Chapter 6
Introduction to Stormwater Treatment Practices

Volume II: Design

Chapter 6

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6.1 Introduction

This chapter introduces stormwater treatment practices that are acceptable for water quality treatment in Connecticut, either alone or in combination with source controls and other treatment practices. The following sections describe three categories of stormwater treatment practices:

- *Primary Stormwater Treatment Practices*
- *Secondary Stormwater Treatment Practices*
- *Stormwater Treatment Train*

This chapter also provides general information on maintenance considerations and performance monitoring for stormwater treatment practices.

Stormwater treatment practices are structural controls primarily designed to remove pollutants from stormwater runoff, but they also can provide other benefits including groundwater recharge, peak runoff attenuation, and stream channel protection. As described in Chapter Three of this Manual, stormwater treatment practices are one element of a comprehensive stormwater management strategy, and should be selected and designed only after consideration of effective site planning/design and source controls that can reduce the volume of runoff and the size and cost of stormwater treatment.

6.2 Primary Stormwater Treatment Practices

The stormwater treatment practices listed in this section, referred to as primary stormwater treatment practices, are capable of providing high levels of water quality treatment as stand-alone devices. A growing body of research on stormwater treatment practices throughout the United States, as well as field experience in Connecticut and other northeastern states, has demonstrated that these practices are capable of:

- *Capturing and treating the design water quality volume (WQV) or design water quality flow (WQF) (see Chapter Seven)*
- *Removing at least 80 percent of the average annual total suspended solids (TSS) load*
- *Removing at least 80 percent of floatable debris, including oil and petroleum products, for all flow rates up to the design water quality flow, either alone or in combination with pretreatment*
- *Acceptable performance or operational longevity in the field*

(NYDEC, 2001; MDE, 2000). The above performance standards assume that these stormwater treatment practices are properly selected, sited, designed, constructed, and maintained in accordance with the guidelines contained in this Manual.

The State of Connecticut has adopted the 80 percent TSS removal goal based on EPA guidance and its widespread use as a target stormwater quality performance standard. TSS is considered a suitable target pollutant constituent for a removal standard because of its widespread impact on water quality and aquatic habitat degradation, because many other pollutants including heavy metals, bacteria, and organic chemicals adsorb to sediment particles, and because it has been the most frequently and consistently sampled stormwater constituent (MADEP, 1997).

Primary stormwater treatment practices can be grouped into five major categories:

Stormwater Ponds: Stormwater ponds maintain either a permanent pool of water or a combination of a permanent pool and extended detention. The permanent pool of water in these systems enhances pollutant removal through mechanisms such as sedimentation, biological uptake, microbial breakdown, gas exchange, volatilization, and decomposition. This category of stormwater ponds does not include traditional dry detention ponds or dry flood control basins, which do not provide significant water quality treatment functions (see the Secondary Treatment Practices described in this chapter). Treatment practices in this category include:

- *Wet pond*
- *Micropool extended detention pond*
- *Wet extended detention pond*
- *Multiple pond system*

Stormwater Wetlands: Stormwater wetlands are constructed wetland systems designed to treat polluted stormwater runoff by several mechanisms, including sedimentation, adsorption, biological uptake, photodegradation, and microbial breakdown. Stormwater wetlands typically include sediment forebays, shallow and deep pool areas, meandering flow paths, and vegetative measures to enhance pollutant removal. Stormwater wetlands are engineered specifically for pollutant removal and flood control purposes. They typically do not have the full range of ecological functions of natural wetlands or wetlands constructed for compensatory storage or wetland mitigation. Stormwater wetland practices in this category include:

- *Shallow wetland*
- *Extended detention wetland*
- *Pond/wetland system*

Infiltration Practices: Infiltration practices are designed to capture, temporarily store, and infiltrate stormwater into porous soils. Pollutant removal occurs through adsorption of pollutants onto soil particles, and subsequent biological and chemical conversion in the soil. Infiltration practices aid in recharging groundwater but must be carefully designed and maintained to prevent clogging and system failure. Infiltration practices in this category include:

- *Infiltration trench*
- *Infiltration basin*

Filtering Practices: Filtering practices treat stormwater runoff by capturing, temporarily storing, and filtering stormwater through sand, soil, organic material, or other porous media. As the water flows through the filter media, sediment particles and attached pollutants, as well as some soluble pollutants, are removed through physical straining and adsorption. Pretreatment is generally required to remove debris and floatables, and prolong the life of the filter. Filtering practices in this category include:

