Pollution Prevention and the MS4 Program

A Guide on Utilizing Pollution Prevention Activities to Meet MS4 General Permit Requirements

Minnesota Pollution Control Agency

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Available in alternative formats

Stormwater Pollution Prevention Integration
CR# 1902

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wq-strm4-26

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Purpose of this guidance

The purpose of this guidance document is to provide communities regulated under the Minnesota Municipal Separate Storm Sewer Systems (MS4) General Permit with basic tools and information that will lead to increased use of pollution prevention (P2) activities within stormwater pollution prevention programs (SWPPPs) and local stormwater programs.

This guidance provides a series of fact sheets on P2 activities that can be utilized by a regulated MS4 to meet the objectives of the MS4 General Permit and enhance local stormwater programs.

What is Pollution Prevention

P2 is a "front-end" method to decrease costs, risks, and environmental concerns. In contrast to managing pollution after it is created, P2 reduces or eliminates pollutants and wastes at its source. Well-intentioned pollution control and management solutions sometimes remove pollutants from one medium only to transfer them, and their liabilities, to another, therefore thoughtful planning and implementation is needed to ensure overall pollutant reduction. P2 is a multimedia approach to solve environmental problems — it does not focus on pollution in a single, isolated medium such as air, water or land.

P2 is an existing requirement of the MS4 General Permit, specifically referred to in minimum control measure (MCM) #6 pollution prevention/good housekeeping for municipal operations. In addition to this MCM, P2 has the potential to aid in meeting the intent of the MS4 General Permit for each of the five other MCMs.

Low Impact Development and P2

For regulated MS4s, low impact development (LID) has the potential to achieve P2 goals under each MCM. The principal goal of LID is to ensure maximum protection of receiving waters by mimicking the natural hydrology of the watershed. This goal is accomplished by using design techniques that minimize, store, infiltrate, evaporate, treat and retain runoff.

Many of the typical best management practices associated with LID are presented in this guidance including open space design; reducing impervious surfaces; pervious pavements; green roofs; rainwater harvesting/stormwater reuse and rain barrel programs; urban forestry and stormwater management; vegetated swales & buffer strips; and establishing an infiltration standard. Adopting an open space or LID ordinance enables a community to allow flexibility in the development process that can result in enhanced water quality protection and stormwater management.

P2 and the MS4 General Permit

The National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) General MS4 Permit requires each regulated MS4 to develop, implement and enforce a SWPPP. The SWPPP must be designed and managed to reduce the discharge of pollutants from storm sewer systems to the maximum extent practicable (MEP). As part of the SWPPP, an MS4 must define best management practices (BMPs) appropriate for its community that address the following six MCMs:

MCM 1 Public Education and Outreach
MCM 2 Public Participation/Involvement
MCM 3 Illicit Discharge Detection and Elimination
MCM 4 Construction Site Stormwater Runoff Control
MCM 5 Post-construction Stormwater Runoff Control
MCM 6 Pollution Prevention/Good Housekeeping for Municipal Operations

Required in addressing each MCM are a list of specific BMPs outlined in Part V.G. of the MS4 General Permit (see http://www.pca.state.mn.us/publications/wq-strm4-50.doc). A variety of P2 activities outlined in this guidance can be used in a SWPPP to satisfy the requirements of Part V.G. and accomplish the goals of each MCM. Matrix 1 within the P2 Activity Selection Tools identifies each P2 activity included in this guidance and its applicable MCM(s).

Public Education and Outreach

The public education and outreach MCM requires regulated MS4s to develop and implement an education program. The program should include distribution of education materials that address each MCM. Developing programs that involve activities to eliminate pollution sources and/or prevent contaminants from entering waterways fall under the category of P2 activities. Examples include educating residents on the importance of keeping lawn clippings and leaf litter off impervious surfaces and the benefits of rain barrels and rainwater harvesting.

Public Participation/Involvement

As residents of a community become involved in the development and implementation of municipal programs, a sense of ownership evolves and results in broader public support for the MS4's overall stormwater management program. The permit requires that a regulated MS4 include the public in the planning of the SWPPP, but coordinating opportunities that engage residents in P2 activities such as through storm drain stenciling programs also help to achieve the goals of this MCM.

Illicit Discharge Detection and Elimination

The objective of this measure is to have regulated MS4s gain a thorough awareness of their stormwater conveyance systems. This awareness will allow the municipality to determine the types and sources of illicit discharges entering the stormwater system, and establish the legal, technical and educational means needed to eliminate these discharges. A P2 activity that can be used to meet this MCM includes the development of a septic system maintenance program.

Construction Site Stormwater Runoff Control

The construction site stormwater runoff control MCM requires a regulated MS4 to develop and begin implementation and enforcement of a program to reduce pollutants in stormwater runoff from construction activities. P2 activities that can be used to meet the goals of this MCM include providing erosion and sediment control training to staff and contractors and providing contractors with references on new BMPs.

Post-construction Stormwater Runoff Control

The post-construction stormwater runoff control MCM requires a regulated MS4 to develop, implement, and enforce a program to address stormwater runoff from new development and re-development. Example P2 activities that can be used to meet this MCM include establishing a buffer ordinance and establishing an infiltration standard.

Pollution Prevention/Good Housekeeping for Municipal Operations

The pollution prevention and good housekeeping MCM requires regulated municipalities to examine and subsequently alter their own actions to help ensure a reduction in the amount and type of pollution that collects on streets, parking lots, open spaces, and storage and vehicle maintenance areas that is discharged to local waterways. The pollutants result from actions such as environmentally damaging land development and flood management practices or poor maintenance of storm sewer systems. Many of the P2 activities included within this report are applicable to this MCM such as vehicle washing and street and parking lot sweeping. It is also possible that other P2 activities within the report could be applicable to this MCM such as ordinance or program development.

Incorporating P2 activities into the SWPPP

The P2 activities described in this guidance are intended to be utilized in any number of ways. They may be used for updates to the MS4's current SWPPP to reflect changes in needs. They may be used for preparation of a new SWPPP for a newly identified facility joining the regulated MS4 community. They can be used when completing Annual Reports to aid in the MS4's assessment of appropriateness for BMPs identified in the current SWPPP. And they can be used when a new SWPPP must be submitted at a time of permit reissuance.

For the 2006-2011 MS4 General Permit, P2 activities can be added as additional BMP summary sheets to the MS4's current SWPPP to better reflect the activities of the regulated MS4 in achieving the objectives of the MS4 General Permit. See the following link for the MPCA's additional BMP summary sheet template: http://www.pca.state.mn.us/publications/wq-strm4-50b.doc.

It should be noted that any BMP can be added to the MS4s current SWPPP without the approval of the MPCA Commissioner as described in Part H.3. of the MS4 General Permit, which gives the following conditions:

- A BMP is added, and none are subtracted,
- A less effective BMP is replaced with a more effective BMP that addresses the same concerns, and
- The commissioner is notified of the modification in the annual report for the year the modification is made.

P2 Activity Selection Tools

This section includes two selection matrices that can be used to identify which P2 activities may be applicable to a regulated MS4. Matrix 1 identifies the P2 activity by applicable MCM. It is important to note that the applicability of a particular P2 practice will depend on the program developed by the MS4.

Additional BMPs may need to be implemented to meet the goals and requirements of approved total maximum daily load studies, nondegradation requirements, and outstanding resource value waters. Matrix 2 identifies the P2 activity by the primary pollutants removed or prevented from entering an MS4. The actual pollutants being addressed depend on the program developed.

