City of Harrisonburg

Stormwater Improvement Plan

KEEP IT CLEAN, HARRISONBURG
STOP POLLUTED RUNOFF

Adopted by City Council
December 12, 2017

Contents

Acknowledgements

This Stormwater Improvement Plan for the City of Harrisonburg has been prepared by staff of the Department of Public Works; A. Morton Thomas & Associates, Inc.; Tetra Tech; and the Stormwater Advisory Committee. This plan would not have been possible without the dedicated efforts of these participants and the involvement of citizens who participated in public meetings and offered their insight and opinions.

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Introduction

The City of Harrisonburg encompasses 17.4 square miles with a population of approximately 53,000 people. Harrisonburg is home to two university campuses – James Madison University and Eastern Mennonite University – as well as numerous other businesses, non-profit organizations, and a vibrant downtown area.

The overall citywide stormwater program has many functions, including meeting all regulatory requirements, managing equipment and resources, developing a budget, prioritizing and scheduling capital projects, coordinating design, installation, inspection, and maintenance of practices, engaging citizens and businesses, and communicating with decision-makers and stakeholders.

The City of Harrisonburg has two important stormwater programs to consider. The City's MS4 permit program is managed through the Department of Public Works and includes operating and maintaining the City's infrastructure as well as implementing this Stormwater Improvement Plan (SWIP). The Department of Planning & Community Development is responsible for administering the Virginia Stormwater Management Program, which reviews development plans and conducts erosion control and stormwater inspections for new development and redevelopment projects in accordance with city ordinances. There is strong coordination between the various departments involved with stormwater, which also include the departments of Public Utilities, Parks and Recreation, as well as many others described in more detail in Appendix E.

The City initiated this SWIP to improve water quality in local waterways and to chart a strategy for the City to comply with state and federal regulations that require the City to manage stormwater pollution entering Blacks Run and the greater Chesapeake Bay watershed. The main objective of the SWIP is to identify capital improvement (construction) projects, programs, and ways to engage Harrisonburg's citizens to manage stormwater and improve water quality. Another objective of the SWIP is to pursue the above strategies in a cost-effective manner and in coordination with other City initiatives:

Stormwater Alphabet Soup

Stormwater management, like many technical and regulatory topics, is characterized by terms that can be confusing if not defined. Some of the more important terms used in this SWIP are defined below.

Best Management Practice (BMP) refers to a stormwater or water management practice designed to reduce pollution in stormwater runoff. The term is one of several used at local, state, and federal levels to generally describe methods for stormwater treatment. Examples from this SWIP include a bioretention pond and urban stream restoration. BMPs can be *new practices*, meaning that they treat an area that previously had no stormwater treatment or *retrofits* which are upgrades or enhancements to existing BMPs that, due to their age or design, do not maximize treatment benefits by today's standards and can be modified to do so.

Impervious Surface refers to any hard surface that does not let rain water pass through to the ground, resulting in more runoff along with the pollutants carried by that runoff. Examples are streets, rooftops, parking lots, sidewalks, and driveways. Approximately 41% of the City of Harrisonburg is comprised of impervious surfaces. By contrast, yards are considered *pervious surfaces;* they do not create as much runoff, but they still account for pollutants that flow to streams, such as sediment and nutrients in fertilizers.

Municipal Separate Storm Sewer System (MS4) is a municipally-operated system of inlets, pipes, ditches, stormwater practices, and other features that collect and carry stormwater runoff to receiving streams, such as Blacks Run. The Federal Clean Water Act regulates MS4s and requires communities (through a permit) to develop a local stormwater program with certain minimum standards. In Virginia, MS4 permits are issued by the Virginia Department of Environmental Quality (DEQ). Harrisonburg, as well as neighboring jurisdictions – such as Bridgewater, James Madison University, Staunton, and Waynesboro – are regulated MS4s with DEQ permits. Harrisonburg has held a MS4 permit since 2003. The MS4 permit is updated by DEQ in 5-year increments.

Regulated/Unregulated Areas refers to areas of the City that fall inside and outside the jurisdiction of the City's MS4 permit. It is important to note that the entire city limits are not included in the MS4 permit – only sections that are connected to streams via inlets, pipes, and ditches (urban stormwater system) are part of the *regulated*

area. Examples include streets, yards, rooftops, and parking lots that feed into the stormwater system. Other parts of the City, such as hillsides or yards that "sheet flow" indirectly to streams are known as *unregulated areas.* Figure 1 illustrates both regulated and unregulated areas within the City. James Madison University holds its own separate MS4 permit, so that land area is not part of the City's MS4. The City's priority is to focus on BMP project implementation in the regulated areas, as that is where pollution reduction efforts will contribute most directly to meeting the permit requirements.

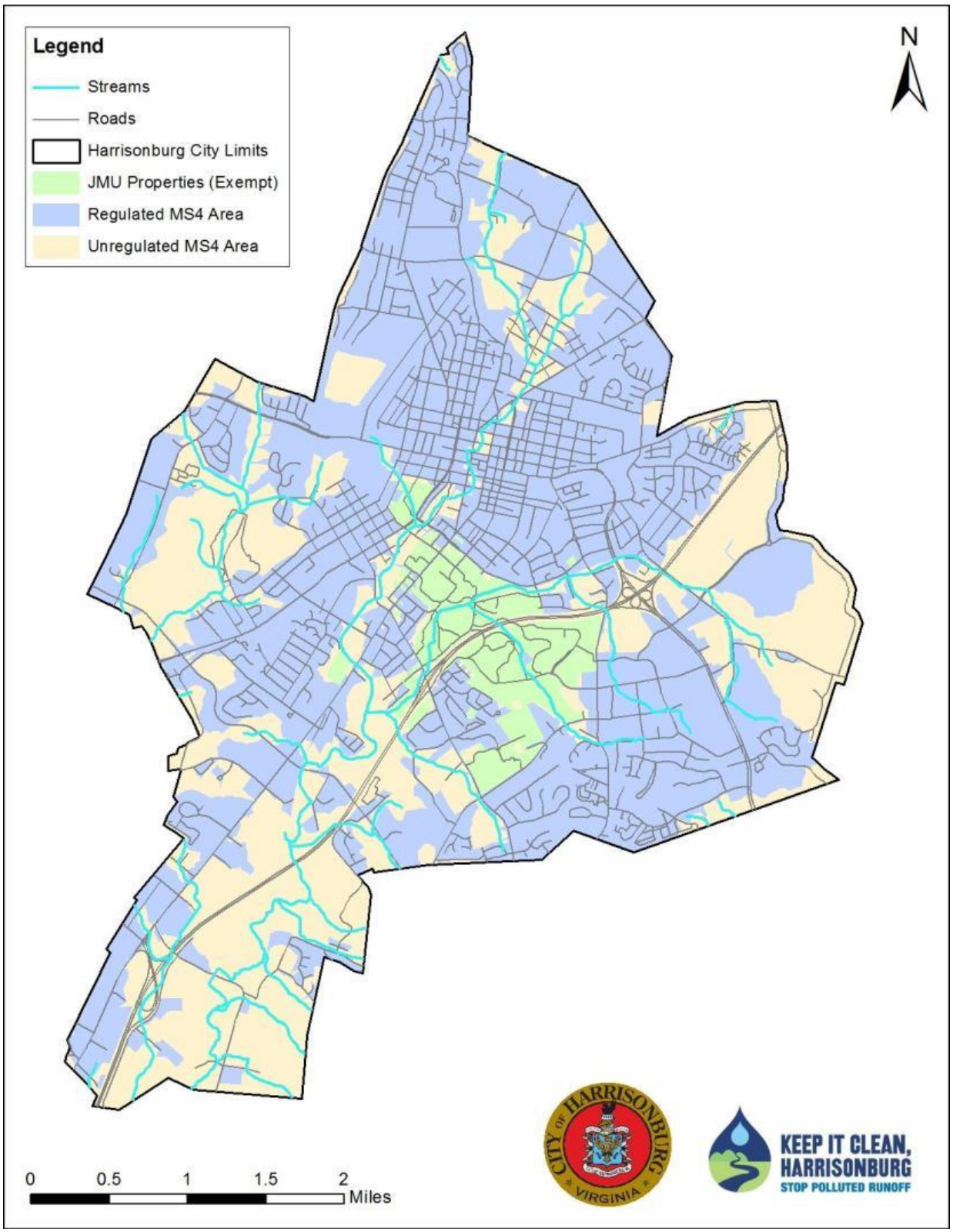
Pollutants are substances that pollute the water by smothering habitats, depleting oxygen, or introducing chemicals that are unhealthy for humans or aquatic life. This SWIP is concerned primarily with three pollutants that are regulated as part of the Chesapeake Bay clean-up and the Blacks Run Cooks Creed clean-up: *Total Phosphorus (TP), Total Nitrogen (TN),* and *Total Suspended Solids (TSS).* TP and TN are *nutrients* that can create excessive algal blooms in waterways and deprive the water of oxygen. TSS is a physical measure of sediment, silt, and other suspended particles that interfere with water clarity, smother aquatic habitats in streams, and can erode or fill stream channels so that drainage and flooding issues are exacerbated. These are not the only three pollutants that affect local waterways, but they are the focus of the regulations and it is believed that reducing these three pollutants will also help reduce other pollutants that impact local waterways.

Total Maximum Daily Load (TMDL) – sometimes referred to as a *pollution diet* – quantifies the maximum amount of pollution a waterway can carry to fulfill the beneficial uses and, importantly, the amount that must be reduced to be within this limit. TMDLs are developed for waterways that do not fulfill their intended beneficial uses (e.g., fishing, swimming, recreation) because of one or more pollutants. The pollution reduction is critical in a regulatory sense, because it becomes a requirement for local and state pollution reduction efforts, including stormwater management programs such as this citywide plan.

The *Chesapeake Bay TMDL* includes the three pollutants noted above: TP, TN, and TSS. The required load reductions are calculated for the entire Chesapeake Bay watershed and each state within the watershed for various "sectors" (e.g., urban, agriculture, forestry). The Chesapeake Bay, through their permitting authority, allocate a proportionate share of the urban load reduction to each MS4 within the Bay watershed under their jurisdiction. Urban load reduction refers to the amount of pollutant needed to be reduced by the City for the waterway to meet water quality standards – or, in the case of a watershed as large as the Chesapeake Bay, – to meet water quality standards for the Shenandoah River and so on and so forth all the way to the Chesapeake Bay. These are often called a Waste Load Allocation (WLA) in the permit requirements. Harrisonburg's MS4 permit requires practices and programs to reduce TP, TN, and TSS loads as the City's contribution to the overall pollutant load reduction for urban areas. Efforts to address the Chesapeake Bay TMDL will also improve local streams and waterways and provide other local benefits tied to this SWIP.

The *Blacks Run & Cooks Creek TMDL* includes the two pollutants noted above: TP and TSS. The required load reductions are calculated for the entire Blacks Run and Cooks Creek watersheds and each contributing entity within the watershed for various "sectors" (e.g., urban, agriculture, industrial). DEQ allocates, through their permitting authority, a proportionate share of the urban load reduction to each sector within the local watershed under their jurisdiction. These are often called a Waste Load Allocation (WLA) in the permit requirements. Harrisonburg's MS4 permit requires practices and programs to reduce TP and TSS loads as the City's contribution to the overall pollutant load reduction for urban areas. Efforts to address the Blacks Run and Cooks Creek TMDL will improve local streams and waterways and provide other local benefits tied to this SWIP.

Figure 1. Harrisonburg Regulated MS4 Areas



Note: JMU properties are exempt from consideration in this plan because the University has its own MS4 permit requirements that are separate from the City's permit requirements.

Goals and Objectives of the SWIP

GOAL 1 – To develop a plan to meet Blacks Run/Cooks Creek and Chesapeake Bay TMDL requirements and associated pollutant reductions in the MS4 permit.

Objective 1.1 – Conduct a citywide assessment of existing watersheds and related city plans.

Objective 1.2 – Identify, evaluate, rank, and prioritize stormwater improvement projects based on their ability to fulfill pollutant reduction requirements in a cost-effective manner.

Objective 1.3 – Identify, evaluate, and prioritize stormwater improvement programs based on their ability to fulfill pollutant reduction requirements in a cost-effective manner.

Objective 1.4 – Coordinate proposed stormwater improvement projects with other city initiatives, programs, and plans.

Objective 1.5 – Tie projects and programs to the Stormwater Utility Fee Credit Program to engage residential and non-residential property owners.

GOAL 2 – To improve local water quality and address drainage issues where feasible by implementing a wide variety of stormwater projects.

Objective 2.1 – Consider local benefits and issues of concern to the community when ranking and prioritizing stormwater improvements and programs.

Objective 2.2 – Identify new programs or program enhancements that may provide public engagement and/or cost savings.

Objective 2.3 – Wherever possible and feasible, address local drainage issues through the implementation of stormwater improvements that are primarily to improve water quality but can also reduce or eliminate drainage concerns.

GOAL 3 - To implement programs and projects in the most cost-effective way.

Objective 3.1 – Utilize the SWIP Excel tool for ranking and preliminary costing purposes.

Objective 3.2 – Create high priority plans for the highest ranked projects that can be used for grant applications.

Objective 3.3 – Implement a Public/Private Partnership program to share the costs and benefits of water quality projects.

Pollutant Load Reductions: How Much & When?

The City's MS4 permit is reauthorized by DEQ in 5-year permit cycles. The total pollutant load reductions are allocated into 3 permit cycles, or a 15-year span. This comprises the current permit cycle (2013 through 2018) as well as the next two cycles (2018 through 2023 and 2023 through 2028). That means that the City has until the year 2028 to provide 100% of required load reductions, divided out through the three permit cycles as follows:

Cycle 1, 2013 – 2018: 5% of the total

Cycle 2, 2018 – 2023: An additional 35% or 40% of the total

Cycle 3, 2023 – 2028: An additional 60% or 100% of the total

The Required Pollutant Load Reductions (Figure 2 and Table 1) lists the actual numerical load reductions required for TN, TP, and TSS for the City. These values are calculated using the regulated MS4 area and methods outlined by the Chesapeake Bay Program and the City's MS4 general permit, along with the *Virginia DEQ Guidance Memo No. 15-2005, Chesapeake Bay TMDL Special Condition Guidance* (DEQ 2015). The values are based on the City of Harrisonburg being within the Potomac River Basin.

Figure 2. Required Pollutant Load Reductions (as a percentage of total required)

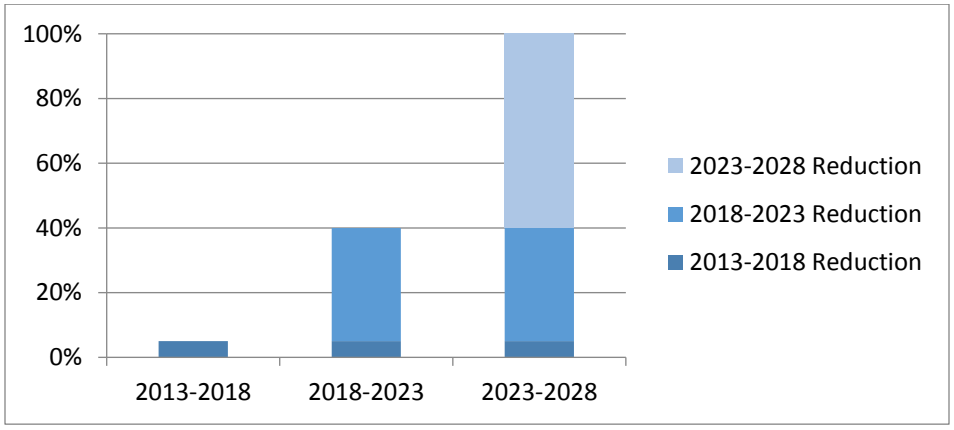


Table 1. Required Pollutant Load Reductions as a Mass Load (Achieved Annually)

Targeted Pollutants	Required Reduction 2013 to 2018: 5% of Total (lbs/yr)	Required Reduction 2018 to 2023: 35% of Total (lbs/yr)	Required Reduction 2023 to 2028: 60% of Total (lbs/yr)	Total Required Reduction: 100% of Total (lbs/yr)
Total Nitrogen (TN)	347	2,337	4,027	6,711
Total Phosphorus (TP)	34	320	531	885
Total Suspended Solids (TSS)	37,978	265,901	455,818	759,697

The take-home points from the sections above:

- The City has a regulatory obligation through the TMDL and MS4 permit to reduce the loads of TP, TN, and TSS in specific amounts by the year 2028 for the Chesapeake Bay TMDL and by an undetermined time for the Blacks Run/Cooks Creek TMDL.
- The selected practices and programs should be cost-effective and provide local benefits.

Practices that Impact Local Water Quality

There are many practices available that can chip away at pollutant loads. The following two sections outline projects and programs as two primary focal points of the SWIP.

The BMP categories addressed in the tables below include Structural BMPs; Urban Stream Restoration; Urban Tree Canopy; Street Sweeping & Catch Basin Cleaning; Septic System to Sanitary Conversions and Homeowner BMPs. To categorize these BMPs further, we have split them into a discussion of projects and programs:

Projects	Structural BMPs (Includes BMP Retrofit), Urban Stream Restoration
Programs	Urban Tree Canopy, Street Sweeping & Catch Basin Cleaning, Septic System to Sanitary System Conversions, Homeowner BMPs

Projects include those practices that will need to go through extensive design, bidding, and construction. Programs include those practices that are imbedded into existing city budgets and are, in most cases, already occurring as a part of regular city operations. The SWIP has identified ways to evaluate and enhance both practices.

When discussing both the local Blacks Run/Cooks Creek TMDL and the Chesapeake Bay TMDL pollution reduction requirements, it is only projects and programs (not nutrient purchasing) that will allow the City to meet both regulations simultaneously.

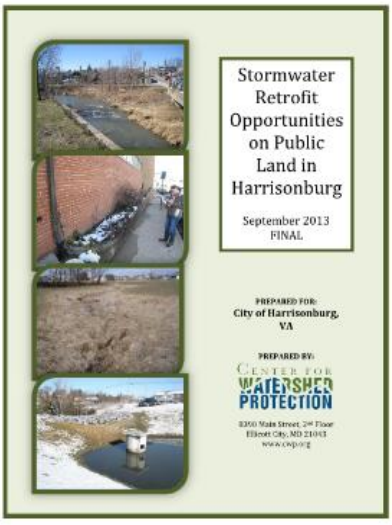
Identifying Water Quality Projects

Building or retrofitting existing stormwater facilities is a cost-efficient practice that also allows for local water quality improvements. The SWIP process evaluated the most promising projects in Harrisonburg and identified, at a planning scale, how widespread the application of each project and program could be across the City, particularly in the MS4 regulated areas.

The City used several sources to identify potential water quality projects. First, the City reviewed the 2013 *Stormwater Retrofit Opportunities on Public Land in Harrisonburg* study by the Center for Watershed Protection (CWP 2013). This review yielded 17 potential BMP locations on public land, some of which are carried over into this plan.

Second, the City used geospatial analysis through an *EPA BMP Siting Tool* to identify the best locations in the City for BMPs to be located based on location, terrain, geology, soils, and other factors. This yielded thousands of potential BMP sites.

Third, the City performed a desktop analysis of the potential BMP sites. After eliminating infeasible BMP locations, the City conducted a field investigation to evaluate the feasibility of each remaining BMP location. Details on the assessment of new BMP sites are in Appendix D, while information on the field investigations are in Appendix E. The City purposely identified more BMPs than necessary to account for BMPs being removed from the plan during implementation for various reasons, such as the inability to secure easements on private land or unexpected site conditions that prevent construction.



Stormwater Retrofit Opportunities on Public Land in Harrisonburg, 2013

Identifying Types of Water Quality Projects (BMP Types)

After undergoing this process, the City had identified BMP locations. The question remained: which BMP types should the City use to meet pollution reduction requirements? The following BMP types were chosen based on their cost efficiency and pollutant removal efficiency as well as their feasibility alongside land development projects. These BMP types are further explained in the tables below.

New Structural BMPs	Bioretention Facilities, Regenerative Stormwater Conveyance, Vegetated Filter Strip, Shallow Marsh/Wet Pond, Enhanced Extended Detention Pond, Public Cisterns
Existing Structural BMPs	BMP Retrofits
Stream Restoration	Urban Stream Restoration

Each table below provides a brief description of the BMP category, the types of BMPs in that category, and example photos. Appendix C provides more detail on the analysis of each BMP category and the process used to analyze that BMP.

The heading of each table also includes a "polluted raindrop" symbol. The number of raindrops is reflective of each BMP's ability to reduce required pollutant loads in Harrisonburg based on the BMP's pollutant removal capabilities. This is provided simply to give a relative sense of how important each BMP may be towards meeting the load reductions. The symbols represent the following:

	BMP or BMP category can reduce 5% or less of the required reduction for TN[1]. The BMP has low pollutant reduction capability and/or can only treat a small amount of land area.
	BMP or BMP category can reduce 5 – 15% of the required reduction for TN[1]. The BMP has moderate pollutant reduction capability and/or can treat a moderate amount of land area.
	BMP or BMP category can reduce up to 30% of the required reduction for TN. The BMP has relatively high pollutant reduction capability and/or can treat a larger amount of land area.

1Total nitrogen (TN) is used here because, based on analysis, it is the most challenging of the three pollutants for Harrisonburg to reduce, and therefore a key selection criteria for BMPs.

