible onsite retrofits or behavior changes would be based on space, number of opportunities, presence of a strong homeowner association (HOA), and other similar factors.

Table 2. 2. Types of Projects Identified during Neighborhood Source Assessment		
Type	**Description**	**Examples**
On-site Retrofits	Homeowners reduce stormwater runoff generated by their lots	• Rain gardens • Rain barrels • Other rooftop disconnection

Table 2. 2. Types of Projects Identified during Neighborhood Source Assessment		
Type	**Description**	**Examples**
Lawn and Landscaping Practices	Better lawn and landscaping practices minimize the use of chemicals and encourage the use of native landscaping, particularly in neighborhoods where high input lawns and extensive turf cover are prevalent	• Improved buffer protection • Native plantings • Turf reduction • Proper fertilizer and pesticide application • Ditch restoration
Open Space Management	Management of neighborhood common areas or courtyards	• Landscaping • Tree planting • Pet waste education • Stream buffer restoration • Trash removal
Education and Outreach	Providing homeowners with additional information to better manage pollution in their residential lots	• Lawn and nutrient management outreach • Rain barrel and rain garden education • Septic system education • Storm drain stenciling

SECTION 3. WATERSHED ASSESSMENT FINDINGS

3.1 Nomenclature

A key to the nomenclature used by field teams during the assessment work is provided in Table 3.1. The naming convention was designed to be flexible for multiple field teams and to immediately impart key information about the site. Identifiers consist of two parts: 1) the type of assessment conducted, and 2) a unique identifier that is employed as a team evaluates a site, reach or project. This nomenclature was carried through the project and is used elsewhere in this *Plan*.

Table 3.1 Site Naming Nomenclature	
Assessment Type	**Abbreviation**
Retrofit	RRI
Hotspot	HSI
Neighborhood	NSA

A summary of general observations as well as high priority projects identified by field crews during the upland assessment are discussed below. The locations of assessed sites are shown in Attachment B and a list of all the sites and identified projects are listed in Attachment A.

3.2 Project Prioritization

Projects were prioritized primarily on their ability to result in 1) stormwater runoff volume reduction and 2) pollution reduction. Opportunities identified within each of the three assessment types – neighborhood, hotspot and stormwater retrofit – were prioritized within each type and not across types. The framework used for prioritization within each assessment type is discussed below.

After the field assessments were completed, a ranking system was developed to prioritize identified management and restoration practices within each practice group. Using best professional judgment, each practice location was assigned points and ranked according to certain factors. The primary factors used to prioritize actions for each practice and their relative weight are shown in Tables 2.2-2.4 below.

3.2.1. Stormwater Retrofit prioritization

Stormwater retrofits were prioritized based on cost and three water quality improvement metrics: 1) the ratio of the treatment volume to the water quality volume; 2) percent reduction of total suspended solids; and 3) annual runoff reduction (Table 3.2). These metrics provide for a comparison of the relative effectiveness that each practice can provide for improving water quality.

In addition, due to flooding concerns in the watershed, extended detention projects were also ranked separately based on the channel protection volume. The required storage volume needed for 24-

hour detention of the one-year storm is not trivial and is roughly comparable to the storage volume for ten-year peak discharge control (Brown and Caraco, 2001). These rankings are based on assumed areas from the field assessment and do not fully capture the complexities of each site. Further investigation is required for all identified projects.

Table 3.2 Stormwater Retrofit Prioritization Factors			
Project Screening Factor	**Total Weight**	**Scoring Criteria**	
Cost	10	Low cost: <$30,000	10
		Medium cost: $30,000-$100,000	5
		High cost: >$100,000	2
Water Quality Improvement 1	30	Tv/WQv[1]: >1	30
		Tv/WQv: 0.5-1	20
		Tv/WQv: <1	10
Water Quality Improvement 2 – Total Suspended Solids (TSS) reduction	30	TSS reduction: > 300 lbs/yr	30
		TSS reduction: 100-300 lbs/yr	20
		TSS reduction: <100 lbs/yr	10
Water Quality Improvement 3 - Annual Runoff reduction	30	Annual Runoff Reduction: >25,000 cf/yr	30
		Annual Runoff Reduction: 10,000-25,000 cf/yr	20
		Annual Runoff Reduction: <10,000 cf/yr	10
Total Points	100		

3.2.2. Neighborhood prioritization

Neighborhoods were prioritized based on two primary factors: 1) the overall restoration potential identified from the neighborhood source assessment and 2) whether the neighborhood had existing stormwater management practices (Table 3.3). It was determined that more benefit could be achieved through the implementation of small-scale, on-site practices where stormwater management facilities do not currently exist. Secondary factors include cost and location relative to streams and stream buffers (neighborhoods with or adjacent to streams / stream buffers given higher priority.

Table 3.3 Neighborhood Prioritization Factors			
Project Screening Factor	**Total Weight**	**Scoring Criteria**	
Water Quality Improvement	34	Neighborhood has no existing stormwater management facilities	34
		Neighborhood has existing stormwater management facilities	17
Restoration Potential	34	High potential for treatment or prevention of pollutants	34
		Medium potential for treatment or prevention of pollutants	25
		Low potential for treatment or prevention of pollutants	10

[1] Tv = Treatment volume; WQv = water quality volume

Table 3.3 Neighborhood Prioritization Factors			
Project Screening Factor	**Total Weight**	**Scoring Criteria**	
Location	20	Neighborhood with or adjacent to stream / stream buffer	20
		Neighborhood not adjacent to stream / stream buffer	10
Cost	12	Low cost: <$5,000	12
		Medium cost: $5,000-$20,000	6
		High cost: >$20,000	3
Total Points	100		

3.2.3. Hotspot prioritization

Hotspots were prioritized based primarily on water quality improvement and secondarily on cost and visibility (Table 3.4). The water quality improvement factor is directly comparable to the severity of the hotspot based on the field assessment. Visibility was chosen as a factor with the idea that business pollution prevention and good housekeeping efforts may serve as demonstration sites to other business or the general public.

Table 3.4 Hotspot Prioritization Factors			
Project Screening Factor	**Total Weight**	**Scoring Criteria**	
Cost	20	Low cost: <$5,000	20
		Medium cost: $5,000-$10,000	10
		High cost: >$10,000	5
Visibility	30	High visibility and potential to raise the public's awareness of the project	30
		Medium visibility and potential to raise the public's awareness of the project	20
		Low visibility and potential to raise the public's awareness of the project	10
Water Quality Improvement	50	Severe hotspot	50
		Confirmed hotspot	40
		Potential hotspot	25
		Not a hotspot	10
Total Points	100		

A list of all the sites visited along with their ranked priority and planning level cost estimates is included in Appendix A. The estimated costs are preliminary and should be used to guide the watershed stakeholders. These estimates should be adapted to include more appropriate local cost estimates where available.

3.3 Tiber Hudson Subwatershed Assessment General Findings

December 10-14, 2012, field work was conducted in the 3.0 square mile Tiber Hudson subwatershed of the Lower Patapsco River. The watershed field assessment strategy aimed to identify opportunities to address stream corridor impacts identified in the Lower Patapsco River Watershed Restoration Action Strategy (2006). The WRAS identified 30% of eroded streams and 40% of impacted buffers (includes both banks) on the 6.4 miles of stream in the watershed. Due to the significant amount of in-stream erosion, poor biological rating and non-supporting habitat, the primary field strategy was to 1) identify potential upland pollution sources in residential and commercial areas; 2) identify opportunities to treat uncontrolled stormwater with new stormwater management facilities; and 3) retrofit existing impervious cover and stormwater management facilities to provide water quality treatment and additional storage where possible.

During these field assessments, the field crew teams, consisting of one Center staff and one or more volunteers from the Patapsco Heritage & Greenway, Howard County Watershed Stewards Academy and other organizations visited over 98 locations in the watershed and used one of three field assessment methodologies to evaluate the feasibility of implementing a management or restoration practice. Approximately 48 potential stormwater retrofit sites, 27 potential hotspot locations and 23 residential neighborhoods were assessed in the Tiber Hudson subwatershed. Table 3.5 provides a summary of general findings from the field assessments.

Table 3.5 General Findings from Tiber Hudson Field Assessments

Task	General Findings
Stormwater Retrofit Inventory	• 48 sites visited • 36 potential stormwater retrofits identified for 28 sites • Types of retrofits include bioretention areas, extended detention, wet ponds, pond retrofits, regenerative stormwater conveyance, permeable pavement, dry swale, wet swale and impervious cover removal
Hotspot Site Investigation	• 27 potential hotspot sites investigated • 17 sites identified as potential, confirmed or severe hotspots primarily related to waste management and the storage of outdoor materials
Neighborhood Source Assessment	• 23 neighborhoods assessed • Pollution severity index: 22 moderate, 1 high • Neighborhood restoration potential: 6 low, 15 moderate and 2 high • Neighborhoods were mix of old and new single family homes, multi-family and townhomes • Types of recommendations include rain barrels, demonstration rain gardens, downspout disconnection, storm drain stenciling, tree planting, buffer management, and nutrient/lawn homeowner management outreach

3.4 Tiber Hudson Subwatershed Opportunities

3.4.1 Stormwater Retrofit Assessment

A total of 48 stormwater retrofit sites were visited by field crews throughout the Tiber Hudson subwatershed and a total of 36 preliminary retrofit concepts were developed at 28 of the sites. Multiple concepts were developed for several of the sites and are indicated by a letter after the site number (i.e., RRI-19B). Altogether, the proposed projects would treat 129 acres, 38 acres of which are impervious. There were no concepts developed for 14 sites that either had adequate stormwater management or significant site constraints such as access or feasibility. A map of the RRI sites visited is found in Appendix B.

Stormwater retrofit opportunities were identified in commercial areas, on road right-of-ways, in open space areas, in parking lots, at churches and in the Baltimore Gas and Electric right-of-way. Eleven high priority retrofit projects were identified throughout the subwatershed (Table 3.6). Nine projects have the potential to provide stormwater storage for larger storm events (Table 3.7). These projects were also ranked separately based on their ability to treat the channel protection volume[2]. A full list of the retrofit opportunities identified in the Tiber Hudson can be found in Appendix A. Table A.1 in Appendix A also indicates which projects were identified for County, State and Federal implementation based on ownership. A summary or costs and water quality benefits of the projects based on ownership breakdown is provided in Table 3.8. Implementation of projects on private property will be a challenge. Some suggestions for accomplishing this are provided in Section 4.1.

Some general observations from the stormwater retrofit assessment are noted below:

- Throughout the watershed, a lack of stormwater treatment was observed in many locations. At many of these sites, untreated stormwater discharges directly to forested buffers, stream channels, or the stormdrain system. Unmanaged stormwater can contribute high pollutant loads to the receiving waterbodies, and can also result in high stormwater runoff flow rates that cause streambank erosion and degrade stream habitat.
- Areas with excess or under-utilized impervious cover were also noted (Figure 3.1). Examples of these sites include Lotte Plaza (RRI_401b), CR Daniels (HSI_8a), the building complex at 3300 North Ridge Road (RRI_31) and the courthouse parking lot (RRI_11).
- A number of new stormwater management facilities were identified (Figure 3.2). These are located in the Baltimore Gas and Electric (BGE) right-of-way (RRI_17), in the road right-of-way at the intersection of Rogers and Ellicott Mills Rd (RRI_8 & RRI_9), and adjacent to Lot G at (lot at the intersection of Ellicott Mills Rd and Main St; RRI_16). At RRI_23, an outfall exhibits significant downstream erosion; addressing peak flows at this location is a priority (Figures 3.3.a and 3.3.b). One existing stormwater management facility, RRI_13, could be retrofitted to accept more water, thereby providing greater storage of stormwater

[2] The channel protection volume protects stream channels from excessive erosion caused by the increase of flow at or near bankful levels of urbanization. It is provided by 24 hour extended detention of the post-developed one-year design storm and, alone, does not meet water quality requirements.

volume (Figure 3.3.c). The facility currently appears to be under-utilized. If additional water is sent to the facility, the outlet structure may need some modification as it is currently degraded.

- Several other notable opportunities for improving water quality include the following:
  - Several projects at the County's facility on Ridge Rd, including two bioretentions and two cisterns;
  - Four projects at the St Johns Lane Bethel Korean Presbyterian Church (RRI_200; Figure 3.4), including two rain gardens, one bioretention and some impervious cover removal (permeable pavers if parking is needed in this location);
  - Bioretention at St. Paul's Catholic Church;
  - Extended detention pond at St. Johns Ln. Seventh Day Adventist Church;
  - Bioretention and rain garden at St. John's Lane Episcopal Church;
  - Street bioretention facilities on Patapsco River Mill Rd (RRI_14 and RRI_114) – this road is very wide and street bioretention facilities will provide water quality treatment for untreated road runoff and likewise serve as traffic-calming devices (Figure 3.5); and
  - Two projects were identified by the courthouse (Figure 3.6). A dry swale is proposed in place of an existing concrete channel to treat half of the lower parking lot. Regenerative stormwater conveyance is proposed to treat most of the runoff from the upper parking lot where runoff is currently creating a large, eroding gully.


(a) **(b)**


(c) **(d)**

Figure 3.1. (a) Under-utilized lot at Lotte Plaza (RRI_401b); (b) Under-utilized lot at CR Daniels (HSI_8a); (c) Under-utilized lot at CR Daniels (RRI_31); and (d) Under-utilized lot at the courthouse (RRI_11).

(a) (b) (c)

Figure 3.2. (a) Drainage area to proposed new wet pond (RRI_17); (b) Proposed location for extended detention pond (RRI_8); and (c) Proposed location for extended detention pond (RRI_16).

(a) (b) (c)

Figure 3.3. (a) Drainage area to proposed practice (RRI_23); (b) outlet structure, currently blown out, at RRI_23; and (c) existing pond off Rogers Ave; more water could be directed to this facility.

(a) (b)

Figure 3.4. (a) Proposed location for a linear bioretention facility at the Korean Presbyterian Church and (b) Proposed location of a rain garden to treat parking lot runoff.

Figure 3.5. Proposed locations for street bioretention facilities on Ellicott Mills Rd.

(a) (b) (c)

Figure 3.6. (a) Eroding gully from runoff by courthouse upper parking lot; (b) proposed area to install a regenerative stormwater conveyance system; and (c) concrete channel to be retrofit to a dry swale by the lower courthouse parking lot.

Table 3.6. Stormwater Retrofit Opportunities in the Tiber Hudson Watershed										
Site ID	**Location**	**Retrofit Concept**	**Drainage Area (ac)**	**Impervious Cover (%)**	**Cost**	**TN Removal (lb/yr)**	**TP Removal (lb/yr)**	**TSS Removal (lb/yr)**	**Annual Runoff Reduction (cf)**	**Priority**
RRI_11	Court House Parking lot	Dry Swale	1.80	90	$24,000	9.34	1.19	326	54,374	High
RRI_111	Upper Court House Parking Lot	Regenerative Stormwater Conveyance	1.05	95	$103,000	8.67	1.01	280	43,379	High
RRI_114a	Corner of Patapsco River Rd & Orange Grove Ct	Bioretention	2.21	80	$23,000	5.44	0.63	176	27,239	High
RRI_17	BGE Right-of-Way - Adjacent to Veterans Elementary School	Wet Pond	16.71	0	$190,000	6.97	1.57	343	0	High
RRI_31	3290 & 3300 North Ridge Road	Permeable Pavement*	0.65	100	$2,000,000	5.97	0.81	239	36,487	High
RRI_501a	Ridge Road Shop - 8800 Ridge Road	Bioretention	1.90	100	$68,000	11.84	1.37	382	59,242	High
RRI_501b	Ridge Road Shop - 8800 Ridge Road	Bioretention	0.83	100	$107,000	8.49	0.99	274	42,505	High
RRI_401a	Lotte Plaza	Bioretention	0.44	100	$58,000	4.52	0.52	146	22,634	High
RRI_401b	Lotte Plaza	Bioretention	1.00	100	$122,000	10.06	1.17	325	50,358	High
RRI_402	BP - Rt 103 and Columbia Pike	Bioretention	0.70	60	$54,000	4.40	0.51	142	22,034	High
RRI_114b	Corner of Patapsco River Rd & Orange Grove Ct	Bioretention	2.15	80	$24,000	5.45	0.63	176	27,252	High

*Another option for this site is impervious cover removal.

Table 3.7. Storage Projects Identified in the Tiber Hudson						
Site ID	**Location**	**Retrofit Concept**	**Drainage Area (ac)**	**Impervious Cover (%)**	**Percent Channel Protection Treatment**	**Rank**
RRI_17	BGE Right-of-Way - Adjacent to Veterans Elementary School	Wet Pond	16.7	0	103%	1
RRI_201	3100 North Ridge Road Lighthouse Senior Living	Wet Pond	1.8	60	74%	2
RRI_33	In BGE Right-of-Way near 3165 Saint Johns Lane	Extended Detention Pond	61.2	15	32%	3
RRI_16	Ellicott City Municipal Parking Lot F	Extended Detention Pond	2.1	60	29%	4
RRI_23	Behind 8615 Manahan Drive	Extended Detention Pond	2.4	25	24%	5
RRI_9	District Court - Multi-Services Center	Extended Detention Pond	1.2	10	22%	6
RRI_13	RRI_13_With New Drainage Area Added	Extended Detention Pond	5.4	25	0%	7
RRI_30	South bound on-ramp to Route 29 from 40	Extended Detention Pond	3.9	95	13%	8
RRI_8	Howard County Government Office Complex	Extended Detention Pond	2.4	95	5%	9

Table 8. Project Cost and Benefits by Ownership											
Ownership	**Number of Projects**	**Total project cost**	**Percent of Total Project Cost**	**TN Removal (lb/yr)**	**Percent of Total TN Removal**	**TP Removal (lb/yr)**	**Percent of Total TP Removal**	**TSS Removal (lb/yr)**	**Percent of Total TSS Removal**	**Annual Runoff Reduction (cf)**	**Percent of Total Annual Runoff Reduction**
County	12	$409,000	11%	58.34	35%	7.03	31%	2,006	24%	306,020	45%
State	2	$84,000	2%	7.77	5%	1.17	5%	604	7%	23,525	3%
Fed	1	$12,000	0%	0.87	1%	0.18	1%	129	2%	0	0%
Private	21	$3,333,000*	87%	99.27	60%	14.49	63%	5,472	67%	346,496	51%

*Private costs include a $2,000,000 permeable pavement project (RRI_31). Another option for this site is impervious cover removal.

3.4.2. Neighborhood Source Assessment

A total of 23 neighborhoods were visited by the field crews. A list of the assessed neighborhoods can be found in Appendix A. Approximately 526 acres of neighborhoods were assessed using the NSA protocol. Sixty percent (310 acres) of area had no apparent stormwater treatment. Twenty percent (~100 acres) of that is in impervious cover, representing a significant area of uncontrolled stormwater. Average forest canopy observed in all of the neighborhoods was 27%.

Less opportunity for projects was observed in multi-family neighborhoods. These neighborhoods also tended to have more exposed soil and sediment deposition on sidewalks. Older, more established neighborhoods had more opportunities for rain gardens and conservation landscaping due to large lot sizes and these also tended to be lacking in stormwater management facilities. Neighborhoods ranged in age from hundreds of years old in the downtown Ellicott City area to less than 10 years old. Neighborhoods in the downtown Ellicott City area can assist with buffer enhancement, particularly plantings and non-native species removal projects, as these houses tend to be directly adjacent to the river (Figures 3.7.a and 3.7.b). This area also tends to have long-term parking on the street, creating a build-up of oil, grease, etc. on the street. Street sweeping would be beneficial and potentially oil/water separators in the storm drain inlets. Some new neighborhoods had very sparse tree canopy as sites were completely cleared prior to construction. Some of these also had very high amounts of impervious cover per lot (NSA_19; Figure 3.7.c), restricting the potential for projects. Some areas of infill and redevelopment within existing neighborhoods were noted. General opportunities for storm drain stenciling and tree planting were noted throughout the watershed, primarily on individual residential lots and ion neighborhood common space areas. Pet waste stations would be beneficial in in some areas (NSA_12 & NSA_10). Street bioretention on Patapsco River Rd, noted above, as well potentially Brittany Dr is a possibility for bigger neighborhood projects. Cul-de-sacs provide an opportunity for stormwater retrofitting and these were noted at NSA_15 and Ridge Rd and Courthouse Dr.

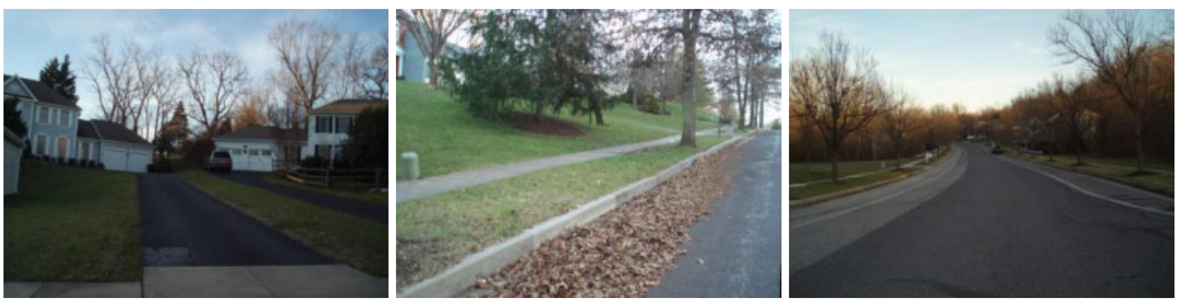
Neighborhoods generally rated moderate for restoration potential, with two rating high and six rating low. Opportunities identified in moderate neighborhoods included rain gardens, tree planting on individual lots and neighborhood common space areas, pet waste stations, storm drain stenciling, downspout disconnection to lawns, rain barrels and rain gardens and buffer management/enhancement. Restoration opportunities in the neighborhoods rated low for restoration potential were limited in opportunity primarily because they were smaller, had steep slopes or because they were very new. The neighborhoods identified as having high restoration potential were detached single family home neighborhoods with ample opportunity for rain gardens, increasing tree canopy as well as other implementation projects such as street bioretention or stream restoration. Only one neighborhood had both a high pollution severity rating and high restoration potential – NSA_25 (Dunloggin Rd area; Figure 3.8). Representative photos from other neighborhoods are shown in Figures 3.9-3.13. Three high priority neighborhoods were identified throughout the subwatershed (Table 3.9).

(a) (b) (c)

Figure 3.7. (a & b) Limited restoration opportunity in some areas of downtown Ellicott City due to space limitations and steep slopes such as at NSA_2. In this neighborhood, trees in the buffer are being threatened by non-native English ivy, which could be removed; and (c) New development with small lots and high impervious cover at NSA_19.

(a) (b) (c)

Figure 3.8. Neighborhood NSA_25 with high pollution severity and high restoration potential. (a) Degraded stream reach is potential for stream restoration or buffer enhancement projects; (b) Street sweeping opportunity; and (c) Downspout connected to driveway could be disconnected to pervious lawn.



(a) (b) (c)

Figure 3.9. (a) Shared driveways could limit the overall imperviousness of neighborhoods as evidenced by two driveways directly adjacent to each other at NSA_13; (b) More street sweeping potential at NSA_13; (c) Excessively wide roads at NSA_13 on Brittany Dr. Street bioretention could be added to treat stormwater and calm traffic.

(a) (b) (c)

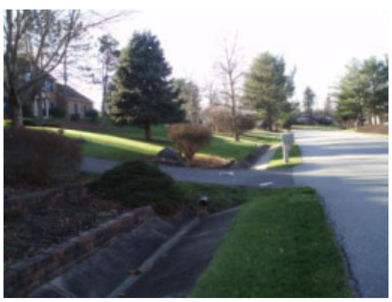
Figure 3.10. (a) Evidence of leaking vehicles at NSA_5; (b) Opportunity for a rain garden between two houses at NSA_7; and (c) High maintenance lawns at NSA_12.

(a) (b) (c)

Figure 3.11. Opportunity for rain gardens in the backs of houses at NSA_14; (b) Stormwater management pond at NSA_14; and (c) Pet waste station at NSA_21.

(a) (b) (c)

Figure 3.12. (a) Concrete channel in stormwater pond could be retrofit to provide water quality treatment at NSA_21; and (b & c) Rain garden or biroretention potential at NSA_21.



(a)

Figure 3.13. (a) Concrete channels could be retrofit to treat stormwater at NSA_27.

Table 3.9. Neighborhood Opportunities in the Tiber Hudson Watershed					
Site_ID	**Location**	**Pollution Severity**	**Restoration Potential**	**Opportunity**	**Priority**
NSA_25	Jacks Way, Dunloggin Rd, Meadowvale Rd, Overhill Dr.	High	High	Rain gardens. Storm drain stenciling. Increase tree canopy. Leaf pick-up. Downspout disconnection. Potential stream restoration project.	High
NSA_13	Brittany Dr., Bali Rd, Pemberton Ct., South and North Bali Ct.	Moderate	High	Rain gardens/downspout disconnection. Storm drain stenciling. Outreach on lawn management. Leaf pick-up. Street bioretention on Brittany Dr. upstream of stream.	High
NSA_3	West End Ellicott City	Moderate	Moderate	Add buffers next to stream. Pick up trash. Downspout disconnection. Street sweeping/cleaning. More setback for farm animals. Increase buffer width.	High

3.4.3. Hotspot Site Investigation

A total of 27 hotspot sites were assessed in the Tiber Hudson subwatershed. Four sites were identified as severe hotspots, seven sites were identified as confirmed hotspots, six sites were identified as potential hotspots and ten sites were not a hotspot. Pollution producing behaviors that were noted were primarily related to storage of outdoor materials and waste management. Vehicle activities were notes at several sites as well as conditions of the physical plant at several sites. The hotspot assessment was conducted from public streets or parking areas; site access was not always obtained. For sites identified as severe or confirmed, a follow-up assessment should be completed on-site with the owner to determine exact activities and operations occurring on the site. Some of these sites may also require an individual NPDES permit with the State and this should be ascertained. Six high priority hotspots were identified throughout the subwatershed (Table 3.10). A full list of hotspot opportunities identified in the Tiber Hudson can be found in Appendix A.

Severe hotspot sites included the following:

- HSI_11, Lotte Plaza, 8801 Baltimore National Pike (Figure 3.14): Multiple pollution sources from used oil container, grease containers and overflowing trash, all of which were draining directly to the storm drain system without treatment. Stormwater retrofits were also proposed for site (RRI 400, RRI 401a & b, and RRI_30).
- HSI_24a, BP at Rt. 103 and Columbia Pike (Figure 3.15): Multiple pollution sources from a used oil container, 50 gallon containers with no labels and lids askew, staining on parking lot and sediment on edge of lot contaminated with oil, grease, etc. Retrofit proposed (RRI 402).
- HSI_400, Williamson's Nursery, 8895 Frederick Rd. (Figure 3.16): Compost, mulch, topsoil in uncontained piles and overflowing onto impervious surfaces. Stream encroachment from commercial activities. Trash (nursery materials) in streams from operations. Dumping of construction materials in floodplain.
- HSI_10, Pie's Auto Body, 3420 Ellicott Center Dr. (Figure 3.17): This site was assessed from an adjacent business complex. Wrecked vehicles stored on impervious cover. Maintenance activities conducted outdoors on impervious surfaces. Dumpster overflowing with trash all around. Equipment and parts stored outdoors. Parking lot stained, dirty and breaking up.

(a) **(b)**

(c) (d)

Figure 3.14. HSI_11, Lotte Plaza (a) Leaking dumspters; (b) Frying grease on parking lot; (c) Oil stains on lot around oil container; and (d) Grease from grease container staining pavement adjacent to storm drain.

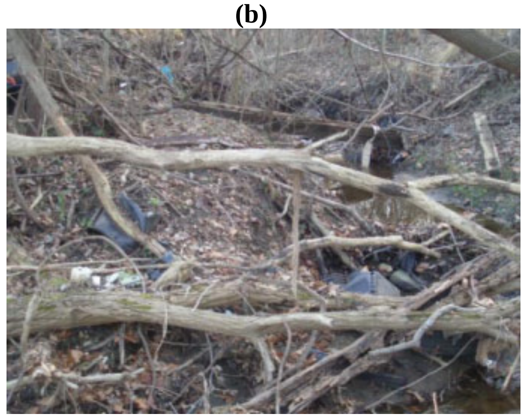
(a) (b)

(c) (d)

Figure 3.15. HSI_24a, BP (a) Oil stains on lot around oil container; (b) Used oil and grease build-up at edge of parking area; (c) Staining from unknown activity is also visible from Google imagery (d) see red circle.

(a) **(b)**

(c) **(d)**

Figure 3.16, HSI_400, Williamson's Nursery. (a & b) Storage of outdoor materials, spilling onto impervious services; (c) Construction materials dumped into stream buffer; and (d) Trash from nursery in the stream corridor.

