Selecting Stormwater BMPs – Identifying The Best Options

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March 2011
2011RIC01PP

Presentation Outline

- Project Background and Need
- Stormwater Best Management Practices Utilized
- Decision Tree 5-Step Process
- Conclusions
- Resources

Step 1 – Select Your Project Type

Step 2 – Describe Your Project

Step 3 – Determine the Regulatory Environment for Your Project

Step 4 – Create a Preliminary BMP Toolbox

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

LRRB Selecting Stormwater BMPs

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Local Road Research Board (LRRB) Mission

The LRRB serves local road transportation practitioners through:

- Development of new initiatives,
- Acquisition of and application of new knowledge, and
- Exploration and implementation of new technologies.

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LRRB Selecting Stormwater BMPs

Intended users:

City and County public works

Young engineers

Developers

Public officials and other non-engineers

The Decision Tree distills information from many manuals and sources into one spot, and provides convenient documentation for how/why decisions are made on a project-by-project basis.

Intended for use with projects for which there is no regional stormwater facility available.

BMP functions that may be required:

-Sediment control

-Nutrient removal

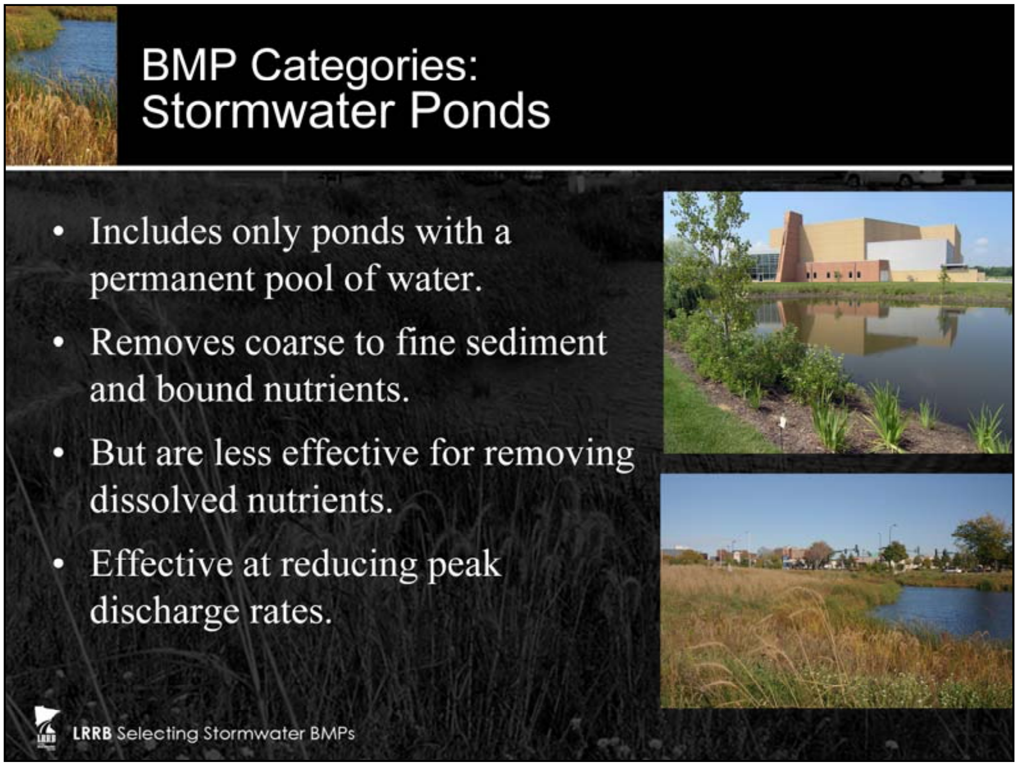
-Volume reduction

-Peak discharge rate control

-Channel protection

BMP Categories

- Primary Focus: BMPs that are commonly used in Minnesota
  - Stormwater Ponds
  - Bioretention Facilities
  - Underground Treatment Devices
  - Underground Detention
  - Infiltration
  - Porous/Pervious/Permeable Pavements
  - Tree or Planter Box



Stormwater ponds are typically installed as an end-of-pipe BMP at the downstream end of a trunk storm sewer system or of a treatment train.

Wet extended detention basins are the only type of pond that complies with the NPDES Permit.

- <u>Dry detention ponds</u> are ones in which the outlet elevation matches or is slightly below that of the inlet elevation. All runoff that enters the pond is consider to leave the pond, but the outlet is restricted to temporarily store the runoff prior to discharge. There is no sediment storage, and sediment that was previously deposited often is carried downstream with larger storm events. Therefore, dry detention ponds provide rate control but no water quality benefits.

- Frequently, <u>unlined wet detention ponds</u> can dry out between storm events if they are constructed in sandy soil due to infiltration. These may still be considered to provide water quality benefits as the runoff has to pond up to a certain depth before it can discharge through the outlet pipe, allowing for sedimentation. Water quality benefits also seen through infiltration of the runoff.

<u>Commonly used names</u>: NURP ponds, multi-cell ponds with a wet forebay, retention ponds, and unlined or lined wet ponds.

<u>Benefits:</u>

-Able to effectively reduce many pollutant loads and control runoff flow rates

-Relatively straightforward design procedure

-Potential wildlife habitat and aesthetic enhancement

-May be used as temporary sedimentation basin during construction

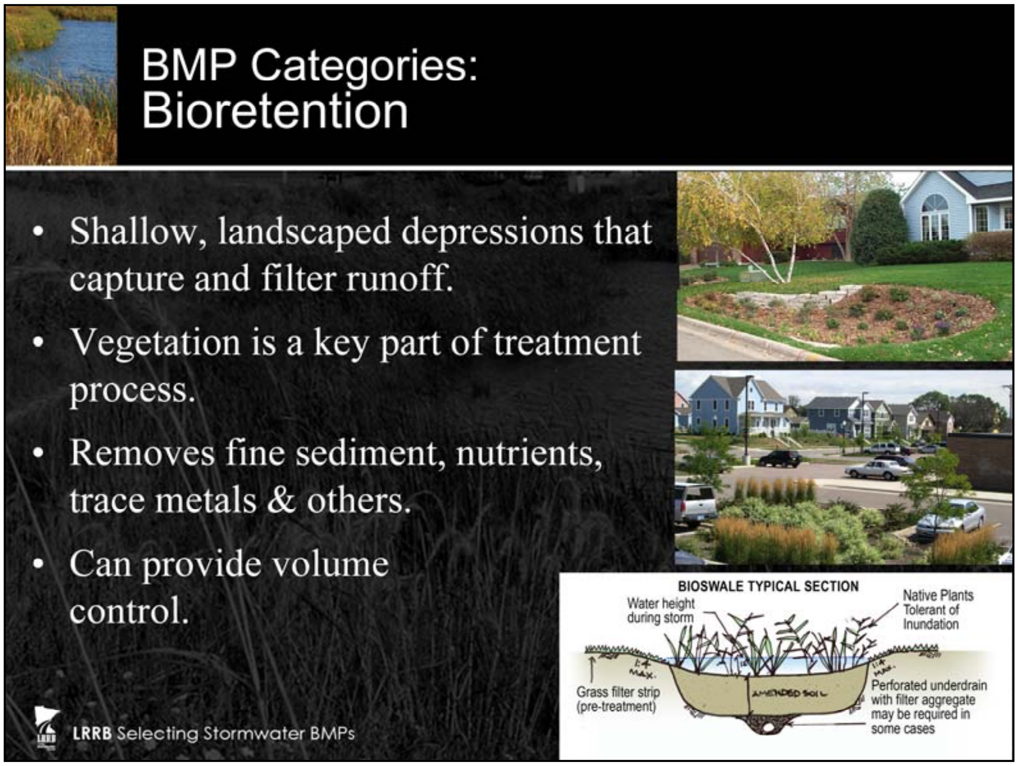
<u>Limitations:</u>

-Relatively large space requirement

-Tends to increase water temperature and may cause downstream thermal impact

-Potential for nuisance insects or odor

-Problematic for areas of low relief, high water table, near-surface bedrock, wellhead protection areas or source waterprotection areas without a liner