- *Surface sand filter*
- *Underground sand filter*
- *Perimeter sand filter*
- *Bioretention*

Water Quality Swales: Water quality swales reduce the velocity of and temporarily store stormwater runoff and promote infiltration. Pollutant removal mechanisms in water quality swales are similar to constructed wetlands and include sedimentation, adsorption, biological uptake, and microbial breakdown. These practices differ from conventional grass channels and ditches that are primarily designed for conveyance, as they provide higher levels of pollutant removal. Practices in this category include:

- *Dry swale*
- *Wet swale*

The above practices generally have the highest removal efficiencies for pollutants such as nutrients and metals, in addition to TSS. Pollutant removal summary data for stormwater treatment practices are included in Chapter Eight.

Other stormwater treatment practices not listed above, such as the secondary treatment practices described in the following section, may be classified as primary practices at the discretion of the local review authority and/or DEP. In order to be considered a primary stormwater treatment practice, a practice must demonstrate the ability to treat the design water quality volume or an equivalent design water quality flow, meet the 80 percent TSS and floatables criteria, and have proven operational longevity. It is conceivable that as treatment systems age, they may lose their effectiveness and may further be considered a pollutant source. The following sections describe criteria for acceptance of new technologies as primary treatment practices.

6.3 Secondary Stormwater Treatment Practices

A number of stormwater treatment practices may not be suitable as stand-alone treatment because they either are not capable of meeting the water quality treatment performance criteria described in the previous section or have not yet received the thorough evaluation needed to demonstrate the capabilities for meeting the performance criteria. These practices, termed secondary stormwater treatment practices, generally fall into either of the following categories:

- *Conventional Practices*
- *Innovative/Emerging Technologies*

Table 6-1 summarizes the rationale for the limited use of these practices for water quality control, as well as applications suitable for their use, such as pretreatment or use in a treatment train to achieve multiple stormwater management objectives and to satisfy the design criteria in Chapter Seven (see Section 6.4 below). Chapter Eleven contains limited design guidance for these secondary practices.

6.3.1 Conventional Practices

Conventional or "public-domain" (as opposed to proprietary) secondary treatment practices are practices that have traditionally been used to provide some water quality benefits, but that do not provide the same level of treatment or broad water quality functions as primary stormwater treatment practices. Consequently, their application is limited to use as pretreatment or supplemental treatment practices in conjunction with primary practices (i.e., a treatment train), or to achieve other objectives such as groundwater recharge, channel protection, and peak runoff attenuation. Conventional secondary treatment practices addressed in this Manual include:

- *Dry Detention Ponds*
- *Underground Detention Facilities*
- *Deep Sump Catch Basins*
- *Conventional Oil/Particle Separators*
- *Dry Wells*
- *Permeable Pavement*
- *Vegetated Filter Strips and Level Spreaders*
- *Grass Drainage Channels*

6.3.2 Innovative/Emerging Technologies

The other category of secondary treatment practices addressed in this Manual includes innovative and emerging technologies, which are typically proprietary systems. Stormwater treatment practices are continually evolving in response to advances in treatment technology, availability and affordability of new technology, and recognition of new treatment needs. These innovative and emerging technologies are those for which preliminary performance data indicate that they may provide a valuable stormwater treatment function. However, unlike the primary stormwater treatment practices described previously in this chapter, these technologies have not been evaluated in sufficient detail to demonstrate proven capabilities for meeting established performance standards, including pollutant removal and field longevity (see **Table 6-1**).

The following section provides examples of recently developed innovative and emerging technologies for stormwater treatment. Chapter Eleven also provides limited design guidance for these technologies. As secondary treatment practices, innovative and emerging technologies are suitable for pretreatment or for use in a treatment train approach. Emerging technologies generally are also good candidates for stormwater retrofits and where land is unavailable for larger systems. Their use as standalone treatment devices (i.e., primary treatment practices) should be evaluated using consistent and technically rigorous protocols. This section describes recommended criteria for evaluating new or emerging stormwater treatment technologies. New or emerging technologies that meet these criteria may be acceptable as primary treatment practices.