(a) **(b)**

Figure 3.17. HSI_10, Pie's Auto Body (a) Open dumpsters with uncontained trash around; and (b) Wrecked vehicles (no leaks observed) and parts stored outside.

Confirmed hotspot sites included the following:

- HSI_9a, Howard County Public Works facility, 8670 Ridge Rd (Figure 3.18.a and 3.18.b.): Heavy equipment, implements (snow shovels) stored outdoors on impervious cover. Stains around outdoor materials. Wrecked vehicles stored outside with no containment. More spill planning needed for fueling area such as perimeter drain and cover on downstream storm drain inlet. Stormwater treatment via underground tank only treats a portion of the facility.

- HSI_3, Parking Lot D, downtown Ellicott City (Figure 3.19.a): Dumpsters with evidence of leakage, overflowing and damaged.
- HSI_1, Phoenix Emporium, 8490 Main St. (Figure 3.19.b): Lids open on grease containers, significant grease stains on street. Lots of cigarette butts.
- HSI_5, West End Services, 8600 Frederick Rd: Private, commercial truck sales and maintenance site, stream runs adjacent to property.
- HSI_24b, Shell Station on Rt 103 and Columbia Pike (Figure 3.198.c): Site has stormceptor that treats front lot and fueling area. Back gravel lot has no stormwater management and used oil containers with no secondary containment. Parking lot stained. Tires stored outside with no cover or containment.
- HSI_9b, US Post Office, 3375 Ellicott Center Dr. (Figure 3.19.d): Evidence of leaks and spills in loading dock right next to storm drain inlet. Dumpster located directly adjacent to stormwater management facility.
- HSI_8b, Ellicott City Storage, 3470 Ellicott Center Dr: Vehicles and trailers stored outdoors. Stains on parking lot.

(a) **(b)**

Figure 3.18. (a) Sediment on parking lot at the County's Ridge Rd. facility; and (b) Covered fueling area at the County's Ridge Rd. facility - Use a perimeter drain or slope the pavement inward so that runoff drains to a blind sump. It might be necessary to install and maintain an oil control device in catch basins that might receive runoff from the fueling area.

(a) **(b)**

(c) (d)

Figure 3.19. (a) Stains from leaking dumpster in Parking lot D in downtown Ellicott City (HSI_3); (b) Unsecure lids and grease stains around containers behind HSI_1; (c) Tires stored outside without cover or containment and used oil container without cover or secondary containment (HSI_24b); and (d) Oil draining to storm drain in loading dock at Ellicott City Post Office (HSI_8b).

Table 3.10. Hotspot Opportunities in the Tiber Hudson Watershed						
Site_ID	**Location**	**Type of Hotspot**	**Description**	**Recommended Actions**	**Status**	**Priority**
HSI_11	Lotte Plaza - 8801 Baltimore National Pike	Vehicle Operations, Outdoor Materials, Waste Management, Physical Plant	Multiple pollution sources from used oil container, grease containers and overflowing trash all draining direct to storm drain without treatment. Retrofits proposed (RRI 400 and RRI 401a & b).	On-site inspection with owner. Containment for grease containers. Stormwater management needed. Excess impervious cover can be removed or retrofit.	Severe	High
HSI_10	Pie's Auto Body - 3420 Ellicott Center Dr.	Vehicle Operations, Outdoor Materials, Waste Management, Physical Plant	Wrecked vehicles. Maintenance outdoors on impervious surfaces. Dumpster overflowing with trash all around. Equipment and parts stored outdoors. Parking lot stained, dirty and breaking up.	Review SWPPP. Store materials under cover. Ensure vehicle fluids are drained. Regular maintenance of dumpster and clean up strewn trash.	Severe	High
HSI_400	Williamson's Nursery - 8895 Frederick Rd Ellicott City	Outdoor Materials, Waste Management	Compost, mulch, topsoil in uncontained piles and overflowing onto impervious surfaces. Stream encroachment from commercial activities. Trash (nursery materials) in streams. from operations. Dumping of construction materials in floodplain.	On-site inspection with owner or review SWPPP. Trash/junk clean-up. Apply setback from stream for activities. Need containment/cover for outdoor materials. Education regarding loading and unloading operations to reduce spillage of materials onto impervious surfaces. Potential stream restoration project upstream of culvert. Evaluate site for SWM potential.	Severe	High
HSI_9b	USPS - 3375 Ellicott Center Dr.	Vehicle Operations, Waste Management	Evidence of leaks and spills in loading dock right next to storm drain inlet. Dumpster located directly adjacent to SWM facility.	Review SWPPP. Relocate dumpster away from SWM facility. Add proprietary treatment device to inlet by loading dock.	Confirmed	High
HSI_24b	Shell station and Valvoline on Rt 103 and Columbia Pike	Vehicle Operations, Outdoor Materials, Waste Management, Physical Plant	Site has SWM via stormceptor that treats front lot and fueling area. Back gravel lot with SWM and used oil containers with no secondary containment. Parking lot stained. Tires stored outside with no cover or containment.	On-site inspection with owner. Add secondary containment for used oil containers.	Confirmed	High

Table 3.10. Hotspot Opportunities in the Tiber Hudson Watershed						
Site_ID	**Location**	**Type of Hotspot**	**Description**	**Recommended Actions**	**Status**	**Priority**
HSI_5	West End Services	Vehicle Operations, Outdoor materials	Private, commercial truck sales and maintenance site, stream runs adjacent to property	On-site inspection with owner. Review SWPP Provide cover and/or secondary containment around fuel tanks	Confirmed	High

SECTION 4. IMPLEMENTATION PLAN

4.1 Watershed Restoration Action Strategies

Based on findings from the field assessment and a brief literature review, the following watershed restoration strategies are established for the Tiber Hudson:

1. *Establish a watershed restoration coordinating body.*

Watershed restoration efforts will be most successful if a single organization or coordinating body assumes responsibility for all aspects of the process. This body would be responsible for coordinating the implementation of projects, tracking implementation on both private and public land, determining the effectiveness of project implementation in meeting watershed goals, filling data gaps, conducting education and outreach efforts and overseeing the enactment of actions identified in this plan. The coordinating body would not be a government entity but would benefit or even necessitate the involvement of a government representative. The coordinating body would include a diverse representation of stakeholders in the watershed from residential homeowners to business representatives to local non-profits. Currently, no coordinating body such as this exists, however, several organizations are active in the watershed and could potentially be brought together for this purpose. These organizations and representative include Patapsco Heritage Greenway, Ellicott City Flood Solution, Howard County Government, Ellicott City Business Association, Green Building Institute, homeowner association representatives, local business representatives, property management companies and local residents. A primary initial action would be formal adoption of the Action Plan by the individual representing organizations.

2. *Educate and engage the watershed community in the restoration process.*

To achieve watershed restoration goals, the entire community will need to become engaged in the process. This will initially involve concerted efforts to generally educate the citizenry about the problems and potential solutions. Following and coincident with initial education efforts, the watershed community will need to become engaged enough to become an active participant in efforts to restore watershed conditions. Details associated with this strategy and the best means to reach out to the community will need to be explored further; options and opportunities should be discussed among some of the primary interested bodies such as those discussed in Strategy 1 above. Appendix D provides a full menu of best management practices that can be used for residential and commercial outreach.

3. *Minimize the creation of impervious surfaces during the development review process.*

County subdivision and land development ordinances dictate the creation of impervious surfaces and the protection of natural resources during the development process. The County should provide a review of their development codes and ordinances to ensure the use of innovative stormwater management practices (e.g. cisterns, bioretention), reduce the amount of impervious cover created (e.g. parking lot size requirements) and protect natural resources (e.g. require tree protection standards). This review can be accomplished using the Code and Ordinance Worksheet available for free at www.cwp.org.

4. *Manage uncontrolled stormwater runoff in neighborhoods, commercial areas and from other impervious surfaces.*

Areas with high impervious cover and no stormwater management were noted throughout the watershed. These areas should be priority for initial actions and projects to treat stormwater runoff. Projects can be a mix of small-scale, on-site practices to larger projects that will provide for treatment for higher amounts of stormwater runoff volume. Stromwater retrofits were identified throughout the watershed. A full list of the identified projects and their relative priority can be found in Appendix A. Projects on public land can be considered first for implementation, as well as high priority projects on private land. Implementation of projects on private property can be challenging. Some recommendations for an approach to private property owners include:

- Establishment of a green business certification program – see an example from Portland, Oregon: http://www.ecobiz.org/becomebiz.htm
- Promote incentives via reimbursements and rebates that will likely be available through the stormwater utility (proposed Watershed Restoration Protection Fund);
- Consider establishing an offsite stormwater mitigation program to incentivize landowner investment in mitigation projects in return for stormwater fee relief. Part of the complex nature of stormwater enterprise programs is the need to balance revenue generation with fee relief to ratepayers, specifically large landowners and institutions. The Center is currently working with Baltimore City to simultaneously accomplish these two goals with an off-site mitigation process that enables ratepayers to finance mitigation projects in return for fee reductions;
- Public funds can be used to support non-profits in conducting targeted outreach to private property owners;
- Public funds may potentially be used to provide a grant revenue source, either through a non-profit or through a new County program, under which private property owners can apply for assistance to design and build stomwater retrofits;
- Public and/or non-profit entities can provide technical assistance to private property owners, e.g. walking the site with landowners to discuss project (pollution prevention or stormwater retrofit) potential;
- Flag private property sites in GIS so that the County is aware when approached, for example, for redevelopment permits and can discuss identified BMP options with landowners. Potentially expedite the permit process if BMPs are installed; and
- Some grant opportunities may be available through funding sources identified in the recently completed S & S Study for the County that could assist with project development on private sites.

5. *Implement pollution prevention measures at private sites and BMPs at public sites.*

During the hotspot assessment, 27 hotspot sites were assessed. Four sites were identified as severe hotspots, seven sites were identified as confirmed hotspots, six sites were identified as potential hotspots and ten sites were not a hotspot. Stormwater pollution prevention plans should be reviewed, enforced and updated at severe and confirmed sites. The County should also review the illicit discharge ordinance to ensure adequate enforcement measures are in place. If the illicit discharge ordinance is not sufficient to provide adequate enforcement, the health code ordinance may provide further back-up. Pollution prevention education and employee training should be conducted at hotspot sites to focus on storage of outdoor materials, waste management and municipal pollution prevention and good housekeeping procedures. Particular attention is needed with regards to used grease containers and their management. The County may wish to consider the potential for business incentive efforts with regards to pollution prevention. Portland, Oregon has a green business certification program for this purpose: http://www.ecobiz.org/becomebiz.htm. A number of BMPs were identified at the County facility on Ridge Rd and these could be used as demonstration practices for the community.

6. *Encourage pollution prevention practices, tree planting and on-site stormwater management in residential neighborhoods.*

Stormdrain inlet marking or stenciling was noted as absent almost every neighborhood. In addition, organic matter and sediment was observed in the street and storm drain network in several neighborhoods. Opportunities exist in neighborhoods to educate homeowners on removing debris from roadways. In addition, the County should consider increasing the frequency of leaf pick up and street sweeping. Highly fertilized lawns were mainly identified in the single family neighborhoods and areas with bare soil and erosion in multi-family neighborhoods. Tree planting on individual lots and in neighborhood common areas were noted throughout. On-site stormwater management using rain gardens and downspout disconnection was noted , particularly in some of the older neighborhoods and neighborhoods adjacent to streams. Initial actions should be targeted to high priority neighborhoods; these can be found in Table 3.8.

7. *Update County WRAS for streams.*

The County completed a stream corridor assessment for streams in the Lower Patapsco in 2006. An additional, very limited, stream corridor assessment was completed for a short section of stream in downtown Ellicott City in 2012. The 2006 stream corridor assessment should be updated to include newly eroded areas, new impacted buffers and to determine the extent of change from the originally identified problem areas. This information will provide a new baseline for current conditions as significant changes have occurred to the in-stream and floodplain conditions in the past 7 years.

8. *Fill data gaps for unidentified stream impairments.*

As indicated above, past studies for the Lower Patapsco indicate that an unidentified impairment may exist in the watershed as determined from assessments of the habitat and benthic community. The studies show the benthic community to be in a more degraded condition than would be indicated by looking at the habitat. Road salt is a suspected contributor based on elevated levels of conductivity measured in the stream. Another potential contributor is illicit discharges. Future studies should assess the potential contribution of both of these sources to stream impairment.

9. Track and monitor the implementation progress.

The coordinating body identified in Strategy 1 should develop an approach to monitoring implementation activities that includes project monitoring, sentinel station monitoring, and project tracking.

Project monitoring should be geared towards quantitative measures of success for both structural and non-structural management and restoration practices (i.e., stormwater retrofits, stream repair projects, etc.). Monitoring methods will depend upon the project, but can involve pre and post biological sampling and cross sections at stream repair projects, and simple accounting of disconnections performed as part of a discharge prevention program.

Continued monitoring is suggested to determine whether interim and long term goals are being achieved. Monitoring stations should be established just upstream of the outlets of each of the three major streams as well as in the upper watersheds, if possible. Trend monitoring is the best way to determine if stream conditions are improving, watershed goals are being met, and progress towards meeting regulatory requirements is being made.

Managing the delivery of a large group of restoration projects within the watershed can be a complex enterprise. Therefore, it is a good idea to create a master project spreadsheet linked to a GIS system that tracks the status of individual projects through final design, permitting, construction, inspection, maintenance and performance monitoring. By tracking the delivery of restoration projects, lessons learned can be identified and implementation progress over time can be assessed, which in turn, helps explain future changes in water resource quality. Project tracking can also improve the delivery of future projects, and creates reports that can document implementation progress for key funders and stakeholders. The tracking system should account for all restoration practices undertaken in the watershed regardless of their type or size. The coordinating body should determine a central entity for tracking overall implementation; this will be linked to Strategy 1.

4.2. Implementation Plan

Implementation is by far the longest and most expensive step in the watershed management process. In fact, restoration and protection costs for a single suburban subwatershed can easily range in the millions of dollars depending on the extent of restoration and protection activities, number of jurisdictions involved, land costs, and other factors. Salaries, land acquisition and construction of projects often account for a majority of these costs. A minimum of twenty years is usually needed to design and construct all the necessary projects, which are normally handled in several annual "batches." Progress in the Tiber Hudson may occur over a shorter timeframe, however, due to several factors, including: 1) new requirements due to be set forth in the County's Municipal Separate Storm Sewer permit, which will likely require retrofitting 20% of uncontrolled impervious surfaces; 2) requirements established under the Chesapeake Bay Total Maximum Daily Load to reduce nutrients and sediment; and 3) a system of credits and reimbursements likely to be established under the County's proposed Watershed Restoration and Protection fee. Sustaining progress over time and adopting the plan as more experience is gained are vital aspects of implementation. Presented below in Table 4.1 are planning partners, phasing and resources for implementing watershed strategies. Appendix C provides a list of potential funding sources to assist with financing watershed restoration efforts.

Table 4.1. Implementation Plan

Strategy	Responsible Parties	Short-Term Action (year 1-3)	Long-Term Action (year 3-10)[1]
1. Establish a watershed restoration coordinating body	Patapsco Heritage Greenway Ellicott City Flood Solution Howard County Government Local businesses and HOAs	4-6 meetings to establish goals and structure Formally adopt Action Plan	Monitor progress towards meeting watershed restoration goals and implementation of Action Plan items Update Action Plan to reflect new data and priorities
2. Educate and engage the watershed community in the restoration process	Coordinating Body	Hold 1-2 open to the public watershed-related events Stencil storm drains and provide other highly "visible" indicators to heighten awareness Develop web-based maps with priority locations and actions for the public to use	Conduct targeted outreach to high and medium priority neighborhoods and hotspot sites Conduct targeted outreach to private property owners regarding stormwater retrofit opportunities, particularly churches and BGE and areas with high impervious coverage Evaluate outreach effectiveness and adjust accordingly
3. Minimize the creation of impervious surfaces during the development review process.	Howard County	Review the County development codes using the Codes and Ordinances Worksheet (COW)	Implement needed code revisions as determined by the COW
4. Manage uncontrolled stormwater runoff in neighborhoods, commercial areas and from other impervious surfaces	Coordinating Body Private landowners Howard County	Identify grant and foundation funding sources for stormwater improvement projects Modify, repair, and/or maintain existing stormwater management facilities to improve water quality performance Begin design and installation of high priority stormwater projects on public land and road rights-of-way projects	Begin design and installation of high priority stormwater projects on private properties Continue to identify retrofit opportunities at schools, neighborhoods, commercial areas, and outfalls that do not have existing BMPs

Table 4.1. Implementation Plan			
Strategy	**Responsible Parties**	**Short-Term Action (year 1-3)**	**Long-Term Action (year 3-10)[1]**
5. Implement pollution prevention measures at private sites and BMPs at public sites	Howard County	Ensure that an enforceable stormwater ordinance for preventing illicit discharges to the storm drain system is in place Provide education on pollution prevention to targeted businesses and implement pollution source control measures Implement BMPs at County facility on Ridge Rd	Develop a *Business Stewardship Outreach Program* that engages the business community in watershed restoration Implement BMPS at private sites
6. Encourage pollution prevention practices, tree planting and on-site stormwater management in residential neighborhoods	Coordinating Body Watershed Stewards Academy HOAs	See items from Strategy 2 regarding outreach Identify neighborhoods and neighborhood leaders to lead efforts Stencil storm drains in high priority neighborhoods Begin implementation of small-scale on-site practices such as downspout disconnection and rain gardens Restore nature buffers, particularly in high priority neighborhoods Conduct residential workshops	Develop and implement widespread downspout disconnection program Encourage widespread tree planting and conservation landscaping in residential neighborhoods
7. Update County WRAS for streams	Howard County	Update 2006 stream corridor assessment to reflect current conditions Engage local residents in the process	New upland actions may need to be integrated into this Action Plan as a result of updating the stream corridor assessment
8. Fill data gaps for unidentified stream impairments	Coordinating Body	Conduct period sampling throughout the watershed for chloride and conductivity	Determine additional action strategies needed as a result of monitoring

Table 4.1. Implementation Plan			
Strategy	**Responsible Parties**	**Short-Term Action (year 1-3)**	**Long-Term Action (year 3-10)[1]**
		Conduct illicit discharge assessment	
9. Track and monitor the implementation progress	Coordinating body	Develop project tracking database in GIS and spreadsheets Establish sentinel monitoring stations Provide a web-based forum for displaying project status and sentinel monitoring station results on an annual basis	Revise this plan as needed based on monitored conditions, changes in watershed conditions and new priorities

4.3 Monitoring Plan

Watershed stakeholders and partners have a vested interest in measuring whether the projects they implement are successful. Success can be measured in a number of ways including direct improvements in watershed indicators (e.g. reduced pollutant loading or improved aquatic insect communities) or indirectly (e.g. number of rain gardens installed, number of volunteers, acres preserved).

The monitoring plan proposed for the Tiber Hudson includes 1) the assessment of individual watershed projects; 2) the monitoring of stream indicators at sentinel monitoring stations to be established; and 3) filling data gaps with regards to stream impairments. Guidance on developing monitoring studies is provided in Law et al. (2008). Information can be input to a tracking system and then used to revise or improve the watershed plan over a five to ten year cycle. Each part of the monitoring plan is described below:

- *Project monitoring* at a small scale (reach or smaller) to illustrate benefits of individual restoration efforts. As stormwater retrofits, neighborhood and business pollution prevention and education strategies are implemented monitoring should be conducted to show effectiveness.

- *Sentinel station monitoring* to track long-term health and water quality trends. Sentinel monitoring stations are fixed, long-term monitoring stations which are established to measure trends in key indicators over many years. Sentinel monitoring is perhaps the best way to determine if conditions are changing in a subwatershed or watershed. Sentinel monitoring stations should be established upstream of the 3 major tributary outflow points. Suggested monitoring includes continuous depth measurements, continuous precipitation and bi-annual assessments of the macroinvertebrate community. See Section 4.3 on measurable goals below.

- *Fill Data Gaps* to identify “missing” impairments in the watershed. Biological communities are more degraded than was reflected through habitat assessments indicating another problem in the watershed. Two reports (Howard County, 2006 and KCI, 2008) note high conductivity levels that may be associated with road salt. To determine whether salt may be causing an adverse impact to the stream, monitoring of chloride concentrations and conductivity is recommended. The overall pollutant load associated with illicit discharges has been shown in recent research to be significant (Lilly et al, 2012). An illicit discharge assessment using the recommended protocols from Brown et al (2004) will quantify the potential baseflow pollutant load contribution from this source in the Tiber Hudson. Illicit discharge elimination is currently being reviewed as a creditable best management practice within the Chesapeake Bay TMDL framework.

4.4 Measurable Goals

It is important to determine measurable watershed restoration goals by which to assess progress. Based on a brief review of literature and best professional judgment, the following long term and interim measureable goals have been established for the Tiber Hudson. A long-term monitoring program will need to be established to determine whether goals are being achieved.

Long-term Goal: Restoration of in-stream biological conditions as represented by aquatic macroinvertebrates. Specifically, restoration actions aim to increase the overall Benthic Index of Biological Integrity (BIBI) score for the watershed as referenced from baseline conditions established for the Lower Patapsco in KCI (2008).

Interim Goal: A decreasing trend in the flashiness index. The flashiness index (Baker et al, 2004) tracks gradual changes in stream flashiness and accounts for interannual variability while masking changes associated with precipitation amounts, intensity and timing associated with either cyclic weather patterns or climate change. The flashiness index can classify streams on a continuum ranging from super stable ground water based streams at one end to very flashy streams at the other end. Restoration of the natural hydrologic regime should show a decrease in the stream flashiness index. A baseline will need to be established before project implementation begins.

After 5 years time, this *Plan* should be updated to include recent watershed developments and monitoring results.

4.5 Project Tracking

Managing the delivery of a large group of restoration projects within a subwatershed can be a complex task. Creating a master project spreadsheet linked to a GIS system can help track the status of individual projects through final design, permitting, construction, inspection, maintenance and any performance monitoring. For non-structural efforts, tracking systems will include measures such as number of stream clean-ups, residents educated, green businesses created, or number of dedicated volunteers. By tracking the delivery of watershed projects, implementation progress can be assessed over time, which in turn, helps explain future changes in stream quality. Project tracking can also improve the delivery of future projects, and creates reports that can document implementation progress for key funders and stakeholders.

The coordinating body should manage implementation tracking. The group may need assistance in setting up a tracking database that makes sense. One option is through Google Maps or other web-based format. The tracking system should account for all watershed practices undertaken in the Action Plan, regardless of their type or size, and track the progress of outlined measurable goals.

SECTION 5. REFERENCES

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Appendix A. Summary of Projects in the Tiber Hudson Subwatershed

Table A.1. Stormwater Retrofit Opportunities in the Tiber Hudson Watershed*										
Site ID	**Location**	**Retrofit Concept**	**Drainage Area (ac)**	**Impervious Cover (%)**	**Cost**	**TN Removal (lb/yr)**	**TP Removal (lb/yr)**	**TSS Removal (lb/yr)**	**Annual Runoff Reduction (cf)**	**Priority**
RRI_11	Court House Parking lot	Dry Swale	1.80	90	$24,000	9.34	1.19	326	54,374	High
RRI_111	Upper Court House Parking Lot	Regenerative Stormwater Conveyance	1.05	95	$103,000	8.67	1.01	280	43,379	High
RRI_114a	Corner of Patapsco River Rd & Orange Grove Ct	Bioretention	2.21	80	$23,000	5.44	0.63	176	27,239	High
RRI_17	BGE Right-of-Way - Adjacent to Veterans Elementary School	Wet Pond	16.71	0	$190,000	6.97	1.57	343	0	High
RRI_31	3290 & 3300 North Ridge Road	Permeable Pavement	0.65	100	$2,000,000	5.97	0.81	239	36,487	High
RRI_501a	Ridge Road Shop - 8800 Ridge Road	Bioretention	1.90	100	$68,000	11.84	1.37	382	59,242	High
RRI_501b	Ridge Road Shop - 8800 Ridge Road	Bioretention	0.83	100	$107,000	8.49	0.99	274	42,505	High
RRI_401a	Lotte Plaza	Bioretention	0.44	100	$58,000	4.52	0.52	146	22,634	High
RRI_401b	Lotte Plaza	Bioretention	1.00	100	$122,000	10.06	1.17	325	50,358	High

Table A.1. Stormwater Retrofit Opportunities in the Tiber Hudson Watershed*										
Site ID	**Location**	**Retrofit Concept**	**Drainage Area (ac)**	**Impervious Cover (%)**	**Cost**	**TN Removal (lb/yr)**	**TP Removal (lb/yr)**	**TSS Removal (lb/yr)**	**Annual Runoff Reduction (cf)**	**Priority**
RRI_402	BP - Rt 103 and Columbia Pike	Bioretention	0.70	60	$54,000	4.40	0.51	142	22,034	High
RRI_114b	Corner of Patapsco River Rd & Orange Grove Ct	Bioretention	2.15	80	$24,000	5.45	0.63	176	27,252	High
RRI_30	South bound on-ramp to Route 29 from 40	Extended Detention Pond	3.92	95	$32,000	3.07	0.62	452	0	Medium
RRI_33	In BGE Right-of-Way near 3165 Saint Johns Lane	Extended Detention Pond	61.22	15	$438,000	18.35	3.72	2,707	0	Medium
RRI_501aAltAdd	Ridge Road Shop - 8800 Ridge Road	Rain Tank/Cistern	0.20	100	$12,000	2.17	0.29	64	17,339	medium
RRI_403	End of Overlook Dr.	Regenerative Stormwater Conveyance	1.00	80	$51,000	5.77	0.67	186	28,879	Medium
RRI_14*	Patapsco River Rd & Rogers Ave	Bioretention	0.71	95	$24,000	4.12	0.48	133	20,624	Medium
RRI_12	St. Paul's Catholic Church	Bioretention	0.64	80	$9,000	2.00	0.23	65	10,014	Medium
RRI_7	Court House Square Office	Bioretention	0.81	75	$20,000	3.64	0.42	117	18,211	Medium
RRI_8	Howard County Government Office	Extended Detention Pond	2.42	95	$7,000	0.70	0.14	103	0	Medium

Table A.1. Stormwater Retrofit Opportunities in the Tiber Hudson Watershed*										
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RRI_16	Ellicott City Parking Lot F	Extended Detention Pond	2.09	60	$25,000	1.57	0.32	232	0	Medium
RRI_19	BGE Right-of-Way - Adjacent to Veterans Elementary School	Wet Swale	13.41	0	$12,000	2.42	0.26	114	0	Medium
RRI_23	Behind 8615 Manahan Drive	Extended Detention Pond	2.38	25	$15,000	0.87	0.18	128	0	Medium
RRI_300	Along Route 29 North of Frederick Road	Regenerative Stormwater Conveyance	1.31	40	$52,000	4.70	0.55	152	23,525	Medium
RRI_501bAlt	Ridge Road Shop - 8800 Ridge Road	Rain Tank/Cistern	0.14	100	$9,000	1.55	0.21	46	12,422	Medium
RRI_500	Ellicott City Post Office - 8656 Ridge Road	Extended Detention Pond	0.83	95	$12,000	0.87	0.18	129	0	Medium
RRI_3b	9120 Frederick Road St. John's Episcopal Church	Rain Garden	0.25	65	$8,000	1.67	0.19	54	8,370	Medium

Table A.1. Stormwater Retrofit Opportunities in the Tiber Hudson Watershed*										
Site ID	**Location**	**Retrofit Concept**	**Drainage Area (ac)**	**Impervious Cover (%)**	**Cost**	**TN Removal (lb/yr)**	**TP Removal (lb/yr)**	**TSS Removal (lb/yr)**	**Annual Runoff Reduction (cf)**	**Priority**
RRI_200a	3165 St Johns Lane Bethel Korean Presbyterian Church	Rain Garden	0.40	95	$6,000	2.39	0.28	77	11,937	Medium
RRI_200b	3165 St Johns Lane Bethel Korean Presbyterian Church	Bioretention	0.92	85	$11,000	2.50	0.29	81	12,522	Medium
RRI_200c	3165 St Johns Lane Bethel Korean Presbyterian Church	Rain Garden	0.66	80	$6,000	2.86	0.33	92	14,310	Medium
RRI_1	3291 St Johns Lane 7th Day Adventist Church	Bioretention	2.10	85	$261,000	15.95	1.58	152	95,591	Medium
RRI_9	District Court - Multi-Services Center	Extended Detention Pond	1.19	10	$6,000	0.26	0.05	38	0	Medium
RRI_13	Ellicott Hills Community	Extended Detention Pond			$11,000	0.38	0.08	56	0	Low
RRI_400	Lotte Plaza	Dry Swale	0.64	100	$2,000	0.40	0.05	14	2,333	Low
RRI_21	Ellicott City Parking Lot - Southwest side of Main St.	Bioretention	0.09	100	$2,000	0.33	0.04	11	1,643	Low