<u>Commonly used names</u>: rain gardens, bio-infiltration basins, bio-filtration basins, bioretention basins, bioswales

Current “trendy” BMP in stormwater management = rain garden

<u>Benefits:</u>

-Can be very effective for removing fine sediment, trace metals, nutrients, bacteria, and organics.

-Provides many additional environmental (habitat, improves air quality, urban micro-climates), social (creates a unique sense of place), and economic benefits (reduces development and maintenance cost, greater lot yield, increases property values).

-Well suited for high impervious areas.

-Reduces runoff volume.

-Flexible design, affording many opportunities for creativity.

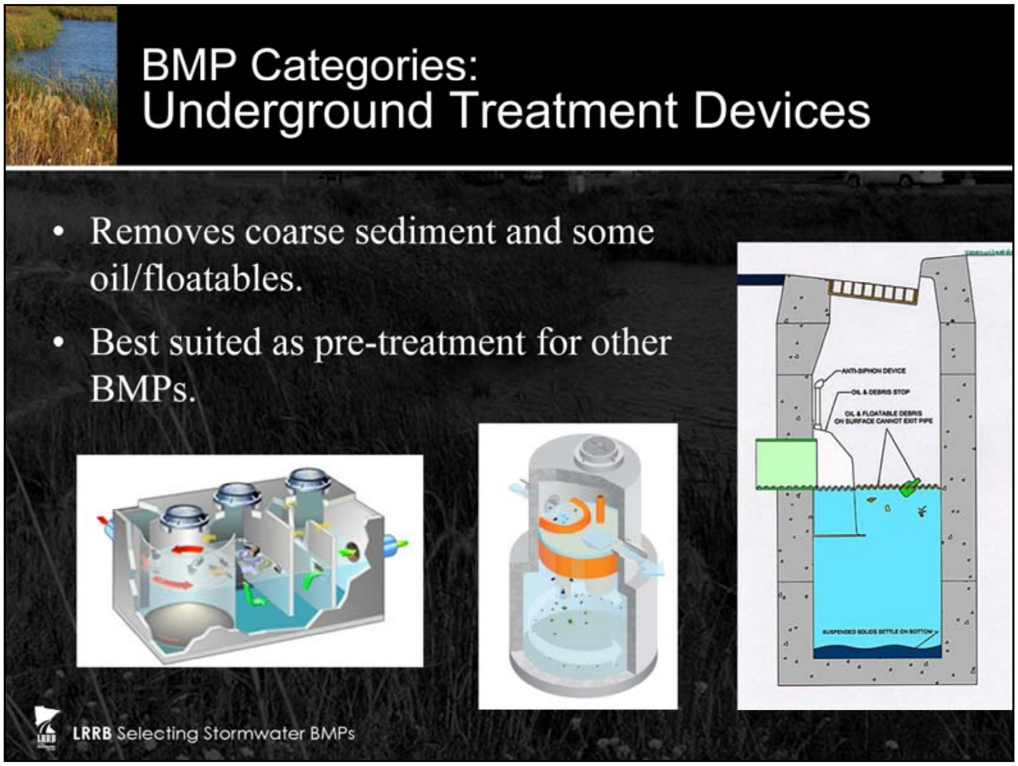
-Less thermal impacts to surface waters than typical wet detention pond.

<u>Limitations:</u>

-Susceptible to clogging by sediment; therefore maintenance and pre-treatment is necessary to maintain effectiveness.

-May not be effective for large drainage areas (use multiple structures, closer to source of runoff).

-Soil medium prone to erosion (use energy reduction measures for incoming stormwater).



They can take a variety of forms and use a variety of technologies or methods to provide stormwater quality treatment. Generally, they act as oil and grit separators using the physical principles of sedimentation for the grit and phase separation for the oil. They are most effective on coarse sediments and have reduced effectiveness at removing pollutants such as nutrients or metals.

Commonly used names: oil/grit separator, grit chamber, sump manhole/catch basin, wet vault, hydrodynamic separator, water quality inlet, and proprietary stormwater treatment device.

Benefits:

-Units are underground and do not consume much land area, which allows the land to be used for other purposes (parking lots, etc.).

-They can often be easily incorporated into fully developed sites and for retrofit of existing systems.

-They can be used for pre-treatment prior to other BMP practices.

-They can be suitable for cold climates if installed below frostline.

-Many provide an easily accessed structure for maintenance.

-Standardized designs allow for relatively easy installation.

Limitations:

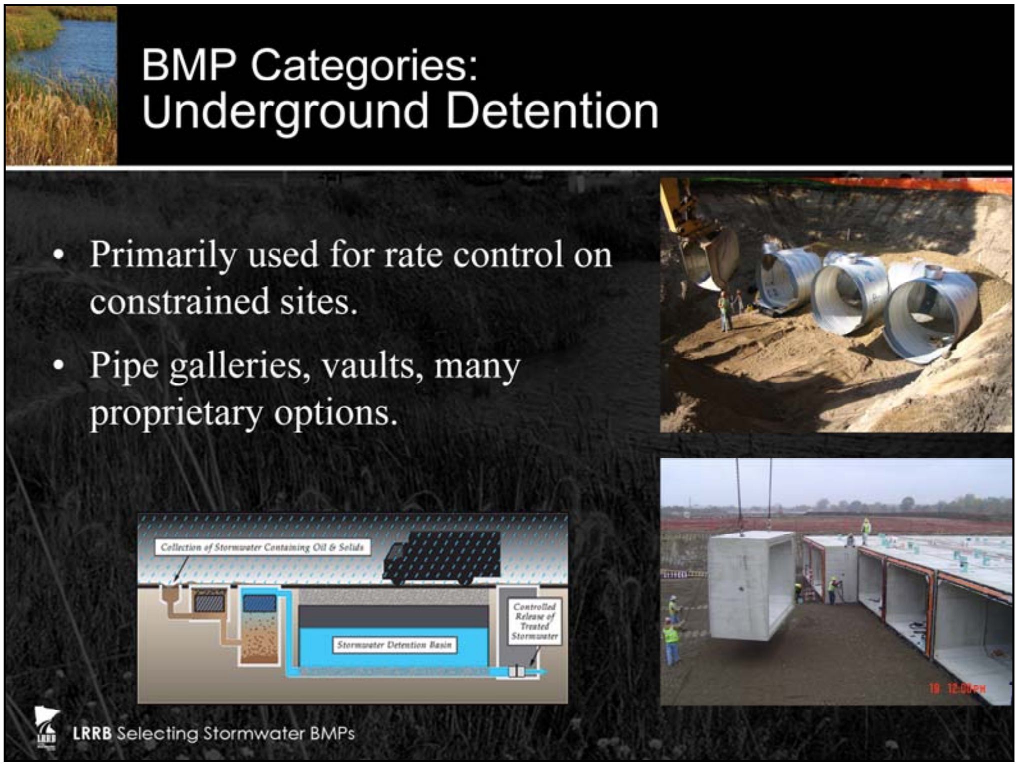
-Each type of unit has specific design constraints and limitations for use.