Table 2: Structural BMPs

<table>
<tr><td colspan="2">  “Structural BMPs” are engineered and constructed practices designed specifically to remove pollutants and provide other community benefits, such as adding green space and habitat, and, in some instances, addressing drainage issues. Many of these practices rely on plants, soil, mulch, and other materials to filter and treat stormwater runoff.</td></tr>
<tr><td>Bioretention Facilities
  </td><td>Bioretention facilities are landscaped practices that use an engineered soil mix as well as plants and mulch to filter stormwater runoff. Most have underdrain pipes to ensure water only ponds temporarily. They are common in parking lot islands, along pavement edges, and as part of commercial site plans. The City owns and maintains a few bioretention facilities, including this facility pictured at City Hall.</td></tr>
<tr><td>Regenerative Stormwater Conveyance (RSC)
  </td><td>Designed to look like a dry stream bed, RSCs are linear open channels that convey and treat stormwater runoff in a stable manner. A series of riffles and shallow pools, along with an underlying sand bed and native vegetation, provide a stable flow path for stormwater. The City has not yet constructed a BMP of this type.</td></tr>
<tr><td>Vegetated Filter Strip
  </td><td>Vegetated filter strips are planted areas, often with amended soils, placed at the edge of parking lots, roadways, or other areas of impervious cover. Runoff flows evenly across the filter strip as sheet flow, allowing plants, mulch, and soil to absorb the runoff. The City owns and maintains a vegetated filter strip on a Harrisonburg Electric Commission property.</td></tr>
</table>

Shallow Marsh / Wet Pond 	Wet ponds are typically used to treat larger drainage areas and have a permanent wet pool surrounded by aquatic vegetation. They often provide extended holding capacity of larger storms and have sediment trapping forebays. Shallow marshes serve a similar function as wet ponds. They differ in that shallow marshes typically have water depths of less than 6 inches to 18 inches and are planted with emergent vegetation.
Enhanced Extended Detention Pond 	An enhanced extended detention basin captures stormwater runoff, detains it after each rain event, and then filters and treats the water before it is discharged. Enhanced extended detention ponds include a pond area to settle out pollutants, and then a shallow marsh with vegetation that further filters and treats stormwater. The City maintains two enhanced extended detention ponds, one is pictured here at the corner of Erickson Avenue and Stone Spring Road.
Public Cisterns 	Cisterns collect roof water and store it temporarily to be used later to water landscaping, as indoor non-potable water (e.g., toilets), or for vehicle washing. This helps to reduce the amount of runoff sent downstream. This plan includes consideration of public cisterns which tend to be larger and homeowner cisterns which are for individual use. This image shows two cisterns in place at the Department of Public Works. This water is used to supply the flusher trucks for daily operations.

Table 3. BMP Retrofits

"BMP Retrofits" are upgrades or enhancements to existing BMPs that, due to their age or design, do not maximize treatment benefits by today's standards and can be modified to do so.

BMP Retrofits	
	Some older stormwater ponds and basins have been on the landscape for many years, but do not provide much benefit for water quality treatment because they were built using old standards that only required flood (water quantity) control. Also, some do not provide aesthetic benefits to the surrounding neighborhood and are difficult to maintain. Retrofitting these old basins means converting them to incorporate more vegetation, improved habitat, and water quality treatment to meet today's BMP standards.

Table 4. Urban Stream Restoration

Many existing streams in Harrisonburg have been impacted by years of urban runoff. These streams are characterized by erosion along the streambanks, cutting into adjacent property, and destroying natural habitat for aquatic life.

	Eroding streams impact adjacent properties and add sediment and silt into waterways. Stream restoration projects stabilize the stream banks. These projects provide water quality benefits because not as much sediment and silt is created within the stream corridor, and more stable stream functions handle pollutants that wash in from the contributing watershed. Restoration projects can be designed to preserve existing trees and to add ecological benefits for habitat. A prominent stream restoration project occurred in Purcell Park.

Urban Stream Restoration is the only BMP category with three "polluted raindrop" symbols for pollutant reduction capabilities. Structural Practices have two, and the remaining categories have one. It should be noted that Urban Stream Restoration reductions are an order of magnitude higher than the other categories, so that figured prominently in the 'Pounds TN Removed' ranking factor, further explained in Table 5.

Ranking Project Opportunities

Certain BMPs are easier to implement, have more benefits (or less constraints), are lower in cost, or help address drainage concerns in the same area. To give priority to the best BMP opportunities, the plan includes the ranking of all potential BMPs. The City ranked three categories of BMPs: new BMPs, BMP retrofits, and urban stream restoration projects. To do this, the City developed ranking factors and scoring guidelines for each BMP. Each ranking factor was given a scoring range and scoring guidelines as to what criteria the BMP had to meet to receive a given score. For example, one of the ranking factors was *land acquisition*. To receive the maximum score of 10 points, the BMP footprint needed to be entirely on city-owned lands. Conversely, if the BMP requires significant easements or property acquisition, it would receive a score of 0.

The ranking factors contain 3 categories: (1) cost and cost-effectiveness, (2) site and schedule constraints, and (3) addressing other city needs. The full list of the 10 ranking factors and details on the scoring guidelines for each factor are presented in Table 5 and further explained in Appendix G.

BMPs were scored using geospatial data (e.g., known drainage problem areas, city properties) and information collected during the field investigation (e.g., photographs, field data forms). As part of the ranking process, the City also estimated the cost of each BMP using a schedule of generalized unit costs with potential additional costs to implement each BMP added based upon site data (e.g., required diversions of flow, utility conflicts, etc.). The final ranking criteria selected is listed in Table 5. The final list of ranked projects is presented in Appendix H.

BMPs, such as bioretention facilities, help reduce excess nutrients and sediment in stormwater runoff.

What about Flooding and Drainage Issues?

The BMPs in this plan were identified and ranked primarily for their benefits to local water quality and to achieve regulatory compliance for the City's MS4 permit; however, this plan does include careful consideration of water quantity issues related to flooding and drainage concerns throughout the City.

A project to eliminate flooding and drainage issues without improving water quality would not meet the basic selection criteria for a BMP, and is not included in the plan; however, all projects in this plan that help to reduce or eliminate flooding and drainage issues received additional points in the ranking.

Locations throughout the City experience a range of flooding and drainage concerns. This site shows an interconnection of Blacks Run between the City of Harrisonburg and James Madison University.

The development of this plan also included reference to the 1999 Storm Water Action Plan which catalogued citywide drainage and erosion concerns, updating city databases of known drainage concerns, and the addition of flooding and drainage concerns identified during the first public meeting. The resulting list of 167 flooding and drainage issues were then mapped in the city GIS databases with short descriptions of the identified concern, as described in more detail in Appendix B.

The City hopes that there will be dual and ancillary benefits to many of the proposed projects, thus reducing resources needed for addressing flooding and drainage issues through separate funding in the future. See how the ranking factors played a role in project identification in Table 5.

Table 5. Project Ranking Factors

Ranking Factor	Scoring Technique	Scoring Range	Max Score
Pounds TN Removed	The project with the highest TN pollutant removal receives the highest score. Projects are scored as a percent of the best pollutant removal, multiplied by 20, so the score can range from 0 to 20.	0-20	20
Cost Effectiveness	Cost effectiveness is calculated by dividing the total project cost by the pounds of TN removed. Projects are scored as a percent of most cost effective project multiplied by 20, so the score can range from 0 to 20.	0-20	20
Project Cost	Project cost includes projected cost for design and construction. The lowest project cost receives the highest score, so the score can range from 0 to 10.	0-10	10
Land Acquisition	Projects located on city-owned land earn the highest score as there will be no land acquisition needed.	10	10
	Projects located on private property where minimal easement acquisitions will be needed earn a mid-range score.	5	
	If a project crosses multiple private properties and significant easement or property acquisition will be needed, the project will earn the lowest score.	0	
Drainage Issues	A project that addresses flooding or infrastructure risk in areas with known drainage issues earns the highest score. Drainage issues have been mapped based on staff knowledge and public involvement.	10	10
	Projects that provide detention or conveyance benefits but are not in area with known drainage issues earn a mid-range score.	5	
	Projects that are purely water quality projects and do not provide additional detention or conveyance benefits earn the lowest score.	0	
Maintenance Burden (Long-term)	Projects that require little maintenance earn the highest score.	10	10
	Projects with a medium maintenance burden will earn a mid-range score.	5	
	When extensive staff time and money is needed to maintain the project, it will earn the lowest score.	0	
Site Constraints & Potential Utility Constraints	If there are no constraints such as large trees or underground utilities that would need to be relocated, then the project will earn the highest score.	7	7
	If there are utilities or vegetation present that would be easy to avoid, such overhead electric or phone lines, then projects will earn this score.	5	
	If access is somewhat constrained, making it difficult for construction or maintenance vehicles to access the site, the project will earn a mid-range score.	3.5	
	If vegetation or utilities are present but relatively easy to avoid and access is only somewhat constrained, then projects will earn this score.	2.5	
	If there is poor access, major grading required, karst topography, or major utilities like a sewer line that must be moved, then a project will earn this score.	1	
	If there is poor access, major grading is required, major utilities must be moved, or karst topography is present, a project will earn the lowest score.	0	
Implementation Schedule	If a project can be implemented in under 12 months, with no permitting requirements, it will earn the highest score.	6	6
	If a project can be implemented in under 12 months with permitting requirements or a project can be implemented in 12 to 24 months with no permitting requirements, it will earn this score.	4	
	If a project can be implemented in 12 to 24 months with permitting requirements or a project cannot be implemented in under 2 years with no permitting requirements, it will earn this score.	2	
	If a project cannot be implemented in under 2 years with permitting requirements, it will earn the lowest score.	0	
Synergy	If a project can be incorporated within other city infrastructure plans and projects and it also provides environmental benefits beyond water quality benefits, then the project will earn the highest score.	5	5
	If a project can be incorporated within other city infrastructure plans and projects (including other potential BMPs) but does not provide additional environmental benefits, then it will earn this score.	4	
	If a project provides multi-purpose or environmental benefits beyond water quality benefits, then the project will earn a mid-range score.	2.5	
	A project will earn the lowest score if it provides only water quality benefits.	0	
Aesthetics / Visual Appeal	If a project adds landscaping or would enhance aesthetics at the site, it will earn the highest score.	2	2
	If the project neither detracts from aesthetics nor adds much in the way of value, or the project is out of general public view, it will earn a mid-range score.	1	
	If a project provides only water quality benefits and does not enhance aesthetics of a site, it will earn the lowest score.	0	

The take-home points from the sections above:

- A document developed in 2013 for BMP analysis on publicly-owned land served as a valuable reference and basis for this SWIP, but public and private properties were analyzed for BMP projects in this SWIP process.
- The City has developed ranking criteria to identify feasible and cost-efficient BMPs. The tool analyzed new BMPs, stream stretches for restoration, and existing BMPs that may be suitable for retrofit. The result is a prioritized list of 145 projects spanning all the aforementioned BMP types.

Identifying Water Quality Programs

There are many programs that can reduce pollutant loads. The SWIP process evaluated the most promising programs feasible in Harrisonburg and identified improvements to those programs that already exist. Each table below provides a brief description of the program category, the different components of that program, and example photos.

The heading of each table also includes a "polluted raindrop" symbol. The number of raindrops is reflective of each BMP's ability to reduce required pollutant loads in Harrisonburg based on the BMP's pollutant removal capabilities. This is provided simply to give a relative sense of how important each BMP may be towards meeting the load reductions. The symbols represent the following:

	BMP or BMP category can reduce 5% or less of the required reduction for TN[1]. The BMP has low pollutant reduction capability and/or can only treat a small amount of land area.
	BMP or BMP category can reduce 5 – 15% of the required reduction for TN[1]. The BMP has moderate pollutant reduction capability and/or can treat a moderate amount of land area.
	BMP or BMP category can reduce up to 30% of the required reduction for TN. The BMP has relatively high pollutant reduction capability and/or can treat a larger amount of land area.

1Total nitrogen (TN) is used here because, based on analysis, it is the most challenging of the three pollutants for Harrisonburg to reduce, and therefore a key selection criteria for BMPs.

Table 6. Urban Tree Canopy

"Urban Tree Canopy" has numerous benefits that include, and expand far beyond, stormwater management. Unfortunately, tree planting does not yield high pollutant removal in comparison to other practices. That being said, maintaining and improving the City's urban tree canopy is still highly encouraged.

Planting trees in urban landscapes can help reduce runoff and absorb pollutants. The City of Harrisonburg is undergoing development of an urban tree canopy report from the Green Infrastructure Center that identifies how to use trees for stormwater management. Tree planting and maintenance of existing trees is currently a component of the Residential Stormwater Utility Fee Credit Program (see section below).

Table 7. Street Sweeping and Catch Basin Cleaning

Many pollutants accumulate on streets, in gutters, and in catch basins. Cleaning the streets and catch basins can remove these pollutants before they wash down into streams through the storm sewer system.

Street Sweeping 	People are familiar with street sweeping as a way to keep cities clean. The grit, sediment, organic material (e.g., leaves), and other debris collected by sweepers are also a pollutant source when they are allowed to wash off into storm drains which convey runoff to streams and waterways. Collecting this material in street sweepers, when done on a regular basis during the right times of year, reduces downstream pollution. The City of Harrisonburg has a robust street sweeping program. Two street sweepers (purchased with Stormwater Utility Fee funds) circulate the entire City one time each month.
Catch Basin Cleaning 	Like street sweeping, cleaning catch basins and storm drain inlets can remove pollutants before they are allowed to wash downstream into the pipes and eventually into waterways. The City of Harrisonburg has an ongoing catch basin cleaning program. Crews have a goal of reaching every city-owned storm drain inlet once a year.

Table 8: Septic System to Sanitary Sewer Conversion

Septic systems have the potential to leak and leach nitrogen into the water table. This excess nitrogen can make its way into local streams and other waterbodies. Connecting a septic system to a sanitary sewer system removes this potential source of excess nitrogen.

	Connecting old septic systems to the City's sanitary sewer system can remove nutrients that may be leaching into the ground and streams. The City has a small number of these older systems, some of which have already been switched over to the sanitary system. Encouraging or requiring property owners to convert from septic to sanitary is a means to meet pollution reduction requirements. This proposed program enhancement is outlined in the Stormwater Utility Fee Program section below.

Table 9: Homeowner BMPs

The City's Stormwater Utility Fee Credit Program allows residential and non-residential property owners to receive a credit on their utility fee if certain BMPs are implemented on their property. For residential properties, there are multiple practices that can receive a credit; the ones noted below are the most widely-used. To receive a fee credit, practices must meet standards outlined in the credit manual: https://www.harrisonburgva.gov/stormwater-utility.

Roof Drain Disconnection 	This practice involves simply routing roof downspouts onto areas of grass or landscaping instead of connecting directly to driveways, streets, or the storm sewer system.
Rain Barrel or Cistern 	Rain barrels collect roof water and store it temporarily to be used later to water gardens, landscaping, and yards. This helps to reduce the amount of runoff sent downstream.
Homeowner Nutrient Management 	The homeowner signs a pledge agreeing to certain lawn care practices involving managing the use of pesticides and fertilizers. These chemicals can end up in stormwater runoff if not applied properly.

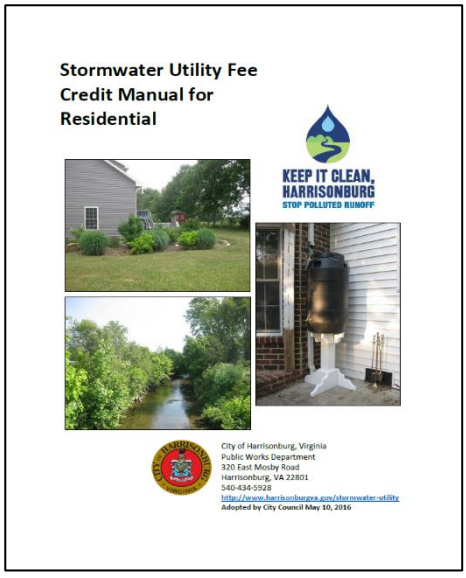
Table 10: Potential Program Enhancement

Program Name	Program Description
Urban Tree Canopy	Review findings and implement recommendations found in the Green Infrastructure Center's 'Utilizing Urban Tree Canopy for Stormwater Management' deliverable package. This document and its findings will be posted here upon completion: https://www.harrisonburgva.gov/stormwater-projects.
Street Sweeping	Maintain current level of service.
Catch Basin Cleaning	Maintain current level of service. Prioritize storm drain cleaning efforts by identifying high priority (poor condition) storm drains to reach at the beginning of each year.
Septic to Sanitary Conversion	1. Include as credit opportunity in the Stormwater Utility Fee Credit Program. 2. Develop a grant program to financially assist with connection fees. Partner with the Shenandoah Valley Soil & Water Conservation District to utilize their grant management expertise. 3. Require regular cleanout of septic systems to ensure system is functioning properly and to track where septic systems are in the City of Harrisonburg.
Homeowner BMPs	See Stormwater Utility Fee Credit Program recommendations (below).

Stormwater Utility Fee Program

The City of Harrisonburg's Stormwater Utility Fee Program became effective on July 1, 2015. The Utility Fee was adopted largely to provide a revenue source for the City to meet the regulatory mandates with the MS4 permits. Revenue collected from the stormwater utility fees is used for the following primary activities:

- Compliance with the Blacks Run/Cooks Creek and Chesapeake Bay TMDL pollution reduction requirements.
- Development of the citywide SWIP (this document) to identify, select, and prioritize capital projects and programs to reduce pollution, manage stormwater, and protect the City's drinking water sources.
- Planning, design and construction of stormwater capital projects, including stormwater management retrofits and community greening projects to reduce pollution and improve water quality. These include projects on city-owned properties and projects in cooperation with other property owners, as identified in this SWIP.
- Coordination of pollution reduction efforts including staff training, pollution prevention and good housekeeping practices for municipal operations, a pollution detection and elimination program, and a public education and outreach program.
- Inspection, maintenance, and operation of City-owned storm sewer systems, natural waterways, and stormwater management practices.



The Stormwater Utility includes a Credit Program whereby residential and non-residential property owners can reduce their fee by implementing one or more practices that help control their site's stormwater runoff. There are two manuals available for residential and non-residential applications that outline the practices and how to calculate the fee reduction. The fee credit is intended to act as an incentive program to engage property owners in stewardship and actions that will assist the City with its pollution reduction responsibilities. The City also can also count these practices submitted by residential property owners (and those voluntary practices by non-residential property owners) towards Blacks Run/Cooks Creek and Chesapeake Bay TMDL pollution reduction requirements. In reviewing SWIP programs, this is an area that could be enhanced to better serve the public as well as the City's reduction requirements.

Table 11. Existing Stormwater Utility Fee Credit Program

Program Name	Program Description
Stormwater Utility Fee Credit Program	The credit program is a mechanism by which property owners can lower their Stormwater Utility Fee. It is available for residential & non-residential property owners, and is a voluntary process that offers a maximum 50% credit. Up to this point, participants have been mostly in the residential category. Available residential practices include: • Roof Drain Disconnection • Rain Barrel/Cistern • Rain Garden • Urban Tree Planting/Maintaining Existing Tree Canopy Cover • Conservation Landscaping • Homeowner Nutrient Management & Lawncare Agreement • Impervious Surface Removal

Table 12. Potential Stormwater Utility Fee Program Enhancement

Program Name	Program Description
Increase Max Credit Offered	Currently the maximum credit is set at 50% for both residential and non-residential credits. An increase in the credit amount would provide extra incentive for property owners to implement practices.
Add Septic to Sanitary Connection	Septic to sanitary sewer connections are creditable under the Chesapeake Bay TMDL program. Adding this as an option to the credit program would allow an extra mechanism for tracking connections and provide property owners with an incentive to connect to the sanitary sewer system.
Streamline Application Process/ other City Initiatives	There are potential water quality incentive programs housed in other departments that could be added to the Stormwater Utility Fee Credit application. Including other city initiatives that improve water quality on the application would mean the credit application process would be streamlined (one application for multiple departments, as opposed to an application for every department's initiatives) and other departments would be able to assist with outreach. An example of this may be an I&I program initiative in correlation with the Public Utilities Department.
Simplify Application Process	The current application process requires a property owner to fill out a .pdf document and then mail/email/or hand in the application. Creating an online application would simplify the process for those applications who wish to fill out a digital application, although paper applications would still be available.

The take-home points from the sections above:

- The City has implemented a variety of pollution reduction programs already and has been able to submit those pollution reductions numbers for Blacks Run/Cooks Creek and Chesapeake Bay TMDL compliance.
- There are opportunities to enhance a few of the programs the City has in place to increase pollution reduction.
-

Are these Projects & Programs Enough?

At the beginning of the SWIP development process, the City analyzed its existing programs in an initial water quality assessment. In this assessment, the City looked at street sweeping, catch basin cleaning, homeowner BMPs and connecting properties on septic to sanitary sewer. These activities are already being conducted in the City (as outlined above) and the City can take credit for these as a part of compliance. In this exercise, the City projected the improvements that these programs could make. Pollution reduction from the existing programs as well as pollution reductions from implementing enhancements was accounted for and outlined below.

Table 13. Summary of Pollutant Loads Reduced from Program Implementation

		TN	TP	TSS
Chesapeake Bay TMDL Total Reduction Required (lbs/yr)		6,711.0	885.0	759,697.0
Implementation Activity (lbs/yr reduced)	Street Sweeping	79.0	26.0	37,153.0
	Catch Basin Cleaning	223.0	50.0	0.0[A]
	Homeowner BMPs	161.0	15.0	0.0[A]
	Septic Connections	291.0	0.0[A]	0.0[A]
Total Reductions (lbs/yr)		754.0	91.0	37,153.0
Load Reduction Gap (lbs/yr)		5,957.0	794.0	722,544.0

[A] THIS PRACTICE DOES NOT RECEIVE LOAD REDUCTION CREDIT FOR THIS POLLUTANT.

As Table 13 shows, there is a remaining load reduction gap from program implementation alone. To fill this gap, the City will install BMP projects throughout the City. Table 14 presents the load reductions from project implementation. The projects listed below have been selected due to their higher rankings from the ten factors outlined in Table 5, expected cost, and other constraints.