Table A.1. Stormwater Retrofit Opportunities in the Tiber Hudson Watershed*										
Site ID	**Location**	**Retrofit Concept**	**Drainage Area (ac)**	**Impervious Cover (%)**	**Cost**	**TN Removal (lb/yr)**	**TP Removal (lb/yr)**	**TSS Removal (lb/yr)**	**Annual Runoff Reduction (cf)**	**Priority**
RRI_3	9120 Frederick Road St. John's Episcopal Church	Bioretention	0.25	30	$5,000	0.63	0.07	20	3,147	Low
RRI_200d	3165 St Johns Lane Bethel Korean Presbyterian Church	Impervious Cover Removal	0.10	100	$10,000	1.21	0.16	36	9,670	Low
RRI_201	3100 North Ridge Road Lighthouse Senior Living	Wet Pond	1.80	60	$34,000	5.61	1.26	276	0	Low

*Green cells - County property or road right-of-way
Blue cells - State property
Brown cells - Federal property

Table A.2. Neighborhood Opportunities in the Tiber Hudson Watershed					
Site_ID	**Location**	**Pollution Severity**	**Restoration Potential**	**Opportunity**	**Priority**
NSA_25	Jacks Way, Dunloggin Rd, Meadowvale Rd, Overhill Dr.	High	High	Rain gardens. Storm drain stenciling. Increase tree canopy. Leaf pick-up. Downspout disconnection. Potential stream restoration project.	High
NSA_13	Brittany Dr., Bali Rd, Pemberton Ct., South and North Bali Ct.	Moderate	High	Rain gardens/downspout disconnection. Stenciling. Outreach on lawn management. Leaf pick-up. Street bioretention on Brittany upstream of stream.	High
NSA_3	West End EC	Moderate	Moderate	Add buffers next to stream. Pick up trash. Downspout disconnection. Street sweeping/cleaning. More setback for farm animals. Increase buffer width.	High
NSA_2	New Cut Rd	Moderate	Low	Buffer enhancement. Outreach regarding lawn/nutrient management.	Medium
NSA_17	Overlook Dr.	Moderate	Moderate	Rain gardens and rain barrels. Storm drain stenciling. Conservation landscaping. Retrofit at end of street (see RRI_403).	Medium
NSA_27	High Point Rd., View Top Rd, Saint John Ln.	Moderate	Moderate	Rain gardens. Outreach re: lawn management.	Medium
NSA_28	Manordale Rd., Clovelly Rd, Foxhill Dr.	Moderate	Moderate	Rain gardens. Tree planting/conservation landscaping. Storm drain stenciling.	Medium
NSA_16	Autumn Hill Dr, Autumn Hill Ct, Crest Pl	Moderate	Moderate	Rain gardens and tree planting.	Medium
NSA_5	Ellicott Terrace Apt	Moderate	Moderate	Bioretention project. Stenciling. Tree Planting	Medium
NSA_10	Papillon	Moderate	Moderate	No mow in stormwater pond. Pet waste stations. Seed areas of bare soil. Clean parking lot.	Medium
NSA_1	Church St	Moderate	Moderate	Downspout disconnection. Rain barrels on some houses. Leaf pick-up/street sweeping. Storm drain stenciling.	Medium

Table A.2. Neighborhood Opportunities in the Tiber Hudson Watershed					
Site_ID	**Location**	**Pollution Severity**	**Restoration Potential**	**Opportunity**	**Priority**
NSA_18	Trail View, Streambank Way, Ellicott View Rd.	Moderate	Moderate	Rain gardens. Stenciling. Clean up trash in stormwater pond. Downspout disconnection.	Low
NSA_19	Woods of Tiber Branch - Tiber Falls Dr., Nelson House Rd., Sears House Ct	Moderate	Low	Downspout disconnection to rain barrels. Outreach regarding lawn management. Storm drain stenciling.	Low
NSA_24	W. Gate Drive	Moderate	Low	Rain gardens. Stenciling. Rain barrels	Low
NSA_15	Kewaydin - Choctaw Dr, Hopi Ct, Zuni Ct.	Moderate	Moderate	Rain gardens. Tree planting. Leaf pick-up. Potential cul-de-sac retrofit.	Low
NSA_22	St Johns Lane and Victoria Drive	Moderate	Low	Rain gardens. Stenciling. Rain barrels	Low
NSA_23	Bicentennial Ct and Ambra Ct	Moderate	Low	Rain gardens. Stenciling. Rain barrels	Low
NSA_20	River Mills - Orange Grove Ct and Upper Mill Ct	Moderate	Moderate	Seed bare soil uphill from stormwater pond. Rain gardens between units. Inspection of stormwater pond. Tree planting.	Low
NSA_7	Dry Creek Ct, Rusty Rim Rd	Moderate	Moderate	Rain Barrel. Rain gardens. Outreach regarding lawn/nutrient management.	Low
NSA_12	Tollhouse & Manahan Dr	Moderate	Moderate	Pet waste education/stations. Outreach regarding lawn/nutrient management. Downspout disconnection. Storm drain stenciling. Tree planting and/or conservation landscaping.	Low
NSA_14	The Bluffs - Quaker Brothers Dr, John Ellicott Dr, Joseph Ellicott Dr	Moderate	Low	Rain gardens on end units and in rear of units. No mow on edge of SW pond. Litter clean-up in and around pond. Tree planting and/or conservation landscaping in common space. Buffer restoration/protection.	Low

Table A.2. Neighborhood Opportunities in the Tiber Hudson Watershed					
Site_ID	**Location**	**Pollution Severity**	**Restoration Potential**	**Opportunity**	**Priority**
NSA_21	Parkview - Off Ridge Rd.	Moderate	Moderate	Outreach for lawn fertilizer reduction. Rain gardens in some locations coupled with downspout disconnection. Remove concrete channel from stormwater pond. Storm drain stenciling. Street sweeping.	Low
NSA_4	Mount Ida Dr	Moderate	Moderate	Rain Gardens. Stenciling. Increase Tree Canopy.	Low

Table A.3. Hotspot Opportunities in the Tiber Hudson Watershed*						
Site_ID	**Location**	**Type of Hotspot**	**Description**	**Recommended Actions**	**Status**	**Priority**
HSI_11	Lotte Plaza - 8801 Baltimore National Pike	Vehicle Operations, Outdoor Materials, Waste Management, Physical Plant	Multiple pollution sources from used oil container, grease containers and overflowing trash all draining direct to storm drain without treatment. Retrofits proposed (RRI 400 and RRI 401a & b).	On-site inspection with owner. Containment for grease containers. Stormwater management needed. Excess impervious cover can be removed or retrofit.	Severe	High
HSI_10	Pie's Auto Body - 3420 Ellicott Center Dr.	Vehicle Operations, Outdoor Materials, Waste Management, Physical Plant	Wrecked vehicles. Maintenance outdoors on impervious surfaces. Dumpster overflowing with trash all around. Equipment and parts stored outdoors. Parking lot stained, dirty and breaking up.	Review SWPPP. Store materials under cover. Ensure vehicle fluids are drained. Regular maintenance of dumpster and clean up strewn trash.	Severe	High
HSI_400	Williamson's Nursery - 8895 Frederick Rd Ellicott City	Outdoor Materials, Waste Management	Compost, mulch, topsoil in uncontained piles and overflowing onto impervious surfaces. Stream encroachment from commercial activities. Trash (nursery materials) in streams. from operations. Dumping of construction materials in floodplain.	On-site inspection with owner or review SWPPP. Trash/junk clean-up. Apply setback from stream for activities. Need containment/cover for outdoor materials. Education regarding loading and unloading operations to minimize exposure of materials to impervious surfaces. Potential stream restoration project upstream of culvert. Evaluate site for SWM potential.	Severe	High
HSI_9b	USPS - 3375 Ellicott Center Dr.	Vehicle Operations, Waste Management	Evidence of leaks and spills in loading dock right next to storm drain inlet. Dumpster located directly adjacent to SWM facility.	Review SWPPP. Relocate dumpster away from SWM facility. Add proprietary treatment device to inlet by loading dock.	Confirmed	High

Table A.3. Hotspot Opportunities in the Tiber Hudson Watershed*						
Site_ID	**Location**	**Type of Hotspot**	**Description**	**Recommended Actions**	**Status**	**Priority**
HSI_24b	Shell station and Valvoline on Rt 103 and Columbia Pike	Vehicle Operations, Outdoor Materials, Waste Management, Physical Plant	Site has SWM via stormceptor that treats front lot and fueling area. Back gravel lot with SWM and used oil containers with no secondary containment. Parking lot stained. Tires stored outside with no cover or containment.	On-site inspection with owner. Add secondary containment for used oil containers.	Confirmed	High
HSI_5	West End Services	Vehicle Operations, Outdoor materials	Private, commercial truck sales and maintenance site, stream runs adjacent to property	On-site inspection with owner. Review SWPP Provide cover and/or secondary containment around fuel tanks	Confirmed	High
HSI_9a	Public Works yard - 8670 Ridge Rd	Vehicle Operations, Outdoor Materials, Waste Management	Heavy equipment, implements (snow shovels) stored outdoors on impervious cover. Stains around outdoor materials. Wrecked vehicles stored outside with no containment. No stormwater treatment.	Review SWPPP. Move materials under cover. Ensure wrecked vehicles are drained of fluids. Look for opportunities to provide SW treatment, if applicable. Perimeter treatment for fueling area.	Confirmed	Medium
HSI_24a	BP at Rt 103 and Columbia Pike	Vehicle Operations, Outdoor Materials, Physical Plant	Multiple pollution sources from used oil container, 50 gallon containers with no labels and lids askew, staining on parking lot and sediment on edge of lot contaminated with oil, etc. Retrofit proposed (RRI 402).	On-site inspection, review SWPPPP. Stormwater management needed.	Severe	Medium
HSI_22	YMCA	Waste Management	Stains around dumpster from garbage trucks. Stains on front lot from vehicles and maintenance activities (yellow-orange stains)	Contact waste management company re: leaking garbage truck. Clean up trash in stormwater facility. Consider adding bioretention to islands in front parking lot.	Potential	Medium

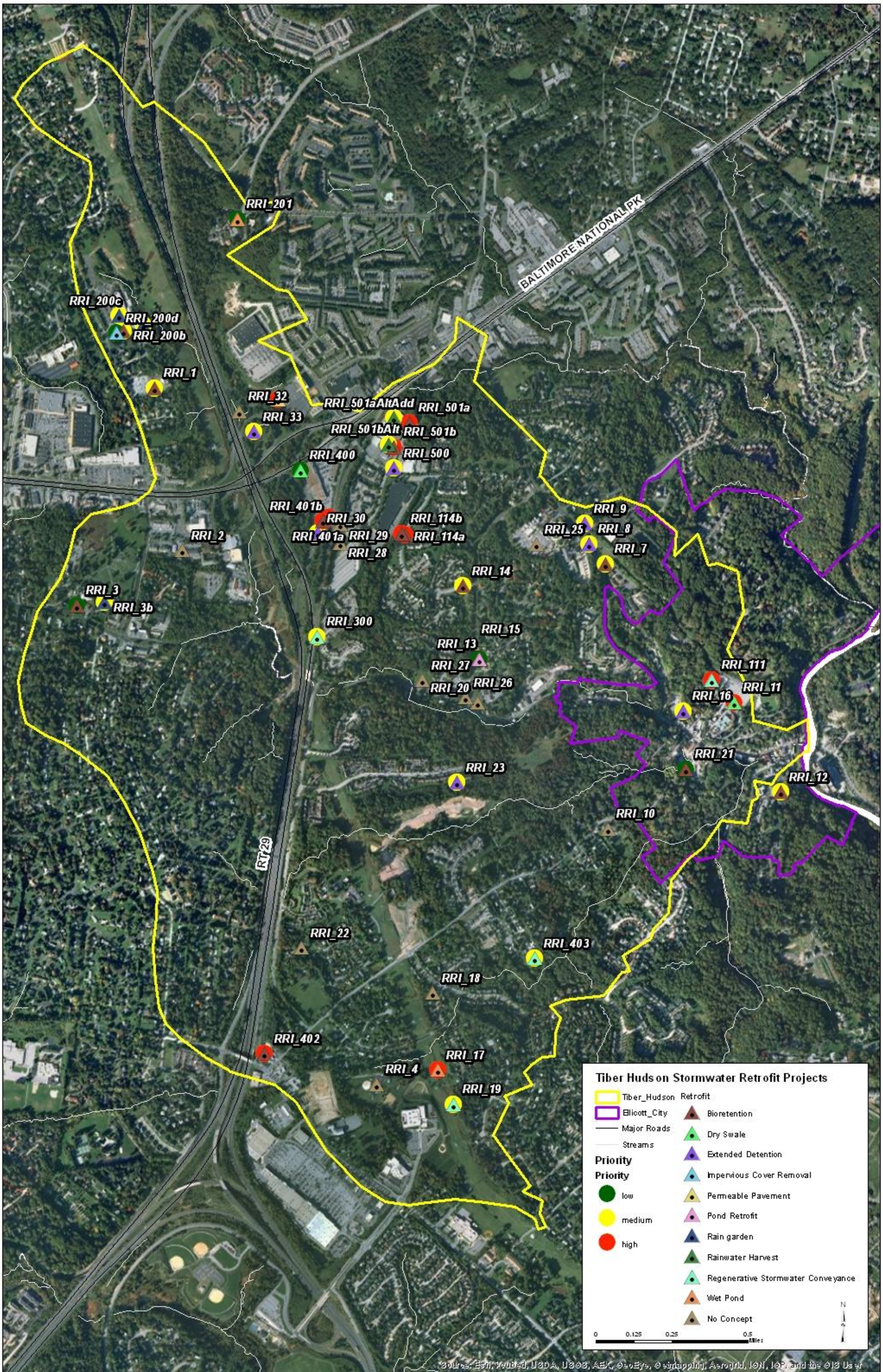
Table A.3. Hotspot Opportunities in the Tiber Hudson Watershed*						
Site_ID	**Location**	**Type of Hotspot**	**Description**	**Recommended Actions**	**Status**	**Priority**
HSI_21	Bethel Korean Presbyterian Church	Outdoor Materials, Waste Management	Outdoor storage of small amount of materials. Storage shed directly discharges to stormwater pond. Trash stored in location directly adjacent to stormwater pond.	Relocate trash receptacles to new location. Move materials into storage shed and secure shed to prevent runoff leaving location.	Potential	Medium
HSI_8b	Ellicott City Storage - 3470 Ellicott Center Dr	Vehicle Operations, Outdoor Materials, Waste Management	Vehicles and trailers stored outdoors. Stains on parking lot.	On-site inspection with owner. Drain fluids from vehicles, add drip pans.	Confirmed	Medium
HSI_3	Parking lot D	Waste Management	Dumpsters with evidence of leakage, overflowing and damaged	Suggest follow-up site inspection. Contact management and include in future education efforts.	Confirmed	Medium
HSI_1	Phoenix Emporium- 8049 Main Street	Waste Management	Lids open on grease containers, significant grease stains on street. Lots of cigarette butts.	Keep grease lids closed and due to proximity to water body build small secondary containment area. Install cigarette but receptacle	Confirmed	Medium
HSI_8a	CR Daniels - 3457 Ellicott Center Dr	Outdoor Materials, Waste Management	Loading and unloading operations. Dumpster with lid open. Organic material build up on lot.	Sweep organic material from lot. Large area of impervious cover with no stormwater treatment. Consider removing some impervious cover and/or adding a bioretention facility at south end of parking lot.	Potential	Low
HSI_24c	Exxon and Valvoline on Rt. 103 and Columbia Pike	Waste Management	Rust stains from dumpster and stains near dumpster, likely from garbage truck.	Review SWPPP. New dumpster. Contact waste management company re: leaking garbage truck.	Potential	Low
HSI_4	Court House, Ellicott City East	Outdoor Materials	Some older stains observed	none	Potential	Low

Table A.3. Hotspot Opportunities in the Tiber Hudson Watershed*						
Site_ID	**Location**	**Type of Hotspot**	**Description**	**Recommended Actions**	**Status**	**Priority**
HSI_17	Miller Brothers Chevrolet and surrounding businesses	Outdoor Materials, Vehicle Activities	Small trickle of water coming from site. Could be from sign vehicle that was present at the time.	Confirm source of discharge	Potential	Low
HSI_23	Veterans E.S.	Waste Management, Turf/Landscaping	Lid open on dumpster. Stains in lot from buses. Some bare soil.	Keep dumpster lid closed. Seed bare soil. Include in future education effort re: increase tree canopy. Contact bus company re: leaking buses.	Not a hotspot	Low
HSI_2	Historic Ellicott City North	Outdoor Materials,	Minor amount of construction debris	Ensure material are removed when construction is complete	Not a hotspot	Low
HSI_7	District Court	Outdoor Materials, Waste Management	Clean site	none	Not a hotspot	Low
HSI_12	3290 North Ridge Road	Waste Management	Clean site	none	Not a hotspot	Low
HSI_14	Walmart	Outdoor Materials, Waste Management	Small amount of trash, small amount of outdoor storage at this time	Reinspection during warmer months	Not a hotspot	Low
HSI_15	Lighthouse Senior Living	Outdoor Materials, Waste Management	Clean site	none	Not a hotspot	Low
HSI_16	St Johns Lane and Old Frederick Road	Outdoor Materials, Waste Management	Small amount of outdoor storage	Southern States stores some materials outdoors during the day. Suggest visit to confirm whether materials are moved indoors at night/weekends	Not a hotspot	Low
HSI_18	Chevrolet Drive	Outdoor Materials, Vehicle Activities	Clean site	none	Not a hotspot	Low

Table A.3. Hotspot Opportunities in the Tiber Hudson Watershed*						
Site_ID	**Location**	**Type of Hotspot**	**Description**	**Recommended Actions**	**Status**	**Priority**
HSI_19	Verizon, Miller Brothers, Chevrolet Drive	Vehicle activities	Clean site	none	Not a hotspot	Low
HSI_20	9050 Baltimore National Pike	Outdoor Materials, Waste Management	Clean site	none	Not a hotspot	Low

*Green cells - County property or road right-of-way
Blue cells - State property
Brown cells - Federal property

Appendix B. Tiber Hudson Site Location Maps



Tiber Hudson Stormwater Retrofit Projects
Tiber_Hudson
Ellicott_City
Major Roads
Streams
Priority
Priority
low
medium
high
Retrofit
Bioretention
Dry Swale
Extended Detention
Impervious Cover Removal
Permeable Pavement
Pond Retrofit
Rain garden
Rainwater Harvest
Regenerative Stormwater Conveyance
Wet Pond
No Concept
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BALTIMORE NATIONAL PK
RT 29
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RRI_400
RRI_401b
RRI_30
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RRI_29
RRI_28
RRI_114b
RRI_114a
RRI_2
RRI_3
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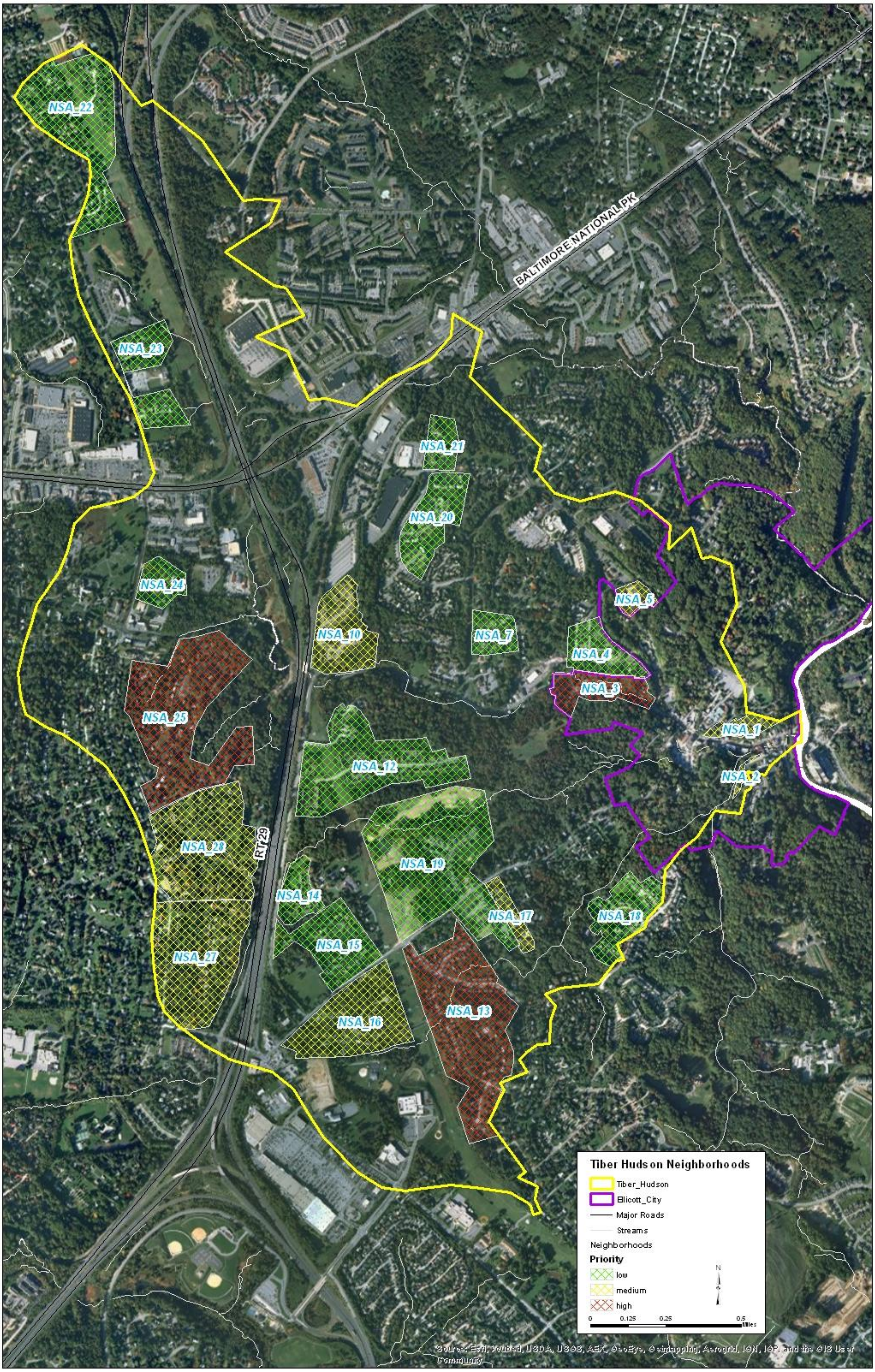
RRI_23
RRI_10
RRI_22
RRI_403
RRI_18
RRI_402
RRI_17
RRI_4
RRI_19
Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community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BALTIMORE NATIONAL PK
NSA_21
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NSA_24
NSA_5
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NSA_7
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NSA_2
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RT 29
NSA_19
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Tiber Hudson Neighborhoods
Tiber_Hudson
Ellicott_City
Major Roads
Streams
Neighborhoods
Priority
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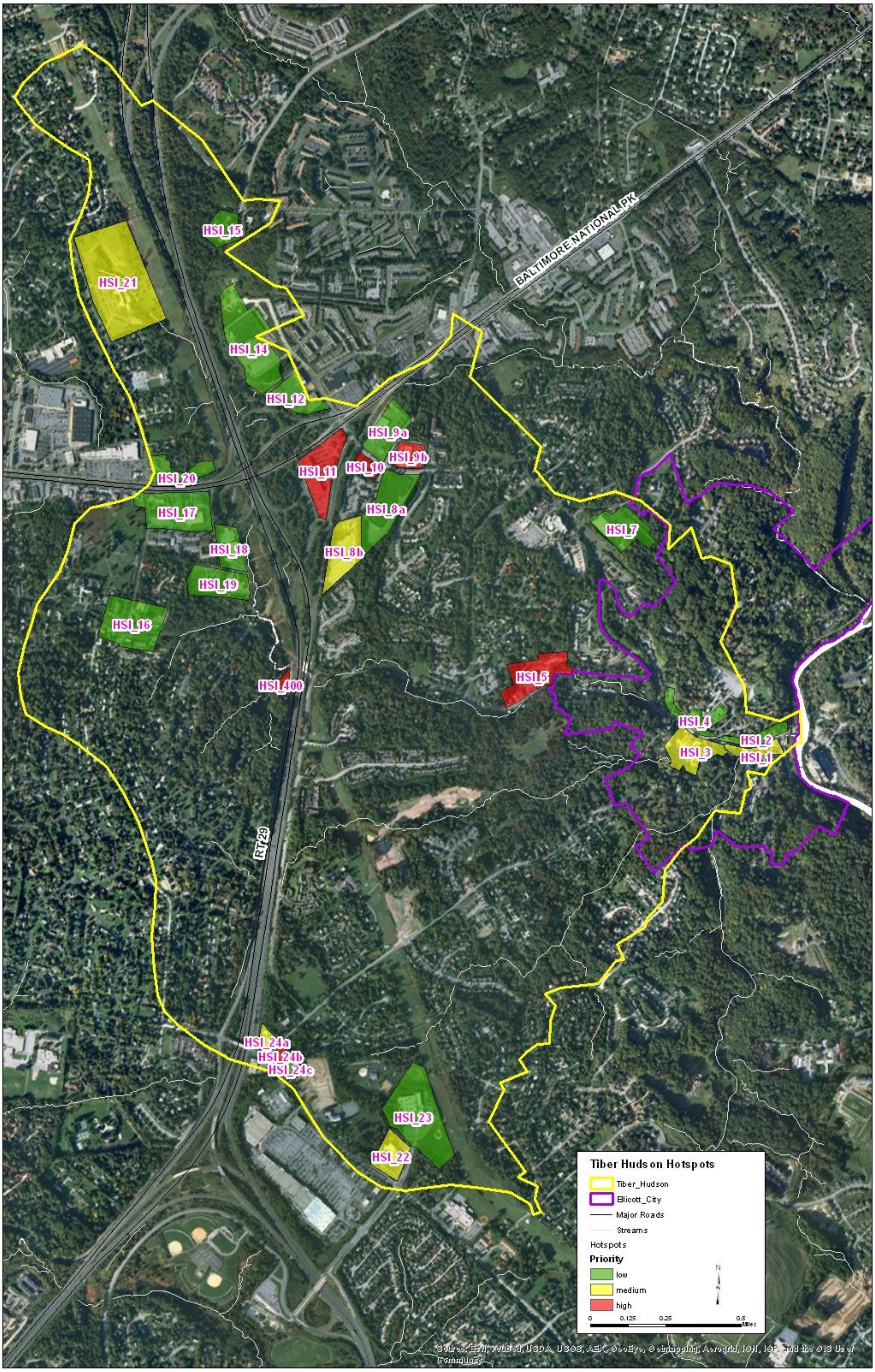
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HSI_7
HSI_18
HSI_8b
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HSI_16
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HSI_400
HSI_4
HSI_2
HSI_3
HSI_1
HSI_24a
HSI_24b
HSI_24c
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HSI_22
Tiber Hudson Hotspots
Tiber_Hudson
Ellicott_City
Major Roads
Streams
Hotspots
Priority
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Miles

Appendix C. Potential Funding Sources

In order to implement all of the actions identified in this Action Plan, additional funding from grants will be required. Table B.1 presents potential funding sources to support the implementation of the Tiber Hudson Action Plan including funding source, applicant eligibility, eligible projects, funding amount, cost share requirements, and grant cycle. The anticipated major grant funding sources include the following:

- **The Chesapeake and Atlantic Coastal Bays Trust Fund:** The Trust Fund was established to provide financial assistance to local governments and political subdivisions for the implementation of nonpoint source pollution control projects. These are intended to achieve the state's tributary strategy developed in accordance with the Chesapeake 2000 Agreement and to improve the health of the Atlantic Coastal Bays and their tributaries. The BayStat Program directs the administration of the Trust Fund, with multiple state agencies receiving moneys, including Maryland Department of Environment (MDE), Department of Natural Resources (DNR), Maryland Department of Agriculture (MDA), and Maryland Department of Planning (MDP).

- **319 Non-point Pollution Grants:** Federal money for restoration implementation is available annually through MDE.

- **Bay Restoration Fund (MDE):** This is a dedicated fund, financed by wastewater treatment plant users, to upgrade Maryland's wastewater treatment plants with enhanced nutrient removal technology. In addition, a similar fee paid by septic system users is utilized to upgrade onsite systems and to pay for cover crops to reduce nitrogen loading to the Bay. Proposed modifications to the fund will allow the fund to be used for implementation of stormwater restoration projects.

- **Stormwater Pollution Control Cost Share Program (MDE):** The Maryland Stormwater Pollution Control Cost-Share Program provides grant funding for stormwater management retrofit and conversion projects in urban areas developed prior to 1984. These projects reduce nutrients, sediments and other pollutant loads entering the state's waterways through the use of infiltration basins, infiltration trenches, vegetated swales, extended detention ponds, bioretention basins, wetlands and other innovative structures.