-Treatment may be reduced if frequent maintenance is not conducted.

-They may not meet local standards when used alone.

-They are generally good for solids and litter, but much less effective for common soluble pollutants.

-These types of facilities require OSHA confined space entry procedures.



Underground detention devices are used to store stormwater runoff temporarily. Stored water is released directly through an outlet pipe back into various downstream conveyance systems or water bodies at rates designed to reduce peak water flows during storms to better mimic predevelopment conditions.

These devices could provide some water quality treatment with design modifications.

Perforated or open bottom underground galleries that allow infiltration into the underlying soil are included in the "Infiltration" BMP category.

Benefits:

-Reduces peak stormwater runoff flow rate.

-Provides extended storage and slow, measured release of collected stormwater runoff.

-Good option for high density or urban areas with limited available space, unusual shapes or where land is expensive.

-Prefabricated modular systems can be relatively quick to install.

-Durability and long life (50 years plus for most systems).

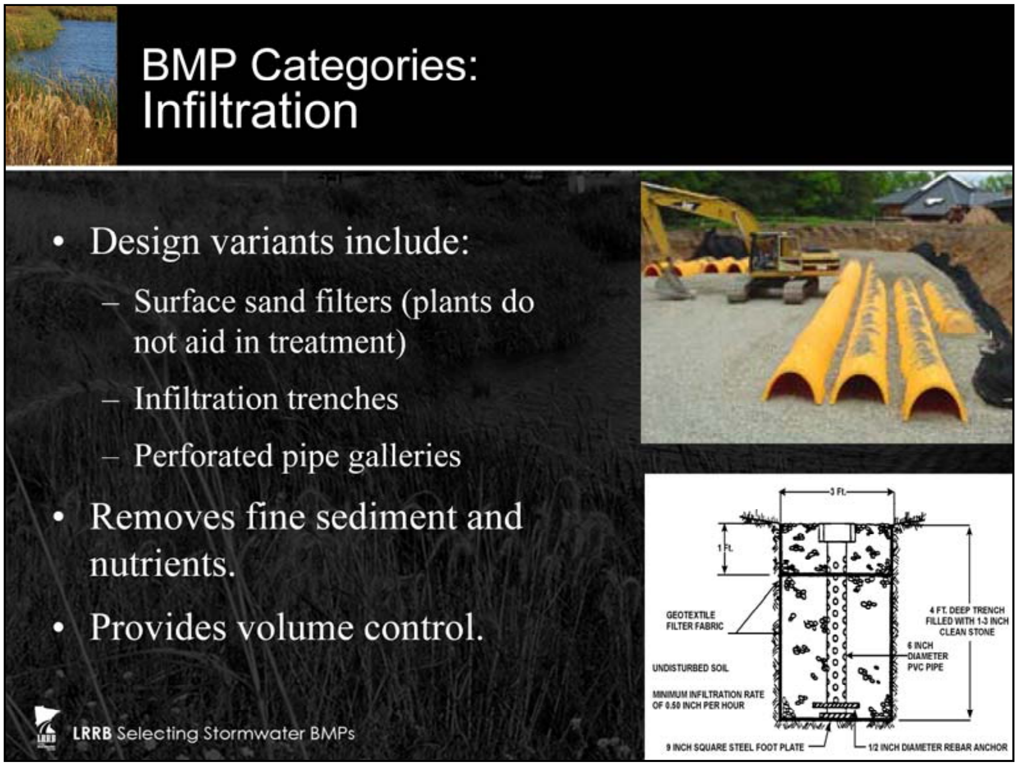
Limitations:

-Provides varying degrees of water quality improvement. To achieve water quality improvement additional stormwater BMPs must be incorporated in-line with storage system.

-Special equipment (and access) is often required to perform routine maintenance.

-There is the potential for noxious gases to form in the system.

-Confined space protocols may be required during inspections and maintenance.



In general terms, infiltration systems can be described as natural or constructed depressions located in permeable soils that capture, store, and infiltrate stormwater runoff. These depressions can be located at the surface of the ground (e.g. infiltration basin) or they can be designed as underground facilities (e.g. structural chamber or excavated pit filled with aggregate such as an infiltration trench). As the stormwater penetrates the underlying soil, chemical, biological, and physical processes remove pollutants and delay or reduce peak stormwater flows.

This section deals with structural practices relying on infiltration processes that are distinguishable from bioretention practices in that the former do not rely on vegetation to aid in the treatment.

Benefits:

-Reduces peak stormwater runoff flow rate.

-Increases groundwater recharge.

-Improves surface water quality.

-Provides thermal benefits to cold water fisheries.

Limitations:

-Effectiveness is sensitive to construction and maintenance practices.

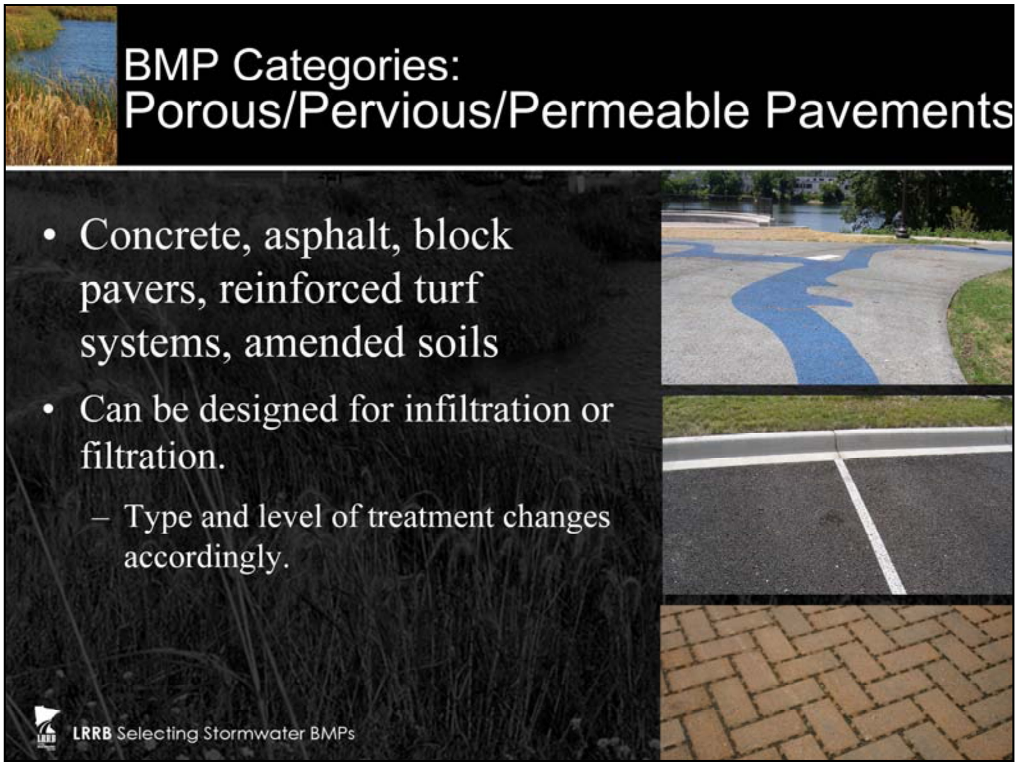
-Tendency to lose effectiveness over time due to clogging if not properly constructed or maintained.

