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# Calculating credits for sand filter



Page video summary ([http://stormwater.pca.state.mn.us/index.php?title=File:Credit\\_page\\_descriptions.mp4](http://stormwater.pca.state.mn.us/index.php?title=File:Credit_page_descriptions.mp4))



**Warning:** Models are often selected to calculate credits. The model selected depends on your objectives. For compliance with the Construction Stormwater permit, the model must be based on the assumption that an instantaneous volume is captured by the BMP.

Credit ([http://stormwater.pca.state.mn.us/index.php/Overview\\_of\\_stormwater\\_credits](http://stormwater.pca.state.mn.us/index.php/Overview_of_stormwater_credits)) refers to the quantity of stormwater or pollutant reduction achieved either by an individual **best management practice** (BMP) or cumulatively with multiple BMPs. Stormwater credits are a tool for local stormwater authorities who are interested in

- providing incentives to site developers to encourage the preservation of natural areas and the reduction of the volume of stormwater runoff being conveyed to a best management practice (BMP);
- complying with permit requirements, including antidegradation (see Construction permit ([https://stormwater.pca.state.mn.us/index.php?title=Construction\\_stormwater\\_program](https://stormwater.pca.state.mn.us/index.php?title=Construction_stormwater_program)); Municipal (MS4) permit ([https://stormwater.pca.state.mn.us/index.php?title=Stormwater\\_Program\\_for\\_Municipal\\_Separate\\_Storm\\_Sewer\\_Systems\\_\(MS4\)](https://stormwater.pca.state.mn.us/index.php?title=Stormwater_Program_for_Municipal_Separate_Storm_Sewer_Systems_(MS4)))); meeting the MIDS performance goal ([http://stormwater.pca.state.mn.us/index.php/Performance\\_goals\\_for\\_new\\_development\\_redevelopment\\_and\\_linear\\_projects](http://stormwater.pca.state.mn.us/index.php/Performance_goals_for_new_development_redevelopment_and_linear_projects)); or meeting or complying with water quality objectives, including **total maximum daily load** ([https://stormwater.pca.state.mn.us/index.php?title=Total\\_Maximum\\_Daily\\_Loads\\_\(TMDLs\)](https://stormwater.pca.state.mn.us/index.php?title=Total_Maximum_Daily_Loads_(TMDLs))) (TMDL) **wasteload allocations** (WLAs).

**Recommended pollutant removal efficiencies, in percent, for sand filters. Sources ([http://stormwater.pca.state.mn.us/index.php/Information\\_on\\_pollutant\\_removal\\_by\\_BMPs#References](http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs#References)).**

TSS=total suspended solids; TP=total phosphorus; PP=particulate phosphorus; DP=dissolved phosphorus; TN=total nitrogen

TSS	TP	PP	DP	TN	Metals	Bacteria	Hydrocarbons
85	50	91	0	35	50	80	80

This page provides a discussion of how sand filter practices can achieve stormwater credits.

## Contents

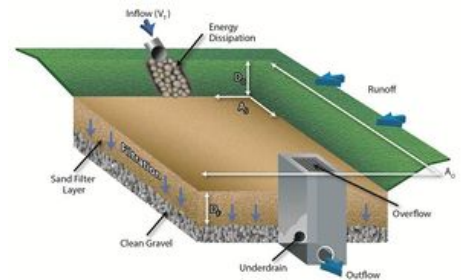
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## Overview

**Sand filters** (<https://stormwater.pca.state.mn.us/index.php?title=Filtration>) are **filtration** (<https://stormwater.pca.state.mn.us/index.php?title=Filtration>) practices that use sand media to filter and remove pollutants from stormwater before entering the downstream stormwater system or BMP.

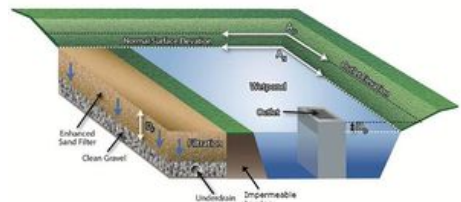
Enhanced sand filters, also known as **iron-enhanced sand filters** ([https://stormwater.pca.state.mn.us/index.php?title=Iron\\_enhanced\\_sand\\_filter\\_\(Minnesota\\_Filter\)](https://stormwater.pca.state.mn.us/index.php?title=Iron_enhanced_sand_filter_(Minnesota_Filter))) or Minnesota Filters, use iron mixed with the filter media to improve removal of dissolved constituents from the stormwater. Common types of sand filters ([http://stormwater.pca.state.mn.us/index.php/Types\\_of\\_iron\\_enhanced\\_sand\\_filter](http://stormwater.pca.state.mn.us/index.php/Types_of_iron_enhanced_sand_filter)) are perimeter filters, surface filters, or underground filters. Enhanced sand filters are commonly implemented as filtration basins, or as filtration benches for **wet ponds** ([https://stormwater.pca.state.mn.us/index.php?title=Stormwater\\_ponds](https://stormwater.pca.state.mn.us/index.php?title=Stormwater_ponds)). Because sand filters are not designed to **infiltrate** ([https://stormwater.pca.state.mn.us/index.php?title=Stormwater\\_infiltration\\_Best\\_Management\\_Practices](https://stormwater.pca.state.mn.us/index.php?title=Stormwater_infiltration_Best_Management_Practices)) or store stormwater, all filters require use of an **underdrain** to convey treated stormwater out of the system.



Schematic illustrating the components and processes for a sand filter system.

## Pollutant Removal Mechanisms

Sand filters primarily remove pollutants through settling and filtration of solids, whereas enhanced sand filters also remove pollutants through chemical binding. Additionally, surface sand filters that incorporate vegetation into the practice will provide biological removal of nutrients via uptake by the vegetation (WEF, Design of Urban Stormwater Controls). While enhanced sand filters are effective in screening solids, the primary water quality benefits they provide are the removal of dissolved constituents including metals and phosphates. Sand filters and enhanced sand filters are not designed to infiltrate and therefore do not provide stormwater volume reduction benefits. Other pollutants ([http://stormwater.pca.state.mn.us/index.php/Calculating\\_credits\\_for\\_sand\\_filter#Other\\_pollutants](http://stormwater.pca.state.mn.us/index.php/Calculating_credits_for_sand_filter#Other_pollutants)) may be addressed by sand filters and enhanced sand filter practices.



Schematic illustrating the components and processes for an enhanced sand filter system.