Examples of Innovative and Emerging Technologies

Most innovative or emerging technologies are proprietary devices developed by various manufacturers and vendors. System designs vary considerably, although most currently available technologies generally can be grouped into one of the following categories:

Catch Basin Inserts: As the name implies, catch basin inserts are placed directly inside of existing catch basins to remove pollutants from stormwater. Stormwater flows into the catch basin and is treated as it passes through the structure. The insert consists of a structure, such as a tray, basket, or bag that typically contains a pollutant removal medium (i.e., filter media) and a method for suspending the structure in the catch basin (Lee, 2001). Although filter media is commonly used, basket-type inserts constructed of wire mesh and fabric bag-type inserts are also used without filter media for removing gross particles (i.e., trash and debris). Although they have the potential to remove total suspended solids, organics, and metals, the removal capabilities depend on the pollutant loading characteristics of the stormwater and the choice of filter medium. Because these devices are limited by the size of the catch basin, there is a relatively short contact time between stormwater and the media for

Table 6-1 Summary of Secondary Stormwater Treatment Practices

Practice	Reasons for Limited Use	Suitable Applications
Conventional Practices		
Dry Detention Ponds	❍ Not intended for water quality treatment. Designed to empty out between storms; lack the permanent pool or extended detention required for adequate stormwater treatment ❍ Settled particulates can be resuspended between storms	❍ Flood control and channel protection
Catch Basins	❍ Limited pollutant removal ❍ No volume control ❍ Resuspension of settled particulates	❍ Pretreatment or in combination with other stormwater treatment practices ❍ Stormwater retrofits
Conventional Oil/ Particle Separators	❍ Limited pollutant removal ❍ No volume control ❍ Resuspension of settled particulates	❍ Pretreatment or in combination with other stormwater treatment practices ❍ Highly impervious areas with substantial vehicle traffic
Underground Detention Facilities	❍ Not intended for water quality treatment ❍ Particulates can be resuspended between storms	❍ Flood control and channel protection ❍ Space-limited or ultra-urban sites
Permeable Pavement	❍ Reduced performance in cold climates due to clogging by road sand and salt ❍ Porous asphalt or concrete recommended for limited use in Connecticut	❍ Modular concrete paving blocks, modular concrete or plastic lattice, or cast-in-place concrete grids are suitable for use in spillover parking, parking aisles, residential driveways, and roadside rights-of-way
Dry Wells	❍ Not intended as stand-alone stormwater runoff quality or quantity control ❍ Potential for clogging/failure ❍ Applicable to small drainage areas ❍ Potential groundwater quality impacts	❍ Infiltration of clean rooftop runoff ❍ Stormwater retrofits ❍ Space-limited ultra-urban ❍ Pretreatment or in combination with other stormwater treatment practices
Vegetated Filter Strips	❍ Typically, cannot alone achieve the 80% TSS removal goal	❍ Pretreatment or in combination with other treatment practices ❍ Limited groundwater recharge ❍ Outer zone of a stream buffer ❍ Residential applications and parking lots
Grass Drainage Channels	❍ Typically, cannot alone achieve the 80% TSS removal goal	❍ Part of runoff conveyance system to provide pretreatment ❍ Replace curb and gutter drainage ❍ Limited groundwater recharge
Level Spreaders	❍ Typically, cannot alone achieve the 80% TSS removal goal	❍ Pretreatment or in combination with other treatment practices ❍ Use with filter strips and at outlets of other treatment practices to distribute flow ❍ Groundwater recharge
Innovative/Emerging Technologies		
Catch Basin Inserts	❍ Limited performance data available ❍ High maintenance and susceptible to clogging	❍ Stormwater retrofits, ultra-urban sites ❍ Small drainage areas without excessive solids loadings ❍ Pretreatment or in combination with other treatment practices
Hydrodynamic Separators	❍ Limited performance data available ❍ Performance varies with flow rate	❍ Pretreatment or in combination with other treatment practices ❍ Stormwater retrofits, ultra-urban sites
Media Filters	❍ Limited performance data available	❍ Pretreatment or in combination with other treatment practices ❍ Stormwater retrofits, ultra-urban sites
Underground Infiltration Systems	❍ Limited performance data available	❍ Groundwater recharge ❍ Stormwater retrofits
Alum Injection	❍ Requires ongoing operation and monitoring ❍ Limited performance data available ❍ Potential for negative impacts to downstream receiving waters	❍ Stormwater retrofits, ultra-urban sites ❍ Pretreatment or in combination with other treatment practices
Advanced Treatment	❍ Requires ongoing operation and monitoring ❍ High cost and level of complexity ❍ Limited performance data available	❍ Only as required, where other primary or secondary practices are insufficient

pollutant removal and little storage area for the material that is removed. Consequently, frequent maintenance is typically required to avoid clogging of the insert and there is the possibility of re-suspension of filtered pollutants (Washington, 2000).