Matrix 1. P2 Activity by Minimum Control Measure

Pollution Prevention Activity	Applicable Minimum Control Measure					
	1	2	3	4	5	6
Erosion & Sediment Control Training	●			●		●
Best Management Practice References	●		●	●	●	●
Vehicle Washing			●			●
Street & Parking Lot Sweeping				●		●
Park & Open Space Fertilizer/Chemical Application Programs	●		●			●
Winter Road Materials Management						●
Storm Drain Stenciling	●	●	●			
Residential Waste Collection & Clean-up Programs	●	●	●			●
Potential Discharge Identification & Risk Reduction	●	●	●			●
Hazardous Material Storage & Handling			●			●
Reducing Pet Waste	●					
Septic System Maintenance Programs	●		●			
Open Space Design					●	
Reducing Impervious Surfaces					●	●
Pervious Pavements					●	●
Green Roofs	●	●			●	●
Rainwater Harvesting/Stormwater Reuse & Rain Barrel Programs	●	●			●	●
Urban Forestry & Stormwater Management					●	●
Vegetated Swales & Buffer Strips	●	●			●	●
Establishing a Buffer Ordinance	●	●				
Retrofitting: Infiltration, Filtration & Bioretention	●	●			●	●
Establishing an Infiltration Standard	●	●			●	
Volume Control Using Compost Materials / Soil Amendments	●				●	●
Environmentally Preferable Purchasing	●	●				●

Matrix 2. P2 Activity by Primary Pollutants Removed

Pollution Prevention Activity	Primary Stormwater Pollutants Removed									
	Runoff Volume	Sediment	Nutrients	BOD	Oil and Grease	Bacteria	Metals	Thermal Loading	Chloride	Other Organic Compounds
Erosion & Sediment Control Training		●	●	●						
Best Management Practice References		●	●	●						
Vehicle Washing			●	●	●		●			
Street & Parking Lot Sweeping		●	●	●						
Park & Open Space Fertilizer/Chemical Application Programs			●							●
Winter Road Materials Management		●	●				●		●	●
Storm Drain Stenciling					●		●			
Residential Waste Collection & Clean-up Programs			●	●			●			
Potential Discharge Identification & Risk Reduction			●	●	●					●
Hazardous Material Storage & Handling					●		●			●
Reducing Pet Waste			●	●		●				
Septic System Maintenance Programs			●	●		●				
Open Space Design	●	●	●					●		
Reducing Impervious Surfaces	●	●	●		●		●	●	●	
Pervious Pavements	●	●	●					●	●	
Green Roofs	●							●		
Rainwater Harvesting/Stormwater Reuse & Rain Barrel Programs	●	●	●				●			
Urban Forestry & Stormwater Management	●		●				●	●		
Vegetated Swales & Buffer Strips	●	●	●					●		
Establishing a Buffer Ordinance	●	●	●					●		
Retrofitting: Infiltration, Filtration & Bioretention	●	●	●				●	●		
Establishing an Infiltration Standard	●	●	●					●		

Pollution Prevention Activity	Primary Stormwater Pollutants Removed									
	Runoff Volume	Sediment	Nutrients	BOD	Oil and Grease	Bacteria	Metals	Thermal Loading	Chloride	Other Organic Compounds
Volume Control Using Compost Materials / Soil Amendments	●	●	●							
Environmentally Preferable Purchasing										

* EPP exhibits a wide spectrum of pollutant reduction benefits and is dependent upon the application(s) of the practice. Benefits are realized from a variety of MS4 activities such as changes in outdoor-use products (e.g. pesticides); pollutant reduction benefits can also be a result of product manufacturing activities.

+ Chloride is reduced because permeable pavements generally require less application of anti-ice material due to properties including permeability and traction.

Pollution Prevention Fact Sheets

The following fact sheets are provided within this guidance:

- Erosion & Sediment Control Training
- Best Management Practice References
- Vehicle Washing
- Street & Parking Lot Sweeping
- Park & Open Space Fertilizer/Chemical Application Programs
- Winter Road Materials Management
- Storm Drain Stenciling
- Residential Waste Collection & Clean-up Programs
- Potential Discharge Identification & Risk Reduction
- Hazardous Material Storage & Handling
- Reducing Pet Waste
- Septic System Maintenance Programs
- Open Space Design
- Reducing Impervious Surfaces
- Pervious Pavements
- Green Roofs
- Rainwater Harvesting/Stormwater Reuse & Rain Barrel Programs
- Urban Forestry & Stormwater Management
- Vegetated Swales & Buffer Strips
- Establishing a Buffer Ordinance
- Retrofitting: Infiltration, Filtration & Bioretention
- Establishing an Infiltration Standard
- Volume Control Using Compost Materials / Soil Amendments
- Environmentally Preferable Purchasing

Additional resources can be found at the end of this document. The additional resources section includes citations and web links to a variety of applicable references and example programs.

Erosion & Sediment Control Training

Developing erosion and sediment control training programs

Erosion and sedimentation is the natural process in which soil and rock material is weathered and carried away by wind, water or ice. Construction activities can increase erosion by removing vegetation, disturbing soil and exposing sediment to the elements. Eroded soil quickly becomes a sedimentation problem when wind and rain carry the soil off the construction site and sediment is deposited in surface waters.

Erosion and sediment control BMPs are necessary at all construction sites to keep soil onsite and prevent unnecessary water pollution. Training individuals responsible for installing, constructing, repairing, maintaining and/or inspecting erosion and sediment control measures and post-construction stormwater management practices at construction sites will result in properly designed, installed and maintained BMPs, improved compliance with permit regulations, and protecting water quality. This fact sheet provides guidance on developing erosion and sediment control training programs.

Benefits / Pollution Reduction

The NPDES/SDS permit for construction stormwater requires that sediment and erosion control BMPs be used on any construction site that disturbs one acre or more of land, however, these BMPs should be installed and utilized on every construction site to prevent erosion and decrease the amount of sediment leaving the site. Sedimentation build-up decreases water levels, negatively impacts water clarity, and destroys aquatic vegetation and habitat resulting in poor water quality.

In addition, the NPDES/SDS permit requires training for any individual performing the following tasks:

- Preparing the stormwater pollution prevention plans (SWPPP)
- Overseeing implementation of, revising, and amending the SWPPP and performing inspections as required in Part IV.E. of the permit
- Performing or supervising the installation, maintenance and repair of erosion and sediment control best management practices

Image Courtesy of Emmons & Olivier Resources, Inc.

Properly installed silt fence will minimize sediment from leaving a site and entering surface waters.

Program Development & Implementation

Training construction and landscaping staff, contractors, and all other persons responsible for BMPs on the importance of using proper design, installation and maintenance techniques improves the chances that BMPs are performing optimally as well as ensures that construction sites are in compliance with state regulations.

Erosion and Sediment Control Training Programs

Many training programs, workshops, and seminars are offered throughout the state of Minnesota. These programs may be advertised and promoted by MS4s to encourage attendance by staff as well as local contractors, project managers, engineers, and construction workers.

The MPCA partners with the University of Minnesota to offer various certification courses to meet the training requirements of the NPDES/SDS permit for construction stormwater. The Minnesota Department of Transportation (MnDOT) requires all individuals working on MnDOT projects to be certified in the courses and to repeat the courses every three years. Information about the certification courses can be found at http://www.erosion.umn.edu/.

The University of Minnesota Extension Stormwater U also offers workshops throughout the year on various stormwater and erosion and sediment control topics. Additionally, the Minnesota Erosion Control Association (MECA) offers workshops and seminars providing valuable training for inspectors, project managers, contractors and designers.

A properly installed rock construction entrance will remove sediment from tires and prevent sediment from leaving a construction site.

Training Topics

Training programs may vary from formal classroom settings to independent study and testing, to hands-on site work experience. No matter how training occurs, the following are suggested components of a good training program.