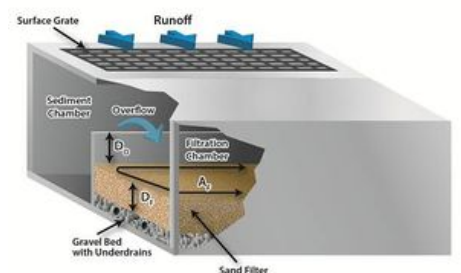
Discussion of pollutant removal and credits for enhanced sand filters are discussed in a separate article ([http://stormwater.pca.state.mn.us/index.php/Calculating\\_credits\\_for\\_iron\\_enhanced\\_sand\\_filter](http://stormwater.pca.state.mn.us/index.php/Calculating_credits_for_iron_enhanced_sand_filter)).

## Location in the Treatment Train

**Treatment trains** ([https://stormwater.pca.state.mn.us/index.php?title=Using\\_the\\_treatment\\_train\\_a\\_proach\\_to\\_BMP\\_selection](https://stormwater.pca.state.mn.us/index.php?title=Using_the_treatment_train_a_proach_to_BMP_selection)) are comprised of multiple **best management practices (BMPs)** that work together to minimize the volume of stormwater runoff, remove pollutants, and reduce the rate of stormwater runoff being discharged to Minnesota wetlands, lakes and streams. Sand filters may be used in a treatment sequence as **pretreatment** (<https://stormwater.pca.state.mn.us/index.php?title=Pretreatment>) for other structural controls, or as a stand-alone BMP.

## Methodology for calculating credits

This section describes the basic concepts and equations used to calculate credits for Total Suspended Solids ([http://stormwater.pca.state.mn.us/index.php/Total\\_Suspended\\_Solids\\_%28TSS%29\\_in\\_stormwater](http://stormwater.pca.state.mn.us/index.php/Total_Suspended_Solids_%28TSS%29_in_stormwater)) (TSS) and Total Phosphorus (TP). Specific methods for calculating credits are discussed later in this article. No volume credit can be obtained for sand filters or enhanced sand filters. Enhanced sand filters are effective at reducing concentrations of other pollutants such as metals. This article does not provide information on calculating credits for pollutants other than TSS and phosphorus, but references ([https://stormwater.pca.state.mn.us/index.php?title=Calculating\\_credits\\_for\\_sand\\_filter#References\\_and\\_suggested\\_reading](https://stormwater.pca.state.mn.us/index.php?title=Calculating_credits_for_sand_filter#References_and_suggested_reading)) are provided that may be useful for calculating credits for other pollutants.



Schematic illustrating the components and processes for a perimeter sand filter system.

## Assumptions and approach

In developing the credit calculations, it is assumed the sand filter practice is properly designed, constructed, and maintained in accordance with the Minnesota Stormwater Manual. If any of these assumptions is not valid, the BMP may not qualify for credits or credits should be reduced based on reduced ability of the BMP to achieve pollutant reductions. For guidance on design, construction, and maintenance, see the appropriate article within the sand filter section of the Manual.

**Warning:** Pretreatment is required for all filtration practices

In the following discussion, the **Water Quality Volume** ([https://stormwater.pca.state.mn.us/index.php?title=Water\\_quality\\_criteria](https://stormwater.pca.state.mn.us/index.php?title=Water_quality_criteria)) ( $V_{WQ}$ ) is delivered as an **instantaneous volume** to the BMP. The  $V_{WQ}$  is stored as water ponded above the filter media and below the overflow point in the BMP. The  $V_{WQ}$  can vary depending on the stormwater management objective(s). For construction stormwater ([https://stormwater.pca.state.mn.us/index.php?title=Construction\\_stormwater\\_program](https://stormwater.pca.state.mn.us/index.php?title=Construction_stormwater_program)), the water quality volume is 1 inch times the area of new impervious surface. For Minimal Impact Design Standards ([http://stormwater.pca.state.mn.us/index.php/Minimal\\_Impact\\_Design\\_Standards](http://stormwater.pca.state.mn.us/index.php/Minimal_Impact_Design_Standards)) (MIDS), the  $V_{WQ}$  is 1.1 inches times the area of impervious surface.

## Volume credit calculations

Sand filters and enhanced sand filters do not provide water quantity control and therefore no volume credit is given.

## Total suspended solid (TSS) credits

The water quality credits for sand filters and enhanced sand filters are based on the treatment volume capacity of the BMP. This equates with volume of water filtered through the BMP before reaching the underdrain ( $V_F$ ). The treatment volume is assumed to be the volume of water that can be stored above the filter media. The event-based volume,  $V_F$ , is given by

$$V_F = 0.5 D_o (A_o + A_s)$$

where

$D_o$  is the depth of water between overflow outlet structure and the sand filter media surface, in feet;

$A_o$  is the surface area of the sand filter at the basin overflow, in square feet; and

$A_s$  is the area at the surface of the filter media, in square feet.

For a sand filter bench, in which a **permanent pool** is maintained in a wet pond,  $V_F$  is calculated as the depth between the overflow and the normal water level of the wet pond.

In the following discussion, the **Water Quality Volume** ([https://stormwater.pca.state.mn.us/index.php?title=Water\\_quality\\_criteria](https://stormwater.pca.state.mn.us/index.php?title=Water_quality_criteria)) ( $V_{WQ}$ ) is delivered instantaneously to the BMP. The  $V_{WQ}$  is stored as water ponded above the filter media and below the overflow point in the BMP. The  $V_{WQ}$  can vary depending on the stormwater management objective(s). For construction stormwater, the water quality volume is 1 inch times the area of new impervious surface. For MIDS, the  $V_{WQ}$  is 1.1 inches times the area of impervious surface.

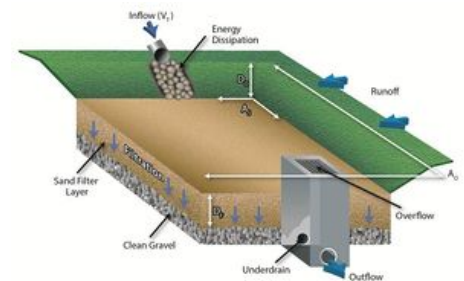
The annual volume filtered can be determined with appropriate modeling tools, including the MIDS calculator. Example values are shown below for a scenario using the MIDS calculator. For example, a sand filter designed to capture 1 inch of runoff from impervious surfaces will capture 89 percent of annual runoff from a site with B (SM) soils.