Table 14. Summary of Pollutant Loads Reduced from High Priority Project Implementation

	Excel Tool Ranking (out of 100)	TN	TP	TSS
Thomas Harrison Middle School BMP Retrofit Beside Parking Lot	74.9	72.0	5.3	3,770.0
Thomas Harrison Middle School BMP Retrofit Beside Basketball Court and Track	77.0	90.1	6.4	4,484.0
Eastern Mennonite University Detention Pond	58.1	144.4	22.2	20,811.0
Eastern Mennonite School Stream Daylighting and Restoration near Parkwood Drive	40.2	39.2	35.5	23,428.0
Virginia Mennonite Retirement Center Enhanced Extended Detention	44.0	252.9	44.1	39,537.0
Harrisonburg Public Utilities Wet Pond	61.0	235.3	31.5	24,240.0
Heritage Oaks Golf Course Pond	53.3	385.3	59.5	50,732.0
Keister Elementary School Stream Restoration	45.2	78.9	71.9	47,410.0
Mountain View Drive Stream Restoration	48.8	100.0	101.5	63,260.0
Northend Greenway Trail and Stream Restoration	55.1	595.0	86.0	40,475.0
East Market Street Median Regenerative Stormwater Conveyance	72.2	417.8	54.2	48,010.0
Project Implementation Total Reductions (lbs/yr)		2410.9	506.2	366,156.0

	Excel Tool Ranking (out of 100)	TN	TP	TSS
Table 13 Program Implementation Total Reductions (lbs/yr)		754.0	91.0	37,153.0
Total Reductions for Project & Program Implementation*		3,161.5	597.2	395,840
Chesapeake Bay TMDL Total Reduction Required (lbs/yr)		6,711.0	885.0	759,697.0
Load Reduction Gap (lbs)		3,549.5	287.8	363,857

* These practices will be revised at the five-year update of the SWIP based on 2nd permit cycle funding opportunities.

The results of this exercise are presented in Table 14. Appendix C contains a detailed look at the water quality assessment, including its technical assumptions and calculations. Based on the assessment, all three pollutants – TN, TP, and TSS –still have a gap (last row in the table) compared to the required pollution reduction for the Chesapeake Bay TMDL. This means that at current project implementation levels, even with an ambitious supporting program, these pollutants cannot be reduced to the levels mandated. This is not an unusual circumstance, as other MS4s in Virginia are wrestling with similar challenges in meeting TN, TP, and TSS reduction requirements by 2023.

The take-home points from the sections above:

- If all program enhancements are implemented and all high-priority projects are implemented the City will still not reach total compliance requirements, *but 60% requirements will be met*. This plan will need to be updated upon entering the third permit cycle to account for the remaining 40%.
- Total reductions required will need to be met by including additional project implementation, additional funding sources, and additional compliance mechanisms to the practices listed above.

Financial Programs

As outlined, even with program enhancement and project implementation the City will still need to incentivize additional project opportunities in the community. Much of this SWIP has focused on BMPs that reduce pollutant loads. However, no BMP can be implemented effectively without a financial program behind it. Table 15 outlines several existing resources that can utilized for pollution reduction ideas. One of the programs, the Virginia Conservation Assistance Program (VCAP), is coordinated by the Shenandoah Valley Soil & Water Conservation District, but is applicable within City limits.

Table 15. Existing City and State Resources

Program Name	Program Description
Stormwater Advisory Committee (SWAC)	• Provides guidance and recommendations on use of stormwater utility fee dollars and guidance in administering the City's stormwater management program
Capital Improvement Plan (CIP) Design-Bid-Build	• Traditional mechanism through CIP to design, publicly bid, and then construct capital improvement projects • Stormwater projects include drainage repairs, stream restoration, and construction of several stormwater BMPs • Subject to project management capacity constraints for the responsible department implementing the CIP

Program Name	Program Description
Virginia Conservation Assistance Program (VCAP)	• Urban cost-share program (to match long-standing cost-share programs for the agricultural sector); Voluntary on the applicant's part • Relatively new as a statewide program • Administered through Soil & Water Conservation Districts • Twelve available BMP practices; large and small • Most popular BMP is conservation landscaping • There are limited funds, statewide

The SWIP has identified several ways to expand and enhance existing program resources to accelerate pollution reduction efforts; Table 16 summarizes some of these. Many involve partnerships with citizens and businesses to achieve higher levels of pollution reduction in a more expedient timeframe. *Public-private partnerships* are being explored across the Chesapeake Bay Watershed and beyond to share responsibility between public and private sectors for local water quality. Many of these partnerships involve innovative financing and contracting mechanisms that are new to the stormwater field, but have been used in other sectors, such as housing, schools and transportation. Appendix E provides more detail on existing and potential future programs and policies for the City's consideration.

Table 16. Potential New Pollution Reduction and Incentive Programs

Program Name	Program Description
Partner with Non-Profits	• Cooperative program between the City and non-profits to identify and deliver BMPs • Can be structured as a grant program administered by a grant-funding agency; example: Anne Arundel County Restoration Grant Program through the Chesapeake Bay Trust • Can also serve as a workforce development program; examples: READY program, Howard County Eco-Works
City Grant Program	• City administers grants directly to property owners to help pay for initial design and/or construction of BMPs • Could be coupled with VCAP and utility crediting to create multiple incentives • Eligible grantees could be scored based on BMP cost-effectiveness or other factors
Reverse Auction	• Funds are made available to low bidders to install BMPs based solely on pollutant reduction benefits ($ per pound) • Probably most usable for residential program expansion by a third party
Public Private Partnership (P3)	• Municipality contracts with a P3 private partner (likely an environmental consulting firm or contractor) to seek, design, build, and maintain projects • Most of the risk, but also the control, is transferred to the private party • Private party will seek the most profitable approach to reach goals • "Pay for Success" is a related model whereby payment is linked to successful delivery of outcomes (e.g., X pounds of pollutant reduced); See Sokulsky and Alexandrovich (2016) for a detailed description from the western states.

Program Name	Program Description
Community-Based Public Private Partnership (CBP3)	• More of a partnership between the municipality and private partner to establish CBP3 administrative structure • Intent is to add community goals (e.g., workforce, neighborhood investment, community greening) onto the traditional P3 approach

Purchasing Nutrient Credits

The SWIP envisions a significant financial investment on the part of the City. Elected officials and City departments have an obligation to ensure that investments reflect cost-effective options and that the City and its citizens will get their money's worth from the selected projects and programs.

Another option considers off-site compliance, meaning that some pollutant reduction credits are obtained from outside of the jurisdictional limits of Harrisonburg through various credit purchases or contractual arrangements with private pollutant banks or other entities that hold a pollution discharge permit. The MS4 permit authorizes this type of "trading" arrangement.

Using off-site pollutant compliance strategies should not be taken lightly, as it means using stormwater fee dollars for improvements whose chief benefits may accrue elsewhere. Given a choice, the City may prioritize making improvements within its boundaries for the benefit of its own citizens. However, several of the off-site options present very cost-effective solutions, so this will become a very strategic decision about balancing costs and benefits.

The City will strategically plan if there is a need to purchase these credits, as the costs are subject to market influences. For instance, as more MS4s like Harrisonburg become interested in purchasing credits, the cost may go up and the supply may become very constrained. In this regard, there are two types of off-site compliance strategies that need to be considered:

1. Annual Credits

Annual credits mean that they must be purchased every year. This arrangement can be executed through a memorandum of understanding (MOU) or contract with the organization that also has a pollution control permit from the State, but has excess credits that it can make available because pollution reductions are above and beyond currently-permitted limits. For the city, the most likely organization that can offer credits is the Harrisonburg Rockingham Regional Sewer Authority (HRRSA).

There is some risk that annual credits may not be available in future years, so the strategy can be viewed as a "stop-gap" or temporary measure to allow time for local BMPs to be designed and constructed. Given that, annual credits can be very cost-effective and should be included in the overall strategy for compliance.

2. Perpetual Credits

As compared to annual credits, perpetual credits are a one-time purchase. Virginia has an established a "Virginia Nutrient Bank" whereby certain property owners and businesses can establish nutrient banks that generate credits for purchase. The pollution reduction actions that generate these credits are usually on agricultural or larger tracts of land through converting pasture to permanent riparian buffers or restoring degraded streams. These credits are regulated and certified by DEQ. DEQ also requires that credit purchasers be within the same or an adjacent watershed as where the credits are generated. For Harrisonburg, this means the Shenandoah/Potomac watershed, and there are currently about 15 nutrient banks that have available nutrient credits.

While perpetual credits do not have the same level of risk as annual credits, they are much more expensive, and therefore would require a higher commitment of stormwater utility funds. At some point, if these credits are more cost-effective than what can be achieved through local BMP implementation, then they become a viable option. These types of credit purchases will need to be programmed well ahead of the actual need though, because, as stated above, the credit markets are subject to the forces of supply and demand, meaning that costs and availability may fluctuate.

Conclusion

The SWIP provides three options for overall TMDL compliance: programs, capital projects, and nutrient credit purchases. Up to this point, regulatory compliance has been achieved by programs; however, as the pollutant removal requirements increase, the City must diversify its approach towards compliance. The SWIP provides a framework to meet the pollution reduction requirements, which will be used to implement a stormwater improvement strategy that maximizes local benefits while providing a cost-effective solution for citizens and property owners paying the stormwater utility fee.

The SWIP Appendices

The development of this plan involved data collection, review and analyses to assess the City's watersheds, review existing City plans and documents, develop new tools and databases to organize information, modeling through the City's geographic information systems (GIS), calculation of pollution load reductions, identification of BMP sites and priority projects, ranking of those projects for the identification of high priority sites, establishing an MS4 compliance budget, and all associated work.

As a result, this SWIP includes extensive technical appendices and supporting information that provide more details on the topics presented in this document and used in the SWIP development.

Appendix A, Watershed Assessment details the review and assessment of existing City information and plans that are relevant to the SWIP, and how this information was organized using various mapping (geospatial) tools for use as supportive information for this plan.

Appendix B, System Capacity Assessment documents the cataloguing of previous and new flooding and drainage issues as well as floodplains and stream erosion concerns.

Appendix C, Water Quality Assessment contains detailed information on the accounting for pollutant load reductions in the plan, as compared to regulatory requirements for MS4 compliance.

Appendix D, Evaluation of Additional BMP Opportunities discusses additional BMPs needed to close the pollutant load reduction gap for Total Nitrogen (TN) and how locations are types of BMPs were selected.

Appendix E, Citywide Program Assessment outlines existing City programs and policies related to managing a citywide stormwater program, including SWIP implementation strategies.

Appendix F, Field Investigations of BMP Opportunities includes field data forms and site sketches for each BMP included in this plan.

Appendix G, Development of a Prioritization and Ranking Tool details the site analysis for each BMP, ranking criteria developed for this plan, unit cost tables for construction and long-term maintenance estimates, and the approach to ranking BMPs.

Appendix H, List of Recommended BMPs identifies, by category and rank, the new BMP opportunities, existing BMP retrofits, and stream restoration projects included in this SWIP.

Appendix I, High Priority Concept Plans includes a conceptual plan and cost estimate for each BMP opportunity identified as a high priority.

Appendix J, Consensus Building Activities includes supporting information for the two public meetings held during the development of this plan, as well as written comments received during the public comment period.

Appendix A: Watershed Assessment

Introduction

As the first step in the Stormwater Improvement Plan development, the City conducted an overall watershed assessment of the City of Harrisonburg in line with the following SWIP Objective 1.1 (see main SWIP report):

The following strategies were employed for the task:

- Collect and review previous city records, reports, studies, and information related to stormwater improvement needs, including relevant citywide master plans.
- Collect and review geospatial data that is provided by the City or available from others for use in this SWIP.

Review of Previous Plans, Studies and Reports

The City conducted a review of previously developed plans and city records for an understanding of past planning the City has done and how past planning can aid in the development of this SWIP. A review of existing plans and city records included the following documents:

1. 2016 MS4 Annual Report
2. 2016 Chesapeake Bay TMDL Action Plan
3. 2016 Street Sweeping Credits
4. 2016 Storm Drain Cleaning Credits
5. 2016 City Owned BMPs Database
6. 2016 Drainage Issues Tracking
7. 2016 Stormwater Improvement Plan Scoping Report
8. 2016 Maintenance Facility SWPPPs
9. 2016 East Market Street BMP Design
10. 2015 Historical BMP Inspection Report
11. 2015 Cost Share Programs Overview
12. 2014 Downtown Streetscape Plan
13. 2013 Drainage Problems List
14. 2013 Stormwater Retrofits on Public Land
15. 2013–2018 MS4 Program Plan
16. 2011 Comprehensive Plan
17. 2010 Bicycle and Pedestrian Plan
18. 2008 Urban Values and Vision Plan
19. 2006 Water Quality Improvement Plan for Blacks Run and Cooks Creek
20. 2002 Blacks Run Greenway Master Plan
21. 1999 Storm Water Action Plan
22. Harrisonburg Downtown Park Plan
23. Cityworks BMP Maintenance Records
24. Routine Inspection and Maintenance Records
25. Maintenance Hard Copy Maps and Spreadsheets
26. City Floodplain Modeling and Mapping
27. City and Non-City GIS data (e.g., NWIS, NRCS soil maps)

The review of these studies and reports can be categorized as shown in Table A-1.

Table A-1. Summary of Previous Plans, Studies, and Reports

Category	Items	Notes
City MS4 Program Reviews and Pollutant Reduction Calculations for Non-Structural BMPs	1, 2, 3, 4, 7, 11, and 15	These documents form the basis for the non-structural BMP calculations of TP, TN and TSS pollutant reductions as well as the review of Citywide programs and policies in the SWIP. City Excel sheets containing pollutant removal calculations for non-structural BMPs were key parts of this data.
Structural BMP Opportunities and Associated Pollutant Reduction Calculations	5, 8, 9, 10, 12, 14, 19, 20, 22, 23 and 27	These documents form the basis of identifying BMP opportunities throughout the City. Document #14 was the primary data source for identifying BMP opportunities on public lands. Document #9 was used for pollutant removal calculations for the three BMP retrofit designs on East Market Street (US-33).
Previously Identified Storm Sewer Capacity Issues	6, 13, 21, 23, 24, 25, and 26	These documents formed the basis of identifying storm sewer capacity issues such as drainage and flooding problems. Document #6 was the primary data source for listing known problems currently.
Citywide Planning Guidance and Goals	2, 7, 16, 17, 18, and 20	These documents were used to determine if BMP recommendations were consistent with previous planning studies important for future coordination to establish synergy A key element was identifying stream reach opportunities consistent with the Blacks Run Greenway Development Plan (Document #20).

Further discussion regarding how these previous data sources help to inform the SWIP can be found in the report chapters that follow.

Review of Geospatial Data

The City maintains a comprehensive database of geospatial data within a geographic information system (GIS) that can help reveal the best potential sites for stormwater improvements. Examples of the relevant types of data that were reviewed and used in this SWIP include:

- Property Boundaries (e.g., JMU boundaries, regulated MS4 area, parcel mapping)
- Land use / land cover (e.g., impervious areas, forested areas, streams)
- Topographic information or contours (elevation data)
- Soil types (including information on karst areas)
- Existing BMP locations
- Storm sewer systems and other utility system mapping

Appendix B: System Capacity Assessment

Introduction

A stormwater system capacity assessment for this SWIP was performed to address Objective 2.3 (see main SWIP document):

The following strategies were employed for the task:

- Designate previously identified drainage issues in a geodatabase
- Incorporate new drainage issues within the geodatabase
- Consider regulatory floodplains throughout the City and drainage issues within the geodatabase to help prioritize stormwater improvement projects

Background

The stormwater program that the City of Harrisonburg manages today can be traced back to its roots in the 1999 Stormwater Action Plan. The Action Plan was developed at a time before water quality regulations, when stormwater problems were identified as areas of flooding and erosion. The Action Plan included more than 30 different problem areas and was estimated to cost $4.5 to $5.0 million to implement. Identified projects were ranked and prioritized based on relative severity and cost.

The Action Plan cautioned that some of the identified problems could be the responsibility of private property owners and that the City Council should work with staff to define the level of service it was responsible for and able to provide to citizens. The plan also cautioned that there likely were additional drainage issues throughout the City, such as stream maintenance concerns, that would require additional public input and that future development patterns were likely to exacerbate and increase the number of problems.

Many of those same recommendations could still be made today, and some of those same identified drainage issues persist as we develop the recommendations contained in this SWIP.

Drainage Issues

The City has tracked drainage issues since 2016 and has tracked issues more informally prior to that time. These issues were compared with the 1999 Action Plan to determine the overall status of the City's drainage concerns. Both lists were developed through an Excel spreadsheet and showed a significant amount of overlap with the 1999 plan. See Phase I public input meeting posters in Appendix J for a compiled map of drainage concerns in the City of Harrisonburg.

Based on a review of this city information and information gathered from the public at the SWIP public meetings, a geodatabase of the drainage issues was developed. The geodatabase linked information that was provided through Excel spreadsheets to a physical location for each site and mapped the general limits for each identified issue. In addition, notes about each drainage issue were included in the geodatabase. It should be noted that drainage concerns will not be addressed as part of this improvement plan directly, nor are all drainage concerns of public concern. The purpose of this geodatabase is to ensure that drainage issues are tracked so the City can determine if they are indirectly improved or changed through the construction of the stormwater improvement projects outlined in this plan.

The drainage geodatabase was categorized based on the most common types of issues, as noted below:

- Debris Issues – These problem areas are associated with debris or clogging issues, resulting in standing water.
- Erosion Issues – These problem areas are where stormwater runoff has created noticeable erosion or soil loss.
- Other Drainage Issues – These are areas with basement and backyard wetness, standing water, and/or slow draining water of other types.
- Public Works Maintenance – These are areas that Public Works staff address on an as-needed basis. These issues are considered city concerns or public issues, because the drainage issues may affect a public street or city property. The specific issue could be any of the above categories.

Figure B-1 shows the identified locations of 167 citywide drainage issues identified throughout the City within this SWIP. The Excel spreadsheet linked to this GIS map is part of the study documentation and will be reviewed and updated as drainage concerns are resolved or new drainage concerns are identified.

Regulatory Floodplains in the City

In addition to the identified drainage concerns noted above, citywide floodplain modeling and mapping is available for use in planning future projects. Figure B-1 also depicts the citywide floodplain designations for consideration in this study.

Consideration of Storm Sewer Capacity Issues

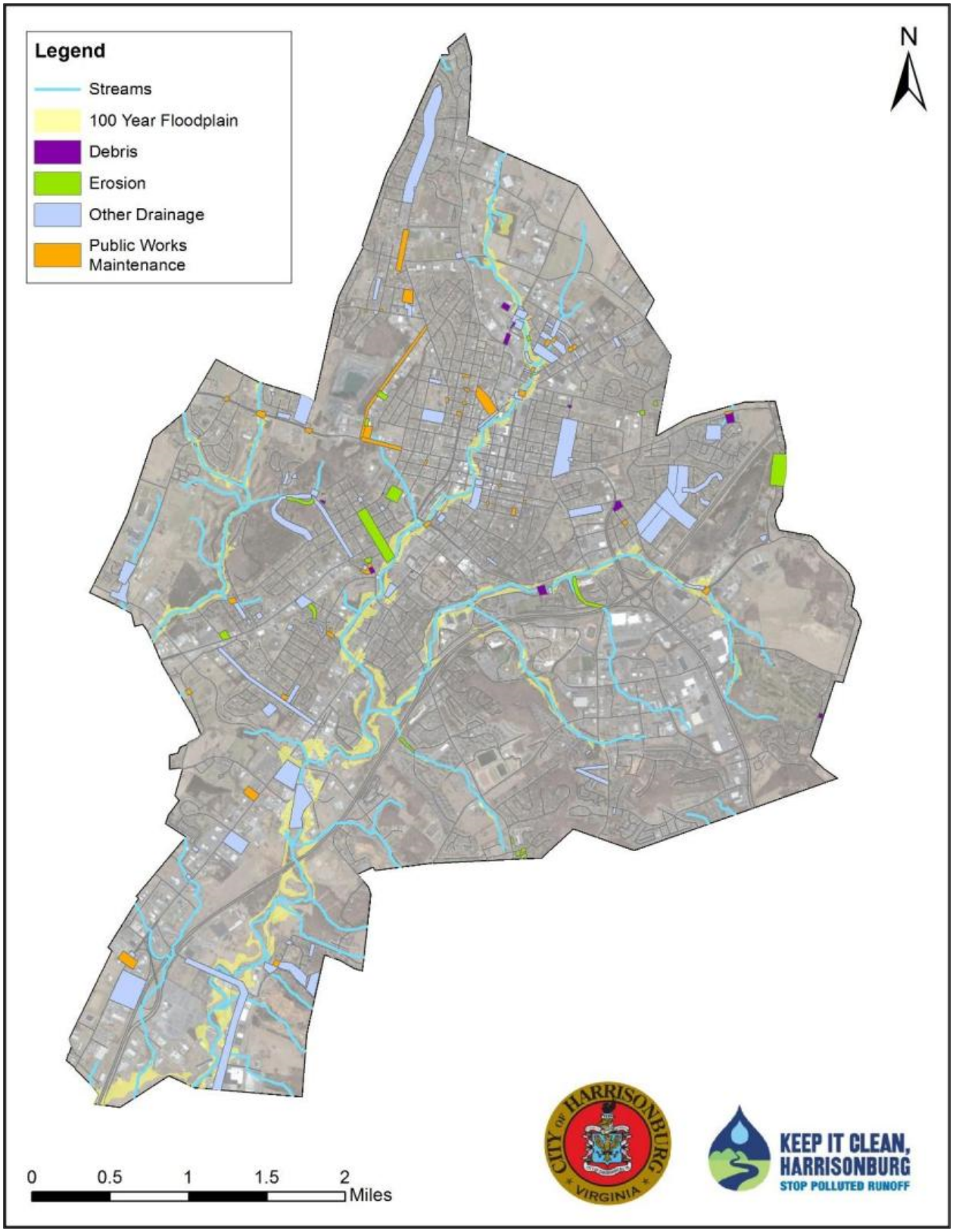
SWIP goals and objectives focus on the needs associated with achieving regulatory compliance within the outlined MS4 permit cycles. Although directly solving drainage issues does not help achieve water quality goals, mapping of drainage concerns assisted (and will continue to assist) in determining the best locations for water quality projects.