-Not recommended for areas with steep slopes, karst topography, adjacent to buildings, or near potential stormwater hotspots.

-Special equipment (and access) is often required to perform routine maintenance for underground infiltration systems.

-Surface infiltration systems may require landscaping capable of handling periods of inundation and drought.

-Typically need to be paired with a pre-treatment device.



Runoff is stored in the stone aggregate base course/storage layer and allowed to infiltrate into the surrounding soil, or collected by an underdrain system and discharged to the storm sewer system or receiving waters.

<u>3 Categories:</u>

1) Porous Pavements – porous surfaces that infiltrate water across the entire surface (i.e. porous asphalt and pervious concrete pavements);

2) Permeable Pavers – impermeable modular blocks or grids separated by spaces or joints that water drains through (i.e. block pavers, plastic grids, etc.);

3) Amended Soils - Fiber or artificial media added to soil to maintain soil structure and prevent compaction.

<u>Benefits:</u>

-Can provide groundwater recharge and reduces stormwater runoff volume.

-Can reduce peak discharge rates by diverting stormwater into the ground and away from the pipe-and-pond stormwater management system.

-Grass pavers can improve site appearance by providing vegetation in areas of low volume parking where there would otherwise be only pavement.

-Increases effective developable area on a site because portions of the stormwater management system are located underneath the paved areas.

-When designed for infiltration, can significantly reduce the need for large stormwater management structures on a site.

-The dead air and void spaces in the base course provide insulation so that the frost line is closer to the surface.

<u>Limitations:</u>

-Permeable paving can be prone to clogging from sand and fine sediments that fill void spaces and the joints between pavers.

-Should be used carefully where frequent winter sanding is necessary because the sand may clog the surface of the material.

-Periodic maintenance is critical, and surfaces should be cleaned with a vacuum sweeper at least three times per year.

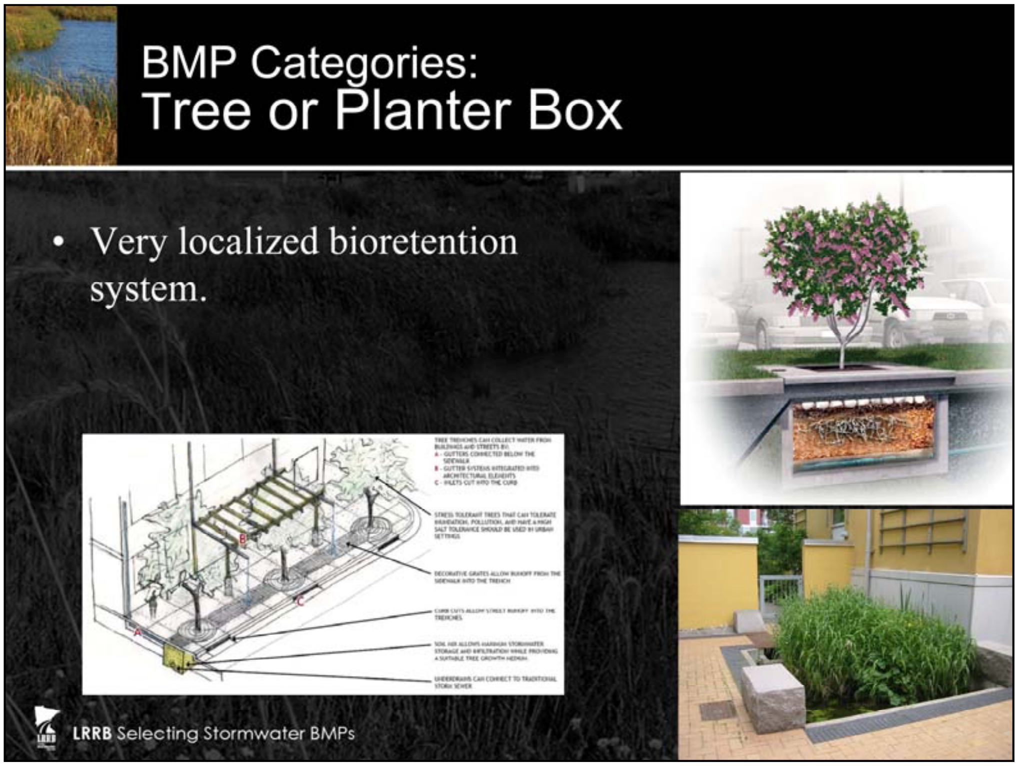
-In cold climates, the potential for frost heave may be a concern for the use of permeable paving. S

-Permeable paving should be used carefully when being used to receive stormwater from other drainage areas, especially any areas that are not fully stabilized.

-May not be suitable for use on steep slopes (>5%).

-May not be suitable for use in high-traffic areas or where it will be subject to heavy axle loads.

-Snow plows can catch the edge of grass pavers and some paving stones. Rollers should be attached to the bottom edge of a snowplow to prevent this problem.



Simple “tree pits” are used for local drainage interception, in which a very shallow ponding area is provided in a “dished” mulch area around the tree or shrub. Tree box filters can be used in highly urbanized streetscapes. The system consists of a container filled with a soil mixture, a mulch layer, underdrain system and a shrub or tree. Stormwater planters are self-contained landscaping areas that capture and temporarily store a fraction of rooftop runoff and filter it through the soil media.

<u>Benefits :</u>

-Can be adaptable to integration with site landscaping, and offer an aesthetically attractive opportunity to provide highly effective stormwater treatment.

-Can be used to meet recharge objectives, where underlying soils are suitable and where allowed by land use and receiving water characteristics.

-Their small scale allows volume and water quality control to be tailored to specific site characteristics and provides the ability to customize stormwater management techniques to target specific pollutants using different soil media.

<u>Limitations:</u>

-Do not use tree box filters to treat runoff from high-load areas.

