Minnesota Department of Transportation

RESEARCH SERVICES

Office of Policy Analysis, Research & Innovation

Decision Tree for Stormwater BMPs

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March 2011

Research Project
Final Report #2011RIC01

LRRB
LOCAL ROAD RESEARCH BOARD

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Technical Report Documentation Page

1. Report No.	2.	3. Recipients Accession No.
MN/RC - 2011RIC01		

4. Title and Subtitle	5. Report Date
Decision Tree for Stormwater BMPs	March 2011
	6.

7. Author(s)	8. Performing Organization Report No.
Michael Marti, David Filipiak, Lisa Goddard	

9. Performing Organization Name and Address	10. Project/Task/Work Unit No.
SRF Consulting Group, Inc. One Carlson Parkway North, Suite 150 Minneapolis, MN 55477-4443	11. Contract (C) or Grant (G) No. RIC Task 1

12. Sponsoring Organization Name and Address	13. Type of Report and Period Covered
Minnesota Department of Transportation Research Services Section 395 John Ireland Boulevard Mail Stop 330 St. Paul, Minnesota 55155	Final Report 14. Sponsoring Agency Code

15. Supplementary Notes

http://www.lrrb.org/pdf/2011RIC01.pdf
http://www.lrrb.org/pdf/2011RIC01PP.pdf

16. Abstract (Limit: 200 words)

The use of stormwater treatment strategies, often referred to as best management practices (BMPs), has increased significantly due to new stormwater regulations. The goal of this project was to create a scoping-level tool that could assist City and County public works staff in the selection of BMPs appropriate for specific projects. This tool walks the user through five (5) steps in the selection process:

1. Select Your Project Type based upon site vs. roadway/linear projects and the amount of space that is likely to be available after project completion.
2. Describe Your Project according to location, receiving waters, soil types, setting, and special site considerations.
3. Determine the Regulatory Environment for Your Project by determining which of the state, local, and federal agencies might have jurisdiction over the project, with the intent to identify the most stringent design criteria.
4. Create a Preliminary BMP Toolbox – from a matrix of seven BMPs, the toolbox will be narrowed to two or three that are most appropriate for the project.
5. Refine BMP Selection by comparing factors such as maintenance, life cycle costs, aesthetics and others.

Appendices contain the cost-benefit analysis and a list of resources. Related PowerPoint, Selecting Stormwater BMPs – Identifying The Best Options, 2011RIC01PP can be found at the link above.

17. Document Analysis/Descriptors		18.Availability Statement
stormwater BMP stormwater regulations BMP Toolbox stormwater ponds bioretention basins underground treatment devices underground detention	infiltration sand filtration media filtration pervious pavement porous pavement stormwater planters tree box	No restrictions. Document available from: National Technical Information Services, Springfield, Virginia 22161

19. Security Class (this report)	20. Security Class (this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	58	

Introduction

As stormwater permit rules become more stringent and performance based, the variety of best management practices (BMPs) is increasing. However, not all BMPs perform the same treatment function or provide the same removal efficiencies. Furthermore, the frequency and intensity of maintenance can vary greatly between BMP types. The Minnesota LRRB has developed a scoping-level tool to assist in the selection of best management practices (BMPs) appropriate for specific projects. This tool is intended to work in conjunction with the Minnesota Stormwater Manual and the Stormwater Maintenance BMP Resource Guide (LRRB 2009RIC12). This tool focuses primarily on the following BMPs that have been heavily used in Minnesota and ones that are becoming more common:

a. Stormwater Ponds
b. Bioretention Facilities
c. Underground Treatment Devices
d. Underground Detention
e. Infiltration
f. Porous/Pervious/Permeable Pavements
g. Tree or Planter Boxes

At the time of printing, this report is a synthesis of the Technical Advisory Committee (TAC) consensus of the most useful information for application in Minnesota.

The inspection and maintenance checklists provided in this report can be downloaded from the LRRB website (http://www.lrrb.org/pdf/2011RIC01.pdf) in portable document format.

Acknowledgements

The authors would like to thank the following individuals and organizations for their contributions to this document:

Technical Advisory Committee

Mel Odens, Mn/DOT (Chair)
Doug Carter, Bolton and Menk
Lisa Cerney, City of Minneapolis
Stephen Druschel, Mankato State University
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Bruce Holdhusen, Mn/DOT
Paul Kauppi, City of Woodbury
Jim Kosluchar, City of Fridley
Renae Kuehl, SRF Consulting Group, Inc.
Bruce Loney, City of Shakopee
Mark Maloney, City of Shoreview
Shahram (Shane) Missaghi, U of M
Bob Moberg, City of Plymouth
Joseph Pelawa, Hakanson-Anderson
Joel Schilling, Schilling Consultants
Jesse Struve, City of Edina
Mark Thompson, City of Elk River

STORMWATER BMPs - DECISION TREE

INSTRUCTIONS FOR USE

This resource is intended to work in conjunction with an earlier LRRB report, *2009RIC12: Stormwater Maintenance BMP Resource Guide* and to assist agencies in selecting stormwater best management practices (BMPs) for a given project. This resource tool is intended for use with projects for which there is no regional stormwater facility available. The tool has five steps that guide the user through

- describing the project,
- determining the regulatory framework surrounding the project,
- creating a BMP toolbox,
- and performing a final screening of the BMPs.

These are recommendations based upon typical situations/conditions. Each project needs to be evaluated on its own parameters, and good engineering judgment should be used to determine if a particular BMP is applicable for the particular project. The general process is as follows:

Step 1 – Select Your Project Type

a. Is the project likely to have a limited amount of space available for BMPs once completed (i.e., is there not likely to be sufficient land area for surface BMPs such as ponds and bioretention basins)?

Examples of a project with limited available space include:

- Less than ___% *(percentage to be filled in by City or County Engineer)* of the area within the project limits is available for surface BMPs.
- For linear projects, the available space does not fall within public right-of-way or within the planned construction limits.
- The available space is too steep for construction of surface BMPs.
- The available space consists primarily of wetlands or floodplains.

If you answered **Yes**, your project is considered to have "Limited Available Space". Otherwise, it is considered to have a "Higher Percentage of Available Space".

Circle one:

Yes / No

b. Is it a Site or Roadway/Linear Project?

Site projects encompass a wide variety of projects including, but not limited to, preliminary plats, residential, commercial/industrial/institutional, and redevelopment projects.

Roadway/Linear project examples include road construction, reconstruction and/or widening, trails, and bridges that are constructed as stand-alone projects (i.e., not part of a site project).

Site or Road/Linear

Based upon answers to the above, go to one of the following sections to create a project-specific toolbox:

	Site Project	Roadway/Linear Project
Limited Available Space	Site-Low Avail. Space	Linear-Low Avail. Space
Higher % of Available Space	Site-High Avail. Space	Linear-High Avail. Space

See next page for Steps 2 through 5.

Continued from Page 1.

Step 2 – Describe Your Project

This step asks the user several questions in an effort to better understand the project, the downstream receiving waters, and design constraints. The answers to these questions will be used in Steps 3 and 4. Design constraints include topography, soils, project setting, contaminated soil or groundwater, bedrock, wellhead protection zones, and other issues that could preclude certain BMPs from being used.

See pages 1 to 2 of the appropriate section as determined in Step 1 above.

Step 3 – Determine the Regulatory Environment for Your Project

A variety of state, local, and federal agencies regulate projects that impact Minnesota's water resources. In many cases, a permit is required from one or more of these agencies before proceeding with the project. This step helps the user determine which agencies may have permitting authority over the project and what their requirements are. The National Pollutant Discharge Elimination System (NPDES) permit from the Minnesota Pollution Control Agency will cover the majority of projects in the state, but other agencies might have permitting authority with more restrictive requirements.

See pages 3 - 5 of the appropriate section as determined in Step 1 above.

Step 4 – Create a Preliminary BMP Toolbox

Using information from the previous steps, this step allows the user to compare the BMPs included in the resource guide and narrow the list of potential BMPs to two or three that meet the regulatory environment. Information for the various BMPs is presented in a table according to the type of project and the anticipated percentage of available space for surface BMPs. The list covers the majority of BMPs typically used in Minnesota but should not be considered an exhaustive list of all potential BMPs.

See pages 6 - 7 of the appropriate section as determined in Step 1 above.

Step 5 – Refine BMP Selection/Select the Right "Tool"

This step allows the user to further refine the selection by comparing such factors as maintenance, life cycle costs and aesthetics.

See pages 8 - 11 of the appropriate section as determined in Step 1 above.

At this point, go to the appropriate section as determined in Step 1 above.

STEP 2 - DESCRIBE YOUR PROJECT
This will help determine which permits and types of BMPs are required and will work effectively for your project.

2.1 Where is the project?

Address/location _____
City/Township _____
County _____

2.2 What lake, river, or stream does it ultimately drain to?

Use USGS quadrangle maps, other types of contour/topographic maps, or the MPCA interactive map tool at
http://pca-gis02.pca.state.mn.us/website/stormwater/csw/viewer.htm

Fill in name or names of the receiving waters.

_____
_____
_____

2.3 What types of soils exist throughout the project area, and in particular at the location(s) of the potential BMPs? Check A, B, C, D, or combinations of.

Use soil boring data if available. Otherwise use County soil surveys, found at:

- http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx (interactive)
- http://soils.usda.gov/survey/online_surveys/minnesota/ (similar to the standard paper copies)

Standard hydrologic soil groups (HSG) are:

Check all that apply:

A. HSG A = sandy soils having low runoff potential with high infiltration rates even when thoroughly wetted. These consist primarily of deep, well to excessively drained sands and/or gravel. ☐
B. HSG B = soils having moderate infiltration rates even when thoroughly wetted, consisting chiefly of moderately deep to deep soils that have moderately fine to moderately coarse textures. These are moderately well to well drained soils. ☐
C. HSG C = soils having slow infiltration rates when thoroughly wetted. These consist primarily of soils with a layer that impedes the downward movement of water, or soils with moderately fine to fine texture and a slow infiltration rate and are somewhat clay-like in nature. ☐
D. HSG D = soils having high runoff potential with very slow infiltration rates when thoroughly wetted. These consist chiefly of clay soils with high swelling potential; soils with a high permanent water table; soils with claypan or clay layer at or near the surface; and shallow soils over nearly impervious materials. ☐

2.4 Does the project fall within a setting likely characterized as:

Check one:

a. Central Business District? ☐
b. Residential, suburban, low-density commercial or campus settings? ☐
c. Rural/ undeveloped? ☐

2.5 Are there special site considerations that could affect the BMP selection?	
a. There are no special site considerations, such as those listed in 2.5.b through 2.5.f.	Yes / No
b. Is there soil or groundwater contamination?	Yes / No
c. What is the depth to bedrock? There must be at least 3 feet of separation from the bedrock elevation to the bottom of any infiltration practice.	_____
d. What is the seasonal high groundwater elevation in the vicinity of the potential BMPs? There must be at least 3 feet of separation from the seasonal high groundwater elevation to the bottom of any infiltration practice.	_____
e. Will the BMP receive runoff from a potential stormwater hotspot (PSH)? PSHs are defined as commercial, industrial, institutional, municipal, or transportation-related operations that produce higher levels of stormwater pollutants, and/ or present a higher potential risk for spills, leaks or illicit discharges. Runoff from these operations may contain soluble pollutants which cannot be effectively removed by current BMPs and can contaminate ground water quality.	Yes / No
f. Does the project fall within a drinking water supply management area (DWSMA), wellhead protection zone (WHPZ), region of karst landforms/aquifers, or region of medium to high groundwater sensitivity? Municipal comprehensive plans typically include the DWSMA boundaries for their municipal wells. A map of Minnesota's DWSMA boundaries with vulnerability ratings can be found at http://www.health.state.mn.us/divs/eh/water/swp/maps/gis/dwsvul.pdf WHPZ boundaries can be found on the County Well Index interactive web tool at http://www.health.state.mn.us/divs/eh/cwi/ Information on Minnesota's karst region can be found at http://www.pca.state.mn.us/water/groundwater/karst.html	Yes / No

- Using the information from **Questions 2.1 through 2.2, go to Step 3** to determine which regulatory agencies have permitting and/or review authority over your project.
- You will use information from **Questions 2.3 through 2.5 in Step 4**, which creates the BMP toolbox specific to the project.

STEP 3 – DETERMINE THE REGULATORY ENVIRONMENT FOR YOUR PROJECT

A variety of state, local, and federal agencies regulate projects that may impact Minnesota's water resources. In many cases, a permit is required from one or more of these agencies before proceeding with the project. This step starts at the broadest level, with the agency that has jurisdiction over most projects that occur within the state. The focus is then narrowed down to the local governmental units. The intent is to determine the most stringent stormwater criteria that affect your project, which will then help determine which BMPs can meet those requirements.

3.1 Does your project require a National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) General Stormwater Permit for Construction Activity from the Minnesota Pollution Control Agency (MPCA) and/or a Stormwater Pollution Prevention Plan? *(Answer questions a-c to determine.)*

- The MPCA has jurisdiction through the NPDES/SDS permit for projects over 1 acre in size or part of a larger common plan of development if less than 1 acre in size.
- **The NPDES/SDS requirements will typically set the minimum stormwater criteria for all projects within the state. Other agencies may require higher levels of treatment.**
- For information on the NPDES/SDS permit, application form and other information, go to http://www.pca.state.mn.us/index.php/water/water-types-and-programs/stormwater/construction-stormwater/construction-stormwater.html

NPDES Permit:	
a. Will the project disturb one or more acres of land? This includes clearing, grading and excavation, but does not include routine maintenance that is performed to maintain the original line and grade, hydraulic capacity or original purpose of the facility. (*MPCA*)	NPDES Permit Required
If **Yes**, a NPDES/SDS permit is required. **Check box; then go to Question 3.1.c.**	☐
b. If No, is the project part of a larger common plan of development? A common plan of development or sale means a contiguous area where multiple separate and distinct land disturbing activities may be taking place at different times, on different schedules, but under one proposed plan. (*MPCA*)	
If **Yes**, a NPDES/SDS permit is required. **Check box; then go to Question 3.1.c.** If **No**, a NPDES/SDS permit is **not** required. **Go to Question 3.2.**	☐
Stormwater Pollution Prevent Plan (SWPPP):	
c. Will the amount of impervious surface increase over that of the existing condition as a result of the project?	Yes / No
If **Yes**, the following components of the SWPPP are required as part of the NPDES/SDS permit as described in Parts III, IV and Appendix A of the permit. See the permit for design criteria. **(Check boxes.)**	SWPPP Components Required
Temporary Sediment Basins (Part III.B)	☐
Permanent Stormwater Management System (Part III.C)	☐
Construction Activity Requirements (Part IV)	☐

If **No**, the following components of the SWPPP are required as part of the NPDES/SDS permit as described in Parts III, IV and Appendix A of the permit. See the permit for design criteria. **(Check boxes.)**

SWPPP Components Required

Temporary Sediment Basins (Part III.B) ☐

Construction Activity Requirements (Part IV) ☐

3.2 Does the county, city, or township have requirements that are MORE STRINGENT than the NPDES permit? *(Answer questions a-e in the table below to determine.)*

- For a listing of potential agencies and their contact information, go to http://www.dnr.state.mn.us/permits/water/water_permit_contacts.html
- Many counties have a Soil and Water Conservation District (SWCD) that can provide recommendations and technical information. For links to the various county SWCDs, go to http://www.maswcd.org/SWCDs_On_The_Web/swcds_on_the_web.htm

Contact each of the potential agencies listed and fill in their criteria for the following questions in the table below:

	County	City	Township
a. Is rate control required (y/n)?			
b. Is volume control (y/n) required?			
c. Is water quality treatment (y/n) required? If yes, what is the specified % removal required for:			
Total suspended solids (TSS):			
Total phosphorus (TP):			
d. Do the BMPs need to provide for downstream channel protection (y/n)? See definition below.			
e. Does the project need to meet an antidegradation (nondegradation) requirement to comply with a MS4 permit (y/n)? See below.			