Hydrodynamic Separators: This group of stormwater treatment technologies is designed to remove large particle total suspended solids and large oil droplets. They consist primarily of cylindrical-shaped devices that are designed to fit in or adjacent to existing stormwater drainage systems (Washington, 2000). The most common mechanism used in these devices is vortex-enhanced sedimentation, also called swirl concentration. In these structures, often called swirl concentrators, stormwater enters as tangential inlet flow into the side of the cylindrical structure. As the stormwater spirals through the chamber, the swirling motion causes the sediments to settle by gravity, removing them from the stormwater (EPA, 2002). Some devices also have compartments or chambers to trap oil and other floatables.

Although swirl concentration is the technology employed by most hydrodynamic separators, some systems use circular screening systems or engineered cylindrical sedimentation. Circular screened systems use a combination of screens, baffles, and inlet and outlet structures to remove debris, large particle total suspended solids, and large oil droplets. Structures using engineered cylindrical sedimentation use an arrangement of internal baffles and an oil and sediment storage compartment. Other proprietary technologies incorporate an internal high flow bypass with a baffle system in a rectangular structure to simulate plug flow operation. When properly engineered and tested, these systems can also be an improvement over conventional oil/particle separators and offer removal efficiencies similar to swirl chamber technologies. Absorbent materials can also be added to these structures to increase removal efficiency of oil and hydrocarbons (Washington, 2000).

Media Filters: In this type of treatment practice, media is placed within filter cartridges that are typically enclosed in concrete vaults. Stormwater is passed through the media, which traps particulates and/or soluble pollutants. Various materials can be used as filter media including pleated fabric, activated charcoal, perlite, amended sand and perlite mixes, and zeolite. Selection of filter media is a function of the pollutants targeted for removal. Pretreatment prior to the filter media is typically necessary for stormwater with high total suspended solids, hydrocarbon, and debris loadings that may cause clogging and premature filter failure (Washington, 2000).

Underground Infiltration Systems: Various types of underground infiltration structures, such as pre-manufactured pipes, vaults, and modular structures, have been developed as alternatives to infiltration trenches and basins for space-limited sites and stormwater retrofit applications. Similar to traditional infiltration trenches and basins, these systems are designed to capture, temporarily store, and infiltrate the design water quality volume over several days. Performance of underground infiltration structures varies by manufacturer and system design. These systems are currently considered secondary treatment practices due to limited field performance data, although pollutant removal efficiency is anticipated to be similar to that of infiltration trenches and basins.

Advanced Treatment: The pollutant removal techniques utilized in drinking water treatment processes are potential advanced treatment options for stormwater (Lee, 2001). Alum has been used extensively as a coagulant in pond and lake management applications. Alum injection has also been used more recently in stormwater applications for reducing concentrations of fine sediment and phosphorus in stormwater discharges to eutrophic water bodies. Water-soluble anionic polyacrylamide (PAM) has also been used as a coagulant in drinking water treatment and pond dredging operations to enhance settling of solids. PAM has also been land applied as an erosion and sedimentation control measure. Recently, the use of PAM in pre-formed shapes such as logs in ditches or open swales has been introduced to enhance removal of fine sediment in stormwater runoff. However, the practicability of methods such as ion exchange, reverse osmosis, disinfection, and ultrafiltration is undocumented for stormwater treatment. The success of these methods in drinking water treatment suggests that they may have potential applications in areas where conventional stormwater treatment methods are unable to meet stringent stormwater quality standards or established waste load allocations. However, these technologies are beyond the scope of this Manual.