- **Innovative Nutrient and Sediment Reduction Program (National Fish and Wildlife Foundation):** The National Fish and Wildlife Foundation (NFWF), in partnership with U.S. Environmental Protection Agency (USEPA) and the Chesapeake Bay Program, will award grants on a competitive basis to support the demonstration of innovative approaches to expand the collective knowledge about the most cost effective and sustainable approaches to dramatically reduce or eliminate nutrient and sediment pollution to the Chesapeake Bay and its tributaries.

- **Chesapeake Bay Stewardship Fund:** The goal of the Chesapeake Bay Stewardship Fund is to accelerate local implementation of the most innovative, sustainable and cost effective strategies to restore and protect water quality and vital habitats within the Chesapeake Bay watershed. The Stewardship Fund offers four grant programs: the Chesapeake Bay Small Watershed Grant Program; the Chesapeake Bay Targeted Watersheds Grant Program; the Chesapeake Bay Conservation Innovation Grant Program; and the Innovative Nutrient and Sediment Reduction Program. Major funding for the Chesapeake Bay Stewardship Fund comes from the USEPA, the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), the U.S. Department of Agriculture Forest Service (USFS), and the National Oceanic and Atmospheric Administration (NOAA).

- **MD State Highway Administration (SHA) Transportation Enhancement Program**
  (TEP): This is a reimbursable, federal-aid funding program for transportation-related community projects designed to strengthen the intermodal transportation system. The TEP supports communities in developing projects that improve the quality of life for their citizens and enhance the travel experience for people traveling by all modes. Among the qualifying TEP categories is environmental mitigation to address water pollution due to highway runoff or to reduce vehicle-caused wildlife mortality while maintaining habitat connectivity.

- **Chesapeake Bay Trust:** Provides grants through a variety of grant programs that focus on environmental education, urban greening, fisheries, and remediation of water quality issues. Specifically the Targeted Watershed Grant Program provides funding for on-the ground solutions that address the most pressing nonpoint source pollution challenges facing a small watershed, and that result in measurable improvements in water quality and wildlife habitat. The program also seeks to support cost effective approaches to Chesapeake Bay restoration actions at the small watershed scale and establish a replicable model of restoration that can be transferred and used throughout the region.

Table B.1. Tiber Hudson Potential Funding Sources			
Managing Agency	**Funding Source**	**Application Eligibility**	**Eligible Projects**
American Forests	Global ReLeaf Program (American Forests)	All public lands or public accessible lands Local government State government	Public Lands Restoration Projects which include local organizations; use innovative restorative practices with potential for general application; minimum 20 acre project area
Chesapeake Bay Trust	Targeted Watershed Initiative Grant Program	Non-profits 501(c) Institutions Soil/Water Conservation Districts Local government	Involve local organizations; address non-point source pollution; projects related to water quality and habitat restoration
Chesapeake Bay Trust	Capacity Building Initiative Grant Program	Non-profit 501(c) with a board on which half the members participate meaningfully and at least one paid staff (or a part-time paid volunteer)	Strengthen an organization through management operations, technology, governance, fundraising and communications
Chesapeake Bay Trust	Stewardship Grant Program	Non-profits 501(c) Schools/universities Soil/Water Conservation Districts Local government	Raise awareness about watershed restoration; design plans which educate citizens on things they can do to aid watershed restoration; educate students about local watersheds, projects geared towards watershed restoration and protection

Table B.1. Tiber Hudson Potential Funding Sources			
Managing Agency	**Funding Source**	**Application Eligibility**	**Eligible Projects**
		State government	
DNR	Clean Water Action Plan Nonpoint Source Program 319 Grant	Non-profits 501(c) Universities Soil/Water Conservation Districts Local government State government	Located in a Category I and Category III watershed as outlined in the MD unified watershed assessment; establish cover crops; address stream restoration and riparian buffers
MDE/DNR	Chesapeake and Atlantic Coastal Bays Trust Fund	Non-profits 501(c) Local government	Non-point source best management practices reducing nitrogen, phosphorous and sediment
NFWF	Chesapeake Bay Small Watersheds Grant Program	Non-profits 501(c) Local government	Community-based projects that improve the condition of local watersheds while building stewardship among citizens; watershed restoration, conservation, and planning
NFWF	Chesapeake Bay Targeted Watersheds Grant Program	Non-profits 501(c) Universities Local government State government	Innovative demonstration type restoration projects
NRCS	Watersheds Operations Program	Local government	Address watershed protection, flood mitigation, water quality, soil erosion, sediment control, habitat enhancement, and wetland creation

Table B.1. Tiber Hudson Potential Funding Sources			
Managing Agency	**Funding Source**	**Application Eligibility**	**Eligible Projects**
		State government Tribes	and restoration
USEPA	Targeted Watersheds Grant Program – Capacity Building Grant Program	Non-profits 501(c) Institutions Local government State government	Promote organizational development of local watershed partnerships; provide training and assistance to local watershed groups
USEPA	Targeted Watersheds Grant Program – Implementation Grant Program	Non-profits 501(c) Universities Local government State government	Watershed restoration and/or protection projects (must include a monitoring component)

Appendix D. Best Management Practice Profile Sheets

N-1	Neighborhood Source Area: Yard REDUCED FERTILIZER USE

Description

The ideal behavior is to not apply fertilizer to lawns. The next best thing for homeowners who feel they must fertilize is to practice natural lawn care: using low inputs of organic or slow release fertilizers that are based on actual needs as determined by a soil test. The obvious negative watershed behavior is improper fertilization, whether in terms of the timing, frequency or rate of fertilizer applications, or a combination of all three. The other important variable to define is who is applying fertilizer in the neighborhood. Nationally, about 75% of lawn fertilization is done by homeowners, with the remaining 25% applied by lawn care companies (Figure 1). This split, however, tends to be highly variable within individual neighborhoods, depending on its income and demographics.

How Fertilizer Influences Water Quality

Recent research has demonstrated that lawn over-fertilization produces nutrient runoff with the potential to cause downstream eutrophication in streams, lakes, and estuaries (Barth, 1995a and 1995b). Scientists have also discovered that nitrogen and phosphorus levels in lawn runoff are about two to 10 times higher than any other part of the urban landscape such as streets, rooftops, driveways or parking lots (Bannerman *et al.*, 1993; Steuer *et al.*, 1997; Waschbusch *et al.*, 2000; Garn, 2002).

Figure 1: Lawn Care Company Truck

Percentage of People Engaging in Fertilizer Use

Lawn fertilization is among the most widespread watershed behaviors in which residents engage. A survey of lawn care practices in the Chesapeake Bay indicated that 89% of citizens owned a yard, and of these, 50% applied fertilizer every year (Swann, 1999). The average rate of fertilization in 10 other regional lawn care surveys was even higher (78%), although this may reflect the fact that these surveys were biased towards predominantly suburban neighborhoods and excluded non-lawn owners. Several studies have measured the frequency of lawn fertilization, and have found that lawns are fertilized about twice a year, with spring and fall being the most common season for applications (Swann, 1999).

A significant fraction of homeowners can be classified as "over-fertilizers" who apply fertilizers above recommended rates. Surveys indicate the number of over-fertilizers at 50% to 70% of all fertilizers (Morris and Traxler, 1996; Swann, 1999; Knox *et al.*, 1995). Clearly, many homeowners, in a quest for quick results or a bright green lawn, are applying more nutrients to their lawns than they actually need.

Variation in Fertilization Behavior

Many regional and neighborhood factors influence local fertilization behavior. From a regional standpoint, climate is a very important factor, as it determines the length of the growing season, type of grass, and the irrigation needed to maintain a lawn. A detailed discussion of the role these factors play in fertilization can be found in Barth (1995a). A host of factors also comes into play at the individual neighborhood scale. Some of the more important variables include average income, market value of houses, soil quality, and the age of the development (Law *et al.*, 2004). Higher rates of fertilization appear to be very common in new suburban neighborhoods where residents seek to establish lawns and landscaping. Also, lawn irrigation systems and fertilization are strongly associated.

Difficulty in Changing Behavior

Changing fertilization behaviors can be hard since the desire for green lawns is deeply rooted in our culture (Jenkins, 1994; Teyssott, 1999). For example, the primary fertilizer is a man in the 45 to 54 year age group (BHI, 1997) who feels that "a green attractive lawn is an important asset in a neighborhood" (De Young, 1997). According to surveys, less than 10% of lawn owners take the trouble to take soil tests to determine whether fertilization is even needed (Swann, 1999; Law *et al.*, 2004). Most lawn owners are ignorant of the phosphorus or nitrogen content of the fertilizer they apply (Morris and Traxler, 1996), and are unaware that grass-cycling can sharply reduce fertilizer needs.

Most residents rely on commercial sources of information when making their fertilization decisions. The average consumer relies on product labels, store attendants, and lawn care companies as their primary, and often exclusive, sources of lawn care information. Consumers are also influenced by direct mail and word of mouth when they choose a lawn care company (Swann, 1999 and AMR, 1997).

Two approaches have shown promise in changing fertilization behaviors within a neighborhood, and both involve direct contact with individual homeowners. The first relies on using neighbors to spread the message to other residents, through master gardening programs. Individuals tend to be very receptive to advice from their peers, particularly if it relates to a common interest in healthy lawns. The second approach is similar in that it involves direct assistance to individuals at their homes (e.g., soil tests and lawn advice) or at the point of sale.

Techniques to Change Behavior

Most communities have primarily relied on carrots to change fertilization behaviors, although sticks are occasionally used in phosphorus-sensitive areas. The following are some of the most common techniques for changing fertilization behaviors:

- Seasonal media awareness campaigns
- Distribution of lawn care outreach materials (brochures, newsletters, posters, etc.; Figure 2)
- Direct homeowner assistance and training
- Master gardener program
- Exhibits and demonstration at point-of-sale retail outlets
- Free or reduced cost for soil testing
- Training and/or certification of lawn care professionals
- Lawn and garden shows on radio
- Local restrictions on phosphorus content in fertilizer

Good Examples

King County, Washington- Northwest Natural Yard Days. This month-long program offers discounts on natural yard care products and educational information about natural yard care in local stores throughout King County and Tacoma. Education specialists came to Saturday and Sunday events at some stores and spent time with buyers to help them make good choices and learn about natural yard care, including the use of organic fertilizers that don't wash off into streams and lakes as easily as "quick release" chemical fertilizers. For more details, consult: http://dnr.metrokc.gov/swd/ResRecy/events/naturalyard.shtml

North Carolina Department of Agriculture Free Residential Lawn Soil Testing. Residents can get a free soil test to determine the exact fertilizer and lime needs for their lawn, as well as for the garden, landscape plants and fruit trees. Information sheets and soil boxes are available from various government agencies, or local garden shops and other businesses. For more information, consult:
http://www.ncagr.com/agronomi/stfaqs.htm

Minnesota Department of Agriculture Phosphorus Lawn Fertilizer Use Restrictions. Starting in 2004, these restrictions limit the concentration of phosphorus in lawn care products and restrict its application at higher rates to specific situations based on need.
http://www.mda.state.mn.us/appd/ace/lawncwaterq.htm

Top Resources

Cornell Cooperative Extension. The Homeowner's Lawn Care Water Quality Almanac.
http://www.gardening.cornell.edu/lawn/almanac/index.html

University of Rhode Island Cooperative Extension Home*A*Syst Healthy Landscapes Program
http://www.healthylandscapes.org/

University of Maryland Cooperative Extension - Home and Garden Information Center.
http://www.agnr.umd.edu/users/hgic/

Turf and Landscape Best Management Practices. South Florida Water Management District and the Broward County Extension Education Division
http://www.sfwmd.gov/org/exo/broward/c11bmp/fertmgt.html

Florida Yards and Neighborhoods Handbook: A Guide to Environmentally Friendly Landscaping
http://hort.ufl.edu/fyn/hand.htm

University of Minnesota Extension Service Low-Input Lawn Care (LILaC)
http://www.extension.umn.edu/distribution/horticulture/DG7552.html

Austin TX, Stillhouse Spring Cleaning
http://www.ci.austin.tx.us/growgreen/stillhouse.htm

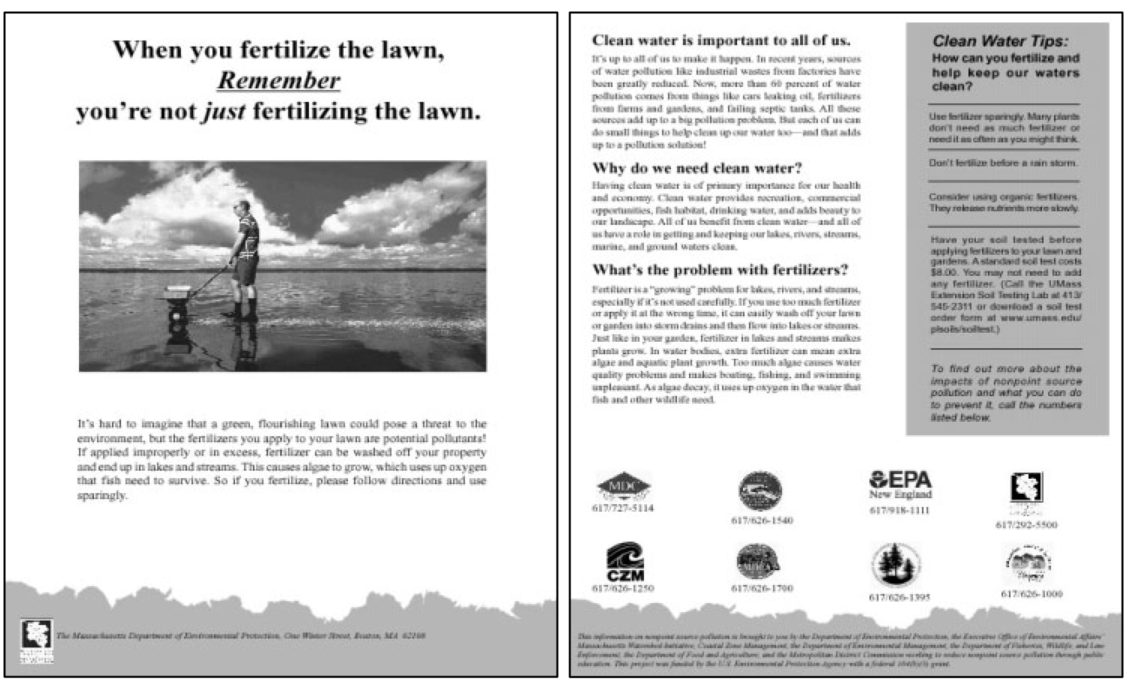


Figure 2: Educational Brochure on Fertilizer
Source: http://www.state.ma.us/dep/brp/wm/files/fertiliz.pdf

N-2	Neighborhood Source Area: Yard
	REDUCED PESTICIDE USE

Description

The ideal watershed behavior is to not apply any insecticides or herbicides to the lawn or garden. Many residents, however, still want to control pests and weeds, so the next best behavior is a natural approach that emphasizes limited use of safer chemicals, proper timing and targeted application methods. The negative residential behavior is over-use or improper application of insecticides and herbicides that are known to have an adverse impact on aquatic life.

How Pesticide Use Influences Subwatershed Quality

The leading source of pesticides to urban streams is homeowner applications in the lawn and garden to kill insects and weeds. The pesticides of greatest concern are insecticides, such as diazinon and chloropyrifos, and a large group of herbicides (CWP, 2003; USGS, 2001; Schueler, 1995; Figure 1). Very low levels of these pesticides can be harmful to aquatic life. According to a national monitoring study, one or more pesticides were detected in 99% of urban streams sampled (USGS, 2001). Pesticide levels in urban streams exceeded national water quality standards to protect aquatic life in one out of every five samples. Even more troubling was the finding that 100% of fish in urban streams had detectable levels of pesticide in their tissues, with 20% exceeding recommended guidelines for fish-eating wildlife (such as racoons, kingfishers, ospreys and eagles).

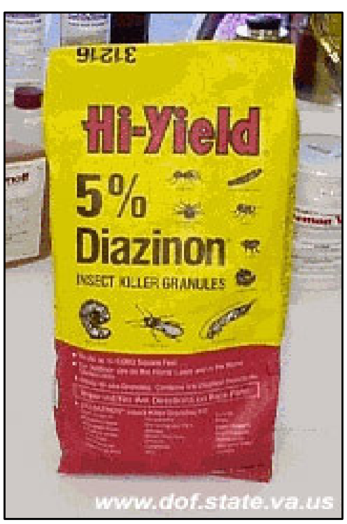


Figure 1: Bag of Pesticide Granules

Percentage of People Engaging in Pesticide Use

About half of Chesapeake Bay residents reported that they had applied pesticides to their lawn or garden (Swann, 1999). Surveys on residential pesticide use for other regions of the country indicate that home pesticide use varies greatly, ranging from a low of 17% to a high of 87% of households (Swann, 1999). According to EPA, the average acre of maintained suburban lawn receives five to seven pounds of pesticides each year.

Variation in Pesticide Use

Many regional and neighborhood factors influence the degree of local pesticide use. From a regional standpoint, climate is an extremely important factor. For example, insecticides are applied more widely in warmer climates where insect control is a year round problem (e.g., 50 to 90% of warm-weather residents report using them). This can be compared to 20 to 50% of insecticide use reported for colder regions where hard winters help keep insects in check (Schueler, 2000b). By contrast, herbicide application rates tend to be higher in colder climates in order to kill weeds that arrive with the onset of spring (e.g., 60 to 75% of cold weather residents report use).

Many neighborhood factors can play a strong role in the degree of pesticide use. These include lot or lawn size, presence of gardens, condition of turf, presence or absence of irrigation and neighborhood age. The average income and demographics within a neighborhood are also thought to play a strong role, particularly if residents rely on lawn care and landscaping companies to maintain their lawns.

Difficulty in Changing the Behavior

Pesticide use is a difficult behavior to change for several reasons. First, many residents want a quick and effective solution to their pest problems. Second, many residents lack awareness about the link between their pesticide use and stream quality. Lastly, many residents rely on commercial sources of information when choosing pesticides, and lack understanding of safer alternatives and practices. As with fertilizers, product labels are the primary source of information about pesticides. Nearly 90% of homeowners rely on them to guide their pesticide use (Swann, 1999). In addition, many residents are unaware of the pesticide application practices that their lawn care company applies to their yard and prefer to rely on professional know-how (Knox *et al*., 1995).

Confusion also stems from the recent growth of "weed and feed" lawn care products that combine weed control and fertilizer in a single bag. In one Minnesota study, 63% of residents reported that they used weed and feed lawn products, but only 24% understood that they were applying herbicides to their lawn (Morris and Traxler, 1996).

Techniques to Change the Behavior

Most communities rely on the same basic combination of carrots to change pesticide use as they do for fertilizer use, since they are so interrelated. The following are some of the most common techniques to change pesticide use:

- Seasonal media awareness campaigns
- Distribution of lawn care outreach materials (brochures, newsletters, posters, etc.)
- Direct homeowner assistance and training
- Master gardener program
- Exhibits and demonstration at point of sale at retail outlets
- Pest advice hotlines
- Training, certification and/or licensing of lawn care professionals and pesticide applicators
- Radio lawn and garden advice shows

Figure 2: Educational Pesticide Brochure
Source: http://www.lacity.org/SAN/wpd/index.htm

N-11	Neighborhood Source Area: Driveway SAFE CAR WASHING

Description

The ideal watershed behavior is to wash cars less often, wash them on grassy areas, and use phosphorus-free detergents and non-toxic cleaning products. Alternatively, residents can use commercial car washes that treat or recycle wash water. The negative behavior is to wash cars in a manner where dirty wash water frequently flows into the street, storm drain system, or the stream. This behavior applies not only to individuals, but to community groups that organize outdoor car washes for charitable purposes (Figure 1).

How Car Washing Influences Subwatershed Quality

Outdoor car washing has the potential to generate high nutrient, sediment, metal, and hydrocarbon loads in many subwatersheds. Detergent-rich water used to wash the grime off cars can flow down the driveway and into the storm drain, where it can be an episodic pollution source during dry weather. Not much is currently known about the quality of car wash water, but local water quality sampling can easily characterize it. Car wash water can also be a significant flow source to streams during dry weather. As an example, a typical hose flowing at normal pressure produces between 630 and 1,020 gallons of water per hour, depending on its diameter. These flows can be sharply reduced if the hose is equipped with a shut-off nozzle.

Figure 1: Poor Practices at a Charity Car Wash Event at a Local Gas Station

Percentage of Residents Engaging in Car Washing

Car washing is one of the most common watershed behaviors in which residents engage. According to surveys, about 55 to 70% of homeowners wash their own cars, with the remainder utilizing commercial car washes (Schueler, 2000b). Of these, 60% of homeowners can be classified as "chronic car-washers," in that they wash their car at least once a month (Smith, 1996; PRG, 1998; and Hardwick, 1997). Between 70 and 90% of residents reported that their car wash-water drained directly to the street, and presumably, to the nearest stream.

Variation in Car Washing

Regional and climatic factors play a strong role in determining the frequency of residential car washing. In colder climates, many residents utilize commercial car washes during the winter months, and then wash their cars themselves during the summer. In warmer climates, residential car washing is often a year-round phenomenon. Neighborhood factors that influence car washing include the number of vehicles per household, lot size, driveway surfaces, income and demographics. Another key factor is the nature of the storm water conveyance system. If a neighborhood has open section roads with grass swales, the impact of car wash water will be less.

Difficulty in Changing Car Washing Behaviors

Residential car washing is a hard watershed behavior to change, since the alternative of using commercial car washes costs more money. In addition, many residents are not aware of the water quality consequences of car washing, nor do they understand the chemical content of the soaps and detergents they use. Lastly, many residents do not understand that their driveway is often directly connected to the storm drain system and the urban stream. Consequently, many communities will need to educate homeowners about the water quality implications of car washing.

Techniques to Change Car Washing Behavior

Several communities have developed effective techniques to promote safer car washing, including:

- Media campaigns to increase awareness about water quality impacts of car washing (billboards, posters, etc.)
- Conventional outreach materials (brochures, posters, water bill inserts)
- Promote use of nozzles with shut-off valves
- Provide information on environmentally safe car washing products at point of sale
- Provide storm drain plugs and wet vacs for charity carwash events
- Provide discounted tickets for use at commercial car washes
- Modify sewer bylaws or plumbing codes to prevent storm drain discharges
- Storm drain marking (see N-21)

Good Examples

Puget Sound Car Wash Association - This charity car wash program allows qualifying nonprofit organizations to raise money for their group by selling tickets that can be redeemed at participating commercial car wash facilities. http://www.charitycarwash.com/

Drain Plugs and Bubble Busters (Kitsap County) – This program provides drain plugs to contain car wash water from charitable car wash events, as well as "bubble busters" to pump out and safely dispose of wash water. http://www.kitsapgov.com/sswm/carwash.htm

Top Resources

RiverSafe Carwash Campaign
http://www.riversides.org/riversafe/

The Dirty Secret of Washing Your Car at Home
http://www.forester.net/sw_0106_trenches.html

Best Management Practices for Controlling Runoff from Commercial Outdoor Car Washing
http://environment.alachua-county.org/Natural_Resources/Water_Quality/Documents/Commercial Outdoor Car Wash.pdf

How to Run a Successful Carwash fundraiser
http://www.carwashguys.com/fundraisers/LASchools.html

Make Your Next Car Wash "Environmentally Smart"
http://www.ci.eugene.or.us/PW/storm/Publications/Carwash fundraiser.pdf

N-5

Neighborhood Source Area: Rooftop

DOWNSPOUT DISCONNECTION

Description

Downspout disconnection spreads rooftop runoff from individual downspouts across the lawn or yard where it filters or infiltrates into the ground. While some disconnections are simple, most require the installation of an on-site storm water retrofit practice. These simple practices capture, store and infiltrate storm water runoff from residential lots, and include rain barrels, rain gardens, French drains or dry wells. *Rain barrels* capture runoff from rooftops and are typically installed on individual roof leaders. Runoff captured in the barrel is stored for later use as supplemental irrigation. *Rain gardens* are shallow, landscaped depressions in the yard used to store and infiltrate runoff from rooftops and other impervious surfaces on the lot. *French drains and dry wells* are shallow small stone trenches used to infiltrate rooftop runoff into the ground, where soils are permeable. More details about on-site retrofit practices can be found in Profile Sheets 0S-15 through 0S-17 in Manual 3.

The ideal watershed behavior is to disconnect all downspouts so individual rooftops deliver no runoff to the storm drain system or stream. The negative watershed behavior is to pipe downspouts across the yard and into the curb or street in order to promote positive drainage (Figure 1).

How Downspout Disconnection Influences Subwatershed Quality

Downspout disconnection reduces the amount of impervious cover on a developed lot that can generate stormwater runoff. In addition to reducing the volume of runoff, downspout disconnection promotes groundwater recharge, reduces storm water runoff volumes, and filters out pollutants through the lawn soil. Since each individual retrofit for downspout disconnection treats only a few hundred or thousand square feet of impervious cover, dozens or hundreds are needed to make a measurable difference at the subwatershed level. Consequently, an intensive campaign to target education, technical assistance, and financial resources within a neighborhood or subwatershed to encourage widespread adoption of disconnection is needed.

Percentage of Residents Engaging in Downspout Disconnection

Data is not currently available to estimate the rate at which homeowners voluntarily disconnect downspouts. The frequency of this behavior is thought to be extremely low in most neighborhoods unless a community aggressively promotes and subsidizes disconnections. If this occurs, homeowner participation rates of 20 to 30% have been reported in pilot projects (Environment Canada, 2001).

Figure 1: Downspout Intentionally Bypassing Landscaped Area and Draining onto Driveway

Variation in Downspout Disconnection

The potential to disconnect downspouts is normally evaluated as part of the Neighborhood Source Assessment component of the USSR survey (see Manual 11). The most important neighborhood factor is the proportion of existing homes directly connected to the storm drain system. Negative neighborhood factors include the presence of basements, compacted soils, and poor neighborhood awareness or involvement. Positive factors are large rooftop areas that are directly connected to the storm drain system, lots with extensive tree canopy, and good neighborhood housekeeping. In general, large residential lots are most suitable for most disconnection retrofits (1/4 acre lots and larger), although rain barrels can be used on lots as small as 4,000 square feet (Figure 2).

To date, the impetus for most disconnection retrofit programs has been to separate residential storm water from sewer flows in older neighborhoods in order to minimize basement sewer backups or combined sewer overflows.

Figure 2: Rain Barrel Used on a Back, Second Floor Balcony

Techniques to Promote Downspout Disconnection

Communities are experimenting with many different carrots to promote disconnection retrofits, including:

- Conventional outreach materials (flyers, brochures, posters)
- Free or discounted rain barrel distribution
- Municipal or schoolyard demonstration projects
- Credits or subsidies for disconnection retrofits
- Direct technical assistance
- Provision of discounted mulch, piping or plant materials
- Modification of sewer and storm water ordinances to promote disconnection
- Mandatory disconnection for targeted subwatersheds

Good Examples

Downspout Disconnection Program (Portland, OR). The City offers residents a credit of $53 per disconnection in the form of a check or a one-time lump sum credit toward their sewer bill after inspection and approval of the work. In addition, neighborhood associations and other civic groups (churches, schools, etc.) can earn $13 for every downspout they disconnect. http://www.portlandonline.com/bes/index.cfm?c=32144

Rain Blocker Program (*City of Chicago)*. The Rain Blocker pilot program is specifically designed to eliminate or greatly reduce the amount of basement flooding caused by sewer surcharge. The program works by restricting the rate of storm water flow into the city sewer system, via installing vortex restrictors within the catch basins of city streets and through downspout disconnection from buildings. http://www.cityofchicago.org/WaterManagement/blocker.html

Neighborhood Rain Gardens (Minneapolis, MN). This program works with neighborhood associations to encourage landscaping for rainwater management. The Fulton Neighborhood Association has worked with eight homeowners to install rain gardens, rain barrels, gutter downspout redirection, and infiltration systems that reduce runoff delivered from individual properties to streets, alleys and sidewalks.
http://www.fultonneighborhood.org/lfrwm.htm

Top Resources

How to Disconnect Your Downspouts (Portland Oregon)
http://www.portlandonline.com/bes/index.cfm?c=32144

Milwaukee Downspout Disconnection Program
http://www.mmsd.com/projects/downspout.cfm

Boston Water and Sewer Commission's Downspout Disconnection Program
http://www.bwsc.org/Customer_Service/Programs/downspout.htm

RainGardens.org
http://www.raingardens.org/

Rain Gardens: A how-to manual for homeowners
http://www.dnr.state.wi.us/org/water/wm/dsfm/shore/documents/rgmanual.pdf

Rain Garden Applications and Simple Calculations
http://www.cwp.org/Community_Watersheds/Rain_Garden.htm

How to Build and Install a Rain Barrel
http://www.cwp.org/Community_Watersheds/brochure.pdf

Skills for Protecting Your Stream: Retrofitting Your Own Backyard
http://www.cwp.org/Community_Watersheds/Retrofitting_Backyard.pdf

N-6

Neighborhood Source Area: Common Areas

PET WASTE PICKUP

Description

The ideal watershed behavior is to pick up and properly dispose of pet waste (Figure 1). The negative watershed behavior is to leave pet waste in common areas and the yard, where it can be washed off in storm water runoff.