By considering areas with drainage concerns for planning water quality improvement projects, the hope is to achieve a more effective project that improves water quality while simultaneously improving stormwater system capacity issues. Some examples of how drainage concerns can help influence the water quality or BMP projects in this plan are as follows:

- Providing/placing BMPs within a drainage area with known drainage issues may help provide quantity control of runoff while also providing water quality benefits.
- BMPs can help keep downstream storm sewers clean of debris, garbage, and sediment.
- Stream stabilization, restoration, and outfall protection projects can help reduce flow velocities, flooding, erosion and sedimentation, as well as reduce debris and clogging issues.

BMP projects can include improving storm sewer systems, channels, and culverts by providing additional inlets and upgrading the capacity of pipes and channels.

Figure B-1. Citywide Storm Sewer Capacity Issues



Appendix C: Water Quality Assessment

Introduction

A water quality assessment was performed to address the SWIP Objectives 1.2, 1.3, and 1,5 (see main SWIP document).

The following strategies were employed for the task:

- Identify BMPs and restoration activities currently implemented or planned by the City
- Calculate and summarize pollution reduction estimates for the current and planned BMPs and restoration activities, and
- Identify the load reduction gap between the planned reductions and the required load reduction targets.

Required Pollutant Load Reductions

For this study, the baseline loading (2009) and required pollutant load reductions were calculated using the information in the City of Harrisonburg TMDL Action Plan (City of Harrisonburg 2015) and the DEQ guidance document (DEQ 2015).

DEQ requires MS4 permittees (e.g., the City of Harrisonburg) to reduce TN, TP, and TSS levels to the target reductions incrementally across three permit cycles. In the first permit cycle by 2018, the City is required to reduce loads by 5 percent, then by an additional 35 percent (40 percent cumulative) by 2023, and then by the remaining 60 percent (100 percent cumulative) by 2028. These resulting load reduction requirements are also summarized in the main SWIP document.

Potential Options for Load Reductions

To meet its load reductions, the City looked at a variety of activities that reduce the amounts of nutrients and sediment in stormwater runoff. The following list of potential restoration activities and BMPs was determined as likely to be implemented with this plan, and are described in the remainder of this appendix. See the main SWIP document for descriptions and photos of these practices.

1. Retrofits to Existing BMPs
2. Urban Stream Restoration
3. Urban Tree Canopy
4. Street Sweeping and Catch Basin Cleaning
5. Septic System to Sanitary Sewer Conversion
6. Homeowner BMPs
7. Nutrient Trading and Programmatic Strategies (discussed in Appendix E of the SWIP)

Retrofits to Existing BMPs

Fifteen (15) existing city-owned BMPs and five (5) existing private BMPs were identified as opportunities for BMP retrofits, listed in Table C-1 and shown in Figure C-1. These retrofits will increase water quality and stormwater volume treatment efficiency through improvements to existing structures or conversions into different BMP types. Most of the existing BMPs are detention ponds (i.e., dry ponds) that were installed to control water volume and that provide little or no water quality benefit. The load reduction credit received by enhancing or retrofitting an existing BMP was determined using the methodology described in DEQ's Chesapeake Bay TMDL guidance (DEQ 2015).

Bay Program efficiencies were obtained from Chesapeake Assessment Scenario Tool (CAST) and were used to estimate potential load reductions from BMP retrofits (CBP 2017). This method requires a determination of the drainage area, pervious/impervious areas, and general land use (e.g., urban, forest, agriculture) to determine a load reduction and does not require a preliminary design of each retrofit.

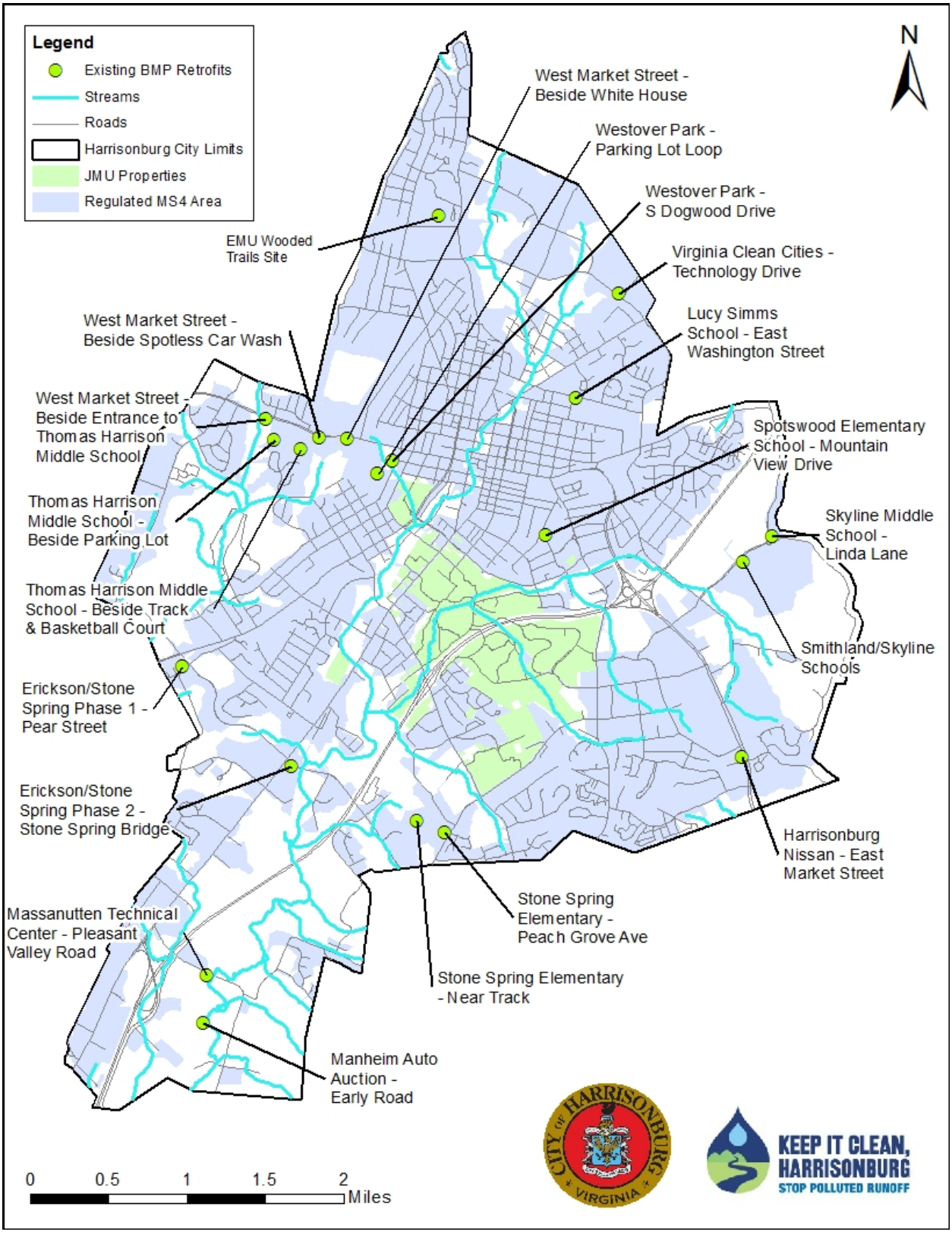
Table C-1. Existing BMP Retrofit Opportunities

Site Name	Existing BMP Type	Enhanced BMP Type	Comment
Westover Park - S Dogwood Drive	Detention Basin	Enhanced Extended Detention	Divert additional drainage area to retrofit based on space availability. Add forebay for pre-treatment.
Westover Park - Parking Lot Loop	Bioretention	Bioretention	Resize and retrofit by redirecting flow and expanding BMP footprint.
Lucy Simms School - East Washington Street	Detention Basin	Bioretention	Convert to bioretention system.
Spotswood Elementary School - Mountain View Drive	Bioretention/ Rain Garden	Bioretention Retrofit	Undersized, Recommended retrofit. Increase size for drainage area and impervious area to facility.
Skyline Middle School - Linda Lane	Extended Detention Basin	Extended Detention	Add permanent pool, micro-pools, and sediment forebay.
Smithland/Skyline Schools	Extended Detention Basin	Enhanced Extended Detention	Add permanent pool, micro-pools, high marsh, and low marsh.
Stone Spring Elementary - Near Track	Detention Basin	Bioretention	Install bioretention providing treatment to smaller isolated area in vicinity of school without treating field. Retain current flow control.
Stone Spring Elementary - Peach Grove Ave	Detention Basin	Bioretention	Large bioretention facility with available space. Continuing to provide existing flow control.
Erickson/Stone Spring Phase 1 - Pear Street	Extended Detention Basin	Extended Detention	Install micro-pools and permanent pool. Improve grading for better access.
Erickson/Stone Spring Phase 2 - Stone Spring Bridge	Extended Detention Basin	Wet Pond	Maintain extended detention basin, but add wet pond.
Thomas Harrison Middle School - Beside Track & Basketball Court	Detention Basin	Bioretention	Convert neglected detention basin to bioretention facility with pre-treatment.
Thomas Harrison Middle School - Beside Parking Lot	Detention Basin	Bioretention	Convert neglected detention basin to bioretention facility with pre-treatment.
West Market Street - Beside Entrance to Thomas Harrison Middle School	Detention Basin	Wet Pond	Convert to wet pond sized to treat drainage area. Will require raising of inflow to prevent backup.
West Market Street - Beside Spotless Car Wash	Detention Basin	Extended Detention	Add permanent pool, micro-pools, sediment forebay. Remove existing trickle ditch and extend flow path.
West Market Street - Beside White House	Detention Basin	Extended Detention	Add permanent pool, micro-pools, and sediment forebay.
EMU Wooded Trails Site**	Detention Basin	Enhanced Extended Detention	Create areas of aquatic vegetation and conservation landscaping. Perform erosion repairs and channel stabilization.

Site Name	Existing BMP Type	Enhanced BMP Type	Comment
Massanutten Technical Center - Pleasant Valley Road**	Detention Basin	Vegetated Filter	Convert to vegetated filter and modify drainage area to incorporate flow from road through drainage diversions.
Manheim Auto Auction - Early Road**	Detention Basin	Wet Pond	Convert to wet pond and increase the drainage area. Install flow diversions, as needed.
Virginia Clean Cities - Technology Drive**	Dry Swale	Bioretention	Convert existing dry swale to higher performing bioretention.
Harrisonburg Nissan - East Market Street**	Dry Swale	Vegetated Filter	Convert existing dry swale to higher performing vegetated filter.

Note: Privately-owned BMPs are marked with **.

Figure C-1. Existing BMP Retrofit Opportunities



Urban Stream Restoration

Twelve (12) potential urban stream restoration projects totaling 7.89 miles were identified based on field observations and are listed in Table C-2 and shown in Figure C-2. As a conservative estimate, this plan assumes that only 70 percent of the total stream restoration project length (5.52 miles) will be implemented through this SWIP.

One thing to note about stream restoration projects is that the City cannot receive the full pollutant reduction credit if the drainage area of the stream being restored extends beyond the City limits or even beyond the *regulated area* of the MS4 that is within the City's boundaries. The main SWIP document explains the difference between MS4 *regulated* and *unregulated* land. DEQ has put out guidance on how stream restoration projects in this category should be credited. In short, any pollutant reduction on unregulated land is "discounted" because the state is already responsible for a certain load reduction for land that is not subject to a permit, such as the MS4. The level of reduction is known as the "baseline." The loads in Table C-2 account for a preliminary assessment of the baseline discounts for identified stream restoration projects.

Table C-2. Urban Stream Restoration Opportunities

Reach ID	Reach Name	Reach Length (mi)	TN (lbs)[a]	TP (lbs)[a]	TSS (lbs)[a]
HB-1	East Mosby Rd to City Limits	3.08	857	788	512,559
HB-3	Mall Creek - Country Club Road	2.01	597	662	424,987
HB-4	Mountain View Drive[b]	0.33	100	101	63,260
HB-5	South Avenue to South Main Street	0.46	150	136	89,688
HB-6	Keister Elementary School	0.20	79	72	47,410
HB-7	Mongers to Ohio Avenue	0.29	93	85	55,920
HB-8	Westover Park to South Willow Street	0.26	90	89	58,682
HB-9	Ice House to Chesapeake Avenue	0.15	49	44	29,226
HB-10	Charles Street to Ashby Avenue	0.24	80	79	50,466
HB-11	North End Greenway Trail[c]	0.43	595	86	40,475
HB-12	Heritage Oaks Golf Course	0.34	92	98	61,585
HB-13	EMU Gym	0.10	39	35	23,428
	Total =	7.89	2,821	2,275	1,457,686
	70% Total =	5.52	1,975	1,593	1,020,380

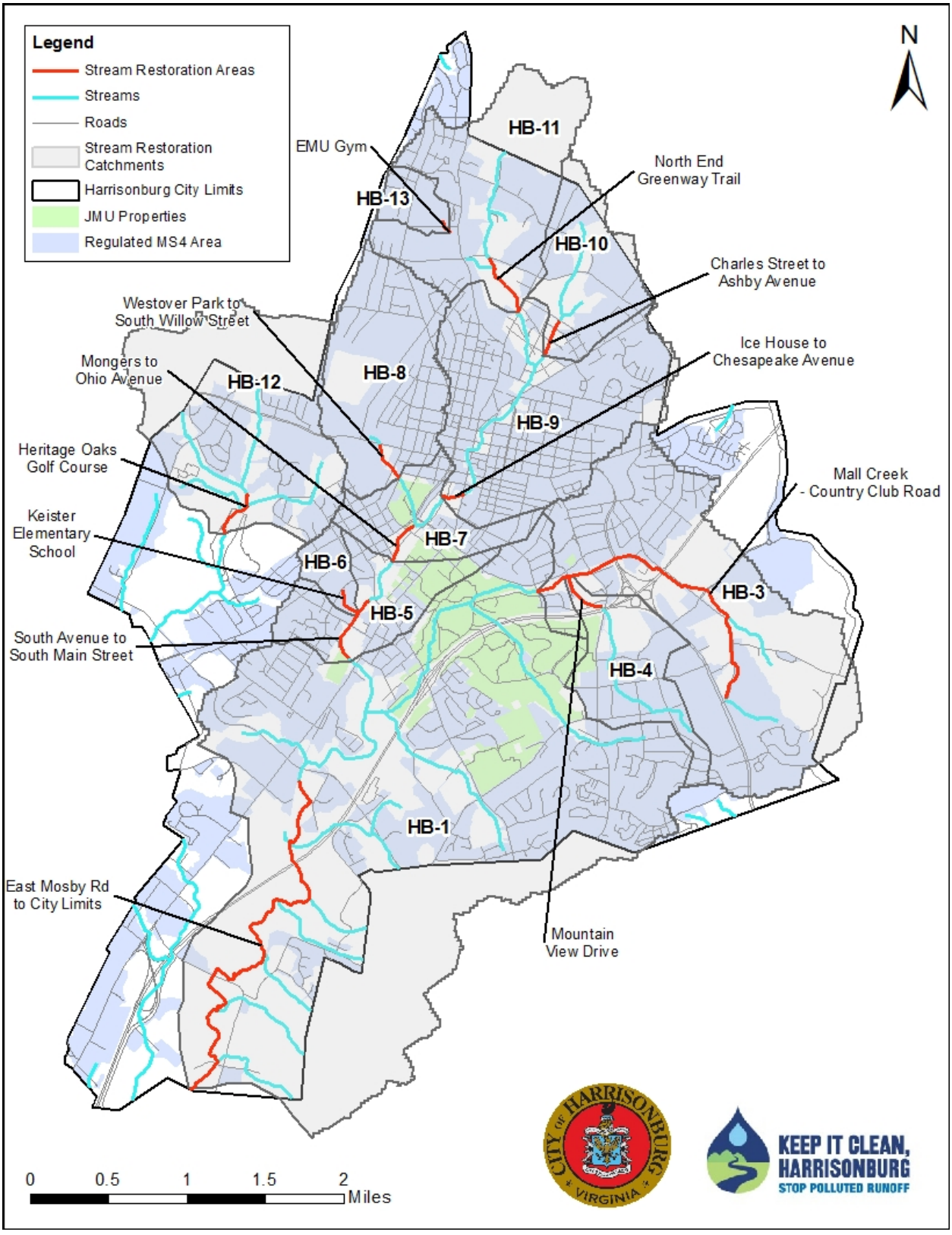
Notes:

[a] Loading rates were obtained from DEQ 2015. TN - 0.075 lbs/linear ft; TP - 0.068 lbs/linear ft; 44.88 lbs/linear ft.

[b] A stream assessment study was recently completed for this project due to concerns related to erosion and exposed utilities. It can be used as reference material for future project planning and implementation.

[c] Load reductions for the North End Greenway stream restoration project were calculated using the actual stream restoration design documents for this project. This project is being privately developed and the City will only receive a portion of the pollutant removal credits.

Figure C-2. Urban Stream Restoration Opportunities



Urban Tree Canopy

Urban Tree Canopy expansion is intended for plantings on developed land and is not intended to result in forest-like conditions. Examples would be trees along a street or tress adjacent to buildings. The Green Infrastructure Center wrote *The City of Harrisonburg: Utilizing Urban Tree Canopy for Stormwater Management,* which evaluates the City's urban tree canopy and how to best incorporate the City's urban forests into stormwater management goals. At this time, the SWIP does not take tree planting into consideration as a pollution reduction strategy because a City program is not currently in place. Any credits for this practice will be in addition to the credits in the SWIP and can be accounted for on a "per tree" basis given documentation of this practice.

Credit for this program is on a tree-by-tree basis as described in the Chesapeake Bay Program's 2016 Expert Panel recommendations (CBP 2016a). Each tree represents 144 ft (1/300th of an acre) and there is no density requirement, so single trees are eligible for credit. Table C-3 presents the tree canopy reductions from the original land use loading rate for turf grass or impervious area.

Table C-3. Tree Canopy BMP Load Reductions

Canopy Type	TN % Reduction	TP % Reduction	TSS % Reduction
Canopy over turf grass	23.8	23.8	5.8
Canopy over impervious	8.5	11.0	7.0

Note: Reductions are the load reductions from the original land use (e.g., impervious cover).
Source: CBP 2016a.

Table C-4 shows the potential load reductions from a hypothetical program to expand urban tree canopy by 300 trees over turf or 300 trees over impervious cover.

Table C-4. Tree Planting BMP Load Reductions

Parameter	# Trees (300 trees per acre)	Load Reduction (lbs)
TN	600	3.83
TP	600	0.28
TSS	600	92.19

The City's website (https://www.harrisonburgva.gov/tree-canopy-grant) has additional information about the City of Harrisonburg's potential tree planting program throughout the City.

Street Sweeping and Catch Basin Cleaning

The City has maintained existing programs for street sweeping and catch basin cleaning, both of which qualify towards pollutant load reductions.

Street Sweeping

Load reductions from street sweeping are based on the type of street sweeping technology and the frequency of sweeping, where one curb mile is equivalent to treatment of one acre (CBP 2016b). The load reductions are calculated using the loading rates, curb miles swept (converted to acres), and reduction efficiencies that vary based on technology and frequency of sweeping. These rates are

expected to remain consistent in the future. Figure C-3 shows the current street sweeping routes in the City. The load reductions for street sweeping in 2016 are shown in Table C-5.

Table C-5. Summary of Load Reductions from Street Sweeping

Lane Miles/ Acres	Harrisonburg Street Cleaning Practice (SCP) #	Description	Approx. Passes/ Year	Removal Rate (%)			Mass Removed (lbs)		
				TN	TP	TSS	TN	TP	TSS
15.62	SCP-1	AST-2PW	100	4	10	21	9.68	3.01	4,264.26
132.24	SCP-3	AST-1P2W	25	2	5	11	40.99	12.76	18,910.32
172.80	SCP-4	AST-1P4W	10	1	3	6	26.78	10.01	13,478.40
3.39	SCP-4 (parking lot)	AST-1P4W	10	1	3	6	0.53	0.20	264.42
4.53	SCP-5 (parking lot)	AST-1P8W	6	0.7	2	4	0.49	0.17	235.56
						Total	**78.47**	**26.15**	**37,152.96**

Notes:
AST = vacuum assisted/vacuum or regenerative air cleaner
2PW = 2 passes per week; 1P2W = 1 pass per every 2 weeks; 1P4W = 1 pass per every 4 weeks; 1P8W = 1 pass per every 8 weeks; Average loads were determined using TN-15.5 lb/acre/yr; TP-1.93 lb/acre/yr; TSS-1,300 lb/acre/yr (CBP 2016b).

Catch Basin Cleaning

The City cleans every City-maintained catch basin annually. This is done by using a vacuum truck to remove accumulated debris in the catch basin.