Criteria for Evaluating New Practices

New and emerging stormwater treatment practices may be acceptable as primary treatment practices if they demonstrate the ability to achieve treatment results consistent with the primary treatment practices described at the beginning of this chapter, specifically:

- *Capture and treatment of the design water quality volume (WQV) or design water quality flow (WQF)*

- *Removal of at least 80 percent of the average annual total suspended solids (TSS) load*
- *Removing at least 80 percent of floatable debris, including oil and petroleum products, for all flow rates up to the design water quality flow (WQF), either alone or in combination with pretreatment*
- *Acceptable performance or operational longevity in the field*
- *Automatic operation during runoff events (i.e., no need for manual activation)*

These capabilities must be demonstrated through field and laboratory testing. Independent validation of data that support specific treatment technology performance claims is recommended. Field performance data should come from field studies conducted under a variety of conditions (e.g., flow rates, contaminant loadings, antecedent moisture conditions, rainfall distribution, land use, percent imperviousness, maintenance intervals) (TARP, 2001). Ideally, the field studies should be conducted over a one-year demonstration period, including cold weather and winter conditions, to capture possible seasonal variations in performance and performance variations as a function of rainfall intensity.

Field data is valuable for verifying performance under actual field conditions. However, the variability of site conditions leads to site-specific performance validation that may be difficult to develop into sizing methodologies. It is recommended that laboratory testing be conducted to establish performance curves for technologies over the full operating range of the system. Performance curves based on laboratory data for various technologies, developed using the same test criteria, applied to the same rainfall and TSS removal model, enable direct comparison between technologies. Laboratory testing must be conducted in accordance with an established protocol for known particle sizes in known concentrations. The Maine Department of Environmental Protection has established one such protocol for comparing innovative technologies.

Performance claim data sets should be collected under a Quality Assurance Project Plan (QAPP) to ensure that the data sets meet data quality objectives and are defensible, and should include flow rates, residence times, and rainfall intensity data with which to interpret these claims. USEPA provides guidance on the development and minimum requirements for a QAPP. (See USEPA references at the end of this chapter.) Standardized test methods and procedures must be used in the collection of data. For example, ASTM methods for flow measurement methods, ASCE hydraulic flow estimation methods, and EPA test methods for water quality analysis are typical standardized test methods. (See TARP (2001)) for a listing of standardized methods for flow and water constituent analysis).

It is recommended that stormwater quality data be collected in accordance with guidance outlined in the Technology Acceptance and Reciprocity Partnership (TARP) Stormwater BMP Demonstration Protocol (2001). The TARP Stormwater BMP Demonstration Protocol has been endorsed by the states of Massachusetts, New York, New Jersey, Illinois, California, Maryland, Pennsylvania, Texas and Virginia to provide a uniform method for demonstrating stormwater technologies and developing test quality assurance plans for certification or verification of performance claims. Treatment efficiencies should be calculated using methods outlined in the joint EPA and ASCE technical memorandum *Determining Urban Stormwater Best Management Practice (BMP) Removal Efficiencies* (URS Greiner Woodward Clyde et al., 1999). In addition, to demonstrate that the performance claims are reliable, significant, and within confidence limits, statistical evaluation of the data must be performed and made available. Performance claims should be given with appropriate confidence intervals (i.e., removal rate of 85% ± 5% at a 95% confidence interval). The EPA Data Quality Assessment Guidance Manual (EPA, 1998) provides information on statistical methods for comparison and validation of data sets.

In addition to performance claims and validation, the following specifications for the treatment technology should be provided:

- *Description of the underlying scientific and engineering principles*
- *Standard drawings, including a process flow diagram*
- *Minimum siting and design specifications necessary to achieve the stated performance*
- *The full range of operating conditions for the technology, including minimum, maximum, and optimal conditions to meet the stated performance claims (flow rate, residence time, rainfall intensity, etc.)*
- *Minimum maintenance requirements to sustain the stated performance*
- *Description of hydraulics and system sizing to meet the performance claims*
- *Discussion of any pretreatment required to meet the stated performance claims*

- *Identification of any special licensing or hauling requirements, safety issues or access requirements associated with installation and/or operation and maintenance*
- *Discussion of the generation, handling, removal and disposal of any discharges, emissions, or other waste byproducts of the treatment technology*

(TARP, 2001). Evaluation protocols and methods similar to those of the TARP Stormwater BMP Demonstration Protocol have also been developed through EPA's Environmental Technology Verification (ETV) program. With funding from the ETV program, the Civil Engineering Research Foundation established the Environmental Technology Evaluation Center (EvTEC), an independent, non-profit verification center that evaluates environmental technologies. EvTEC is collaborating with the Washington State Department of Transportation to verify performance of innovative stormwater treatment practices under field operating conditions. These evaluations are expected to provide comparable, peer-reviewed performance data on these systems (CERF, 2002).