- The purpose of channel protection criteria is to prevent habitat degradation and erosion in urban streams caused by an increased frequency of bankfull and sub-bankfull stormwater flows and to minimize downstream channel enlargement and incision that is a common consequence of urbanization.
- For information on what a MS4 permit is, see: http://www.pca.state.mn.us/water/water-types-and-programs/stormwater/municipal-stormwater/municipal-separate-storm-sewer-systems-ms4.html#whatis

  For an interactive map of MS4 entities within the state, visit: http://pca-gis02.pca.state.mn.us/website/stormwater/ms4_smt/viewer.htm

3.3 Does your project fall within a watershed district or watershed management organization with permitting authority or that will need to review and approve the project? *(Answer questions a-e in the table below to determine)*

- **Watershed district and watershed management organizations typically have the MOST STRINGENT requirements for stormwater management.**
- For a listing of potential agencies and their contact information, go to http://www.dnr.state.mn.us/permits/water/water_permit_contacts.html

Fill in the name(s) of the watershed agencies:

1. _____
2. _____
3. _____
4. _____

Contact each of the potential agencies listed and fill in their criteria for the following questions in the table below:

	Watershed Agency 1	Watershed Agency 2	Watershed Agency 3	Watershed Agency 4
a. Is rate control required (y/n)?				
b. Is volume control (y/n) required?				
c. Is water quality treatment (y/n) required? If yes, what is the specified % removal required for:				
Total suspended solids (TSS):				
Total phosphorus (TP):				
d. Do the BMPs need to provide for downstream channel protection (y/n)? See definition with 2.2.				
e. Does the project need to meet an antidegradation (nondegradation) requirement to comply with a MS4 permit (y/n)? See information with 2.2.				

3.4 Based upon the answers to Questions 3.2 through 3.3, check the box to the right if you answered "yes" to any of the questions for any agency. For % removal of TSS and TP, list the MOST STRINGENT (highest) value of all agencies reviewed:

Check all that apply:

Rate control: ☐
Volume control: ☐
Water quality treatment: ☐
% TSS removal required: _____
% TP removal required: _____
Channel protection: ☐
Nondegradation: ☐

3.5 Does the project drain to a special or impaired water as defined by the MPCA? Check http://pca-gis02.pca.state.mn.us/website/stormwater/csw/viewer.htm

Yes / No

Using this information, go to **Step 4** to start creating a BMP toolbox specific to your project.

STEP 4 – CREATE A PRELIMINARY BMP TOOLBOX

This step allows you to compare the BMPs included in the Stormwater Maintenance BMP Resource Guide and narrow the list of potential BMPs to two or three. You can further refine the list by completing Step 5 which covers maintenance and costs.

You will first start by determining which BMPs are most able to provide the type of treatment needed to meet permitting or other requirements (such as a Total Maximum Daily Load (TMDL), Environmental Assessment, Environmental Impact Statement, or approved requirement) . **Highlight or circle the information as you go.** In some cases, you may reach the end of this step and realize that due to site constraints or special considerations you are not able to meet all of the regulatory requirements. For example, a roadway project may fall within a watershed district that requires volume reduction, but the depth to groundwater or bedrock may be insufficient to allow construction of infiltration or bioretention practices. Make a note that additional coordination with the regulatory agencies may be needed to determine if specific requirements can be waived or met in another manner.

In the following tables, BMPs are ranked as follows:

REC = Recommended for this application

MAYBE = May be useful for this application with conditions or provides specified treatment to a lesser degree

N/A = Not recommended for this application or does not provide specified treatment

Using the two or three BMPs that result from your work with the appropriate Step 4 table for your project, go to **Step 5** to further refine the list using maintenance, life cycle costs, and aesthetics factors.

TABLE 4 – PRELIMINARY BMP TOOLBOX FOR **SITE** PROJECTS WITH **LIMITED AVAILABLE SPACE**[1]

	BMP Category						
	Stormwater Pond (e.g., ponds with permanent pools of water, such as NURP ponds, and multi-cell ponds)	**Bioretention** (e.g., rain gardens, bio-infiltration, bio-filtration, and bio-swales)	**Underground Treatment Devices** (e.g., proprietary hydrodynamic separators, sump catch basins and wet vaults)	**Underground Detention** (e.g., pipe galleries, concrete vaults, proprietary storage systems generally used for temporary detention of water and rate control)	**Infiltration** [e.g., surface practices that do not rely on vegetation (sand filter) and underground systems (perforated pipe gallery)]	**Porous/Pervious/ Permeable Pavements** (e.g., porous asphalt, pervious concrete, permeable pavers, reinforced/amended soils)	**Tree or Planter Box** (e.g., tree pits, tree box filters, stormwater planters)
Primary Treatment Provided (See question 3.4)							
a. Rate Control	**REC**	**N/A**	**N/A**	**REC**	**MAYBE**	**REC**	**N/A**
b. Volume Control	**N/A**	**REC**	**N/A**	**N/A**	**REC**	**REC**	**MAYBE**
c. Water Quality	**REC**	**REC**	**MAYBE**	**N/A**	**REC**	**MAYBE**	**MAYBE**
TSS Removal Required (%)	60-90%	85-100%	35%	0-20%	100%	90%[2]	85-100%[3]
TP Removal Required (%)	34-73%	65-100%	0%	0%	100%	45-65%	65-100%
d. Channel Protection	**REC**	**MAYBE**	**N/A**	**REC**	**MAYBE**	**MAYBE**	**MAYBE**
e. Nondegradation requirement	**MAYBE**	**REC**	**N/A**	**N/A**	**REC**	**MAYBE**	**MAYBE**
Comments	- Removal efficiencies depend on the type of pond. - Wet extended detention basins are the only type of pond complying with the NPDES Permit.	- Higher removal efficiencies are when designed as bio-infiltration basins. - Very sensitive to construction techniques and good plant establishment.	- Use mainly as pre-treatment (not allowed as sole treatment device in many instances).	- Typically, only used for rate control.	- Pre-treatment is required. - Very sensitive to construction techniques.	- Higher removal efficiencies are when practice is designed for infiltration. - Very sensitive to construction techniques.	- Avoid use to treat runoff from high-load areas.[4] - Removal efficiencies are not yet well documented. - Higher removal efficiencies are when designed for infiltration.
Soil Type Considerations (See Question 2.3)	Best suited for **HSG B, C or D** soils. Line ponds in HSG A & some HSG B soils to maintain a permanent pool.	Best suited for **HSG A and B** soils. Use in HSG C or D soils will require special soil mixes and underdrains.	No restrictions based on hydrologic soil group.	No restrictions based on hydrologic soil group.	Best suited for **HSG A and B** soils. NOT recommended for use in HSG C or D soils. Check setback distance recommendations for building foundations and other items.	Best suited for **HSG A and B** soils. Use in HSG C or HSG D soils will require perforated underdrains.	Best suited for **HSG A and B** soils. Use in HSG C or D soils will require special soil mixes and underdrains.

	Stormwater Pond			Bioretention			Underground Treatment Devices			Underground Detention			Infiltration			Porous/Pervious/ Permeable Pavements			Tree or Planter Box		
Project Setting (See Question 2.4)	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undev-eloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undev-eloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undev-eloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undev-eloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undev-eloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undev-eloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undev-eloped Land
Special Site Considerations (See Question 2.5)																					
a. There are no special site considerations.	**N/A**	**REC**	**REC**	**N/A**	**REC**	**REC**	**REC**	**REC** – As pre-treatment	**MAYBE** – As pre-treatment	**REC**	**REC**	**REC**	**REC** – Under-ground	**REC**	**REC**	**REC**	**REC**	**MAYBE**	**REC**	**REC**	**MAYBE**
b. Soil/groundwater contamination ***Check design with MPCA.***	**N/A**	**MAYBE**	**MAYBE**	**N/A**	**REC** – May require liner depending on type of contamination.		**REC**	**REC**	**REC**	**REC** – May require liner or special precautions			**N/A** – In most circumstances, NOT RECOMMENDED depending on type of contamination.			**MAYBE** – In most circumstances, not recommended without a liner depending on type of contamination.			**REC**	**REC**	**REC**
c/d. Less than 3 feet to bedrock or seasonal high groundwater table	**N/A**	**MAYBE** – Potential construction issues due to shallow bedrock.		**N/A** – NOT RECOMMENDED Look at rainwater reuse if volume reduction is required.			**REC**	**REC**	**MAYBE**	**MAYBE** – Potential constructions issues.			**N/A** – NOT RECOMMENDED Look at rainwater reuse if volume reduction is required.			**MAYBE** – If adequate depth for aggregate base, use impermeable liner and perforated underdrains.			**MAYBE** – May need to keep isolated from groundwater or raise to achieve separation		
e. PSH runoff	**N/A**	**REC** – May require liner and excellent pre-treatment.		**N/A**	**MAYBE** – Use impermeable liner and underdrain.		**REC**	**REC**	**MAYBE**	**REC** – May require excellent pre-treatment and special precautions.			**N/A** – NOT RECOMMENDED.			**MAYBE** – Use impermeable liner and underdrain.			**MAYBE** – May need to keep isolated from groundwater.		
f. DWSMA, WHPZ, karst, or sensitive groundwater	**N/A**	**MAYBE** – May require liner to prevent interaction with groundwater. **NOT recommended in karst areas.**		**N/A**	**MAYBE** – Depending on land use, may require impermeable liner and underdrain.		**REC**	**REC**	**MAYBE**	**REC**	**REC**	**REC**	**MAYBE** – But NOT recommended if potential stormwater pollution sources are evident.			**MAYBE** – Use impermeable liner and underdrain.			**REC**	**REC**	**REC**
Drainage to Special or Impaired Water (See Question 3.5)	**N/A**	**MAYBE**	**MAYBE**	**N/A**	**REC** – With cautions for use related to PSHs.		**REC** – Use as pre-treatment upstream of another BMP.		**N/A**	**MAYBE** – As part of a treatment train If the receiving water is sensitive to increases in flow rates.			**REC** – Recommended unless target TMDL pollutant is a soluble nutrient or chloride			**MAYBE** – (recommended w/ conditions)			**REC** – With cautions for use related to PSHs.		

STEP 5 – REFINE BMP SELECTION/SELECT THE RIGHT "TOOL"

This step allows you to further refine the selection by comparing such factors as maintenance, life cycle costs and aesthetics.

In **Step 4,** you came up with a list of two or three BMPs that could be appropriate for your project. Use the following **Table 5**, to compare other factors for each of those BMPs that will help narrow the list further. **Highlight or circle the information as you go.**

In the tables, BMPs are ranked as follows:

Capital Costs – The average ranges are given relative to each other given identical areas being treated.

Maintenance Burden – The average cost includes more frequent, minor inspection/maintenance work as well as less frequent, major maintenance work such as dredging or system replacement.

Relative Life Expectancy – Life expectancies for the various BMPs are compared against each other, assuming that the design of each BMP was appropriate to their specific drainage areas.

TABLE 5 – Final BMP Screening [5], [6]

	BMP Category						
	BMPs Typically Used for General Applications					BMPs Typically Used for Specialized Applications	
	Stormwater Pond (e.g., ponds with permanent pools of water, such as NURP ponds, and multi-cell ponds)	**Bioretention** (e.g., rain gardens, bio-infiltration, bio-filtration, and bio-swales)	**Underground Treatment Devices** (e.g., proprietary hydrodynamic separators, sump catch basins and wet vaults)	**Underground Detention** (e.g., pipe galleries, concrete vaults, proprietary storage systems generally used for temporary detention of water and rate control)	**Infiltration** [e.g., surface practices that do not rely on vegetation (sand filter or rock trench) and underground systems (perforated pipe gallery)]	**Porous/Pervious/ Permeable Pavements** (e.g., porous asphalt, pervious concrete, permeable pavers, reinforced/amended soils)	**Tree or Planter Box** (e.g., tree pits, tree box filters, stormwater planters)
Capital Cost	Low [α]	Moderate [α]	High	Moderate to high	High	Moderate to high	Moderate
Maintenance Burden							
Ease of Maintenance (Mn Stm Man)	Easy to medium	Medium	Medium	Medium to difficult depending on access	Medium to difficult (depending on system used)	Medium	Easy to medium
Typical Annual Operations and Maintenance Costs	Low	Low	Medium to high	Low to medium	High	Medium to high Typical maintenance = regular sweeping with vacuum sweeper.	Low to medium
Typical Major Maintenance Costs	High	Medium to high	Medium to high	High	High	High	Medium [β]
Frequency of Major Maintenance	Low – Every 5 - 25 years	Medium to high – Every 1 - 5 years	Low	Low – Every 5 - 25 years	Medium – Every 3 - 5 years	Low to medium	Medium to high – Every 1 – 5 years [β]
Relative Life Expectancy	High	Medium	Medium	Medium to high	Medium	Lowest	Low to medium
Relative Life Cycle Cost	Low to moderate	Moderate	High	Moderate to high	High	Moderate to high	Moderate
Cost Effectiveness (2005 $/lb) [δ, 7]							
TSS Removal	$215	$150	Not available.	Typically not used for water quality treatment.	Not available.	$20 - $150	$155
TP Removal	$95,100	$52,300	Not available.	Typically not used for water quality treatment.	Not available.	$9,900 - $76,500	$54,200
Cost Effectiveness per Acre Treated (2005 $/acre)	$30,500	$25,900	Not available.	$52,300	Not available.	$3,300 - $25,200	$26,800
Other Factors							
Aesthetics	Can be designed as an amenity but success is dependent upon appropriate sizing of the pond for the drainage area. In highly visible areas, pre-treatment may be desired to remove trash prior to discharging to the pond.	Typically designed as part of the landscaping plan, but requires regular weeding/plant maintenance to maintain appearance.	Typically not visible	Typically not visible	Depending on the design, above-ground systems typically have low aesthetic appeal. Underground systems have no aesthetic impact.	Depending on system used, they can be seen as an amenity. Porous asphalt and pervious concrete applications may have low community acceptance initially.	Typically designed as part of the landscaping plan, but requires regular weeding/plant maintenance to maintain appearance.
Nuisance Factors	Moderate to high potential for mosquitoes or other nuisance insects, geese, floatables and odors.	Moderate potential for mosquitoes or other nuisance insects and overgrown vegetation.	Moderate potential for mosquitoes and odors. Potential to skip maintenance since "out of sight – out of mind." Access manholes frequently under pavement or within streets.	Typically dry, but some potential for mosquitoes and odors. Access manholes frequently under pavement or within streets.	Pre-treatment cells may be prone to odors and facilitate to mosquito/insect breeding. Susceptible to failure if poorly installed/maintained. Underground practices not seen/not maintained.	Heaving/settling of individual pavers. Some systems may not meet "Wheels and Heels" criteria.	Potential for overgrown vegetation.
Safety Concerns	A safety bench is strongly recommended, but may still pose safety concern for drowning. Berms that function as dams have a potential to fail.	Typically do not pose any safety concerns.	Confined spaces may pose hazard to maintenance crews.	Confined spaces may pose hazard to maintenance crews.	Typically do not pose any safety concerns.	May increase traction in wet weather events due to larger aggregate size.	Typically do not pose any safety concerns.
Spill Containment	Can provide a high degree of protection if outlet designed to provide skimming.	Minimal protection for bio-infiltration without upstream spill containment manhole. Moderate to high protection for bio-filtration if outlet for underdrains can be blocked.	Typically designed to provide spill containment.	Can provide a high degree of spill containment by blocking system outlet.	Minimal protection without upstream spill containment manhole.	Minimal protection for infiltration without upstream spill containment manhole. Moderate to high protection for filtration if outlet for underdrains can be blocked.	N/A for systems providing treatment for rooftops. Minimal protection for systems providing treatment for pavement.

See table notes on the following page.

Notes for Table 5:

[α] Does not include the cost to acquire land if the BMP is not located in a remnant parcel or outlot.

[β] Major maintenance work is dependent on the system and its intended use. For instance, if the tree box filter treats only its immediate surroundings, once the tree canopy develops, rainfall is intercepted prior to reaching the ground. In this case, the owner may decide to reduce major maintenance tasks. However, if the BMP is designed for infiltration and evapotranspiration of runoff from a larger area, major maintenance tasks must be performed in order for the BMP to continue providing treatment for this area.

[δ] For consistency, the cost effectiveness for each BMP category was determined using the present value of whole life costs using the WERF whole life costs spreadsheet tools (published 2005) as determined for a 10-acre residential watershed with ¼-acre lots (38% impervious) in HSG B soils. The annual TSS and TP loadings were determined using P8, and the removal efficiency of each BMP was assumed to be the average the range given in Tables 3.A through 3.D. Each BMP was assumed to have a "Medium" level of maintenance for consistency; the WERF spreadsheet tool has costs associated with Low, Medium and High levels of maintenance, which vary for each BMP category. The square footage of the porous/pervious/permeable pavements was assumed to be 10% of the impervious surface, and the capital costs were assumed to be "High" in order to compensate for deeper aggregate sections that may be typically used in cold weather climates.