Erosion and sediment control fundamentals

A training course should include an explanation of what erosion is, how it happens, and how it relates to water quality. This will provide some background and explanation as to why properly maintained and functioning erosion and sediment control BMPs are so important in protecting water quality.

NPDES requirements and the MPCA's permit process

The MPCA regulates construction stormwater discharges through the NPDES/SDS Permit for Construction Stormwater Program. Any construction site that disturbs one acre or more of land is required to obtain a permit from the MPCA. The permit process includes a permit application and the development of a stormwater pollution prevention plan (SWPPP). The SWPPP is required to have documentation of all sediment and erosion control BMPs in an erosion control plan that will be used on the construction site.

The permit includes maintenance requirements for BMPs as well as specific inspection requirements. Instruction on all of the permit requirements and the permit process as well as assistance with developing a comprehensive SWPPP and erosion control plan should be included in a sediment and erosion control training course.

Permanent and temporary erosion and sediment control BMPs

When training individuals, it is important to include information about proper design, installation, inspection, and maintenance for each type of BMP. It is also helpful to include specific product examples as well as specific examples of implementation, both successful and not successful.

There are many types of erosion and sediment controls that could be covered in a training program. The following is a condensed list of recommended BMPs to discuss in a training program.

- Site phasing
- Construction entrances
- Protecting natural vegetation and undisturbed areas
- Low impact development
- Temporary diversions
- Temporary down drains
- Sediment retention basins
- Dewatering
- Perimeter control
- Stockpile protection
- Surface roughening and slope tracking
- Minimize slopes
- Stormdrain inlet protection
- Outlet protection
- Temporary and permanent stabilization
- Specific BMPs related to working near or around water

Training and Certification Standards

It is recommended that MS4's develop and enforce training and certification standards for anyone that is responsible for installing, constructing, repairing, maintaining or inspecting erosion and sediment control BMPs. This training and certification requirement could be written into current ordinances or permitting rules.

The City of Boise, Idaho requires that any permitted construction site must specify one individual that is in charge of the erosion and sediment control program. The person must be trained and certified by the City of Boise. In addition, some construction projects are required to submit an erosion and sediment control plan to the city for review and approval. This plan must be prepared by an individual trained and certified with the City of Boise as well. The training program includes topics such as requirements, regulatory background, and best management practices and erosion and sediment control plans. The training session ends with a written exam and certification is valid for three years.

Maintenance Considerations

Training sessions should be up to date with new technology and BMP practices available. See the fact sheet on Best Management Practices References for more information on tracking up to date information.

Typical Cost

The development of a training program will require staff time; however, there are numerous resources and examples of training programs and certification requirements from around the state and the country. By utilizing currently established training programs as an alternative to developing a new program or to enhance a program in development, an MS4 can save time and money.

Best Management Practice (BMP) References

BMP resources for municipal staff and contractors

Best management practices (BMPs) for managing stormwater on construction sites are ever evolving and growing in number. Keeping informed of the latest innovative BMPs and the new and improved tools available is integral to successfully preventing erosion and migration of sediment from construction sites. See the Erosion and Sediment Control Training fact sheet for additional information related to developing an overall program on municipal erosion and sediment control training. This fact sheet provides guidance on how MS4s and contractors can stay informed about new BMP resources that could be included as part of the MS4 overall training program on erosion and sediment control.

New inlet protection BMPs inserted into a catch basin can effectively decrease the amount of sediment entering surface waters by trapping sediment and filtering stormwater runoff from a construction site.

Benefits / Pollution Reduction

Exposed soils and other construction site pollutants can be carried off site by rainwater, snowmelt, or wind and deposited in local waterways. Sedimentation build-up decreases water levels, negatively impacts water clarity, and can damage aquatic vegetation and habitat resulting in poor water quality. The use of proper erosion and sediment control and site management BMPs can prevent sediment and other pollutants from leaving construction sites and protect our waterways.

New technologies are being developed continually. Improved products mean better protection with potential additional benefits such as lower costs, less maintenance, more efficient installation time, and sturdier reusable products. In addition, new technologies become available regularly to replace, maintain, enhance or otherwise contribute to the effectiveness of currently installed BMPs.

Program Development & Implementation

A MS4 program could include two main components: 1) An updated list of BMPs that are encouraged or required to be used within the MS4, and 2) A dissemination tool that allows for this list and associated resources to reach contractors and interested parties locally.

BMP references should be made available to MS4 staff, contractors, inspectors, construction crews, and any other individual responsible for installing, constructing, repairing, maintaining, or inspecting erosion and sediment control measures. MS4 staff will need ways to find new, up to date information and ways to disseminate it. Because new technologies and practices are constantly evolving, the tools for disseminating the information must be flexible so regular updates can be made.

Updated List of BMPs

A list of BMPs with associated description and applicability can be developed based on many available resources. The BMP list should be reviewed at a minimum semi-annually and updated as needed based on new BMP information. The following are resources that provide new and up to date information about stormwater management and erosion and sediment control through workshops, webcasts, newsletters, print publications and online articles.

Erosion and Sediment Control Certification Program
http://www.erosion.umn.edu/

- Educational opportunities and workshops.
- Website has online newsletter and mailing list sign-up

ESCN TV
http://www.escn.tv/

- Weekly webcast
- Website has e-mail newsletter sign-up

Stormwater Magazine
http://www.stormh2o.com/

- Print publication published 8 times a year
- Website has e-mail newsletter sign-up

Grading and Excavation Contractor
http://gradingandexcavation.com/index.aspx
- Print publication published 7 times a year
- Website has e-mail newsletter sign-up

Erosion Control – Official Journal of the International Erosion Control Association
http://erosioncontrol.com/index.aspx
- Print publication published 7 times a year
- Website has e-mail newsletter sign-up

Land and Water Magazine http://www.landandwater.com
- Print publication and online resources
- Annual publication of Buyer's Guide, a directory of products and services

Minnesota Erosion Control Association
http://www.mnerosion.org/
- Regular events and workshops held featuring products and practices
- Website has e-mail newsletter sign-up
- Annual MECA Conference held in March with educational opportunities

International Erosion Control Association
http://www.ieca.org/
- Online resources for education opportunities, workshops, and webcasts
- Website has e-mail newsletter sign-up
- Online Listserve for IECA members

Watch your dirt.com http://www.watchyourdirt.com/
- Blog and online videos

Minnesota Stormwater Manual
http://www.pca.state.mn.us/water/stormwater/stormwater-manual.html
- Comprehensive state manual for explanation of water quality problems and available BMPs

Image Courtesy of Emmons & Olivier Resources, Inc.

Erosion control blankets made of various natural and synthetic materials can provide structural stability to bare surfaces and slopes.

Dissemination Tool

A tool should be used to regularly communicate BMP information to developers, designers, engineers, contractors and other interested parties. A list of individuals and organizations that typically work within the MS4 should be generated and updated frequently. In addition, the dissemination tool should be able to reach MS4 staff as well as any other individuals responsible for installing, constructing, repairing, maintaining, or inspecting erosion and sediment control measures. Also consider the variability in delivery methods needed to get to all targets; for example, electronic materials may be useful in an office situation while personnel working in the field may benefit from hard copy materials.

Newsletters
Send out monthly, bimonthly, semiannual or annual newsletters electronically or in postal mail with new information and highlighted products and practices. The newsletters could be targeted towards business, construction companies, and contractors as well as municipal staff.

Annual training and workshops
Provide annual training workshops that highlight new technologies and erosion and sediment control practices. See the fact sheet on Erosion and Sediment Control Training for more information on training sessions.

Websites
Establish a webpage on an MS4 website that highlights new technologies and provides contractors with additional information and online resources. Advertise the website and its resources in permitting materials and at certification training sessions.