**Annual volume, expressed as a percent of annual runoff, treated by a BMP as a function of soil and** ([https://stormwater.pca.state.mn.us/index.php?title=Water\\_quality\\_criteria](https://stormwater.pca.state.mn.us/index.php?title=Water_quality_criteria)) **Water Quality Volume** ([https://stormwater.pca.state.mn.us/index.php?title=Water\\_quality\\_criteria](https://stormwater.pca.state.mn.us/index.php?title=Water_quality_criteria)). **See footnote<sup>1</sup> for how these were determined.**

Link to this table

Soil	Water quality volume ( $V_{WQ}$ ) (inches)				
	0.5	0.75	1.00	1.25	1.50
A (GW)	84	92	96	98	99
A (SP)	75	86	92	95	97
B (SM)	68	81	89	93	95
B (MH)	65	78	86	91	94
C	63	76	85	90	93

<sup>1</sup>Values were determined using the MIDS calculator. BMPs were sized to exactly meet the water quality volume for a 2 acre site with 1 acre of impervious, 1 acre of forested land, and annual rainfall of 31.9 inches.



Schematic illustrating the dimensions used for calculating water quality credits for a sand filter system. The volume is calculated as a ponded volume between the overflow and filter media.

The event-based TSS credit for sand filters,  $M_{TSS}$  in pounds, is given by

$$M_{TSS} = 0.0000624 R_{TSS} EMC_{TSS} V_F$$

where

$R_{TSS}$  is the TSS removal fraction for sand filters,  
 $EMC_{TSS}$  is the **event mean concentration** of TSS in runoff, in milligrams per liter, and  
 0.0000624 is a conversion factor.

If the sand filter is not the upstream most BMP in the treatment train,  $EMC_{TSS}$  should be dependent on the  $M_{TSS}$  effluent from the next upstream tributary BMP. Information on EMCs for TSS can be found here ([http://stormwater.pca.state.mn.us/index.php/Total\\_Suspended\\_Solids\\_%28TSS%29\\_in\\_stormwater#Source\\_and\\_concentrations\\_of\\_TSS\\_in\\_urban\\_stormwater](http://stormwater.pca.state.mn.us/index.php/Total_Suspended_Solids_%28TSS%29_in_stormwater#Source_and_concentrations_of_TSS_in_urban_stormwater)). Information on pollutant removal can be found here ([http://stormwater.pca.state.mn.us/index.php/Information\\_on\\_pollutant\\_removal\\_by\\_BMPs](http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs)). The recommended pollutant removal value ( $R_{TSS}$ ) for sand filters is 0.85.

The annual TSS credit, in pounds, is given by

$$M_{TSS} = 2.72 R_{TSS} EMC_{TSS} F V_{annual}$$

where

F is the fraction of annual runoff treated by the BMP,  
 $V_{annual}$  is annual runoff in acre-feet, and  
 2.72 is a conversion factor.

### Example calculation

Assume a 2 acre site with 1 acre of impervious and 1 acre of forested land. Annual rainfall is 31.9 inches and the soil is B (SM) with an infiltration rate of 0.45 inches per hour. The sand filter is designed to treat 1 inch of runoff from the site, or 89 percent of annual runoff (see table above ([http://stormwater.pca.state.mn.us/index.php/Annual\\_volume\\_treated\\_as\\_a\\_function\\_of\\_soil\\_and\\_water\\_quality\\_volume](http://stormwater.pca.state.mn.us/index.php/Annual_volume_treated_as_a_function_of_soil_and_water_quality_volume))). The TSS EMC is 54.5 milligrams per liter and the removal efficiency of the BMP is 0.85. The MIDS calculator was used to calculate an annual runoff of 2.3446 acre-feet delivered to the BMP. The annual TSS reduction is therefore

$$2.72 * 0.85 * 54.5 * 0.89 * 2.3446 = 263 \text{ pounds}$$

### Total phosphorus (TP)

TP reduction credit is made up of 55 percent **particulate phosphorus** (PP) and 45 percent **dissolved phosphorus** (DP) removal through filtered stormwater. The event-based TP removal,  $M_{TP}$  in pounds, is given by

$$M_{TP} = 0.0000624 ((0.55 R_{PP}) + (0.45 R_{DP})) EMC_{TP} V_F$$

where

- $R_{PP}$  is the removal fraction for particulate phosphorus,
- $R_{DP}$  is the removal fraction for dissolved phosphorus, and
- $EMC_{TP}$  is the event mean concentration for total phosphorus in runoff, in milligrams per liter.

Sand filters only receive DP credit if iron ([http://stormwater.pca.state.mn.us/index.php/Iron\\_enhanced\\_sand\\_filter\\_%28Minnesota\\_Filter%29](http://stormwater.pca.state.mn.us/index.php/Iron_enhanced_sand_filter_%28Minnesota_Filter%29)) is incorporated in the filter media. Information on phosphorus removal fractions (percentages) can be found here ([http://stormwater.pca.state.mn.us/index.php/Information\\_on\\_pollutant\\_removal\\_by\\_BMPs](http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs)). Recommended values are 0.91 for  $R_{PP}$ , 0 for  $R_{DP}$  when no iron is incorporated into the sand filter, and either 0.40 or 0.60 for  $R_{DP}$  when iron is incorporated into the sand filter, depending on the design, construction, and maintenance characteristics of the filter ([https://stormwater.pca.state.mn.us/index.php?title=Calculating\\_credits\\_for\\_iron\\_enhanced\\_sand\\_filter#Credit\\_summary](https://stormwater.pca.state.mn.us/index.php?title=Calculating_credits_for_iron_enhanced_sand_filter#Credit_summary)).

Annual TP Credit for sand filters is dependent on the ratio of the fraction of annual runoff volume treated by the BMP. This fraction can be calculated using the Minimal Impact Design Standards (MIDS) calculator ([http://stormwater.pca.state.mn.us/index.php/MIDS\\_calculator](http://stormwater.pca.state.mn.us/index.php/MIDS_calculator)) or other models (see above ([https://stormwater.pca.state.mn.us/index.php?title=Calculating\\_credits\\_for\\_sand\\_filter#Credits\\_based\\_on\\_models](https://stormwater.pca.state.mn.us/index.php?title=Calculating_credits_for_sand_filter#Credits_based_on_models))). The annual TSS credit, in pounds, is given by

$$M_{TP} = 2.72 ((0.55 R_{PP}) + (0.45 R_{DP})) EMC_{TSS} F V_{annual}$$

where

- F is the fraction of annual runoff treated by the BMP,
- $V_{annual}$  is annual runoff in acre-feet, and
- 2.72 is a conversion factor.

The assumption of 55 percent particulate phosphorus and 45 percent dissolved phosphorus is likely inaccurate for certain land uses, such as industrial, transportation, and some commercial areas. Studies indicate particulate phosphorus comprises a greater percent of total phosphorus in these land uses. It may therefore be appropriate to modify the above equation with locally derived ratios for particulate and dissolved phosphorus. For more information on fractionation of phosphorus in stormwater runoff, link here ([https://stormwater.pca.state.mn.us/index.php?title=Event\\_mean\\_concentrations\\_of\\_total\\_and\\_dissolved\\_phosphorus\\_in\\_stormwater\\_runoff#Ratios\\_of\\_particulate\\_to\\_dissolved\\_phosphorus](https://stormwater.pca.state.mn.us/index.php?title=Event_mean_concentrations_of_total_and_dissolved_phosphorus_in_stormwater_runoff#Ratios_of_particulate_to_dissolved_phosphorus)).