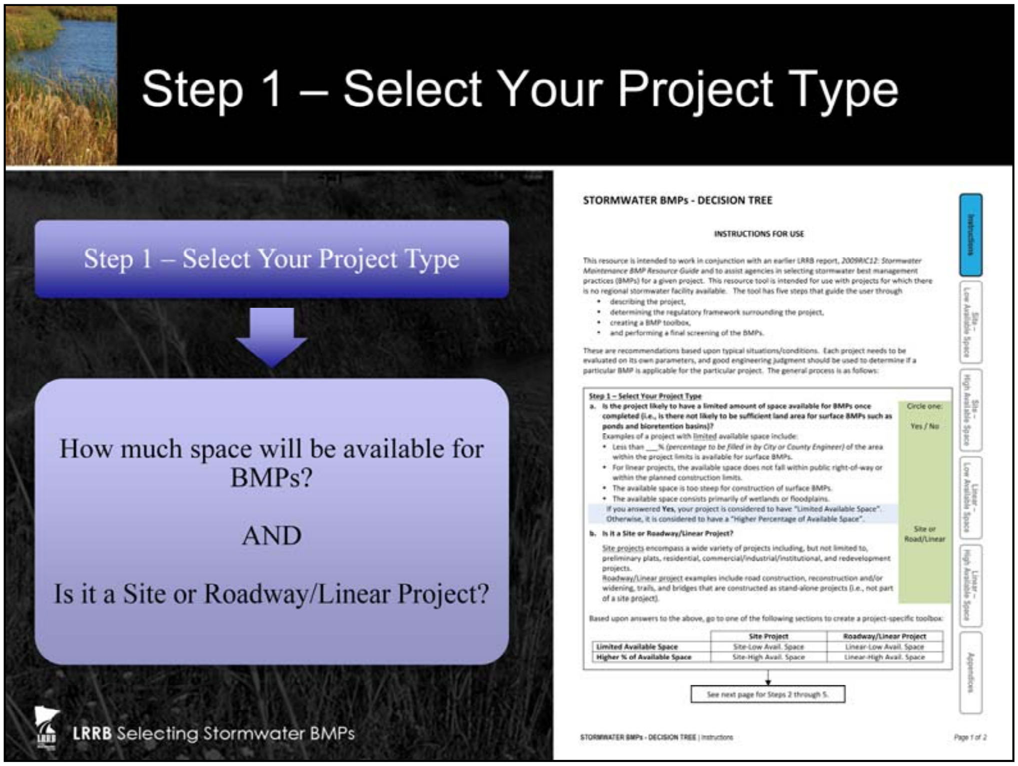
-Cannot be constructed until up gradient areas are fully stabilized.

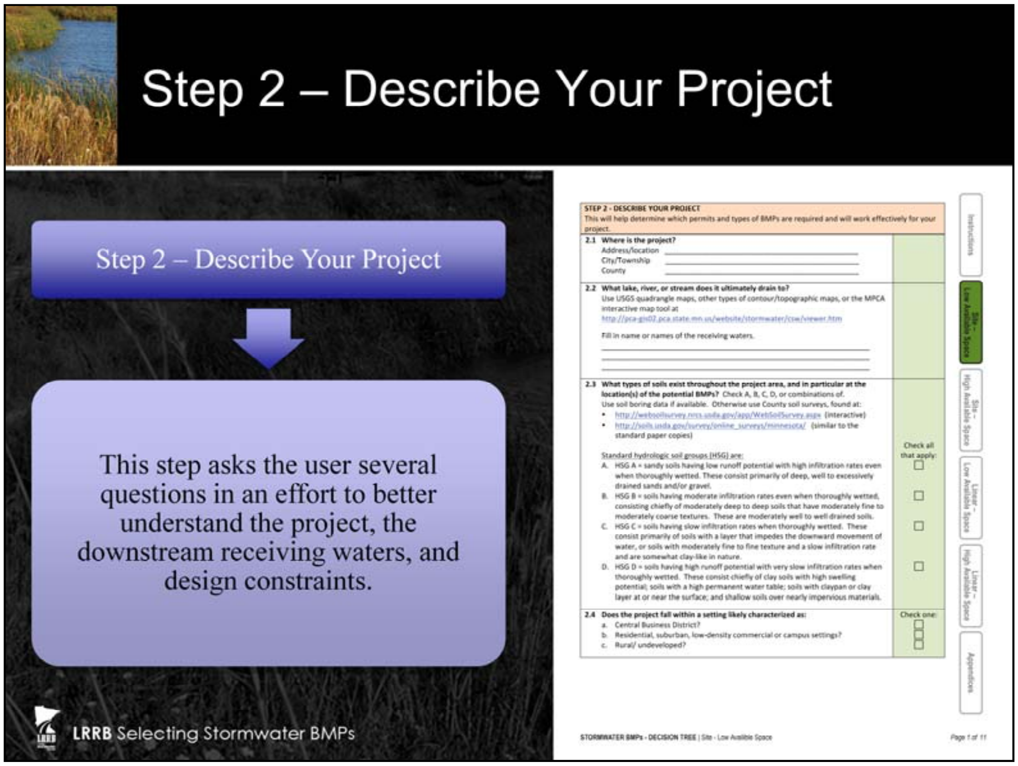
-Typically used in highly visible areas and therefore, may require frequent inspection to remove trash and tree/vegetation maintenance.

Decision Tree for BMPs: A 5-Step Process

- Step 1 – Select Your Project Type
- Step 2 – Describe Your Project
- Step 3 – Determine the Regulatory Environment for Your Project
- Step 4 – Create a Preliminary BMP Toolbox
- Step 5 – Refine BMP Selection/Select the Right "Tool"