Maintenance Considerations

Maintenance includes continually seeking information on new technologies and BMP practices. Any tools for dissemination of the information will need to be maintained on a regular basis so that they include the most up to date information.

Typical Cost

Staff time and effort staying knowledgeable on BMPs as well as direct cost for holding workshops, developing, printing, and mailing newsletters, and setting up a webpage will be associated with this type of program. Some or all of these costs can be off-set through the municipal permit fee structure or stormwater utility fee.

Vehicle Washing

Vehicle fleet wash water management

MS4 vehicle washing involves the removal of dust and dirt from the exterior of trucks, boats and other vehicles, as well as the cleaning of cargo areas and engines and other mechanical parts. Washing of vehicles and equipment generates oil, grease, sediment and metals in the wash water as well as degreasing solvents, cleaning solutions and detergents used in the cleaning operations.

The impacts of these constituents discharging to downstream water bodies include increased biochemical oxygen demand (BOD), increased temperature and acidity, and reduced oxygen levels. These environmental effects cause potentially fatal physiological disorders and reduced immune status in aquatic fish and other organisms.

The EPA considers wash water to be a non-stormwater discharge (i.e. illicit discharge); therefore, wash water from a facility must be directed to a sanitary sewer or treated on-site prior to discharge. MS4s often own and maintain their own fleet of vehicles that may include cars, tractors, trucks, parks equipment, and other types of vehicles. This fact sheet provides guidance on techniques to reduce water pollution from the washing of MS4 vehicle fleets applicable to MS4 SWPPPs.

Benefits / Pollution Reduction

Appropriate vehicle wash water treatment and disposal helps to maintain the clarity, temperature and oxygen levels of downstream water bodies by keeping associated pollutants out of storm drains.

Program Development & Implementation

Programs designed to manage vehicle wash water include a combination of the elements identified below. The program elements implemented are dependent on the MS4's access and authority to discharge to sanitary sewer, available resources, and size of staff and vehicle fleet.

Contracting Vehicle Washing Services

Properly maintained commercial washing and steam cleaning businesses are usually better equipped to handle wash waters and are permitted to discharge wash water to the sanitary sewer system. Negotiate with commercial car washes and steam cleaning businesses to handle fleet

Unrestricted flickr ® Image

vehicle washing whenever possible. This option eliminates the cost of building the proper facility and the liability of operating it. However, this option may not be feasible for fleets of higher quantity or vehicles of larger size.

Wash Racks

MS4s with a large fleet of vehicles might consider building MS4-operated wash racks. Wash racks are designed to collect wash water and ultimately discharge to the sanitary sewer rather than the storm sewer. Wash racks consist of designated, paved wash areas that are bermed or sloped to contain and direct wash water to a collection point. Wash water is collected in a sump connected to the sanitary sewer, an on-site process treatment system, or an enclosed recycling system. Connections to the sanitary sewer need approval from the sewer authority and may require pretreatment.

On-site Treatment

Another suitable option is to contain and treat all wash water on the premises by using a detention pond or bermed area that will retain the wash water on site to evaporate and infiltrate. An individual NPDES/SDS permit is needed for such a treatment system. Separate containment is required for salt brine.

MS4-Operated Vehicle Washing Facility BMPs

Designated area

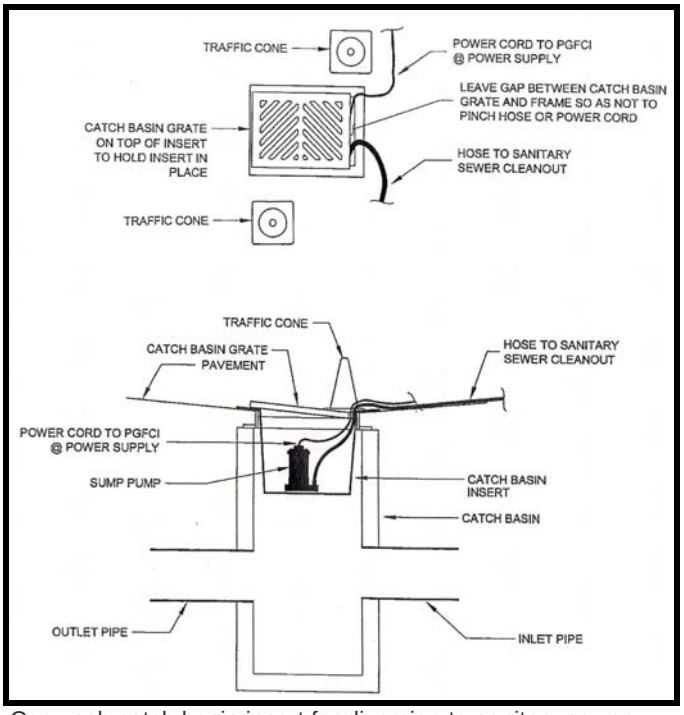
Wash all vehicles in designated areas only. Wash vehicles inside or under cover wherever possible. When washing outdoors, provide an impervious concrete wash pad with a collection system. Alternatively, consider a pervious wash area where infiltration precludes runoff to storm drains. Depth to ground water table and local geology must be

considered in this case; avoid this practice in areas with shallow ground water tables and karst topography.

Collect wash water

Wash all vehicles in designated areas designed to collect and hold wash water before discharge to the sanitary sewer system (e.g. berming). Pretreatment may be required prior to discharge to the treatment plant. Contact your sewer authority early in the design process. In areas not served by a sanitary sewer, haul contents of the holding tank to a treatment plant. If the parking lot has a catch basin connected to a storm sewer, this can be used as a collection point. The storm sewer could be temporarily blocked or plugged so that a temporary pump or vacuum could collect the wash water which can then be disposed of in a sanitary sewer or holding tank.

Image Courtesy of City of Centralia, Washington



Car wash catch basin insert for diversion to sanitary sewer.

Minimize run-on

Minimize the run-on of rain water or snowmelt to the designated wash area through berming or diking the area.

Avoid detergents

Avoid detergents whenever possible by considering power washing and steam cleaning. If detergents are necessary, a phosphate-free, non-toxic, biodegradable soap is recommended. However, even detergents labeled biodegradable or phosphate-free are not safe to discharge to the storm drain; both require treatment provided by the sanitary sewer system in order to reap the environmental benefits. In fact, phosphate replacement chemicals may be more toxic than phosphate. No water that contains any detergent should discharge to the stormwater system. Detergents should also be avoided if an oil/water separator is used for pretreatment prior to discharge to the sanitary sewer.

Dry pre-wash

Initially clean vehicles without using water (e.g., sweep loose material in cargo areas), collect the loosened material, and dispose of properly as solid waste.

Wash vehicles on paved surfaces. If not on a wash rack, collect water with a catch basin insert like the one shown below.

Conserve water

Conserve water when rinsing and washing vehicles.

Concrete washouts

Use water tight above-or below-grade concrete washouts for concrete trucks. Remove materials by vacuuming once the washout is at or near 75 percent capacity. Dispose of materials in an approved manner by checking with the local sanitary sewer authority to determine if there are special disposal requirements for concrete wash water. Educate users (MS4 staff and/or subcontractors) on concrete washout use and maintenance. See the MPCA Concrete Washout Guidance in the Additional Resources section for more information.

Storm drain stenciling

Stenciling storm drains will help remind employees to wash vehicles only in designated areas and away from storm drains (see the fact sheet on Storm Drain Stenciling).

Easy-access cleanup supplies

Provide cleanup supplies near designated wash areas to facilitate immediate cleanup. Use dry cleanup methods (e.g. absorbents) rather than hosing down the area to prevent discharge to storm drains.