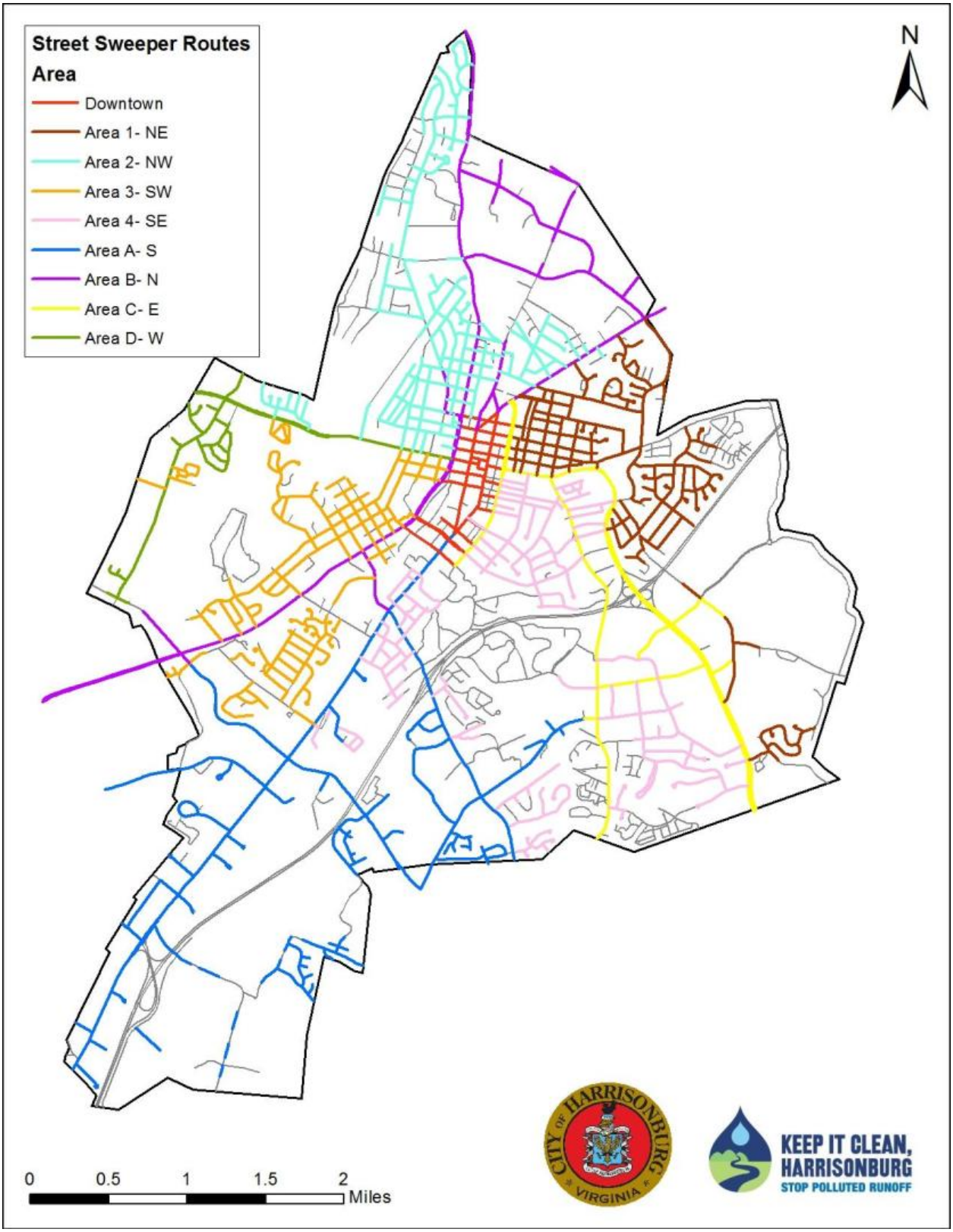
The method for calculating the load reductions from catch basin cleaning is the mass load converted to a dry weight, times an enrichment factor (CBP 2016b). The conversion from mass load to dry weight is 0.7. The enrichment factors are different based on the material collected—sediments or organic matter—as shown in Table C-6, along with the amount of material removed in fiscal year 2016. As a conservative assumption, all material was assumed to be sediment, as opposed to organic material, which provides additional nutrient load reductions. There is no TSS load reduction credit for catch basin cleaning.

Table C-6. Enrichment Factors for Catch Basin Cleaning

	Material Removed (lbs)	Dry Load (lbs)	Removal Rate (%)	Mass Removed (lbs)
TN	117,960	82,572	0.27%	222.9
TP			0.06%	49.5

Note: Removal rate source: CBP 2016b

Figure C-3. Street Sweeping Routes



Septic System to Sanitary Sewer Conversion

The City can claim TN credits for the practice of converting onsite septic systems to sanitary sewer connections. This is because older septic systems are not very efficient at processing the nutrients from household wastewater. Nutrients can leach into the ground and be conveyed through shallow groundwater flow to streams and waterbodies.

Virginia guidance is that TN reductions are calculated as 9 lb/year/person with 60 percent attenuation from the drain-field to the edge of stream, resulting in a 3.6 lb/year/person credit for each conversion to sanitary sewer. The number of people per sewer connection is estimated using the U.S. Census data for the average number of people per household. In Harrisonburg, the average is 2.69 people per household (U.S. Census Bureau 2017). Per city records, 19 households were converted from septic to sanitary sewer between 2006 and 2016, yielding a TN reduction of 184 lbs/year. The City projects that another 11 connections will be made or found during the next few permit cycles, yielding an additional 106.5 lbs/year TN reduction, when all 30 systems are connected. There are approximately 100 properties within the City that have onsite septic systems.

Homeowner BMPs

As explained in the main SWIP document, a stormwater utility fee credit is available to both residential and non-residential customers that implement on-site BMPs. There are credit manuals for both categories on the City's stormwater webpage that outline the types of practices authorized and how to calculate the fee credit. There are 10 practices for residential properties. However, three have been used most frequently by homeowners since the program's inception. These are: rain barrels, roof drain disconnections, and nutrient management plans.

The City can take pollutant reduction credit for the load reductions from homeowner implementation of these practices. Table C-7 summarizes the TN and TP reduction efficiencies for these homeowner BMPs from land use loads without BMPs. There is no TSS credit for these practices. The homeowner BMP credits are valid for five years with regular maintenance. For the credit to continue beyond five years, the City requires a reapplication to verify the practice is still in place and functioning correctly. Load reduction calculations assume that verification is complete and all practices continue to receive credit.

Table C-7. Reduction Efficiencies for Homeowner BMPs

Homeowner BMP Type	TN % Reduction	TP % Reduction
Rain Barrels	28	33
Roof Drain Disconnection	45	52
Nutrient Management Plan	6	3

Source: Goulet and Schueler, 2014.

The load reduction calculations for rain barrels and roof drain disconnections use the acres of impervious area treated times the land use loading rate and the removal rate. For nutrient management plans, the load reduction is calculated as the impervious area times the land use loading rate and the removal rate. A compliance factor (assumed 75 percent) was also applied to nutrient management plans. The compliance factor for rain barrels and roof drain disconnections is 100 percent, so the full load reduction credit is used for these two practices.

The load reductions from the current 2015 and 2016 records for participation amount to 71.37 and 39.93 pounds of TN, and 4.96 and 3.32 pounds of TP, respectively. To calculate the potential additional load reductions from future participation in the homeowner BMP program, we assumed that the rate of participation in subsequent years will follow a consistent percentage decline as willing homeowners are less likely to be found in subsequent years. The change in new load reductions between 2015 and 2016 was applied to the years 2017–2023. The change in TN is a 44 percent reduction in annual additional load reductions, and the change in TP is 33 percent. Table C-8 summarizes the annual load reduction projections through 2023 and provides the projected cumulative load reduction through that timeframe.

Table C-8. Annual Additional Load Reductions from Homeowner BMPs

	2015	2016	2017	2018	2019	2020	2021	2022	2023	Cumulative Load Reduction
TN (lbs)	71.37	39.93	22.34	12.50	7.00	3.91	2.19	1.22	0.69	161.14
TP (lbs)	4.96	3.32	2.22	1.49	1.00	0.67	0.45	0.30	0.20	14.60

Summary of Load Reductions

Table C-9 summarizes the projected nutrient and sediment load reductions from each structural and non-structural activity as described in this chapter and provides the total projected reductions from all planned activities.

Table C-9. Summary of Load Reductions by Implementation Activity

		TN	TP	TSS
Total Reduction Needed (lbs)		6,711.0	885.5	759,697
Implementation Activity (lbs reduced)	Annual Street Sweeping / Catch Basin Cleanout	301.4	75.7	37,153
	Stream Restoration	1,974.3	1,592.6	1,020,380
	Homeowner BMPs	161.1	14.6	0[a]
	Septic Connections	290.5	0[a]	0[a]
	Existing BMP Retrofits[b]	817.3	122.9	97,883
Total Reductions (lbs)		3,544.7	1,805.8	1,155,416
Load Reduction Gap (lbs)		3,166.3	0.0	0

[a] This practice does not receive load reduction credit for this parameter.

[b]. See Appendix H for details.

With the currently planned and implemented activities, the TP and TSS load reductions can be met with a large amount of load reduction kept in reserve; however, there is a significant gap in the TN reductions of an estimated 3,166 pounds. Additional BMPs are needed to address the gap. These additional BMPs are discussed in Appendix D.

Appendix D:
Evaluation of Additional BMP Opportunities

Introduction

Aside from the BMPs addressed in Appendix C, other candidate BMPs were identified in accordance with the SWIP Objectives 1.2, 1.4, and 2.3 (see main SWIP document):

The following strategies were employed for the task:

- Utilize a BMP siting tool to identify, at a planning level, where additional BMPs can be best located to address any gaps in required pollutant load reductions.
- Utilize a GIS desktop assessment to further refine BMP siting decisions and to develop a list of new BMPs to address the TN reduction needs outlined in Appendix C.

New BMPs

Any new structural BMPs are eligible to receive load reduction credit unless they are associated with another MS4 permittee or are structural BMPs installed as part of a development project in the VSMP program. Those practices installed as part of a development project in the VSMP program will receive credit under the permit associated with the planned construction activity, but will not receive credit through the City's MS4 permit requirements.

Structural BMPs installed between January 1, 2006 and June 30, 2009 on public lands are eligible to receive full load reduction credit if they had not previously been reported to DEQ. The City does not have any BMPs that fit this classification. Any BMPs installed prior to 2006 are not eligible to receive credit, except for incremental credit associated with future BMP improvements, retrofits, and restorations. This includes several stream restoration projects that the City performed prior to 2009, such as the Downtown Harrisonburg stream bank restoration and the Fire Station #1 stream bank restoration. The original BMP functionality (pre-2006) has been incorporated into the Chesapeake Bay Watershed model baseline and is already credited by default. The Purcell Park stream restoration was completed in July 2009 but the funds used for the project came from a mitigation bank established to meet another program's reduction requirements so this stream restoration is also not eligible to receive Chesapeake Bay TMDL credits. That being said, some of the BMPs outlined above *were* eligible for credit in the local Blacks Run/Cooks Creek TMDL.

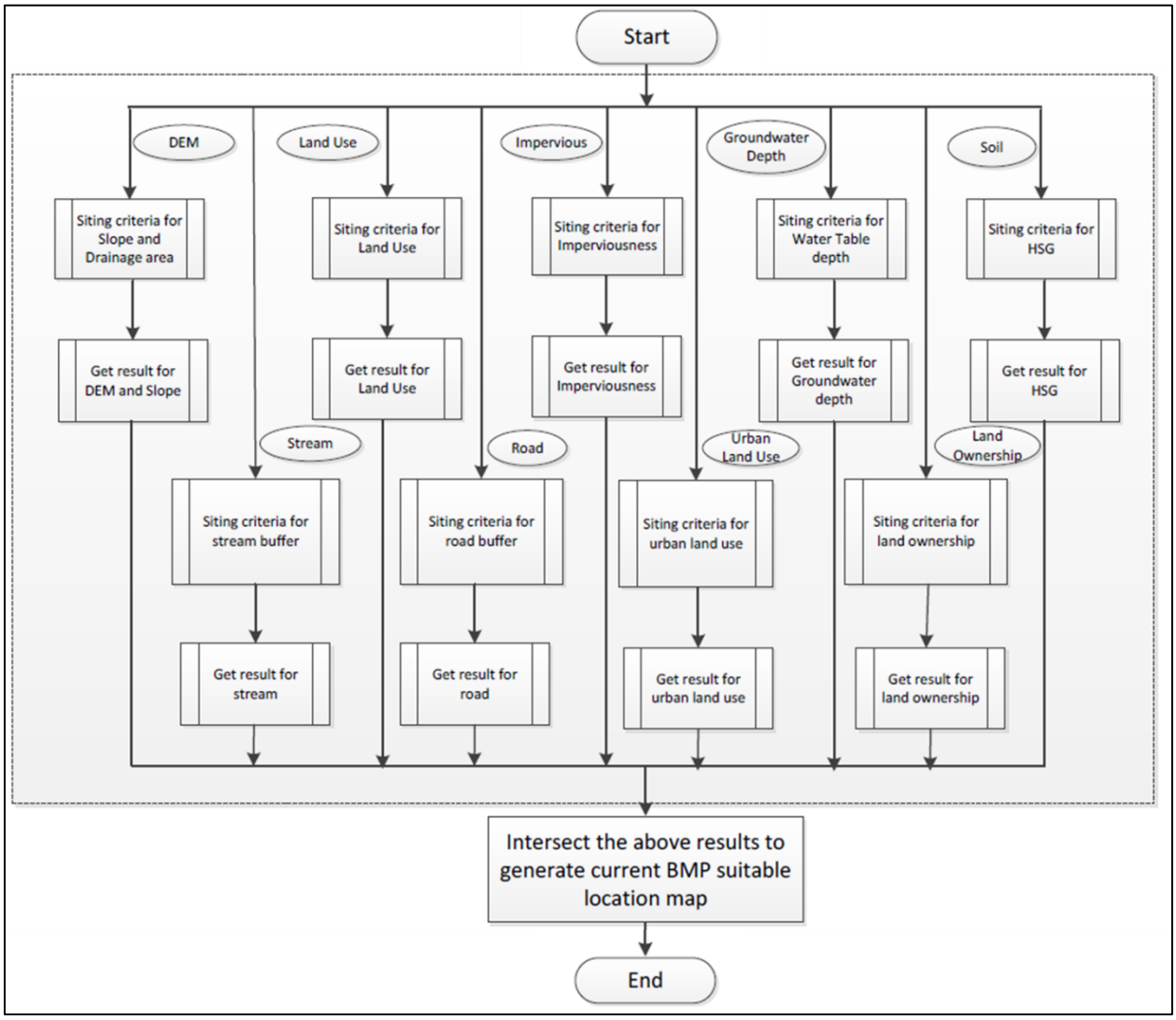
Bay Program efficiencies from CAST were used in the development of the SWIP to the extent possible to estimate potential load reductions from planned BMPs (CPB 2017). This method requires a determination of the drainage area, pervious/impervious areas, and general land use (e.g., urban, forest, agriculture) to determine a load reduction but does not require a preliminary design of each planned BMP.

BMP Siting Tool

A GIS based utility tool in the U.S. Environmental Protection Agency's (EPA's) System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) model (USEPA 2017) was used to help determine where BMPs can potentially be implemented to address the TN pollutant removal gap.

The BMP Siting Tool evaluated geospatial data to arrive at the potential BMP footprint results. Figure D-1 presents the overall data flow and processing of the tool. The tool accepts up to nine input GIS layers (ovals in Figure D-1) and applies the corresponding suitability criteria to filter those layers before intersecting with each other to highlight the locations that meet the siting criteria for the given BMP. Not all input layers are required, but more input layers yield more refined results. The accuracy of the results depends on the resolution and quality of input spatial data.

Figure D-1. Data flow chart in BMP Siting Tool.



The general methodology for using the BMP Siting Tool is:

- Select the structural BMP types for siting analysis.
- Define the site suitability criteria for each BMP type.
- Gather GIS data required for the selected site suitability criteria.
- Develop a geodatabase for the selected GIS data.
- Process GIS data to the preferred projection type and spatial extent.

- Define data layers in the "Data Management" input screen of the Siting Tool.
- Enter the site suitability criteria for each selected BMP in the input screen.
- Run the Siting Tool to produce resulting locations of recommended BMP sites.

The Siting Tool was used to select suitable locations for BMPs types—bioretention systems, vegetated filter strips, and wet ponds—using defined site suitability criteria such as slope, proximity to roads and buildings, and impervious areas. Table D-1 presents the suitability criteria for each selected BMP type, which were based on the default criteria available in the Siting Tool. The criteria were further refined using the DEQ stormwater design specification factsheets.

Table D-1. Site suitability criteria for selected structural BMP types.

	Wet Pond	Bioretention	Vegetative Filter Strip
Drainage area (acre)	> 10	< 5	< 2
Slope (%)	< 10%	< 5%	< 5%
Hydrologic soil group	C, D	A, B	A, B
Stream buffer (ft)	> 20	> 100	> 100
Building buffer (ft)	> 100	> 100	> 100
Karst area buffer (ft)	> 100	> 200	> 200
Public right-of-way (ft)	--	< 100	< 100

Wet pond criteria were also used to evaluate BMP sites for shallow marshes in the SWIP.

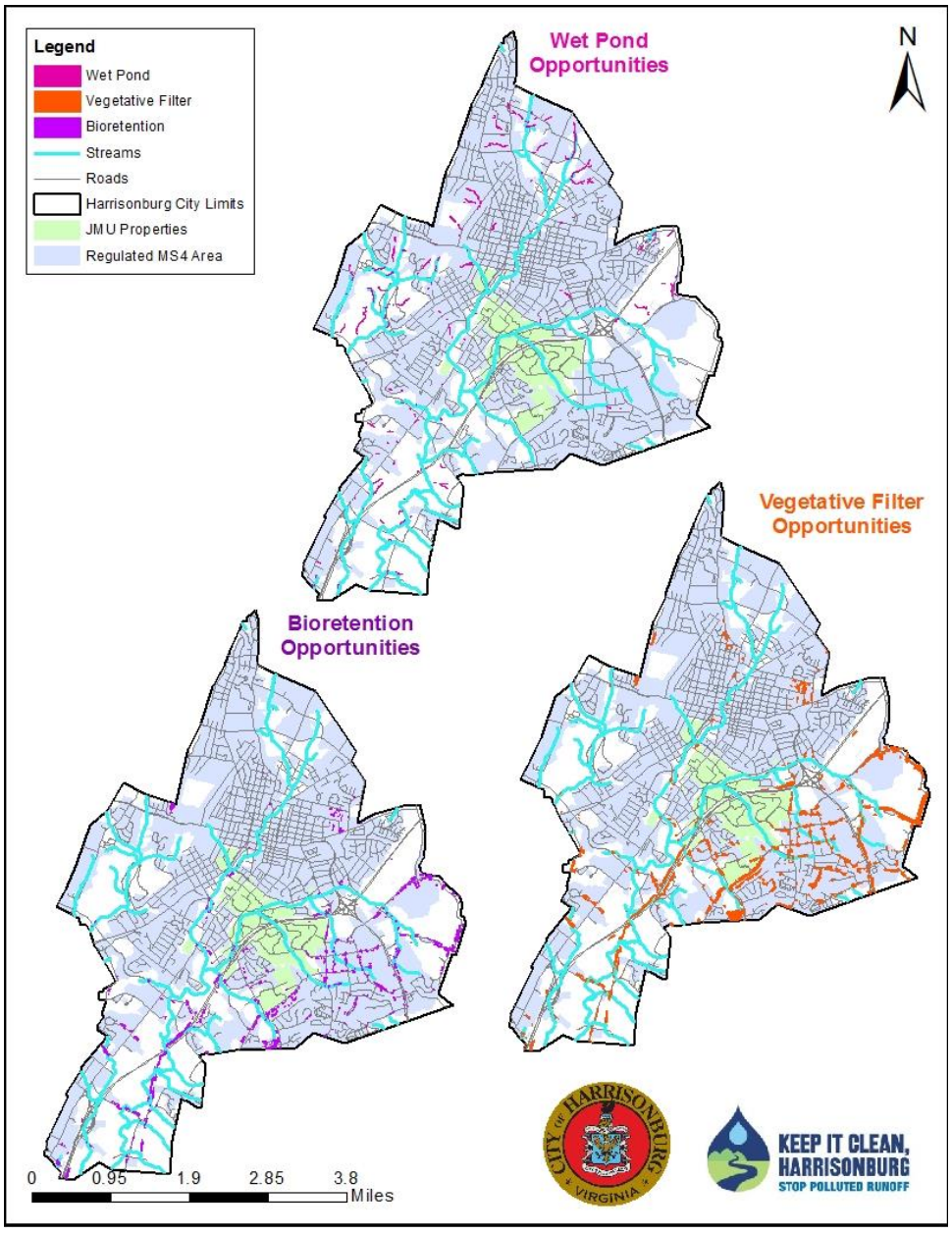
Table D-2 shows the data format of the required GIS data using the selected suitability criteria. Three-meter resolution digital elevation models (DEM) were downloaded from the U.S. Geological Survey National Elevation Dataset (USGS 2015) and soil geospatial data for the City were obtained from the U.S. Department of Agriculture's Web Soil Survey (USDA 2017). All other GIS data layers were used from the City's GIS data warehouse.

Table D-2. GIS data requirement for selected structural BMP types.