LRRB Selecting Stormwater BMPs

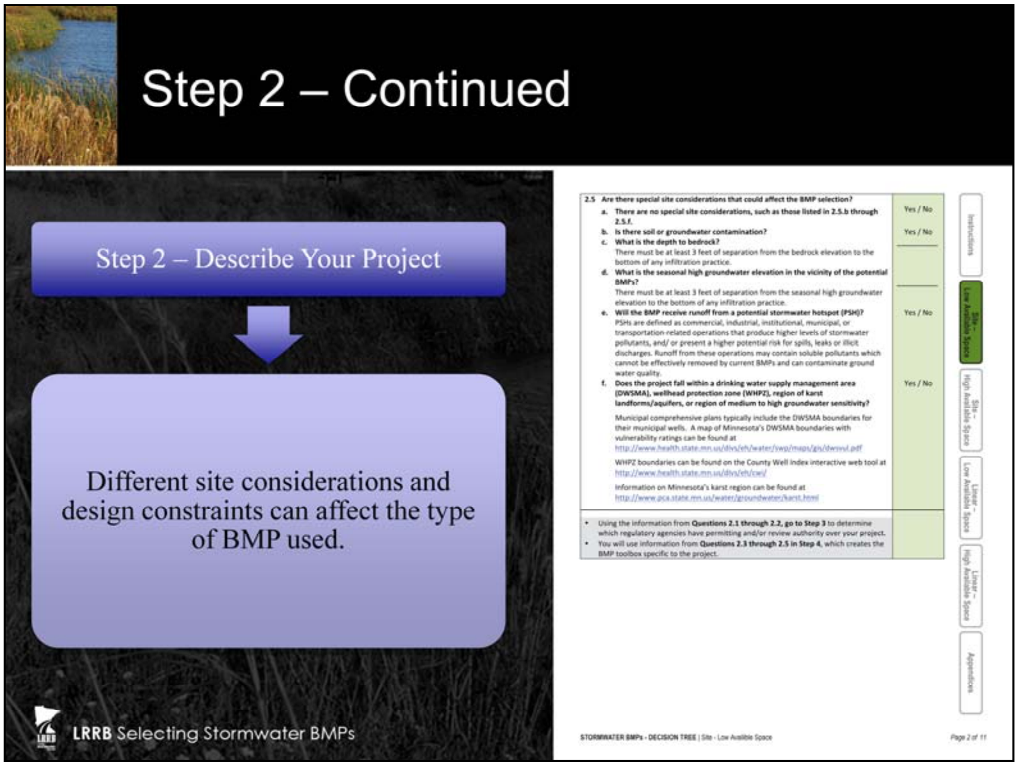

Step 1 – Select Your Project Type
Step 1 – Select Your Project Type
How much space will be available for BMPs?
AND
Is it a Site or Roadway/Linear Project?
LRRB Selecting Stormwater BMPs
STORMWATER BMPs - DECISION TREE
INSTRUCTIONS FOR USE
This resource is intended to work in conjunction with an earlier 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.
STORMWATER BMPs - DECISION TREE | Instructions
Page 1 of 2
Instructions
Site – Low Available Space
Site – High Available Space
Linear – Low Available Space
Linear – High Available Space
Appendices



The answers to these questions will be used in Steps 3 and 4

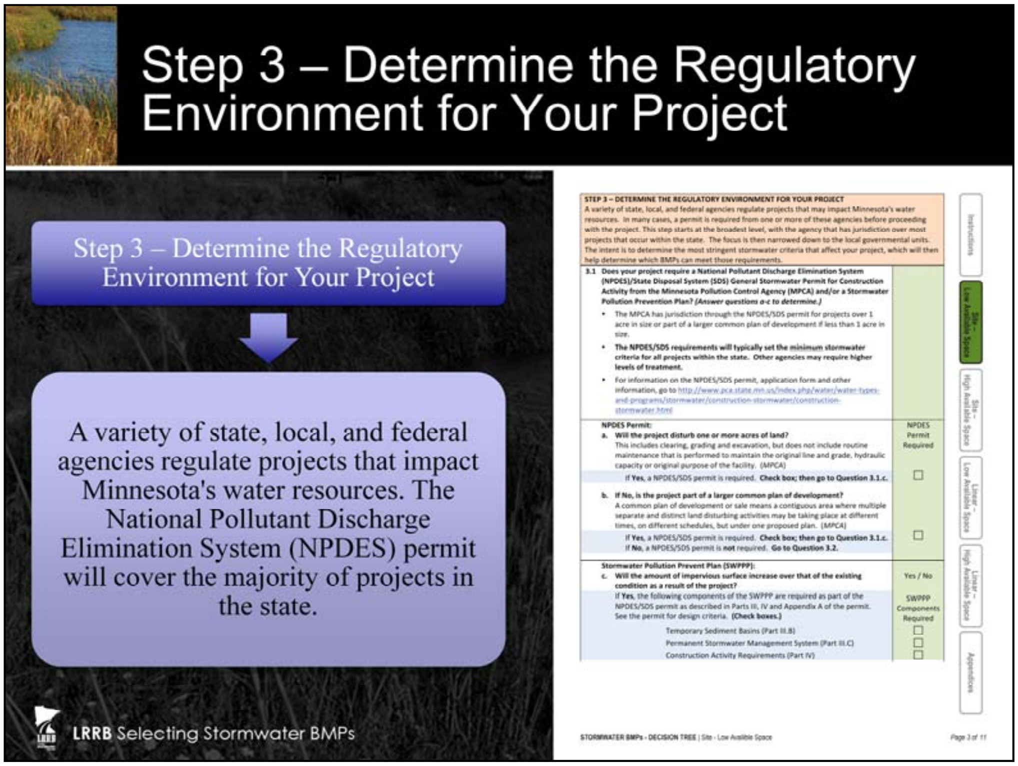
Soil types may affect which BMPs will be practicable or require design modifications

Project setting – may dictate the form and aesthetics of the BMP



Special site considerations: soil/groundwater contamination, shallow groundwater/bedrock, potential stormwater hotspots, DWSMA, karst, etc.

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.



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.

Step 3 – Continued

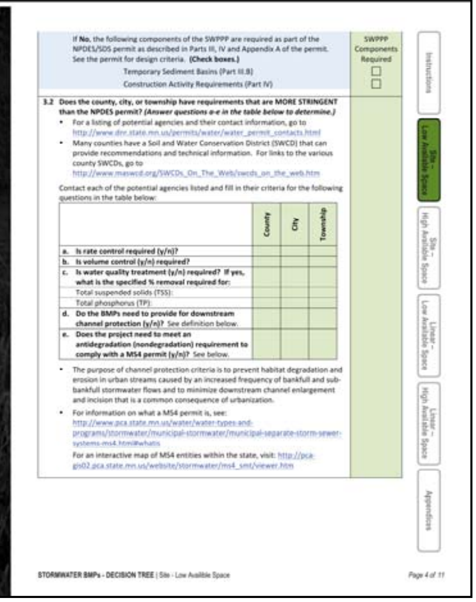
Step 3.2 – Are there other entities with regulatory authority? Which are the most stringent?

County, city, township ordinance?

Watershed district or management organization rules?

Potential requirements:

- Rate control
- Water Quality
- Volume reduction
- Channel protection
- Antidegradation (Nondegradation)



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

Instructions | Site – Low Available Space | Site – High Available Space | Linear – Low Available Space | Linear – High Available Space | Appendices

STORMWATER BMPs - DECISION TREE | Site - Low Availble Space

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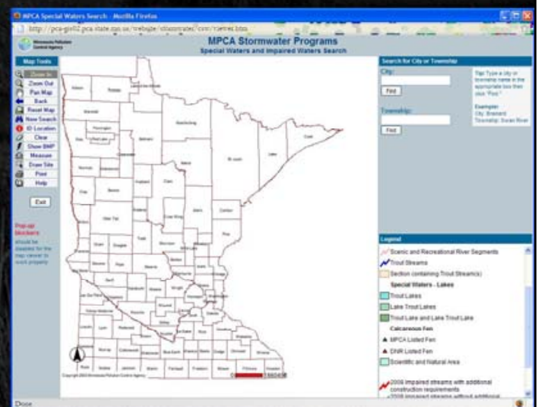
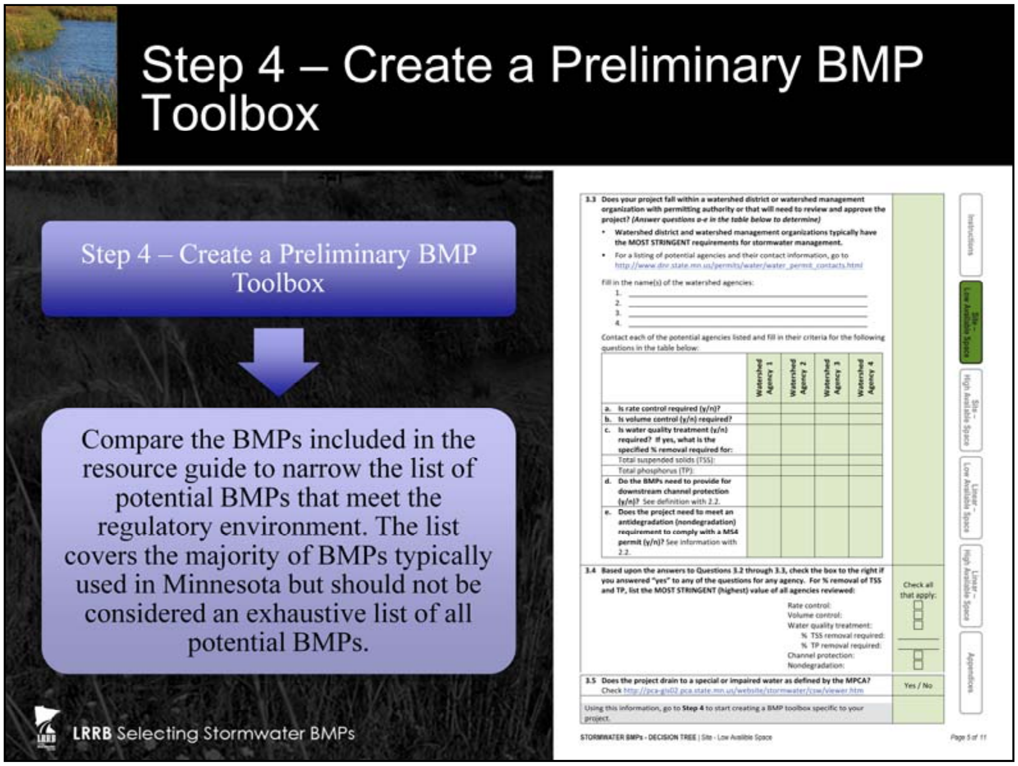
Step 3 – Continued

