ISSUE PAPERS "I & J"

BMP Fact Sheets and Engineering Specifications Part 1

Date: June 9, 2005

To: Minnesota Stormwater Manual Sub-Committee

From: EOR and CWP

INTRODUCTION

The Stormwater Steering Committee has created a vision of a manual that will be the first stop for Minnesotans who are interested in applying proper stormwater management practices to their site, whether the site is an entire watershed, a single family lot or something in between. Volume 1 will focus on who, what, where, when and why of northern climate stormwater management, while Volume 2 will be the place to go to guide the user on the question of how to properly manage stormwater. Please refer to Issue Paper A, dated November 4, 2004 for additional background on the organization of the upcoming stormwater manual as well as descriptions of BMP lists and selection matrices.

This issue paper is the first of two papers that focus on the Best Management Practice content to be included in Volume 2. The Manual Sub-Committee may recall that initially the consultant team had proposed to divide the discussion of best management practices into two issue paper sessions: the first focused on Engineering Specifications and the second on Operation, Maintenance and Cost. At the March sub-committee meeting, the group concurred with a proposal to reorganize these final two issue papers such that each issue paper will include the full content of one BMP specification, containing fact sheets, engineering specifications, O&M considerations and cost estimation.

The BMPs listed in Issue Paper A have been divided into the following sets for Issue Papers I and J:

Issue Paper I/J – Part 1

Pollution Prevention Fact Sheets
Better Site Design Fact Sheets
Runoff Volume Minimization Fact Sheets
Bioretention Devices Fact Sheet and Engineering Specifications
Stormwater Filtration Practices Fact Sheet and Engineering Specifications
Infiltration Practices Fact Sheet and Engineering Specifications

Issue Paper I/J – Part 2 (July, 2005)

Temporary Construction Sediment Control Fact Sheets
Stormwater Ponds Fact Sheet and Engineering Specifications
Stormwater Wetlands Fact Sheet and Engineering Specifications
Supplemental Pre- and Post-Treatment BMP Fact Sheets

Much of the content of these engineering papers has been taken from other well-prepared stormwater manuals. The consultant team relied on many sources, but most content is from the following:

Vermont
Georgia
Connecticut
Wisconsin
Metropolitan Council
Rice Creek Watershed District

This is the first draft of engineering papers for review by the Manual Sub-Committee. The committee is asked to look at three aspects of the product:

Visual organization
General content, outline and structure
Specific Technical Content

Reviewers should keep in mind that these papers are still evolving. Technical inconsistencies will constantly be corrected as the manual moves into final production. Electronic links will be added as a last step, to best preserve the currency of ever changing web addresses. Throughout this issue paper are content and technical questions raised by the consultant team for consideration by the Manual Sub-Committee which will be incorporated into later drafts.

ISSUE PAPER A – BMP ORGANIZATION

The following is a refresher on the BMP recommendations contained in Issue Paper A. Issue Paper A served as framework for these engineering papers; but we have allowed some aspects of the organization to further evolve. The following is an update of the list of engineering papers from Issue Paper A:

Non-Structural or Planning Level BMPs - The first level of BMP application occurs at the planning stage and is intended to minimize the impact of development. The process set out in the manual will promote site design and practices that prevent pollution and minimize the increase in stormwater volume. The result will be smaller end-of-the pipe stormwater facilities. The manual will be prepared with these at the forefront so that the impacts of both stormwater runoff quality and quantity problems are considered prior to initiation of activity. The first three groupings are intended to address these aspects of runoff management. We propose to describe these BMPs in the Manual in narrative terms (fact sheets), as opposed to preparing full engineering sheets as will be done for the structural BMPs.

Better Site Design

- Natural area conservation (reforestation, stream/shoreline/wetland buffers)
- Open space design
- Reduction of impervious surfaces including roof leader, parking lots, driveway and sidewalk disconnection, and reduced street width
- Grass channels in lieu of curb and gutter
- Soil amendments

Pollution Prevention Practices: Residential, Commercial/Industrial, Municipal

- Housekeeping including landscaping, street sweeping, pavement maintenance, catch basin maintenance and litter control
- Atmospheric controls including wind erosion and dust, as well as regulatory emission regulations
- Chemical controls including salt management, fertilizer/pesticide management and spill prevention
- Animal waste management
- Stream-bank stabilization

