Minnesota Stormwater Manual Update
Pretreatment

prepared for

Minnesota Pollution Control Agency
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RESPEC

Minnesota Stormwater Manual Update Pretreatment

Topical Report RSI-2610

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1.0 IMPORTANCE OF PRETREATMENT

Review and update the section in the Manual called Importance of pretreatment . This section should provide a general definition of pretreatment, an overview of the general types of pretreatment (e.g. filtering, settling), and a summary of NPDES permit requirements for pretreatment. The section is general and not specific to individual BMPs and should not contain specific design, construction or maintenance information.

Sediment, trash, debris, and organic material found in stormwater runoff often clog and significantly affect the functionality of structural stormwater best management practices (BMPs). Reducing these burdens prior to entering structural stormwater BMP(s) will preserve their long-term functionality, particularly for filtration and infiltration BMPs. The purpose of pretreatment is to reduce maintenance and prolong the lifespan of structural stormwater BMPs by removing trash, debris, organic material, coarse sediments, and pollutants (e.g., nutrients, heavy metals, hydrocarbons) potentially associated with this material, prior to entering structural stormwater BMPs. Implementing pretreatment devices also improves aesthetics by capturing debris in focused or hidden areas which are more amenable for removal.

Pretreatment practices serve an important role in the stormwater treatment network. They are installed immediately preceding one or more structural stormwater BMPs and are designed with consideration of the flow network and the downstream structural stormwater BMP characteristics. Pretreatment is highly recommended as an integral part of all post-construction structural stormwater BMPs and is required as part of Minnesota's NPDES/SDS Construction Stormwater (CSW) General Permit for filtration/infiltration water quality BMPs (section III.D.1.d). Pretreatment practices are NOT stand-alone treatment practices and should only be installed in conjunction with a treatment practice immediately downstream.

Pretreatment practices include settling devices, screens, and pretreatment vegetated filter strips. Selecting the appropriate pretreatment device is critical and is primarily based on the downstream structural BMP, and the contributing drainage area (size, land use, underlying soils, trees/vegetation, etc.). The variety of pretreatment methods and flexibility of design allows for site-specific utilization of the most applicable pretreatment practice. It is recommended that pretreatment practices be designed to be easily maintained and capture a minimum of 25% of the sediment from runoff. Pollutants are captured primarily by physical screening or sedimentation/settling. Figure 1-1 shows the spectrum of particles sizes and classes, and typical ranges of treatment for pretreatment, conventional structural stormwater BMPs, and structural stormwater BMPs that incorporate advanced treatment processes.

Pretreatment practices capture solids that are quickly settled or screened, including gross solids and most sand particles (roughly 100 microns (µm) and larger), although some pretreatment practices also capture floatables. In many watersheds, this material accounts for a large portion of the total pollutant load as shown in Figure 1-1. Installing multiple pretreatment practices of the same type in series rarely increases performance because the pollutants will be captured by the first practice (if properly designed and maintained) and subsequent pretreatment practices will not be effective. Structural stormwater BMPs such as wet ponds and filtration practices generally capture large silts in addition to sands and gross solids, approximately down to 10 µm-sized particles (See Figure 1-1). To capture fine silts, clays, and dissolved or colloidal pollutants, structural stormwater BMPs with advanced treatment such as infiltration, chemical reactions, or biodegradation must be used.

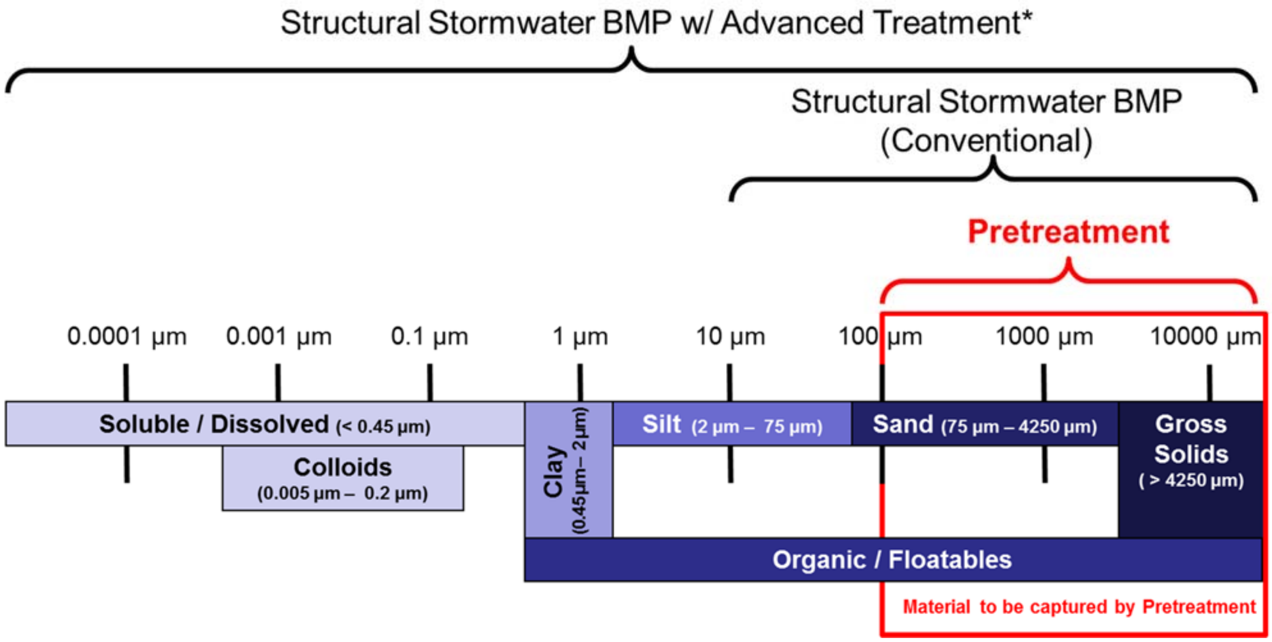

Figure 1-1: Pollutant Spectrum and Treatment Ranges by Pretreatment, Structural Stormwater BMP, and Structural Stormwater BMP with Advanced Treatment (image courtesy: A. Erickson, R. Bintner, J. Gulliver, and RESPEC).

Mentions of Pretreatment in the Current Permit:

III.D.1.a of NPDES: The method selected by the Permittee(s) must remove settleable solids, floating materials, and oils and grease from the runoff to the maximum extent practicable before runoff enters the infiltration/filtration system. Filtration systems must be designed to remove at least 80 percent of total suspended solids.

III.D.1.d of NPDES: To prevent clogging of the infiltration or filtration system, the Permittee(s) must use a pretreatment device such as a vegetated filter strip, small sedimentation basin, or water quality inlet (e.g., grit chamber) to settle particulates before the stormwater discharges into the infiltration or filtration system.

2.0 METHODS OF PRETREATMENT

Review and update the section in the Manual called Methods of pretreatment . Provide a list of pretreatment methods and include a short summary for each method. The list should include, but is not limited to Proprietary Settling Devices, Non-proprietary Settling Devices, Screens, pretreatment vegetated filter strips, and forebays. Make recommendations, if appropriate, to the PM for adding or combining different practices. This information is of a general nature. Include the following information in the deliverable for this task.