Avoid cleaning chemicals

Cleaning chemicals can contain ingredients that pose threats to human health if they enter ground water and drinking water supplies and can be highly toxic to fish and other aquatic life. Consider these questions:

- What are the goals in using chemical cleaners?
- Are these goals aesthetic only?
- Have you tried pressure cleaning with plain water then steam cleaning without chemicals to see whether these goals can still be achieved?
- Can you eliminate the use of some or all cleaning chemicals?

Also consider the ingredients of the chemical products used. Demand that vendors provide the *complete* ingredient list for each cleaner, so you can evaluate the potential risks of using the product since any materials end up in the environment, even if discharged indirectly through the sanitary sewer. Avoid the following ingredients, specifically: dispersants and emulsifiers, alkylphenol ethoxylate (APE) non-ionic surfactant, petroleum distillates (*e.g.,* kerosene, white spirits, mineral spirits, Stoddard solvent, petroleum naphtha), hexane, methyl ethyl ketone (MEK), toluene, xylenes and naphthalene, alkyl benzene sulfonates (ABS) and linear alkyl sulfonates (LAS), molybdenum, caustic soda (sodium hydroxide) and potassium hydroxide that can contain significant levels of mercury, phosphates, glycols, and acids.

An existing building could be used or a concrete or asphalt pad constructed that is large enough for at least one truck to be washed. The pad should have a collection sump and the wash water would flow by gravity or be pumped from the collection point to an existing sanitary sewer line. It is preferable to have a roof over the washing area to keep clean stormwater out.

Recycle Wash Water

Utilize recycle units to reuse wash water prior to disposal. Since recycle units clean wash water only enough so that the water is suitable for washing, rinsing will still have to be done with fresh water. Normally, recycle units do not remove detergents, dissolved solids or heavy metals. This will enable reduced detergent usage. However, hazardous waste limits should be known to determine how many cycles of reuse can be conducted while remaining under the limit.

Employee Training

Train employees and subcontractors in the MS4's vehicle washing procedures to avoid illicit discharges.

Example Program

The City of Centralia, WA, operates a Fish Friendly (Charity) Car Wash Program that has special kits available for parking lot charity car washes that pump wash water into the sanitary sewer system, keeping contaminants out of storm drains and local surface waters. All City charities and groups can borrow the kits at no charge from the Surface and Stormwater Management Department. The car wash kit includes event signs indicating that it is a Fish Friendly Car Wash. The Fish Friendly (Charity) Car Wash Program also includes disseminating public education materials in the form of letters, flyers and press releases targeted at local charities and special interest groups, as well as local businesses.

Maintenance Considerations

Plumbing, recycling, and pretreatment systems require periodic inspection and maintenance. Containment berms should be inspected for failures; holding tanks and concrete washout volumes should be inspected for remaining capacity and emptied when at 75 percent capacity. A wash rack's paved surfaces and sump should be inspected and cleaned periodically to remove buildup of particulate matter or other pollutants. The area surrounding the wash rack should be visually inspected for leaks, overspray, or other signs of ineffective containment due to faulty design or physical damage to berms.

Typical Cost

Building a new wash rack and recycling unit can be expensive ($2,000 to $5,000 for berm construction; $10,000 to $30,000 for plumbing modifications; $60,000 to $200,000 for onsite treatment and recycling). Costs associated with discharge to the sanitary sewer (e.g. required pretreatment) could be reduced or eliminated with a recycling system. However, for facilities that cannot recycle their wash water, the cost of pretreating wash water prior to discharge to the sanitary sewer can represent a cost limitation. Collection and hauling of contaminated water to sewage treatment plants is an additional cost. The purchase of wash water containment equipment is often a one-time expense and this equipment is often used for a number of years.

Costs for contracting with commercial car washes can vary depending on the size of the fleet. Rates are subject to negotiation, but they would constitute an annual operating cost that could be included as part of the MS4 budget. If the appropriate facilities are available, vehicle washing BMPs are relatively inexpensive housekeeping measures (e.g. berms, wet/dry vacuums, cleanup supplies).

Street & Parking Lot Sweeping

Key components of a successful sweeping program

Pollutants collect on surfaces in between storm events as a result of atmospheric deposition, vehicle emissions, winter road maintenance, construction site debris, trash, road wear and tear, and litter from adjacent lawn maintenance (grass clippings). Sweeping of materials such as sand, salt, leaves and debris from city streets, parking lots and sidewalks prevents them from being washed into storm sewers and surface waters.

Timing, frequency and critical area targeting greatly influence the effectiveness of sweeping. This fact sheet provides an overview of studies assessing the benefits of street and parking lot sweeping and guidance on improving the pollution reduction benefits of sweeping programs applicable to MS4 SWPPPs.

Benefits / Pollution Reduction

Regular street sweeping reduces the amount of pollutants that get washed into the storm drain and ultimately discharge to lakes, rivers and wetlands. Targeted pollutants include sediment, trash and debris, leaves, organic matter and nutrients; metals and hydrocarbons. The following pollutant removal efficiencies for total solids (TS), total phosphorus (TP) and total nitrogen (TN) are from a conceptual model developed by the Center for Watershed Protection based on research findings from a variety of studies.

Image Courtesy of Emmons & Olivier Resources, Inc.

Street sweepings can be filtered and recycled for sanding or filling.

The lower removal efficiencies represent monthly street sweeping by a mechanical street sweeper. The upper efficiencies characterize the pollutant removal efficiencies using a regenerative air or vacuum street sweeper at weekly frequencies. Note that the relatively high frequencies of sweeping generate particularly low removal efficiencies, indicating that sweeping, although an effective aesthetic practice, does not necessarily translate into improved water quality. This is a similar finding of Selbig and Bannerman (2007) in their study of street sweeping in Madison, WI. Even so, every pound of trash and debris removed by sweeping is another pound not entering local waterbodies.

Pollutant Removal Efficiencies (%) from Street Sweeping for Total Solids, Total Phosphorus and Total Nirogent

Frequency	Technology	TS	TP	TN
Monthly	Mechanical	9	3	3
	Regenerative Air/Vacuum	22	4	4
Weekly	Mechanical	13	5	6
	Regenerative Air/Vacuum	31	8	7

Source: Deriving Reliable Pollutant Removal Rates for Municipal Street Sweeping and Storm Drain Cleanout Programs in the Chesapeake Bay Basin. Center for Watershed Protection.

Program Development & Implementation

Surface Sweeping Program Assessment

The Center for Watershed Protection recommends considering the following questions in order to improve the efficiency and effectiveness of your surface sweeping program.

- What surfaces or streets in the community are dirtier than others (e.g. have higher street particulate matter loadings compared to others)? Which streets drain to sensitive water bodies? Prioritize streets with higher loadings. The City of Rochester, New York, has an online street sweeping request form. This contributes to the City's ability to identify dirty streets and surfaces for more frequent cleaning.

  Many cities identify street areas draining to sensitive receiving waters, such as lakes, or to BMPs that could clog with debris and prioritize sweeping on those streets. Consider conducting a street and storm drains investigation, a visual inspection of pollutant accumulation along streets, curbs and gutters, in lake deltas, and storm drain inlets based on the Center for Watershed Protection's Urban Subwatershed

Restoration Manual No. 11: Unified Subwatershed and Site Reconnaissance: A User's Manual. (See the Additional Resources section).