How Pet Waste Influences Subwatershed Quality

Pet waste has been found to be a major source of fecal coliform bacteria and pathogens in many urban subwatersheds (Schueler, 1999). A typical dog poop contains more than three billion fecal coliform bacteria and as many as 10% of dogs are also infected with either *giardia* or salmonella, which is not surprising considering they drink urban creek water. Fecal coliform bacteria are frequently detected in urban streams and rivers after storms, with levels as high 5,000 fecal coliform per tablespoon. Thus, it is not uncommon for urban and suburban creeks to frequently violate bacteria standards for swimming and water contact recreation after larger rainstorms.

Percentage of Residents that Pick Up After Pets

Surveys indicate that about 40% of all households own one or more dogs (Swann, 1999). Not all dog owners, however, are dog walkers. Only about half of dogs are walked regularly. About 60% of dog walkers claim to pick up after their dog some or all of the time (Swann, 1999; HGIC, 1998; and Hardwick, 1997). The primary disposal method reported by residents for pet waste is the trash can, with toilets coming in distant second. Dog walkers that do not pick up after their dogs are highly resistant to change; nearly half would not pick up even if confronted with fines or complaints from neighbors (Swann, 1999). Men are also prone to pick up after their dogs less often than women (Swann, 1999).

Figure 1: Pet Waste Pickup Station

Techniques to Promote Pet Waste Pickup

The key technique is to educate residents on sanitary and convenient options for retrieving and disposing of pet waste. Several communities have used both carrots and sticks to get more owners to pick up after their pets, including:

- Mass media campaigns of the water quality impacts of pet waste
- Conventional outreach materials (brochures, flyers, posters)
- Pooper bag stations in parks, greenways and common areas
- Educational signs in same areas
- "Pooper scooper" ordinances and enforcement
- Banning dogs from beaches and waterfront areas
- Providing designated "dog parks"

Good Examples

Water Quality Consortium Nonpoint Source Education Materials
The Water Quality Consortium implemented an ad campaign focused on four themes: a man pushing a fertilizer spreader, a car driving on water leaking oil, a man washing his car, and man walking his dog. Each ad explains how the behavior leads to water pollution and provides specific tips outlining what residents can do to protect water quality.
http://www.psat.wa.gov/Programs/Pie_Ed/Water_Ed_Materials.htm

Pick It Up - It's Your Doodie Campaign (Gwinnett County Parks & Recreation Department) - The county park agency provides plastic grocery bags for pet owners to use to clean up after their pets as part of a pilot program. The baggies are attached to a wooden post at a local park. Underneath a sign explains their purpose. Pet owners are also encouraged to bring replacement bags when they visit the park.
http://www.gwinnettcitizen.com/0203/doodie.html

Top Resources

Public Open Space and Dogs: A Design and Management Guide for Open Space Professionals and Government
http://www.petnet.com.au/openspace/frontis.html

Considerations for the Selection and Use of Pet Waste Collection Systems in Public Areas
http://www.ecy.wa.gov/programs/wq/nonpoint/pet_waste/petwaste_station.pdf

Properly Disposing of Pet Waste
http://www.cleanwatercampaign.com/what_can_i_do/pet_waste_home.html

Managing Pet and Wildlife Waste to Prevent Contamination of Drinking Water
U.S. EPA Source Water Protection Practices Bulletin.
http://www.epa.gov/safewater/protect/pdfs/petwaste.pdf

N-7	Neighborhood Source Area: Common Areas
	BUFFERSCAPING

Description

Many neighborhoods built in the last few decades still have a decent stream corridor protected by buffers, flood plain setbacks or wetland protection requirements. The stream corridor that remains is often in common or private ownership. The ideal watershed behavior is to respect the boundaries of the stream corridor and expand it where possible through "bufferscaping" and backyard planting of native plants and trees. The negative watershed behavior is stream corridor encroachment, through clearing, dumping, allowing invasive plant species to spread from private yards, and erecting structures (Figure 1).

How Bufferscaping Influences Subwatershed Quality

A forested stream corridor is an essential ingredient of a healthy stream, except in certain arid and semi-arid regions. Bufferscaping can add to the total area of the stream corridor, provide wildlife habitat and enhance the structure and function of the buffer. By contrast, encroachment activities diminish the quality, function and attractiveness of the stream buffer.

Percentage of People Encroaching on/Expanding the Stream Corridor

Data is not currently available to estimate the rate at which homeowners add to the stream corridor, but several troubling studies have examined the degree of residential buffer encroachment. Many residents perceive buffers as an extension of their backyard, and think little of removing trees, dumping yard wastes or erecting structures on their land. A major reason is that nearly 60% of residents are ignorant of the boundaries and intended purpose of stream buffers (Heraty, 1993). Studies of wetland buffer encroachment in Washington residential areas found that 95% of buffers were visibly altered, 40% to such a degree that their functional value was eliminated (Cooke, 1991). Other studies of Maryland buffers indicate encroachment rates of as much as 1% of area buffer per year. Clearly, residential awareness and behaviors in regard to the stream corridor need to be improved in many subwatersheds.

Neighborhood Factors that Contribute to Buffer Stewardship

Several factors play a role in how buffers are managed within a neighborhood: the age of the development, lot size, activism of homeowner association, boundary signs, and the prior existence of stream buffer or flood plain regulations.

Figure 1: A New Subdivision Encroaching on the Stream Buffer

Techniques to Encourage Buffer Stewardship

Protecting or expanding stream buffers requires direct education and interaction with individual property owners that back up to the buffer. Some useful techniques include:

- Bufferscaping assistance and guides
- Community buffer walks
- Buffer boundary inspections
- Boundary signs (Figure 2)
- Defining unallowed uses in local stream buffer ordinances
- Presentations to community associations
- Adopt-a-stream program
- Financial incentives for bufferscaping

http://sites.state.pa.us/PA_Exec/Fish

Figure 2: Sign Identifying a Buffer Boundary C14

Good Examples

Burnett County, WI Natural Shoreline Incentives. The county pays homeowners to enroll in a program to maintain shorelines in their natural state. The program asks for a voluntary commitment by placing a covenant on a homeowner's property stating that the shoreline will remain natural. Program members receive a payment of $250 after an initial inspection that certifies the property meets program standards, and the shoreline covenant is recorded. Participants also receive an annual deduction from their tax statement as a thank you.
http://www.burnettcounty.com/burnett/lwcd/preserve.html

Tennessee Valley Authority Banks and Buffers Software: A Guide to Selecting Native Plants for Streambanks and Shorelines includes software application to help homeowners select plants for bufferscaping. It also contains selected characteristics and environmental tolerances of 117 plants and more than 400 color photographs illustrating habitat and growth form.
http://www.tva.gov/river/landandshore/stabilization/websites.htm

Top Resources

The Architecture of Urban Stream Buffers
http://www.stormwatercenter.net/Library/Practice/39.pdf

Chesapeake Bay Riparian Handbook: A Guide for Establishing and Maintaining Riparian Forest Buffers
http://www.chesapeakebay.net/pubs/subcommittee/nsc/forest/riphbk.pdf

Riparian Forest Buffer Design, Establishment, and Maintenance
http://www.agnr.umd.edu/MCE/Publications/Publication.cfm?ID=13

Riparian Area Management: A Citizen's Guide
http://www.co.lake.il.us/elibrary/publications/smc/riparian.pdf

Backyard Buffers for the South Carolina Lowcountry
http://www.scdhec.net/ocrm/pubs/backyard.pdf

Alliance for the Chesapeake Bay – Backyard Buffers
http://www.acb-online.org/pubs/projects/deliverables-158-1-2003.pdf

Cayuga County, NY – Green Thumbs for Blue Water Workshops
http://www.co.cayuga.ny.us/wqma/greenthumbs

Tree-mendous Maryland
http://www.dnr.state.md.us/forests/treemendous/

N-8	Neighborhood Source Area: Common Areas	
	STORM DRAIN MARKING CC	

Description

The ideal watershed behavior is to get residents to fully understand the connection between storm drains and downstream waters and avoid any activity that discharges pollutants. This awareness is most often created by marking or stenciling storm drain inlets with a "Don't dump, drains to..." message (Figure 1). The negative watershed behavior is to use storm drains as a means of disposal for trash, yard waste and household products.

How Storm Drain Marking Influences Water Quality

Storm drain marking sends a clear message to keep trash and debris, leaf litter and organic matter out of the storm drain system. Stencils may also reduce residential spills and illicit discharges. Marking is also a direct and local way to increase watershed awareness and practice neighborhood stewardship. The actual water quality benefits of storm drain marking have yet to be demonstrated through field research or monitoring. Still, marking is always a sign of good neighborhood housekeeping. Santa Monica, CA also marks the hotline phone number on storm drains to report water quality problems and illegal dumping.

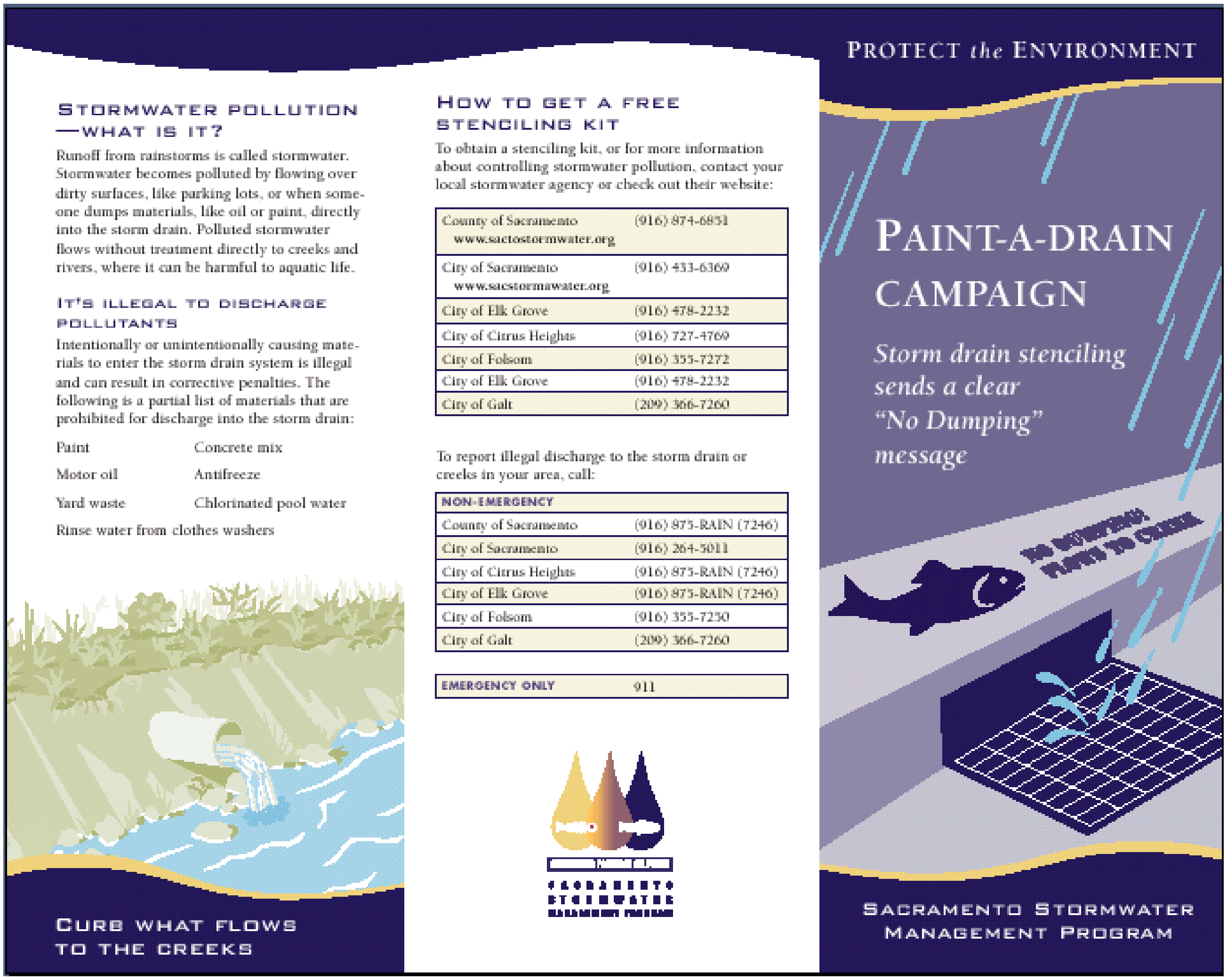
Percentage of Residents Engaging in Storm Drain Marking

This behavior does not require extensive resident participation; only a few trained volunteers are needed to thoroughly mark storm drains within a neighborhood. Volunteers can include scouts, service groups, high school students, neighborhood associations, and other volunteers. Normally, marking is "sanctioned" by the local public works authority or environmental agency, so it is important to coordinate closely with them (Figure 2). Table 1 provides guidance for marking storm drains.

Factors to Consider in Storm Drain Marking

The only significant impediment to storm drain marking is when a neighborhood is primarily served by open channels or grassed channels, rather than enclosed storm drains.

Figure 1: Storm Drain Marking



PROTECT *the* ENVIRONMENT

STORMWATER POLLUTION —WHAT IS IT?

Runoff from rainstorms is called stormwater. Stormwater becomes polluted by flowing over dirty surfaces, like parking lots, or when someone dumps materials, like oil or paint, directly into the storm drain. Polluted stormwater flows without treatment directly to creeks and rivers, where it can be harmful to aquatic life.

IT'S ILLEGAL TO DISCHARGE POLLUTANTS

Intentionally or unintentionally causing materials to enter the storm drain system is illegal and can result in corrective penalties. The following is a partial list of materials that are prohibited for discharge into the storm drain:

Paint	Concrete mix
Motor oil	Antifreeze
Yard waste	Chlorinated pool water
Rinse water from clothes washers	

CURB WHAT FLOWS TO THE CREEKS

HOW TO GET A FREE STENCILING KIT

To obtain a stenciling kit, or for more information about controlling stormwater pollution, contact your local stormwater agency or check out their website:

County of Sacramento www.sactostormwater.org	(916) 874-6851
City of Sacramento www.sacstormwater.org	(916) 433-6369
City of Elk Grove	(916) 478-2232
City of Citrus Heights	(916) 727-4769
City of Folsom	(916) 355-7272
City of Elk Grove	(916) 478-2232
City of Galt	(209) 366-7260

To report illegal discharge to the storm drain or creeks in your area, call:

NON-EMERGENCY	
County of Sacramento	(916) 875-RAIN (7246)
City of Sacramento	(916) 264-5011
City of Citrus Heights	(916) 875-RAIN (7246)
City of Elk Grove	(916) 875-RAIN (7246)
City of Folsom	(916) 355-7230
City of Galt	(209) 366-7260

EMERGENCY ONLY	911

SACRAMENTO STORMWATER MANAGEMENT PROGRAM

PAINT-A-DRAIN CAMPAIGN

Storm drain stenciling sends a clear "No Dumping" message

NO DUMPING FLOWS TO CREEK

SACRAMENTO STORMWATER MANAGEMENT PROGRAM

Figure 2: Educational Brochure on Storm Drain Marking/Stenciling
Source: http://www.sactostormwater.org/documents/stencil_brochure_03.pdf

Table 1: Storm Drain Marking Guidance
• Enlist one person to serve as the team leader, and make sure he/she knows all marking rules and safety procedures. • Review all safety procedures before marking. • Marking should be performed by at least two people, so one can be on the lookout for oncoming vehicles. Safety vests and traffic cones can be used to alert vehicles. • Remember to wear old cloths and shoes. • Bring paper towels or a rag to wipe up and two trash bags – one for the wet stencil (when necessary), which is not garbage, and one to pick-up garbage along the way. • Keep track of all storm drain stencils and turn this information over to the team leader or the appropriate local government agency. • Do not mark any storm drains with vehicles parked nearby. • Record the locations of any storm drains that have leaves, grass clippings, oil, or other pollutants. • Properly dispose of all trash at the end of the day, and return all empty paint cans and supplies to the team leader.
Information adapted from the following sources: *http://www.deq.state.la.us/assistance/litter/stormdrain.htm* Storm Drain Stenciling: A Manual for Communities (GI-212) *developed by the Texas Natural Resource Conservation Commission*

Top Resources

Texas Natural Resource Conservation Commission's Storm Drain Stenciling: A Guide for Communities. This extensive guide includes information on how to get volunteers involved, guidelines and materials for marking, reviews of five marking programs, and sample recognition certificates, press releases, door hangers, and public service announcements. http://www.tnrcc.state.tx.us/exec/sbea/education.html

The Urban Dweller's Guide To Watersheds http://www.museumca.org/creeks/umbrella.html

University of Wisconsin-Extension Water Resources Program Storm Drain Stenciling Web Page http://clean-water.uwex.edu/wav/stormdrain/index.htm

Earthwater Stencils Home Page http://www.earthwater-stencils.com/

Storm Drain Stenciling Project Guidelines http://www.epa.gov/adopt/patch/html/guidelines.html

The Ocean Conservancy's Storm Drain Sentries http://www.oceanconservancy.org/site/PageServer?pagename=op_sentries

South Carolina Department of Health and Environmental Control's Water Watch Campaign: Conducting a Storm Drain Tagging Project http://www.scdhec.net/water/pubs/wwtag2.pdf

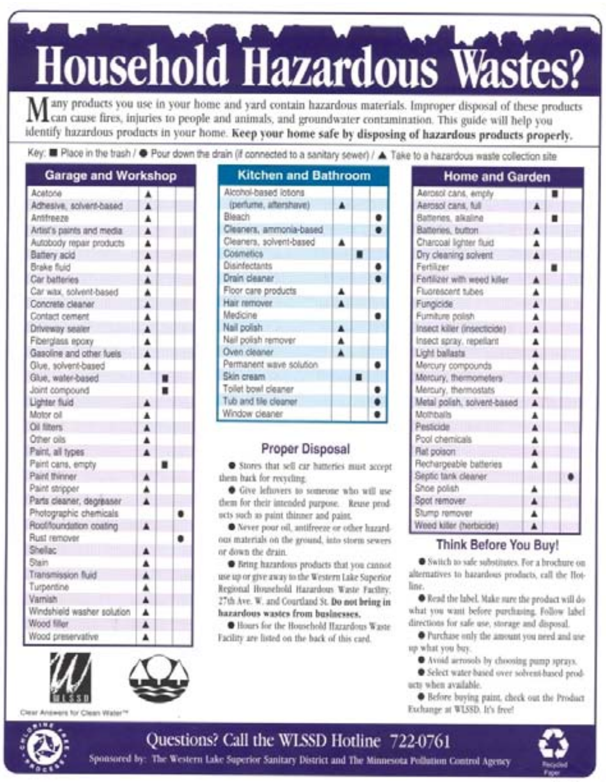
Multilingual Storm Drain Stenciling GreenSpace Partners worked with local watershed groups and volunteers to stencil storm drains with messages in English, Somali and Spanish. http://www.greeninstitute.org/GSP/programs/stormwater/stencils/stencils.html

North Carolina's Storm Drain Stenciling Project This project was piloted in 1994 along coastal NC watersheds and has received support from many state and national organizations and has received the "Take Pride in North Carolina" Award. http://www.bae.ncsu.edu/bae/programs/extension/wqg/smp-18/stormdrain/

N-14	Neighborhood Source Area: Garage HOUSEHOLD HAZARDOUS WASTE COLLECTION

Description

The average garage contains many products that are classified as hazardous waste, including paints, stains, solvents, used motor oil, excess pesticides, and cleaning products. The ideal watershed behavior is to regularly participate in household hazardous waste (HHW) collection days, and to be careful when rinsing paintbrushes, cleaning pesticide applicators and fertilizer spreaders, and fueling outdoor power equipment (Figure 1). The negative watershed behavior is continued storage, improper disposal or illegal dumping of household hazardous wastes, and poor cleaning, refueling and rinsing practices.



Household Hazardous Wastes?

Many products you use in your home and yard contain hazardous materials. Improper disposal of these products can cause fires, injuries to people and animals, and groundwater contamination. This guide will help you identify hazardous products in your home. **Keep your home safe by disposing of hazardous products properly.**

Key: ■ Place in the trash / ● Pour down the drain (if connected to a sanitary sewer) / ▲ Take to a hazardous waste collection site

Garage and Workshop			
Acetone	▲		
Adhesive, solvent-based	▲		
Antifreeze	▲		
Artist's paints and media	▲		
Autobody repair products	▲		
Battery acid	▲		
Brake fluid	▲		
Car batteries	▲		
Car wax, solvent-based	▲		
Concrete cleaner	▲		
Contact cement	▲		
Driveway sealer	▲		
Fiberglass epoxy	▲		
Gasoline and other fuels	▲		
Glue, solvent-based	▲		
Glue, water-based		■	
Joint compound		■	
Lighter fluid	▲		
Motor oil	▲		
Oil filters	▲		
Other oils	▲		
Paint, all types	▲		
Paint cans, empty		■	
Paint thinner	▲		
Paint stripper	▲		
Parts cleaner, degreaser	▲		
Photographic chemicals			●
Roof/foundation coating	▲		
Rust remover			●
Shellac	▲		
Stain	▲		
Transmission fluid	▲		
Turpentine	▲		
Varnish	▲		
Windshield washer solution	▲		
Wood filler	▲		
Wood preservative	▲		

Kitchen and Bathroom			
Alcohol-based lotions (perfume, aftershave)	▲		
Bleach			●
Cleaners, ammonia-based			●
Cleaners, solvent-based	▲		
Cosmetics		■	
Disinfectants			●
Drain cleaner			●
Floor care products	▲		
Hair remover	▲		
Medicine			●
Nail polish	▲		
Nail polish remover	▲		
Oven cleaner	▲		
Permanent wave solution			●
Skin cream		■	
Toilet bowl cleaner			●
Tub and tile cleaner			●
Window cleaner			●

Home and Garden			
Aerosol cans, empty		■	
Aerosol cans, full	▲		
Batteries, alkaline		■	
Batteries, button	▲		
Charcoal lighter fluid	▲		
Dry cleaning solvent	▲		
Fertilizer		■	
Fertilizer with weed killer	▲		
Fluorescent tubes	▲		
Fungicide	▲		
Furniture polish	▲		
Insect killer (insecticide)	▲		
Insect spray, repellant	▲		
Light ballasts	▲		
Mercury compounds	▲		
Mercury, thermometers	▲		
Mercury, thermostats	▲		
Metal polish, solvent-based	▲		
Mothballs	▲		
Pesticide	▲		
Pool chemicals	▲		
Rat poison	▲		
Rechargeable batteries	▲		
Septic tank cleaner			●
Shoe polish	▲		
Spot remover	▲		
Stump remover	▲		
Weed killer (herbicide)	▲		

Proper Disposal

- Stores that sell car batteries must accept them back for recycling.
- Give leftovers to someone who will use them for their intended purpose. Reuse products such as paint thinner and paint.
- Never pour oil, antifreeze or other hazardous materials on the ground, into storm sewers or down the drain.
- Bring hazardous products that you cannot use up or give away to the Western Lake Superior Regional Household Hazardous Waste Facility, 27th Ave. W. and Courtland St. **Do not bring in hazardous wastes from businesses.**
- Hours for the Household Hazardous Waste Facility are listed on the back of this card.

Think Before You Buy!

- Switch to safe substitutes. For a brochure on alternatives to hazardous products, call the Hotline.
- Read the label. Make sure the product will do what you want before purchasing. Follow label directions for safe use, storage and disposal.
- Purchase only the amount you need and use up what you buy.
- Avoid aerosols by choosing pump sprays.
- Select water based over solvent-based products when available.
- Before buying paint, check out the Product Exchange at WLSSD. It's free!

Clear Answers for Clean Water™

Questions? Call the WLSSD Hotline 722-0761

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Figure 1: Household Hazardous Waste Disposal Guidelines

Source: http://www.duluthstreams.org/understanding/impact_oil.html

How It Influences Water Quality

According to EPA, the average home/garage accumulates as much as 100 pounds of household hazardous waste per year**.** Nationally, households are collectively estimated to generate more than 1.6 million tons of household hazardous wastes annually. The proportion of HHW that reaches the storm drain system is not well known. Most HHW appears to be stored indefinitely, thrown out with the trash, or flushed down the sink/toilet, which is not environmentally acceptable. The key unknown is what fraction of HHW is illegally dumped into the storm drain. It is probable that most HHW enters the storm drain system during outdoor rinsing of pesticide applicators and outdoor painting cleanup. HHW that reaches the storm drain system can potentially be toxic to downstream aquatic life.

Percentage of Residents Engaging in HHW Collection

Homeowner participation in HHW collection programs is usually quite low, with several studies indicating participation rates of one to 5% (HGAC, 2004).

Variation in Participation

Convenience and awareness appear to be critical factors influencing participation in household hazardous waste collection programs. Participation is inversely related to the distance homeowners must travel to recycle waste, restrictions on what can be accepted and the number of days each year that collection events are held.

Techniques to Increase Participation

Communities continue to experiment with improved techniques to make HHW collection more convenient for residents, including:

- Mass media campaigns to educate residents on proper outdoor cleaning/rinsing
- Conventional outreach to notify residents about HHW collection days
- More frequent HHW collection days
- Providing curbside disposal options for certain HHW
- Establishing permanent collection facilities at solid waste facilities
- Providing mobile HHW pickup
- Waiving disposal fees at landfills
- Storm drain marking (see N-21)

Good Examples

The City of Denver Pilot Door-to-Door HHW Collection Program. This unique program assists residents in proper disposal and recycling of household hazardous wastes. Residents are permitted one HHW collection annually and receive a collection date and an HHW Kit that can hold up to 75 pounds. The program not only provides a curbside pick-up program for household hazardous waste, but also educates citizens on how to prevent the accumulation of chemicals in the garage.
http://www.denvergov.org/admin/template3/forms/INSERT1.pdf

King County Wastemobile. The Wastemobile is a traveling collection program that goes to two sites in the county per month to accept HHW and provide information about alternatives to hazardous products. The Wastemobile is funded through a surcharge on solid waste disposal and wastewater discharge, and residents utilizing the Wastemobile are not charged a fee on site.
http://www.govlink.org/hazwaste/house/disposal/wastemobile/

Top Resources

EPA Household Hazardous Waste Website
http://www.epa.gov/epaoswer/non-hw/muncpl/hhw.htm

Guide to Household Hazardous Wastes
http://www.epa.gov/grtlakes/seahome/housewaste/house/products.htm

Household Hazardous Waste: Steps to Safe Management
A guide for residential homeowners that describes household hazardous waste and the dangers of improper disposal.
http://www.epa.gov/epaoswer/non-hw/househld/hhw.htm

Household Hazardous Waste (HHW) Management: A Manual for One Day Community Collection Programs
A manual that helps communities plan for one-day, drop-off HHW collection programs. Provides community leaders with guidance on all aspects of planning, organizing, and publicizing a HHW collection program.
http://www.epa.gov/epaoswer/non-hw/househld/hhw/cov_toc.pdf

Department of Defense - Household Hazardous Waste Topic Hub
http://wrrc.p2pays.org/p2rx/toc.cfm?hub=16&subsec=7&nav=7&CFID=23448&CFTOKEN=55325833

Household/Small Business Hazardous Waste: A Manual for Sponsoring a Collection Event
http://www.dep.state.pa.us/dep/deputate/airwaste/wm/Hhw/Documents/TechMan.pdf

N-20	Neighborhood Source Area: Common Areas	
	BUFFERSCAPING	

Description

Many neighborhoods built in the last few decades still have a decent stream corridor protected by buffers, flood plain setbacks or wetland protection requirements. The stream corridor that remains is often in common or private ownership. The ideal watershed behavior is to respect the boundaries of the stream corridor and expand it where possible through "bufferscaping" and backyard planting of native plants and trees. The negative watershed behavior is stream corridor encroachment, through clearing, dumping, allowing invasive plant species to spread from private yards, and erecting structures (Figure 1).

How Bufferscaping Influences Subwatershed Quality

A forested stream corridor is an essential ingredient of a healthy stream, except in certain arid and semi-arid regions. Bufferscaping can add to the total area of the stream corridor, provide wildlife habitat and enhance the structure and function of the buffer. By contrast, encroachment activities diminish the quality, function and attractiveness of the stream buffer.