- A general description of each practice.
- A description of the function of each practice, including mechanism(s) of pollutant removal.
- A table summarizing and comparing characteristics of each practice, including but not limited to mechanism of pollutant removal (e.g. filtering, settling, etc.), general pollutant removal (e.g. low, medium, high), general cost (e.g. low, medium, high), general maintenance requirements (low, medium, high), and general space requirements (low, medium, high).
- A table summarizing applicability of each practice, using the applicability criteria described below under Task D, Subtask 2.
- Photos, schematics, or other images illustrating each practice.

There are several recommended pretreatment practices that are compatible with structural stormwater BMPs. Differences in each pretreatment practice should be understood to ensure the selected practice is appropriate to the site, the downstream structural stormwater BMP, and maintenance capabilities of the individual or organization responsible for maintenance. The pretreatment descriptions presented below and in the following tables are provided to assist in the selection of the proper pretreatment practice for the site-specific loading condition and proposed structural stormwater BMP. The descriptions highlight the types of pretreatment practices, their mechanism of pollutant removal, and their differences as follows:

- **Pretreatment Settling Devices** are flow-through structures or devices, proprietary or non-proprietary, above or below ground, where settling is the primary mechanism of pollutant removal. Some of these devices also provide treatment in addition to settling by utilizing a variety of mechanisms to separate and capture pollutant-laden material. Aliases for these devices include water quality inlets, flow-through devices, hydrodynamic separators, grit chambers, forebays, sump manholes, and other descriptors.
    - Settling Devices are typically designed to dissipate flow energy and detain runoff to allow coarse sediments to settle out of the water column.
    - Some Settling Devices use multiple chambers equipped with baffles, weirs, sumps or orifices to manage flow and capture pollutants; hoods or inverted elbows to retain floating organic material, oil and debris.

- **Pretreatment Screens** are small catch basins or conveyance trenches in which screening is the primary mechanism of pollutant removal. These pretreatment devices use a perforated plate or mesh screen to separate and collect sediment, trash, debris and organic material as runoff passes over or through them. Screens often comprise thin sheets of metal, plastic, or fabric (e.g., geotextile) with holes or slots that allow water to pass through but limit particulate pollutant passage by deflection or sieving.

- **Pretreatment Vegetated Filter Strips**, also sometimes called buffer strips or buffers, are sloped soil surfaces that rely on shallow (i.e., water level < height of the vegetation), distributed flow through dense vegetation to reduce flow velocity, allow particles to settle, and allow particle interception by the vegetation as their primary mechanisms of pollutant removal. Pretreatment vegetated filter strips are not to be confused with treatment vegetated filter strips <link>, which are designed and used as stand-alone structural stormwater BMPs. Concentrated or channelized flow is common to structural stormwater BMP treatment swales <link to swales>, but is not appropriate for pretreatment vegetated filter strips.

Provided below is summary information describing pretreatment characteristics, suitability and potential compatibility with primary structural stormwater BMPs. Table 2-1 is a summary of the pretreatment practice characteristics including methods of pollutant removal, relative pollutant removal, relative capital costs, maintenance and space requirements. Table 2-2 summarizes the applicability of the pretreatment practices relative to cold climate suitability, retrofit suitability, suitability for ultra-urban settings, and suitability as a stand-alone BMP. Table 2-3 summarizes the compatibility of the three pretreatment practices for typical structural stormwater BMPs. There is additional discussion below about the criteria assessed in developing the tables as well as other considerations to account for when using these tables.

Table 2-1. Pretreatment Practice Summary of Characteristics*

Pretreatment Practice	Mechanism of Pollutant Removal	Relative Pollutant Removal	Relative Capital Cost	Relative Maintenance Frequency	Relative Maintenance Effort	Relative Space Requirements
Pretreatment Settling Devices	Screening & Settling	Medium	Medium to High	Medium	Low to Medium	Low to Medium
Pretreatment Screens	Screening	Low	Low	High	Medium	Low
Pretreatment Vegetated Filter Strips	Screening & Settling	Medium	Low	Low	High	High

*There is additional discussion below about the criteria assessed in developing the table and other considerations.

Table 2-2. Pretreatment Practice Applicability*

Pretreatment Practice	Cold Climate Suitability	Retrofit Suitability	Suitability for Ultra-Urban Settings
Pretreatment Settling Devices	Medium to High	Medium	Low to High
Pretreatment Screens	Low	High	High
Pretreatment Vegetated Filter Strips	Medium	Low to Medium	Low

*There is additional discussion below about the criteria assessed in developing the table and other considerations.

Table 2-3. Pretreatment Practice Compatibility with Downstream Structural Stormwater BMPs*

	Pretreatment Practices		
Structural Treatment Practices	Pretreatment Settling Devices	Pretreatment Screens	Pretreatment Vegetated Filter Strips
Infiltration Practices			
Bioinfilitration/bioretention with no underdrain (rain garden)	X	X	X
Infiltration Basin	X	X	X
Infiltration Trench	X	X	X
Permeable Pavement with no underdrain	(As elevations allow)		X
Tree Trench/Tree Box with no underdrain	X	X	X
Stormwater Re-use and rainwater harvesting	X	X	X
Filtration Practices			
Biofiltration/Bioretention with an underdrain	X	X	X
Permeable Pavement with an underdrain	(As elevations allow)		X
Tree Trench/Tree Box with an underdrain	X	X	X
Swales	X	X	X
Sand Filters	X	X	X
Iron Enhanced Sand Filter	X	X	X
Green Roofs			
Wet Sedimentation Basin and Regional Ponds			
Stormwater Ponds	X	X	X
Stormwater Wetlands	X	X	X

*There is additional discussion below about the criteria assessed in developing the table and other considerations.

Pretreatment Characteristics (Table 2-1)

Pretreatment as defined above relies upon two primary treatment mechanisms (1) settling and/or (2) physical screening. Settling refers to the method of slowing flow velocities and temporarily detaining flow to allow solids denser than water to settle out of the flow. Screening refers to the method of removing solids by a porous material with a minimal thickness, such as a single sheet of metal with holes in it, as water flows through it, or forcing water to flow through submerged outlets to capture floatables.

Relative pollutant removal is classified as either low, medium or high. These descriptions are relative across pretreatment practices and account for the ability of a specific pretreatment practice to remove coarse sediments, trash and debris, and organic material. The ratings do not imply that removal exceeds any numeric threshold, but rather that the practice removes more pollutants than pretreatment practices rated lower. Stormwater pollutants such as nutrients, non-coarse sediments, pathogens, hydrocarbons, metals, and pesticides that are associated with coarse sediments, trash, debris and organic material captured by pretreatment practices will also be captured.

Relative capital cost is classified as low, medium or high. This refers to the anticipated cost required for purchasing the practice and/or the installation costs that are required to implement the pretreatment practice so that it operates as designed. It does not include the land use costs or lifecycle maintenance costs. This is a relative comparison among all pretreatment practices and it is important to note that the costs vary from site to site.

Relative maintenance frequency and effort are classified as low, medium or high. Maintenance frequency reflects how often maintenance will typically be required for these practices. Maintenance effort reflects the anticipated time, skill of labor, and equipment necessary to complete maintenance. These vary depending on pretreatment device placement (ease of access), size and the pollutants/soil types in the watershed. These values are relative to the other pretreatment practices.