- What proportion of streets and surfaces in the community is swept? Increase this proportion to the extent feasible. The City of Rochester, New York, developed a database to track street sweeping and calculate the total lane miles swept annually. This provides a benchmark for setting goals for future years.
- What is the frequency of street sweeping for public streets? Ensure the frequency is at a minimum twice per year (in the fall after the leaves have fallen and in the spring after the snow is gone to get the sand and winter debris); see the recommendations in the Key Program Elements section below.
- What problems affect the performance of street sweeping (e.g., on-street parking, inadequate budget, untrained operators, distance to storage and disposal facilities)? Once identified, explore means to address the problems.
- What technology is being used? Increase the range of particle size swept by using regenerative air or vacuum sweepers.
- What is the size of the street sweeper fleet? Consider if fleet size is a barrier to efficiency. Many cities hire contractors rather than buy their own sweepers.
- How do you dispose of material collected from the street sweepers? For example, the City of Madison hauls most debris to the county landfill where it gets used as a daily cover for the trash and therefore, is disposed of at no charge. In the fall, when most collected material is leaves, the material is composted at a county site. Some cities filter and recycle their street sweepings for sanding or fill. For additional guidance on reusing street sweepings, see Managing Street Sweepings by MPCA in the Additional Resources section.

An ideal surface sweeping program would answer yes to the following questions. Any missing program elements should be further considered to improve the surface sweeping program:

- Does your community schedule leaf pickup and subsequent street sweeping in the fall to pick up leaves and other organic matter? Do sweepers pick up leaf piles?
- Does your community schedule street sweeping in the early spring to pick up sand, salt and other street deicing materials?
- Does your community use street sweeping equipment (e.g. regenerative-air sweepers, vacuum-assist sweepers) that is capable of picking up a wide range of sediment particles?
- Is tandem sweeping used?
- Are no-parking zones used to increase pick up efficiency?
- Does your MS4 provide regular stormwater pollution prevention training and education to employees and contractors involved with street sweeping activities?

Key Program Elements

Sweeper technology and operations

Water quality protection is dependent on the sweeper's pick-up efficiency of fine-grained sediment because many pollutants are adsorbed to them. Street sweeping has historically been more effective at removing only large-sized particles providing little pollution prevention but, new technologies are emerging that will remove smaller, fine-grained particles.

Types of sweepers

There are three main types of sweepers including mechanical broom, regenerative-air, and vacuum-assist. Mechanical broom sweepers are typically the least expensive but are better suited to pick up large-grained sediment particles and clean wet surfaces. They tend to create dust during operation, potentially increasing atmospheric loading of dust and/or increasing the amount of fine particles on the pavement that could ultimately wash through storm drains to surface waters. Regenerative air and vacuum-assist sweepers are better at removing fine-grained sediment particles, but are less effective on wet surfaces and are more expensive. Using a mechanical sweeper for large particles followed by a regenerative-air cleaner can be effective. No matter the equipment, tandem sweeping (when one sweeper follows another along the same route to pick up missed material) improves removal efficiency. A single sweeper that makes multiple passes on a surface has the same effect.

In early 2008, Minnesota Local Road Research Board's Research Implementation Committee (LRRB-RIC) completed helpful guides to street sweeping. Specifically, the Resource for Implementing a Street Sweeping Practice includes information sheets that provide guidance for technical staff, policy and decision makers on: best practices overview, types of sweepers, reasons for sweeping and sweeping and roadway function.

Sweeper frequency

Part of the LRRB-RIC research identified that Minnesota falls behind other states in terms of street sweeping frequency. Study surveys showed that Minnesota street sweeping frequency falls lower than nationwide averages. A typical Minnesota city sweeps two times annually, in spring and fall, while the national average was 10 times each year. At a minimum, sweeping should occur in early spring (before rainfall) and in the fall after most leaves

have dropped. Early spring sweeping gathers remnant pollutants from winter activities including sand and de-icing material. Fall street sweeping should be coordinated with leaf pickup especially in MS4s with substantial deciduous trees. An additional sweeping in June, after trees drop seeds and flowers, will provide additional targeted phosphorus removal. Make it a priority to sweep surfaces adjacent to MS4 infiltration practices, if applicable. The Center for Watershed Protection recommends an optimal sweeper frequency of about twice between each runoff-producing rainfall event. The cities of Rochester, New York, and Rochester, MN, have more aggressive street sweeping programs focused on maximum water quality protection.

The City of Rochester, New York, has the following street sweeping schedule:

- Early season sweeping begins in the spring, as sweepers clean the debris that accumulated during the winter months. The program runs roughly May through October.
- Arterial streets are swept twice a week
- Residential streets are swept every two weeks on a rotation cycle (to accommodate alternate side parking)
- Streets in the central business district are swept daily

The City of Rochester, MN, includes the following in its SWPPP:

> "The annual sweeping cycle usually begins in the spring. A full-city sweep is conducted to remove sediment and litter that have accumulated over the winter. Sweeping continues throughout the summer primarily to collect litter, but also to target known chronic problem areas, such as certain industrial areas or topographic areas that serve as sediment and debris collection points (e.g., the bottoms of hills). Due to the variety of tree species and density of trees, fall sweeping necessitates multiple cycles in multiple areas to collect leaves. When temperatures permit, sand is swept from streets during the winter months".

In addition, the City's street sweeping program includes sweeping the central business district twice per week with their single vacuum sweeper because it is more effective than their mechanical broom sweepers. After the grinding and milling phases of road rehabilitation projects, the City sweeps the area first with the mechanical sweeper and second by the vacuum sweeper to collect the residual coarse and fine material.

The City of Minneapolis focuses on its parkways and chain of lakes for additional sweeping above and beyond spring and fall sweeping. This program also accommodates additional sweeping in other areas as needs arise.

Access to curbs

Pollutants including leaves and debris tend to gather at the curb of streets and parking lots. Street sweepers must be able to access these areas in order to be effective. Consider methods to prevent cars from parking in areas where/ when street sweeping is to occur (e.g. temporary no-parking restrictions and signage on streets and surfaces scheduled for sweeping and coordination with local police to patrol designated routes).

Distance to storage and disposal facilities

Travel time to storage and disposal facilities can reduce the time spent sweeping streets. Consider options to reduce distances between facilities so that slow-moving street sweepers have faster access.

Staff training

Train operators and associated staff once a year on the importance of water quality, the pollution prevention capabilities of street sweeping and how to properly drive and maintain sweepers.

Maintenance Considerations

The key maintenance issue for street sweeping programs is maintenance of the street sweepers. Street sweepers should be maintained to function at optimal efficiency and the vehicle fleet should be kept up to date with new technologies that improve pollutant removal (e.g. fine-grained particle pick-up). Installing an automatic greasing system on sweepers can decrease maintenance time and reduce wear on critical parts, which can keep the sweeper on the job longer with fewer unscheduled maintenance hassles. Maintaining surfaces through more frequent sweeping may reduce the frequency necessary for catch basin cleaning.

Typical Cost

Staffing and equipment are the largest costs for street sweeping programs. Conventional street sweepers can range from $60,000 to $125,000, depending on the make, model and equipment enhancements. Prices can be as high as $180,000 for newer technologies. The average useful life is about four years, varying based on frequency of use. Cost savings can be seen by using equipment that can be

converted to other uses. For example, the City of Jordan, MN, purchased a sweeper that converts to a sander and snowplow in the winter. Training for operators must be included in operation and maintenance budgets. Costs are small for parking restriction notifications/signage. Parking tickets are an effective reminder to obey parking restrictions and can be used as a source of revenue for the program.

Park & Open Space Fertilizer / Chemical Application Programs

Minimization of and training for chemical application

Fertilizers, herbicides, and insecticides have various ecological effects, toxicity, and chemical fate and transport based on the product's chemical components. Depending on the chemicals' characteristics, they can have unintended harmful effects on terrestrial and aquatic plants and animals, and can end up in our soil, water, and air. Nitrates from fertilizers can migrate through the soil profile and contaminate ground water supplies beyond safe drinking water levels.

