Section 2
Implementation Guidelines

2.1 Applying BMPs to Development Practices

Post construction stormwater BMPs should be applied when areas are developed or redeveloped. In general, development changes the land cover from pervious areas that can infiltrate rain water to impervious areas that do not infiltrate rain water. Impervious areas such as roof tops, driveways, streets, and parking lots increase the amount of impervious area, which increases the amount of stormwater runoff. Studies have shown that impervious areas accumulate more pollutants that runoff with the first flush of stormwater. Therefore, stormwater BMPs should be applied to developments or redevelopments to reduce the impacts of the increased impervious area.

A guideline for applying BMPs to development or redevelopment projects is the impervious to pervious ratio. For a given project, the amount of impervious and pervious area should be calculated and reviewed by the local jurisdiction. The calculated ratio of impervious to pervious area gives an indication of the impact of the development to the water quality of the receiving water body. A ratio of 1 or greater indicates a very high water quality impact, which will require the implementation of stormwater BMPs. A ratio of less than 1 indicates a likely need for BMPs depending on the soils and the water quality event. Appendix H contains figures of the impervious to pervious ratio verses excess water quality volume for each city at the 85 and 90 percent rainfall events. Two figures (85-percent and 90-percent events, respectively) for each City are provided as a guide for when BMPs should be applied to sites for impervious to pervious ratios of less than 1 by hydrologic soils group (HSG). BMPs are required within the shaded area of the graph based on the impervious to pervious ratios and HSG.

The HSG of the site soils should be determined from the Natural Resources Conservation Service (NRCS) county soil survey. Appendix B provides a general map of the HSG by City. Soils on sites developed since the publication of the NRCS soil survey should be decreased a HSG (e.g. HSG B would be HSG C). The HSG used should also be reduced one level if the existing site soils are not protected and restored. During development soils are significantly impacted either by compaction, which reduces infiltration, or removal of the top soil during site grading which is often not restored. In either case, the developed HSG used with Appendix H should be reduced one level (e.g. HSG B to HSG C). The original soils HSG should only be used if the native site soils are removed prior to construction, stockpiled, and restored after construction.

In some cases, an on-site infiltration test, or percolation test, may be used to determine the actual pervious area infiltration rate. In those cases, Table 2-1 can be used to determine the HSG for the site. It is recommended that at least three locations be

tested with this method, and the median infiltration rate then used for determining the HSG in Table 2-1.

Table 2-1 Infiltration Rates by HSG

HSG	Median Infiltration Rate (in/hr)
A	0.375
B	0.225
C	0.100
D	0.025

Example:

A new single family residential development in Emporia, Kansas with a total area of 4.5 acres has the following proposed impervious area:

Imp. Cover	*Area (sq. ft)*
Streets	*21,500*
Sidewalks	*3,285*
Driveway	*16,500*
Buildings	*24,750*
Total	*66,035*

The impervious/pervious ratio is 66,035/129,985 = 0.51

The existing site soils are HSG B. The developer does NOT plan on removing, stockpiling, and restoring the native soils so the developed site soils are HSG C.

Assuming a 90-percent rainfall event for Emporia, Kansas, the corresponding figure in Appendix H indicates that BMPs are required for this site (within the shaded area).

The developer will need to apply post construction BMPs to this site.

The figures provided in Appendix H are a guideline for applying BMPs to new development or redevelopment. Local jurisdictions may require BMPs outside of the shaded area in cases where there is an existing TMDL or the site area drains to a sensitive water body. Check with your local jurisdiction in these cases.

As development within a community occurs, Table 2-2 provides guidance in how to apply BMPs to a given site, based on type of development and the drainage area to that development. The table provides applicability guidelines for each BMP in relation to the type of development. For example, infiltration trenches have a low applicability to industrial development due to a potential ground water pollution risk. On the other hand, bioretention has a high applicability to development of commercial sites, based on the drainage area to the site and the water quality treatment that the BMP provides.

Table 2-2 Development Matrix for BMP Application

BMP	Agricultural and Park Land	Residential Large Lot >2 acre	Residential Small Lot <2 acre	Multi-Family	Commercial	Industrial	Streets/ Parking Lots	Drainage Area
Lot Level BMPs	M	H	H	H	M	M	M	< 1/8 acre
Bioretention	L	L	L	M	H	H	H	< 4 acres
Vegetated Swale	M	H	L	M	M[1]	M	M	< 5 acres
Filter Strips	H	H	M	M	H	H	H	< 2 acres[3]
Infiltration Trench	L	L	L	M	H	L[2]	H	< 5 acres
Extended Dry Detention	H	S	S	S	H, S	H, S	M	> 10 acres
Extended Wet Detention	H	S	S	S	H, S	H, S	M	Water budget > 40 acres
H	High applicability							
M	Medium applicability							
L	Low applicability							
S	Subdivision level applicability							

1 Consider trash and floatables during selection and design.

2 Consider potential ground water pollution risk during selection and design.

3 Limit concentrated flow.

Specific policy regarding implementation of BMPs in relation to development, redevelopment, and public improvement projects should be defined by the respective municipality, county, or agency that adopts this manual.