Relative space requirements are classified as low, medium or high. Space requirements are the anticipated footprint used by the specific pretreatment practice after installation. This varies for a specific pretreatment practice, but provides a relative comparison of the footprint required for the various pretreatment practices. If the practice is large, but located below ground it is considered to have a small footprint and is classified as low.

Pretreatment Applicability (Table 2-2)

Cold climate suitability is classified as low, medium or high. This refers to the anticipated capability of a particular pretreatment practice to function and provide pretreatment for elevated sediment concentrations in spring and snowmelt related runoff relative to the other pretreatment practices. Winter variability factors that affect pretreatment mechanisms include reduced biological activity, reduced settling velocities, frost heave, reduced drainage basin infiltration and variable thawing and freezing cycles. Variations of weather-driven events such as rainfall-upon-snow events, peak spring runoff and snow storage/management are also cold climate factors affecting pretreatment. If the functionality of a pretreatment practice is greatly affected by cold climate factors, the practice is classified as low. If the pretreatment's functionality remains consistent year-round, it is classified as high.

Retrofit suitability is classified as low, medium or high and reflects the relative effort required to insert a specific pretreatment practice with an existing structural stormwater BMP. This does not include the effectiveness of the pretreatment practice (provided in Table 2-1), but rather a measure of anticipated total effort (planning, design, installation, and related expenses) and space required to insert the pretreatment practice within existing infrastructure. A high retrofit suitability indicates the pretreatment practice requires relatively minimal effort, space or both to retrofit the practice into existing infrastructure. A low retrofit suitability suggests that the pretreatment practice will require significant effort, space, or both to install the practice into existing infrastructure.

Suitability for ultra-urban settings is classified as low, medium or high. Factors include size of the pretreatment footprint, linked infrastructure requirements and constraints, limitations associated with highly impervious contributing areas, and application within traditional curb and gutter and stormsewer systems. Ultra-urban settings typically have high land values, complex infrastructure, and substantial impervious area. Pretreatment practices that require minimal space or are underground, have simple infrastructure requirements and are relatively simple to retrofit into existing infrastructure are often most suitable to ultra-urban settings and are classified as high. A low classification indicates a practice either requires substantial space or requires significant effort to install in ultra-urban areas.

Pretreatment Practice Compatibility with Downstream Structural Stormwater BMPs (Table 2-3)

Pretreatment compatibility with structural stormwater BMPs is wide ranging and summarized in Table 2-3, however, site specific characteristics will help guide which practice is best suited in a given application. Factors such as size, topography, site use, pollutant type, and flow (overland/concentrated) will often distinguish which pretreatment practice is best suited for that BMP or site. Taking into consideration the most common type of pollutant (large debris, small debris, hydrocarbons, etc.), space limitations, topography, and receiving flow type will lead to the best-suited pretreatment practice at a given site. Some examples include:

- If a small residential rain garden is installed, a pretreatment vegetated filter strip is often recommended instead of an underground settling device because the rain garden is above ground.
- In highly urban areas with little space available, an underground settling device is recommended instead of a sediment forebay due to high land values.
- On a steep site, an underground settling device is recommended because it would be difficult to grade an above ground settling device.
- In areas and structural stormwater BMPs with more natural vegetation, a pretreatment vegetative filter strip is highly recommended instead of a screen because a pretreatment vegetative filter strip visually matches the site.
- Pretreatment screens are highly recommended for areas with leaf debris or other large debris because screens are well-suited for capturing such debris, though frequent maintenance is likely required.
- If the receiving BMP is an underground filtration system, a below ground settling device is recommended instead of an above ground settling device, particularly if construction is in tandem.
- For channelized flow, a pretreatment vegetated filter strip is not recommended because much of the flow would bypass untreated, whereas an above ground settling device such as a forebay is highly recommended because it captures and provides pretreatment for channelized or pipe flow.
- If the pretreatment device is receiving sheet flow, a vegetative filter strip is highly recommended because they are designed specifically for distributed overland sheet flow.

Cost Considerations

Although cost is variable depending on the specific site properties and the size of the pretreatment practice, Table 2-1 provides general guidance for selecting a pretreatment practice based on capital cost. In addition to capital costs, land value cost and lifecycle maintenance costs should be considered when selecting a pretreatment practice. The capital cost is the cost of purchasing the practice and/or the costs to implement the practice which will vary based on site conditions, type of practice, and size of the practice. Land value costs will be highly variable and largely dependent upon the potential of the site to generate revenue or other benefits within the pretreatment practice footprint. Maintenance costs are a long-term cost representing the combined frequency of maintenance and the effort required to carry out the maintenance, including acquisition of maintenance equipment, personnel training, labor, and disposal of accumulated sediment and debris. Maintenance costs should also consider how the pretreatment practice reduces maintenance costs in the structural stormwater BMP. To more fully understand the entire cost of installing one pretreatment practice from another, all three costs (capital, land value, and maintenance) should be considered on a site by site basis. Some examples include:

- Some underground settling devices have expensive capital costs, but these may be offset by placement underground, thereby reducing land acquisition expense.
- A pretreatment practice (e.g., underground settling device) with expensive capital costs may be offset by savings of maintenance costs if the party in charge has other similar practices and an established, streamlined maintenance program/equipment for that specific type of practice (e.g., a vacuum truck).

3.0 PRETREATMENT PRACTICES

For each of the methods discussed under Task C, include the following information as appropriate and applicable to the practice (see vegetated filter strips for an example).

It is important to tailor the pretreatment practice to the specific site and type of receiving structural stormwater BMP. Many factors influence the choice of pretreatment practices, including but not limited to: (1) contributing area characteristics (drainage area, connected imperviousness, land uses, soils, slopes, dominant vegetation, source controls in place, and availability of public lands); (2) existing infrastructure (above and below ground); and (3) type of structural stormwater BMP. For example, infiltration/filtration BMPs require removal of solids in pretreatment practices. The following section will describe the specific strengths and weaknesses, as well as applicability to certain stormwater pollutant scenarios for the various pretreatment practices.

3.1 PRETREATMENT SETTLING DEVICES

3.1.1 Applicability and Suitability

Include a discussion of whether the practice can be used for the following situations and what considerations or constraints apply for the practice to be applicable.

- ~~Appropriate contributing impervious surfaces (e.g. roads, small parking lots, residential driveways, roofs, etc.)~~
- ~~Stormwater hotspots and spill control~~
- Cold climate, including snow storage suitability
- Retrofit suitability
- Suitability for ultra-urban settings
- ~~Receiving water suitability (see example)~~
- As a stand-alone BMP

Pretreatment practices are NOT stand-alone treatment practices and should only be installed in conjunction with a treatment practice immediately downstream. The applicability of pretreatment settling devices with regard to the cold climate considerations, retrofits, ultra-urban settings and other considerations is presented below.