Layer type	Layer name	Data type	Field name	Field type	Field value
DEM	NED 1/9 arc-second	Raster	VALUE	Float	Elevation
Impervious footprints	Final_Impervious2016	Raster	VALUE	Integer	0–100
Land use	land_use_overlay_2013	Raster	VALUE	Integer	LUCODE
Karst areas	Harrisonburg DGMR Karst Reconnaissance	Raster	VALUE	Integer	LUCODE
Roads	publicrightofway	Polygon	N/A	N/A	N/A
Soil	Soil_Corrosivity_Hburg	Polygon	MUKEY	String	SSURGO map unit key
Buildings	citybuildings	Polygon	LU_DESC	String	"Buildings"
Streams	HarrisonburgStreams	Polyline	N/A	N/A	N/A
Land use lookup	LUC_Lookup	Table	LUCODE	Integer	VALUE field
			LUNAME	String	Land Use name
			SUITABLE	Short	"1" or "0" (1 = suitable; 0 = unsuitable)
Soil lookup	HSG_Lookup	Table	MUKEY	String	MUKEY field
			HYDGRP	String	"A", "B", "C", or "D"

The output of the BMP Siting Tool analysis is a geospatial representation of the City that highlights the areas that meet the specified site suitability criteria for placement of the selected BMPs. These areas correspond to the area that is available for the BMP to be built, also called the BMP footprint. The Siting Tool results are highly data-driven and the accuracy of the results depends on the accuracy of underlying GIS input data. The preliminary results for wet pond, bioretention, and vegetative filter strip are shown Figure D-2. These areas were then further analyzed through a GIS desktop assessment for suitability and the preliminary results were narrowed down. For the SWIP, the Siting Tool was used to identify potential locations for BMPs throughout Harrisonburg. Areas owned by James Madison University and VDOT were not included in this analysis because they hold their own MS4 Permits.

Figure D-2. BMP Opportunities Identified by the BMP Siting Tool



Desktop Geospatial Analysis

The BMP Siting Tool identified hundreds of potential BMP footprint locations throughout the City that had to be narrowed down through a desktop assessment.

Footprints that were in the MS4 and were on government, institutional, or vacant properties were evaluated first, followed by other BMPs in the MS4 areas. Footprints were not considered if they intersected with JMU, VDOT rights of way, or existing or proposed BMPs. The footprints intersecting JMU and VDOT land were selected for elimination because they have their own MS4 permit and SWIP requirements. Properties within the City's MS4 area were selected because they receive the most credit for treated acres under the City's MS4 permit.

A desktop analysis was performed to help reduce the potential locations of the BMPs and to identify the best potential BMPs locations for the SWIP. This was completed by using additional site constraints (e.g., areas of known flooding issues) and other preferences.

The desktop analysis first looked at aerial imagery for location feasibility of each BMP to determine if it was feasible. For instance, a BMP was removed from consideration if the footprint was in a forested area or on a sports field (e.g., baseball field). Proposed BMPs were then reviewed against the existing BMP points, and proposed BMPs were removed from consideration if there was an existing BMP at that location. If the footprint location seemed feasible, then the drainage area was determined using the stormwater network and topographic contours. These BMPs were then evaluated further for inclusion in the SWIP.

BMP Load Reduction Calculations

The DEQ *Chesapeake Bay TMDL Special Condition Guidance* gives municipalities three methods for calculating the load reductions from BMPs. This SWIP uses the Chesapeake Bay Program efficiencies as the default method. The calculation is typically drainage area (acres) multiplied by the BMP efficiency multiplied by the unit loading rate (lbs/acre/yr), as defined in the City's MS4 Permit for pervious and impervious urban surfaces. There are two special circumstances in calculating these load reductions that must be accounted for: BMP treatment trains and BMPs draining unregulated areas.

- BMP Treatment Trains: Treatment trains occur when the treated effluent (discharge) from one BMP flows into a second BMP for additional treatment. The DEQ *Chesapeake Bay TMDL Special Condition Guidance* states that the "impact of treatment trains should also be considered by permittees" (DEQ 2015). To account for the benefits of the first BMP, the pollutant load going into the downstream BMP needs to be reduced before its load reduction is calculated. For instance, BMP A flows into BMP B. The total initial load is 10 lbs for BMP A and 20 lbs for BMP B. If the efficiency of BMP A is 50%, then there is only 5 lbs flowing out of the drainage area for BMP A instead of 10 lbs. This means that only 15 lbs is entering BMP B instead of 20 lbs, thus lowering the amount of pollutant reduction possible from BMP B. If the efficiency of BMP B is also 50%, then the City would only receive 7.5 lbs of reduction credit BMP B, instead of 10 lbs without the BMP treatment train effect.
- Unregulated Areas: The City must account for meeting baseline loads for BMPs installed outside the MS4 regulated area, which is defined by areas where stormwater flows to or through the City's stormwater conveyance systems (DEQ 2015). This plan mainly contains

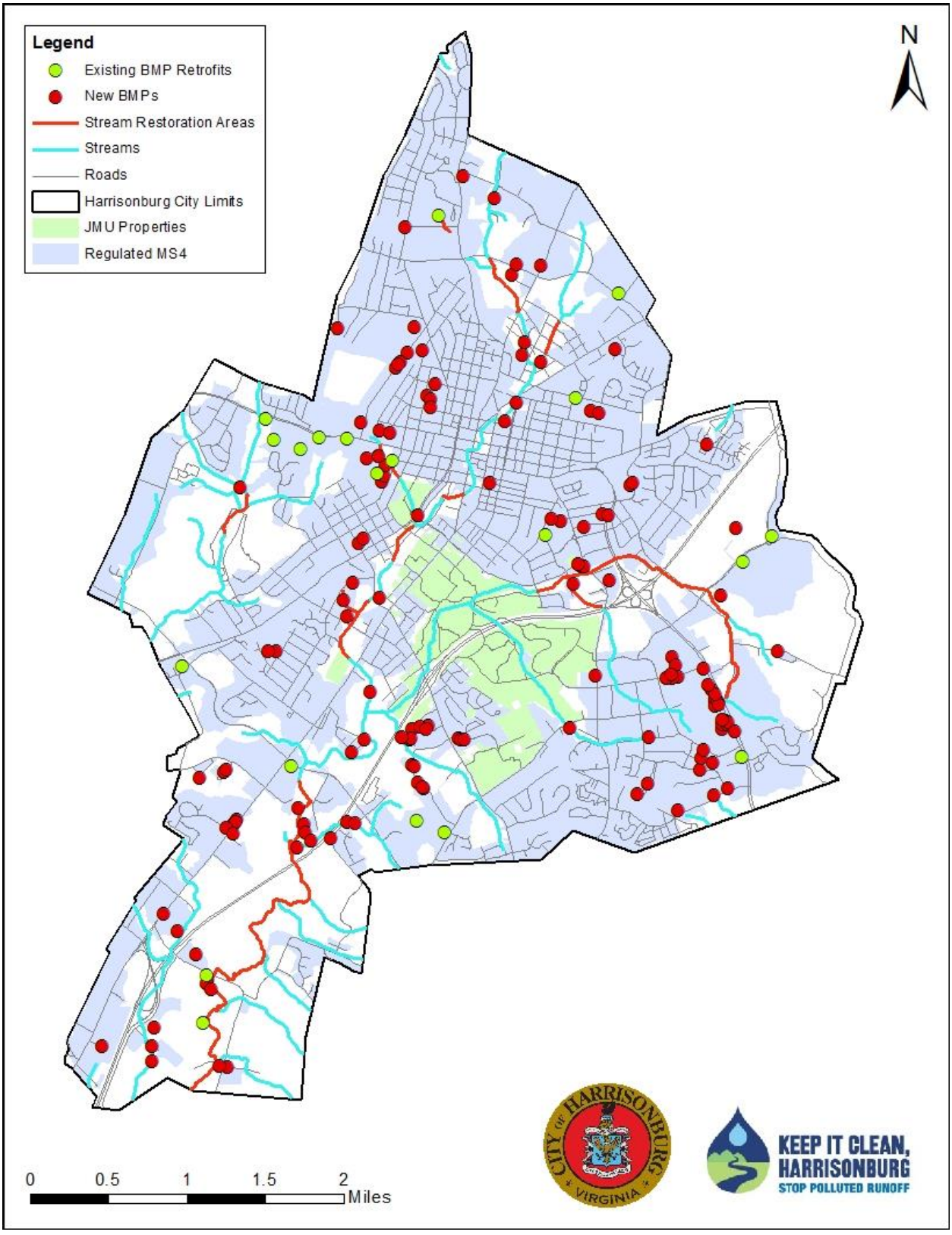
BMPs that drain parts of the regulated areas because the City will receive more load reduction credit than BMPs that treat unregulated areas.

Overall, the additional BMP opportunities identified in this SWIP are listed in Table H-1 and summarized in Table D-3 below, matching the latest excel workbook. They address the TN load reduction gap identified in Table C-9 with a significant contingency factor of more than thirty percent. This contingency factor allows the City to choose the best projects as they take a closer look at site conditions or run into other challenges during the design, bidding, and construction of each new BMP. The additional BMPs in the SWIP offset any BMPs that are removed or revised later.

Table D-3. Summary of Identified New BMP Opportunities

BMP Type	# of Sites	Drainage Area (acres)	Impervious Drainage Area (acres)	TN Reduced (lb/yr)	TP Reduced (lb/yr)	TSS Reduced (lb/yr)
Bioretention	96	163	96	1,558	134	98,977
Regenerative Stormwater Conveyance (RSC)	1	107	47	418	54	48,010
Shallow Marsh	1	3	1	6	1	805
Veg Filter Strip	40	267	169	2,141	215	159,611
Wet Pond	7	1,317	259	1,430	213	184,901
Total	145	1,856	572	5,553	617	492,303

Figure D-3. Location of SWIP projects



Appendix E: Citywide Program Assessment

Introduction

An assessment of the City's programs and policies was performed in accordance with Objectives 1.4, 1.5, 2.1, 2.2, and 3.3 (see main SWIP document):

The following strategy was employed for the task:

- Review existing City programs in place that contribute to implementing the SWIP and provide recommendations for adapting programs and policies to be more targeted, efficient, and effective at meeting the MS4 Permit goals.

New Development, Redevelopment, and Existing Developed Land

The list of program components above represents a complex mix of technical and administrative programs and policies that must fit together into a cohesive and effective citywide stormwater program. An important element of the program is fostering understanding by citizens and those who must follow related ordinances (e.g., developers and contractors).

It is important to note that all land uses are affected by the program:

- New development and redevelopment activities are regulated through the VSMP, and individual projects undergo plan review, permitting, and inspections.
- Existing developed land was primarily developed in the past with no stormwater controls or using controls that do not meet current standards. Existing developed land constitutes most of the land in the City, so it cannot be ignored when searching for opportunities for pollutant removal. The City is using the SWIP process to explore possible retrofits on both public and private land.

Retrofits are considered voluntary in that property owners cannot be compelled through regulations to build the retrofits, but the City must still meet the citywide TMDL reduction targets required by the MS4 Permit. Even though cooperation is voluntary, many stakeholders and landowners should be engaged to assist the City in complying with the MS4 Permit requirements and improving environmental resources within the City, not only for regulatory compliance, but for the benefits to local water quality for the City of Harrisonburg.

The Challenges: Timely and Cost-Effective Solutions

The TMDL Special Conditions in the MS4 Permit will require 100% reduction of the City's allocated pollutant loads for total phosphorus (TP), total nitrogen (TN), and total suspended solids (TSS) through three five-year permit cycles from 2013 to 2028. The overlapping challenges for the City include:

- Regulatory Uncertainty: Decision making at the local level is complicated by Chesapeake Bay Program modeling and load allocation updates and revised BMP crediting guidance by the DEQ (or the EPA). Shifting policies mean uncertainty about whether selected BMPs will be credited consistently through all three permit cycles and beyond.
- Blend of Regulatory & Incentive Programs: The program combines regulatory and incentive/voluntary approaches to meet load reduction targets and assure citizens and ratepayers that the program is being administered equitably. Regulatory programs are

generally prescribed by state VSMP regulations and the MS4 Permit. Incentive programs have more flexibility in their structure and scope.

- Stewardship of Ratepayer Funds: The program must provide a mix of practices that deliver a good value to the ratepayers. This will involve seeking the most cost-effective local BMPs and perhaps considering off-site options (e.g., purchase of nutrient credits) if the cost of locally implemented BMPs rises too high to be considered cost effective. This can be especially important in meeting the 100 percent reduction targets during the third permit cycle, when the more cost-effective BMP solutions have already been implemented during previous permit cycles.

Active vs. Passive Incentive Program Options

Some of the programs outlined in the tables above can be considered "passive" in that the information is put out to the public and program participation is self-selecting. For example, the stormwater utility fee credit program is publicized and promoted by the City, but homeowners must take initiative to install the BMPs on their property. Although this approach does not have the highest pollutant reductions, these incentive programs also serve to meet other MS4 goals, such as public involvement and outreach. In fact, the public engagement in local water quality may be the most valuable attribute of such programs.

Table E-~~Table E-1~~ shows Harrisonburg's Stormwater Utility Fee credit activities for 2015 and 2016. Almost all fee credits were granted for residential applications, and, of the ten available practices in the credit manual, three were most popular, presumably due to their relative simplicity and low up-front cost. Table E-1 also shows a spike in interest in fee credits when the utility is new, but participation declines over time. Subsequent years will reveal whether this trend downward holds for the Harrisonburg stormwater utility fee credit program. Projections, including the downward trending participation, estimate that fee credit practices can achieve reductions of 161.14 and 14.60 pounds of TN and TP respectively by 2023 (Error! Reference source not found.~~Table C-9~~).

Table E-1. Harrisonburg's Stormwater Utility Credits for 2015 and 2016

	2015	2016
Disconnects	121	92
Rain Barrels	40	34
Nutrient Management Plans	126	123
Non-Residential or Industrial Permits	4 (all EMU campus: 2 voluntary + 2 VSMP)	0

While passive approaches are an important part of the local program, they are not sufficient to achieve the significant pollutant removals necessary to meet the requirements. A more active program could incorporate other initiatives.

An important feature of a more active strategy is deliberately targeting the most promising, cost-effective practices. These may be improvements on commercial or industrial sites with large areas of impervious cover. Generally, for these types of property owners, the relatively small Stormwater Utility Fee and the potential credit are not enough of an incentive to warrant significant investments in new BMPs or water quality retrofits. The goal of additional incentive mechanisms or an "active" program

would be to increase participation and subsequent benefits. An active incentive program would focus on properties that have:

- Large areas of impervious cover with little or outdated stormwater treatment.
- Good opportunities on the site for retrofits (e.g., older, poorly-functioning basins or ponds, or degraded stream reaches).
- Willing property owners.
- Property owners or operators with capabilities for long-term operation and maintenance of BMPs, if that is a requirement of the local incentive program.

The tables in the SWIP provide some potential program models for a more active crediting system. Models include a utility-administered grant program, partnerships with nonprofit organizations, and other types of Public/Private Partnerships or Community-Based Public/Private Partnerships (U.S. EPA Region 3, 2015). The latter type of program is currently being implemented by various larger, Phase I MS4s in Maryland, and are also being considered by some Virginia communities. The stated advantages of a P3 or CBP3 are that they can overcome the sometimes-sluggish rate of delivery of BMPs when administered solely by public agencies, expand BMP financing options, and share the risk of BMP implementation between the public and private sectors.

Other features of a P3 and CBP3 include:

- Involves one or more private partners
- Executed through a formal mechanism, such as a contract
- Stipulates a length of time for performance of the tasks
- Depending on the program, the P3 can cover: (1) finding the best BMP sites, (2) designing, permitting, and building the BMPs, and (3) conducting operation and maintenance for a specified period.

P3 and CBP3 are sophisticated programs that require active partners and administrative oversight by the local program. Also, market conditions within the Harrisonburg region may or may not support a fully-functional P3 or CBP3, and may necessitate scaled-down models. The models developed in Maryland came about in response to aggressive regulatory challenges and were initiated in communities with large staffs. The model should be adapted to a smaller setting, and thus would offer a different market potential for the private partner. The City of Charlottesville is currently looking to adapt a CBP3 model to a Phase II Virginia MS4, so there will likely be lessons to draw from that experience for others considering such a program.

Trading or Pollutant Credit Sharing

The tables in the SWIP summarize options that would be considered “off-site,” in that pollutant credits are obtained through purchase or contract from another entity outside the City. Many MS4s would prefer to use local funds to construct local projects, and the City’s Stormwater Advisory Committee has stated explicitly its preference to use stormwater utility funds within City limits. However, there are several factors that may prompt consideration of off-site credits, at least as a second-tier option. Among them are the more stringent pollutant reductions associated with future permit cycles and the higher cost of local BMPs after the “easier” and less expensive practices are implemented first. Harrisonburg has several options for purchasing off-site credits:

- Purchase “perpetual” credits through the Virginia Nutrient Credit Exchange. These credits are generated by permanent pollutant reductions achieved on agricultural or urban lands within the same watershed. An example would be a farm that converts pasture to a permanent riparian buffer. It is important to note that these credits can only be used to comply with the Chesapeake Bay TMDL, and NOT for the local Blacks Run/Cooks Creek TMDL.
- Purchase “annual or term” credits through the Virginia Nutrient Credit Exchange, also within the same watershed. An example would be pollutant reductions above and beyond permitted limits generated by a wastewater treatment plant. This type of credit must be purchased every year that the MS4 Permittee wishes to obtain the credits. As such, there is some risk that the credits may not be available in some years, so the strategy can also be viewed as a “stop-gap” or temporary measure to allow time for local BMPs to be designed and constructed. Again, the credits can only be used for the Chesapeake Bay TMDL reductions.
- Like the bullet above, the MS4 Permittee may also execute a contract with another permitted entity, such as the Harrisonburg-Rockingham Regional Sewer Authority (HRRSA), to obtain annual credits without using the Virginia Nutrient Credit Exchange.

The purchase of off-site credits, which type, and in which permit cycle are strategic decisions based on the feasibility, cost, and schedule of meeting pollutant reduction targets with local BMPs. As highlighted above, the strategy can include permanent and/or annual credits.

The tables in the SWIP also note a form of credit sharing that is not off-site, and that is the coordination of pollutant reductions between City-managed VSMP projects (new development or redevelopment projects that must comply with stormwater regulations) and the MS4 Permittee. For instance, the MS4 may generate pollutant reductions through BMP implementation, some of which can be shared with a VSMP project where on-site stormwater controls are infeasible or very expensive. This is a good strategy to consider; the main risk is that the same load reductions cannot be claimed by both a VSMP project and the MS4 permittee. It should also be noted that City VSMP projects are also eligible, with some restrictions, to purchase permanent credits from the Virginia Nutrient Credit Exchange, and this would not “rob” any pollutant reductions from the MS4 program.

MS4 Program Recommendations

Harrisonburg’s MS4 Permit has many options to consider in expanding and refining City programs and policies for stormwater. The key is to select the most appropriate and achievable options based on the staffing, resources, and community preferences. Based on consultation with City staff, the following recommendations should be considered further. Some of these are procedural steps that involve working with the community to better gauge the best path forward.

- Convene focus groups to get a sense of the willingness of various stakeholders to participate in potential incentive programs. Target groups may include commercial, industrial, institutional, residential, and multi-family property owners. These focus groups would provide feedback on the current incentive programs and utility fee/credits, as well as input on if and how to scale expanded strategies.
- Work with the Central Shenandoah Planning District Commission (CSPDC) to host a P3 or CBP3 Workshop to include other local MS4 Permit holders.

- Develop a stormwater utility grant program for targeted private BMP implementation. Develop a scoring system to identify the most promising retrofits, and a marketing strategy to engage property owners (starting with the focus groups noted above). Consult with the City Attorney and other officials on any considerations for giving grants to private property owners (e.g., long-term maintenance responsibilities).
- Explore the possibilities of other future P3 or CBP3 options by putting out an RFI or RFQ to gauge private interest and capabilities.
- Explore strategically-purchased pollutant credits in the following priority order: 1) annual or term point source credits as a strategy to allow more time for local BMP implementation, and 2) permanent or perpetual nonpoint source credits to close any unavoidable gaps in the second and third permit cycles. Consider timely purchase of credits before demand from other MS4s drives up the cost.

Appendix F:
Field Investigations of BMP Opportunities

Introduction

Once BMP opportunities were identified for inclusion in the SWIP, the study team conducted site assessments for several weeks to help evaluate each BMP opportunity in accordance with SWIP objective 1.2 (see main SWIP document).

BMP Sites

An inspection form was developed for use at all identified BMP sites in the SWIP, with criteria informing the ranking criteria being used for the SWIP. The inspection forms were used for new BMP sites and existing BMP retrofit sites. At each site, the following was documented:

- Hand written notes were documented on the form.
- GIS maps of the site and contributing drainage area were marked with field notes.
- Digital photographs were taken.

Urban Stream Restoration

For urban stream restoration projects, stream rapid assessment protocols were utilized during a stream walk of each impaired stream reach, and the following was documented:

- Scoring was noted on Riparian Corridor Assessment Field Data Sheets.
- Scoring was input into an Excel Workbook for a summary of assessment results.
- GIS maps of the site were marked with field notes.
- Digital photographs were taken.

The resulting field data notes and documentation for each BMP site are too large to be included as an appendix item, but an example is included. The remainder of the inspection information can be located at Public Works. Also included in this SWIP appendix is the City's notification letter for the fieldwork involved in these BMP evaluations since both public and private properties were involved and an example of the Riparian Corridor Assessment Field Data Sheets used in urban stream restoration assessment.