EPA and NSF International, an independent, nonprofit testing organization, have developed a testing protocol under the ETV program to determine the viability of runoff treatment technologies and other wet weather flow controls, including urban runoff, combined sewer overflows (CSO), and sanitary sewer overflows (SSO). Participants in the study include vendors who want to demonstrate the effectiveness of their technologies. Results of the pilot will be useful to a variety of stakeholders including municipalities, businesses, vendors, consulting engineers, and regulatory agencies. Once verification reports have been completed, vendors may use the results in their marketing efforts. Results will be made publicly available through EPA's and NSF's Web sites at http://www.epa.gov/etv and http://www.nsf.org/etv, respectively.

6.4 Stormwater Treatment Train

Stormwater treatment practices can be combined in series to enhance pollutant removal or achieve multiple stormwater objectives. The use of a series of treatment practices, as well as site planning techniques and source controls, is referred to as "stormwater treatment trains". The use of a treatment train approach can:

- *Increase the level and reliability of pollutant removal*
- *Accomplish multiple stormwater management objectives (pollutant removal, groundwater recharge, channel protection, peak runoff attenuation, etc.)*
- *Increase the lifespan of treatment devices by distributing pollutant removal over multiple practices or controls*
- *Reduce the potential for resuspension of sediment by reducing flow velocities and increasing flow paths*
- *Allow the use of a wider array of treatment practices, including supplemental practices for pretreatment*

A treatment train may consist of the following types of practices in series to satisfy the design criteria in Chapter Seven:

- *Multiple primary treatment practices*
- *A combination of primary and secondary treatment practices*
- *Multiple secondary treatment practices (at the discretion of the review authority)*

The use of multiple stormwater treatment practices increases the maintenance required to preserve the overall effectiveness of the system. In general, the least expensive and most easily maintained components should be placed at the most upstream point in the treatment train to reduce the maintenance requirements of the downstream components (Metropolitan Council, 2001). The individual treatment practice descriptions in Chapter Eleven include guidance on routine and non-routine maintenance.

6.5 Maintenance

Stormwater treatment practices require regular maintenance to perform successfully. Failure to perform adequate maintenance can lead to reductions in pollutant removal efficiency or actually increase pollutant loadings and aggravate downstream impacts. Stormwater treatment practices should be routinely inspected and maintained following construction to ensure that the controls are in proper working condition and operating as designed. General maintenance guidelines for stormwater treatment practices are summarized below. Chapter Eleven contains recommended maintenance for specific stormwater treatment practices. **Appendix E** contains maintenance inspection checklists for specific stormwater treatment practices. Additional information on maintenance of stormwater treatment practices can be found in the documents listed at the end of this chapter.

General maintenance requirements for stormwater treatment practices include:

Inspections: Inspections should be performed at regular intervals to ensure proper operation of stormwater treatment practices. Inspections should be conducted at least annually, with additional inspections following large storms. Inspections should include a comprehensive visual check for evidence of the following (not all items apply to every treatment practice):

- *Accumulation of sediment or debris at inlet and outlet structures*
- *Erosion, settlement, or slope failure*
- *Clogging or buildup of fines on infiltration surfaces*
- *Vegetative stress and appropriate water levels for emergent vegetation*
- *Algae growth, stagnant pools, or noxious odors*
- *Deterioration of pipes or conduits*
- *Seepage at the toe of ponds or wetlands*
- *Deterioration or sedimentation in downstream channels and energy dissipators*
- *Evidence of vandalism*
- *Evidence of structural damage by beavers, muskrats, and other wildlife*

Routine Maintenance: Routine maintenance should be performed on a regular basis to maintain proper operation and aesthetics. Routine maintenance should include:

- *Debris and litter removal*
- *Silt and sediment removal*
- *Terrestrial vegetation maintenance*
- *Aquatic vegetation maintenance*
- *Maintenance of mechanical components (valves, gates, access hatches, locks)*

Non-routine Maintenance: Non-routine maintenance refers to corrective measures taken to repair or rehabilitate stormwater controls to proper working condition. Non-routine maintenance is performed as needed, typically in response to problems detected during routine maintenance and inspections, and can include:

- *Erosion and structural repair*
- *Sediment removal and disposal*
- *Nuisance control (odors, mosquitoes, weeds, excessive litter)*