**Example calculation**

Assume a 2 acre site with 1 acre of impervious and 1 acre of forested land. Annual rainfall is 31.9 inches and the soil is B (SM) with an infiltration rate of 0.45 inches per hour. The sand filter is designed to treat 1 inch of runoff from the site, or 89 percent of annual runoff (see table above ([http://stormwater.pca.state.mn.us/index.php/Annual\\_volume\\_treated\\_as\\_a\\_function\\_of\\_soil\\_and\\_water\\_quality\\_volume](http://stormwater.pca.state.mn.us/index.php/Annual_volume_treated_as_a_function_of_soil_and_water_quality_volume))). The TP EMC is 0.3 milligrams per liter and the removal efficiency of the BMP is 0.91 for particulate P and 0 for dissolved P. The MIDS calculator was used to calculate an annual runoff of 2.3446 acre-feet delivered to the BMP. The annual TP reduction is therefore

$$2.72 * ((0.55 * 0.91) + (0.45 * 0)) * 0.3 * 0.89 * 2.3446 = 0.85 \text{ pounds}$$

If the sand filter were enhanced with iron, the annual TP reduction would be

$$2.72 * ((0.55 * 0.91) + (0.45 * 0.6)) * 0.3 * 0.89 * 2.3446 = 1.31 \text{ pounds}$$

**Methods for calculating credits**

This section provides specific information on generating and calculating credits from sand filters for total suspended solids (TSS) and total phosphorus (TP). Stormwater runoff pollution reductions (“credits”) may be calculated using one of the following methods:

1. Quantifying pollution reductions based on accepted hydrologic models
2. The Simple Method and MPCA Estimator
3. MIDS Calculator
4. Quantifying pollution reductions based on values reported in literature
5. Quantifying pollution reductions based on field monitoring

**Credits based on models**

**Warning:** The model selected depends on your objectives. For compliance with the Construction Stormwater permit, the model must be based on the assumption that an instantaneous volume is captured by the BMP.

Users may opt to use a water quality model or calculator to compute TSS and/or TP pollutant removal for the purpose of determining credits for sand filters. The available models described below are commonly used by water resource professionals, but are not explicitly endorsed or required by the Minnesota Pollution Control Agency. Furthermore, many of the models listed below cannot be used to determine compliance with the Construction Stormwater General permit ([https://stormwater.pca.state.mn.us/index.php?title=Construction\\_stormwater\\_program](https://stormwater.pca.state.mn.us/index.php?title=Construction_stormwater_program)) since the permit requires the water quality volume to be calculated as an **instantaneous volume**.

Use of models or calculators for the purpose of computing pollutant removal credits should be supported by detailed documentation, including:

- Model name and version
- Date of analysis
- Person or organization conducting analysis
- Detailed summary of input data
- Calibration and verification information
- Detailed summary of output data

The following table lists water quality models that are commonly used by water resource professionals to predict the pollutant removal capabilities of a single or multiple stormwater BMPs. The table can be used to guide a user in selecting the most appropriate model for computing TSS and/or TP removal for sand filter BMPs. In using this table to identify models appropriate for sand filters, use the sort arrow on the table and sort by *Filter BMPs*. Models identified with an *X* may be appropriate for using with sand filters.

**Comparison of stormwater models and calculators. Additional information and descriptions for some of the models listed in this table can be found at this link ([http://stormwater.pca.state.mn.us/index.php/Available\\_stormwater\\_models\\_and\\_selecting\\_a\\_model](http://stormwater.pca.state.mn.us/index.php/Available_stormwater_models_and_selecting_a_model)). Note that the Construction Stormwater General Permit ([https://stormwater.pca.state.mn.us/index.php?title=Construction\\_stormwater\\_program](https://stormwater.pca.state.mn.us/index.php?title=Construction_stormwater_program)) requires the water quality volume to be calculated as an instantaneous volume, meaning several of these models cannot be used to determine compliance with the permit.**

Link to this table

Access this table as a Microsoft Word document: File:Stormwater Model and Calculator Comparisons table.docx.

Model name	BMP Category				Reuse	Manu- factured devices	Assess TP removal?	Assess TSS removal?	Assess volume reduction?	Comments
	Constructed basin BMPs	Filter BMPs	Infiltrator BMPs	Swale or strip BMPs						

Model name	Constructed basin BMPs	Filter BMPs	BMP Category			Reuse	Manu- factured devices	Assess TP removal?	Assess TSS removal?	Assess volume reduction?	Comments
			Infiltrator BMPs	Swale or strip BMPs							
Center for Neighborhood Technology Green Values National Stormwater Management Calculator ( <a href="http://cnt.org/tools/green-values-calculator">http://cnt.org/tools/green-values-calculator</a> )	X	X	X			X		No	No	Yes	Does not compute volume reduction for some BMPs, including cisterns and tree trenches.
CivilStorm ( <a href="http://www.bentley.com/en-US/Products/CivilStorm/">http://www.bentley.com/en-US/Products/CivilStorm/</a> )								Yes	Yes	Yes	CivilStorm has an engineering library with many different types of BMPs to choose from. This list changes as new information becomes available.
EPA National Stormwater Calculator ( <a href="http://www.epa.gov/nrmrl/wswrd/wq/models/swc/">http://www.epa.gov/nrmrl/wswrd/wq/models/swc/</a> )	X		X			X		No	No	Yes	Primary purpose is to assess reductions in stormwater volume.
EPA SWMM ( <a href="http://www.epa.gov/water-research/storm-water-management-model-swmm">http://www.epa.gov/water-research/storm-water-management-model-swmm</a> )	X		X			X		Yes	Yes	Yes	User defines parameter that can be used to simulate generalized constituents.
HydroCAD ( <a href="http://www.hydrocad.net/">http://www.hydrocad.net/</a> )	X		X	X				No	No	Yes	Will assess hydraulics, volumes, and pollutant loading, but not pollutant reduction.
infoSWMM ( <a href="http://www.innovyze.com/products/infoswmm/">http://www.innovyze.com/products/infoswmm/</a> )	X		X			X		Yes	Yes	Yes	User defines parameter that can be used to simulate generalized constituents.
infoWorks ICM ( <a href="http://www.innovyze.com/products/infoworks_icm/">http://www.innovyze.com/products/infoworks_icm/</a> )	X	X	X	X				Yes	Yes	Yes	
i-Tree-Hydro ( <a href="http://www.itreetools.org/hydro/index.php">http://www.itreetools.org/hydro/index.php</a> )			X					No	No	Yes	Includes simple calculator for rain gardens.
i-Tree-Streets ( <a href="http://www.itreetools.org/streets/index.php">http://www.itreetools.org/streets/index.php</a> )								No	No	Yes	Computes volume reduction for trees, only.