Cold Climate Suitability: Some settling devices are designed to be installed below ground and are often installed below the frost line. If they are installed below the frost line, settling devices will likely perform their designed function during the winter, which is an advantage compared to other pretreatment devices. Settling devices exposed to atmospheric air temperatures through open grates and stormsewers will be affected by freeze/thaw cycles if ice develops within the structure and causes short-circuiting (bypassing) or damages the structure or its components. In addition, settling devices that are small will be overwhelmed by high runoff volumes and pollutant loads from major thaw events and spring snowmelt. As a result, more frequent maintenance is often necessary prior to and during these conditions. Settling devices may capture less sediment during cold climate conditions due to reduced settling velocities.

Forebays are effective in cold climates when properly designed, such as incorporating additional space for the accumulation of snow and ice as well as meltwaters from major thaw events and spring runoff.

Forebays may also be used for snow storage in winter months, adding to their overall functionality, provided they are designed to account for the additional volume of snow and ice and that snow storage does not impede flow into or out of the forebay during major thaw events and spring snowmelt.

Retrofit Suitability: Settling devices are often suitable to be installed within existing infrastructure and during redevelopment with constraints as noted in Table 2.1 and 2.2.

Ultra-urban Suitability: Underground settling devices are highly suitable for ultra-urban settings because they require a small (underground) footprint and settled materials are stored out of sight prior to removal. Above ground settling devices, including forebays, are suitable for ultra-urban applications if adequate space is available and forebay aesthetics are acceptable. Routine removal of trash and accumulated debris are a common factor for all pretreatment devices.

Other Considerations: Some underground settling devices have limited storage capacities and a limited range of design flows. As such, these devices should be sized appropriately for the contributing watershed characteristics. If these characteristics exceed their design capabilities, a different pretreatment practice should be selected. In addition, some devices allow captured sediment to be susceptible to resuspension and discharge to the structural stormwater BMP during high-flow events. Such settling devices should be installed off-line or with bypasses to avoid washouts during these high-flow events.

3.1.2 Advantages and Limitations

Provide a discussion of the advantages and limitations for each practice. Factors to be considered include but are not limited to pollutant removal capability, cost, ease of construction, ease of maintenance, space and other design considerations, and compatibility with other BMPs.

The advantages and limitations of settling devices with regard to the pollutant removal capabilities, cost, ease of construction and maintenance, space and other design considerations and compatibility are presented below.

Advantages: Underground structures with surface manholes provide access for maintenance staff to inspect sediment and debris accumulations, and with the proper equipment such as a vacuum truck, maintenance is relatively easy and inexpensive. These devices often allow easy placement within the existing stormwater infrastructure in many situations. Underground devices are space efficient and out of sight which allows for use in areas where there is little or no surface area for installation of a pretreatment practice. Because accumulated sediment and debris are stored underground and out of public sight, these devices are also beneficial in areas with strict aesthetic requirements.

If designed properly and easily accessible, maintenance for above ground settling devices is relatively simple and inexpensive. A visible forebay will also facilitate visual inspection to determine when maintenance is necessary. Installing a depth gauge to measure sediment depth will aid in efficient visual assessment of accumulated material. Some settling devices are configured to capture floatables including oil and grease.

Limitations: Contributing area characteristics (size, land use, underlying soils, etc.) will affect sizing, design and the configuration of pretreatment settling devices. Pollutant removal is typically limited to coarse sediments and debris, although some devices also capture floatables, oil, and grease. Fine sediments and associated pollutants such as metals and nutrients are not effectively treated by settling devices and are more vulnerable to high flow events causing resuspension and discharge of previously captured sediments. Dissolved pollutants are not to be considered treated/removed by pretreatment settling devices. Pretreatment settling devices installed offline or with a bypass mechanism result in some fraction of the event delivered to the downstream BMP without pretreatment. In certain conditions, organic debris stored underwater in underground devices produce biological activity, anoxic conditions, or both and result in conversion of particulate pollutants into dissolved forms (e.g., particulate phosphorus into dissolved phosphorus). Stagnant water in some underground devices can also become mosquito habitat, but local organizations (e.g., Metropolitan Mosquito Control District) are often available to provide design input for treatment (e.g., access ports). Some proprietary devices are expensive and require heavy equipment for installation. When underground utilities conflict with underground practices, the cost and difficulty of design and installation increase. Other potential site-specific challenges include presence of bedrock and high groundwater. Maintenance costs for underground devices increase if a vacuum truck is not available, because third-party contracts or capital investments in equipment and personnel training (particularly if involving confined space entry) are required. If located in a high-traffic area, requisite safety and traffic controls are necessary to allow access for maintenance. A poorly maintained forebay filled with debris is often aesthetically displeasing. If the settling device does not have the REQUIRED maintenance access, sediment removal is more difficult and expensive. It is also REQUIRED that a maintenance plan be developed and followed, because these devices are often neglected.

3.1.3 Applicable Processes

Provide a summary of applicable processes for the practice, including but not limited to the suitability of the practice for volume reduction, peak flow reduction, sedimentation, filtration, sorption, settling, and biological processes. If applicable, discuss how the applicability of these practices varies as a function of design for the practice. For example, filter strips may be designed to pool water and allow for some infiltration, although typically this practice achieves very little volume reduction.

Settling devices rely primarily on sedimentation, in which coarse sediments and debris sink or fall out of the collected stormwater. Some settling devices also provide secondary screening to improve the capture of floatables and sediment. Stormwater management processes **not provided in settling devices** include volume reduction, peak flow reduction (minimal), infiltration (typically very minimal), filtration, sorption and biological treatment.

3.1.4 Applicability to MPCA Stormwater Permits

Provide a summary of the applicability of the practice to MPCA stormwater permits. Cite specific pretreatment requirements in the permit and the applicability of the practice to that requirement. If applicable, include a discussion of other permit requirements, such as the required 3 foot separation distance if the pretreatment practice is designed to infiltrate water

If designed properly, this practice meets the intent of the construction stormwater permit as identified in section III.D.1.D as pretreatment for an infiltration or filtration system. Section III.D.1.D in stormwater construction permit reads:

> To prevent clogging of the infiltration or filtration system, the **Permittee(s)** must use a pretreatment device such as a vegetated filter strip, small sedimentation basin, or water quality inlet (e.g., grit chamber) to settle particulates before the **stormwater** discharges into the infiltration or filtration system.

3.1.5 Volume Reduction

Provide information on volume reduction of the practice and the design specifications necessary to achieve the volume reductions.

Stormwater volume reduction is not provided by settling devices as all of the water that flows into the device exits the device after settling occurs.

3.1.6 Water Quality Benefits (For MPCA Informational Purposes Only)

Provide a discussion of water quality benefits of the practice, including information on pollutant removal. If sufficient data are available provide statistical summary information, including median, minimum, and maximum removal rates (or 1st and 3rd quartiles), based on event mean concentrations (influent and effluent). Include a discussion of factors that affect removal rates, such as length for filter strips. If sufficient data are not available, provide the relative pollutant removal efficiency (low, medium, high). See list of recommended references for a starting point for gathering this information. Information will be provided for the following pollutants.

- Total suspended solids
- Total phosphorus
- Total nitrogen
- Bacteria – provide information for fecal coliform bacteria, e. coli, and pathogenic bacteria if available
- Metals – provide information for specific metals if available
- Hydrocarbons – provide information for specific classes of hydrocarbons (e.g. VOCs, semi-volatiles, PAHs) if available

The following material is not intended for use in the manual. Our research found that there wasn't sufficient data to be able to give values without confusing readers, but is provided here for MPCA reference.