Stormwater treatment practice operation and maintenance requirements are an integral part of a site stormwater management plan (see Chapter Nine). These requirements should include, at a minimum, detailed inspection and maintenance tasks, schedules, responsible parties, and financing provisions. The owner typically maintains stormwater treatment practices at commercial, industrial, and rental residential developments. These facilities generally have staff dedicated to maintenance activities or contract for such services. Maintenance of non-rental residential installations is typically performed by private landowners or property/homeowners associations, which in many cases do not have the technical expertise, resources, or funds to inspect and maintain their stormwater systems. In some cases, local government may accept responsibility for inspecting and maintaining stormwater treatment practices. Local governments should require legally binding maintenance agreements for stormwater treatment practices to clearly delineate maintenance responsibilities. Potential funding mechanisms include general tax revenues, stormwater utility fees, inspection or permit fees, and dedicated funds from land developers. Public education is critical for the success of any stormwater financing program.

Many municipalities consider stormwater treatment practices such as ponds, wetlands, and other "wet" treatment systems as regulated wetland areas, and therefore subject to local inland wetlands and watercourses regulations. Sediment removal and other common maintenance activities may require approval from the local Inland Wetlands and Watercourses Commission, which presents a potential regulatory hurdle to consistent maintenance. To facilitate this approval process, municipalities could issue up to a five-year maintenance permit in conjunction with the primary Inland Wetlands and Watercourses permit for the development or redevelopment project. The permit holder would be responsible for renewing or requesting reissuance of the maintenance permit at five-year intervals. Municipalities should identify all such stormwater management facilities for which they are responsible and issue a five-year renewable maintenance permit. This type of an approach is analogous to DEP's renewable five-year maintenance permits issued to DOT and other state-regulated entities for statewide drainage maintenance activities.

6.6 Performance Monitoring

Currently, there are very limited performance data for stormwater treatment practices in the State of Connecticut. Performance data from the majority of previous monitoring studies conducted throughout the United States are limited by differences in design, performance goals, site parameters, storm events, flow and pollutant loadings, seasonal variations, monitoring methods, efficiency calculation methods or simply by the lack of or inadequacy of information. Several major initiatives are underway nationally to provide a more useful set of data on the effectiveness of individual stormwater treatment practices, and to better understand the relationship between treatment practice design and performance. These include:

- *The Center for Watershed Protection's* National Pollutant Removal Performance Database *(Winer, 2000)*
- *The American Society of Civil Engineers (ASCE)* National Stormwater Best Management Practices (BMP) Database *(Urban Water Resources Research Council of ASCE and Wright Water Engineers, Inc., 2001)*
- *Water Environment Research Foundation (WERF)* Critical Assessment of Stormwater Control (BMP) Selection Issues *(WERF, in progress)*

These databases contain the results of performance studies for individual stormwater treatment practices throughout the United States. While they provide a starting point for pollutant removal estimates, the usefulness of the data is still extremely limited for many of the reasons stated above. The reliability of the data will continue to increase as the results from additional studies are added.

Very few performance monitoring studies have been performed in Connecticut or elsewhere in New England. Performance monitoring is recommended for new and existing stormwater treatment practices in Connecticut to develop a representative and reliable performance database that is specific to the State of Connecticut. Performance monitoring is designed to provide information on the following issues:

- *What degree of pollution control does the treatment practice provide under typical operating conditions?*
- *How does efficiency vary from pollutant to pollutant?*
- *How does efficiency vary with various input concentrations?*
- *How does efficiency vary with storm characteristics such as rainfall amount, rainfall density, antecedent weather conditions?*
- *How do design variables affect performance?*
- *How does efficiency vary with different operational and/or maintenance approaches?*
- *Does efficiency improve, decay, or remain the stable over time?*
- *How does the system's efficiency, performance, and effectiveness compare relative to other stormwater treatment practices?*
- *Does the treatment practice reduce toxicity to acceptable levels?*
- *Does the treatment practice cause an improvement or protect in downstream biotic communities?*
- *Does the treatment practice have potential downstream negative impacts?*

(URS Greiner Woodward Clyde et al., 1999). Standardized test methods and procedures should be used for stormwater performance monitoring studies. Performance monitoring should be consistent with the methods and protocols described previously in this chapter for evaluating new stormwater treatment technologies and the guidance documents referenced therein.

Additional Information Sources

Technology Acceptance and Reciprocity Partnership (TARP), Pennsylvania Department of Environmental Protection,
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