Step 3.5 – Does the project drain to a special or impaired water?

Check the MPCA website to determine:

http://pca-gis04.pca.state.mn.us/website/stormwater/csw/viewer.htm





Goal = end up with two or three potential BMPs

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.

Step 4 – Continued

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

	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%			85-100%		
TP Removal Required (%)	34-73%			65-100%			0%			0%			100%			45-85%			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. - 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.		
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	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.		

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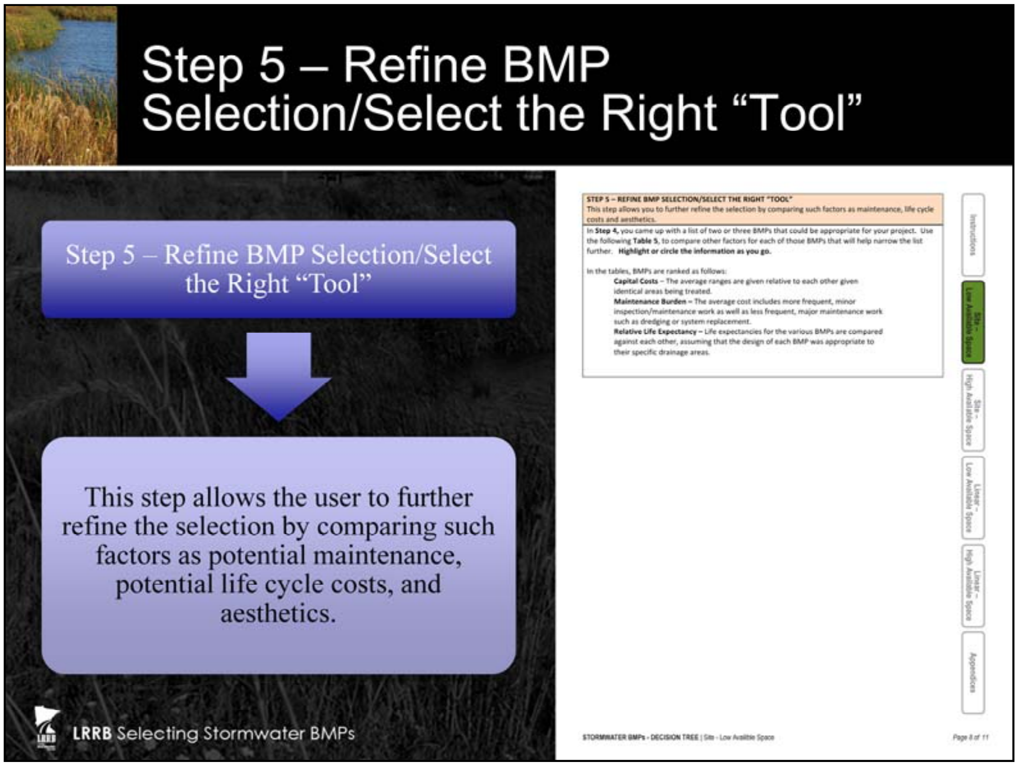
Step 4 – Continued

	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)
Primary Treatment Provided (See question 3.4)		
a. Rate Control	**REC**	**N/A**
b. Volume Control	**N/A**	**REC**
c. Water Quality	**REC**	**REC**
TSS Removal Required (%)	60-90%	85-100%
TP Removal Required (%)	34-73%	65-100%
d. Channel Protection	**REC**	**MAYBE**
e. Nondegradation requirement	**MAYBE**	**REC**
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.
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.
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

Step 4 – Continued

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
Special Site Considerations (See Question 2.5)						
a. There are no special site considerations.	**N/A**	**REC**	**REC**	**N/A**	**REC**	**REC**
b. Soil/groundwater contamination ***Check design with MPCA.***	**N/A**	**MAYBE**	**MAYBE**	**N/A**	**REC** – May require liner depending on type of contamination.	
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.		
e. PSH runoff	**N/A**	**REC** – May require liner and excellent pre-treatment.		**N/A**	**MAYBE** – Use impermeable liner and underdrain.	
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.	
Drainage to Special or Impaired Water (See Question 3.5)	**N/A**	**MAYBE**	**MAYBE**	**N/A**	**REC** – With cautions for use related to PSHs.	

LRRB


Step 5 – Refine BMP Selection/Select the Right "Tool"
Step 5 – Refine BMP Selection/Select the Right "Tool"
This step allows the user to further refine the selection by comparing such factors as potential maintenance, potential life cycle costs, and aesthetics.
LRRB Selecting Stormwater BMPs
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.
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Step 5 – Continued

TABLE 5 – Final BMP Screening

	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	Moderate	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
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 – 3 years
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)							
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 searched 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.