Runoff Volume Minimization: Volume Reduction

- Pervious pavement

Runoff Volume Minimization: Capture and Reuse

- Green roofs/rooftop gardens
- Rain barrels/cisterns

Temporary Construction Sediment Control

- Pre-construction
- Resource protection (buffers)
- Runoff control (sediment control basins)
- Perimeter controls (access and egress, inlet protection)
- Slope stabilization
- Rapid stabilization of exposed soils
- Inspection and maintenance

Structural BMPs - The BMPs that follow will have a "fact sheet" summarizing the BMP with additional pages of engineering details. Design variations will be part of the sheet compilation: for example, ponds are a single category, with variable features of pond design such as storage volume and physical configuration described within the design sheet.

Bioretention

- Rain gardens
- Depressed parking lot islands
- Stormwater planters

Filtration (can be pre-treatment or focus of full treatment)

- Media filters (surface, underground, perimeter/Delaware) described by media and function
- Surface flow (vegetative) filters including narrative on limitations for water quality improvement

Infiltration

- Trenches
- Basins
- Underground infiltration systems
- Drywells

Ponds (design based upon components needed to fulfill the desired function)

- Components include forebay/pre-treatment, various storage volumes, physical configuration
- Functions include water quality (including thermal impact) and flow control (rate and volume), which determine whether they are wet/dry or some combination

Wetlands (selection criteria similar to ponds)

- Components include pre-treatment (see also next section), various storage volumes (detention needed), biologic character
- Functions include primarily water quality and flow control, but could also include ecological factors

Supplemental Pre- and Post-Treatment BMPs - The final category of BMPs are those that are generally, but not always, included in the stormwater treatment train as a supplement to the primary treatment device. There is the possibility, however, that these devices could be the only BMP used. Our approach will be to describe these in less detail than the previous sections. Instead, the designer will be guided through a process of determining the function a generic device serves within the treatment train. Once manufacturers are involved, then each designer should be able to assess the proposed device against the needed function. We will also generically describe the proprietary device categories rather than listing individual companies and risking some omissions.

Supplemental Treatment (discussed for function within a treatment train)

- Proprietary sediment removal devices
- Catch basin inserts
- Wet vaults
- Chemical treatment* (ferric chloride, alum, polyacrylamides)
- Skimmers
- Sorbents
- Thermal protection (ex. maintain tree canopy)
- Biological additives (ex. chitosan)

* Note: these chemical treatments will have limited use in the State of Minnesota because of the potential toxic effects associated with them; care will be taken to assess these impacts in the BMP discussions.