Annual TSS Loading = 1894.3 pounds
Annual TP Loading = 6.0 pounds

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[1] Minnesota Pollution Control Agency, Minnesota Stormwater Manual, Version 2, 2005. The Minnesota Stormwater Manual provided the majority of the information in the table unless noted.

[2] New Hampshire Stormwater Manual, Vol. 2, Revision: 1.0, Appendix B BMP Pollutant Removal Efficiency, 2008.

[3] Virginia Stormwater Management Program, Technical Bulletin #6: Minimum Standard 3.11C Filterra Bioretention Filter System, revised November, 1, 2002.

[4] New Hampshire Stormwater Manual, Vol. 2, Revision: 1.0, Appendix B BMP Pollutant Removal Efficiency, 2008.

High-load areas are defined as:

1. Any land use or activity in which regulated substances are exposed to rainfall or runoff, with the exception of road salt applied for deicing of pavement on the site;
2. Any land use or activity that typically generates higher concentrations of hydrocarbons, metals or suspended solids than are found in typical stormwater runoff, including but not limited to:
   - Industrial facilities subject to the NPDES/SDS Industrial Stormwater Multi-Sector General Permit, not including areas where industrial activities do not occur, such as at office buildings and their associated parking facilities or in drainage areas at the facility where a certification of no exposure pursuant to 40 CFR §122.26(g) will always be possible;
   - Petroleum storage facilities;
   - Petroleum dispensing facilities;
   - Vehicle fueling facilities;
   - Vehicle service, maintenance and equipment cleaning facilities;
   - Fleet storage areas;
   - Public works storage areas;
   - Road salt facilities;
   - Commercial nurseries;
   - Non-residential facilities with uncoated metal roofs with a slope flatter than 20%;
   - Facilities with outdoor storage, loading, or unloading of hazardous substances, regardless of the primary use of the facility; and
   - Facilities subject to chemical inventory under Section 312 of the Superfund Amendments and Reauthorization Act of 1986 (SARA).

[5] Iowa Stormwater Management Manual, version 2, December 5, 2008.

[6] Minnesota Pollution Control Agency, Minnesota Stormwater Manual, Version 2, 2005.

[7] Water Environmental Research Foundation (WERF), Performance and Whole Life Costs of Best Management Practices and Sustainable Urban Drainage Systems, Vol.2, 2005.

STEP 2 - DESCRIBE YOUR PROJECT
This will help determine which permits and types of BMPs are required and will work effectively for your project.

2.1 Where is the project?

Address/location _____

City/Township _____

County _____

2.2 What lake, river, or stream does it ultimately drain to?

Use USGS quadrangle maps, other types of contour/topographic maps, or the MPCA interactive map tool at
http://pca-gis02.pca.state.mn.us/website/stormwater/csw/viewer.htm

Fill in name or names of the receiving waters.

_____

_____

_____

2.3 What types of soils exist throughout the project area, and in particular at the location(s) of the potential BMPs? Check A, B, C, D, or combinations of.
Use soil boring data if available. Otherwise use County soil surveys, found at:

- http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx (interactive)
- http://soils.usda.gov/survey/online_surveys/minnesota/ (similar to the standard paper copies)

Check all that apply:

Standard hydrologic soil groups (HSG) are:

A. HSG A = sandy soils having low runoff potential with high infiltration rates even when thoroughly wetted. These consist primarily of deep, well to excessively drained sands and/or gravel. ☐

B. HSG B = soils having moderate infiltration rates even when thoroughly wetted, consisting chiefly of moderately deep to deep soils that have moderately fine to moderately coarse textures. These are moderately well to well drained soils. ☐

C. HSG C = soils having slow infiltration rates when thoroughly wetted. These consist primarily of soils with a layer that impedes the downward movement of water, or soils with moderately fine to fine texture and a slow infiltration rate and are somewhat clay-like in nature. ☐

D. HSG D = soils having high runoff potential with very slow infiltration rates when thoroughly wetted. These consist chiefly of clay soils with high swelling potential; soils with a high permanent water table; soils with claypan or clay layer at or near the surface; and shallow soils over nearly impervious materials. ☐

2.4 Does the project fall within a setting likely characterized as: Check one:

a. Central Business District? ☐

b. Residential, suburban, low-density commercial or campus settings? ☐

c. Rural/ undeveloped? ☐

2.5 Are there special site considerations that could affect the BMP selection?	
a. There are no special site considerations, such as those listed in 2.5.b through 2.5.f.	Yes / No
b. Is there soil or groundwater contamination?	Yes / No
c. What is the depth to bedrock? There must be at least 3 feet of separation from the bedrock elevation to the bottom of any infiltration practice.	_____
d. What is the seasonal high groundwater elevation in the vicinity of the potential BMPs? There must be at least 3 feet of separation from the seasonal high groundwater elevation to the bottom of any infiltration practice.	_____
e. Will the BMP receive runoff from a potential stormwater hotspot (PSH)? PSHs are defined as commercial, industrial, institutional, municipal, or transportation-related operations that produce higher levels of stormwater pollutants, and/ or present a higher potential risk for spills, leaks or illicit discharges. Runoff from these operations may contain soluble pollutants which cannot be effectively removed by current BMPs and can contaminate ground water quality.	Yes / No
f. Does the project fall within a drinking water supply management area (DWSMA), wellhead protection zone (WHPZ), region of karst landforms/aquifers, or region of medium to high groundwater sensitivity? Municipal comprehensive plans typically include the DWSMA boundaries for their municipal wells. A map of Minnesota's DWSMA boundaries with vulnerability ratings can be found at http://www.health.state.mn.us/divs/eh/water/swp/maps/gis/dwsvul.pdf WHPZ boundaries can be found on the County Well Index interactive web tool at http://www.health.state.mn.us/divs/eh/cwi/ Information on Minnesota's karst region can be found at http://www.pca.state.mn.us/water/groundwater/karst.html	Yes / No
• Using the information from **Questions 2.1 through 2.2, go to Step 3** to determine which regulatory agencies have permitting and/or review authority over your project. • You will use information from **Questions 2.3 through 2.5 in Step 4**, which creates the BMP toolbox specific to the project.	

STEP 3 – DETERMINE THE REGULATORY ENVIRONMENT FOR YOUR PROJECT

A variety of state, local, and federal agencies regulate projects that may impact Minnesota's water resources. In many cases, a permit is required from one or more of these agencies before proceeding with the project. This step starts at the broadest level, with the agency that has jurisdiction over most projects that occur within the state. The focus is then narrowed down to the local governmental units. The intent is to determine the most stringent stormwater criteria that affect your project, which will then help determine which BMPs can meet those requirements.

3.1 Does your project require a National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) General Stormwater Permit for Construction Activity from the Minnesota Pollution Control Agency (MPCA) and/or a Stormwater Pollution Prevention Plan? *(Answer questions a-c to determine.)*

- The MPCA has jurisdiction through the NPDES/SDS permit for projects over 1 acre in size or part of a larger common plan of development if less than 1 acre in size.
- **The NPDES/SDS requirements will typically set the minimum stormwater criteria for all projects within the state. Other agencies may require higher levels of treatment.**
- For information on the NPDES/SDS permit, application form and other information, go to http://www.pca.state.mn.us/index.php/water/water-types-and-programs/stormwater/construction-stormwater/construction-stormwater.html

NPDES Permit:

a. Will the project disturb one or more acres of land?
This includes clearing, grading and excavation, but does not include routine maintenance that is performed to maintain the original line and grade, hydraulic capacity or original purpose of the facility. (*MPCA*)

NPDES Permit Required

If **Yes**, a NPDES/SDS permit is required. **Check box; then go to Question 3.1.c.** ☐

b. If No, is the project part of a larger common plan of development?
A common plan of development or sale means a contiguous area where multiple separate and distinct land disturbing activities may be taking place at different times, on different schedules, but under one proposed plan. (*MPCA*)

If **Yes**, a NPDES/SDS permit is required. **Check box; then go to Question 3.1.c.**
If **No**, a NPDES/SDS permit is **not** required. **Go to Question 3.2.** ☐

Stormwater Pollution Prevent Plan (SWPPP):

c. Will the amount of impervious surface increase over that of the existing condition as a result of the project?

Yes / No

If **Yes**, the following components of the SWPPP are required as part of the NPDES/SDS permit as described in Parts III, IV and Appendix A of the permit. See the permit for design criteria. **(Check boxes.)**

SWPPP Components Required

Temporary Sediment Basins (Part III.B)	☐
Permanent Stormwater Management System (Part III.C)	☐
Construction Activity Requirements (Part IV)	☐

If **No**, the following components of the SWPPP are required as part of the NPDES/SDS permit as described in Parts III, IV and Appendix A of the permit. See the permit for design criteria. **(Check boxes.)** Temporary Sediment Basins (Part III.B) Construction Activity Requirements (Part IV)	SWPPP Components Required ☐ ☐

3.2 Does the county, city, or township have requirements that are MORE STRINGENT than the NPDES permit? *(Answer questions a-e in the table below to determine.)*

- For a listing of potential agencies and their contact information, go to http://www.dnr.state.mn.us/permits/water/water_permit_contacts.html
- Many counties have a Soil and Water Conservation District (SWCD) that can provide recommendations and technical information. For links to the various county SWCDs, go to http://www.maswcd.org/SWCDs_On_The_Web/swcds_on_the_web.htm

Contact each of the potential agencies listed and fill in their criteria for the following questions in the table below:

	County	City	Township
a. Is rate control required (y/n)?			
b. Is volume control (y/n) required?			
c. Is water quality treatment (y/n) required? If yes, what is the specified % removal required for:			
Total suspended solids (TSS):			
Total phosphorus (TP):			
d. Do the BMPs need to provide for downstream channel protection (y/n)? See definition below.			
e. Does the project need to meet an antidegradation (nondegradation) requirement to comply with a MS4 permit (y/n)? See below.			

- The purpose of channel protection criteria is to prevent habitat degradation and erosion in urban streams caused by an increased frequency of bankfull and sub-bankfull stormwater flows and to minimize downstream channel enlargement and incision that is a common consequence of urbanization.
- For information on what a MS4 permit is, see: http://www.pca.state.mn.us/water/water-types-and-programs/stormwater/municipal-stormwater/municipal-separate-storm-sewer-systems-ms4.html#whatis

  For an interactive map of MS4 entities within the state, visit: http://pca-gis02.pca.state.mn.us/website/stormwater/ms4_smt/viewer.htm

3.3 Does your project fall within a watershed district or watershed management organization with permitting authority or that will need to review and approve the project? *(Answer questions a-e in the table below to determine)*

- **Watershed district and watershed management organizations typically have the MOST STRINGENT requirements for stormwater management.**
- For a listing of potential agencies and their contact information, go to http://www.dnr.state.mn.us/permits/water/water_permit_contacts.html

Fill in the name(s) of the watershed agencies:

1. _____
2. _____
3. _____
4. _____

Contact each of the potential agencies listed and fill in their criteria for the following questions in the table below:

	Watershed Agency 1	Watershed Agency 2	Watershed Agency 3	Watershed Agency 4
a. Is rate control required (y/n)?				
b. Is volume control (y/n) required?				
c. Is water quality treatment (y/n) required? If yes, what is the specified % removal required for:				
Total suspended solids (TSS):				
Total phosphorus (TP):				
d. Do the BMPs need to provide for downstream channel protection (y/n)? See definition with 2.2.				
e. Does the project need to meet an antidegradation (nondegradation) requirement to comply with a MS4 permit (y/n)? See information with 2.2.				

3.4 Based upon the answers to Questions 3.2 through 3.3, check the box to the right if you answered "yes" to any of the questions for any agency. For % removal of TSS and TP, list the MOST STRINGENT (highest) value of all agencies reviewed:

Check all that apply:

Rate control: ☐
Volume control: ☐
Water quality treatment: ☐
% TSS removal required: _____
% TP removal required: _____
Channel protection: ☐
Nondegradation: ☐

3.5 Does the project drain to a special or impaired water as defined by the MPCA? Check http://pca-gis02.pca.state.mn.us/website/stormwater/csw/viewer.htm

Yes / No

Using this information, go to **Step 4** to start creating a BMP toolbox specific to your project.

STEP 4 – CREATE A PRELIMINARY BMP TOOLBOX

This step allows you to compare the BMPs included in the Stormwater Maintenance BMP Resource Guide and narrow the list of potential BMPs to two or three. You can further refine the list by completing Step 5 which covers maintenance and costs.

You will first start by determining which BMPs are most able to provide the type of treatment needed to meet permitting or other requirements (such as a Total Maximum Daily Load (TMDL), Environmental Assessment, Environmental Impact Statement, or approved requirement) . **Highlight or circle the information as you go.** In some cases, you may reach the end of this step and realize that due to site constraints or special considerations you are not able to meet all of the regulatory requirements. For example, a roadway project may fall within a watershed district that requires volume reduction, but the depth to groundwater or bedrock may be insufficient to allow construction of infiltration or bioretention practices. Make a note that additional coordination with the regulatory agencies may be needed to determine if specific requirements can be waived or met in another manner.

In the following tables, BMPs are ranked as follows:

REC = Recommended for this application

MAYBE = May be useful for this application with conditions or provides specified treatment to a lesser degree

N/A = Not recommended for this application or does not provide specified treatment

Using the two or three BMPs that result from your work with the appropriate Step 4 table for your project, go to **Step 5** to further refine the list using maintenance, life cycle costs, and aesthetics factors.

TABLE 4 – PRELIMINARY BMP TOOLBOX FOR **SITE** PROJECTS WITH **HIGHER PERCENTAGE OF AVAILABLE SPACE**[1]

	BMP Category						
	Stormwater Pond (e.g., ponds with permanent pools of water, such as NURP ponds, and multi-cell ponds)	**Bioretention** (e.g., rain gardens, bio-infiltration, bio-filtration, and bio-swales)	**Underground Treatment Devices** (e.g., proprietary hydrodynamic separators, sump catch basins and wet vaults)	**Underground Detention** (e.g., pipe galleries, concrete vaults, proprietary storage systems generally used for temporary detention of water and rate control)	**Infiltration** [e.g., surface practices that do not rely on vegetation (sand filter) and underground systems (perforated pipe gallery)]	**Porous/Pervious/ Permeable Pavements** (e.g., porous asphalt, pervious concrete, permeable pavers, reinforced/amended soils)	**Tree or Planter Box** (e.g., tree pits, tree box filters, stormwater planters)
Primary Treatment Provided (See Question 3.4)							
a. Rate Control	**REC**	**N/A**	**N/A**	**REC**	**MAYBE**	**REC**	**N/A**
b. Volume Control	**N/A**	**REC**	**N/A**	**N/A**	**REC**	**REC**	**MAYBE**
c. Water Quality	**REC**	**REC**	**MAYBE**	**N/A**	**REC**	**MAYBE**	**MAYBE**
TSS Removal Required (%)	60-90%	85-100%	35%	0-20%	100%	90%[2]	85-100%[3]
TP Removal Required (%)	34-73%	65-100%	0%	0%	100%	45-65%	65-100%
d. Channel Protection	**REC**	**MAYBE**	**N/A**	**REC**	**MAYBE**	**MAYBE**	**MAYBE**
e. Nondegredation requirement	**MAYBE**	**REC**	**N/A**	**N/A**	**REC**	**MAYBE**	**MAYBE**
Comments	- Removal efficiencies depend on the type of pond. - Wet extended detention basins are the only type of pond complying with the NPDES Permit.	- Higher removal efficiencies are when designed as bio-infiltration basins. - Very sensitive to construction techniques and good plant establishment.	- Use mainly as pre-treatment (not allowed as sole treatment device in many instances).	- Typically, only used for rate control.	- Pre-treatment is required. - Very sensitive to construction techniques.	- Higher removal efficiencies are when practice is designed for infiltration. - Very sensitive to construction techniques.	- Avoid use to treat runoff from high-load areas.[4] - Removal efficiencies are not yet well documented. - Higher removal efficiencies are when designed for infiltration.
Soil Type Considerations (See Question 2.3)	Best suited for **HSG B, C or D** soils. Line ponds in HSG A & some HSG B soils to maintain a permanent pool of water.	Best suited for **HSG A and B** soils. Use in HSG C or D soils will require special soil mixes and underdrains.	No restrictions based on hydrologic soil group.	No restrictions based on hydrologic soil group.	Best suited for **HSG A and B** soils. NOT recommended for use in HSG C or D soils. Check setback distance recommendations for building foundations and other items.	Best suited for **HSG A and B** soils. Use in HSG C or HSG D soils will require perforated underdrains.	Best suited for **HSG A and B** soils. Use in HSG C or D soils will require special soil mixes and underdrains.