It is important to pay special attention to when in the construction process a specific BMP is defined and/or installed. Site conditions during installation can affect the overall function of both non-structural and structural BMPs, and ultimately the respective BMPs' long-term success. Table 2-3 outlines the earliest possible installation time for a BMP during the site construction process.

Table 2-3 BMP Earliest Installation

Prior to any Land Disturbance	
Stream Buffer	Boundary of buffer or preservation area should be delineated with orange construction fence and silt fence.
Preserve Existing Vegetation	
Erosion and Sediment Control / Land Disturbance Plan	
Filter Strips	Can be used in conjunction with other erosion control measures, as part of a comprehensive land disturbance plan
Extended Dry Detention	Possible sedimentation basin location. After drainage area stabilization, will require cleaning/dredging and converting to detention.
Extended Wet Detention	
Site Stabilization	
Rain Gardens (non lot level)	Drainage area to BMP stabilized, with a minimum of 70% vegetation density
Bioretention	
Vegetated Swale	
Infiltration Trench	
Individual Lot Close-Out and/or Issuance of Occupancy Permit	
Restoration of Native Vegetation	Post infrastructure and building construction; Part of final site stabilization; Installed prior to issuance of occupancy permit
Lot Level BMPs	

2.2 Guidelines for BMPs in Series (Treatment Train)

The preferred approach for water quality improvement is a combination of stormwater BMPs in series called a "treatment train." A treatment train can increase pollutant removal efficiency by providing additional treatment and volume reduction. Selection of treatment train components should be based on a combination of local and state stormwater requirements, site characteristics, development needs, runoff sources, financial resources, and BMP characteristics (such as space requirements, design capacities, and construction and maintenance costs). (MARC, 2008)

A treatment train is two or more BMPs in series that capture, filter, then infiltrate or store and treat stormwater. The combination of processes provides cumulative water quality benefits. The BMPs chosen for a treatment train should be placed in series as follows:

- (1) Capture at source (rain barrels),
- (2) Filter overland flow (swales; filter strips),
- (3a) Infiltration systems (bioretention; infiltration trench; rain gardens),

Or,

- (3b) Treatment and storage (extended wet detention; extended dry detention).

Depending on the combination of BMPs chosen, different levels of water quality benefits can be experienced. Table 2-4 presents BMP combinations for treatment trains and the associated applicability for water quality benefits.

Table 2-4 Treatment Trains and Water Quality Benefits

Treatment Trains and Water Quality Benefits							
	Second BMP in Series						
First BMP in Series	Infiltration Trench	Filter Strip	Vegetated Swale	Rain Garden	Bioretention	Extended Wet Detention	Extended Dry Detention Basin
Filter Strip	H		L	H	H	M	M
Vegetated Swale	H	L		M	H	M	L
Bioretention[1]			M			M	M
Extended Wet Detention			L			M	M
Extended Dry Detention Basin			L			L	L
H	High						
M	Medium						
L	Low						

(1) Assumes underdrain system.

2.3 Design Considerations for BMP Implementation

Design considerations for BMP implementation can be divided among three broad categories: planning and design, construction practices, and maintenance/inspection. All should be considered and outlined prior to a project beginning construction. These processes will be presented in more detail in Sections 3, 4, and 5. The following is a series of questions agencies, planners, designers, and contractors should consider during the BMP project process.

2.3.1 Planning and Design (Section 3 and Section 4)

As a project enters the planning and design stage, some key questions to ask in relation to applicability and design of BMPs include:

- What is the existing land use of the site?
- What is the designated land use of the site?
- What is the area of the project site?
- What is the total tributary drainage area of the site being developed, including the site and any drainage area to the site?
- How much impervious area is planned for the site? Are pervious alternatives an option?
- What is the ground slope of the site?
- What portions of the site will be left undisturbed, if any?
- Is there any known downstream water quality or flooding issues?
- What are the adjoining land uses to the site?
- What vegetation is planned for the site?
- Where are the BMPs located?
- Who will be responsible for long-term maintenance of any infrastructure and/or BMPs installed?
- What percentage of the site area drains to proposed BMPs?
- Have maintenance and access easements/agreements been defined for the BMP?
- Have complete construction plans, including at a minimum design plans and details, vegetation plan (if required), and implementation schedule, been provided for use by a contractor?