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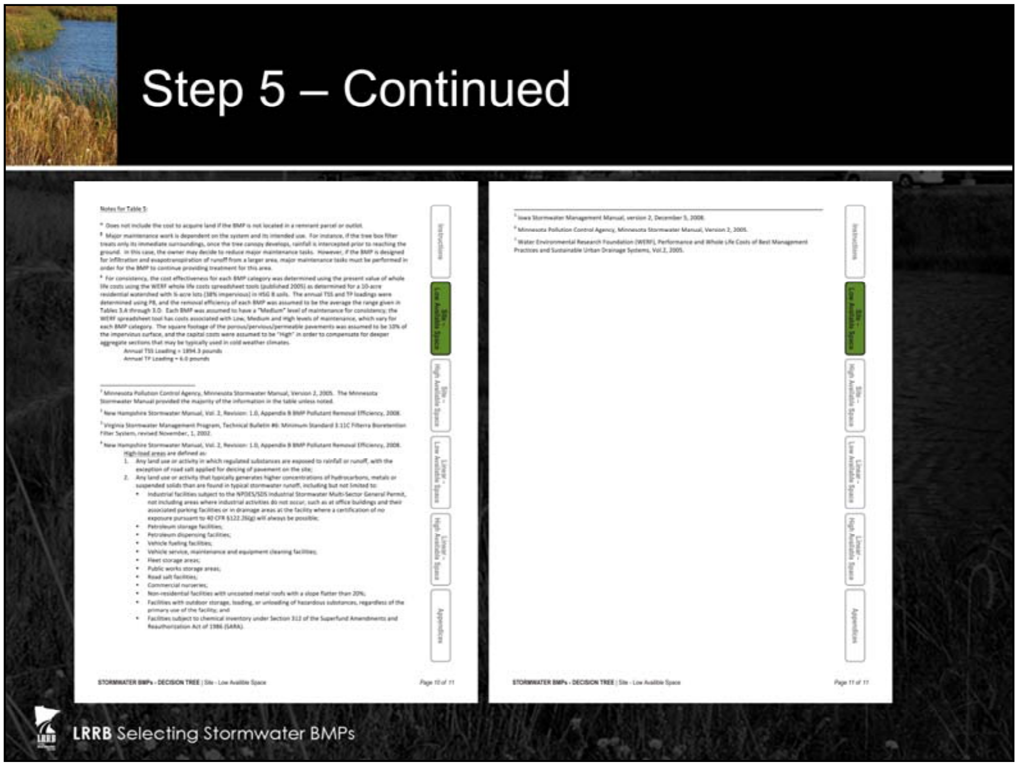
Step 5 – Continued

	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)
Capital Cost	Low $^{\alpha}$	Moderate $^{\alpha}$
Maintenance Burden		
Ease of Mainten-ance (Mn Stm Man)	Easy to medium	Medium
Typical Annual Operations and Maintenance Costs	Low	Low
Typical Major Maintenance Costs	High	Medium to high
Frequency of Major Maintenance	Low – Every 5 - 25 years	Medium to high – Every 1 - 5 years
Relative Life Expectancy	High	Medium
Relative Life Cycle Cost	Low to moderate	Moderate

Step 5 – Continued

Cost Effectiveness per Acre Treated (2005 $/acre)	$30,500	$25,900
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.
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.
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.
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.

LRRB Selecting Stormwater BMPs


Step 5 – Continued
LRRB Selecting Stormwater BMPs

Step 5 – Continued

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.

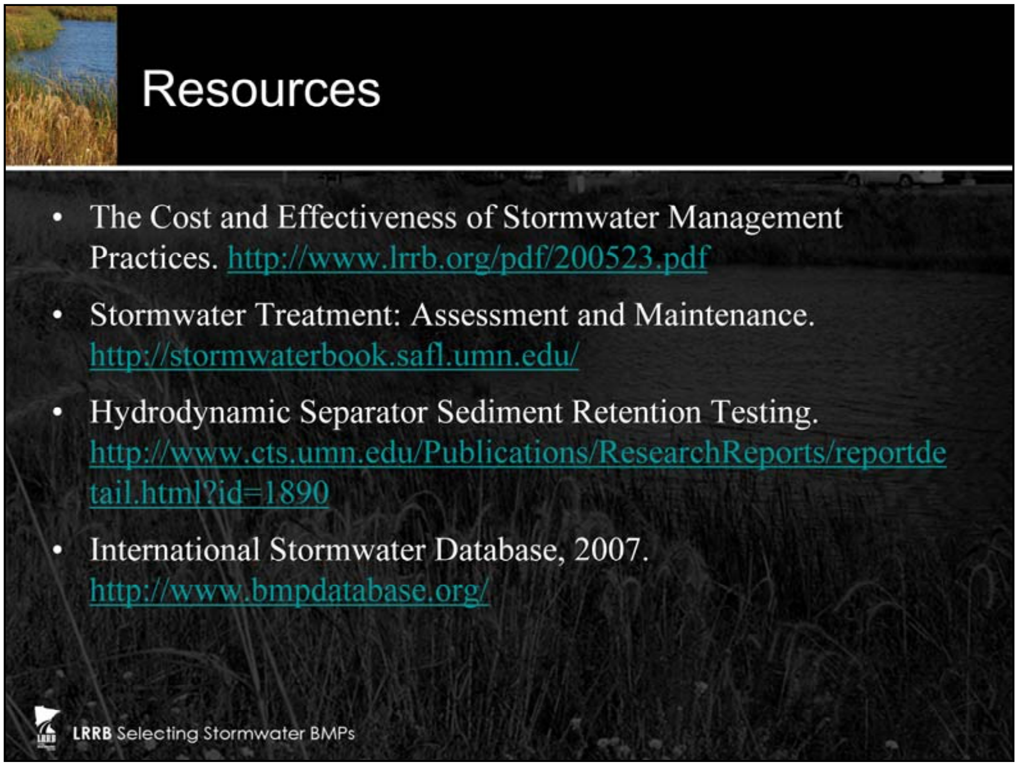
[2] New Hampshire Stormwater Manual, Vol. 2, Revision: 1.0, Appendix B BMP Pollutant Removal Efficiency, 2008.

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

Summary of 5-Step Process

- Assists during the scoping phase of your projects.
  - Typically used when a regional pond is not available.
- Helps select BMPs based upon their performance and your project requirements.
- Provides documentation for how decisions have been made.

LRRB Selecting Stormwater BMPs


Resources
The Cost and Effectiveness of Stormwater Management Practices. http://www.lrrb.org/pdf/200523.pdf
Stormwater Treatment: Assessment and Maintenance. http://stormwaterbook.safl.umn.edu/
Hydrodynamic Separator Sediment Retention Testing. http://www.cts.umn.edu/Publications/ResearchReports/reportdetail.html?id=1890
International Stormwater Database, 2007. http://www.bmpdatabase.org/
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Resources

- Minnesota Stormwater Manual, version 2. http://www.pca.state.mn.us/index.php/water/water-types-and-programs/stormwater/stormwater-management/minnesota-s-stormwater-manual.html
- Urban Stormwater Management in the United States from the National Academy of Sciences. http://www.nap.edu/catalog.php?record_id=12465#toc
- Post-Project Monitoring of BMPs/SUDS to Determine Performance and Whole-Life Costs, Vol. 1. http://www.werf.org/AM/Template.cfm?Section=Search&Template=/CustomSource/Research/PublicationProfile.cfm&id=01-CTS-21T

Resources

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

Resources

- A Public Works Perspective on the Cost vs. Benefit of Various Stormwater Management Practices. http://www.co.washington.mn.us/client_files/documents/phe/ENV/GW-CostBenefit.pdf
- The Economics Of Structural Stormwater BMPs In North Carolina. http://www.bae.ncsu.edu/stormwater/PublicationFiles/EconStructuralBMPs2003.pdf
- Iowa Stormwater Management Manual, ver. 2. http://www.intrans.iastate.edu/pubs/stormwater/index.cfm


Questions?
LRRB website: www.lrrb.org
Find the Decision Tree and this presentation at
http://www.lrrb.org/pdf/2011RIC01.pdf
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