	Stormwater Pond			Bioretention			Underground Treatment Devices			Underground Detention			Infiltration			Porous/Pervious/ Permeable Pavements			Tree or Planter Box		
Project Setting (See Question 2.4)	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undeveloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undeveloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undeveloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undeveloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undeveloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undeveloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undeveloped Land
Special Site Considerations (See Question 2.5)																					
a. There are no special site considerations.	**N/A**	**REC**	**REC**	**MAYBE** – Pocket rain garden	**REC**	**REC**	**REC**	**MAYBE** – As pre-treatment only	**MAYBE** – As pre-treatment only	**REC**	**MAYBE**	**N/A**	**REC** – Under-ground	**REC**	**REC** – Surface	**REC**	**REC**	**MAYBE**	**REC**	**REC**	**N/A**
b. Soil/groundwater contamination ***Check design with MPCA.***	**N/A**	**REC**	**REC**	**MAYBE** – Above option w/ liner	**REC** – May require liner depending on type of contamination.		**REC**	**MAYBE**	**N/A**	**REC** – May require liner, other	**MAYBE** – May require liner or special precautions		**N/A** – In most circumstances, NOT recommended depending on type of contamination.			**MAYBE** – In most circumstances, not recommended without a liner depending on type of contamination.			**REC** – With liner	**REC**	**REC**
c/d. Less than 3 feet to bedrock or seasonal high groundwater table	**N/A**	**MAYBE** – Potential construction issues.		**N/A** – NOT RECOMMENDED Look at rainwater reuse if volume reduction is required.			**REC**	**MAYBE**	**N/A**	**MAYBE** – Potential constructions issues.			**N/A** – NOT RECOMMENDED Look at rainwater reuse if volume reduction is required.			**MAYBE** – If adequate depth for aggregate base, use impermeable liner and perforated underdrains.			**MAYBE** – May need to keep isolated from groundwater or raise to achieve separation		
e. PSH runoff	**N/A**	**REC** – May require liner and excellent pre-treatment.		**MAYBE** – Above option w/ liner	**MAYBE** – Use impermeable liner and underdrain.		**REC**	**MAYBE**	**N/A**	**MAYBE** – May require excellent pre-treatment and special precautions.			**N/A** – NOT RECOMMENDED.			**MAYBE** – Use impermeable liner and underdrain.			**MAYBE** – May need to keep isolated from groundwater.		
f. DWSMA, WHPZ, karst, or sensitive groundwater	**N/A**	**REC** – May require liner to prevent interaction with groundwater. **NOT recommended in karst areas.**		**MAYBE** – Above option w/ liner	**MAYBE** – Depending on land use, may require impermeable liner and underdrain.		**REC**	**MAYBE**	**N/A**	**MAYBE**	**MAYBE**	**MAYBE**	**REC** – But NOT recommended if potential stormwater pollution sources are evident.			**MAYBE** – Use impermeable liner and underdrain.			**REC** – May require liner	**REC**	**REC**
Drainage to Special or Impaired Water (See Question 3.5)	**N/A**	**MAYBE**	**MAYBE**	**MAYBE** – Above option	**REC** – With cautions for use related to PSHs.		**N/A**	**N/A**	**N/A**	**MAYBE** – As part of a treatment train If the receiving water is sensitive to increases in flow rates.			**REC** – Recommended unless target TMDL pollutant is a soluble nutrient or chloride.			**MAYBE** – (recommended w/ conditions)			**REC** – With cautions for use related to PSHs.		

STEP 5 – REFINE BMP SELECTION/SELECT THE RIGHT "TOOL"

This step allows you to further refine the selection by comparing such factors as maintenance, life cycle costs and aesthetics.

In **Step 4,** you came up with a list of two or three BMPs that could be appropriate for your project. Use the following **Table 5**, to compare other factors for each of those BMPs that will help narrow the list further. **Highlight or circle the information as you go.**

In the tables, BMPs are ranked as follows:

Capital Costs – The average ranges are given relative to each other given identical areas being treated.

Maintenance Burden – The average cost includes more frequent, minor inspection/maintenance work as well as less frequent, major maintenance work such as dredging or system replacement.

Relative Life Expectancy – Life expectancies for the various BMPs are compared against each other, assuming that the design of each BMP was appropriate to their specific drainage areas.

TABLE 5 – Final BMP Screening [5], [6]

	BMP Category						
	BMPs Typically Used for General Applications					BMPs Typically Used for Specialized Applications	
	Stormwater Pond (e.g., ponds with permanent pools of water, such as NURP ponds, and multi-cell ponds)	**Bioretention** (e.g., rain gardens, bio-infiltration, bio-filtration, and bio-swales)	**Underground Treatment Devices** (e.g., proprietary hydrodynamic separators, sump catch basins and wet vaults)	**Underground Detention** (e.g., pipe galleries, concrete vaults, proprietary storage systems generally used for temporary detention of water and rate control)	**Infiltration** [e.g., surface practices that do not rely on vegetation (sand filter or rock trench) and underground systems (perforated pipe gallery)]	**Porous/Pervious/ Permeable Pavements** (e.g., porous asphalt, pervious concrete, permeable pavers, reinforced/amended soils)	**Tree or Planter Box** (e.g., tree pits, tree box filters, stormwater planters)
Capital Cost	Low [α]	Moderate [α]	High	Moderate to high	High	Moderate to high	Moderate
Maintenance Burden							
Ease of Mainten-ance (Mn Stm Man)	Easy to medium	Medium	Medium	Medium to difficult depending on access	Medium to difficult (depending on system used)	Medium	Easy to medium
Typical Annual Operations and Maintenance Costs	Low	Low	Medium to high	Low to medium	High	Medium to high Typical maintenance = regular sweeping with vacuum sweeper.	Low to medium
Typical Major Maintenance Costs	High	Medium to high	Medium to high	High	High	High	Medium [β]
Frequency of Major Maintenance	Low – Every 5 - 25 years	Medium to high – Every 1 - 5 years	Low	Low – Every 5 - 25 years	Medium – Every 3 - 5 years	Low to medium	Medium to high – Every 1 – 5 years [β]
Relative Life Expectancy	High	Medium	Medium	Medium to high	Medium	Lowest	Low to medium
Relative Life Cycle Cost	Low to moderate	Moderate	High	Moderate to high	High	Moderate to high	Moderate
Cost Effectiveness (2005 $/lb) [δ, 7]							
TSS Removal	$215	$150	Not available.	Typically not used for water quality treatment.	Not available.	$20 - $150	$155
TP Removal	$95,100	$52,300	Not available.	Typically not used for water quality treatment.	Not available.	$9,900 - $76,500	$54,200
Cost Effectiveness per Acre Treated (2005 $/acre)	$30,500	$25,900	Not available.	$52,300	Not available.	$3,300 - $25,200	$26,800
Other Factors							
Aesthetics	Can be designed as an amenity but success is dependent upon appropriate sizing of the pond for the drainage area. In highly visible areas, pre-treatment may be desired to remove trash prior to discharging to the pond.	Typically designed as part of the landscaping plan, but requires regular weeding/plant maintenance to maintain appearance.	Typically not visible	Typically not visible	Depending on the design, above-ground systems typically have low aesthetic appeal. Underground systems have no aesthetic impact.	Depending on system used, they can be seen as an amenity. Porous asphalt and pervious concrete applications may have low community acceptance initially.	Typically designed as part of the landscaping plan, but requires regular weeding/plant maintenance to maintain appearance.
Nuisance Factors	Moderate to high potential for mosquitoes or other nuisance insects, geese, floatables and odors.	Moderate potential for mosquitoes or other nuisance insects and overgrown vegetation.	Moderate potential for mosquitoes and odors. Potential to skip maintenance since "out of sight – out of mind." Access manholes frequently under pavement or within streets.	Typically dry, but some potential for mosquitoes and odors. Access manholes frequently under pavement or within streets.	Pre-treatment cells may be prone to odors and facilitate to mosquito/insect breeding. Susceptible to failure if poorly installed/maintained. Underground practices not seen/not maintained.	Heaving/settling of individual pavers. Some systems may not meet "Wheels and Heels" criteria.	Potential for overgrown vegetation.
Safety Concerns	A safety bench is strongly recommended, but may still pose safety concern for drowning. Berms that function as dams have a potential to fail.	Typically do not pose any safety concerns.	Confined spaces may pose hazard to maintenance crews.	Confined spaces may pose hazard to maintenance crews.	Typically do not pose any safety concerns.	May increase traction in wet weather events due to larger aggregate size.	Typically do not pose any safety concerns.
Spill Containment	Can provide a high degree of protection if outlet designed to provide skimming.	Minimal protection for bio-infiltration without upstream spill containment manhole. Moderate to high protection for bio-filtration if outlet for underdrains can be blocked.	Typically designed to provide spill containment.	Can provide a high degree of spill containment by blocking system outlet.	Minimal protection without upstream spill containment manhole.	Minimal protection for infiltration without upstream spill containment manhole. Moderate to high protection for filtration if outlet for underdrains can be blocked.	N/A for systems providing treatment for rooftops. Minimal protection for systems providing treatment for pavement.

See table notes on the following page.

Notes for Table 5:

[α] Does not include the cost to acquire land if the BMP is not located in a remnant parcel or outlot.

[β] Major maintenance work is dependent on the system and its intended use. For instance, if the tree box filter treats only its immediate surroundings, once the tree canopy develops, rainfall is intercepted prior to reaching the ground. In this case, the owner may decide to reduce major maintenance tasks. However, if the BMP is designed for infiltration and evapotranspiration of runoff from a larger area, major maintenance tasks must be performed in order for the BMP to continue providing treatment for this area.

[δ] For consistency, the cost effectiveness for each BMP category was determined using the present value of whole life costs using the WERF whole life costs spreadsheet tools (published 2005) as determined for a 10-acre residential watershed with ¼-acre lots (38% impervious) in HSG B soils. The annual TSS and TP loadings were determined using P8, and the removal efficiency of each BMP was assumed to be the average the range given in Tables 3.A through 3.D. Each BMP was assumed to have a "Medium" level of maintenance for consistency; the WERF spreadsheet tool has costs associated with Low, Medium and High levels of maintenance, which vary for each BMP category. The square footage of the porous/pervious/permeable pavements was assumed to be 10% of the impervious surface, and the capital costs were assumed to be "High" in order to compensate for deeper aggregate sections that may be typically used in cold weather climates.

Annual TSS Loading = 1894.3 pounds
Annual TP Loading = 6.0 pounds

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[1] Minnesota Pollution Control Agency, Minnesota Stormwater Manual, Version 2, 2005. The Minnesota Stormwater Manual provided the majority of the information unless noted.

[2] New Hampshire Stormwater Manual, Vol. 2, Revision: 1.0, Appendix B BMP Pollutant Removal Efficiency, 2008.

[3] Virginia Stormwater Management Program, Technical Bulletin #6: Minimum Standard 3.11C Filterra Bioretention Filter System, revised November, 1, 2002.

[4] New Hampshire Stormwater Manual, Vol. 2, Revision: 1.0, Appendix B BMP Pollutant Removal Efficiency, 2008.

High-load areas are defined as:

1. Any land use or activity in which regulated substances are exposed to rainfall or runoff, with the exception of road salt applied for deicing of pavement on the site;
2. Any land use or activity that typically generates higher concentrations of hydrocarbons, metals or suspended solids than are found in typical stormwater runoff, including but not limited to:
   - Industrial facilities subject to the NPDES/SDS Industrial Stormwater Multi-Sector General Permit, not including areas where industrial activities do not occur, such as at office buildings and their associated parking facilities or in drainage areas at the facility where a certification of no exposure pursuant to 40 CFR §122.26(g) will always be possible;
   - Petroleum storage facilities;
   - Petroleum dispensing facilities;
   - Vehicle fueling facilities;
   - Vehicle service, maintenance and equipment cleaning facilities;
   - Fleet storage areas;
   - Public works storage areas;
   - Road salt facilities;
   - Commercial nurseries;
   - Non-residential facilities with uncoated metal roofs with a slope flatter than 20%;
   - Facilities with outdoor storage, loading, or unloading of hazardous substances, regardless of the primary use of the facility; and
   - Facilities subject to chemical inventory under Section 312 of the Superfund Amendments and Reauthorization Act of 1986 (SARA).

[5] Iowa Stormwater Management Manual, version 2, December 5, 2008.

[6] Minnesota Pollution Control Agency, Minnesota Stormwater Manual, Version 2, 2005.

[7] Water Environmental Research Foundation (WERF), Performance and Whole Life Costs of Best Management Practices and Sustainable Urban Drainage Systems, Vol.2, 2005.

STEP 2 - DESCRIBE YOUR PROJECT
This will help determine which permits and types of BMPs are required and will work effectively for your project.

2.1 Where is the project?

Address/location _____

City/Township _____

County _____

2.2 What lake, river, or stream does it ultimately drain to?

Use USGS quadrangle maps, other types of contour/topographic maps, or the MPCA interactive map tool at
http://pca-gis02.pca.state.mn.us/website/stormwater/csw/viewer.htm

Fill in name or names of the receiving waters.

_____

_____

_____

2.3 What types of soils exist throughout the project area, and in particular at the location(s) of the potential BMPs? Check A, B, C, D, or combinations of.

Use soil boring data if available. Otherwise use County soil surveys, found at:

- http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx (interactive)
- http://soils.usda.gov/survey/online_surveys/minnesota/ (similar to the standard paper copies)

Check all that apply:

Standard hydrologic soil groups (HSG) are:

A. HSG A = sandy soils having low runoff potential with high infiltration rates even when thoroughly wetted. These consist primarily of deep, well to excessively drained sands and/or gravel. ☐

B. HSG B = soils having moderate infiltration rates even when thoroughly wetted, consisting chiefly of moderately deep to deep soils that have moderately fine to moderately coarse textures. These are moderately well to well drained soils. ☐

C. HSG C = soils having slow infiltration rates when thoroughly wetted. These consist primarily of soils with a layer that impedes the downward movement of water, or soils with moderately fine to fine texture and a slow infiltration rate and are somewhat clay-like in nature. ☐

D. HSG D = soils having high runoff potential with very slow infiltration rates when thoroughly wetted. These consist chiefly of clay soils with high swelling potential; soils with a high permanent water table; soils with claypan or clay layer at or near the surface; and shallow soils over nearly impervious materials. ☐

2.4 Does the project fall within a setting likely characterized as:

Check one:

a. Central Business District? ☐

b. Residential, suburban, low-density commercial or campus settings? ☐

c. Rural/ undeveloped? ☐

2.5 Are there special site considerations that could affect the BMP selection? **a. There are no special site considerations, such as those listed in 2.5.b through 2.5.f.** **b. Is there soil or groundwater contamination?** **c. What is the depth to bedrock?** There must be at least 3 feet of separation from the bedrock elevation to the bottom of any infiltration practice. **d. What is the seasonal high groundwater elevation in the vicinity of the potential BMPs?** There must be at least 3 feet of separation from the seasonal high groundwater elevation to the bottom of any infiltration practice. **e. Will the BMP receive runoff from a potential stormwater hotspot (PSH)?** PSHs are defined as commercial, industrial, institutional, municipal, or transportation-related operations that produce higher levels of stormwater pollutants, and/ or present a higher potential risk for spills, leaks or illicit discharges. Runoff from these operations may contain soluble pollutants which cannot be effectively removed by current BMPs and can contaminate ground water quality. **f. Does the project fall within a drinking water supply management area (DWSMA), wellhead protection zone (WHPZ), region of karst landforms/aquifers, or region of medium to high groundwater sensitivity?** Municipal comprehensive plans typically include the DWSMA boundaries for their municipal wells. A map of Minnesota's DWSMA boundaries with vulnerability ratings can be found at http://www.health.state.mn.us/divs/eh/water/swp/maps/gis/dwsvul.pdf WHPZ boundaries can be found on the County Well Index interactive web tool at http://www.health.state.mn.us/divs/eh/cwi/ Information on Minnesota's karst region can be found at http://www.pca.state.mn.us/water/groundwater/karst.html	Yes / No Yes / No _____ _____ Yes / No Yes / No
• Using the information from **Questions 2.1 through 2.2, go to Step 3** to determine which regulatory agencies have permitting and/or review authority over your project. • You will use information from **Questions 2.3 through 2.5 in Step 4**, which creates the BMP toolbox specific to the project.	