Appendix G: Development of a Prioritization and Ranking Tool

Introduction

A standardized set of criteria will be applied to prioritize and rank each identified BMP opportunity in the SWIP, including new BMPs, existing BMP retrofits, and stream restoration projects to help meet Objectives 1.2, 1.3, 1.4,.2.1, 2.3, 3.1, and 3.2 (see main SWIP document)

Ranking Factor Development

The City developed ranking factors and scoring guidelines for three categories of BMPs: new BMPs, existing BMP retrofits, and stream restoration projects. These ranking factors and scoring guidelines were developed so that they could be updated in the future to accommodate changes in City priorities and goals, thus changing the rankings. The Public Land Study (CWP 2013) was used as the initial basis for developing the ranking factors. The final list of 10 ranking factors can be separated into 3 categories as follows. SWAC input was used to further craft the ranking factors. The final list of 10 ranking factors can be separated into 3 categories as follows:

- Cost and Cost-effectiveness Ranking Factors are based on the nitrogen load reduction and the cost percentile compared to the other BMPs in the category (new BMPs, existing BMP retrofits, and stream restoration projects).
    - Pounds TN Removed Percentile
    - Cost Effectiveness ($/lb TN) Percentile
    - Project Cost (design/construction) Percentile
    - 50 out of 100 points are in this category to give a high priority to cost effective BMPs
- Site and Schedule Constraints Ranking Factors consider how easy it would be to implement a BMP. These factors consider land ownership, utility conflicts (above and below ground), slope of the site, access limitations (e.g., fenced area, distance from parking), permitting requirements, and if there are other City projects that the BMP could be bundled with.
    - Land Acquisition
    - Site Constraints & Potential Utility Constraints
    - Implementation Schedule
    - Synergy
    - 28 put of 100 points are in this category
- Other Ranking Factors look at other problems (e.g., drainage) or issues (e.g., increased operation and maintenance costs) the BMP might address, along with some benefits (aesthetics).
    - Drainage Issues
    - Long-term Maintenance Burden
    - Aesthetics /Visual Appeal
    - 22 out of 100 points are in this category

Ranking Factors and Scoring Guidelines

SWAC reviewed and provided comments on the City's draft ranking factors and scoring guidelines. The finalized factors and guidelines are presented in Table G-1. The final list of BMPs and their rankings are

included in Appendix H. The BMP ranking scores were used to determine the high priority BMPs (Appendix I).

Table G-1. SWIP Ranking Factors and Scoring Guidelines

Ranking Factor	Scoring Guidelines	Score
Pounds TN Removed	Each retrofit scored as % of best TN removal × 20. Maximum Score = 20	20
Cost Effectiveness ($/lb TN)	Each retrofit scored as % of best cost effectiveness × 20. Maximum Score = 20	20
Project Cost ($ design/ construction)	Each retrofit scored as % of highest cost × 10. Then subtract from 10 (10-X) for final score. Maximum Score = 10	10
Land Acquisition	City owned lands = 10	10
	Minimal easement acquisitions = 5	
	Significant easement or property acquisitions = 0	
Drainage Issues	Addresses flooding/infrastructure risk in area with known drainage issues = 10	10
	Provides detention or conveyance benefits but not in area with known drainage issues = 5	
	Does not provide additional detention or conveyance benefits = 0	
Maintenance Burden (Long-term)	Low maintenance burden = 10	10
	Medium maintenance burden = 5	
	High maintenance burden = 0	
Site Constraints & Potential Utility Constraints	No apparent site or utility constraints = 7	7
	Vegetation or utilities present but relatively easy to avoid (e.g., electric or phone lines) = 5	
	Access somewhat constrained = 3.5	
	Vegetation or utilities present but relatively easy to avoid (e.g., electric or phone lines) AND Access somewhat constrained = 2.5	
	Poor access, major grading required, or karst area OR Major utilities must be moved (e.g., sewer) = 1	
	Poor access, major grading required, or karst area AND Major utilities must be moved (e.g., sewer) = 0	
Implementation Schedule	Project can be implemented in under 12 months, with no permitting requirements = 6	6
	Project can be implemented in under 12 months, with permitting requirements = 4 OR Project can be implemented in 12 to 24 months, with no permitting requirements = 4	
	Project can be implemented in 12 to 24 months, with permitting requirements = 2 OR Project cannot be implemented in under 2 years, with no permitting requirements = 2	
	Project cannot be implemented in under 2 years, with permitting requirements = 0	
Synergy	Project can be incorporated within other city infrastructure plans and projects AND provides environmental benefits beyond SWM = 5	5
	Project can be incorporated within other city infrastructure plans and projects, including other potential BMPs = 4	
	Project may provide multi-purpose or environmental benefits beyond SWM = 2.5	
	Other project benefits are very unlikely = 0	
	Practice adds landscaping and/or would enhance aesthetics at the site = 2	2

Ranking Factor	Scoring Guidelines	Score
Aesthetics / Visual Appeal	Practice neither detracts from aesthetics nor adds much in the way of value OR project out of general public view = 1	
	Practice would not decrease aesthetics based on the practice type and location= 0	
	TOTAL =	100

Cost Development

Two ranking factors rely on knowing the cost of each BMP. Knowing the exact cost of each BMP would require design plans for each. Therefore, at the SWIP development stage, the City developed unit costs for each BMP type instead as described below.

The main source of cost information was obtained from CAST, which was developed for the Chesapeake Bay Program (CBP 2017). CAST has unit cost information ($/impervious acre) for construction costs in 2006 dollars. The City used the Construction Cost Index (CCI) adjustment factors to convert these costs to 2016 dollars. The CAST unit costing information has multiple costing metrics (or categories); the City chose to use the median retrofit category from the *Urban BMP Unit Cost Spreadsheet* for this SWIP. The City calculated the unit soft/preconstruction costs (e.g., planning, design) as a percentage of the unit construction costs. The *Urban BMP Unit Cost Spreadsheet* was used as a guide to estimate a median soft/preconstruction cost factor of 22.5% for all BMPs.

In addition to the design and construction costs, the City calculated the operation and maintenance (O&M) costs for the useful life of the BMP, which was assumed to be 25 years for all BMP types. The annual unit O&M costs were calculated as a percentage of the construction cost using BMP-specific factors (based on the severity of necessary O&M to keep facility functioning) provided in the *Urban BMP Unit Cost Spreadsheet*. The lifetime O&M unit costs were computed as a product of annual O&M unit costs and the useful BMP life. The total unit cost was computed as a sum of the unit costs for construction, preconstruction, and O&M.

There are two exceptions to this procedure: stream restoration and the East Market Street Regenerative Stormwater Conveyance (RSC) project. The unit cost for design and construction of stream restoration projects was based on the construction estimates for the Mountain View Drive stream restoration project in a recent study, as a local example. The overall cost proposal for that project was divided by the stream length being restored to get the unit cost per linear foot. The O&M unit costs were taken from the CAST values. Similarly, the unit cost for the East Market Street Regenerative Stormwater Conveyance project was based on the actual engineering cost estimate for that project. The O&M unit cost was considered the same as for stream restoration.

The unit costs are for the average installation of a given BMP. Site conditions (e.g., utilities) can increase the cost of individual BMPs. To account for this, "add-on" unit costs were estimated using professional experience for the following considerations.

- Trench drain/flow diversion
- Underdrain
- Curb cuts
- Move utilities
- Move stormwater structure

- Utility crossing (stream restoration only)
- Excessive pavement or vegetation removal

While performing BMP ranking, the City recorded whether the BMP could require one of the cost add-ons. This information was then used to adjust the estimated cost of that BMP in the SWIP.

Future SWIP Updates and Tracking

The City created a SWIP project tool using Microsoft Excel. The Excel tool contains all the load reduction calculations, BMP ranking determinations, and cost calculations for new BMPs, existing BMP retrofits, and stream restoration projects in a single Excel worksheet. Having all this information in one spreadsheet makes future updates to the SWIP easy. Future updates could include refined unit costs (based on observations during initial BMP implementation) or changes to the ranking factors and scoring guidelines. The City can also remove and replace non-viable projects in the SWIP. The spreadsheet also contains load reduction calculation worksheets for street sweeping, catch basin cleaning, septic connections, homeowner BMPs, and tree planting. Finally, the spreadsheet has a worksheet for the City to track progress towards the SWIP load reduction goals (Figure G-1). The tool contains a *ReadMe* tab that instructs users how to add new implementation activities to their respective sheets, update BMP ranking information, and update cost information. The SWIP tool is fully editable and adaptable to future program needs by the City.

Figure G-1. Screenshot of the SWIP Project Excel Tool for Tracking SWIP Progress.

Stormwater Implementation Plan		TN Load Reduction (lb/yr)	TP Load Reduction (lb/yr)	TSS Load Reduction (lb/yr)
Total Reduction Needed		6,711.0	885.0	759,697
SWIP Restoration Activity	Street Sweeping	301.4	75.7	37,153
	Stream Restoration	1,974.3	1,592.6	1,020,380
	Homeowner BMP	161.1	14.6	0
	Septic Connections	290.5	0.0	0
	BMP Retrofits	817.3	122.9	97,883
	New BMPs	5,553.0	617.0	492,303
Total SWIP Reductions		9,097.7	2,422.9	1,647,720

Implemented Restoration Activities		TN Load Reduction (lb/yr)	TP Load Reduction (lb/yr)	TSS Load Reduction (lb/yr)
SWIP Restoration Activity	Street Sweeping	78.8	26.2	37,153
	Stream Restoration	100.0	101.5	63,260
	Homeowner BMP	133.6	10.5	0
	Septic Connections	184.0	0.0	0
	BMP Retrofits	36.8	6.6	6,379
	New BMPs	131.1	10.0	7,123
Other	Tree Planting	0.2	0.0	2
Total Implemented Reductions		664.5	154.8	113,917
Load Reduction Gap		6,046.5	730.2	645,780

Tracking					
ID / Year	Restoration Type	TN Load Reduction (lb/yr)	TP Load Reduction (lb/yr)	TSS Load Reduction (lb/yr)	Notes
2016	Street Sweeping	78.8	26.20	37,153	**Update yearly**
2016	Septic Connections	184.0	0.00	0	Existing connections
2012	New BMPs	1.3	0.12	0	Water Cisterns at DPW
2017	New BMPs	129.8	9.90	7,123	Thomas Harrison MS
2017	BMP Retrofits	36.8	6.60	6,379	Westover Park
2017	Homeowner BMP	133.6	10.50	0	5 homeowners
2017	Stream Restoration	100.0	101.50	63,260	Mountain View Dr
2017	Tree Planting	0.2	0.01	2	30 Trees

Note: Values in the *Implemented Restoration Activities* and *Tracking* tables are for illustration purposes only.

Appendix H: List of Recommended BMPs

A complete list of BMPs in the SWIP is compiled in this report appendix to help meet SWIP objectives 1.2, 1.3, 3.1 and 3.2 (see main SWIP document). This includes the new BMPs, stream restoration projects, and existing BMP retrofits. The ranking score was done separately for each BMP category and the BMPs are shown from highest to lowest ranking within each BMP category in this list. The BMP cost is for design and construction. It does not include operation and maintenance.

Table H-1. List of BMPs in the SWIP

Category Ranking	BMP Category	BMP ID	Site Names	BMP Type	Ranking Score	Load Reduction (lb/yr)			BMP Cost
						TN	TP	TSS	
1	New BMPs	Veg 518	Parks and Recreation Facility - Waterman Drive	Veg Filter Strip	78.7	50.3	4.6	3,429	$99,567
2	New BMPs	H10-D	Ralph Sampson Park - Basketball Courts	Bioretention	76.4	30.7	2.0	1,154	$66,957
3	New BMPs	Veg 405	Morrison Park	Veg Filter Strip	76.1	88.9	7.5	5,450	$252,634
4	New BMPs	Veg 512	Maryland Ave - by Railroad Tracks	Veg Filter Strip	73.5	124.5	10.5	7,874	$226,219
5	New BMPs	Bio 15	Waterman Elementary School	Bioretention	73.2	35.4	2.5	1,645	$81,740
6	New BMPs	Bio 533	Westover Park (B)	Bioretention	73.0	21.0	1.5	960	$51,238
7	New BMPs	Bio 502	Norwood Street Field	Bioretention	72.8	34.4	2.8	2,020	$117,922
8	New BMPs	Veg 402	Ramblewood Road (2100 Block)	Veg Filter Strip	72.5	76.1	6.2	4,532	$125,310
9	New BMPs	H42-A	East Market Street Median	RSC	72.2	417.8	54.2	48,010	$755,060
10	New BMPs	Veg 527b	Kiwanis Park (B)	Veg Filter Strip	71.9	30.4	2.7	2,015	$66,846
11	New BMPs	H11	Ralph Sampson Park - Cul-de-sac	Veg Filter Strip	71.3	6.2	0.6	424	$12,478
12	New BMPs	Veg 403n	Westover Park (D)	Veg Filter Strip	67.3	5.0	0.4	323	$8,986
13	New BMPs	H38-C	Harrisonburg Central Stores (North)	Bioretention	66.3	24.8	2.3	1,731	$109,814
14	New BMPs	H37	Harrisonburg Public Works	Veg Filter Strip	65.5	7.3	0.6	544	$20,977
15	New BMPs	Veg 501	Holy Myrrhbearers Orthodox Christian Church - S. Main Street	Veg Filter Strip	65.4	236.1	19.2	13,409	$413,584
16	New BMPs	Veg 529	Chicago Avenue Bike Trail	Veg Filter Strip	64.8	9.4	0.9	706	$21,206
17	New BMPs	Veg 504	Frazier Quarry	Veg Filter Strip	64.3	23.1	2.2	1,675	$49,096
18	New BMPs	H4b	HEC Operations - N. Liberty Street (South)	Bioretention	64.0	39.3	3.5	2,878	$202,695
19	New BMPs	Veg 86	Pheasant Run Townhomes	Veg Filter Strip	63.8	23.4	2.0	1,453	$43,169
20	New BMPs	Veg 524	East Market Street (800 Block)	Veg Filter Strip	63.8	243.9	30.9	22,709	$715,299
21	New BMPs	Bio 514	Electric Substation - Mt. Clinton Pike	Bioretention	63.2	22.7	2.3	1,757	$114,267
22	New BMPs	H50	Old South High Street	Bioretention	63.1	17.4	1.5	1,080	$64,092
23	New BMPs	Veg 511	Emerson Lane beside Fine Earth Landscape Management	Veg Filter Strip	63.1	260.9	26.3	18,338	$494,002
24	New BMPs	Veg 522a	Massanutten Technical Center (B)	Veg Filter Strip	62.9	10.8	0.8	697	$38,753
25	New BMPs	H38-B	Harrisonburg Central Stores (South)	Bioretention	62.6	10.3	0.9	728	$47,473
26	New BMPs	Veg 516	Harrisonburg Mennonite Church - South High Street (B)	Veg Filter Strip	62.2	15.3	1.5	1,116	$32,876
27	New BMPs	Veg 231a	Packaging Corporation of America - Pleasant Valley Road (A)	Veg Filter Strip	61.5	35.5	3.5	2,691	$81,383
28	New BMPs	Veg 27	Motel 6 - South Main Street	Veg Filter Strip	61.1	24.6	1.9	1,353	$34,940
29	New BMPs	Veg 520	Rockingham New Holland - W. Market Street	Veg Filter Strip	61.1	97.1	7.2	4,869	$117,838

Category Ranking	BMP Category	BMP ID	Site Names	BMP Type	Ranking Score	Load Reduction (lb/yr)			BMP Cost
						TN	TP	TSS	
30	New BMPs	WP 552	Harrisonburg Public Utilities	Wet Pond	61.0	235.3	31.5	24,240	$1,374,110
31	New BMPs	Bio 46a	Valley Mall (Popeye's)	Veg Filter Strip	61.0	289.2	45.3	34,604	$1,067,825
32	New BMPs	H4a	HEC Operations - N. Liberty Street (North)	Bioretention	60.9	29.4	2.4	2,100	$165,157
33	New BMPs	Veg 62a	Hunters Ridge Apartments (E)	Veg Filter Strip	60.4	10.6	0.9	654	$19,958
34	New BMPs	Bio 18a	Waterman Drive (C)	Bioretention	60.3	32.3	2.9	2,103	$146,151
35	New BMPs	Bio 44a	First Church of the Brethren (Back)	Bioretention	59.8	22.2	2.0	1,501	$91,958
36	New BMPs	Veg 522b	Massanutten Technical Center (C)	Veg Filter Strip	59.4	8.7	0.7	687	$38,374
37	New BMPs	WP 9	Keister Elementary	Wet Pond	59.3	114.4	23.7	20,618	$786,254
38	New BMPs	Bio 507	Harrisonburg Rescue Squad	Bioretention	59.2	7.2	0.6	465	$28,565
39	New BMPs	Bio 407	Mosby Heights Bus Shelter	Bioretention	59.2	24.7	1.9	1,374	$79,596
40	New BMPs	Veg 231b	Packaging Corporation of America - Pleasant Valley Road (B)	Veg Filter Strip	59.1	5.7	0.4	334	$11,132
41	New BMPs	Bio 14a	Holtzman Propane	Bioretention	58.8	49.0	3.5	2,370	$121,282
42	New BMPs	Veg 120	Summit Avenue (South)	Veg Filter Strip	58.7	30.5	2.0	1,268	$48,668
43	New BMPs	Veg 505	George's Inc. - N. Liberty Street	Veg Filter Strip	58.6	24.0	2.4	1,815	$53,500
44	New BMPs	Bio 18b	Waterman Drive (D)	Bioretention	58.5	27.8	2.5	1,810	$129,836
45	New BMPs	Bio 44b	First Church of the Brethren (Side)	Bioretention	58.3	11.1	1.0	693	$41,501
46	New BMPs	H38-A	Harrisonburg Public Utilities	Bioretention	57.3	8.6	0.7	630	$49,676
47	New BMPs	Bio 515	Harrisonburg Mennonite Church - South High Street (A)	Bioretention	57.0	9.1	0.8	593	$35,983
48	New BMPs	H31	Purcell Park	Bioretention	56.9	18.1	1.4	1,291	$103,716
49	New BMPs	H29-B	Keister Elementary - Parking Lot	Bioretention	56.7	4.9	0.5	362	$23,461
50	New BMPs	H201	Fire Station #3 - Lucy Drive	Bioretention	56.6	4.0	0.4	284	$18,045
51	New BMPs	Veg 33	Chestnut Ridge Apartments (B)	Veg Filter Strip	56.4	8.3	0.5	298	$6,294
52	New BMPs	Veg 29	Tenneco Inc - Abbot Lane	Veg Filter Strip	56.3	30.3	2.6	2,069	$67,292
53	New BMPs	Veg 404	Millwood Loop	Veg Filter Strip	55.9	45.2	4.0	2,944	$85,343
54	New BMPs	Veg 531b	Ramblewood Road (East)	Veg Filter Strip	55.9	12.7	0.6	271	$1,729
55	New BMPs	Veg 531a	Ramblewood Road (West)	Veg Filter Strip	55.5	12.5	0.6	302	$3,211
56	New BMPs	Veg 532	Monroe Street (North)	Veg Filter Strip	55.5	15.5	1.0	963	$36,481
57	New BMPs	Bio 79b	Hardee's - Reservoir Street (B)	Bioretention	55.4	7.4	0.7	522	$35,118
58	New BMPs	Bio 17b	Waterman Drive (B)	Bioretention	55.3	62.9	4.9	3,380	$405,358
59	New BMPs	Veg 523	Manheim Auto Auction	Veg Filter Strip	55.0	130.0	11.6	10,629	$398,202
60	New BMPs	Veg 400	United Rentals - Leray Circle	Veg Filter Strip	55.0	64.1	5.4	4,215	$156,301
61	New BMPs	Veg 23	Chestnut Ridge Apartments (A)	Veg Filter Strip	54.8	30.6	2.2	1,467	$86,211
62	New BMPs	Bio 17a	Waterman Drive (A)	Bioretention	54.7	48.1	3.3	2,136	$322,481
63	New BMPs	Bio 503b	Trinity Presbyterian Church (East)	Bioretention	54.1	4.9	0.5	335	$20,801
64	New BMPs	Bio 506	Holly Court	Bioretention	54.0	27.8	2.4	1,735	$112,283
65	New BMPs	Bio 79a	Hardee's - Reservoir Street (A)	Bioretention	53.5	3.0	0.3	187	$13,811
66	New BMPs	WP 551	Heritage Oaks Golf Course Pond	Wet Pond	53.3	385.3	59.8	50,732	$2,358,705
67	New BMPs	Bio 503a	Trinity Presbyterian Church (West)	Bioretention	53.0	3.6	0.3	259	$16,535
68	New BMPs	Bio 312a	Liberty Square Community - Founders Way	Bioretention	52.6	100.6	8.7	6,323	$473,008
69	New BMPs	H8-A	Waterman Elementary School (North)	Bioretention	52.6	17.0	1.5	1,138	$119,354
70	New BMPs	Veg 62b	Hunters Ridge Apartments (F)	Veg Filter Strip	52.5	5.2	0.5	377	$12,923