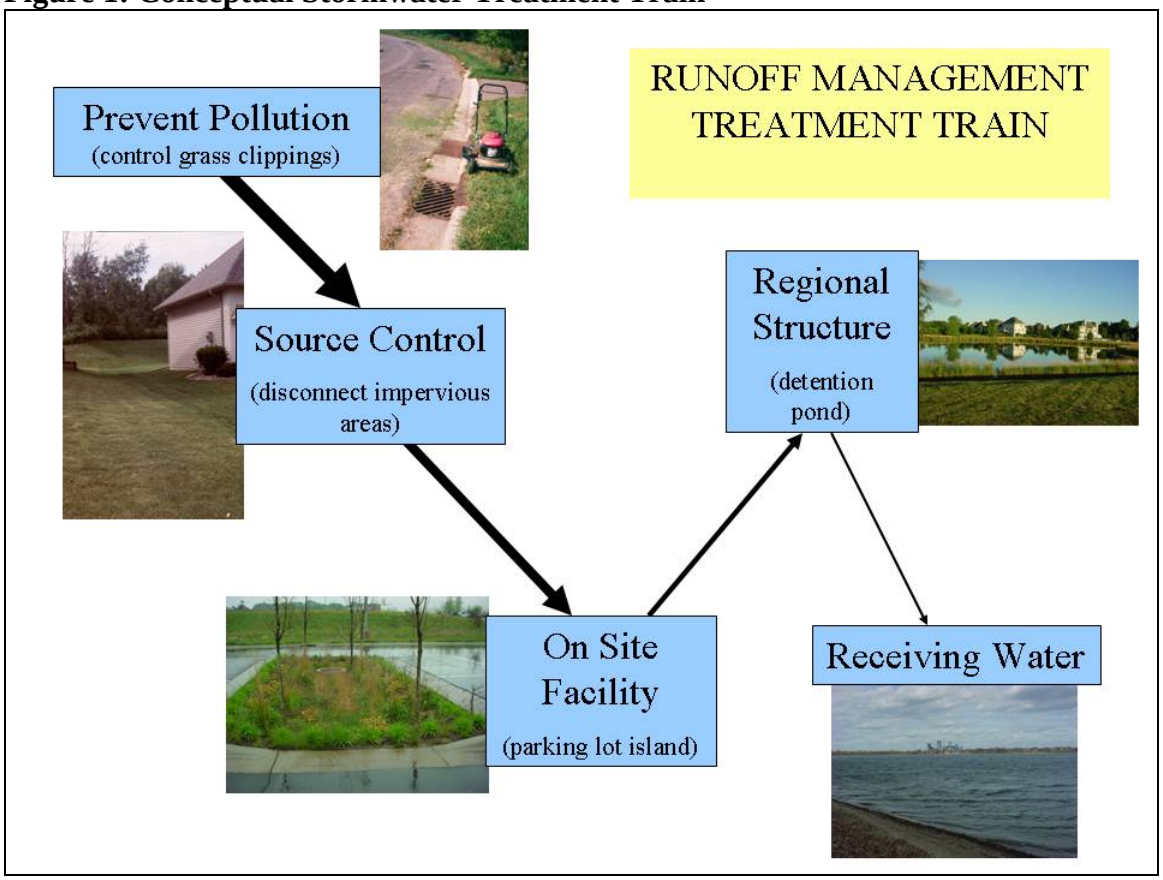
CREATING A STORMWATER MANAGEMENT SYSTEM

The target audience for the Manual is the stormwater practitioner who needs to know about all facets of proper stormwater management. This could include a city water planner, an engineering consultant, a state regulator, a watershed manager or any of a number of other potential users. The Manual is designed to address variable levels of expertise, but it is not all-inclusive because of the need to keep it a manageable size. For this reason, when appropriate, links will take the user to many excellent documents already available. Those users who already know material presented in the Manual need only peruse it for a refresher if needed, then move on to the element they need.

The manual will present BMPs as components within a multifaceted system of stormwater management. It will be set up to lead designers and/or site managers through a process of pollution prevention and runoff volume controls before locating and sizing structural BMPs. It is always assumed that the first step in stormwater management is to reduce the amount of runoff occurring by soaking in as much precipitation as possible where it occurs. Because full runoff reduction is usually not possible, the Manual will show us ways to reduce exposing polluting material to runoff by keeping our land surfaces clean. When polluting materials cannot be kept out of runoff, a mix of simple to complex best management practices or BMPs are presented to reduce the amount of pollution that gets to our state's receiving waters. Best Management Practices will be

presented as components of a properly managed stormwater system rather than a practice to plunk onto the site at the end of a pipe, as shown in the schematic in Figure 1.

Figure 1: Conceptual Stormwater Treatment Train



Issue Paper A presented a set of steps to guide a designer through BMP selection. Subsequent issue papers presented information on other aspects of site based stormwater management, including sizing, cold climate considerations and receiving water criteria. The initial steps are presented below, and supplemented with additional steps to guide the user through the entire process of stormwater management. This is the feature of the manual that will bring together procedures that were discussed in detail in previous issue papers.

Step A: Establish pollution prevention practices

Issue Paper A	BMP List and Selection Matrix
Issue Paper H	Potential Stormwater Hotspots, Pollution Prevention, Groundwater Concerns and Related Issues
Issue Paper I	Engineering Specifications – Part 1

Step B: Design site to minimize runoff

Issue Paper A	BMP List and Selection Matrix

Issue Paper D	Unified Sizing Criteria
Issue Paper I	Engineering Specifications – Part 1

Step C: Select temporary construction sediment control techniques

Issue Paper A	BMP List and Selection Matrix
Issue Paper J	Engineering Specifications – Part 2

Step D: Evaluate site specific factors

Identify watershed factors

Issue Paper A	BMP List and Selection Matrix
Issue Paper E	Receiving Water Based Stormwater Criteria