2.3.2 Construction Practices (Section 4 and Section 5)

As a project enters the construction stage, some key questions to ask in relation to the construction and implementation of BMPs include:

- Has an erosion and sediment control plan, including site stabilization, been defined for the site?
- Has erosion control and land disturbance practices been defined using a phased approach?
- How will silt, sediment, and construction activity affect proposed BMPs?
- When in the construction schedule should the BMP be constructed? How does this compare to the growing season?
- When in the construction schedule should the BMP be put on-line?
- How will the construction of the BMP be validated? Who will inspect and do initial maintenance of the BMP?
- Has the maintenance and inspection requirements been recorded with property?

2.3.3 Maintenance and Inspection (Section 5)

As a BMP comes on-line and therefore becomes part of infrastructure routine maintenance and inspection practices, some considerations include:

- Who will be responsible for on-going maintenance of the BMP?
- Have short and long-term maintenance schedules been defined for the BMP?
- Have short and long-term maintenance plans been defined for the BMP?
- How will inspection and maintenance activities be monitored and documented?

2.4 Public Outreach

The installation of a BMP presents itself as an education tool for the community. Post construction BMPs are often installed in areas of high visibility to the public. Using signage, the Internet, brochures, and community programs provides opportunities for those who live, work, and play near a BMP to learn about this piece of infrastructure, and even aid in its long-term success by helping to maintain it.

Routine maintenance tasks can provide volunteer opportunities for the community. This can be accomplished in a number of ways. Regardless of how volunteers are utilized, inspection and maintenance guidelines would still need to be established by the overseeing agency. The agency would also need to document any inspection and

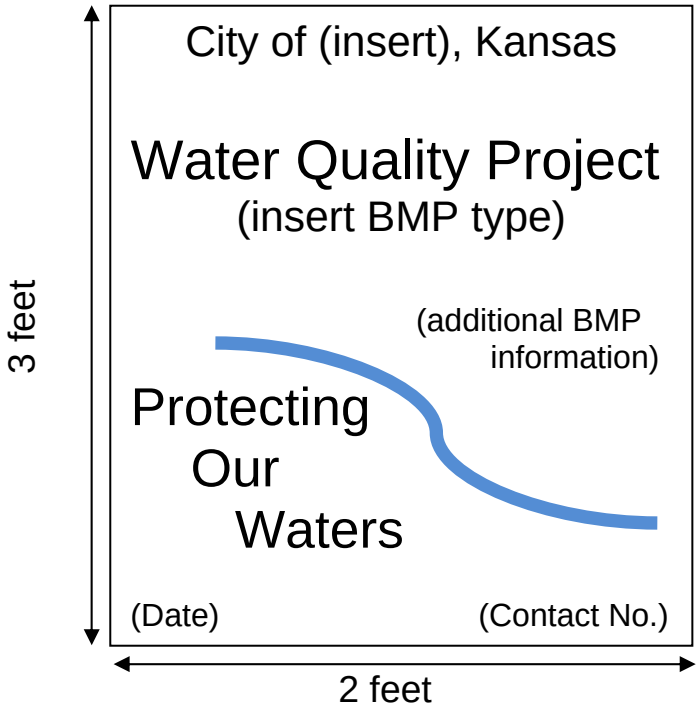
maintenance performed by this organization to ensure the long-term integrity of the BMP. Examples include:

- **Green Team.** A "Green Team" comprised of community volunteer members could be established to routinely inspect and complete some maintenance tasks on a BMP. The Green Team could even be a management point for interested volunteer organizations throughout the community, designating which volunteer organization is going to perform what maintenance, and when this will occur.

- **Adopt-A-BMP.** Similar to the "Adopt-A-Highway" program, an agency can implement an "Adopt-A-BMP" program. An adopting business or volunteer group could contribute funding or time to inspection and maintenance of the BMP. This program could be utilized for funding and/or long-term maintenance programs.

Signs and brochures provide great opportunities for communication and discussion in the community. It is recommended that each BMP installed be designated using signage defined by the respective agency. To identify a BMP from other surrounding vegetation and development, a sign should be installed at a location in which the BMP would be most accessed. Signage can range from simply stating the type of BMP installed, to complete details on what it is, and why it is installed. Below is an example of a recommended format for a BMP informational sign:

Figure 2-1 Recommended Format for a BMP Informational Sign



Any signs that will be adjacent to public streets should follow Manual of Uniform Traffic Control Devices (MUTCD) guidelines. Design criteria for sign to be installed (size, height of lettering, color, site placement, information to be included) can be agency specific or project specific and should be defined during the planning and design stage of a project.

Brochures can also be good educational tools for BMPs. See Appendix F for an example of a BMP brochure used by the North Carolina Forest Service.

2.5 References

North Carolina Division of Forest Resources.
http://www.dfr.state.nc.us/publications/WQ0307.pdf.

MARC and APWA. 2008. *Manual of Best Management Practices for Stormwater Quality.* Available at www.marc.org/environment/Water/bmp_manual.htm.