Phosphorus from fertilizers contributes to eutrophication of surface water bodies that depletes oxygen levels and can lead to fish kills. This fact sheet provides guidance on program development for minimizing fertilizer and pesticide application.

Benefits / Pollution Reduction

Practicing proper fertilizer, herbicide, and pesticide application reduces the risk of these materials being transported by stormwater to downstream water bodies. Minimizing chemical use by employing best management practices (BMPs) for both application and material handling helps to eliminate a significant cause of stormwater pollution. Some BMPs have the potential to reduce costs associated with grounds keeping and maintenance, while improving the aesthetics and vegetative health of grounds where they're implemented.

Program Development & Implementation

Programs designed to manage and minimize chemical application typically include a combination of the elements identified below. The BMPs and chemical alternatives discussed can provide the content for training programs and public education materials.

Integrated Pest Management

Integrated pest management (IPM) is a pest control system that employs mechanical, biological, cultural, and/or chemical mechanisms as determined by a thorough evaluation of the conditions rather than addressing every condition with chemicals.

The following are IPM strategies:

- Cultural control – selected timing and location of plantings to avoid pests
- Host resistance – planting vegetation that is resistant to pests
- Mechanical control – weeding; setting insect traps
- Biological control – stocking beetles to attack purple loosestrife; protecting naturally-occurring insect predators, parasites, and pathogens
- Chemical control – using the least toxic pesticides available wherever possible

IPM strategies are employed only when pest populations reach an unacceptable economic or aesthetic threshold.

Chemical Preparation and Handling Best Management Practices

The following guidelines should be followed when preparing and handling chemicals:

- Select the least toxic products available to minimize waste and applicator exposure
- Use products only as directed, reading and following all labels
- Inspect, maintain, and calibrate equipment used for mixing and application
- Prepare only as much herbicide/pesticide as is needed
- Be prepared with cleanup materials to cleanup spills immediately; use dry cleanup methods (e.g. squeegee and dust pan) rather than hosing down the spill site
- Close containers tightly after each use, even if planning to reopen them soon
- Store chemicals safely in a ventilated, well lit area that is away from drinking water wells or any other permanent or intermittent water bodies
- Dispose of rinse water properly and recycle containers properly. For pesticides, triple rinsing or pressure rinsing with reuse of rinse water for future pesticide applications is recommended by the University of Minnesota. Proper rinsing of pesticide containers is also a requirement of Minnesota State and federal law.
- Monitor all fertilizer/pesticide application quantities and sites in order to provide guidance for future treatments
- Keep products in their original containers and mark the date of purchase on each container. Use older materials first.

Chemical Application Best Management Practices

The following guidelines should be followed when preparing and handling chemicals:

- Employ IPM
- Consider having the soil tested before applying fertilizer in order to determine what nutrients must be added
- Avoid application over impervious surfaces; sweep granular fertilizer back onto the grass to prevent it from washing into the storm sewer system
- Apply when sufficient calm, dry weather is in the forecast to prevent drift and washoff. Lawn fertilization programs should begin in fall, not in spring; this will prevent shallow root growth. Tree and shrub fertilization programs should occur in late fall or early spring when the plants are dormant.
- Do not apply to bare or eroding soil
- Do not apply near water systems such as streams and lakes unless the product is specifically designed for use in shoreline or aquatic environments
- Do not apply near wells
- Do not over fertilize. Too much nitrogen will cause plants to grow shallow roots creating a less hardy landscape (e.g. especially bad for athletic fields and parks) that requires more watering. Healthy trees and shrubs do not require annual fertilizing.
- Consider causes such as poor soils, insects, disease, or current weather patterns before applying fertilizer as a remedy for poor growth

Fertilizer Alternatives

Organic fertilizer

Most organic fertilizers release nutrients more slowly and contain lower concentrations of nutrients. The slow-release function provides the lower concentration of nutrients over a longer period of time which is good for sandy soils where fast-release fertilizers can leach nutrients into the ground water. Fast-release fertilizers are more effective for heavy clay or compacted soils. Organic fertilizers have the additional benefit of recycling waste that would otherwise contribute to landfills and/or pollution.

Grass clippings

Mulching mowers create fine grass clippings that will break down and add nitrogen and organic matter to the soil. Leave grass clippings on the lawn over the season to provide the equivalent of one regular fertilizer application that will not cause thatch.

Aerate

Aerating a compacted lawn punches holes in the soil to allow air, water, and nutrients to reach the roots. Leave the small plugs of thatch and soil on your lawn and they will quickly decompose. The best time to aerate is in the early fall.

Compost

Apply a thin layer of compost (1/4" or less) to provide nutrients and additional water retention properties to combat dry periods. High-quality compost is available in nurseries by the bag or in bulk, or you can make your own. The best time to apply compost to lawn is in the spring using a wheelbarrow, shovel and lawn rake. A 1/4" layer requires about one cubic yard of compost per 1,500 to 2,000 square feet of lawn area.

Soybean fertilizer

Michigan State University began using soybeans as turf fertilizer in 2000. Their studies suggest that soybeans perform equal to or better than chemical fertilizers. Ground soybeans provide a slow-release of nutrients to the lawn and are harmless to people, pets, and other plant material. In addition, soybeans are phosphorus-free. Because they are organic, each application improves the growing media, and they will not burn the grass.

Public Education Brochures

Develop public education brochures to encourage residents to limit chemical use by educating them about the human health risks and natural resource impacts associated with improper application. Typically tri-folded, double-sided informational sheets can be mass-mailed to educate residents. If ordinances or fines are associated with improper chemical application, these would also be included in this education piece.

Chemical Application Ordinance

Introduce a law enforced by the MS4 whereby individuals or entities responsible for chemical application receive a fine for chemical application that varies from product labeling. Other city-developed regulations might include required soil testing before fertilizer application.

Fertilizer and Pesticide Applicator Licensing

The Minnesota Department of Agriculture (MDA) requires all persons who apply fertilizer or pesticide for hire (regardless of whether the product is custom blended, bagged, bulk, etc.) to obtain a fertilizer or pesticide applicator license, respectively from the MDA. A license is required for any application, including applications to lawns, plants (including trees and shrubs), and interior landscapes. Annual attendance at applicator recertification workshops is required.