Model name	Constructed basin BMPs	Filter BMPs	BMP Category			Reuse	Manu- factured devices	Assess TP removal?	Assess TSS removal?	Assess volume reduction?	Comments
			Infiltrator BMPs	Swale or strip BMPs							
LSPC ( <a href="https://cfpub.epa.gov/si/si_public_record_Report.cfm?Lab=NERL&amp;dirEntryId=75860&amp;CFID=22884508&amp;CFTOKEN=98267566">https://cfpub.epa.gov/si/si_public_record_Report.cfm?Lab=NERL&amp;dirEntryId=75860&amp;CFID=22884508&amp;CFTOKEN=98267566</a> )	X		X	X			Yes	Yes	Yes	Though developed for HSPF, the USEPA BMP Web Toolkit can be used with LSPC to model structural BMPs such as detention basins, or infiltration BMPs that represent source control facilities, which capture runoff from small impervious areas (e.g., parking lots or rooftops). Region-specific input data not available for Minnesota but user can create this data for any region.	
MapShed ( <a href="http://wikiwatershed.org/help/model-help/mapshed/">http://wikiwatershed.org/help/model-help/mapshed/</a> )	X	X	X	X			Yes	Yes	Yes		
MCWD/MWMO Stormwater Reuse Calculator ( <a href="http://minnehahacreek.org/sites/minnehahacreek.org/files/Stormwater%20Harvesting%20and%20Reuse%20Model_v2.0.xlsx">http://minnehahacreek.org/sites/minnehahacreek.org/files/Stormwater%20Harvesting%20and%20Reuse%20Model_v2.0.xlsx</a> )						X	Yes	No	Yes	Computes storage volume for stormwater reuse systems	
Metropolitan Council Stormwater Reuse Guide Excel Spreadsheet ( <a href="http://www.metrocouncil.org/Wastewater-Water/Planning/Water-Supply-Planning.aspx">http://www.metrocouncil.org/Wastewater-Water/Planning/Water-Supply-Planning.aspx</a> )						X	No	No	Yes	Computes storage volume for stormwater reuse systems. Uses 30-year precipitation data specific to Twin Cities region of Minnesota. Includes user-defined feature that can be used for manufactured devices and other BMPs.	
MIDS Calculator ( <a href="http://stormwater.pca.state.mn.us/index.php/MIDS_calculator">http://stormwater.pca.state.mn.us/index.php/MIDS_calculator</a> )	X		X	X	X	X	Yes	Yes	Yes		

Model name	Constructed basin BMPs	Filter BMPs	BMP Category			Reuse	Manu- factured devices	Assess TP removal?	Assess TSS removal?	Assess volume reduction?	Comments
			Infiltrator BMPs	Swale or strip BMPs							
MIKE URBAN (SWMM or MOUSE) ( <a href="http://www.mikebydhi.com/Products/Cities/MIKEURBAN.aspx">http://www.mikebydhi.com/Products/Cities/MIKEURBAN.aspx</a> )	X		X			X		Yes	Yes	Yes	User defines parameter that can be used to simulate generalized constituents.
P8 ( <a href="http://www.walker.net/p8/">http://www.walker.net/p8/</a> )	X		X	X		X		Yes	Yes	Yes	
PCSWMM ( <a href="http://www.chiwater.com/Software/PCSWMM/">http://www.chiwater.com/Software/PCSWMM/</a> )	X		X			X		Yes	Yes	Yes	User defines parameter that can be used to simulate generalized constituents.
PLOAD ( <a href="http://water.epa.gov/scitech/datait/models/basins/framework.cfm#models">http://water.epa.gov/scitech/datait/models/basins/framework.cfm#models</a> )	X	X	X	X		X		Yes	Yes	No	User-defined practices with user-specified removal percentages.
PondNet ( <a href="http://www.walker.net/">http://www.walker.net/</a> )	X							Yes	No	Yes	Flow and phosphorus routing in pond networks. PondPack can calculate first-flush volume, but does not model pollutants. It can be used to calculate pond infiltration.
PondPack ( <a href="http://www.bentley.com/en-US/Products/PondPack">http://www.bentley.com/en-US/Products/PondPack</a> )	X		[					No	No	Yes	
RECARGA ( <a href="http://dnr.wi.gov/topic/stormwater/standards/recarga.html">http://dnr.wi.gov/topic/stormwater/standards/recarga.html</a> )			X					No	No	Yes	
SHSAM ( <a href="https://shsam.barr.com/">https://shsam.barr.com/</a> )						X		No	Yes	No	Several flow-through structures including standard sumps, and proprietary systems such as CDS, Stormceptors, and Vortechs systems
SUSTAIN ( <a href="http://www.epa.gov/water-research/system-urban-stormwater-treatment-and-analysis-integration-sustain">http://www.epa.gov/water-research/system-urban-stormwater-treatment-and-analysis-integration-sustain</a> )	X	X	X	X	X	X		Yes	Yes	Yes	Categorizes BMPs into Point BMPs, Linear BMPs, and Area BMPs



Model name	Constructed basin BMPs	Filter BMPs	BMP Category			Reuse	Manu- factured devices	Assess TP removal?	Assess TSS removal?	Assess volume reduction?	Comments
			Infiltrator BMPs	Swale or strip BMPs							
SWAT ( <a href="http://swat.tamu.edu/">http://swat.tamu.edu/</a> )	X	X	X					Yes	Yes	Yes	Model offers many agricultural BMPs and practices, but limited urban BMPs at this time.
Virginia Runoff Reduction Method ( <a href="https://swbmp.vwrrc.vt.edu/vrrm/">https://swbmp.vwrrc.vt.edu/vrrm/</a> )	X	X	X	X	X	X		Yes	No	Yes	Users input Event Mean Concentration (EMC) pollutant removal percentages for manufactured devices.
WARMF ( <a href="https://www.epri.com/research/products/3002011868">https://www.epri.com/research/products/3002011868</a> )	X	X						Yes	Yes	Yes	Includes agriculture BMP assessment tools. Compatible with USEPA Basins
WinHSPF ( <a href="https://www.researchgate.net/figure/The-WinHSPF-interface-available-through-BASINS_fig1_274344576">https://www.researchgate.net/figure/The-WinHSPF-interface-available-through-BASINS_fig1_274344576</a> )	X		X	X				Yes	Yes	Yes	USEPA BMP Web Toolkit available to assist with implementing structural BMPs such as detention basins, or infiltration BMPs that represent source control facilities, which capture runoff from small impervious areas (e.g., parking lots or rooftops).
WinSLAMM ( <a href="http://www.winslammm.com/default.html">http://www.winslammm.com/default.html</a> )	X	X	X	X				Yes	Yes	Yes	
XPSWMM ( <a href="https://www.innovyze.com/en-us/products/xpswmm">https://www.innovyze.com/en-us/products/xpswmm</a> )	X		X			X		Yes	Yes	Yes	User defines parameter that can be used to simulate generalized constituents.