Identify climate and terrain factors

Issue Paper A	BMP List and Selection Matrix
Issue Paper G	Cold Climate Considerations
Issue Paper H	Potential Stormwater Hotspots, Pollution Prevention, Groundwater Concerns and Related Issues

Evaluate stormwater treatment suitability

Issue Paper E	Receiving Water Based Stormwater Criteria
Issue Paper H	Potential Stormwater Hotspots, Pollution Prevention, Groundwater Concerns and Related Issues

Assess physical feasibility at the site

Issue Paper A	BMP List and Selection Matrix
Issue Paper H	Potential Stormwater Hotspots, Pollution Prevention, Groundwater Concerns and Related Issues

Identify community and environmental factors

Issue Paper A	BMP List and Selection Matrix
Issue Paper C	Regulatory Framework

Identify location specific restrictions and setbacks

Issue Paper A	BMP List and Selection Matrix
Issue Paper H	Potential Stormwater Hotspots, Pollution Prevention, Groundwater Concerns and Related Issues

Step E: Compute water quantity sizing

Issue Paper B	Precipitation Frequency Analysis and Use
Issue Paper D	Unified Sizing Criteria for Minnesota

Step F: Select structural BMPs

Issue Paper A	BMP List and Selection Matrix
Issue Paper I&J	Engineering Specifications

Step G: Size structural BMPs

Issue Paper I&J Engineering Specifications

Step H: Create O&M Plan

Issue Paper I &J Engineering Specifications

STEP F: SELECT BEST MANAGEMENT PRACTICE

Using the procedures set up in the Minnesota Stormwater Manual, it is conceivable that two or three BMPs could be linked together within one site. For example, overflow from a bioretention device could flow to a vegetated filter/swale, which discharges into a stormwater pond. The treatment train approach allows Best Management Practices to be incorporated throughout the site rather than the traditional location at the end-of-pipe. Following the steps detailed in the section above, the site designer can establish specific site and receiving water considerations. At this point the specific BMP that fits the characteristics of the stormwater as well as the needs of the site can be selected. The planner/designer/operator will understand which pollutants must be removed from the stormwater runoff and will have identified the most appropriate locations on the site for structural BMP. Table 1 can then be used to select the BMP that fits the pollutant of concern.

Table 1: Primary and Secondary BMP Pollutant Removal Mechanisms

BMP Group	Mechanisms									
	Water Quality						Water Quantity			
	Screening/ Filtration	Infiltration/ Recharge	Settling	Biological Uptake	Temperature Control	Soil Adsorption	Volume Control	Rate Control	Velocity Control	Evapo-transpiration
Pollution Prevention	**Not applicable – pollutants not exposed to stormwater**									
Minimize Volume		**s**			**s**		**P**	**s**		
Construction Sediment Control										
Bioretention Devices	**P**	**s**	**s**	**s**		**s**	**s**	**s**		**s**
Filtration Practices	**P**	**s**		**s**		**s**		**s**		**s**
Infiltration Practices	**s**	**P**		**s**	**P**	**s**	**s**	**s**		
Ponds										
Wetlands										
Supplemental Treatment	**Each supplemental and proprietary device should be carefully studied to learn the primary and secondary pollutant removal functions.**									
P = Primary Pollutant Removal Mechanism s = Secondary Pollutant Removal Mechanism										

STEP G: SIZE BMPs
STEP H: PREPARE O&M MANUAL

ENGINEERING PAPERS - GENERAL

The engineering specifications included in the appendices of this issue paper are intended to be a guide for designers to follow. General information of BMP suitability as well as detailed design guidance is included. Each engineering specification starts with a two page fact sheet that can be used as a stand-alone education piece or as an introduction to the more detailed information contained in the longer specifications. Pollution Prevention, Runoff Minimization, Temporary Sediment Control and Supplemental Practices are presented as a series of two page fact sheets. Bioretention Devices, Filtration Practices, Infiltration Practices, Ponds and Wetlands contain the expanded engineering specifications.

Issue: Is the fact sheet format balanced and useable as a stand-alone document?

The infiltration practices engineering paper was formatted to the style proposed for the final manual. Due to the evolving content of all the papers, we limited the final formatting to this one paper plus all the fact sheets. The content of the bioretention and filtration papers are presented as content only, and will be formatted in the draft manual. Included in each specification are discussions of BMP suitability, major design elements, design procedures, O&M procedures, cost determinations, and references.