STEP 3 – DETERMINE THE REGULATORY ENVIRONMENT FOR YOUR PROJECT

A variety of state, local, and federal agencies regulate projects that may impact Minnesota's water resources. In many cases, a permit is required from one or more of these agencies before proceeding with the project. This step starts at the broadest level, with the agency that has jurisdiction over most projects that occur within the state. The focus is then narrowed down to the local governmental units. The intent is to determine the most stringent stormwater criteria that affect your project, which will then help determine which BMPs can meet those requirements.

3.1 Does your project require a National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) General Stormwater Permit for Construction Activity from the Minnesota Pollution Control Agency (MPCA) and/or a Stormwater Pollution Prevention Plan? *(Answer questions a-c to determine.)*

- The MPCA has jurisdiction through the NPDES/SDS permit for projects over 1 acre in size or part of a larger common plan of development if less than 1 acre in size.
- **The NPDES/SDS requirements will typically set the minimum stormwater criteria for all projects within the state. Other agencies may require higher levels of treatment.**
- For information on the NPDES/SDS permit, application form and other information, go to http://www.pca.state.mn.us/index.php/water/water-types-and-programs/stormwater/construction-stormwater/construction-stormwater.html

	NPDES Permit Required
NPDES Permit:	
a. Will the project disturb one or more acres of land? This includes clearing, grading and excavation, but does not include routine maintenance that is performed to maintain the original line and grade, hydraulic capacity or original purpose of the facility. (*MPCA*)	
If **Yes**, a NPDES/SDS permit is required. **Check box; then go to Question 3.1.c.**	☐
b. If No, is the project part of a larger common plan of development? A common plan of development or sale means a contiguous area where multiple separate and distinct land disturbing activities may be taking place at different times, on different schedules, but under one proposed plan. (*MPCA*)	
If **Yes**, a NPDES/SDS permit is required. **Check box; then go to Question 3.1.c.** If **No**, a NPDES/SDS permit is **not** required. **Go to Question 3.2.**	☐

	Yes / No
Stormwater Pollution Prevent Plan (SWPPP):	
c. Will the amount of impervious surface increase over that of the existing condition as a result of the project?	
If **Yes**, the following components of the SWPPP are required as part of the NPDES/SDS permit as described in Parts III, IV and Appendix A of the permit. See the permit for design criteria. **(Check boxes.)**	SWPPP Components Required
Temporary Sediment Basins (Part III.B)	☐
Permanent Stormwater Management System (Part III.C)	☐
Construction Activity Requirements (Part IV)	☐

If **No**, the following components of the SWPPP are required as part of the NPDES/SDS permit as described in Parts III, IV and Appendix A of the permit. See the permit for design criteria. **(Check boxes.)** Temporary Sediment Basins (Part III.B) Construction Activity Requirements (Part IV)	SWPPP Components Required ☐ ☐

3.2 Does the county, city, or township have requirements that are MORE STRINGENT than the NPDES permit? *(Answer questions a-e in the table below to determine.)*

- For a listing of potential agencies and their contact information, go to http://www.dnr.state.mn.us/permits/water/water_permit_contacts.html
- Many counties have a Soil and Water Conservation District (SWCD) that can provide recommendations and technical information. For links to the various county SWCDs, go to http://www.maswcd.org/SWCDs_On_The_Web/swcds_on_the_web.htm

Contact each of the potential agencies listed and fill in their criteria for the following questions in the table below:

	County	City	Township
a. Is rate control required (y/n)?			
b. Is volume control (y/n) required?			
c. Is water quality treatment (y/n) required? If yes, what is the specified % removal required for:			
Total suspended solids (TSS):			
Total phosphorus (TP):			
d. Do the BMPs need to provide for downstream channel protection (y/n)? See definition below.			
e. Does the project need to meet an antidegradation (nondegradation) requirement to comply with a MS4 permit (y/n)? See below.			

- The purpose of channel protection criteria is to prevent habitat degradation and erosion in urban streams caused by an increased frequency of bankfull and sub-bankfull stormwater flows and to minimize downstream channel enlargement and incision that is a common consequence of urbanization.
- For information on what a MS4 permit is, see: http://www.pca.state.mn.us/water/water-types-and-programs/stormwater/municipal-stormwater/municipal-separate-storm-sewer-systems-ms4.html#whatis

  For an interactive map of MS4 entities within the state, visit: http://pca-gis02.pca.state.mn.us/website/stormwater/ms4_smt/viewer.htm

3.3 Does your project fall within a watershed district or watershed management organization with permitting authority or that will need to review and approve the project? *(Answer questions a-e in the table below to determine)*

- **Watershed district and watershed management organizations typically have the MOST STRINGENT requirements for stormwater management.**
- For a listing of potential agencies and their contact information, go to http://www.dnr.state.mn.us/permits/water/water_permit_contacts.html

Fill in the name(s) of the watershed agencies:

1. _____
2. _____
3. _____
4. _____

Contact each of the potential agencies listed and fill in their criteria for the following questions in the table below:

	Watershed Agency 1	Watershed Agency 2	Watershed Agency 3	Watershed Agency 4
a. Is rate control required (y/n)?				
b. Is volume control (y/n) required?				
c. Is water quality treatment (y/n) required? If yes, what is the specified % removal required for:				
Total suspended solids (TSS):				
Total phosphorus (TP):				
d. Do the BMPs need to provide for downstream channel protection (y/n)? See definition with 2.2.				
e. Does the project need to meet an antidegradation (nondegradation) requirement to comply with a MS4 permit (y/n)? See information with 2.2.				

3.4 Based upon the answers to Questions 3.2 through 3.3, check the box to the right if you answered "yes" to any of the questions for any agency. For % removal of TSS and TP, list the MOST STRINGENT (highest) value of all agencies reviewed:

Check all that apply:

Rate control: ☐
Volume control: ☐
Water quality treatment: ☐
% TSS removal required: _____
% TP removal required: _____
Channel protection: ☐
Nondegradation: ☐

3.5 Does the project drain to a special or impaired water as defined by the MPCA? Check http://pca-gis02.pca.state.mn.us/website/stormwater/csw/viewer.htm

Yes / No

Using this information, go to **Step 4** to start creating a BMP toolbox specific to your project.

STEP 4 – CREATE A PRELIMINARY BMP TOOLBOX

This step allows you to compare the BMPs included in the Stormwater Maintenance BMP Resource Guide and narrow the list of potential BMPs to two or three. You can further refine the list by completing Step 5 which covers maintenance and costs.

You will first start by determining which BMPs are most able to provide the type of treatment needed to meet permitting or other requirements (such as a Total Maximum Daily Load (TMDL), Environmental Assessment, Environmental Impact Statement, or approved requirement) . **Highlight or circle the information as you go.** In some cases, you may reach the end of this step and realize that due to site constraints or special considerations you are not able to meet all of the regulatory requirements. For example, a roadway project may fall within a watershed district that requires volume reduction, but the depth to groundwater or bedrock may be insufficient to allow construction of infiltration or bioretention practices. Make a note that additional coordination with the regulatory agencies may be needed to determine if specific requirements can be waived or met in another manner.

In the following tables, BMPs are ranked as follows:

REC = Recommended for this application

MAYBE = May be useful for this application with conditions or provides specified treatment to a lesser degree

N/A = Not recommended for this application or does not provide specified treatment

Using the two or three BMPs that result from your work with the appropriate Step 4 table for your project, go to **Step 5** to further refine the list using maintenance, life cycle costs, and aesthetics factors.

TABLE 4 – PRELIMINARY BMP TOOLBOX FOR **ROADWAY/LINEAR** PROJECTS WITH **LIMITED AVAILABLE SPACE**[1]

	BMP Category																							
	Stormwater Pond (e.g., ponds with permanent pools of water, such as NURP ponds, and multi-cell ponds)			**Bioretention** (e.g., rain gardens, bio-infiltration, bio-filtration, and bio-swales)			**Underground Treatment Devices** (e.g., proprietary hydrodynamic separators, sump catch basins and wet vaults)			**Underground Detention** (e.g., pipe galleries, concrete vaults, proprietary storage systems generally used for temporary detention of water and rate control)			**Infiltration** [e.g., surface practices that do not rely on vegetation (sand filter) and underground systems (perforated pipe gallery)]			**Porous/Pervious/ Permeable Pavements** (e.g., porous asphalt, pervious concrete, permeable pavers, reinforced/amended soils)			**Tree or Planter Box** (e.g., tree pits, tree box filters, stormwater planters)		
Primary Treatment Provided (See Question 3.4)																								
a. Rate Control	**REC**			**N/A**			**N/A**			**REC**			**MAYBE**			**REC**			**N/A**		
b. Volume Control	**N/A**			**REC**			**N/A**			**N/A**			**REC**			**REC**			**MAYBE**		
c. Water Quality	**REC**			**REC**			**MAYBE**			**N/A**			**REC**			**MAYBE**			**MAYBE**		
TSS Removal Required (%)	60-90%			85-100%			35%			0-20%			100%			90%[2]			85-100%[3]		
TP Removal Required (%)	34-73%			65-100%			0%			0%			100%			45-65%			65-100%		
d. Channel Protection	**REC**			**MAYBE**			**N/A**			**REC**			**MAYBE**			**MAYBE**			**MAYBE**		
e. Nondegredation requirement	**MAYBE**			**REC**			**N/A**			**N/A**			**REC**			**MAYBE**			**MAYBE**		
Comments	- Removal efficiencies depend on the type of pond. - Wet extended detention basins are the only type of pond complying with the NPDES Permit.			- Higher removal efficiencies are when designed as bio-infiltration basins. - Very sensitive to construction techniques and good plant establishment.			- Use mainly as pre-treatment (not allowed as sole treatment device in many instances).			- Typically, only used for rate control.			- Pre-treatment is required. - Very sensitive to construction techniques.			- Higher removal efficiencies are when practice is designed for infiltration. - Very sensitive to construction techniques.			- Avoid use to treat runoff from high-load areas.[4] - Removal efficiencies are not yet well documented. - Higher removal efficiencies are when designed for infiltration.		
Soil Type Considerations (See Question 2.3)	Best suited for HSG B, C or D soils. Line ponds in HSG A & some HSG B soils to maintain a permanent pool of water.			Best suited for HSG A and B soils. Use in HSG C or D soils will require special soil mixes and underdrains.			No restrictions based on hydrologic soil group.			No restrictions based on hydrologic soil group.			Best suited for HSG A and B soils. NOT recommended for use in HSG C or D soils. Check setback distance recommendations for building foundations and other items.			Best suited for HSG A and B soils. Use in HSG C or HSG D soils will require perforated underdrains.			Best suited for HSG A and B soils. Use in HSG C or D soils will require special soil mixes and underdrains.		
Project Setting (See Question 2.4)	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undeveloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undeveloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undeveloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undeveloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undeveloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undeveloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undeveloped Land
Special Site Considerations (See Question 2.5)																								
a. There are no special site considerations.	**N/A**	**MAYBE**	**MAYBE**	**N/A**	**MAYBE**	**MAYBE**	**REC**	**REC** – As pre-treatment	**MAYBE** – As pre-treatment	**REC**	**REC**	**MAYBE**	**REC** – Under-ground	**REC**	**REC** – Surface	**MAYBE** – Depending on road class, traffic volumes, adjacent land uses & maintenance program			**REC**	**REC**	**MAYBE**
b. Soil/groundwater contamination ***Check design with MPCA.***	**N/A**	**MAYBE**	**MAYBE**	**N/A**	**MAYBE** – May require liner depending on type of contamination.		**REC**	**REC**	**N/A**	**REC** – May require liner or special precautions			**N/A** – In most circumstances, NOT recommended depending on type of contamination.			**N/A** – In most circumstances, not recommended without a liner depending on type of contamination.			**REC**	**REC**	**N/A**
c/d. Less than 3 feet to bedrock or seasonal high groundwater table	**N/A**	**MAYBE** – Potential construction issues.		**N/A** – NOT RECOMMENDED			**REC**	**REC**	**N/A**	**REC** – Potential constructions issues.			**N/A** – NOT RECOMMENDED			**MAYBE** – See answer to a. If adequate depth for aggregate base, use impermeable liner and underdrains.			**MAYBE** – May need to keep isolated from groundwater or raise to achieve separation		
e. PSH runoff	**N/A**	**MAYBE** – May require liner and excellent pre-treatment.		**N/A**	**MAYBE** – Use impermeable liner and underdrain.		**REC**	**REC**	**N/A**	**REC** – May require excellent pre-treatment and special precautions.			**N/A** – NOT RECOMMENDED.			**MAYBE** – See answer to a. Use impermeable liner and underdrain.			**MAYBE** – May need to keep isolated from groundwater.		
f. DWSMA, WHPZ, karst, or sensitive groundwater	**N/A**	**MAYBE** – May require liner to prevent interaction with groundwater. **NOT recommended in karst areas.**		**N/A**	**MAYBE** – Depending on land use, may require impermeable liner and underdrain.		**REC**	**REC**	**N/A**	**REC**	**REC**	**REC**	**REC** – But NOT recommended if potential stormwater pollution sources are evident.			**MAYBE** – See answer to a. Use impermeable liner and underdrain.			**REC**	**REC**	**N/A**
Drainage to Special or Impaired Water (See Question 3.5)	**N/A**	**MAYBE**	**MAYBE**	**N/A**	**MAYBE** – With cautions for use related to PSHs.		**REC** – Use as pre-treatment upstream of another BMP.		**N/A**	**MAYBE –** As part of a treatment train If the receiving water is sensitive to increases in flow rates.			**REC** – Recommended unless target TMDL pollutant is a soluble nutrient or chloride			**MAYBE** – (recommended w/ conditions)			**REC** – With cautions for use related to PSHs.		

STEP 5 – REFINE BMP SELECTION/SELECT THE RIGHT "TOOL"

This step allows you to further refine the selection by comparing such factors as maintenance, life cycle costs and aesthetics.

In **Step 4,** you came up with a list of two or three BMPs that could be appropriate for your project. Use the following **Table 5**, to compare other factors for each of those BMPs that will help narrow the list further. **Highlight or circle the information as you go.**

In the tables, BMPs are ranked as follows:

Capital Costs – The average ranges are given relative to each other given identical areas being treated.

Maintenance Burden – The average cost includes more frequent, minor inspection/maintenance work as well as less frequent, major maintenance work such as dredging or system replacement.

Relative Life Expectancy – Life expectancies for the various BMPs are compared against each other, assuming that the design of each BMP was appropriate to their specific drainage areas.