### The Simple Method and MPCA Estimator

The Simple Method is a technique used for estimating storm pollutant export delivered from urban development sites. Pollutant loads are estimated as the product of **event mean concentration** and runoff depths over specified periods of time (usually annual or seasonal). The method was developed to provide an easy yet reasonably accurate means of predicting the change in pollutant loadings in response to development. Ohrel (<http://www.stormwatercenter.net/Library/Practice/13.pdf>) (2000) states: "In general, the Simple Method is most appropriate for small watersheds (<640 acres) and when quick and reasonable stormwater pollutant load estimates are required". Rainfall data, land use (runoff coefficients), land area, and pollutant concentration are needed to use the Simple Method. For more information on the Simple Method, see The Simple method to Calculate Urban Stormwater Loads (<http://www.stormwatercenter.net/monitoring%20and%20assessment/simple%20meth/simple.htm>) or The Simple Method for estimating phosphorus export.

Some simple stormwater calculators utilize the Simple Method (EPA STEPL (<https://www.epa.gov/nps/spreadsheet-tool-estimating-pollutant-loads-stepl>), Watershed Treatment Model ([https://www.stormwatercenter.net/monitoring%20and%20assessment/watershed\\_treatment\\_model.htm](https://www.stormwatercenter.net/monitoring%20and%20assessment/watershed_treatment_model.htm))). The MPCA developed a simple calculator for estimating load reductions for TSS, total phosphorus, and bacteria. Called the **MPCA Estimator** ([http://stormwater.pca.state.mn.us/index.php/Guidance\\_and\\_examples\\_for\\_using\\_the\\_MPCA\\_Estimator](http://stormwater.pca.state.mn.us/index.php/Guidance_and_examples_for_using_the_MPCA_Estimator)), this tool was developed specifically for complying with the MS4 General Permit TMDL annual reporting requirement ([https://stormwater.pca.state.mn.us/index.php?title=Forms,\\_guidance,\\_and\\_resources\\_for\\_completing\\_the\\_TMDL\\_annual\\_report\\_form](https://stormwater.pca.state.mn.us/index.php?title=Forms,_guidance,_and_resources_for_completing_the_TMDL_annual_report_form)). The MPCA Estimator provides default values for pollutant concentration, **runoff coefficients** ([https://stormwater.pca.state.mn.us/index.php?title=Runoff\\_coefficients\\_for\\_5\\_to\\_10\\_year\\_storms](https://stormwater.pca.state.mn.us/index.php?title=Runoff_coefficients_for_5_to_10_year_storms)) for different land uses, and precipitation, although the user can modify these and is encouraged to do so when local data exist. The user is required to enter area for different land uses and area treated by BMPs within each of the land uses. BMPs include infiltrators (e.g. **bioinfiltration**, **infiltration basin** (<https://stormwater.pca.state.mn.us/index.php?title=Infiltration>), tree trench, **permeable pavement** ([https://stormwater.pca.state.mn.us/index.php?title=Permeable\\_pavement](https://stormwater.pca.state.mn.us/index.php?title=Permeable_pavement)), etc.), filters ( **biofiltration** (<https://stormwater.pca.state.mn.us/index.php?title=Bioretention>), **sand filter** (<https://stormwater.pca.state.mn.us/index.php?title=Filteration>), **green roof** ([https://stormwater.pca.state.mn.us/index.php?title=Green\\_roofs](https://stormwater.pca.state.mn.us/index.php?title=Green_roofs))), constructed **wet pond** ([https://stormwater.pca.state.mn.us/index.php?title=Stormwater\\_ponds](https://stormwater.pca.state.mn.us/index.php?title=Stormwater_ponds)), **stormwater wetland** ([https://stormwater.pca.state.mn.us/index.php?title=Stormwater\\_wetlands](https://stormwater.pca.state.mn.us/index.php?title=Stormwater_wetlands)), and **swale** ([https://stormwater.pca.state.mn.us/index.php?title=Dry\\_swale\\_\(Grass\\_swale\)](https://stormwater.pca.state.mn.us/index.php?title=Dry_swale_(Grass_swale)))/ **filter strip** ([https://stormwater.pca.state.mn.us/index.php?title=Overview\\_for\\_pretreatment\\_vegetated\\_filter\\_strips](https://stormwater.pca.state.mn.us/index.php?title=Overview_for_pretreatment_vegetated_filter_strips)). The MPCA Estimator includes standard removal efficiencies for these BMPs, but the user can modify those values if better data are available. Output from the calculator is given as a load reduction (percent, mass, or number of bacteria) from the original estimated load. Default TSS removal fractions are 0.85 for sand filters, 0.84 for wet basins and 0.73 for constructed wetlands. Default removal fractions for TP are 0.50 for wet basins and 0.38 for constructed wetlands.

**Caution:** The MPCA Estimator should not be used for modeling a stormwater system or selecting BMPs.

Because the MPCA Estimator does not consider BMPs in series, makes simplifying assumptions about runoff and pollutant removal processes, and uses generalized default information, it should only be used for estimating pollutant reductions from an estimated load. It is not intended as a decision-making tool.

**Download MPCA Estimator here** ([https://stormwater.pca.state.mn.us/index.php?title=File:MPCA\\_simple\\_estimator\\_version\\_3.0\\_March\\_5\\_2021.xlsx](https://stormwater.pca.state.mn.us/index.php?title=File:MPCA_simple_estimator_version_3.0_March_5_2021.xlsx))

## MIDS calculator

The Minimal Impact Design Standards (MIDS) best management practice (BMP) calculator is a tool used to determine stormwater runoff volume and pollutant reduction capabilities of various BMPs, including sand filters. The MIDS calculator estimates the stormwater runoff volume reductions for various BMPs and annual pollutant load reductions for total phosphorus (including a breakdown between particulate and dissolved phosphorus) and total suspended solids (TSS). The calculator was intended for use on individual development sites, though capable modelers could modify its use for larger applications. Users of the calculator should note that sizing information is not needed for sand filters. Instead, the calculator assumes the sand filter will be properly designed following guidelines from the Manual.