Proprietary settling devices are designed to remove suspended sediments and floatables such as trash and debris through gravitational settling and/or cyclonic separation. There are several testing programs that provide certification or verification of performance of proprietary technologies. For example, the Washington Department of Ecology certifies proprietary stormwater treatment devices. In order to receive certification for pretreatment, a proprietary device must achieve at least 50% removal of TSS when the influent TSS is greater than 100 mg/L, and an effluent TSS concentration of 50 mg/L or less is required if influent TSS is between 50 and 100 mg/L (Ecology, 2015). For Technology Assessment Protocol – Ecology from the state of Washington's Department of Ecology (TAPE) certification, laboratory testing must use Sil-Co-Sil 106 particles. Field testing of the technology is also required and particle size will vary under field conditions. No other contaminant is required to be tested for the TAPE pretreatment certification. Similarly, the New Jersey Department of Environmental Protection (NJDEP) requires manufactured treatment devices *to be verified by the New Jersey Corporation for Advanced Technology (NJCAT). NJCAT tests devices based on the Technology Acceptance Reciprocity Partnership (TARP), whereby devices are tested to verify the manufacturer's performance claim (NJCAT, 2015). Information on performance can be found by these two verification programs or other third party verification programs when considering which proprietary settling devices might be best suited for pretreatment. For best performance always follow manufacturer specifications for design, installation and maintenance. Finally, the SHSAM program (https://www.barr.com/WhatsNew/SHSAM/SHSAMapp.asp) is another tool for estimating suspended solids removal based on drainage area and the size of the practice.*

In general, the sediment removal rate of proprietary devices decreases as flow increases through the device (Taylor et al., 2003). In a study to validate the performance of a hydrodynamic separator, larger particles (150 microns to 600 microns) were removed at rates between 60 and 98% while flow rate was varied between 154 and 650 gallons per minute. Smaller particles (75 microns) were removed at 62-69% at flow rates of 154-157 gallons per minute, and 40-46% at flow rates of 360 to 371 gallons per minute (Taylor et al., 2003).

Proprietary settling devices are designed to remove solids, and therefore are capable of removing nutrients, bacteria and hydrocarbons when these pollutants are part of, or bound to, particles. Nutrient removal depends upon the relationship between phosphorus or nitrogen attachment and sediment size of the particles in the runoff. Kayhanian, et al. (2007) analyzed the results from 34 highway water quality stations and a total of 634 storms to determine the mean and median concentrations of stormwater pollutants. They report that the mean and median concentrations of Ortho-Phosphorus (Ortho-P) were 0.11 and 0.06 mg/L, respectively, with a standard deviation of 0.2 mg/L. For total phosphorus, the mean and median concentrations were 0.29 and 0.18 mg/L, respectively, with a standard deviation of 0.4 mg/L. Maestre and Pitt (2005) found similar results for runoff in municipalities throughout the United States, which had median concentrations of 0.13 and 0.27 mg/L for Ortho-P and total phosphorus, respectively. For nitrogen, Kayhanian, et al. (2007) report that the mean and median concentrations of nitrate were 1.07 and 0.6 mg/L with a standard deviation of 2.6 mg/L, and were 2.06 and 1.4 with a standard deviation of 1.9 mg/L for were total Kjeldahl nitrogen (TKN), respectively. Maestre and Pitt (2005) found similar results with median concentrations of 0.44, 0.60, and 1.4 mg/L for Ammonia (NH_3), Nitrite + Nitrate (NO_2 + NO_3), and TKN, respectively. Some studies, however, have shown that much of the nitrogen present in stormwater in the dissolved form of nitrate (Taylor et al., 2005). This suggests that nitrate is roughly half of total (Kjeldahl) nitrogen concentrations, but varies substantially, both between storms and between locations. Typically, little to no nitrogen is removed from stormwater runoff through proprietary settling devices, other than sediment or organic bound material. Stormwater manuals from California, Virginia, and New Hampshire credit proprietary settling devices with approximately 15-40% removal of phosphorus, but only 5-10% of nitrogen (California Department of Transportation, 2004; Virginia Department of Ecology, 1999; Comprehensive Environmental Inc. and New Hampshire Department of Environmental Services, 2008).

Similar to phosphorus, an understanding of the relationship between metals and sediment association for the runoff from a particular site is important to estimate the type and amount of metals removed. Proprietary settling devices will capture metals, particularly toxic metals, that are bound to particles captured within the proprietary device. Kayhanian et al. (2007) found that the particulate fraction for Arsenic, Copper, Cadmium, and Zinc was 36 - 70% while Maestre and Pitt (2005) found that the particulate fraction was 50 - 55% for the same metals. Other factors, including pH and the presence of other metals, also affect metal association (Wilson et al., 2007). Proprietary devices with cartridges may be another solution to reduce metals (and other pollutants) <link to stormwater manual>.

Some proprietary settling devices such as hydrodynamic separators also include compartments to capture oil and other floatables, such as trash (Virginia DEQ, 1999). Tests have shown removal rates of oil between 10% and 98%. High flow rates (>30 gallons per minute) decrease the removal rate of hydrocarbons while increased loading of oil (>90 mg/L) has been shown to increase the removal rate (Coventry University, no date; Contech, 2006a). TAPE approval designates that a technology has achieved “no ongoing or recurring visible sheen and a daily average petroleum hydrocarbon (TPH) concentration no greater than 10 mg/L with a maximum of 15 mg/L for discrete samples” (Ecology, 2015).

Underground settling devices are sometimes referred to as vaults or sumps and remove sediments through sedimentation, and in certain cases, hydrocarbons through gravity separation and coalescence (DDOE, 2013; TRPA, 2014). Underground vaults are designed with or without baffles. Vaults without baffles are primarily used to settle out sediments upstream of an infiltration BMP (DDOE, 2013). Hydrocarbons have been captured in an underground vault when baffles and coalescing plates are used to slow flow and allow hydrocarbons to float to the surface (TRPA, 2014).

Non-proprietary settling devices can also be used in conjunction with or as a part of proprietary settling devices to increase performance. One such configuration could include a hydrodynamic separator followed by a sedimentation vault. This system could remove trash, sediment, debris and hydrocarbons from stormwater.

The sediment removal efficiency of forebays depends upon the size and design of the forebay, as well as sediment loading (Maniquiz-Redillas et al., 2014). In order to achieve maximum sediment removal, forebays are typically designed to contain 10% of the water quality volume, should be deep enough to prevent resuspension of settled solids (Horsley Witten Group, University of New Hampshire Stormwater Center, and Loon Environmental, 2010; Virginia DEQ, 2011) depending on frequency of maintenance, and designed to withstand velocities of incoming runoff from the design storm without scouring (Massachusetts Department of Environmental Protection, 2008). It is important that forebays include a zone for energy dissipation and a zone for settling of sediments. The Massachusetts Department of Environmental Protection assigns forebays a 25% removal credit for TSS when they are designed to hold 0.1 inch/impervious acre (Massachusetts Department of Environmental Protection, 2008). Many stormwater manuals do not give separate TSS removal credit for forebays, but rather include the TSS removed by the forebay in the performance of the downstream BMP (Virginia DEQ, 2011). Currently, Minnesota does not provide credit for TSS removal for a pretreatment practice.