Category Ranking	BMP Category	BMP ID	Site Names	BMP Type	Ranking Score	Load Reduction (lb/yr)			BMP Cost
						TN	TP	TSS	
71	New BMPs	Bio 46c	Valley Mall (Belk B)	Bioretention	52.5	16.9	1.7	1,289	$83,030
72	New BMPs	H9	Rockingham County Administrative Center	Bioretention	52.2	12.4	1.1	972	$73,619
73	New BMPs	Bio 251d	Blue Stone Hills Drive (100 Block)	Bioretention	52.0	31.1	2.0	1,357	$68,506
74	New BMPs	Bio 202	Leray Circle	Bioretention	52.0	32.5	3.0	2,294	$149,120
75	New BMPs	Bio 414	Foxhill Townhomes (A)	Bioretention	51.9	10.5	0.9	720	$46,938
76	New BMPs	Bio 256a	Pearl Lane (North)	Bioretention	51.8	10.3	0.6	366	$18,374
77	New BMPs	Bio 79c	Hardee's - Reservoir Street (C)	Bioretention	51.8	3.1	0.3	211	$15,651
78	New BMPs	Bio 251b	Emerald Drive Cul-de-sac	Bioretention	51.5	51.2	4.1	2,744	$201,560
79	New BMPs	Bio 46h	Target (Parking Lot)	Bioretention	51.4	15.8	1.6	1,173	$77,088
80	New BMPs	Bio 401	University Place Condos - South Ave	Bioretention	50.6	20.0	1.3	873	$52,372
81	New BMPs	Bio 256b	Pearl Lane (South)	Bioretention	50.4	12.1	0.9	658	$42,253
82	New BMPs	Bio 406	Westover Park (C)	Bioretention	50.4	3.0	0.3	204	$24,900
83	New BMPs	Bio 201	Sandtrap Lane - NE Corner	Bioretention	50.2	41.4	3.1	2,151	$122,366
84	New BMPs	Bio 46e	Valley Mall (Belk D)	Bioretention	49.6	5.8	0.6	440	$28,959
85	New BMPs	H8-B	Waterman Elementary School (South)	Bioretention	49.4	6.0	0.5	401	$74,768
86	New BMPs	Bio 86a	Pheasant Run Townhomes	Bioretention	48.9	28.9	2.1	1,803	$146,099
87	New BMPs	Bio 519b	Foxhill Townhomes (B)	Bioretention	48.8	4.9	0.5	341	$21,596
88	New BMPs	Veg 51b	United Bank - University Boulevard (East)	Veg Filter Strip	48.7	6.5	0.6	444	$26,501
89	New BMPs	Bio 408	Mosby Heights Townhomes	Bioretention	48.7	15.6	1.2	1,113	$87,767
90	New BMPs	Bio 405	West Side Baptist Church - W. Wolfe Street	Bioretention	48.3	23.8	2.1	1,575	$95,187
91	New BMPs	Bio 57a	Hunters Ridge Apartments (A)	Bioretention	48.0	2.8	0.2	162	$9,837
92	New BMPs	Bio 519a	Foxhill Townhomes Welcome Center - Devon Lane	Bioretention	47.6	4.8	0.4	334	$21,333
93	New BMPs	H16	Massanutten Regional Library	Bioretention	47.4	1.7	0.2	135	$9,671
94	New BMPs	Bio 46d	Valley Mall (Belk C)	Bioretention	47.2	3.4	0.3	262	$17,978
95	New BMPs	SM 403	Westover Park (A)	Shallow Marsh	47.2	5.7	0.9	805	$81,997
96	New BMPs	Veg 80	Kenmore Street	Veg Filter Strip	47.0	20.7	1.6	1,108	$49,833
97	New BMPs	Bio 306	Divine Unity Community Church - Country Club Road	Bioretention	46.7	11.7	1.0	900	$71,024
98	New BMPs	Bio 52a	Hampton Inn - University Blvd (North)	Bioretention	45.5	18.1	1.7	1,244	$88,282
99	New BMPs	WP 517	Sunchase Apartments	Wet Pond	45.5	70.5	13.6	13,293	$588,695
100	New BMPs	WP 28	Motel 6 - South Main Street	Wet Pond	45.2	72.3	12.1	10,550	$496,960
101	New BMPs	Bio 527a	Kiwanis Park (A)	Bioretention	45.2	6.0	0.5	394	$33,998
102	New BMPs	Bio 251c	Vista Terrace Estates - Blue Stone Hills Drive	Bioretention	45.0	60.3	5.2	3,733	$220,731
103	New BMPs	Bio 115	Virginia Clean Cities - Technology Drive	Bioretention	44.6	16.6	1.3	1,118	$88,860
104	New BMPs	Bio 45b	Valley Mall (Kohl's B)	Bioretention	44.6	31.2	4.8	3,638	$250,260
105	New BMPs	Bio 409	Mountain View Drive (1100 Block)	Bioretention	44.4	17.3	1.6	1,216	$126,325
106	New BMPs	WP 17	Virginia Mennonite Retirement Community	Wet Pond	44.0	252.9	44.1	39,537	$1,582,656
107	New BMPs	Bio 521	Blue Stone Hills Dentistry and Benchmark Mortgage, Inc.	Bioretention	43.9	8.4	0.8	632	$41,405
108	New BMPs	Bio 45d	Valley Mall (Kohl's D)	Bioretention	43.3	1.5	0.1	111	$8,837
109	New BMPs	Bio 24a	Harrisonburg Hyundai (A)	Bioretention	42.8	13.5	1.3	1,006	$75,060

Category Ranking	BMP Category	BMP ID	Site Names	BMP Type	Ranking Score	Load Reduction (lb/yr)			BMP Cost
						TN	TP	TSS	
110	New BMPs	Bio 45c	Valley Mall (Kohl's C)	Bioretention	42.6	1.1	0.1	78	$6,716
111	New BMPs	Veg 51a	United Bank - University Boulevard (West)	Veg Filter Strip	42.5	4.5	0.4	323	$23,276
112	New BMPs	Bio 52bc	Hampton Inn - University Blvd (South)	Bioretention	42.2	10.6	1.0	729	$58,189
113	New BMPs	Veg 51c	Valley Mall (JCPenney)	Veg Filter Strip	42.1	3.7	0.3	220	$19,219
114	New BMPs	Bio 45e	Valley Mall (Kohl's E)	Bioretention	41.5	9.9	1.5	1,155	$83,013
115	New BMPs	Bio 402b	Reherd Acres - Vine Street (900 Block - East)	Bioretention	41.0	12.2	1.2	898	$68,372
116	New BMPs	Bio 412	Squire Hill Apartments	Bioretention	41.0	9.8	0.9	661	$55,047
117	New BMPs	Bio 251a	Evelyn Byrd Avenue (2500 block)	Bioretention	40.9	47.9	4.0	2,517	$364,810
118	New BMPs	Bio 241	Harrisonburg Truck Services	Bioretention	40.9	10.0	1.0	723	$55,588
119	New BMPs	Bio 526	EMU University Commons - Park Road	Bioretention	40.8	7.9	0.8	603	$91,140
120	New BMPs	WP 550	Linda Lane Quarry	Wet Pond	39.5	299.7	28.1	25,931	$1,024,428
121	New BMPs	Veg 60	Hunters Ridge Apartments (D)	Veg Filter Strip	39.4	13.6	1.3	1,011	$91,581
122	New BMPs	Bio 522c	Massanutten Technical Center (A)	Bioretention	38.9	12.8	1.1	975	$86,936
123	New BMPs	Bio 46g	Target (Entrance)	Bioretention	38.9	11.6	1.1	672	$242,115
124	New BMPs	Bio 528	Roses Stores	Bioretention	38.8	23.2	2.2	1,801	$185,195
125	New BMPs	Bio 46b	Valley Mall (Belk A)	Bioretention	38.2	5.4	0.5	417	$78,846
126	New BMPs	Bio 519c	Foxhill Townhomes (C)	Bioretention	37.9	5.1	0.5	345	$31,657
127	New BMPs	Bio 58b	Hunters Ridge Apartments (C)	Bioretention	37.6	6.7	0.6	429	$36,282
128	New BMPs	Bio 45f	Valley Mall (Kohl's F)	Bioretention	35.6	1.8	0.2	138	$21,342
129	New BMPs	Bio 46i	Valley Mall (Wells Fargo)	Bioretention	35.1	6.5	0.6	439	$130,987
130	New BMPs	Bio 413	Foxhill Townhomes (D)	Bioretention	34.1	5.2	0.5	356	$72,863
131	New BMPs	Bio 402a	Reherd Acres - Vine Street (900 Block - West)	Bioretention	34.0	3.9	0.3	250	$26,842
132	New BMPs	Bio 259	IHOP - University Blvd	Bioretention	33.6	15.2	1.4	1,062	$166,190
133	New BMPs	Bio 24e	Harrisonburg Hyundai (E)	Bioretention	33.5	4.9	0.5	386	$35,513
134	New BMPs	Bio 24b	Harrisonburg Hyundai (B)	Bioretention	33.3	4.8	0.5	377	$34,918
135	New BMPs	Bio 24g	Harrisonburg Hyundai (G)	Bioretention	33.0	4.7	0.5	367	$34,295
136	New BMPs	Bio 58a	Hunters Ridge Apartments (B)	Bioretention	32.6	1.7	0.2	110	$17,419
137	New BMPs	Bio 46f	Valley Mall (Belk D)	Bioretention	32.4	3.7	0.4	264	$157,528
138	New BMPs	Bio 45a	Valley Mall (Kohl's A)	Bioretention	32.0	3.4	0.3	244	$76,165
139	New BMPs	Bio 24d	Harrisonburg Hyundai (D)	Bioretention	30.7	2.9	0.3	226	$25,210
140	New BMPs	Bio 410	Suntrust Bank - East Market Street	Bioretention	30.5	8.1	0.8	594	$87,970
141	New BMPs	Bio 24c	Harrisonburg Hyundai (C)	Bioretention	30.4	2.5	0.3	197	$23,395
142	New BMPs	Bio 24f	Harrisonburg Hyundai (F)	Bioretention	29.0	0.8	0.1	63	$14,762
143	New BMPs	Bio 400c	University Fields at Port Road (C)	Bioretention	28.7	6.2	0.6	433	$97,300
144	New BMPs	Bio 400a	University Fields at Port Road (A)	Bioretention	27.4	2.7	0.2	183	$61,816
150	New BMPs	Bio 400b	University Fields at Port Road (B)	Bioretention	26.4	2.3	0.2	171	$71,568
1	Stream Rest.	HB-11	North End Greenway Trail	Stream Restoration	55.1	595.0	86.0	40,475	$2,350,985
2	Stream Rest.	HB-4	Mountain View Drive	Stream Restoration	48.8	100.0	101.5	63,260	$1,928,849
3	Stream Rest.	HB-6	Keister Elementary School	Stream Restoration	45.2	78.9	71.9	47,410	$1,087,470

Category Ranking	BMP Category	BMP ID	Site Names	BMP Type	Ranking Score	Load Reduction (lb/yr)			BMP Cost
						TN	TP	TSS	
4	Stream Rest.	HB-1	East Mosby Rd to City Limits	Stream Restoration	42.6	856.5	787.8	512,559	$17,064,682
5	Stream Rest.	HB-13	EMU Gym	Stream Restoration	40.2	39.2	35.5	23,428	$536,767
6	Stream Rest.	HB-10	Charles Street to Ashby Avenue	Stream Restoration	39.0	79.6	78.9	50,466	$1,317,568
7	Stream Rest.	HB-8	Westover Park to South Willow Street	Stream Restoration	37.7	89.9	88.8	58,682	$1,459,400
8	Stream Rest.	HB-3	Mall Creek - Country Club Road	Stream Restoration	34.9	597.2	662.2	424,987	$11,358,001
9	Stream Rest.	HB-5	South Avenue to South Main Street	Stream Restoration	33.3	149.9	135.9	89,688	$2,520,239
10	Stream Rest.	HB-7	Mongers to Ohio Avenue	Stream Restoration	27.5	93.4	84.7	55,920	$1,573,618
11	Stream Rest.	HB-12	Heritage Oaks Golf Course	Stream Restoration	19.0	92.0	97.8	61,585	$1,833,466
12	Stream Rest.	HB-9	Ice House to Chesapeake Avenue	Stream Restoration	16.9	48.8	44.3	29,226	$1,039,072
1	BMP Retrofits	92-14	Thomas Harrison Middle School - Beside Track & Basketball Court	Bioretention	77.0	90.1	6.4	4,484	$271,781
2	BMP Retrofits	91-13	Thomas Harrison Middle School - Beside Parking Lot	Bioretention	74.9	72.0	5.3	3,770	$235,884
3	BMP Retrofits	77-12	West Market Street - Beside Entrance to Thomas Harrison Middle School	Wet Pond	74.4	80.1	12.6	11,858	$572,581
4	BMP Retrofits	121-50	Lucy Simms School - East Washington Street	Bioretention	72.7	27.8	2.4	1,748	$119,022
5	BMP Retrofits	223-522	Massanutten Technical Center - Pleasant Valley Road	Veg Filter Strip	68.9	20.9	1.4	1,244	$14,433
6	BMP Retrofits	81-8	Stone Spring Elementary - Peach Grove Ave	Bioretention	67.4	45.2	3.3	2,320	$150,913
7	BMP Retrofits	79-16	Westover Park - Parking Lot Loop	Bioretention	65.3	12.5	1.3	975	$65,221
8	BMP Retrofits	88-9	Stone Spring Elementary - Near Track	Bioretention	65.1	43.4	3.6	2,748	$194,203
9	BMP Retrofits	82-11	West Market Street - Beside Spotless Car Wash	Extended Detention	64.1	22.2	1.1	3,657	$170,878
10	BMP Retrofits	89-10	West Market Street - Beside White House	Extended Detention	63.5	13.8	0.8	2,775	$142,700
11	BMP Retrofits	158-133	Erickson/Stone Spring Phase 2 - Stone Spring Bridge	Wet Pond	63.1	51.8	16.8	16,544	$706,316
12	BMP Retrofits	222-523	Manheim Auto Auction - Early Road	Wet Pond	59.8	105.5	14.1	17,248	$500,599
13	BMP Retrofits	WP 5	EMU Wooded Trails Site	Enhanced Extended Detention	58.1	144.4	22.2	20,811	$927,997
14	BMP Retrofits	97-23	Skyline Middle School - Linda Lane	Extended Detention	56.1	12.1	0.6	1,155	$240,593
15	BMP Retrofits	83-6	Westover Park - S Dogwood Drive	Enhanced Extended Detention	52.7	42.7	22.3	5,246	$1,203,652
16	BMP Retrofits	110-83	Erickson/Stone Spring Phase 1 - Pear Street	Extended Detention	51.9	5.1	0.4	800	$210,892

Category Ranking	BMP Category	BMP ID	Site Names	BMP Type	Ranking Score	Load Reduction (lb/yr)			BMP Cost
						TN	TP	TSS	
17	BMP Retrofits	0-43-H45-A	Spotswood Elementary School - Mountain View Drive	Bioretention	50.2	2.5	0.8	276	$56,466
18	BMP Retrofits	Bio 530	Virginia Clean Cities - Technology Drive	Bioretention	46.7	16.1	0.8	224	$118,594
19	BMP Retrofits	275-17	Smithland/Skyline Schools	Enhanced Extended Detention	45.1	0.0	6.4	0	$369,082
20	BMP Retrofits	Veg 509	Harrisonburg Nissan - East Market Street	Veg Filter Strip	44.2	9.1	0.4	0	$48,182

Appendix I: High Priority Concept Plans

Introduction

In evaluating the highest ranked BMP opportunities from within the list of recommended BMPs in Appendix H, the City chose locations to be further developed into high priority concept plans. These high priority concept plans support future implementation of highly ranked projects in accordance with SWIP objective 3.2 (see main SWIP document).

High Priority Concept Plans

Locations where high priority concept plans were identified by the City are listed in Table 14 of the SWIP document.

1. Three (3) high priority concept plans were identified prior to the SWIP development (Mountain View Drive Stream Restoration, North End Greenway Trail & Stream Restoration, and East Market Street Regenerative Stormwater Conveyance Channel). In each case, additional information about these BMP projects are available under separate cover, so they are not included in Appendix I.

2. Five (5) high priority plans were identified as part of the SWIP development (BMPs near EMU/VMRC and at Thomas Harrison Middle School). In each case, additional information about these BMP projects are shown on the attached concept plans, including:

    a. Project names and watershed characteristics from the SWIP excel workbook including TN, TP and TSS removal goals.

    b. Additional calculated TN and TP removal goals based on the Virginia Runoff Reduction Method (VRRM) for comparison to the bay program pollutant reduction goals in the SWIP.

    c. The total cost for design and construction based on a conceptual plan and preliminary cost estimate for each BMP (instead of the bay program adaptation). Cost per pound of TN and TP removals are also based on this refined cost estimate.

Additional High Priority Concept Plans

Three (3) additional high priority projects have been identified by the City as part of this SWIP development process, however they do not have an associated high priority concept plan at this time. They include:

a. Harrisonburg Public Utilities Wet Pond

b. Heritage Oaks Golf Course Pond

c. Keister Elementary School Stream Restoration

Conceptual plans for these may be added to this SWIP appendix later, or developed outside of the SWIP report writing. Additional high priority project needs in future permit cycles can also be developed using a similar format to Appendix I.

Appendix J: Consensus Building Activities

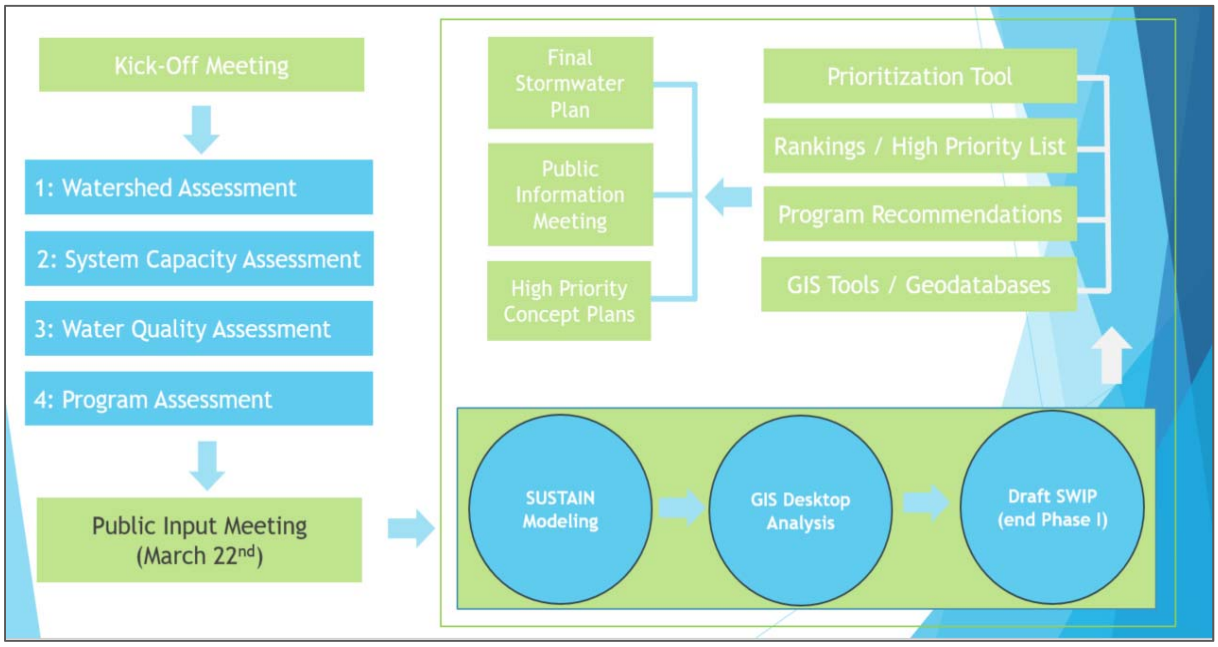
As part of the SWIP, the City conducted multiple Skype meetings and conference calls to coordinate milestones with the study team. This appendix documents the following consensus building activities:

- Two (2) Presentations to the Stormwater Advisory Committee (SWAC);
- Two (2) Public Input Meetings.

Stormwater Advisory Committee (SWAC)

The City of Harrisonburg has a SWAC that helped guide the development of the SWIP over the past year. The first presentation to SWAC was made on March 8, 2017. It began with the introductions of consulting team members, followed by an explanation of the work flow diagram for the study as shown in Figure J-1, below.

Figure J-1. SWIP Work Flow Diagram.



As shown in this diagram, the Phase I SWIP was broken into four categories of citywide evaluations and stormwater assessments. The first SWAC presentation on March 8, 2017 provided an opportunity to present the results of these initial evaluations and to discuss the planned public input meeting and associated meeting materials.

The Phase II SWIP was focused on identifying, ranking, and prioritizing BMP opportunities to meet the requirements of the MS4 permit, especially as it relates to the pollution reduction gap for Total Nitrogen (TN) that was identified in the plan. The second SWAC presentation on October 4, 2017 presented the list of BMP opportunities and the prioritization and ranking tools to be used to compare them. SWAC also discussed the second public input meeting and meeting materials.

Public Input Meetings

The initial findings of the SWIP were presented through a first public input meeting on March 22, 2017. Using an open house format, the public was invited to arrive at any time between 5:00 and 7:00 p.m. to discuss the City's stormwater program with designated persons from the City and the consulting team, using a series of presentation boards to discuss issues from. In addition, a public comment sheet was utilized to solicit written comments from meeting attendees and comment sheets were accepted after the meeting until April 7, 2017. In reviewing the public comments received, the following observations can be made.

- Through the comments received, the open house format seemed to provide attendees a better understanding of the City's stormwater program and an introduction to the goals for developing a Stormwater Improvement Plan for MS4 permit compliance.
- One of the stations at the public meeting was focused on identifying storm sewer capacity issues and flooding problems citywide. Additional concerns that were raised during the meeting were added to the City's GIS database developed with this study.
- The comment sheet requested input on the prioritization factors for ranking stormwater projects and there was no apparent consensus, meaning that a multi-faceted approach to stormwater compliance is warranted. In discussions with SWAC, it was clear that a high priority would be the unit cost per pound of pollutant reduction crediting (e.g. $/pound for TN). Other factors are important to a lesser extent.
- Given its apparent cost effectiveness, there was an emphasis during the meeting and afterwards to provide increased opportunities for City residents to assist in meeting the pollution reduction goals by making water quality improvements on their private properties as part of the Stormwater Utility Fee Residential Credit Program.
- There were also discussions about expanding incentives to private homeowners and commercial business for implementing private BMPs for the MS4 program moving forward. This includes grants and/or increasing the current 50% fee reduction cap in the Stormwater utility Fee Residential and Non-Residential Credit Programs.

The second public input meeting on October 18, 2017 was also an open house format allowing citizens to arrive at any time, and was focused primarily on discussing the specific BMP types and locations included in the SWIP recommendations.

For both public meetings, written public comment forms were requested as well as input after the second public meeting online. Copies of these comments are attached to this report appendix.

References

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