Download the MIDS Calculator

The MIDS calculator is designed in Microsoft Excel with a graphical user interface (GUI), packaged as a windows application, used to organize input parameters. The Excel spreadsheet conducts the calculations and stores parameters, while the GUI provides a platform that allows the user to enter data and presents results in a user-friendly manner.

Detailed guidance and examples have been developed for all BMPs in the calculator, including sand filters ([http://stormwater.pca.state.mn.us/index.php/Requirements,\\_recommendations\\_and\\_information\\_for\\_using\\_sand\\_filter\\_as\\_a\\_BMP\\_in\\_the\\_MIDS\\_calculator](http://stormwater.pca.state.mn.us/index.php/Requirements,_recommendations_and_information_for_using_sand_filter_as_a_BMP_in_the_MIDS_calculator)). An overview of individual input parameters and workflows is presented in the MIDS Calculator User Documentation ([http://stormwater.pca.state.mn.us/index.php/User%E2%80%99s\\_Guide](http://stormwater.pca.state.mn.us/index.php/User%E2%80%99s_Guide)).

## Credits based on reported literature values

A simplified approach to computing a credit would be to apply a reduction value found in literature to the pollutant mass load or concentration (EMC) of the sand filter BMP. Concentration reductions resulting from treatment can be converted to mass reductions if the volume of stormwater treated is known.

Designers may use the pollutant reduction values reported in this manual ([http://stormwater.pca.state.mn.us/index.php/Information\\_on\\_pollutant\\_removal\\_by\\_BMPs](http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs)) or may research values from other databases and published literature. Designers who opt for this approach should

- select the median value from pollutant reduction databases that report a range of reductions, such as from the International BMP Database;

- select a pollutant removal reduction from literature that studied a sand filter BMP with site characteristics and climate similar to the device being considered for credits;
- review the article to determine that the design principles of the studied biofiltration are close to the design recommendations for Minnesota, as described in this manual ([http://stormwater.pca.state.mn.us/index.php/Design\\_criteria\\_for\\_filtration](http://stormwater.pca.state.mn.us/index.php/Design_criteria_for_filtration)) and/or by a local permitting agency; and
- give preference to literature that has been published in a peer-reviewed publication.

The following references summarize pollutant reduction values from multiple studies or sources that could be used to determine credits. Users should note that there is a wide range of monitored pollutant removal effectiveness in the literature. Before selecting a literature value, users should compare the characteristics of the monitored site in the literature against the characteristics of the proposed sand filter BMP, considering such conditions as watershed characteristics, sizing, and climate factors.

- International Stormwater Best Management Practices (BMP) Database (<https://bmpdatabase.org/>) Pollutant Category Summary Statistical Addendum: TSS, Bacteria, Nutrients, and Metals
  - Compilation of BMP performance studies published through 2011
  - Provides values for TSS, Bacteria, Nutrients, and Metals
  - Applicable to grass strips, bioretention, bioswales, detention basins, green roofs, manufactured devices, media filters, porous pavements, wetland basins, and wetland channels
- Updated BMP Removal Efficiencies from the National Pollutant Removal Database (2007) & Acceptable BMP Table for Virginia (<http://lshs.tamu.edu/docs/lshs/end-notes/updated%20bmp%20removal%20efficiencies%20from%20the%20national%20pollutant%20re-2854375963/updated%20bmp%20removal%20efficiencies%20from%20the%20national%20pollutant%20removal%20database.pdf>)
  - Provides data for several structural and non-structural BMP performance evaluations
- The Illinois Green Infrastructure Study (<http://www.epa.state.il.us/green-infrastructure/docs/draft-final-report.pdf>)
  - Figure ES-1 summarizes BMP effectiveness
  - Provides values for TN, TSS, peak flows / runoff volumes
  - Applicable to permeable pavements, constructed wetlands, infiltration, detention, filtration, and green roofs
- New Hampshire Stormwater Manual (<https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/2020-01/wd-08-20b.pdf>)
  - Volume 2, Appendix B summarizes BMP effectiveness
  - Provides values for TSS, TN, and TP removal
  - Applicable to basins and wetlands, stormwater wetlands, infiltration practices, filtering practices, treatment swales, vegetated buffers, and pre-treatment practices
- Weiss, P.T., J.S. Gulliver and A.J. Erickson. 2005. The Cost and Effectiveness of Stormwater Management Practices: Final Report (<http://www.lrb.org/media/reports/200523.pdf>)
  - Table 8 and Appendix B provides pollutant removal efficiencies for TSS and P
  - Applicable to wet basins, stormwater wetlands, bioretention filter, sand filter, infiltration trench, and filter strips/grass swales

## Credits based on field monitoring

Field monitoring may be made in lieu of desktop calculations or models/calculators as described. Careful planning is HIGHLY RECOMMENDED before commencing a program to monitor the performance of a BMP. The general steps involved in planning and implementing BMP monitoring include the following.

1. Establish the objectives and goals of the monitoring. When monitoring BMP performance, typical objectives may include the following.
  1. Which pollutants will be measured?
  2. Will the monitoring study the performance of a single BMP or multiple BMPs?
  3. Are there any variables that will affect the BMP performance? Variables could include design approaches, maintenance activities, rainfall events, rainfall intensity, etc.
  4. Will the results be compared to other BMP performance studies?
  5. What should be the duration of the monitoring period? Is there a need to look at the annual performance vs the performance during a single rain event? Is there a need to assess the seasonal variation of BMP performance?
2. Plan the field activities. Field considerations include
  1. equipment selection and placement;
  2. sampling protocols including selection, storage, and delivery to the laboratory;
  3. laboratory services;
  4. health and Safety plans for field personnel;
  5. record keeping protocols and forms; and
  6. quality control and quality assurance protocols
3. Execute the field monitoring
4. Analyze the results

This manual contains the following guidance for monitoring.

- Recommendations and guidance for utilizing monitoring to meet TMDL permit requirements
- Recommendations and guidance for utilizing lake monitoring to meet TMDL permit requirements
- Recommendations and guidance for utilizing stream monitoring to meet TMDL permit requirements
- Recommendations and guidance for utilizing major stormwater outfall monitoring to meet TMDL permit requirements
- Recommendations and guidance for utilizing stormwater best management practice monitoring to meet TMDL permit requirements

The following guidance manuals have been developed to assist BMP owners and operators on how to plan and implement BMP performance monitoring.