TABLE 5 – Final BMP Screening [5], [6]

	BMP Category						
	BMPs Typically Used for General Applications					BMPs Typically Used for Specialized Applications	
	Stormwater Pond (e.g., ponds with permanent pools of water, such as NURP ponds, and multi-cell ponds)	**Bioretention** (e.g., rain gardens, bio-infiltration, bio-filtration, and bio-swales)	**Underground Treatment Devices** (e.g., proprietary hydrodynamic separators, sump catch basins and wet vaults)	**Underground Detention** (e.g., pipe galleries, concrete vaults, proprietary storage systems generally used for temporary detention of water and rate control)	**Infiltration** [e.g., surface practices that do not rely on vegetation (sand filter or rock trench) and underground systems (perforated pipe gallery)]	**Porous/Pervious/ Permeable Pavements** (e.g., porous asphalt, pervious concrete, permeable pavers, reinforced/amended soils)	**Tree or Planter Box** (e.g., tree pits, tree box filters, stormwater planters)
Capital Cost	Low [α]	Moderate [α]	High	Moderate to high	High	Moderate to high	Moderate
Maintenance Burden							
Ease of Maintenance (Mn Stm Man)	Easy to medium	Medium	Medium	Medium to difficult depending on access	Medium to difficult (depending on system used)	Medium	Easy to medium
Typical Annual Operations and Maintenance Costs	Low	Low	Medium to high	Low to medium	High	Medium to high Typical maintenance = regular sweeping with vacuum sweeper.	Low to medium
Typical Major Maintenance Costs	High	Medium to high	Medium to high	High	High	High	Medium [β]
Frequency of Major Maintenance	Low – Every 5 - 25 years	Medium to high – Every 1 - 5 years	Low	Low – Every 5 - 25 years	Medium – Every 3 - 5 years	Low to medium	Medium to high – Every 1 – 5 years [β]
Relative Life Expectancy	High	Medium	Medium	Medium to high	Medium	Lowest	Low to medium
Relative Life Cycle Cost	Low to moderate	Moderate	High	Moderate to high	High	Moderate to high	Moderate
Cost Effectiveness (2005 $/lb) [δ, 7]							
TSS Removal	$215	$150	Not available.	Typically not used for water quality treatment.	Not available.	$20 - $150	$155
TP Removal	$95,100	$52,300	Not available.	Typically not used for water quality treatment.	Not available.	$9,900 - $76,500	$54,200
Cost Effectiveness per Acre Treated (2005 $/acre)	$30,500	$25,900	Not available.	$52,300	Not available.	$3,300 - $25,200	$26,800
Other Factors							
Aesthetics	Can be designed as an amenity but success is dependent upon appropriate sizing of the pond for the drainage area. In highly visible areas, pre-treatment may be desired to remove trash prior to discharging to the pond.	Typically designed as part of the landscaping plan, but requires regular weeding/plant maintenance to maintain appearance.	Typically not visible	Typically not visible	Depending on the design, above-ground systems typically have low aesthetic appeal. Underground systems have no aesthetic impact.	Depending on system used, they can be seen as an amenity. Porous asphalt and pervious concrete applications may have low community acceptance initially.	Typically designed as part of the landscaping plan, but requires regular weeding/plant maintenance to maintain appearance.
Nuisance Factors	Moderate to high potential for mosquitoes or other nuisance insects, geese, floatables and odors.	Moderate potential for mosquitoes or other nuisance insects and overgrown vegetation.	Moderate potential for mosquitoes and odors. Potential to skip maintenance since "out of sight – out of mind." Access manholes frequently under pavement or within streets.	Typically dry, but some potential for mosquitoes and odors. Access manholes frequently under pavement or within streets.	Pre-treatment cells may be prone to odors and facilitate to mosquito/insect breeding. Susceptible to failure if poorly installed/maintained. Underground practices not seen/not maintained.	Heaving/settling of individual pavers. Some systems may not meet "Wheels and Heels" criteria.	Potential for overgrown vegetation.
Safety Concerns	A safety bench is strongly recommended, but may still pose safety concern for drowning. Berms that function as dams have a potential to fail.	Typically do not pose any safety concerns.	Confined spaces may pose hazard to maintenance crews.	Confined spaces may pose hazard to maintenance crews.	Typically do not pose any safety concerns.	May increase traction in wet weather events due to larger aggregate size.	Typically do not pose any safety concerns.
Spill Containment	Can provide a high degree of protection if outlet designed to provide skimming.	Minimal protection for bio-infiltration without upstream spill containment manhole. Moderate to high protection for bio-filtration if outlet for underdrains can be blocked.	Typically designed to provide spill containment.	Can provide a high degree of spill containment by blocking system outlet.	Minimal protection without upstream spill containment manhole.	Minimal protection for infiltration without upstream spill containment manhole. Moderate to high protection for filtration if outlet for underdrains can be blocked.	N/A for systems providing treatment for rooftops. Minimal protection for systems providing treatment for pavement.

See table notes on the following page.

Notes for Table 5:

[α] Does not include the cost to acquire land if the BMP is not located in a remnant parcel or outlot.

[β] Major maintenance work is dependent on the system and its intended use. For instance, if the tree box filter treats only its immediate surroundings, once the tree canopy develops, rainfall is intercepted prior to reaching the ground. In this case, the owner may decide to reduce major maintenance tasks. However, if the BMP is designed for infiltration and evapotranspiration of runoff from a larger area, major maintenance tasks must be performed in order for the BMP to continue providing treatment for this area.

[δ] For consistency, the cost effectiveness for each BMP category was determined using the present value of whole life costs using the WERF whole life costs spreadsheet tools (published 2005) as determined for a 10-acre residential watershed with ¼-acre lots (38% impervious) in HSG B soils. The annual TSS and TP loadings were determined using P8, and the removal efficiency of each BMP was assumed to be the average the range given in Tables 3.A through 3.D. Each BMP was assumed to have a "Medium" level of maintenance for consistency; the WERF spreadsheet tool has costs associated with Low, Medium and High levels of maintenance, which vary for each BMP category. The square footage of the porous/pervious/permeable pavements was assumed to be 10% of the impervious surface, and the capital costs were assumed to be "High" in order to compensate for deeper aggregate sections that may be typically used in cold weather climates.

Annual TSS Loading = 1894.3 pounds
Annual TP Loading = 6.0 pounds

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[1] Minnesota Pollution Control Agency, Minnesota Stormwater Manual, Version 2, 2005. The Minnesota Stormwater Manual provided the majority of the information unless noted.

[2] New Hampshire Stormwater Manual, Vol. 2, Revision: 1.0, Appendix B BMP Pollutant Removal Efficiency, 2008.

[3] Virginia Stormwater Management Program, Technical Bulletin #6: Minimum Standard 3.11C Filterra Bioretention Filter System, revised November, 1, 2002.

[4] New Hampshire Stormwater Manual, Vol. 2, Revision: 1.0, Appendix B BMP Pollutant Removal Efficiency, 2008.

High-load areas are defined as:

1. Any land use or activity in which regulated substances are exposed to rainfall or runoff, with the exception of road salt applied for deicing of pavement on the site;
2. Any land use or activity that typically generates higher concentrations of hydrocarbons, metals or suspended solids than are found in typical stormwater runoff, including but not limited to:
   - Industrial facilities subject to the NPDES/SDS Industrial Stormwater Multi-Sector General Permit, not including areas where industrial activities do not occur, such as at office buildings and their associated parking facilities or in drainage areas at the facility where a certification of no exposure pursuant to 40 CFR §122.26(g) will always be possible;
   - Petroleum storage facilities;
   - Petroleum dispensing facilities;
   - Vehicle fueling facilities;
   - Vehicle service, maintenance and equipment cleaning facilities;
   - Fleet storage areas;
   - Public works storage areas;
   - Road salt facilities;
   - Commercial nurseries;
   - Non-residential facilities with uncoated metal roofs with a slope flatter than 20%;
   - Facilities with outdoor storage, loading, or unloading of hazardous substances, regardless of the primary use of the facility; and
   - Facilities subject to chemical inventory under Section 312 of the Superfund Amendments and Reauthorization Act of 1986 (SARA).

[5] Iowa Stormwater Management Manual, version 2, December 5, 2008.

[6] Minnesota Pollution Control Agency, Minnesota Stormwater Manual, Version 2, 2005.

[7] Water Environmental Research Foundation (WERF), Performance and Whole Life Costs of Best Management Practices and Sustainable Urban Drainage Systems, Vol.2, 2005.

STEP 2 - DESCRIBE YOUR PROJECT
This will help determine which permits and types of BMPs are required and will work effectively for your project.

2.1 Where is the project?

Address/location _____

City/Township _____

County _____

2.2 What lake, river, or stream does it ultimately drain to?

Use USGS quadrangle maps, other types of contour/topographic maps, or the MPCA interactive map tool at
http://pca-gis02.pca.state.mn.us/website/stormwater/csw/viewer.htm

Fill in name or names of the receiving waters.

_____

_____

_____

2.3 What types of soils exist throughout the project area, and in particular at the location(s) of the potential BMPs? Check A, B, C, D, or combinations of.

Use soil boring data if available. Otherwise use County soil surveys, found at:

- http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx (interactive)
- http://soils.usda.gov/survey/online_surveys/minnesota/ (similar to the standard paper copies)

Check all that apply:

Standard hydrologic soil groups (HSG) are:

A. HSG A = sandy soils having low runoff potential with high infiltration rates even when thoroughly wetted. These consist primarily of deep, well to excessively drained sands and/or gravel. ☐

B. HSG B = soils having moderate infiltration rates even when thoroughly wetted, consisting chiefly of moderately deep to deep soils that have moderately fine to moderately coarse textures. These are moderately well to well drained soils. ☐

C. HSG C = soils having slow infiltration rates when thoroughly wetted. These consist primarily of soils with a layer that impedes the downward movement of water, or soils with moderately fine to fine texture and a slow infiltration rate and are somewhat clay-like in nature. ☐

D. HSG D = soils having high runoff potential with very slow infiltration rates when thoroughly wetted. These consist chiefly of clay soils with high swelling potential; soils with a high permanent water table; soils with claypan or clay layer at or near the surface; and shallow soils over nearly impervious materials. ☐

2.4 Does the project fall within a setting likely characterized as:

Check one:

a. Central Business District? ☐

b. Residential, suburban, low-density commercial or campus settings? ☐

c. Rural/ undeveloped? ☐

2.5 Are there special site considerations that could affect the BMP selection?	
a. There are no special site considerations, such as those listed in 2.5.b through 2.5.f.	Yes / No
b. Is there soil or groundwater contamination?	Yes / No
c. What is the depth to bedrock? There must be at least 3 feet of separation from the bedrock elevation to the bottom of any infiltration practice.	_____
d. What is the seasonal high groundwater elevation in the vicinity of the potential BMPs? There must be at least 3 feet of separation from the seasonal high groundwater elevation to the bottom of any infiltration practice.	_____
e. Will the BMP receive runoff from a potential stormwater hotspot (PSH)? PSHs are defined as commercial, industrial, institutional, municipal, or transportation-related operations that produce higher levels of stormwater pollutants, and/ or present a higher potential risk for spills, leaks or illicit discharges. Runoff from these operations may contain soluble pollutants which cannot be effectively removed by current BMPs and can contaminate ground water quality.	Yes / No
f. Does the project fall within a drinking water supply management area (DWSMA), wellhead protection zone (WHPZ), region of karst landforms/aquifers, or region of medium to high groundwater sensitivity? Municipal comprehensive plans typically include the DWSMA boundaries for their municipal wells. A map of Minnesota's DWSMA boundaries with vulnerability ratings can be found at http://www.health.state.mn.us/divs/eh/water/swp/maps/gis/dwsvul.pdf WHPZ boundaries can be found on the County Well Index interactive web tool at http://www.health.state.mn.us/divs/eh/cwi/ Information on Minnesota's karst region can be found at http://www.pca.state.mn.us/water/groundwater/karst.html	Yes / No
• Using the information from **Questions 2.1 through 2.2, go to Step 3** to determine which regulatory agencies have permitting and/or review authority over your project. • You will use information from **Questions 2.3 through 2.5 in Step 4**, which creates the BMP toolbox specific to the project.	

STEP 3 – DETERMINE THE REGULATORY ENVIRONMENT FOR YOUR PROJECT

A variety of state, local, and federal agencies regulate projects that may impact Minnesota's water resources. In many cases, a permit is required from one or more of these agencies before proceeding with the project. This step starts at the broadest level, with the agency that has jurisdiction over most projects that occur within the state. The focus is then narrowed down to the local governmental units. The intent is to determine the most stringent stormwater criteria that affect your project, which will then help determine which BMPs can meet those requirements.

3.1 Does your project require a National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) General Stormwater Permit for Construction Activity from the Minnesota Pollution Control Agency (MPCA) and/or a Stormwater Pollution Prevention Plan? *(Answer questions a-c to determine.)*

- The MPCA has jurisdiction through the NPDES/SDS permit for projects over 1 acre in size or part of a larger common plan of development if less than 1 acre in size.
- **The NPDES/SDS requirements will typically set the minimum stormwater criteria for all projects within the state. Other agencies may require higher levels of treatment.**
- For information on the NPDES/SDS permit, application form and other information, go to http://www.pca.state.mn.us/index.php/water/water-types-and-programs/stormwater/construction-stormwater/construction-stormwater.html

NPDES Permit: — NPDES Permit Required

a. Will the project disturb one or more acres of land?
This includes clearing, grading and excavation, but does not include routine maintenance that is performed to maintain the original line and grade, hydraulic capacity or original purpose of the facility. (*MPCA*)

If **Yes**, a NPDES/SDS permit is required. **Check box; then go to Question 3.1.c.** ☐

b. If No, is the project part of a larger common plan of development?
A common plan of development or sale means a contiguous area where multiple separate and distinct land disturbing activities may be taking place at different times, on different schedules, but under one proposed plan. (*MPCA*)

If **Yes**, a NPDES/SDS permit is required. **Check box; then go to Question 3.1.c.**
If **No**, a NPDES/SDS permit is **not** required. **Go to Question 3.2.** ☐

Stormwater Pollution Prevent Plan (SWPPP):

c. Will the amount of impervious surface increase over that of the existing condition as a result of the project? — Yes / No

If **Yes**, the following components of the SWPPP are required as part of the NPDES/SDS permit as described in Parts III, IV and Appendix A of the permit. See the permit for design criteria. **(Check boxes.)** — SWPPP Components Required

Temporary Sediment Basins (Part III.B)	☐
Permanent Stormwater Management System (Part III.C)	☐
Construction Activity Requirements (Part IV)	☐

If **No**, the following components of the SWPPP are required as part of the NPDES/SDS permit as described in Parts III, IV and Appendix A of the permit. See the permit for design criteria. **(Check boxes.)** Temporary Sediment Basins (Part III.B) Construction Activity Requirements (Part IV)	SWPPP Components Required ☐ ☐

3.2 Does the county, city, or township have requirements that are MORE STRINGENT than the NPDES permit? *(Answer questions a-e in the table below to determine.)*

- For a listing of potential agencies and their contact information, go to http://www.dnr.state.mn.us/permits/water/water_permit_contacts.html
- Many counties have a Soil and Water Conservation District (SWCD) that can provide recommendations and technical information. For links to the various county SWCDs, go to http://www.maswcd.org/SWCDs_On_The_Web/swcds_on_the_web.htm

Contact each of the potential agencies listed and fill in their criteria for the following questions in the table below:

	County	City	Township
a. Is rate control required (y/n)?			
b. Is volume control (y/n) required?			
c. Is water quality treatment (y/n) required? If yes, what is the specified % removal required for:			
Total suspended solids (TSS):			
Total phosphorus (TP):			
d. Do the BMPs need to provide for downstream channel protection (y/n)? See definition below.			
e. Does the project need to meet an antidegradation (nondegradation) requirement to comply with a MS4 permit (y/n)? See below.			

- The purpose of channel protection criteria is to prevent habitat degradation and erosion in urban streams caused by an increased frequency of bankfull and sub-bankfull stormwater flows and to minimize downstream channel enlargement and incision that is a common consequence of urbanization.
- For information on what a MS4 permit is, see: http://www.pca.state.mn.us/water/water-types-and-programs/stormwater/municipal-stormwater/municipal-separate-storm-sewer-systems-ms4.html#whatis

  For an interactive map of MS4 entities within the state, visit: http://pca-gis02.pca.state.mn.us/website/stormwater/ms4_smt/viewer.htm

3.3 Does your project fall within a watershed district or watershed management organization with permitting authority or that will need to review and approve the project? *(Answer questions a-e in the table below to determine)*

- **Watershed district and watershed management organizations typically have the MOST STRINGENT requirements for stormwater management.**
- For a listing of potential agencies and their contact information, go to http://www.dnr.state.mn.us/permits/water/water_permit_contacts.html

Fill in the name(s) of the watershed agencies:

1. _____
2. _____
3. _____
4. _____

Contact each of the potential agencies listed and fill in their criteria for the following questions in the table below:

	Watershed Agency 1	Watershed Agency 2	Watershed Agency 3	Watershed Agency 4
a. Is rate control required (y/n)?				
b. Is volume control (y/n) required?				
c. Is water quality treatment (y/n) required? If yes, what is the specified % removal required for:				
Total suspended solids (TSS):				
Total phosphorus (TP):				
d. Do the BMPs need to provide for downstream channel protection (y/n)? See definition with 2.2.				
e. Does the project need to meet an antidegradation (nondegradation) requirement to comply with a MS4 permit (y/n)? See information with 2.2.				

3.4 Based upon the answers to Questions 3.2 through 3.3, check the box to the right if you answered "yes" to any of the questions for any agency. For % removal of TSS and TP, list the MOST STRINGENT (highest) value of all agencies reviewed:

Check all that apply:

Rate control: ☐
Volume control: ☐
Water quality treatment: ☐
% TSS removal required: _____
% TP removal required: _____
Channel protection: ☐
Nondegradation: ☐

3.5 Does the project drain to a special or impaired water as defined by the MPCA? Check http://pca-gis02.pca.state.mn.us/website/stormwater/csw/viewer.htm

Yes / No

Using this information, go to **Step 4** to start creating a BMP toolbox specific to your project.