Another factor that influences TSS removal efficiency is sediment loading. A study by Maniquiz-Redillas et al. (2014) found that 15-35% of sediment was captured in a forebay when TSS loading ranged from 10 x 10^3 to 85 x 10^3 kg/year. According to the study, a majority of the sediments captured had a diameter ranging from 0.075-2 mm. Particles less than 0.075 mm constituted only 7% of the captured sediments (Maniquiz-Redillas et al., 2014). More detailed studies should be reviewed or conducted to understand the performance if the sediment loading size is different.

Similar to proprietary settling devices, the removal of nutrients, hydrocarbons and bacteria is dependent upon the relationship of those pollutants to the sediment removed. Stormwater manuals do not give credit to forebays for the removal of these constituents.

3.2 PRETREATMENT SCREENS

3.2.1 Applicability and Suitability

Include a discussion of whether the practice can be used for the following situations and what considerations or constraints apply for the practice to be applicable.

- ~~Appropriate contributing impervious surfaces (e.g. roads, small parking lots, residential driveways, roofs, etc.)~~
- ~~Stormwater hotspots and spill control~~
- Cold climate, including snow storage suitability
- Retrofit suitability
- Suitability for ultra-urban settings
- ~~Receiving water suitability (see example)~~
- As a stand-alone BMP

Pretreatment practices are NOT stand-alone treatment practices and should only be installed in conjunction with a treatment practice immediately downstream. The applicability of screens with regard to the cold climate, retrofits, and ultra-urban settings is presented below.

Cold Climate Suitability: Screens are not suitable for use in cold climates when snow and ice is able to accumulate on the screen, because screens that become frozen often result in short-circuiting (bypass) or backflows. Ice accumulation also often prevents screens from adequately pretreating high runoff volumes and pollutant loads during major thaw and spring snowmelt events in cold climates. Screens also do not provide snow storage capacity.

Retrofit Suitability: Screens are often suitable to retrofit with a variety of structural stormwater BMPs due to their small footprint.

Ultra-Urban Suitability: Screens are often effectively used in ultra-urban settings due to their small footprint but above ground screens are often constrained by aesthetics, traffic/safety and cold weather factors.

3.2.2 Advantages and Limitations

Provide a discussion of the advantages and limitations for each practice. Factors to be considered include but are not limited to pollutant removal capability, cost, ease of construction, ease of maintenance, space and other design considerations, and compatibility with other BMPs.

The advantages and limitations of screens with regard to the pollutant removal capabilities, cost, ease of construction and maintenance, space and other design considerations and compatibility are presented below.

Advantages: Screens are an effective means of pretreatment in certain instances. They screen out sediment and debris efficiently in a small amount of space. The initial costs are often relatively inexpensive because screen systems are not complex. This also allows for simple maintenance which typically requires access to the screen and manual removal of sediment and debris, sometimes including washing with clean water to dislodge collected sediment and debris. Construction consists of installing a screen device in place, with relatively minimal labor costs and often without heavy equipment. Because screens typically have a small footprint, they are suitable for many BMPs and retrofit with many preexisting structures with minimal construction. Screens do provide discrete locations for the interception of large debris thus potentially saving expenses associated with collecting trash from structural stormwater BMPS.

Limitations: Screens should be inspected after each storm, until a site-specific, seasonal maintenance routine is developed. For most screen materials and design, pollutant removal is limited to trash, debris and coarse sediments while all other pollutants will pass through to the structural stormwater BMP. If the screen diameters are too small, collected material will clog the screen and increase cleaning frequency. Some seasons (e.g., spring snowmelt, spring leaf-out debris, autumn deciduous leaf-fall) or contributing areas (e.g., heavily wooded residential areas without street sweeping, commercial businesses with plastic bags, etc.) often produce a substantial amount of large sediment and debris, resulting in the need for inspections to determine an effective maintenance protocol. Screen systems often do not have much collection capacity and thus reduce in effectiveness or clog after a series of storm events. Without frequent maintenance, this ultimately diminishes the overall effectiveness of the system and thus careful consideration of screen design (size, diameter of openings, contributing area) is required to treat the range of expected seasonal flows and solids load.

3.2.3 Applicable Processes

Provide a summary of applicable processes for the practice, including but not limited to the suitability of the practice for volume reduction, peak flow reduction, sedimentation, filtration, sorption, settling, and biological processes. If applicable, discuss how the applicability of these practices varies as a function of design for the practice. For example, filter strips may be designed to pool water and allow for some infiltration, although typically this practice achieves very little volume reduction.

Screens provide a very specific and limited function of collecting large pollutants from stormwater runoff at defined sites along the stormwater flow network. Screens do not provide volume reduction, peak flow reduction, sedimentation, infiltration, filtration, sorption and biological processes.

3.2.4 Applicability to MPCA Stormwater Permits

Provide a summary of the applicability of the practice to MPCA stormwater permits. Cite specific pretreatment requirements in the permit and the applicability of the practice to that requirement. If applicable, include a discussion of other permit requirements, such as the required 3 foot separation distance if the pretreatment practice is designed to infiltrate water

If designed properly, this practice meets the intent of the construction stormwater permit as identified in section III.D.1.D as pretreatment for an infiltration or filtration system. Section III.D.1.D in stormwater construction permit reads:

To prevent clogging of the infiltration or filtration system, the **Permittee(s)** must use a pretreatment device such as a vegetated filter strip, small sedimentation basin, or water quality inlet (e.g., grit chamber) to settle particulates before the **stormwater** discharges into the infiltration or filtration system.

3.2.5 Volume Reduction

Provide information on volume reduction of the practice and the design specifications necessary to achieve the volume reductions.

Stormwater volume reduction is not provided by pretreatment screens because water flowing into the device exits after the screen removes the sediment and large debris.

3.2.6 Water Quality Benefits (For MPCA Informational Purposes Only)

Provide a discussion of water quality benefits of the practice, including information on pollutant removal. If sufficient data are available provide statistical summary information, including median, minimum, and maximum removal rates (or 1st and 3rd quartiles), based on event mean concentrations (influent and effluent). Include a discussion of factors that affect removal rates, such as length for filter strips. If sufficient data are not available, provide the relative pollutant removal efficiency (low, medium, high). See list of recommended references for a starting point for gathering this information. Information will be provided for the following pollutants.

- Total suspended solids
- Total phosphorus
- Total nitrogen
- Bacteria – provide information for fecal coliform bacteria, e. coli, and pathogenic bacteria if available
- Metals – provide information for specific metals if available
- Hydrocarbons – provide information for specific classes of hydrocarbons (e.g. VOCs, semi-volatiles, PAHs) if available

The following material is not intended for use in the manual. Our research found that there wasn't sufficient data to be able to give values without confusing readers, but is provided here for MPCA reference.

Screens used for stormwater pretreatment provide screening, or physical straining, of sediment, trash and debris from stormwater. Screens are not to be confused with filters, which refer to the passing of stormwater through a media to remove pollutants. Screens used for stormwater pretreatment are typically manufactured devices that are placed at stormwater inlets.