**Urban Stormwater BMP Performance Monitoring** (<https://www3.epa.gov/npdes/pubs/montcomplete.pdf>)

Geosyntec Consultants and Wright Water Engineers prepared this guide in 2009 with support from the USEPA, Water Environment Research Foundation, Federal Highway Administration, and the Environment and Water Resource Institute of the American Society of Civil Engineers. This guide was developed to improve and standardize the protocols for all BMP monitoring and to provide additional guidance for Low Impact Development (LID) BMP monitoring. Highlighted chapters in this manual include:

- Chapter 2: Developing a monitoring plan. Describes a seven-step approach for developing a monitoring plan for collection of data to evaluate BMP effectiveness.
- Chapter 3: Methods and Equipment for hydrologic and hydraulic monitoring
- Chapter 4: Methods and equipment for water quality monitoring
- Chapters 5 (Implementation) and 6 (Data Management, Evaluation and Reporting)
- Chapter 7: BMP Performance Analysis
- Chapters 8 (LID Monitoring), 9 (LID data interpretation)], and 10 (Case studies).

**Evaluation of Best Management Practices for Highway Runoff Control (NCHRP Report 565)** ([http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp\\_rpt\\_565.pdf](http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_565.pdf))

AASHTO (American Association of State Highway and Transportation Officials) and the FHWA (Federal Highway Administration) sponsored this 2006 research report, which was authored by Oregon State University, Geosyntec Consultants, the University of Florida, and the Low Impact Development Center. The primary purpose of this report is to advise on the selection and design of BMPs that are best suited for highway runoff. The document includes chapters on performance monitoring that may be a useful reference for BMP performance monitoring, especially for the performance assessment of a highway BMP.

- Chapter 4: Stormwater Characterization
  - 4.2: General Characteristics and Pollutant Sources
  - 4.3: Sources of Stormwater Quality data
- Chapter 8: Performance Evaluation
  - 8.1: Methodology Options
  - 8.5: Evaluation of Quality Performance for Individual BMPs
  - 8.6: Overall Hydrologic and Water Quality Performance Evaluation
- Chapter 10: Hydrologic Evaluation
  - 10.5: Performance Verification and Design Optimization

**Investigation into the Feasibility of a National Testing and Evaluation Program for Stormwater Products and Practices** ([https://www.wef.org/globalassets/assets-wef/3---resources/topics/o-z/stormwater/stormwater-institute/wef-stepp-white-paper\\_final\\_02-06-14.pdf](https://www.wef.org/globalassets/assets-wef/3---resources/topics/o-z/stormwater/stormwater-institute/wef-stepp-white-paper_final_02-06-14.pdf))

- In 2014 the Water Environment Federation released this White Paper that investigates the feasibility of a national program for the testing of stormwater products and practices. The report does not include any specific guidance on the monitoring of a BMP, but it does include a summary of the existing technical evaluation programs that could be consulted for testing results for specific products (see Table 1 on page 8).

**Caltrans Stormwater Monitoring Guidance Manual (Document No. CTSW-OT-13-999.43.01)**

The most current version of this manual was released by the State of California, Department of Transportation in November 2013. As with the other monitoring manuals described, this manual does include guidance on planning a stormwater monitoring program. However, this manual is among the most thorough for field activities. Relevant chapters include.

- Chapter 4: Monitoring Methods and Equipment
- Chapter 5: Analytical Methods and Laboratory Selection
- Chapter 6: Monitoring Site Selection
- Chapter 8: Equipment Installation and Maintenance
- Chapter 10: Pre-Storm Preparation
- Chapter 11: Sample Collection and Handling
- Chapter 12: Quality Assurance / Quality Control
- Chapter 13: Laboratory Reports and Data Review
- Chapter 15: Gross Solids Monitoring

**Optimizing Stormwater Treatment Practices: A Handbook of Assessment and Maintenance** (<http://stormwaterbook.safl.umn.edu/>)

This online manual was developed in 2010 by Andrew Erickson, Peter Weiss, and John Gulliver from the University of Minnesota and St. Anthony Falls Hydraulic Laboratory with funding provided by the Minnesota Pollution Control Agency. The manual advises on a four-level process to assess the performance of a Best Management Practice.

- Level 1: Visual Inspection (<https://stormwaterbook.safl.umn.edu/assessment-programs/visual-inspection>)
- Level 2: Capacity Testing (<https://stormwaterbook.safl.umn.edu/assessment-programs/capacity-testing>)
- Level 3: Synthetic Runoff Testing (<http://stormwaterbook.safl.umn.edu/assessment-programs/synthetic-runoff-testing>)
- Level 4: Monitoring (<https://stormwaterbook.safl.umn.edu/assessment-programs/monitoring>)

Level 1 activities do not produce numerical performance data that could be used to obtain a stormwater management credit. BMP owners and operators who are interested in using data obtained from Levels 2 and 3 should consult with the MPCA or other regulatory agency to determine if the results are appropriate for credit calculations. Level 4, Monitoring, is the method most frequently used for assessment of the performance of a BMP.

Use these links to obtain detailed information on the following topics related to BMP performance monitoring:

- Water Budget Measurement (<https://stormwaterbook.safl.umn.edu/water-budget-measurement>)
- Sampling Methods (<https://stormwaterbook.safl.umn.edu/sampling-methods>)
- Analysis of Water and Soils (<https://stormwaterbook.safl.umn.edu/analysis-water-and-soils>)
- Data Analysis for Monitoring (<https://stormwaterbook.safl.umn.edu/data-analysis>)

## Other pollutants

In addition to TSS and phosphorus, sand filters can reduce loading of other pollutants. According to the International Stormwater Database (<http://www.bmpdatabase.org/Docs/Simple%20Summary%20BMP%20Database%20July%202012%20Final.pdf>), studies have shown that sand filter BMPs are effective at reducing concentrations of pollutants, including metals, and bacteria. A compilation of the pollutant removal capabilities from a review of literature are summarized below.

### Relative pollutant reduction from sand filter systems for metals, nitrogen, bacteria, and organics.

Link to this table

Pollutant	Constituent	Treatment capabilities <sup>1</sup>
Metals <sup>2</sup>	Cadmium, Chromium, Copper, Zinc, Iron, Nickel, Lead	Medium/High <sup>3</sup>
Nitrogen	Total nitrogen	Low/medium
	Total Kjeldahl nitrogen	Medium
Bacteria	Fecal coliform, e. coli	Medium
Organics		Medium/High <sup>4</sup>

<sup>1</sup> Low: < 30%; Medium: 30 to 65%; High: >65%

<sup>2</sup> Results are for total metals only

<sup>3</sup> Treatment capabilities for Cd and Cr are based on results of a single study by Kurz, 1998. This study shows low (9.3%) removal rates for Cr.

<sup>4</sup> High if amended with clay or organic matter

## References and suggested reading

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