Percentage of People Encroaching on/Expanding the Stream Corridor

Data is not currently available to estimate the rate at which homeowners add to the stream corridor, but several troubling studies have examined the degree of residential buffer encroachment. Many residents perceive buffers as an extension of their backyard, and think little of removing trees, dumping yard wastes or erecting structures on their land. A major reason is that nearly 60% of residents are ignorant of the boundaries and intended purpose of stream buffers (Heraty, 1993). Studies of wetland buffer encroachment in Washington residential areas found that 95% of buffers were visibly altered, 40% to such a degree that their functional value was eliminated (Cooke, 1991). Other studies of Maryland buffers indicate encroachment rates of as much as 1% of area buffer per year. Clearly, residential awareness and behaviors in regard to the stream corridor need to be improved in many subwatersheds.

Neighborhood Factors that Contribute to Buffer Stewardship

Several factors play a role in how buffers are managed within a neighborhood: the age of the development, lot size, activism of homeowner association, boundary signs, and the prior existence of stream buffer or flood plain regulations.

Figure 1: A New Subdivision Encroaching on the Stream Buffer

Techniques to Encourage Buffer Stewardship

Protecting or expanding stream buffers requires direct education and interaction with individual property owners that back up to the buffer. Some useful techniques include:

- Bufferscaping assistance and guides
- Community buffer walks
- Buffer boundary inspections
- Boundary signs (Figure 2)
- Defining unallowed uses in local stream buffer ordinances
- Presentations to community associations
- Adopt-a-stream program
- Financial incentives for bufferscaping

Figure 2: Sign Identifying a Buffer Boundary

Good Examples

Burnett County, WI Natural Shoreline Incentives. The county pays homeowners to enroll in a program to maintain shorelines in their natural state. The program asks for a voluntary commitment by placing a covenant on a homeowner's property stating that the shoreline will remain natural. Program members receive a payment of $250 after an initial inspection that certifies the property meets program standards, and the shoreline covenant is recorded. Participants also receive an annual deduction from their tax statement as a thank you.
http://www.burnettcounty.com/burnett/lwcd/preserve.html

Tennessee Valley Authority Banks and Buffers Software: A Guide to Selecting Native Plants for Streambanks and Shorelines includes software application to help homeowners select plants for bufferscaping. It also contains selected characteristics and environmental tolerances of 117 plants and more than 400 color photographs illustrating habitat and growth form.
http://www.tva.gov/river/landandshore/stabilization/websites.htm

Top Resources

The Architecture of Urban Stream Buffers
http://www.stormwatercenter.net/Library/Practice/39.pdf

Chesapeake Bay Riparian Handbook: A Guide for Establishing and Maintaining Riparian Forest Buffers
http://www.chesapeakebay.net/pubs/subcommittee/nsc/forest/riphbk.pdf

Riparian Forest Buffer Design, Establishment, and Maintenance
http://www.agnr.umd.edu/MCE/Publications/Publication.cfm?ID=13

Riparian Area Management: A Citizen's Guide
http://www.co.lake.il.us/elibrary/publications/smc/riparian.pdf

Backyard Buffers for the South Carolina Lowcountry
http://www.scdhec.net/ocrm/pubs/backyard.pdf

Alliance for the Chesapeake Bay – Backyard Buffers
http://www.acb-online.org/pubs/projects/deliverables-158-1-2003.pdf

Cayuga County, NY – Green Thumbs for Blue Water Workshops
http://www.co.cayuga.ny.us/wqma/greenthumbs

Tree-mendous Maryland
http://www.dnr.state.md.us/forests/treemendous/

N-21

Neighborhood Source Area: Common Areas

STORM DRAIN MARKING

Description

The ideal watershed behavior is to get residents to fully understand the connection between storm drains and downstream waters and avoid any activity that discharges pollutants. This awareness is most often created by marking or stenciling storm drain inlets with a "Don't dump, drains to..." message (Figure 1). The negative watershed behavior is to use storm drains as a means of disposal for trash, yard waste and household products.

How Storm Drain Marking Influences Water Quality

Storm drain marking sends a clear message to keep trash and debris, leaf litter and organic matter out of the storm drain system. Stencils may also reduce residential spills and illicit discharges. Marking is also a direct and local way to increase watershed awareness and practice neighborhood stewardship. The actual water quality benefits of storm drain marking have yet to be demonstrated through field research or monitoring. Still, marking is always a sign of good neighborhood housekeeping. Santa Monica, CA also marks the hotline phone number on storm drains to report water quality problems and illegal dumping.

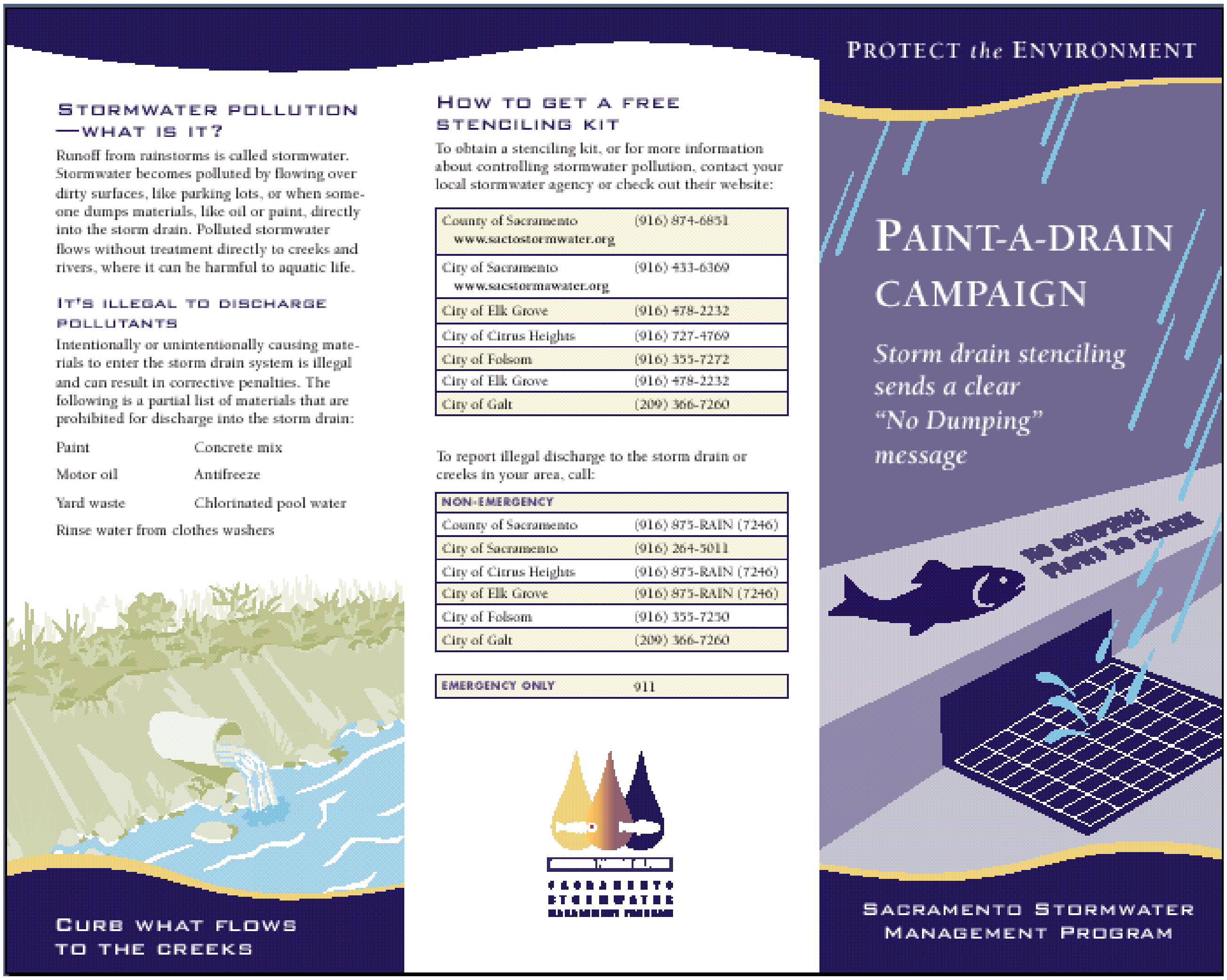
Percentage of Residents Engaging in Storm Drain Marking

This behavior does not require extensive resident participation; only a few trained volunteers are needed to thoroughly mark storm drains within a neighborhood. Volunteers can include scouts, service groups, high school students, neighborhood associations, and other volunteers. Normally, marking is "sanctioned" by the local public works authority or environmental agency, so it is important to coordinate closely with them (Figure 2). Table 1 provides guidance for marking storm drains.

Factors to Consider in Storm Drain Marking

The only significant impediment to storm drain marking is when a neighborhood is primarily served by open channels or grassed channels, rather than enclosed storm drains.

Figure 1: Storm Drain Marking



STORMWATER POLLUTION —WHAT IS IT?

Runoff from rainstorms is called stormwater. Stormwater becomes polluted by flowing over dirty surfaces, like parking lots, or when someone dumps materials, like oil or paint, directly into the storm drain. Polluted stormwater flows without treatment directly to creeks and rivers, where it can be harmful to aquatic life.

IT'S ILLEGAL TO DISCHARGE POLLUTANTS

Intentionally or unintentionally causing materials to enter the storm drain system is illegal and can result in corrective penalties. The following is a partial list of materials that are prohibited for discharge into the storm drain:

Paint	Concrete mix
Motor oil	Antifreeze
Yard waste	Chlorinated pool water
Rinse water from clothes washers	

CURB WHAT FLOWS TO THE CREEKS

HOW TO GET A FREE STENCILING KIT

To obtain a stenciling kit, or for more information about controlling stormwater pollution, contact your local stormwater agency or check out their website:

County of Sacramento www.sactostormwater.org	(916) 874-6851
City of Sacramento www.sacstormwater.org	(916) 433-6369
City of Elk Grove	(916) 478-2232
City of Citrus Heights	(916) 727-4769
City of Folsom	(916) 355-7272
City of Elk Grove	(916) 478-2232
City of Galt	(209) 366-7260

To report illegal discharge to the storm drain or creeks in your area, call:

NON-EMERGENCY	
County of Sacramento	(916) 875-RAIN (7246)
City of Sacramento	(916) 264-5011
City of Citrus Heights	(916) 875-RAIN (7246)
City of Elk Grove	(916) 875-RAIN (7246)
City of Folsom	(916) 355-7230
City of Galt	(209) 366-7260

EMERGENCY ONLY	911

PROTECT *the* ENVIRONMENT

PAINT-A-DRAIN CAMPAIGN

Storm drain stenciling sends a clear "No Dumping" message

SACRAMENTO STORMWATER MANAGEMENT PROGRAM

Figure 2: Educational Brochure on Storm Drain Marking/Stenciling

Source: http://www.sactostormwater.org/documents/stencil_brochure_03.pdf

Table 1: Storm Drain Marking Guidance
• Enlist one person to serve as the team leader, and make sure he/she knows all marking rules and safety procedures. • Review all safety procedures before marking. • Marking should be performed by at least two people, so one can be on the lookout for oncoming vehicles. Safety vests and traffic cones can be used to alert vehicles. • Remember to wear old cloths and shoes. • Bring paper towels or a rag to wipe up and two trash bags – one for the wet stencil (when necessary), which is not garbage, and one to pick-up garbage along the way. • Keep track of all storm drain stencils and turn this information over to the team leader or the appropriate local government agency. • Do not mark any storm drains with vehicles parked nearby. • Record the locations of any storm drains that have leaves, grass clippings, oil, or other pollutants. • Properly dispose of all trash at the end of the day, and return all empty paint cans and supplies to the team leader.
Information adapted from the following sources: *http://www.deq.state.la.us/assistance/litter/stormdrain.htm* Storm Drain Stenciling: A Manual for Communities (GI-212) *developed by the Texas Natural Resource Conservation Commission*

Top Resources

Texas Natural Resource Conservation Commission's Storm Drain Stenciling: A Guide for Communities. This extensive guide includes information on how to get volunteers involved, guidelines and materials for marking, reviews of five marking programs, and sample recognition certificates, press releases, door hangers, and public service announcements. http://www.tnrcc.state.tx.us/exec/sbea/education.html

The Urban Dweller's Guide To Watersheds
http://www.museumca.org/creeks/umbrella.html

University of Wisconsin-Extension Water Resources Program Storm Drain Stenciling Web Page
http://clean-water.uwex.edu/wav/stormdrain/index.htm

Earthwater Stencils Home Page
http://www.earthwater-stencils.com/

Storm Drain Stenciling Project Guidelines
http://www.epa.gov/adopt/patch/html/guidelines.html

The Ocean Conservancy's Storm Drain Sentries
http://www.oceanconservancy.org/site/PageServer?pagename=op_sentries

South Carolina Department of Health and Environmental Control's Water Watch Campaign: Conducting a Storm Drain Tagging Project
http://www.scdhec.net/water/pubs/wwtag2.pdf

Multilingual Storm Drain Stenciling GreenSpace Partners worked with local watershed groups and volunteers to stencil storm drains with messages in English, Somali and Spanish. http://www.greeninstitute.org/GSP/programs/stormwater/stencils/stencils.html

North Carolina's Storm Drain Stenciling Project This project was piloted in 1994 along coastal NC watersheds and has received support from many state and national organizations and has received the "Take Pride in North Carolina" Award.
http://www.bae.ncsu.edu/bae/programs/extension/wqg/smp-18/stormdrain/

RR-2	Rooftop Retrofit Design Sheets	
	RAIN BARRELS	

Description

Rain barrels are used to capture, store and reuse residential rooftop runoff. They consist of a simple stormwater collection device that stores rainwater from individual rooftop downspouts. Stored water can be used as a source of outdoor water for car washing or lawn or garden watering. The rooftop runoff stored in a rain barrel would normally flow onto a paved surface and eventually into a storm drain. Rain barrels typically have a capacity of 50 to 100 gallons of water (Figure 1).

Rain barrels can be applied to new and existing residential developments. They are most applicable for single family residential and townhouse uses. Rain barrels can have benefits on both a site level and subwatershed wide basis. Rain barrels promote water conservation, reduce water demand, and lower irrigation costs and demand (a rain barrel can save homeowners about 1,300 gallons of water during the peak summer months). Rain barrels are inexpensive and easy to build and install and create stronger watershed awareness.

Feasibility

Rain barrels are a common on-site retrofit practice to treat rooftop runoff from individual homes. Because each rain barrel retrofit treats such a small area, dozens or hundreds are needed to make a measurable difference at the subwatershed level. Consequently, widespread homeowner implementation of rain barrels requires targeted education, technical assistance and financial subsidies.

The potential to retrofit with rain barrels is normally evaluated as part of the neighborhood source assessment of the USSR. The most important factor is the proportion of existing homes that are directly connected to the storm drain system. In general, neighborhoods with residential lot sizes as small as 4000 square feet can be effectively retrofit with rain barrels (Figure 2). Negative neighborhood factors include the presence of basements, limited space for barrel de-watering, and lack of active homeowner association.

Regional and Climatic Considerations - Several issues pertaining to water quality, climate, and algae and mosquito control should be taken into account in design. Water

Figure 1: Installed Rain Barrel

quality is usually not a major issue unless the stored water will be used for drinking water, which is not recommended without additional filtering and treatment. Rooftop runoff contains trace metals, such as zinc, copper and lead. The presence of these metals, however, should not adversely affect the use of rooftop runoff for supplemental lawn and garden irrigation.

Rain barrels require modification in regions with cold winters. Rain barrels do not function if temperatures regularly reach the freezing mark during winter months. Consequently, rain barrels should be drained and disconnected during winter months to ensure that frozen water does not damage the rain barrel, to back up into downspouts or overflow into a building foundation. Alternatively, rain barrels can be installed inside a building or garage.

Figure 2: Rain barrel installed on a balcony due to space constraints on a small lot. C

It is important to reduce the amount of organic matter entering the barrel to prevent algae from growing in a rain barrel. This can be a problem for rain barrels serving a downspout whose gutters fill with leaves and other debris.

Since rain barrels have standing water, there is some risk that they may become mosquito-breeding sites. Simple solutions to reduce mosquito breeding include routine emptying of the barrel on a five day cycle to interfere with breeding time required by mosquitoes or screening the rainwater inlet so mosquitoes cannot enter the rain barrel (USWG, 2003).

Site Constraints and Permits - Rain barrels may not be appropriate in high-density urban settings where there is little or no green space to irrigate using the collected water. Similarly, neighborhoods where homes are close together may not have adequate surface area to safely discharge rain barrel overflow. Lastly, installation of rain barrels in neighborhoods where downspouts are already disconnected provides little or no retrofit benefit.

Implementation

Design - Rain barrels are much easier to design compared to other on-site retrofit practices. Still, the rain barrel should always incorporate the same basic design elements of any good stormwater practice, such as pretreatment (clean gutters), adequate storage capacity, and safe conveyance of flooding with rain barrel overflows).

Construction - Rain barrels can be purchased or custom made from large plastic drums (typically 55-gallon drums). They are relatively easy to construct using a few basic components available from hardware stores. Installation of a typical rain barrel involves disconnecting individual downspouts and redirecting it into the top of the rain barrel.

Rain barrels have an overflow pipe that redirects the rainwater back into the downspout or onto the lawn or other pervious surface when the rain barrel is full. Other rain barrel components may include spigots, connector barrels, mosquito proofing, and even water filters (CWP, 2003).

Maintenance – The maintenance required for rain barrels involves regular dewatering of the barrel to preserve capacity for the next storm event. Roof gutters should be inspected to ensure that leaves and organic matter are not entering the downspout to the rain barrel. In addition, the rain barrel, gutters, and downspouts need to be checked for leaks or obstructions. Lastly, the overflow pipe should be checked to ensure that overflow is draining in a non-erosive manner

Cost - Although costs vary across manufacturers, the average cost of a single rain barrel ranges from about $50 to $300, with an average of about $150 The cost per cubic foot treated is about $25 per cubic foot treated (ranging from $7 to $40) Costs can be reduced if volunteers or watershed groups perform the instillation. Consult Profile Sheet 0S-10 for some helpful resources on rain barrel delivery.

Further Resources

The following internet resources are recommended for a detailed description on how to build and install a rain barrel.

How to Build and Install a Rain Barrel
http://www.cwp.org/Community_Watersheds/brochure.pdf

Rain Barrels for Dummies: Unofficial Guidance for Backyard Retrofitters.
http://www.cwp.org/Community_Watersheds/Rain_Barrel.htm

King County, WA. Rain Barrel Information and Sources for the Pacific Northwest.
http://dnr.metrokc.gov/wlr/PI/rainbarrels.htm

Low Impact Development Center (LID). Rain Barrels and Cisterns.
http://www.lid-stormwater.net/raincist/raincist_maintain.htm

Maryland Green Building Program: Building a Simple Rain Barrel.
http://www.dnr.state.md.us/ed/rainbarrel.html

City of Bremerton. Rain Barrel Program: A Modern Spin On An Old Idea.
http://www.cityofbremerton.com/content/sw_makeyourownrainbarrel.html

Portland, OR Downspout Disconnection Program
http://www.portlandonline.com/bes/index.cfm?c=43081

RR-3	Rooftop Retrofit Design Sheets RAIN GARDENS	

Rain gardens capture, filter and infiltrate residential rooftop runoff, and consist of small, landscaped depressions that are usually 6 to 18 inches deep. A sand/soil mixture below the depression is planted with native shrubs, grasses or flowering plants (Figure 1). Rooftop runoff is detained in the depression for no more than a day until it either infiltrates or evapotranspires. Rain gardens can replenish groundwater, reduce stormwater volumes, and remove pollutants. A rain garden allows at least 30% more water to infiltrate into the ground compared to a conventional lawn (UWEO, 2002).

Rain gardens can be applied to existing single-family homes within targeted neighborhoods. Rain gardens have many benefits including increased watershed awareness and personal stewardship, improved neighborhood appearance, and creation of habitat for birds and butterflies. Rain gardens must be properly maintained; otherwise they may create basement flooding and standing water, and become an eyesore. For this reason, implementation of rain gardens requires a dedicated homeowner and community buy-in.

Feasibility

Rain gardens are essentially a non-engineered form of bioretention that treats rooftop runoff from individual roof leader. (see Profile Sheet ST-4). Because each rain garden treats a rather small area, dozens or hundreds are needed to make a measurable difference at the subwatershed level. Consequently, widespread homeowner implementation of rain gardens requires targeted education, technical assistance and financial subsidies.

The potential to retrofit rain gardens is normally evaluated as part of the neighborhood source assessment of the USSR. The most

Figure 1: Rain Garden

important factor is the proportion of existing homes that are directly connected to storm drain system. In general, neighborhoods with large residential lot sizes are most suitable (1/4 acre lots and larger). Negative neighborhood factors include the presence of basements, compacted soils, and poor neighborhood awareness. Positive factors are large rooftop areas that are directly connected to the storm drain system, lots with extensive tree canopy and good neighborhood housekeeping.

Regional and Climatic Considerations - One common misperception associated with rain gardens is that they provide a breeding ground for mosquitoes. Mosquitoes need three to seven days to breed, and standing water in the rain garden should last for only a few hours after most storms USWG, 2003).

Plant selection is also an important element of a successful rain garden. Considerations should include drought-tolerant plants that will not require much watering, but can withstand wet soils for up to 24 hours. Plant selection also depends on the amount of sun the garden receives. Xeriscaping (the practice of landscaping to conserve water) is recommended in arid climates (Figure 2). For a listing of the native plants in your region, visit: http://plants.usda.gov/ (USDA NRCS). This database allows the user to search for plants by name (common or scientific) or by state or county.

Site Constraints and Permits - The site constraints for rain gardens include soils and proximity to the house. The garden should be located a minimum of 10 feet away from the house to prevent basement seepage. Rain gardens work best in areas with well-drained soils. However, performance can be enhanced in poorly draining soils by providing an underdrain system or soil amendments.

Implementation

Design - The surface area of a rain garden should be between 20% and 30% of the roof area it drains to it to ensure it can temporarily hold water from a 1-inch rainstorm. Further guidance on sizing a rain garden is provided in Table 1.

To ensure that the water flows from the impervious surface to the garden, maintain at least a 1% slope from the lawn down to the rain garden (a shallow swale can be used). A downspout extension can be used to direct rooftop flow into the garden.

Construction - Construction of rain gardens is simple but requires physical labor to dig the garden, prepare the soil, and plant desired species. Select plants that have a well-established root system and plant them approximately one foot apart (UWEO, 2002). More information on how to install rain gardens can be found online in the Further Resources section.

Figure 2: Xeriscaped Garden

Table 1: Rain Garden Sizing Example
30' x 30' house footprint
¼ of this area drains to one downspout
15' x 15' = 225 sf
20% of 225sf = 45sf
30% of 225sf = 67.5 sf
The rain garden area should be between 45 and 67.5 square feet, depending on the soil type (use 20% for sandier soils in Soil Group A)

Maintenance - Maintenance of rain gardens is essential to ensure public acceptance and proper performance, and reduce nuisance problems. Typical maintenance includes periodic watering and weeding. The use of native plants can significantly reduce overall yard maintenance needs since they require less mowing, watering and fertilizer than conventional lawns.

Cost - The cost to construct a rain garden includes labor for construction and design, plants, and soil mixture. Design and construction costs can vary widely depending on the complexity of the project. Rain gardens typically cost about $4.00 per cubic foot of runoff treated (ranging from $3 to $5). Do-it-yourselfers can create beautiful rain gardens for a fraction of this cost.

Further Resources

Center for Watershed Protection *How to Install a Rain Garden*. http://www.cwp.org/Community_Watersheds/brochure.pdf

UWEO (University of Wisconsin Extension Office). Rain Gardens: http://clean-water.uwex.edu/pubs/pdf/home.gardens.pdf

Bannerman, R. and E. Considine. 2003. Rain Gardens: A how-to manual for homeowners http://www.dnr.state.wi.us/org/water/wm/dsfm/shore/documents/rgmanual.pdf

Center for Watershed Protection . *Rain Garden Applications and Simple Calculations*. http://www.cwp.org/Community_Watersheds/Rain_Garden.htm

Friends of Bassett Creek. 2000. *Rain Gardens: Gardening with Water Quality in Mind*. http://www.mninter.net/~stack/bassett/gardens.html.

Minneapolis, MN Neighborhood Rain Gardens http://www.fultonneighborhood.org/lfrwm.htm

Portland, OR Downspout Disconnection Program http://www.portlandonline.com/bes/index.cfm?c=43081

Rain Gardens for Stormwater Bioretention and Ecological Restoration.. http://www.nwf.org/campusecology/files/reillyprop.pdf

"Plotting to Infiltrate? Try Rain Gardens." *Yard and Garden Line News* 3(6). http://www.extension.umn.edu/yardandgarden/YGLNews/YGLN-May0101.html

West Michigan Environmental Action Council and the City of Grand Rapids RainGardens.org. http://www.raingardens.org

How to Build and Install a Rain Barrel

What Is a Rain Barrel?

A rain barrel collects and stores rainwater from your rooftop to use later for things like lawn and garden watering. Water collected in a rain barrel would normally flow through your downspout, onto a paved surface, and eventually into a storm drain.

Why Use Rain Barrels?

- Rain barrels help **lower water costs** (a rain barrel can save approximately 1,300 gallons of water during peak summer months).
- Storing rainwater for garden and lawn use helps **recharge groundwater** naturally .
- Rain barrels **reduce water pollution** by reducing stormwater runoff, which can contain pollutants like sediment, oil, grease, bacteria, and nutrients.
- Rain barrels are **inexpensive and easy** to build and install.

SUPPLIES

- ✔ One 55-gallon drum
- ✔ One 5' section vinyl garden hose (3/4" OD x 5/8" ID)
- ✔ One 4" diameter atrium grate (basket used in garden ponds and pool skimmers)
- ✔ One 1/2" PVC male adapter
- ✔ One 3/4" x 1/2" PVC male adapter
- ✔ One 5' section of drain hose, drain line, or sump pump line (1-1/4")
- ✔ One 1-1/4" female barbed fitting and one 1-1/4" male threaded coupling
- ✔ One vinyl gutter elbow
- ✔ Drill (or a hole saw)
- ✔ Router, jig saw or coping saw
- ✔ Measuring tape

Optional

- ✔ Waterproof sealant (silicone caulk, PVC glue)
- ✔ Teflon tape
- ✔ Fiberglass window screen material or mosquito netting
- ✔ Cinder blocks or wooden crate

Instructions

Steps 1-3 below explain how to build and install your rain barrel. The supplies listed above can all be found at most home improvement and hardware stores. The 55-gallon drums are available for $5 from the Pepsi Bottling Company in Baltimore, or you can purchase a ready-to-install barrel from the South River Federation. For more information contact the Rain Barrel Community Action Team at #410-721-0661 or actionteams@southriverfederation.org.

Sources

Pepsi Bottling Company
Charlie Dickerson #410-366-3500

South River Federation
Rain Barrel Community Action Team
#410-721-0661
actionteams@southriverfederation.org

Arlington Echo Outdoor Education Center
www.arlingtonecho.org

Maryland Green Building Program
www.dnr.state.md.us/smartgrowth/greenbuilding/rainbarrel.html

Weems Creek Conservancy
www.weemscreek.org

STEP 1. Cut Holes in Barrel

- Cut lower drain hole

Measure about 1 inch above the bottom of the barrel where the barrel side begins to rise toward the top. Using a ¾" bit (or hole saw), drill a hole through the barrel.

- Cut upper drain hole

Mark the upper drain hole according to where you want the overflow to be located in relationship to the lower drain. Use a 1-5/8" hole saw to cut out the overflow hole.

- Cut top hole for atrium grate (filter)

Using the atrium grate as a template for size, mark a circle at the center of the top of the drum (locating the rainwater inlet in the center of the barrel lets you pivot the barrel without moving the downspout). Drill a ½" hole inside of the marked circle. Use a router, jigsaw or coping saw to cut until the hole is large enough to accommodate the atrium grate, which filters out large debris. Don't make the hole too big – you want the flange of the atrium grate to fit securely on the top of the barrel without falling in.

- Cut notch to hold hose

Using a ½" bit or hole saw, cut out a notch at the top of the barrel rim (aligned so that it is above the lower drain hole). The notch should be large enough so that the end of the hose with the adapter will firmly snap into place.

STEP 2. Set Up Barrel and Modify Downspout

- Set up barrel

Since water will only flow from the garden hose when the hose is below the barrel, place the barrel on high ground or up on cinder blocks or a sturdy wooden crate underneath your downspout.

- Modify your downspout

Cut your existing downspout using a saw so that the end can be placed over the top of your rain barrel. Use a 3" vinyl downspout elbow to connect the two downspout pieces (or use a downspout adapter and a piece of corrugated plastic pipe). Trim the end of the downspout if necessary.