Points to consider when choosing a screen include the size of the screen openings, the anticipated flow rate through the screen, and the debris holding capacity of the device. A pilot study in the state of California found that catch basin inserts with five-millimeter (mm) openings captured 100 percent of trash in runoff generated by a one-year, one-hour storm (Burns, 2014). Larger openings in the screen will allow small debris such as wrappers or cigarette butts to pass through the screen. The District Department of Environment captured 17,000 pounds of trash in 2012 using trash traps as a part of their TMDL implementation strategy (DDOE, 2013).

Screens will provide a reduction in nutrients, bacteria, or hydrocarbons if those pollutants are attached to trash or debris captured by the screen. For example, leaf litter is often a large source of nutrients in stormwater runoff, and effectively managing leaf litter has been used by communities to control phosphorus loads in stormwater (City of Madison, 2015). Another reason it is important to clean screens out regularly is to avoid the possibility of nutrients being leached out over time, which reduces the overall effectiveness of nutrient removal by screens. Capture of trash such as food containers, diapers and pet waste will also reduce bacteria (USEPA, 2012). Screens that capture trash and other debris should be cleaned and maintained regularly to prevent over-accumulation of trash, which will limit pretreatment performance (USEPA, 2014).

3.3 PRETREATMENT VEGETATED FILTER STRIPS

3.3.1 Applicability and Suitability

Include a discussion of whether the practice can be used for the following situations and what considerations or constraints apply for the practice to be applicable.

- ~~Appropriate contributing impervious surfaces (e.g. roads, small parking lots, residential driveways, roofs, etc.)~~
- ~~Stormwater hotspots and spill control~~
- Cold climate, including snow storage suitability
- Retrofit suitability
- Suitability for ultra-urban settings
- ~~Receiving water suitability (see example)~~
- As a stand-alone BMP

Pretreatment practices are NOT stand-alone treatment practices and should only be installed in conjunction with a treatment practice immediately downstream. The applicability of pretreatment vegetated filter strips with regard to the cold climate, retrofits, ultra-urban settings and other considerations is presented below.

Cold Climate Suitability: During winter months, pretreatment vegetated filter strips will become frozen and covered by ice and snow to some extent. This will diminish the effectiveness of the practice if flows become channelized, resulting in reduced trapping of sediments. Once the snow and ice melts, sheet flow is re-established, and vegetation actively removes sediment, pretreatment filter strips will provide some snowmelt treatment. Pretreatment vegetated filter strips are often less effective during cold climate conditions due to reduced biological activity (dormant vegetation) and reduced settling velocities. Storing snow on pretreatment vegetated filter strips is not recommended because it will extend the duration of ineffective treatment due to increased snowpack. In rare instances, some types of invasive annual vegetation reduce perennial cover which results in periods of unestablished vegetation during periods of runoff (e.g., winter thaws and spring snowmelt events) and less pretreatment.

Retrofit Suitability: Pretreatment vegetated filter strips tend to require more space than other pretreatment practices, which often limits retrofit suitability.

Ultra-Urban Suitability: Pretreatment vegetated filter strips tend to require more space than other pretreatment practices, and thus they are often not suitable in ultra-urban settings where space is limited.

Other Considerations: Channelized inflows to the pretreatment vegetated filter strips must be avoided because concentrated flows will reduce the effectiveness of the practice. For some sites, footprint area is a constraint because pretreatment vegetated filter strips often require more surface area than other pretreatment practices. Pretreatment vegetated filter strips are not designed to infiltrate water, but treatment filter strips are suitable as part of a structural stormwater BMP <include link to BMP page>.

3.3.2 Advantages and Limitations

Provide a discussion of the advantages and limitations for each practice. Factors to be considered include but are not limited to pollutant removal capability, cost, ease of construction, ease of maintenance, space and other design considerations, and compatibility with other BMPs.

The advantages and limitations of pretreatment vegetated filter strips with regard to the pollutant removal capabilities, cost, ease of construction and maintenance, space and other design considerations and compatibility are discussed below.

Advantages: Pretreatment vegetated filter strips provide many advantages as a pretreatment practice. They effectively remove sediments from stormwater runoff. The construction of this practice is often relatively simple compared to other pretreatment practices, though it does require a level spreader along with establishment of vegetative cover including periodic vegetation maintenance. Pretreatment vegetated filter strips are often easily accessible which makes maintenance more manageable and often have less non-routine maintenance costs (e.g. do not require the use of heavy equipment). Pretreatment vegetated filter strips offer aesthetic aspects enhancing stormwater designs desired in green infrastructure settings.

Limitations: Pretreatment vegetated filter strips require runoff to be conveyed in shallow, distributed sheet flow. To maintain their effectiveness, pretreatment vegetated filter strips require regular routine inspection and maintenance to remove accumulated sediment and debris. Sediment and debris that is not removed often results in flow bypass or channelization of erosive flows through the pretreatment vegetated filter strip. Sites requiring re-sloping/grading and imported specification soils often incur additional construction costs due to the use of heavy equipment and associated labor. High loadings of pollutants might damage the vegetation (e.g., vegetation adjacent to a roadway or parking lot with high application rates of deicers). Proper siting and design will improve long-term performance and reduce maintenance expenses. Although pretreatment vegetated filter strips are suitable for many receiving structural stormwater BMPs, space and site requirements (e.g., slope, flow distribution) are the most common limits for the applicability of this practice.

3.3.3 Applicable Processes

Provide a summary of applicable processes for the practice, including but not limited to the suitability of the practice for volume reduction, peak flow reduction, sedimentation, filtration, sorption, settling, and biological processes. If applicable, discuss how the applicability of these practices varies as a function of design for the practice. For example, filter strips may be designed to pool water and allow for some infiltration, although typically this practice achieves very little volume reduction.

Pretreatment vegetated filter strips are designed to provide sedimentation and screening (by vegetation) to treat stormwater runoff prior to entering a structural stormwater BMP. Pretreatment vegetated filter strips are especially effective at capturing excess sediment in stormwater runoff by settling solids. Pretreatment vegetated filter strips provide limited (due to size) volume reduction, peak flow reduction, infiltration, and biological treatment. Stormwater management processes not provided in pretreatment vegetated filter strips include filtration and sorption.

3.3.4 Applicability to MPCA Stormwater Permits

Provide a summary of the applicability of the practice to MPCA stormwater permits. Cite specific pretreatment requirements in the permit and the applicability of the practice to that requirement. If applicable, include a discussion of other permit requirements, such as the required 3 foot separation distance if the pretreatment practice is designed to infiltrate water

If designed properly, this practice meets the intent of the construction stormwater permit as identified in section III.D.1.D as pretreatment for an infiltration or filtration system. Section III.D.1.D in stormwater construction permit reads:

> To prevent clogging of the infiltration or filtration system, the **Permittee(s)** must use a pretreatment device such as a vegetated filter strip, small sedimentation basin, or water quality inlet (e.g., grit chamber) to settle particulates before the **stormwater** discharges into the infiltration or filtration system.

3.3.5 Volume Reduction

Provide information on volume reduction of the practice and the design specifications necessary to achieve the volume reductions.