Issue: are there any important topics missing from the format of the engineering papers? Is the flow of information properly organized?

BMP Suitability

The goal of this section is to allow the designer to conduct a preliminary screening to learn if the BMP is feasible for the site.

Design Elements

This section will discuss the major features of each BMP variant described in the section. In addition to the typical design elements, the papers include discussions of cold climate design modifications and retrofit feasibility.

Design Procedures

Step by step procedures, loosely based on the procedures in the Georgia Stormwater Manual, with modifications appropriate for Minnesota are included. It should be noted that the steps refer the designer back to Better Site Design procedures in order that the space dedicated to stormwater management within any site is optimized for both location and size. The procedures suggest that designers fit the stormwater practice into the space available, then check the hydraulics to determine if the size is adequate for managing the Water Quality Volume (see Issue Paper D: Unified Sizing Criteria). This technique

works well for infiltration, for example, since it may be advantageous to infiltrate as much runoff as the site allows. Bioretention and Filtration guidance recommend sizing based on water quality volume. The Minnesota procedure is purposely intended to optimize the space available for BMPs on each site.

O&M Procedures

Operation and Maintenance is discussed in terms of phasing:

Design Phase Maintenance Considerations
Construction Phase Maintenance
Post Construction Operation and Maintenance

It will be recommended that designers prepare an operation and maintenance manual that is specific to the site and BMPs. Such a manual should include inspection and maintenance checklists for the site caretakers. The Minnesota Stormwater Manual will include recommended checklists in the appendix to the final manual.

Cost Considerations

The cost considerations section of the engineering papers are set up to guide users through developing a cost to construct, operate and maintain the BMPs selected for their sites. In reports researched for this issue paper, it was found that typically BMP construction cost is presented as a cost per area. Often it can be unclear whether the area is the size of the site or the size of the BMP. Such generic costs are useful for approximating the cost of stormwater management; however actual costs may be highly variable based on site specific conditions, such as site slopes or soils conditions. Other complications with overly simplified BMP costs include variability in unit prices due to either inflation and/or regional differences in a state the size of Minnesota. Therefore, it is proposed that construction and O&M costs in these BMP Engineering Specifications contain components of cost estimation for each structural BMP. Worksheets containing specific unit costs and regional indices will be contained in the Appendices of the final manual.

A state the size of Minnesota does have regional variations in unit prices. The final manual will use unit costs for St. Paul with an index factor to apply to other cities. Users interested in other locations in the state should select the city closest to their site and multiply the St. Paul based cost by the recommended index. The following indices were based on RSMeans data for Spring, 2005:

Bemidji	0.963
Brainerd	1.003
Detroit Lakes	0.962
Duluth	0.991
Mankato	0.990
Minneapolis	1.035
Rochester	0.983
St. Paul	1.000

St. Cloud	1.002
Thief River Falls	1.042
Willmar	0.961
Windom	0.935

In April, 2005 the University of Minnesota, Department of Civil Engineering published a report on the cost effectiveness of stormwater management practices. This paper studies the actual cost and pollutant removal capabilities of actual BMPs from throughout the United States. This is a valuable report for people interested in learning more about the comparative costs/benefits of pollutant removal for structural BMPs.

Issue: should the Minnesota Stormwater Manual include both generic unit costs for specific BMPs in addition to the cost worksheets described above? Pros and cons include:

Pros:	Easy to use to determine general budgets
	Appropriate for feasibility studies
Cons:	Site variability could result in actual costs being dramatically different than generic unit costs.

Engineering Specifications

Engineering specifications that describe more detailed material requirements and/or construction practices will be included in the appendix of the final manual. Creation of an appendix with technical specifications eliminates duplication of information that is applicable to multiple BMPs.

The final engineering specifications will reference Mn/DOT material and construction specifications where appropriate. Mn/DOT is preparing to retire their 2000 Standard Specifications and replace with a new and improved 2005 edition. Since the 2005 edition will included expanded requirements for stormwater management, it is appropriate to wait for the new specifications before creating references in the Minnesota Stormwater Manual.