STEP 3. Assemble Parts

- Attach garden hose to lower drain hole

Screw in the ½" PVC male adapter to the lower drain hole. The hard PVC threads cut matching grooves into the soft plastic of the barrel. Unscrew the ½" PVC male adapter from the hole. Wrap threads tightly with teflon tape (optional). Coat the threads of the coupler with waterproof sealant (optional). Screw the coated adapter back into the hole and let it sit and dry for 24 hours (optional). Attach 5' foot garden hose to the PVC male adapter. Attach the ¾" x ½" PVC male adapter to the other end of the hose (this can be readily adapted to fit a standard garden hose).

- Attach drain hose to upper drain hole

Put the 1¼" male threaded coupling inside the barrel with the threads through the hole. From the outside, screw the 1¼" female barbed fitting onto the threaded coupling. Use silicone on the threads (optional). Attach 5' section of drain hose to upper fitting.

- Place atrium grate and screen in top hole

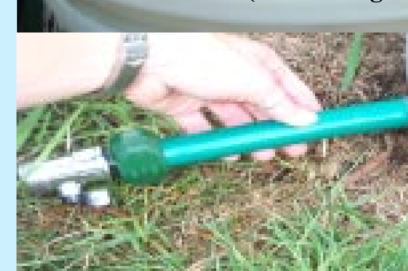
Using PVC glue, secure a piece of fine mesh window screen inside or outside of the atrium grate to filter out debris and control mosquitoes (optional). Place the atrium grate into the hole (basket down).

- Position the downspout

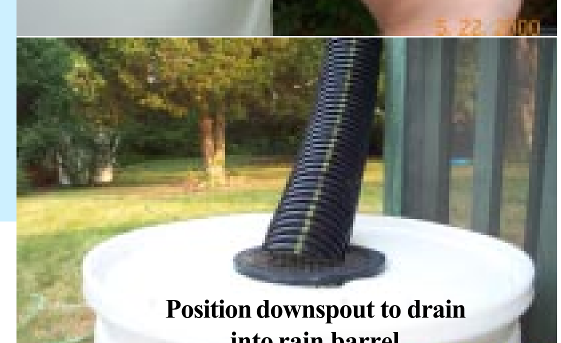
Position the end of your downspout so it drains onto the atrium grate on the rain barrel.


Tools and supplies


Cut hole for atrium grate (for filtering leaves)


Attach garden hose for watering


Attach overflow hose


Position downspout to drain into rain barrel

This instructional flyer was created by the South River Federation and the Center for Watershed Protection August, 2002

This project was funded through a grant from the Chesapeake Bay Trust

How to Install a Rain Garden

What Is the South River Federation?

The South River Federation (SRF) is a non-profit organization dedicated to restoring, protecting and preserving the South River watershed. For more information on how you can help the protect the South River or for information about membership, rain barrels or rain gardens, visit SRF's website at www.geocities.com/RainForest/Wetlands/2002/ or call Drew Koslow, SRF president, at #410-990-9173 or send email to membership@southriverfederation.org

Source: Roger Bannerman

What Is a Rain Garden?

A rain garden uses native landscaping to soak up rain water from your downspout. The middle part of the garden holds several inches of water, allowing it to slowly infiltrate into the ground instead of being delivered to the stormdrain all at once.

Why Install a Rain Garden?

A rain garden allows 30% more water to infiltrate into the ground than a conventional lawn. This helps replenish the groundwater supply (important during a drought!), and reduces the amount of pollution that reaches our streams through stormwater runoff. Since studies show that the first inch of rainfall is responsible for the bulk of the pollutants in stormwater, a rain garden is designed to temporarily hold water from a one-inch rainstorm, and slowly filter out many common pollutants like sediment, oil, grease and nutrients. Rain gardens require less watering and fertilizer than conventional lawns, and provide habitat for birds and butterflies.

Source: Corinne Reed-Miller

15 feet 15 feet 1/4 of the roof drains to one downspout = 15' x 15'

Instructions

Follow the three steps below to install a rain garden in your yard. Materials you'll need include plants for the garden (see plant list below); a hose, rope or string; a level; a shovel or spade; humus or other soil amendments (optional); a measuring tape; and a downspout extension (also optional).

Step 1: Size and Locate your Rain Garden

First, measure the footprint of your house and determine how much of your rooftop area drains to the downspout you're using for your garden (for gutters with a downspout at each end, assume that half the water goes to each downspout). Be sure you measure the house footprint only; do not take the roof slope into account. The surface area of your rain garden should be between 20% and 30% of the roof area that will drain into the rain garden. Locate the garden at least 10 feet away from the house (to prevent soggy basements), and maintain a minimum 1% slope from the lawn down to the rain garden (you can also create a shallow ditch to ensure the water flows from roof to the garden, or use a downspout extension to direct the flow into the garden). Lay out the boundary of the garden with a rope.

Rain garden sizing example:
30' x 30' house area
1/4 of this area drains to one downspout
15' x 15' = 225 ft^2
20% of 225ft^2 = 45ft^2
30% of 225ft^2 = 67.5ft^2
The rain garden area should be between 45 and 67.5 square feet, depending on soil type (use 20% for sandier soils).

lay out the site

Source: Roger Bannerman

Step 2: Dig the Rain Garden

To enable the rain garden to hold several inches of water during a storm, you'll have to dig a hole 3-4 inches deep across the entire surface of the garden. If the soil lacks organic material, you can improve it by digging the hole 5-6 inches deep, and adding 2-3 inches of humus or other organic material. Make sure the bottom is level. Next, test how the garden will hold water during a storm by letting water flow into the rain garden from a hose placed at the downspout. Based on this test, make any necessary adjustments (e.g., create a berm on the lower side of the garden using the diggings, or use a downspout extension or shallow ditch to direct the water into the garden).

dig down 3-4 inches

Source: Corinne Reed-Miller

Step 3: Add Plants to the Rain Garden

Choose drought-tolerant plants that won't require much watering, but make sure they can withstand wet soils for up to 24 hours. A list of native plants that meet these criteria is provided below. Also take into account how much sun your garden receives. It's often helpful to draw out a planting plan before you start, and mark planting areas within the garden with string. After planting, weeding may be required until the plants become more established. You may also need to periodically prune some of the plants to let others grow. In the winter, leave dead or dormant plants standing and cut back in the spring. Your garden may need a bit more maintenance than a lawn in the beginning, but in the long run it will be easier to care for and provide many added benefits!

add plants

Source: Corinne Reed-Miller

Native Plants for Rain Gardens

= sun or part sun *= part sun/part shade* *= shade*

Ferns
- rattlesnake fern
- hay-scented fern

Grasses
- blue wood sedge
- Canada wild rye
- bottle brush grass
- Virginia wild rye

Perennials
- butterflyweed
- New England aster
- joe-pye weed
- wild snakeroot
- cardinal flower
- wild bergamot
- blue-eyed grass
- Solomon's seal
- black-eyed Susan
- wild pink
- purple coneflower
- yellowflag iris
- St. John's wort
- early goldenrod
- daylily
- hosta
- grass-leaf blazingstar

Shrubs
- mountain laurel
- highbush blueberry
- spicebush
- inkberry
- sweet pepperbush

a beautiful two-year old rain garden!

Source: Roger Bannerman

Sources

Weems Creek Conservancy www.weemscreek.org

Rain Gardens: A household way to improve water quality in your community University of Wisconsin -Extension and Wisconsin Department of Natural Resources http://clean-water.uwex.edu/pubs/raingarden/gardens.pdf

This instructional flyer was created by the South River Federation and the Center for Watershed Protection, August 2002
This project was funded through a grant from the Chesapeake Bay Trust

Downspout Disconnection

Why Should I disconnect?
During a heavy storm, each downspout on your home can deliver 12 gallons a minute to the sewer system, which can contribute to basement backups and sewer overflows. By simply disconnecting a downspout, you can make a difference in keeping excess water out of the sewer system.

Who Should Disconnect?
Nearly everyone!

How??

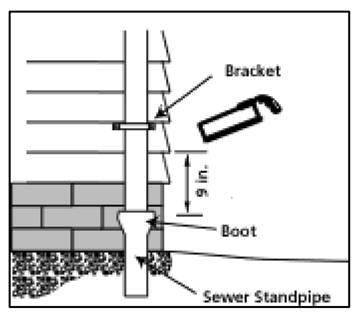
SUPPLIES
1. **Hacksaw**
2. **Tape measure**
3. **Hammer**
4. **Screw driver**
5. **Pliers**
6. **Sheet Metal Screws**
7. **Elbows**
8. **Downspout pipe extension**
9. **Bag of quick drying concrete**
   -OR-
10. **Cap or Plugs**
11. **Splash blocks**

Step 1: Decide Where the Water Will Go
Keep in mind:

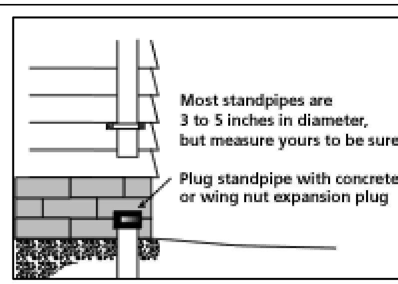
- The slope of the yard must not drain water toward the house.
- Downspouts must extend at least six feet away from a basement and two feet away from a crawl space (foundation).
- The end of the downspout extension should be at least five feet from your property line. More room may be needed if the yard slopes toward the neighbor's house.

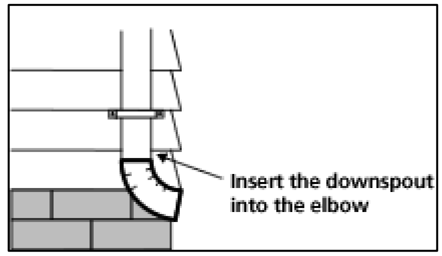
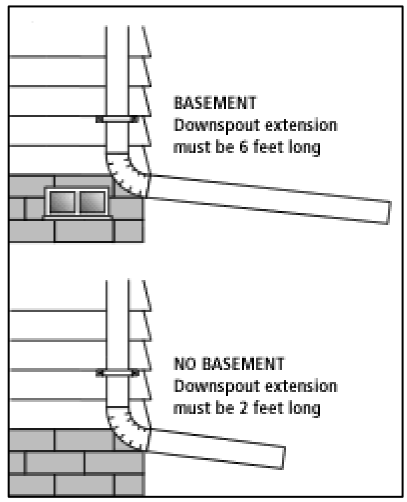
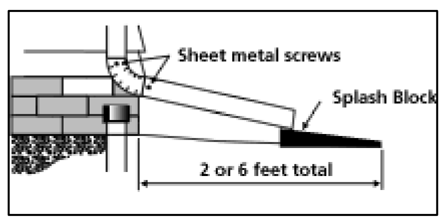
Step 2: Determine What Materials You Will Need
Downspout elbows and extensions come in a few standards shapes, sizes and materials. Are they round? Rectangular? Aluminum? See the supplies list on this page.

Step 3: Cut the Downspout
Cut the existing downspout about 9" above the sewer standpipe. **CAUTION: Aluminum gutters can be extremely sharp after cutting. Protect your hands with work gloves.**



Step 4: Seal the Sewer Standpipe
Next, seal the sewer standpipe. This prevents water getting into the system. Once the downspout has been cut off, you have 3 options for sealing the standpipe: with concrete, a simple rubber cap or a wing-nut test plug if available cap sizes don't fit.



Step 5: Attach an Elbow Insert the downspout INTO the elbow, if you put the elbow into the downspout, it will leak. Use the screws to secure it in place. You may need to crimp the end of the downspout with a pair of pliers to get a good fit.	
STEP 6: Attach a Downspout Pipe Extension Use a hacksaw to cut the extension to the desired length. Attach the extension to the end of the elbow, making sure the elbow fits inside it. The required length of the extension will depend on individual situations. If the house has a basement the downspouts must drain at least six feet from the basement wall. If the house has no basement, downspouts must drain the water two feet from the foundation (at least six feet from a nearby basement). Using a splash block, as in step 7, the extension can be shorter, but the extension plus the length of the block must be at least equal to the minimum required lengths (six feet from a basement, two feet from the foundation if no basement). The end of the downspout pipe extension needs to be at least five feet from your property line. More room may be needed if your yard slopes toward your neighbor's house.	
STEP 7: Secure Pieces & Splash Blocks Secure the elbow and the extension with sheet metal screws. It may be helpful to pre-drill holes for the screws. Place a splash block at the end of the downspout to prevent erosion where the roof water drains.	

Note: Graphics form the City of Bremmerton, WA website: http://www.cityofbremerton.com/content/dd_downspoutdisconnections.html

ST-3d	Retrofit Design Sheets	
	CONSTRUCTED WETLANDS	

Typical Constraints

Constructed wetlands are subject to several constraints when it comes to retrofitting:

Contributing Drainage Area: The contributing drainage area must be large enough to sustain a permanent water level within a stormwater wetland. A minimum of 25 acres of drainage area is typically needed to maintain constant water elevations in humid regions, although the precise area varies based on local hydrology. The minimum drainage area can be relaxed if the bottom of the retrofit intercepts the groundwater table or if designers are willing to accept periodic wetland drawdown. Designers should note that these “pocket” wetlands will have lower pollutant removal, higher excavation costs, and a greater risk of invasive plant colonization.

Space Requirements: Wetland retrofits require a footprint ranging between 3 and 5% of the contributing drainage area, depending on the average depth of the wetland and the extent of its deep pool features.

Available Head: The depth of a wetland retrofit is usually constrained by the head available on the site. The bottom elevation is fixed by the elevation of the existing downstream conveyance system to which the retrofit will ultimately discharge. Head requirements for constructed wetlands are typically less than wet ponds because of their shallow nature - a minimum of two to four feet of head is usually needed.

Minimum Setbacks: Local ordinances and design criteria should be consulted to determine minimum setbacks to property lines, structures, utilities, and wells. As a general rule, wetland retrofits should be setback at least 10 feet from property lines, 25 feet from building foundations, 50 feet from septic system fields and 100 feet from private wells.

Depth to Water Table: The depth to the groundwater table is not a major constraint for constructed wetlands as a high water table can maintain wetland conditions within the retrofit. Designers should keep in mind that high groundwater inputs may reduce pollutant removal rates and increase excavation costs.

Community and Environmental Considerations for Constructed Wetlands

Constructed wetlands can generate several community and environmental concerns:

Aesthetics: Wetland retrofits can create wildlife habitat and become an attractive community feature. Designers should carefully think through how the wetland community will evolve over time, as the future plant community seldom resembles the one initially planted. Constructed wetlands require continual vegetative management to maintain desired wetland species, control woody growth and prevent invasive plants from taking over.

Existing Wetlands: It can be tempting to construct a stormwater wetland within an existing natural wetland, but this should never be done unless it is part of a broader effort to restore a degraded urban wetland approved by the local or state wetland review authority. Designers should investigate the wetland status of adjacent areas to determine if the discharge from the constructed wetland will change the hydroperiod of a downstream natural wetland (see Cappiella et al., 2006b, for guidance on minimizing stormwater discharges to existing wetlands).

Regulatory Status: Constructed wetlands built for the express purpose of stormwater treatment are not considered jurisdictional wetlands in most regions of the country, but designers should check with their wetland permit authority to ensure this is the case.

Existing Forests: Given the large footprint of constructed wetlands, there is a strong chance that construction may cause extensive tree clearing. Designers should preserve mature trees during retrofit layout, and may want to use a wooded wetland concept to create a forested wetland community (see Cappiella *et al*., 2006b).

Stream Warming Risk: Constructed wetlands have a moderate risk of stream warming. If the retrofit discharges to temperature-sensitive waters, designers should consider the wooded wetland design, and any ED storage should be released in less than 12 hours.

Safety Risk: Constructed wetlands are safer than other pond options, although forebays and micropools should be designed with benches to reduce safety risks.

Mosquito Risk: Mosquito control can be a concern for stormwater wetlands if they are under-sized or have a small contributing drainage area. Few mosquito problems are reported for well designed, properly-sized and frequently maintained constructed wetlands (Santana *et al*., 1994) but no design can eliminate them completely. Simple precautions can be taken to minimize mosquito breeding habitat within a wetland retrofit, such as constant inflows, benches that create habitat for natural predators, and constant pool elevations (see Walton 2003 and MSSC, 2005).

Design Issues for Constructed Wetland Retrofits

Several elements should be considered when designing constructed wetland retrofits:

Sediment Forebays: Forebays should be located at all major inlets to trap sediment and preserve the capacity of the main wetland treatment cell. A major inlet is defined as serving at least 10% of the retrofit is contributing drainage area. The forebay should be at least four feet deep, contain about 15% of the total retrofit WQv, and have a variable width aquatic bench.

Constructed Wetland Layout: The layout of the stormwater wetland affects its pollutant removal capability and plant diversity. Performance is enhanced when the wetland has multiple cells, longer flowpaths, and a high surface area to volume ratio. Whenever possible, constructed wetlands should be irregularly shaped with a long, sinuous flow path.

Microtopography: Retrofits should have variable microtopography - a mix of shallow, intermediate, and deep areas that promote dense and diverse vegetative cover.

Planting Strategy: Wetland retrofits should outline a realistic, long-term planting strategy to establish and maintain desired wetland vegetation. The plan should indicate how wetland plants will be established within each pondscaping zone (e.g., wetland plants, seed-mixes, volunteer colonization, and tree and shrub stock) and whether soil amendments are needed to get plants started. The future species trajectory of wetland retrofits is hard to predict, so several different strategies should be considered. Several excellent resources on wetland planting strategies are available (Schueler, 1992; and Shaw and Schmidt, 2003).

Wooded Wetland vs. Emergent Wetland Model: The traditional model for constructed wetlands has been a shallow emergent marsh. In many parts of the country, however, forested wetlands are the most common natural wetland community. In these regions, it may be desirable to design the wetland as a wooded wetland to more closely match local wetland types and reduce future wetland management problems (Cappiella et al., 2006a).

Maintenance Access: Good maintenance access should always be provided to the forebay so that crews can remove sediments and preserve wetland treatment capacity. More frequent sediment removal will be needed if the retrofit is undersized or has a small contributing drainage area.

Maintenance Issues for Constructed Wetland Retrofits

Several maintenance issues can be addressed during the design of constructed wetland retrofits:

Sediment Removal: Frequent sediment removal from the forebay is essential to maintain the function and performance of a constructed wetland. Maintenance plans should schedule cleanouts every five years or so, or when inspections indicate that 50% of the forebay capacity has been lost. Designers should also check to see whether removed sediments can be spoiled on-site or must be hauled away. Sediments excavated from constructed wetlands are not usually considered toxic or hazardous, and can be safely disposed by either land application or land filling.

Clogging: There is always some risk that the low flow orifice and any upstream flow splitters may clog. Clogging can quickly change design water elevations for the wetland and possibly kill wetland vegetation. The inlet and outlet structures to the wetland should be inspected frequently to discover any clogging problems.

Vegetation Management: Managing wetland vegetation is an important ongoing maintenance task. Designers should expect significant changes in wetland species composition over time. Invasive plants should be dealt with as soon as they colonize the wetland. Vegetation may need to be periodically harvested if the retrofit becomes overgrown. Construction contracts should include a care and replacement warranty extending at least two growing seasons after initial planting to selectively replant portions of the wetland that fail to take.

Trash Removal: Cleanups should be scheduled at least once a year to remove trash and debris from the retrofit.

Adapting Constructed Wetlands for Special Climates and Terrain

Cold Climates: Wetland performance decreases when snowmelt runoff delivers high pollutant loads. Shallow constructed wetlands can freeze in the winter, which allows runoff to flow over the ice layer and exit without treatment. Inlet and outlet structures close to the surface may also freeze, further diminishing wetland performance. Several design tips can improve wintertime performance for wetland retrofits (see Profile Sheets ST-1d and ST-2d).

Salt loadings are higher in cold climates due to winter road maintenance. High chloride inputs have a detrimental effect on native wetland vegetation, and can shift the wetland to more salt-tolerant species such as cattails (Wright *et al*., 2007). Designers should choose salt-tolerant species when crafting their planting plan and consider reducing salt application in the contributing drainage area to the retrofit.

Arid Climates: Constructed wetlands are hard to establish in regions with low annual rainfall and high evapotranspiration rates. These climates make it difficult to maintain a constant pool water elevation throughout the growing season. Designers should always check to make sure there is an adequate water balance to support a wetland throughout the year - otherwise the potential of algal blooms, odors and other nuisances will increase sharply. When in doubt, install clay or synthetic liners to prevent water loss via infiltration. Wetland vegetation flourishes when temperatures are warm and the growing season is long or year-round. Regular mowing or even harvesting should be considered to keep vegetative growth in check.

Karst Terrain: Even shallow pools in active karst terrain can increase the risk of sinkhole formation and groundwater contamination. Designers should always conduct geotechnical investigations in karst terrain to assess this risk. If in doubt, designers should employ an impermeable liner and maintain at least three feet of vertical separation from the underlying karst layer.

Constructed Wetland Installation Costs

Constructed wetlands are less expensive on a unit area basis than wet ponds and extended detention ponds since they require less excavation and need fewer safety features (Wossink & Hunt, 2003). On the other hand, some constructed wetlands have a larger surface footprint. These construction cost savings may disappear if land must be acquired to install the retrofit.

Wossink and Hunt (2003) developed an equation to predict the cost of new wetland construction based on the acreage of the contributing drainage area treated (updated to 2006 dollars):

$$BCC = (4{,}465)(A^{0.484})$$

Where:
A = Size of contributing drainage area (acres)
BCC = Base construction cost (2006 dollars)

Brown and Schueler (1997) devised a similar equation for new wetland and pond construction based on storage volume needed that yields slightly higher costs:

$$BCC = (27.95)(V_s^{0.701})$$

Where:
V_s = Total storage volume (ft^3)
BCC = Base construction cost (2006 dollars)

Based on typical wetland sizes, the equations yield a median construction cost of $2,900 per impervious acre treated (range: $2,000 to $9,600). Few retrofit sites will meet the criteria for use of these equations. Under most retrofit conditions, wetland retrofit construction costs will be 3 to 4 times greater than new wetland construction (see Chapter 2 and Appendix E).

Constructed Wetland Design Resources

Vermont Stormwater Management Manual
http://www.anr.state.vt.us/dec/waterq/cfm/ref/Ref_Stormwater.cfm

Connecticut 2004 Stormwater Management Manual
http://dep.state.ct.us/wtr/stormwater/strmwtrman.htm#download

Stormwater Management Manual for Western Washington
http://www.ecy.wa.gov/programs/wq/stormwater/manual.html

Minnesota Stormwater Manual
http://www.pca.state.mn.us/water/stormwater/stormwater-manual.html

BIORETENTION

Typical Constraints

Bioretention can be applied in most soils or topography since runoff percolates through an engineered soil bed and is returned to the stormwater system. Key constraints when retrofitting with bioretention include:

Available Space: Not every open area will be a good candidate for bioretention. To start with, designers should look for open areas that are at least five to 10% of the contributing drainage area and are free of underground utilities.

Site Topography: Bioretention is best applied when contributing slopes are more than 1% and less than 5%. Ideally, the proposed treatment area will be located in depression to minimize excavation costs.

Available Head: Bioretention retrofits are fundamentally constrained by the invert elevation of the existing conveyance system they discharge to. These elevations generally establish the bottom elevation needed to tie the underdrain from the bioretention area into the storm drain system. In general, four to five feet of elevation above this invert is needed to drive stormwater through a proposed bioretention area. Less head is needed if underlying soils are permeable enough to dispense with the underdrain.

Water Table: Bioretention should always be separated from the water table to ensure groundwater does not intersect with the filter bed. Mixing can lead to possible groundwater contamination or practice failure. A separation distance of 3 feet is recommended between the bottom of the filter bed and the seasonally high water table.

Overhead Wires: Designers should also check whether future tree growth in the bioretention area will interfere with existing overhead utility lines.

Soils: Soil conditions do not constrain the use of bioretention although they determine whether an underdrain is needed. Impermeable soils in Hydrologic Soil Group C or D usually require an underdrain, whereas A or B soils often do not. Designers should verify soil permeability when designing a bioretention retrofit, using the on-site soil investigation methods presented in Appendix H.

Community and Environmental Considerations for Bioretention Retrofits

Bioretention is a popular practice, since it can meet local landscaping requirements and improve site appearance. The only major drawbacks relate to who will handle future landscape maintenance and whether landowners will modify or replace the bioretention area in the future. If bioretention areas will be installed on private lots, homeowners need to be educated on their routine maintenance tasks and fully understand their intended stormwater function.

Design Issues for Bioretention

Several issues should be considered when designing bioretention retrofits:

Pretreatment: Pretreatment can prevent premature clogging and prolong the effective function of bioretention retrofits. Several pretreatment measures can be used, including directing runoff over a grass filter strip, adding a three to six inch drop or installing a pea gravel diaphragm that spreads flow evenly and drops out larger sediment particles. A two-cell design is recommended when bioretention is used as a storage retrofit or for larger on-site applications. The first cell is a sediment forebay that pretreats runoff and traps sediment before discharge into the main bioretention cell.

Landscaping is critical to the function and appearance of bioretention areas. Where possible, a combination of native trees, shrubs, and herbaceous plant species are preferred. Plants should be able to tolerate both wet and dry conditions. Most upland vegetation does not do well in the deepest center areas that are more frequently inundated. "Wet footed" plants, such as wetland forbs, should be planted near the center, whereas upland species are better for the edges of the bioretention area. Regional lists of plant species suitable for bioretention areas can be found at the end of this profile sheet.

Type of media: The choice of filter media is important to provide adequate drainage, support plant growth and optimize pollutant removal within the filter bed. Early design guidance recommended a mix of 50-60% sand, 20-30% topsoil and 20-30% organic leaf compost. The topsoil component should consist of loamy sand, sandy loam, or loam with a clay content no greater than 5%. Hunt and Lord (2006a) has recently advocated a bioretention soil mix with a greater proportion of sand (85-88% sand; 8-12% fines; and 3-5% organic matter) as a more effective choice for pollutant removal. They also strongly recommend that topsoil be tested to ensure that it has a low phosphorus index value to prevent phosphorus leaching. If nitrogen removal is the goal, it may be advisable to increase the percentage of soil fines.

Designers should also ensure that the media is well mixed and homogeneous. The media should have an infiltration rate of 1.0 to 2.0 inches per hour as recent research indicates that pollutant removal is optimized in this range.

Depth of Media: Early bioretention design guidance recommended a minimum filter bed depth of 4 feet. However, the filter bed may be reduced in depth to 1.5 to 2.5 feet in certain retrofit applications, particularly when available head is limited. Research has shown that good pollutant removal can still be achieved in filter beds as shallow as 1.5 feet, with the possible exception of nitrogen (Davis, 2005, and Hunt *et al.*, 2006). It is doubtful that filter beds less than 1.5 feet deep can provide reliable pollutant removal efficiency over the long run. Designers should also remember that filter beds need to be at least 4 feet deep to provide enough soil volume for the root structure of mature trees (i.e., use turf, perennials or shrubs instead of trees for shallower filter beds).

Underdrain: In many bioretention retrofits, filtered runoff will be collected by a perforated underdrain and conveyed to the storm drain system. If the site has permeable soils, however, the underdrain can be reduced or eliminated altogether. The need for an underdrain depends on the permeability of the underlying soils, which have often been previously altered or compacted in many retrofit situations. Soil permeability rates should always be verified when designing a bioretention retrofit (see Appendix H). If an underdrain is required at a bioretention retrofit, it should have a minimum diameter of 6 inches and be placed in a foot deep gravel bed.

Overflow: Designers should always incorporate an overflow structure to safely bypass larger storms around the bioretention retrofit. The invert of the overflow should be placed at the maximum water surface elevation of the bioretention area, which is typically 6 to 12 inches above the surface of the filter bed.

Surface Cover: A three-inch layer of hardwood mulch on the surface of the filter bed enhances plant survival, suppresses weed growth, and pretreats runoff before it reaches the filter bed. Shredded hardwood bark mulch makes a very good surface cover, as it retains a significant amount of nitrogen and typically will not float away. On the other hand, hardwood mulch needs to be replaced every few years, may not be durable or attractive enough for certain retrofit situations, and may not be available in some regions of the country. In these situations, designers may wish to consider alternative covers such as turf, river stone, gravel or pumice stone.

Contributing Drainage Area: Designers should always verify that the actual contributing area and inlet elevations are accurately determined at the retrofit site. Designers should walk the site during a rainstorm to look at actual flowpaths to the proposed treatment area, and confirm these boundaries using fine resolution topographic surveys.

Bioretention Maintenance Issues

Bioretention requires seasonal landscaping maintenance to establish and maintain vigorous plant cover:

Vegetation Management: Vegetation management is an important to sustain the pollutant removal and landscaping benefits of the bioretention area. The construction contract should include a care and replacement warranty to ensure vegetation gets properly established and survives during the first growing season after construction.