STEP 4 – CREATE A PRELIMINARY BMP TOOLBOX

This step allows you to compare the BMPs included in the Stormwater Maintenance BMP Resource Guide and narrow the list of potential BMPs to two or three. You can further refine the list by completing Step 5 which covers maintenance and costs.

You will first start by determining which BMPs are most able to provide the type of treatment needed to meet permitting or other requirements (such as a Total Maximum Daily Load (TMDL), Environmental Assessment, Environmental Impact Statement, or approved requirement) . **Highlight or circle the information as you go.** In some cases, you may reach the end of this step and realize that due to site constraints or special considerations you are not able to meet all of the regulatory requirements. For example, a roadway project may fall within a watershed district that requires volume reduction, but the depth to groundwater or bedrock may be insufficient to allow construction of infiltration or bioretention practices. Make a note that additional coordination with the regulatory agencies may be needed to determine if specific requirements can be waived or met in another manner.

In the following tables, BMPs are ranked as follows:

REC = Recommended for this application

MAYBE = May be useful for this application with conditions or provides specified treatment to a lesser degree

N/A = Not recommended for this application or does not provide specified treatment

Using the two or three BMPs that result from your work with the appropriate Step 4 table for your project, go to **Step 5** to further refine the list using maintenance, life cycle costs, and aesthetics factors.

TABLE 4 – PRELIMINARY BMP TOOLBOX FOR **ROADWAY/LINEAR** PROJECTS WITH **HIGHER PERCENTAGE OF AVAILABLE SPACE**[1]

	BMP Category																							
	Stormwater Pond (e.g., ponds with permanent pools of water, such as NURP ponds, and multi-cell ponds)			**Bioretention** (e.g., rain gardens, bio-infiltration, bio-filtration, and bio-swales)			**Underground Treatment Devices** (e.g., proprietary hydrodynamic separators, sump catch basins and wet vaults)			**Underground Detention** (e.g., pipe galleries, concrete vaults, proprietary storage systems generally used for temporary detention of water and rate control)			**Infiltration** [e.g., surface practices that do not rely on vegetation (sand filter) and underground systems (perforated pipe gallery)]			**Porous/Pervious/ Permeable Pavements** (e.g., porous asphalt, pervious concrete, permeable pavers, reinforced/amended soils)			**Tree or Planter Box** (e.g., tree pits, tree box filters, stormwater planters)		
Primary Treatment Provided (See Question 3.4)																								
a. Rate Control	**REC**			**N/A**			**N/A**			**REC**			**MAYBE**			**REC**			**N/A**		
b. Volume Control	**N/A**			**REC**			**N/A**			**N/A**			**REC**			**REC**			**MAYBE**		
c. Water Quality	**REC**			**REC**			**MAYBE**			**N/A**			**REC**			**MAYBE**			**MAYBE**		
TSS Removal Required (%)	60-90%			85-100%			35%			0-20%			100%			90%[2]			85-100%[3]		
TP Removal Required (%)	34-73%			65-100%			0%			0%			100%			45-65%			65-100%		
d. Channel Protection	**REC**			**MAYBE**			**N/A**			**REC**			**MAYBE**			**MAYBE**			**MAYBE**		
e. Nondegredation requirement	**MAYBE**			**REC**			**N/A**			**N/A**			**REC**			**MAYBE**			**MAYBE**		
Comments	- Removal efficiencies depend on the type of pond. - Wet extended detention basins are the only type of pond complying with the NPDES Permit.			- Higher removal efficiencies are when designed as bio-infiltration basins. - Very sensitive to construction techniques and good plant establishment.			- Use mainly as pre-treatment (not allowed as sole treatment device in many instances).			- Typically, only used for rate control.			- Pre-treatment is required. - Very sensitive to construction techniques.			- Higher removal efficiencies are when practice is designed for infiltration. - Very sensitive to construction techniques.			- Avoid use to treat runoff from high-load areas.[4] - Removal efficiencies are not yet well documented. - Higher removal efficiencies are when designed for infiltration.		
Soil Type Considerations (See Question 2.3)	Best suited for HSG B, C or D soils. Line ponds in HSG A & some HSG B soils to maintain a permanent pool of water.			Best suited for HSG A and B soils. Use in HSG C or D soils will require special soil mixes and underdrains.			No restrictions based on hydrologic soil group.			No restrictions based on hydrologic soil group.			Best suited for HSG A and B soils. NOT recommended for use in HSG C or D soils. Check setback distance recommendations for building foundations and other items.			Best suited for HSG A and B soils. Use in HSG C or HSG D soils will require perforated underdrains.			Best suited for HSG A and B soils. Use in HSG C or D soils will require special soil mixes and underdrains.		
Project Setting (See Question 2.4)	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undeveloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undeveloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undeveloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undeveloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undeveloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undeveloped Land	Central Business District	Residential, Suburban, Campus, Low Density Commercial	Rural/Undeveloped Land
Special Site Considerations (See Question 2.5)																								
a. There are no special site considerations.	**N/A**	**REC**	**REC**	**MAYBE** – Pocket rain garden	**REC**	**REC**	**REC**	**MAYBE** – As pre-treatment only	**MAYBE** – As pre-treatment only	**REC**	**MAYBE**	**N/A**	**REC** – Under-ground	**REC**	**REC** – Surface	**MAYBE** – Depending on road class, traffic volumes, adjacent land uses & maintenance program			**REC**	**REC**	**MAYBE**
b. Soil/groundwater contamination ***Check design with MPCA.***	**N/A**	**REC**	**REC**	**MAYBE** – Above option w/ liner	**REC** – May require liner depending on type of contamination.		**REC**	**MAYBE** – As pre-treatment	**N/A**	**MAYBE** – May require liner or special precautions			**N/A** – In most circumstances, NOT recommended depending on type of contamination.			**N/A** – In most circumstances, not recommended without a liner depending on type of contamination.			**REC –** With liner	**REC**	**MAYBE**
c/d. Less than 3 feet to bedrock or seasonal high groundwater table	**N/A**	**MAYBE** – Potential construction issues.		**N/A** – NOT RECOMMENDED			**REC**	**MAYBE** – As pre-treatment	**N/A**	**REC** – Potential constructions issues.			**N/A** – NOT RECOMMENDED			**MAYBE** – See answer to a. If adequate depth for aggregate base, use impermeable liner and underdrains.			**MAYBE** – May need to keep isolated from groundwater or raise to achieve separation		
e. PSH runoff	**N/A**	**REC** – May require liner and excellent pre-treatment.		**MAYBE** – Above option w/ liner	**MAYBE** – Use impermeable liner and underdrain.		**REC**	**MAYBE**	**N/A**	**REC** – May require excellent pre-treatment and special precautions.			**N/A** – NOT RECOMMENDED.			**MAYBE** – See answer to a. Use impermeable liner and underdrain.			**MAYBE** – May need to keep isolated from groundwater.		
f. DWSMA, WHPZ, karst, or sensitive groundwater	**N/A**	**REC** – May require liner to prevent interaction with groundwater. **NOT recommended in karst areas.**		**MAYBE** – Above option w/ liner	**MAYBE** – Depending on land use, may require impermeable liner and underdrain.		**REC**	**MAYBE** – As pre-treatment	**N/A**	**REC**	**MAYBE**	**MAYBE**	**REC** – But NOT recommended if potential stormwater pollution sources are evident.			**MAYBE** – See answer to a. Use impermeable liner and underdrain.			**REC –** May require liner	**REC**	**MAYBE**
Drainage to Special or Impaired Water (See Question 3.5)	**N/A**	**MAYBE**	**MAYBE**	**MAYBE** – Above option	**REC** – With cautions for use related to PSHs.		**REC** – Use as pre-treatment upstream of another BMP.		**N/A**	**MAYBE –** As part of a treatment train If the receiving water is sensitive to increases in flow rates.			**REC** – Recommended unless target TMDL pollutant is a soluble nutrient or chloride			**MAYBE** – (recommended w/ conditions)			**REC** – With cautions for use related to PSHs.		

STEP 5 – REFINE BMP SELECTION/SELECT THE RIGHT "TOOL"

This step allows you to further refine the selection by comparing such factors as maintenance, life cycle costs and aesthetics.

In **Step 4,** you came up with a list of two or three BMPs that could be appropriate for your project. Use the following **Table 5**, to compare other factors for each of those BMPs that will help narrow the list further. **Highlight or circle the information as you go.**

In the tables, BMPs are ranked as follows:

Capital Costs – The average ranges are given relative to each other given identical areas being treated.

Maintenance Burden – The average cost includes more frequent, minor inspection/maintenance work as well as less frequent, major maintenance work such as dredging or system replacement.

Relative Life Expectancy – Life expectancies for the various BMPs are compared against each other, assuming that the design of each BMP was appropriate to their specific drainage areas.

TABLE 5 – Final BMP Screening [5], [6]

	BMP Category						
	BMPs Typically Used for General Applications					BMPs Typically Used for Specialized Applications	
	Stormwater Pond (e.g., ponds with permanent pools of water, such as NURP ponds, and multi-cell ponds)	**Bioretention** (e.g., rain gardens, bio-infiltration, bio-filtration, and bio-swales)	**Underground Treatment Devices** (e.g., proprietary hydrodynamic separators, sump catch basins and wet vaults)	**Underground Detention** (e.g., pipe galleries, concrete vaults, proprietary storage systems generally used for temporary detention of water and rate control)	**Infiltration** [e.g., surface practices that do not rely on vegetation (sand filter or rock trench) and underground systems (perforated pipe gallery)]	**Porous/Pervious/ Permeable Pavements** (e.g., porous asphalt, pervious concrete, permeable pavers, reinforced/amended soils)	**Tree or Planter Box** (e.g., tree pits, tree box filters, stormwater planters)
Capital Cost	Low [α]	Moderate [α]	High	Moderate to high	High	Moderate to high	Moderate
Maintenance Burden							
Ease of Maintenance (Mn Stm Man)	Easy to medium	Medium	Medium	Medium to difficult depending on access	Medium to difficult (depending on system used)	Medium	Easy to medium
Typical Annual Operations and Maintenance Costs	Low	Low	Medium to high	Low to medium	High	Medium to high Typical maintenance = regular sweeping with vacuum sweeper.	Low to medium
Typical Major Maintenance Costs	High	Medium to high	Medium to high	High	High	High	Medium [β]
Frequency of Major Maintenance	Low – Every 5 - 25 years	Medium to high – Every 1 - 5 years	Low	Low – Every 5 - 25 years	Medium – Every 3 - 5 years	Low to medium	Medium to high – Every 1 – 5 years [β]
Relative Life Expectancy	High	Medium	Medium	Medium to high	Medium	Lowest	Low to medium
Relative Life Cycle Cost	Low to moderate	Moderate	High	Moderate to high	High	Moderate to high	Moderate
Cost Effectiveness (2005 $/lb) [δ, 7]							
TSS Removal	$215	$150	Not available.	Typically not used for water quality treatment.	Not available.	$20 - $150	$155
TP Removal	$95,100	$52,300	Not available.	Typically not used for water quality treatment.	Not available.	$9,900 - $76,500	$54,200
Cost Effectiveness per Acre Treated (2005 $/acre)	$30,500	$25,900	Not available.	$52,300	Not available.	$3,300 - $25,200	$26,800
Other Factors							
Aesthetics	Can be designed as an amenity but success is dependent upon appropriate sizing of the pond for the drainage area. In highly visible areas, pre-treatment may be desired to remove trash prior to discharging to the pond.	Typically designed as part of the landscaping plan, but requires regular weeding/plant maintenance to maintain appearance.	Typically not visible	Typically not visible	Depending on the design, above-ground systems typically have low aesthetic appeal. Underground systems have no aesthetic impact.	Depending on system used, they can be seen as an amenity. Porous asphalt and pervious concrete applications may have low community acceptance initially.	Typically designed as part of the landscaping plan, but requires regular weeding/plant maintenance to maintain appearance.
Nuisance Factors	Moderate to high potential for mosquitoes or other nuisance insects, geese, floatables and odors.	Moderate potential for mosquitoes or other nuisance insects and overgrown vegetation.	Moderate potential for mosquitoes and odors. Potential to skip maintenance since "out of sight – out of mind." Access manholes frequently under pavement or within streets.	Typically dry, but some potential for mosquitoes and odors. Access manholes frequently under pavement or within streets.	Pre-treatment cells may be prone to odors and facilitate to mosquito/insect breeding. Susceptible to failure if poorly installed/maintained. Underground practices not seen/not maintained.	Heaving/settling of individual pavers. Some systems may not meet "Wheels and Heels" criteria.	Potential for overgrown vegetation.
Safety Concerns	A safety bench is strongly recommended, but may still pose safety concern for drowning. Berms that function as dams have a potential to fail.	Typically do not pose any safety concerns.	Confined spaces may pose hazard to maintenance crews.	Confined spaces may pose hazard to maintenance crews.	Typically do not pose any safety concerns.	May increase traction in wet weather events due to larger aggregate size.	Typically do not pose any safety concerns.
Spill Containment	Can provide a high degree of protection if outlet designed to provide skimming.	Minimal protection for bio-infiltration without upstream spill containment manhole. Moderate to high protection for bio-filtration if outlet for underdrains can be blocked.	Typically designed to provide spill containment.	Can provide a high degree of spill containment by blocking system outlet.	Minimal protection without upstream spill containment manhole.	Minimal protection for infiltration without upstream spill containment manhole. Moderate to high protection for filtration if outlet for underdrains can be blocked.	N/A for systems providing treatment for rooftops. Minimal protection for systems providing treatment for pavement.

See table notes on the following page.

Notes for Table 5:

[α] Does not include the cost to acquire land if the BMP is not located in a remnant parcel or outlot.

[β] Major maintenance work is dependent on the system and its intended use. For instance, if the tree box filter treats only its immediate surroundings, once the tree canopy develops, rainfall is intercepted prior to reaching the ground. In this case, the owner may decide to reduce major maintenance tasks. However, if the BMP is designed for infiltration and evapotranspiration of runoff from a larger area, major maintenance tasks must be performed in order for the BMP to continue providing treatment for this area.

[δ] For consistency, the cost effectiveness for each BMP category was determined using the present value of whole life costs using the WERF whole life costs spreadsheet tools (published 2005) as determined for a 10-acre residential watershed with ¼-acre lots (38% impervious) in HSG B soils. The annual TSS and TP loadings were determined using P8, and the removal efficiency of each BMP was assumed to be the average the range given in Tables 3.A through 3.D. Each BMP was assumed to have a "Medium" level of maintenance for consistency; the WERF spreadsheet tool has costs associated with Low, Medium and High levels of maintenance, which vary for each BMP category. The square footage of the porous/pervious/permeable pavements was assumed to be 10% of the impervious surface, and the capital costs were assumed to be "High" in order to compensate for deeper aggregate sections that may be typically used in cold weather climates.

Annual TSS Loading = 1894.3 pounds
Annual TP Loading = 6.0 pounds

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[1] Minnesota Stormwater Manual provided the majority of the information unless noted.

[2] New Hampshire Stormwater Manual, Vol. 2, Revision: 1.0, Appendix B BMP Pollutant Removal Efficiency, 2008.

[3] Virginia Stormwater Management Program, Technical Bulletin #6: Minimum Standard 3.11C Filterra Bioretention Filter System, revised November, 1, 2002.

[4] New Hampshire Stormwater Manual, Vol. 2, Revision: 1.0, Appendix B BMP Pollutant Removal Efficiency, 2008.

High-load areas are defined as:

1. Any land use or activity in which regulated substances are exposed to rainfall or runoff, with the exception of road salt applied for deicing of pavement on the site;
2. Any land use or activity that typically generates higher concentrations of hydrocarbons, metals or suspended solids than are found in typical stormwater runoff, including but not limited to:
   - Industrial facilities subject to the NPDES/SDS Industrial Stormwater Multi-Sector General Permit, not including areas where industrial activities do not occur, such as at office buildings and their associated parking facilities or in drainage areas at the facility where a certification of no exposure pursuant to 40 CFR §122.26(g) will always be possible;
   - Petroleum storage facilities;
   - Petroleum dispensing facilities;
   - Vehicle fueling facilities;
   - Vehicle service, maintenance and equipment cleaning facilities;
   - Fleet storage areas;
   - Public works storage areas;
   - Road salt facilities;
   - Commercial nurseries;
   - Non-residential facilities with uncoated metal roofs with a slope flatter than 20%;
   - Facilities with outdoor storage, loading, or unloading of hazardous substances, regardless of the primary use of the facility; and
   - Facilities subject to chemical inventory under Section 312 of the Superfund Amendments and Reauthorization Act of 1986 (SARA).