POLLUTION PREVENTION PRACTICES

As discussed in many places in the Minnesota Stormwater Manual, the first step in stormwater management will be for the stormwater manager/planner to remove potential pollutants from the stormwater path before they are mobilized by runoff. This technique is important for all property owners, regardless of the land use, and regardless if the site is to be retrofitted, planned or under construction. Property owners will need to understand the various sources of pollutants of their property and recommended pollution

prevention practices. The following graphic from Issue Paper H demonstrates the potential sources from a larger commercial or industrial site.

Figure 2: Potential Pollutant Sites

Pollution prevention could be organized by type of pollutant (such as fertilizer use), by type of practice (such as sweeping) or by land use. For this manual, the consultant team has elected to present pollution prevention techniques as sets of practices organized by land use: residential, commercial/industrial, and municipal. The result is three fact sheets, contained in Appendix A, that are aimed at instructing property managers of all the practices they should incorporate into their property maintenance routines.

RUNOFF MINIMIZATION TECHNIQUES

Runoff minimization techniques, important components of better site design (BSD), low impact development (LID), conservation design and sustainable development, are beneficial for both new construction and retrofit projects. These techniques are appropriate for all sizes of sites. Because these techniques either reduce or minimize the volume of runoff, incorporation of these into site designs will result in smaller structural BMPs. Net benefits can include less land dedicated to structural stormwater management, lower BMP construction expenses, and lower BMP O&M costs.

BIORETENTION DEVICES

Other state stormwater manuals have presented bioretention devices as a sub-set of filtration or infiltration practices. Due to the growing popularity of bioretention, plus the ease of locating in upper portions on a site, the Minnesota Stormwater Manual will present bioretention as the first structural BMP for the stormwater treatment train.

FILTRATION PRACTICES

Filtration is a well developed practice with much guidance information available. However, winter issues often discourage designers from applying filtration to a Minnesota site. A thorough cold climate section in this engineering paper elaborates on design features that will ensure successful operation in Minnesota.

INFILTRATION PRACTICES

Infiltration is relatively new to Minnesota, but the use is rapidly gaining acceptance. Yet there are design features that deserve thorough discussion:

Minimum depth between bottom of basin and groundwater or bedrock
Minnesota Pollution Control Agency allows a minimum separation of 3 feet. In comparison, the Wisconsin DNR set the minimum separation at 5 feet. This depth changes from state to state, with the least restrictive in Minnesota. The consultant team strongly recommends that the MPCA consider changing to a minimum depth of 5 feet to ensure that the temporary groundwater mound that is created during active infiltration does not intersect the bottom of the infiltration basin. An unsaturated vadose zone is necessary for proper pollutant removal by the soils. If the entire zone between the infiltration basin and the seasonal high groundwater table is saturated by the temporary groundwater mound, then the effective zone for pollutant removal is eliminated.

Soil infiltration rates: field testing or average long-term rates?
Three techniques for determining infiltrattion rates have been used by designers: laboratory testing, field testing, and average long-term rates from operating infiltration basins. Laboratory testing typically results in very rapid soil infiltration rates that cannot be duplicated in the field. Therefore many designers prefer field testing for infiltration rates. While field testing will predict the pre-construction infiltration rate, it may or may not reflect the post-construction infiltration rate. Post construction will change the hydrology at the infiltration location and will change the level of pollutants and solids contained in the runoff. Long-term averages from actual sites, for each hydrologic soil group, reflects the decline in infiltration rates caused by clogging and frequent saturation.

Should Minnesota develop an infiltration modeling tool?
Wisconsin has developed a continuous simulation infiltration model that can be used to predict the seasonal variability in infiltration basin operation. The model, named RECARGA, is an excellent tool for designers to use to ensure that the water quality volume is fully infiltrated before the next storm begins. The Wisconsin model is

available for use outside their state, but there are differences in soils and rainfall frequency in Minnesota that cannot be adjusted in their model. The best tool for Minnesota would be one that is specific to the conditions in our state. Creation of a similar tool is strongly advised.

APPENDIX A: Pollution Prevention Fact Sheets

APPENDIX B: Runoff Minimization Fact Sheets

APPENDIX C: Bioretention Devices Fact Sheet and Engineering Specifications

APPENDIX D: Filtration Practices Fact Sheet and Engineering Specifications

APPENDIX E: Infiltration Practices Fact Sheet and Engineering Specifications

APPENDIX F: Construction Inspection Checklists

APPENDIX G: Operation, Maintenance and Management Inspection Checklists