Surface Cover/Filter Bed: The surface of the filter bed can become clogged with fine sediments over time. Core aeration or deep tilling may relieve the problem. The surface cover layer will need to be removed and replaced every two or three years. The inlets and pretreatment measures for the bioretention retrofit also need frequent inspections to ensure they are working properly and to remove deposited sediments.

Training Landscape Contractors: Maintenance can be performed by landscaping contractors who are already providing similar landscaping services on the property, but they will need training on bioretention maintenance tasks.

Adapting Bioretention for Special Climates and Terrain

Bioretention areas can be applied almost everywhere, with the proper design modifications:

Arid Climates: Bioretention areas should be landscaped with drought-tolerant plant species. A xeriscaping approach is preferred since supplemental irrigation makes little sense in arid and semi-arid climates. It may also be advisable to switch from mulch to a more durable surface cover such as riverstone or pumice. The planting plan may also have fewer trees and plants to minimize the need for supplemental irrigation. Designers should recognize that longer growing seasons increase both the frequency and cost of landscape maintenance.

Cold Climates: Bioretention areas can be used for snow storage as long as an overflow is provided and they are planted with salt-tolerant, non-woody plant species (for a species list, consult MSSC, 2005). While several studies have shown that bioretention operates effectively in winter conditions, it is a good idea to extend the filter bed and underdrain pipe below the frost line and/or oversize the underdrain by one pipe size to reduce the freezing potential.

Karst Terrain: Bioretention should utilize impermeable liners and underdrains when located in an active karst area. A geotechnical investigation may be needed to confirm that three feet of vertical separation exists from the underlying rock layer.

Bioretention Installation Costs

The cost to construct bioretention areas are extremely variable, and are strongly influenced by the area treated, the depth of filter bed, the presence or absence of an underdrain and whether it is professionally designed, installed or landscaped. Wossink and Hunt (2003) report that bioretention has the lowest construction costs of all new stormwater treatment options serving smaller drainage areas from 1 to 5 acres. On the other hand, the unit costs to retrofit bioretention in highly urban settings may be 10 to 20 times higher (See Appendix E). The long-term maintenance costs for bioretention areas are not expected to be very different from normal landscaping maintenance costs.

Brown and Schueler (1997) developed equations to predict the base construction cost of bioretention as a function of the water quality volume provided. When these equations are adjusted to 2006 dollars, they yield:

$$BCC = (7.62)(WQ_v^{0.990})$$

Where:
WQ_v = Water quality volume (ft^3)
BCC = Base construction cost (2006 dollars)

More recently, Wossink and Hunt (2003) developed equations to predict the cost of new bioretention construction as a function of their contributing drainage area. This equation yields lower cost estimates compared to the Brown equation:

$$BCC = (11{,}781)(A^{1.088})$$

Where:
A = Size of contributing drainage area (acres)
BCC = Base construction cost (2006 dollars)

Using these equations, it is possible to establish median bioretention costs of $25,400 per impervious acre treated (range: $19,900 to $41,750). Construction cost drops sharply when site soils are permeable enough to dispense with an underdrain (although this is not a common retrofit situation).

Bioretention Design Resources

Several state and local stormwater manuals provide useful bioretention design guidance:

Prince George's Co., MD Bioretention Manual
http://www.goprincegeorgescounty.com/Government/AgencyIndex/DER/ESD/Bioretention/bioretention.asp?nivel=foldmenu(7)

Lake Co., OH Bioretention Guidance Manual
http://www2.lakecountyohio.org/smd/Forms.htm

Low Impact Development Technical Guidance Manual for Puget Sound, WA
http://www.psat.wa.gov/Publications/LID_tech_manual05/lid_index.htm

Wisconsin Stormwater Management Technical Standards
http://www.dnr.state.wi.us/org/water/wm/nps/stormwater/techstds.htm#Post

Maryland Stormwater Design Manual
http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp

Typical Constraints

Stormwater filters can be applied in most regions of the country and most types of urban land. It is important to note that stormwater filters are not always cost-effective to retrofit on a widespread basis, given their high unit cost and small area served. Design constraints for filter retrofits include:

Available Head: The principal retrofit constraint for stormwater filters is available head which is defined as the vertical distance between the top elevation of the filter and the bottom elevation of the existing storm drain system that accepts its runoff. Designers can quickly estimate available head at a proposed retrofit site by locating the closest stormwater inlet or manhole. The difference in elevation between the surface and the invert elevation of the underground storm drain pipe gives a rough approximation of the available head. The head required for stormwater filters ranges from two to ten feet, depending on the design variant. Thus, it is difficult to employ filters in extremely flat terrain since they require gravity flow through the filter. The one exception is the perimeter sand filter, which can be applied at sites with as little as two feet of head.

Contributing Drainage Area: Sand filters are best applied on small sites that are as close to 100% impervious as possible. A maximum contributing drainage area of five acres is recommended for surface sand filters, and a maximum contributing drainage area of two acres is recommended for perimeter or underground filters (Claytor and Schueler, 1996). Filters have been used on larger drainage areas in the past, but they tend to experience greater clogging problems.

Space Required: The amount of space required for a filter retrofit depends on the design variant selected. Both sand and organic surface filters typically consume about 2 to 3% of the contributing drainage area, while perimeter sand filters typically consume less than 1%. Underground stormwater filters generally consume no surface land except manholes needed for maintenance access.

Community and Environmental Concerns for Filter Retrofits

Stormwater filters have a few community and environmental concerns:

Aesthetics: The main drawback with stormwater filters is their appearance - many are imposing concrete boxes that tend to accumulate a lot of trash and debris. Retrofit designers should try to soften up the appearance of surface filters and make sure they are routinely maintained.

Mosquito Breeding: There is a risk that underground and perimeter filters may create potential habitat for mosquito breeding. If this is a concern, designers should keep standing water in sedimentation chambers to a minimum.

Groundwater: Filters are recommended when groundwater protection is an issue since they do not normally interact with groundwater and therefore have less potential to contaminate it.

Design Issues for Filter Retrofit Applications

Several unique design issues are involved with filter retrofits, as follows:

Pretreatment: Adequate pretreatment is needed to prevent premature filter clogging and ensure retrofit longevity. Either wet or dry pretreatment chambers can be used to capture and remove coarse sediment particles before they reach the filter bed. Designers should allocate at least 25% of the total WQv to pretreatment. Additional pretreatment measures may include a grass filter strip installed prior to the filter and regular sweeping of the street or parking lot. If a proprietary filter is used, designers should check to see whether the device has adequate pretreatment volume. The sedimentation chamber should be designed to allow maintenance crews to get vactor trucks close to the retrofit for cleanouts.

Type of Media: The normal filter media consists of clean, washed concrete sand with individual grains between 0.02 and 0.04 inches in diameter. Alternatively, organic media can be used, such as a peat/sand mixture or a leaf compost mixture. The decision to use organic media in a stormwater filter depends on which stormwater pollutants are targeted for removal. Organic media may enhance pollutant removal performance with respect to metals and hydrocarbons (Claytor & Schueler, 1996). Recent research, however, has shown that organic media can actually leach soluble nitrate and phosphorus, suggesting it is a poor choice when nutrients are the pollutant of concern.

Type of Filter: The choice of which sand design filter design to apply depends on available space and head, and the desired level of pollutant removal. In ultra-urban situations where surface space is at a premium, underground sand filters are often the only design that can be used. Surface and perimeter filters are often a more economical choice when adequate surface area is available.

Depth of Media: The depth of the filter media plays a role in how quickly stormwater moves through the filter bed and how well it removes pollutants. Recent design guidance recommends that a minimum filter bed depth ranging from 18 and 24 inches.

Impervious Drainage Area: In retrofit situations, the contributing drainage area should be as close to 100% impervious as possible in order to reduce the risk that eroded sediments will clog the filter.

Overflow: Most filtering practices are designed as off-line systems so that all flows enter the filter, but larger flows overflow to an outlet chamber, and are not treated. Exceptions include the perimeter filter and most underground filters. Runoff from larger storm events should be bypassed using an overflow structure or a flow splitter. Claytor and Schueler (1996) and ARC (2001) provide design guidance for flow splitters for filtering practices.

Drawdown: Stormwater filters should be designed to drain or dewater within 48 hours after a storm event to reduce the potential for nuisance conditions.

Maintenance Issues for Filter Retrofits

Several maintenance issues can addressed during retrofit design to reduce future maintenance operations, including:

Access: Good maintenance access is needed to allow crews to perform regular inspections and maintenance activities. Stormwater filters should be clearly visible at the retrofit site so inspectors and maintenance crews can easily find them. Adequate signs or markings should be provided at manhole access points for underground filters.

Confined Space Issues: Underground filters are often classified as an underground confined space. Consequently, special OSHA rules and training are needed to protect the workers that access them. These procedures often involve training on confined space entry, venting and the use of gas probes.

Sediment/Filter Bed Removal: Sediments will need to be regularly removed from the pretreatment chamber every three to five years. The filter bed media may also need to be replaced on the same schedule.

Site Inspections: Regular site inspections are critical to schedule sediment removal operations, replace filter media and relieve any surface clogging. Frequent inspections are especially needed for underground and perimeter filter retrofits since they are out of sight and can be easily forgotten.

Sediment Testing: Designers should check to see whether the filter is treating runoff from a hotspot site. If so, crews may need to test sediments before disposing of trapped sediments or filter bed media. Sediment testing is not needed if the filter does not receive runoff from a designated stormwater hotspot.

Adapting Filters for Special Climates and Terrain

Stormwater filters can be successfully employed when certain design modifications are made:

Cold Climates: Surface or perimeter filters may not always be effective during the winter months. The main problem is ice that forms over and within the filter bed. Ice formation may briefly cause nuisance flooding if the filter bed is still frozen when spring melt occurs. To avoid these problems, filters should be inspected before the onset of winter (prior to the first freeze) to dewater wet chambers and scarify the filter surface. Other measures to improve winter performance include:

- Placing a weir placed between the pretreatment chamber and filter bed to reduce ice formation as a more effective substitute than a traditional standpipe orifice.
- Extending the filter bed below the frost line to prevent freezing within the filter bed
- Oversizing the underdrain to encourage more rapid drainage to minimize freezing of the filter bed
- Expanding the sediment chamber to account for road sanding. Pretreatment chambers should be sized for up to 40% of the WQv

Arid Climates: Designers may want to increase storage in the pretreatment chamber to handle higher sediment loads expected in arid climates. Dry sedimentation chambers should be sized up to 40% of the WQv. Wet pretreatment is seldom feasible in arid climates.

Karst Terrain: Stormwater filters are a good option in active karst areas since they are not connected to groundwater and therefore minimize the risk of sinkhole formation and groundwater contamination.

Installation Costs for Filtering Practices

Stormwater filters have one of the highest unit construction costs of any stormwater treatment option treating small drainage areas. The cost to construct a stormwater filter depends on the region and design variant used (Table 1). For surface sand filters, Brown and Schueler (1997) reported construction costs ranging between about $3.00 and $8.00 per cubic foot of water quality volume treated (2006 dollars). Wossink and Hunt (2003) developed a cost prediction equation for stormwater filter construction based on drainage area treated. The updated equation is:

$$BCC = (55{,}515)(A^{0.882})$$

Where:

A = Size of contributing drainage area (acres)

BCC = Base construction cost (2006 dollars)

While underground and perimeter sand filters are the most expensive filtering practice, they consume minimal surface land, making them a cost-effective practice in ultra-urban areas where land prices are at a premium.

Design Resources

Several existing stormwater manuals provide useful guidance on stormwater filter design:

District of Columbia Stormwater Management Guidebook
http://dchealth.dc.gov/DOH/site/default.asp?dohNav=|33110|

The Minnesota Stormwater Manual
http://www.pca.state.mn.us/water/stormwater/stormwater-manual.html

Maryland Stormwater Design Manual
http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp

Design of Stormwater Filtering Systems. Center for Watershed Protection
http://www.cwp.org/PublicationStore/special.htm

Georgia Stormwater Management Manual
http://www.georgiastormwater.com

Design Variant	Median Cost Per Impervious Acre Treated	Range in Cost
Simple Surface Filter	$ 18,150	$ 10,900 to $29,000
Structural Sand Filter	$ 72,000	$ 58,100 to $79,900
Underground Sand Filter	$ 234,000	$ 100,800 to $ 270,000
See Appendix E: Simple surface filter lacks structural elements and reinforced concrete		

ST-6d

Retrofit Design Sheets

INFILTRATION

Typical Constraints

Numerous constraints need to be assessed to ensure infiltration is feasible at a proposed retrofit site, including:

Soils: Soil permeability is the single biggest factor when evaluating infiltration retrofits. A minimum infiltration rate of <u>at least</u> 0.5 inches/hour is needed to make the retrofit work. Several studies have shown that ultimate infiltration rates decline by as much as 50% from initial rates, so designers should be very conservative and not force infiltration on questionable soils. On-site infiltration investigations should always be conducted to establish the actual infiltration capacity of underlying soils using methods presented in Appendix H.

Avoid Stormwater Hotspots: Never infiltrate runoff from a hotspot operation. Make sure to conduct a HSI on all operations in the contributing area to determine the potential risk of groundwater contamination. If a site is classified as a stormwater hotspot, then runoff must be fully treated by another practice prior to infiltration.

Contributing Drainage Area: Infiltration retrofits are best applied to small contributing drainage areas that are as close to 100% impervious as possible. If the contributing contains any pervious area, it must be properly stabilized with dense vegetation, both during and after construction, to prevent eroded sediments from prematurely clogging the facility. Additionally, the maximum contributing drainage area to an infiltration trench should be limited to one acre or less. The maximum contributing drainage area to underground infiltration systems should be limited to five acres or less. Infiltration practices serving larger drainage areas tend to experience more chronic clogging problems.

Space Required: The typical footprint of an infiltration retrofit ranges from 5 to 10% of its contributing drainage area, but varies depending on its depth, storage void, space, and infiltration rate.

Minimum Setbacks: As a general rule, infiltration retrofits should be setback at least 10 feet from property lines, 25 feet from building foundations, 100 feet from septic system fields, 100 feet from private wells, 100 feet from surface waters, 400 feet from surface drinking water sources and 1,200 feet from public water supply wells.

Depth to Water Table/Bedrock: Infiltration retrofits should be separated at least three feet from the water table to ensure groundwater never intersects with the floor of the infiltration practice, which could cause groundwater contamination or practice failure. A three foot separation distance should be maintained between the bottom of the infiltration retrofit and any confining bedrock layer.

Community and Environmental Considerations for Infiltration Retrofits

Several community and environmental concerns can arise when infiltration retrofits are proposed:

Nuisance Conditions: Poorly designed infiltration retrofits can create potential nuisance problems such as basement flooding, poor yard drainage and standing water. In most cases, these problems can be minimized through adequate setbacks, on-site soil testing and pretreatment.

Mosquito Risk: Infiltration retrofits can potentially create mosquito breeding conditions if they clog and have standing water for extended periods.

Groundwater Protection: Communities that rely on groundwater for drinking water are often concerned about potential stormwater contamination. Designers should investigate the prevailing land use in the contributing drainage area. Runoff from potential stormwater hotspots should never be infiltrated. For residential and institutional land uses, infiltration is desirable since it replenishes groundwater supplies. Infiltration retrofits in these areas should have over-sized and redundant pretreatment to reduce the risk that stormwater pollutants or spills will reach groundwater.

Groundwater Injection Permits: Groundwater injection permits may be required in some areas of the country. Designers should investigate whether or not a proposed infiltration retrofit is subject to a state or local groundwater injection permit.

Design Issues for Infiltration Retrofit Applications

The design of infiltration retrofits should be more conservative than the design of new infiltration practices to promote longevity. A series of design elements can minimize the risk of practice failure:

Pretreatment is essential to extend the longevity of infiltration retrofits. Designers should include at least two pretreatment measures in every retrofit, such as grass swales, filter strips, sump pits, sediment forebays or plunge pools.

Off-line Design: Infiltration retrofits should be designed off-line so they only receive the target WQv and bypass larger storm flows. A flow splitter or overflow structure can be used for this purpose; design guidance for small flow splitters can be found in Claytor and Schueler (1996) and ARC (2001).

Small Contributing Drainage Areas: The contributing drainage area to each infiltration retrofit should be less than one acre, and be distributed in multiple locations around the site. Ideally, the contributing drainage area should be entirely impervious to preclude the possibility that eroded sediments from pervious areas will clog the retrofit. Designers should also try to keep the depth of the infiltration retrofit to less than four to six feet.

Rapid Drawdown: When possible, infiltration retrofits should be sized so that the target WQv rapidly infiltrates within 24 to 36 hours (rather than the standard 48 hour drawdown limit for new practices). This design approach provides a factor of safety to prevent nuisance ponding conditions.

Conservative Infiltration Rates. Underlying soils should have a minimum infiltration rate of at least 0.5 inches per hour. Several test pits are needed to measure the infiltration rates across a proposed retrofit site. Appendix H provides guidance on performing infiltration testing. However, infiltration rates of 1.0 to 2.0 inches per hour are ideal. Designers may wish to cut measured infiltration rates in half to approximate the long term infiltration rate.

No Filter Fabric on Bottom: The use of geotextile filter fabric along the bottom of infiltration retrofits should be avoided. Experience has shown that filter fabric is prone to clogging, and that a layer of coarse washed stone (choker stone) is a more effective substitute.

Observation Wells: One or more observation wells should be installed within infiltration retrofits so that drawdown rate can be measured after storm events. Observation wells typically consist of perforated PVC pipes that are four to six inches in diameter and extend from the surface to the bottom of the infiltration retrofit.

Maintenance Issues with Infiltration Retrofits

Historically, infiltration practices have had a high failure rate compared to other stormwater treatment options (Galli, 1992). A conservative retrofit design approach should greatly reduce the risk of initial retrofit failure (Figure 1). Even so, the future performance of infiltration requires a strong commitment to regular inspection and maintenance. Designers should only choose infiltration when they are confident that the landowner or municipal agency will be a responsible maintainer in the future. The

Figure 1: Failed Infiltration Trench

maintainer should be expected to handle the following ongoing tasks:

Site Inspections: Regular site inspections are critical to the performance and longevity of infiltration retrofits. The drawdown rate of the retrofit should be measured at the observation wells at least twice a year. It is recommended that infiltration rates be checked in observation wells three days following a storm event greater than one half inch in depth. If standing water is still observed in the well after three days, this is a clear sign that that clogging has become a problem. Additionally, pretreatment devices and flow diversion structures should be checked for sediment buildup and structural damage.

Sediment Removal/Trench Reconstruction: Sediment will need to be regularly removed from pretreatment facilities. If major clogging occurs, the practice may need to be reconstructed. Good maintenance access is needed to allow crews and heavy equipment to perform maintenance tasks.

A maintenance plan should be created that identifies the party responsible for maintenance and specifies ongoing maintenance tasks over a prescribed schedule.

Adapting Infiltration for Special Climates and Terrain

Although infiltration practices have been successfully employed in both cold and arid climates, several design modifications are needed to ensure they function properly:

Cold Climates: Infiltration retrofits are generally not feasible in extremely cold climates experiencing permafrost, but they can be designed to withstand more moderate winter conditions. The main problem is ice forming in the voids or the subsoils below which may briefly cause nuisance flooding when spring melt occurs. These problems can be avoided if the bottom of the retrofit extends below the frost line.

If the retrofit treats roadside runoff, it may be desirable to divert flow in the winter to prevent movement of chlorides into groundwater and prevent clogging by road sand. Alternatively, pretreatment measures can be oversized to account for the additional sediment load caused by road sanding (up to 40% of the WQv). Care should be taken to ensure that infiltration retrofits are setback at least 25 feet from roadways to prevent potential frost heaving of road pavements.

Arid Climates: The key concern in arid and semi-arid watersheds is the greater risk of potential clogging due to higher sediment loads. Consequently, over-sized pretreatment should be strongly emphasized, and the contributing drainage area should be kept as close to 100% impervious as possible.

Karst Terrain: Infiltration retrofits should not be used in active karst regions unless geotechnical investigations have eliminated concerns about sinkhole formation and groundwater contamination.

Installation Costs for Infiltration Retrofits

Very little construction cost information about infiltration practices is available. Because their construction methods are similar, the cost for infiltration practices are assumed to be comparable to bioretention areas (Appendix E). Consequently, the cost to construct infiltration practices at new development sites is estimated to be $25,400 per impervious acre treated (range: $19,900 to $41,750). Few retrofit sites will meet new development conditions; however, most retrofits will cost 1.5 to 2.0 times more than new infiltration practices.

Infiltration Design Resources

Several recent stormwater manuals present updated design criteria for infiltration practices:

New Jersey Stormwater Best Management Practices Manual
http://www.nj.gov/dep/watershedmgt/bmpmanualfeb2004.htm

Pennsylvania Draft Stormwater Best Management Practices Manual
http://www.dep.state.pa.us/dep/subject/advcoun/Stormwater/stormwatercomm.htm

Green Technology: The Delaware Urban Runoff Management Approach
http://www.dnrec.state.de.us/DNREC2000/Divisions/Soil/Stormwater/New/GT_Stds%20&%20Specs_06-05.pdf

New York State Stormwater Management Design Manual
http://www.dec.state.ny.us/website/dow/toolbox/swmanual/index.html

ST-7d	Retrofit Design Sheets	
	SWALES	

Typical Constraints

Constraints to consider when evaluating a potential swale retrofit include:

Contributing Drainage Area: The maximum contributing drainage area to a swale retrofit should be five acres and preferably less.

Space Required: Swale retrofits usually consume about five to 15% of their contributing drainage area.

Site Topography: Site topography constrains swale retrofits; some gradient is needed to provide water quality treatment but not so much that treatment is impeded. Swales generally work best on sites with relatively flat slopes (e.g., less than 5% slope for grass channels and 2% for wet and dry swales). Steeper slopes create rapid runoff velocities that can cause erosion and do not allow enough contact time for infiltration or filtering. Swales perform poorly in extremely flat terrain because they lack enough grade to create storage cells, and lack head to drive the system.

Available Head: A minimum amount of head is needed to implement each swale retrofit. Dry swales typically require three to five feet of head since they require a filter bed and underdrain. Wet swales require about two feet of head, whereas grass swales need only a foot. Designers should measure gradient in the field to ensure enough head exists to drive the swale retrofit.

Hydraulic Capacity of Existing Open Channel: Most open channels were originally sized with enough capacity to convey runoff from the ten-year storm, and be non-erosive during the two-year design storm event. In many cases, the open channel may be under-capacity due to upstream development or past sedimentation. The capacity of the existing open channel should be verified during the retrofit project investigation. Field observations that may indicate an existing channel is undersized channel include excessive erosion of the channel side slopes, poor vegetative stabilization and overbank debris.

Width of Existing Right of Way or Easement: Designers should investigate whether the existing right of way or stormwater easement is wide enough to accommodate retrofit construction and maintenance access. In most cases, the existing channel will need to be widened or flows split into adjacent off-channel treatment cells.

Depth to Water Table: Designers should separate the bottom of the swale from the groundwater by at least two feet for dry swales and grass channels. It is permissible to intersect the water table for wet swales, since the pool enhances water quality treatment.

*Soils: S*oil permeability influences which swale design variant will work best in the existing channel. Designers should note that past construction and compaction may have severely reduced the permeability of the original swale soils. Several on-site tests should be conducted at the proposed retrofit to measure actual soil infiltration retrofit rates (see Appendix H). In general, grass swales are restricted to soils in Hydrologic Soil Groups A or B. Dry swales also work well on these soils, but can be applied to more impermeable C or D soils if an underdrain is used. Wet swales work best on more impermeable C or D soils.

Utilities: Many utilities run along or underneath open channels, so designers should always check for utility lines or crossings at each swale retrofit site. The presence of dry or wet utilities usually renders a swale retrofit infeasible.

Community and Environmental Considerations for Swale Retrofits

Swale retrofits are normally accepted by communities if they are properly designed and maintained, but require approval by multiple landowners to secure additional right of way. The main concerns of adjacent residents are perceptions that swale retrofits will create nuisance conditions or will be hard to maintain. Common concerns include the continued ability to mow grass, landscape preferences, weeds, standing water, and mosquitoes. For these reasons, wet swales are not recommended in residential settings - the shallow, standing water in the swale is often viewed as a potential nuisance by homeowners. Dry swales are a much better alternative.

Key Design Issues for Swale Retrofits

Several design elements can ensure the swale retrofit performs effectively over the long run:

Pretreatment: Adequate pretreatment is needed to trap sediments before they reach the main treatment cell of the swale retrofit. A small sediment forebay located at the upstream end of the swale often works best. A pea gravel flow spreader along the top of each bank can pretreat lateral runoff from the road shoulder to the swale.

Swale Dimensions: Swales should have a bottom width ranging from two to eight feet to ensure an adequate surface area exists along the bottom of the swale for filtering. If a swale will be wider than eight feet, designers should incorporate berms, check dams, level spreaders or multi-level cross sections to prevent braiding and erosion within the swale bottom. Swale retrofits should be designed with a parabolic or trapezoidal cross section and have side slopes no steeper than 3:1 (h:v). Designers should seek side slopes much less than 3:1 to promote more treatment of lateral sheet flow, if space is available.

Ponding Depth: Drop structures or check dams can be used to create ponding cells along the length of the swale. The maximum ponding depth in a swale should not exceed 18 inches at the most downstream point. The average ponding depth throughout the swale should be 12 inches.

Drawdown: Dry swale retrofits should be designed so that the desired WQv is completely filtered within six hours or less. This drawdown time can be achieved by using a sandy soil mix or an underdrain along the bottom of the swale. No minimum drawdown time is required for wet swale retrofits.

Swale Media: Dry swales require replacement of native soils with a prepared soil media. The soil media provides adequate drainage, supports plant growth and facilitates pollutant removal within the dry swale. The soil media should have an infiltration rate of at least one foot per day and be comprised of a mix of native soil, sand and organic compost similar to bioretention design recommendations presented in ST-4. At least 18 inches of soil media should be mixed into the swale bottom.

Underdrain: Underdrains are provided in dry swale retrofits to ensure they drain properly after storms. The underdrain should have a minimum diameter of 6 inches and be encased in a foot deep gravel bed. Underdrains are not needed in wet swales or grass channels.

Swale Maintenance Requirements

Swale maintenance often fits within normal turf management operations that are already being performed. Swale retrofits are often located near landowners that have real or perceived concerns on how the swale may affect their front yards and property value. Therefore, designers should consider how to:

- Minimize standing water
- Minimize interference of check dams with regular mowing
- Manage vegetative growth in the future
- Educate residents on how to properly maintain the swale over time

Regular inspections should be conducted on the swale retrofit to schedule maintenance operations such as sediment removal, spot revegetation and inlet stabilization. Maintenance crews may need to be educated on the purpose and maintenance needs of swale retrofits installed along streets or highway right-of-way.

Adapting Swales for Special Climates and Terrain

Swale retrofits can be applied in most climates and terrain with some design modifications:

Cold Climates: Swales can store snow and treat snowmelt runoff. If roadway salt is applied, swales should be planted with salt-tolerant and non-woody plant species. Consult the Minnesota Stormwater Manual for a list of salt-tolerant grass species (MSSC, 2005). The dry swale underdrain pipe should extend below the frost line and be oversized by one pipe size to reduce the chances of freeze-up.

Arid Climates: It is extremely hard to maintain a wet swale retrofit in arid and semi-arid climates. Swales should be planted with drought-tolerant vegetation and the planting plan should specify fewer broad-leaved plants to minimize the need for supplemental irrigation. A xeriscaping approach is preferred for any swale in arid or semi-arid regions since irrigation makes little sense and is expensive in these regions.

Karst Terrain: Swale retrofits should utilize impermeable liners and underdrains to prevent sinkhole formation in active karst areas.

Swale Installation Costs

Only limited cost data has been published on swale construction costs. Equations to estimate swale costs for new construction are outlined in Appendix E. The projected cost for swales at new development sites is estimated to be $18,150 per impervious acre treated (range: $10,900 to $36,300). Few retrofit sites will meet the construction conditions for new development sites; most swale retrofits will cost about twice as much, particularly if they involve off-channel treatment.

Swale Design Tools

New York State Stormwater Management Design Manual
http://www.dec.state.ny.us/website/dow/toolbox/swmanual/index.html

Vermont Stormwater Management Manual
http://www.anr.state.vt.us/dec/waterq/cfm/ref/Ref_Stormwater.cfm

Stormwater Management Manual for Western Washington
http://www.ecy.wa.gov/programs/wq/stormwater/manual.html#How_to_Find_the_Stormwater_Manual_on_the

CNMI and Guam Stormwater Management Manual
http://www.guamepa.govguam.net/programs/water/index.html