[5] Iowa Stormwater Management Manual, version 2, December 5, 2008.

[6] Minnesota Pollution Control Agency, Minnesota Stormwater Manual, Version 2, 2005.

[7] Water Environmental Research Foundation (WERF), Performance and Whole Life Costs of Best Management Practices and Sustainable Urban Drainage Systems, Vol.2, 2005.

APPENDIX A | Cost Benefit Analysis

LRRB Task 1 - Stormwater BMP Selection
Cost-Benefit Analysis

SRF Comm #6770
LAG 8/27/2010

Table 5 of the Decision Tree includes information on the relative cost-benefits of the various categories of BMPs. These numbers were determined using Whole Life Costs as researched by the Water Environmental Research Foundation (WERF). For consistency, the cost effectiveness for each BMP category was determined using the present value of whole life costs using the WERF whole life costs spreadsheet tools (published 2005) as determined for a 10-acre residential watershed with ¼-acre lots (38% impervious) in HSG B soils. The annual TSS and TP loadings were determined using P8, which is a water quality modeled developed by William Walker. The removal efficiency of each BMP was assumed to be the average the range given in Table 4. As the WERF spreadsheet tool has costs associated with Low, Medium and High levels of maintenance, which vary for each BMP category, a "Medium" level of maintenance was assumed for consistency. The square footage of the porous/pervious/permeable pavements was assumed to be 10% of the impervious surface, and the capital costs were assumed to be "High" in order to compensate for deeper aggregate sections that may be typically used in cold weather climates.

Assumptions:

10-acre residential watershed used for all BMP types to compare cost per pound removed
P8 used to determine TSS and TP loading on an average annual basis given the following:
Pervious CN = 61
Indirectly connected impervious fraction = 0.05
Directly connected impervious fraction = 0.33
MSP4997.pcp precipitation file w/ data stored from 10/1/94 through 9/30/95
MSP4997.tmp temperature file
nurp50.p8p particle file

TSS loading generated from drainage area (lbs) = 1894.3
TP loading generated from drainage area (lbs) = 6.0

Whole Life Cycle (WLC) costs were determined using the spreadsheet tool from WERF (Performance and Whole Life Costs of Best Management Practices and Sustainable Urban Drainage Systems, Vol.2, 2005)

Same drainage area information as above
Base facility cost = $5,000 per acre
Engineering & planning = 25% of base cost
Took average of removal efficiency range

BMP Type	Assumed Level of Maintenance	Estimated WLC (Present Value)	Est. TSS Removal Eff. (%)	Pounds TSS Removed	EST. TP Removal Eff. (%)	Pounds TP Removed	TSS Rem. Cost ($/lb)	TP Rem. Cost ($/lb)	Cost Per Acre Treated ($/acre)
Stormwater Pond (Wet)	Medium	$305,211	75	1420.7	53.5	3.2	$214.83	$95,081.31	$30,521.10
Bioretention	Medium	$258,784	92.5	1752.2	82.5	5.0	$147.69	$52,279.60	$25,878.40
Underground Detention (assumed to be equivalent to WERF BMP type "Cistern")	Medium	$522,648	10	189.4	0	0.0	$2,759.06	N/A (no TP removal)	$52,264.85
Permeable Pavement									
Porous Asphalt: assumed high capital cost for deeper agg. section in cold climates	Medium	$32,715	90	1704.9	55	3.3	$19.19	$9,913.63	$3,271.50
Pervious Concrete: assumed high capital cost as above	Medium	$166,785	90	1704.9	55	3.3	$97.83	$50,540.99	$16,678.53
Permeable Pavers: assumed high capital cost as above	Medium	$252,289	90	1704.9	55	3.3	$147.98	$76,451.33	$25,228.94
In-curb Planter Vault (assumed to be equivalent to Planter Box)	Medium	$268,069	92.5	1752.2	82.5	5.0	$152.99	$54,155.31	$26,806.88

APPENDIX B | Resources Summary

Stormwater Best Management Practices – Resources Summary

The information provided in these summaries was gathered from the sources and, in many cases, contain information that comes directly from the summaries provided by the authors.

1. "The Cost and Effectiveness of Stormwater Management Practices"

Authors: Weiss, R. T., Gulliver, J. S., and Erickson, A. J. (2005). Minnesota Department of Transportation, Research Services Section, St. Paul, MN.

Website: http://www.lrrb.org/pdf/200523.pdf

Summary: The authors, researchers at Valparaiso University and the University of Minnesota, collected data from sites across the United States and analyzed the cost and effectiveness of several stormwater management practices for treating urban rainwater runoff. The stormwater management practices discussed in this document were dry detention basins, wet basins, sand filters, constructed wetlands, bioretention filters, infiltration trenches, and swales. This document is intended for use by planners and designers to estimate the total cost, and corresponding total suspended solids and phosphorus removal, of installing a stormwater management practice at a given site.

2. **"Stormwater Treatment: Assessment and Maintenance."**

Authors: Gulliver, J.S., A.J. Erickson, and P.T. Weiss (editors). 2010. University of Minnesota, St. Anthony Falls Laboratory. Minneapolis, MN.

Website: http://stormwaterbook.safl.umn.edu/

Summary: This website is an online manual that has been developed to help users ***assess the performance of, and schedule maintenance for,*** stormwater treatment practices. It is intended as a supplement to the Minnesota Stormwater Manual, which provides guidance for the *design and installation* of stormwater treatment practices.

This online manual provides a standardized methodology for the assessment and maintenance of stormwater treatment practices. It creates guidelines for assessing performance, reporting results, and scheduling maintenance which allows for comparison across geography, stormwater treatment practice type, season, and watershed.

Existing and developing communities are installing a wide variety of urban stormwater treatment practices in order to protect or rehabilitate receiving waters. These efforts incur costs while their environmental effectiveness is still in question, and the many variables involved (e.g., seasons, geology, topography, storm events, etc.) have made it historically difficult to compare results (Weiss et al. 2007). After assessment results are compared with stormwater management goals, users are able to proceed more effectively with their maintenance actions. To meet the needs of existing and developing communities, "Stormwater Treatment: Assessment and Maintenance" provides guidance on:

- The steps necessary to develop an assessment program including methods to consider before establishing a monitoring program
- Four levels of assessment ranging from visual inspection to monitoring;
- More accurate methods for flow measurement in stormwater conveyance systems;
- Advanced sampling methodologies that will help minimize typical sources of bias;
- Maintenance schedules and recommendations for appropriate action;
- Data on maintenance of stormwater treatment practices in the State of Minnesota;
- Data analyses and standardized visual inspection checklists;

The intended audience for this online manual is diverse including engineers and planners, consultants, watershed districts, municipal staff, natural resource managers and many others. Therefore, a series of case studies are also included to provide users with practical examples.

3. "Hydrodynamic Separator Sediment Retention Testing"

Authors: Saddoris, D.,McIntire, C., Mohseni, O., Gulliver, J. March 2010. Minnesota Department of Transportation and Minnesota Local Roads Research Board, Minneapolis, MN.

Website: http://www.cts.umn.edu/Publications/ResearchReports/reportdetail.html?id=1890

Summary: A team at the St. Anthony Falls Laboratory developed a testing method designed to assess the sediment retention, washout, and resuspension in hydrodynamic separators under flow rates exceeding their maximum design treatment rates. This report describes the team's research and the methods they developed to assess the sediment retention, washout, and resuspension in three different devices. A general washout function for all hydrodynamic separators was not developed, but the methods described in the paper can be applied to other types of hydrodynamic separators in order to develop a washout function specific to each device. This testing was primarily intended to be used in establishing the required frequency for cleaning installed hydrodynamic separators. This estimation could then be incorporated to determine the annual and long term costs for these devices. The information in this report will allow designers to develop more accurate cost analysis and upkeep guidelines for individuals or organizations considering the use of hydrodynamic separators.

4. International Stormwater Database (2007)

Authors: Developed by Wright Water Engineers, Inc. and Geosyntec Consultants for the Water Environment Research Foundation (WERF), the American Society of Civil Engineers (ASCE)/Environmental and Water Resources Institute (EWRI), the American Public Works Association (APWA), the Federal Highway Administration (FHWA), and U.S. Environmental Protection Agency (EPA).

Website: http://www.bmpdatabase.org/

Summary: The BMP Database is a website intended to provide data on BMP designs and performance that is scientifically defensible and consistent. Over 300 BMP studies are available on this website. The data may be used for research and analysis of BMP performance and cost, which may be information essential to designers and regulators when selecting appropriate BMPs for different situations. The website can be tailored to the particular user:

- Low-intensity: basic performance summary information for public officials, casual users and those needing quick answers,
- Mid-intensity: detailed Statistical Analysis regarding individual BMPs for use by consultants, designers, public works staff,
- Researcher: master database for use by University professors,
- Data providers: data entry spreadsheets for use by public agencies, consulting firms, university researchers,
- New to BMP monitoring: guidance for public agencies, consulting firms, university researchers, graduate students.

The website also provides other resources for individuals or organizations that wish to conduct their own assessments, such as BMP monitoring guidance, performance evaluation protocols, and reporting protocols.

5. Minnesota Stormwater Manual, version 2

Authors: Minnesota Stormwater Steering Committee (2008). Minnesota Pollution Control Agency, St. Paul, MN.

Website: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/stormwater/stormwater-management/minnesota-s-stormwater-manual.html

Summary: The Minnesota Stormwater Manual was created to walk a user through the various steps of design, installation, and operation of a structural runoff management facility. It is divided into two volumes, with the first being directed towards integrated stormwater management. This portion of the manual addresses the relationships between the many factors that influence stormwater behavior, including water volume, rate, and quality. The first volume also contains the necessary background information to apply proper stormwater management techniques and provides guidance for choosing appropriate BMPs to meet particular stormwater management objectives. The second volume contains technical details and engineering guidance that are necessary for stormwater managers and regulators and BMP designers. Technical details included in the second volume are basic climate patterns and the effect of cold weather on BMPs, runoff quality characteristics, and methods/models used to assess different management approaches. BMP design information is also included in this portion of the manual, and various physical and land use factors are discussed. The manual is primarily for use by stormwater practitioners who need to be familiar with all aspects of urban stormwater management, which includes a wide variety of people, such as engineers, contractors, regulators, watershed managers, and city water planners. However, it is flexible enough to be used by people with various levels of expertise. The manual also provides guidance for regulatory matters, and directs readers to appropriate agencies for answers to numerous regulatory questions.

6. "Urban Stormwater Management in the United States" from the National Academy of Sciences

Authors: Committee on Reducing Stormwater Discharge Contributions to Water Pollution, National Research Council (2008). "Urban Stormwater Management in the United States."

Website: http://www.nap.edu/catalog.php?record_id=12465#toc

Summary: This paper identifies a number of problems with the current stormwater programs, including the effectiveness and longevity of many BMPs, their requirements for monitoring, the conflicting regulations within government, and the lack of resources for review and compliance. It then proceeds to provide a series of recommendations on how to best stipulate provisions in stormwater permits to ensure that discharges will not cause or contribute to exceedances of water quality standards, essentially outlining an entirely new permitting structure.

7. Post-Project Monitoring of BMPs/SUDS to Determine Performance and Whole-Life Costs, Vol. 1

Authors: Water Environmental Research Foundation (WERF 2004). Alexandria, VA.

Website:
http://www.werf.org/AM/Template.cfm?Section=Search&Template=/CustomSource/Research/PublicationProfile.cfm&id=01-CTS-21T

Summary: This paper reports on the first phase of a two phase project that is being conducted in an attempt to assess the differences and commonalities between BMPs and SUDS (Sustainable Urban Drainage Systems). This first phase includes a literature review and a survey and review of the stormwater authorities and organizations in the United States and United Kingdom. The review was done to determine the availability of cost and performance data on commonly used BMPs and SUDS. The review identified gaps which remained in the knowledge of performance and whole-life costs of BMPs and SUDS. Whole life costing and performance protocols were developed for BMPs and SUDS, and this paper discusses the performance protocols developed (whole life costing is discussed in resource 8). This paper will enable organizations to better assess the maintenance commitments associated with specific BMPs and SUDS, and will allow managers of stormwater programs to determine the current status of their stormwater facilities. This provides improved confidence in the use and performance of BMPs and SUDS, which is an important aspect for organizations and designers of these treatment systems.

8. Performance and Whole Life Costs of Best Management Practices (BMPs) and Sustainable Urban Drainage Systems (SUDS), Vol.2

Authors: Water Environmental Research Foundation (WERF 2005). Alexandria, VA.

Website:

Main Document:
http://www.werf.org/AM/Template.cfm?Section=Search&Template=/CustomSource/Research/PublicationProfile.cfm&id=01-CTS-21-TA

Whole Life Cost Tool:
http://www.werf.org/AM/Template.cfm?Section=Research_Profile&Template=/CustomSource/Research/PublicationProfile.cfm&id=SW2R08

Summary: This report, based on a three year study examining stormwater management systems in the United States and Britain, provides an understanding of performance issues, upkeep requirements, and financial liabilities associated with the use of BMPs and SUDS. The report provides guidance on the selection, design, and maintenance of these systems and whole life costing information on various designs. Analysis done using whole life costing indicated that larger, low maintenance facilities were more effective than smaller, higher maintenance facilities. This document also used monitoring information from BMP and SUDS sites to identify which designs are preferred in numerous settings. This information will be useful for selection processes in organizations that intend to implement these systems. It will also be helpful for planners in the design process, as it allows planners to estimate future outlays and develop a funding system for sustaining ongoing maintenance requirements. This publication also has an accompanying tool, which has the ability to model whole life costs. This product is available on the WERF website, and its subscription I.D. is 01CTS21TAT.

9. A Public Works Perspective on the Cost vs. Benefit of Various Stormwater Management Practices

Authors: Minnesota Chapter of the American Public Works Association (2008)

Website: http://www.co.washington.mn.us/client_files/documents/phe/ENV/GW-CostBenefit.pdf

Summary: When selecting the most appropriate Best Management Practice, the life cycle cost vs. benefit of a BMP is an important consideration, but is not, in many cases, formally considered when selecting a practice. The cost for maintenance and operation of these BMPs to assure they function as designed is also overlooked in many cases.

This document provides the results of a cost vs. benefit analysis that was completed for a wide range of BMPS by public works staff and consultants in the Twin Cities metropolitan area to provide policymakers with their perspectives on what are truly the BMPs available to address these stormwater management considerations.

10. The Economics Of Structural Stormwater BMPs In North Carolina

Authors: Wossink, A. and Hunt, B. Department of Agricultural and Resource Economics, North Carolina State University, Raleigh, NC (2003)

Website: http://www.bae.ncsu.edu/stormwater/PublicationFiles/EconStructuralBMPs2003.pdf

Summary: Urban stormwater runoff and the associated negative quantitative and qualitative effects can be controlled by various best management practices (BMPs). These innovations run along the continuum of small, or site specific, to large, or regional, scale practices. This publication focuses on which BMPs work best at removing selected pollutants and their relative costs for NC conditions. The costs of BMPs include both installment (construction and land) and annual operating costs (inspection and maintenance). Construction costs and annual operating costs are statistically analyzed for effects of scale by means of the estimation of BMP specific nonlinear equations relating the costs to watershed size. Structural stormwater BMPs require initial capital investments and then annual operating costs. To estimate total economic impacts the Present Value of Costs approach was used. Annual costs were

related to the area treated and to the removal effectiveness of the specific BMP for a proper economic evaluation.

11. Iowa Stormwater Management Manual, version 2

Authors: Iowa State University Institute for Transportation

Website: http://www.intrans.iastate.edu/pubs/stormwater/index.cfm

Summary: The purpose of this manual is to present planning and design guidelines for the management of stormwater quality and quantity in the urban environment. Jurisdictions with Phase I and Phase 2 NPDES stormwater permits may use alternative methods and design strategies for meeting post-construction requirements for stormwater quality improvement, including the information in this manual. While this manual includes most of the commonly-used stormwater management BMPs, it is not a comprehensive list. The material in this manual includes the hydrologic design and implementation of stormwater quality best management practices (BMPs) and traditional analysis and design of stormwater runoff conveyance for larger storm events to prevent flooding. Additional guidance is provided on improved site planning to reduce runoff volume through reduction of impervious area and increased emphasis on infiltration practices.