Pretreatment vegetated filter strips are designed to ease maintenance and prolong the lifespan of the downstream structural stormwater BMP, and thus provide limited volume reduction (due to size). Pretreatment vegetated filter strips are not to be confused with the structural stormwater BMP treatment vegetated filter strips <link>, which are designed and used as a stand-alone structural stormwater BMP to reduce stormwater runoff volumes.

3.3.6 Water Quality Benefits (For MPCA Informational Purposes Only)

Provide a discussion of water quality benefits of the practice, including information on pollutant removal. If sufficient data are available provide statistical summary information, including median, minimum, and maximum removal rates (or 1st and 3rd quartiles), based on event mean concentrations (influent and effluent). Include a discussion of factors that affect removal rates, such as length for filter strips. If sufficient data are not available, provide the relative pollutant removal efficiency (low, medium, high). See list of recommended references for a starting point for gathering this information. Information will be provided for the following pollutants.

- Total suspended solids
- Total phosphorus
- Total nitrogen
- Bacteria – provide information for fecal coliform bacteria, e. coli, and pathogenic bacteria if available
- Metals – provide information for specific metals if available

- Hydrocarbons – provide information for specific classes of hydrocarbons (e.g. VOCs, semi-volatiles, PAHs) if available

The following material is not intended for use in the manual. Our research found that there wasn't sufficient data to be able to give values without confusing readers, but is provided here for MPCA reference.

Properly designed pretreatment vegetated filter strips slow runoff velocities and allow sediment to settle. Pretreatment vegetated filter strips also remove portions of other pollutants in runoff, including small particulates, hydrocarbons, heavy metals and nutrients such as phosphorus and nitrogen. Filter strips remove pollutant load through sedimentation, filtration, infiltration, biological uptake, and microbial activity.

The water quality benefit of a pretreatment vegetated filter strip is dependent upon factors such as the length of the flow path and slope, stormwater flow rate through the pretreatment vegetated filter strip, the type, density, and length of vegetation, the ability to maintain sheet flow through the pretreatment vegetated filter strip and the soil properties that influence infiltration rate. The ability to maintain sheet flow is often cited as a crucial factor for the success of filter strips (lakesuperiorstreams.org; Virginia DEQ, 1999)

In general, pretreatment vegetated filter strips are very effective at removing solids from stormwater if there is adequate flow path length and if sheet flow is maintained through the BMP with low rate of flow (Goel et al., 2004; Abu-Zreig et al., 2003; Gharabaghi et al., 2000). Solids removal varies between 50 and 98% depending on filter strip characteristics (NJ DEP, 2014; Goel et al., 2004; Abu-Zreig et al., 2003; Gharabaghi et al., 2000). Gharabaghi et al., 2000 found that 50% of sediments settled in the first 2.5 meters of a vegetated filter strip and an additional 25-45% of sediments settled in the next 2.5 meters. They also concluded that increased solids removal was minimal in flow path lengths greater than 10 meters. Some stormwater manuals require a minimum filter strip length of 10 feet with a slope of <2% (Inver Grove Heights, 2006; Wisconsin Department of Natural Resources, 2014). Other manuals specify that the minimum length for filter strips is 25 feet with a slope of <2% (Virginia DEQ, 1999), and requires four feet be added to the length for each 1% of slope greater than 2%. Virginia DEQ (1999) suggests that an ideal filter strip length is between 80 and 100 feet.

Assuming no infiltration, phosphorus removal is due to settling of solids and ranges from 32-79% based on the length of the flow path (Abu-Zreig et al., 2003). Some removal of dissolved nutrients occurs if the filter strip is designed to infiltrate water.

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APPENDIX A

DEFINITIONS

APPENDIX A: DEFINITIONS

A.1 DEFINITIONS

Realizing there is considerable overlap and variations in the terminology used for pretreatment practices, prepare a table clarifying terminology. For example, vegetated buffer, filter strip, and grass swale may be classified as similar or different pretreatment practices by different entities.

Terminology Table	Definition
Baffle	A device used to restrain water flow.
BMP	Best Management Practice: one of many different structural or non–structural methods used to treat runoff, including such diverse measures as ponding, street sweeping, filtration through a rain garden and infiltration to a gravel trench.
Forebay	An artificial pool or reservoir that slows/temporarily detains flow to allow sediments and other solids to settle out. (Synonyms; sediment forebay, sediment pool, small sediment basin, impoundment, basin, storage structure, excavated pit, upfront settling basin)
Grass Swale	A vegetated channel that conveys stormwater while allowing for settling of sediments and debris (Synonyms; Vegetated waterway, grass channel, drainage ditch)
Grease	Oil based pollutant.
Grit	Coarse sediments such as smaller, loose particles of sand and stone or other heavy solid materials that have specific gravities or setting velocities substantially greater than those of organic particles.
Media Filter	Filtration of stormwater through a variety of different filtering materials whose purpose is to remove pollution from runoff.
Multiple Chambers	A design consisting of several, separate structures (manholes, catch basins, tanks, chambers, etc.) intended to increase pollutant removal, treat higher flow rates, or both.
Non-proprietary Settling Device	System that is installed in stormwater sewers and that utilizes a sump to settle out sediment and other solids while also providing protection to the outlet to contain floatables, oil and grit. (Synonyms; standard sump manhole, water quality inlet, deep sump catch basins, modified catch basins)
Off-Line	Installation in which flow is diverted from the main stormwater sewer system into a device, but diverted flow is limited so that devices are not flushed during large storm events.
Orifice	An opening structure found in forebay designs to control flow rates.
Proprietary Devices	Devices that are privately developed and owned.

Terminology Table	Definition
Proprietary Settling Device	Privately developed systems that utilize a variety of mechanisms to settle out sediments and solids. The devices are installed along stormwater sewer systems and some contain multiple chambers and use more advanced technology than non-proprietary settling devices. (Synonyms; flow through structures, vortex separator systems)
Rhizosphere	The region of soil in the vicinity of plant roots in which the chemistry and microbiology is influenced by their growth, respiration, and nutrient exchange.
Screening	The process of removing sediments and solids from flowing stormwater via a screen. (Synonyms; Filtering)
Scum	A dirt or froth layer on the water surface.
Settling	The process of removing sediments and solids by slowing the velocity of flow to allow the pollutants to settle out of the water column.
Solids	Particulate pollutants consisting of sediments, debris and/or trash.
Stormwater Hotspot	Activities or practices that produce relatively high levels of often specific stormwater pollutants.
Structural Stormwater Best Management Practice	A stationary and permanent BMP that is designed, constructed and operated to prevent or reduce the discharge of pollutants in stormwater
Pretreatment Vegetated Filter Strip	Vegetated slopes that convey stormwater as sheet flow to allow settling of sediments and solids. (Synonyms; vegetated buffer, vegetated buffer strip, grassed filter strips, grass filters)
Vortex separator systems	A mechanism used in many proprietary settling devices that uses the circular flow within a chamber to separate solids from the stormwater. (Synonyms; swirl separators, hydrodynamic separators, swirl concentrators, flow through structures)
Weir	A flow or water level control device, often consisting of a thin plate (sharp-crested).