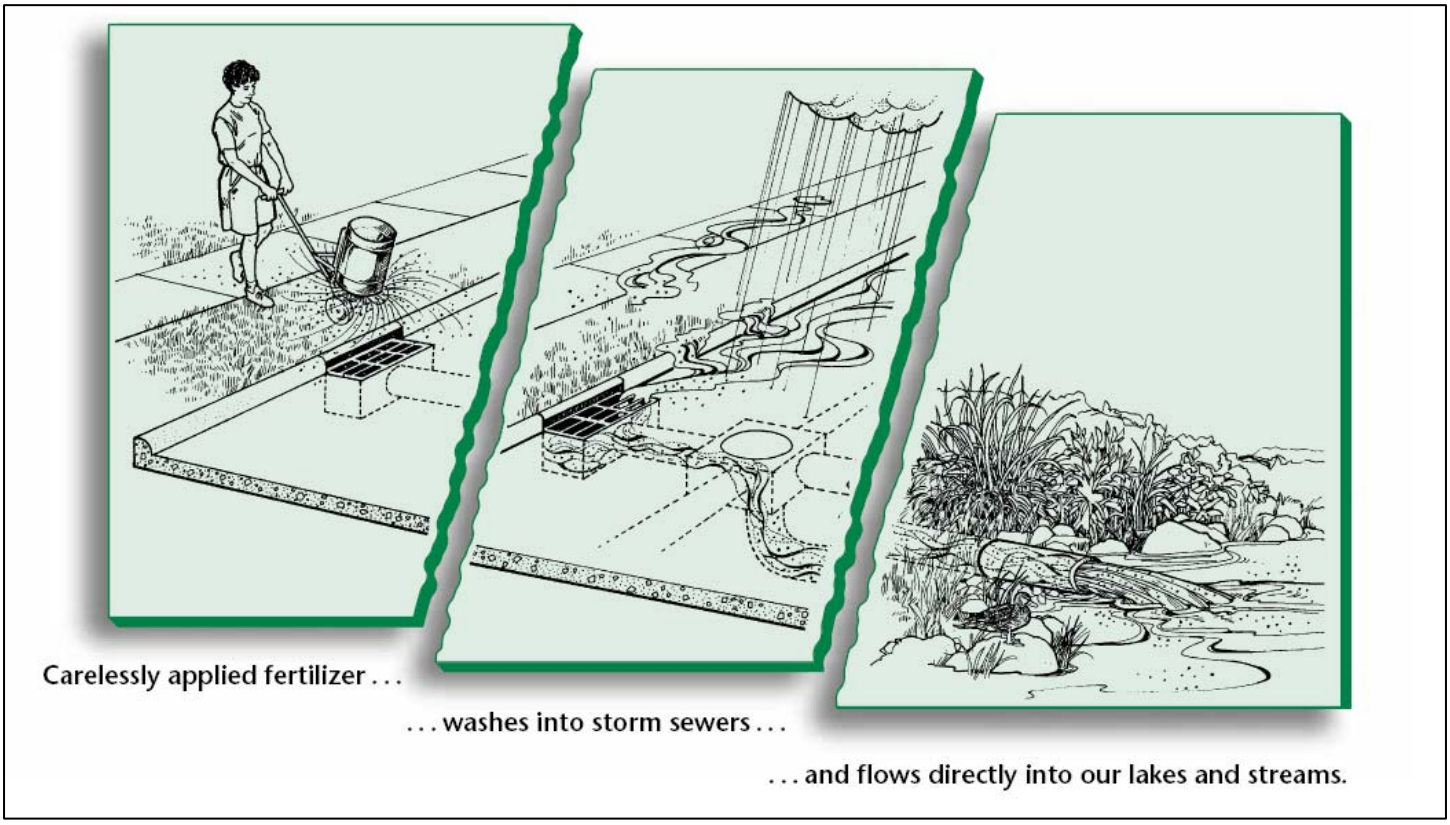
Maintenance Considerations

If monitoring application rates at project sites in order to provide guidance for future application rates and methods (an effective chemical application BMP), it is important to maintain good records and use staff time to visit application sites.

Typical Cost

A soil sample and nutrient test costs less than $25 per sample and is easily the best value for fertilizer minimization. Soybean and organic fertilizers can be up to three times the cost of standard chemical fertilizer. Reduced labor costs associated with fewer applications in larger amounts can help to offset this cost. However, alternative practices employed in place of fertilizers (see Fertilizer Alternatives above) can easily be less expensive than chemical application. Similarly, practicing IPM can reduce herbicide and pesticide application costs.

Image adapted from WI DNR, Lawn and Garden Fertilizers



Winter Road Materials Management

Management of winter road materials and associated pollutants

The concentration of chloride is increasing in our surface and ground water largely due to stormwater runoff from road salt storage piles, areas of excessive application, or simply from years of repeated application since chloride does not degrade in soil and water. Chloride in road salt and road salt additives (e.g. ferrocyanide for anti-caking) can create toxic conditions for fish, insects and vegetation.

Sodium from road salt can compromise soil structure thereby reducing its water retention capacity and increasing the potential for erosion. It can also reach levels in ground water that pose drinking water problems. Associated materials that could also pose water quality problems could include sand (anti-skid agent) and phosphorus related to both the salt and the sand. This fact sheet provides guidance on the management of winter road materials.

Benefits / Pollution Reduction

Minnesota Statute 160.215 states that the application of salt and chemicals for snow removal and road de-icing shall be restricted to reduce the pollution of waters. Proper road salt storage, handling, and application reduce the risk of downstream water resources pollution and can reduce die-off of exposed vegetation, fish, and other aquatic organisms. Best management practices (BMPs) can also protect ground water supplies from contamination Ground water is the source of approximately 70% of the drinking water in Minnesota. Efficient storage, handling, and application rates can also reduce materials costs. Details on the nature of the salt problem and possible approaches to controlling it are contained in the Minnesota Stormwater Manual (Chapter 9).

Program Development & Implementation

Salt Management Plans

A municipal salt management plan is a commitment to implementing BMPs while fulfilling a community's obligation to provide safe, efficient and cost-effective roads. The plan should identify BMPs to reduce the negative environmental impacts of road salt. The plan should apply to all winter maintenance personnel including staff and contractors. The Canadian Public Works Association (CPWA) and Transportation Association of Canada (TAC) provide helpful guidance on salt management plans. The CPWA and TAC recommend the following framework for a salt management plan:

Salt management policy and objectives
Adopt a salt management policy that commits to measurable improvements in salt management practices.

Review of current practices
Inventory current practices to form a benchmark against which progress can be measured and tracked. Consider current application rates for each material, percentage of fleet with electronic spreader controls, BMPs implemented in salt-vulnerable areas, percentage of sand/salt piles covered, percentage of snow disposal sites with water management systems, and percentage and frequency of staff receiving training.

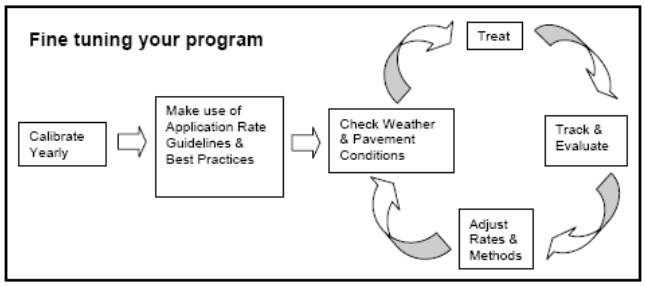


Image Adapted from MPCA Winter Parking Lot and Sidewalk Maintenance Manual

Documentation of policies, procedures and guidelines
Level of service for each roadway type, salt/sand application rates, managed salt/sand storage, good housekeeping practices, equipment calibration and re-calibration, training, snow disposal, incorporation of salt management consideration into road design and construction, and salt vulnerable areas.

Proposed approaches, including BMPs and assigned responsibilities
Identify clear tasks, schedules with milestones, budget considerations and assigned responsibilities for implementing BMPs. Address the following four areas of concern: general road use, salt use in salt vulnerable areas, salt storage and mixing, and snow storage and disposal.

Training
Include a comprehensive education and training program that demonstrates the value of new procedures and ensures that managers, supervisors, and operators are

competent in delivering the new program. The training program should also include a public element whereby the public is educated on proposed and existing winter maintenance practices. Public education could include adjusting driving behavior based on roadway conditions. Training is available through MnDOT and MPCA Road Salt Education Program (see the Additional Resources section).

Monitoring, reporting and analysis
In order to identify progress as compared to benchmarks, measure and assess the indicators identified based on a 'review of current practices.' Assign responsibility for monitoring and recording to ensure the task is accomplished. As an example, the type of benchmark data collected could include: the amount of salt/sand applied by driver and road covered, the calibration and maintenance history for each application vehicle, or the annual amount of salt applied per unit of weather/precipitation, such as degrees below 32ºF or inch of snow. Any data that help the community track use and allow for increased efficiency and decreased overall salt use will be helpful to document.

Management review
Annually review the previous year's salt management practices and results to review progress. Communicate progress to staff, senior management, the public and local politicians. Use the annual review to guide next year's plan and identify new opportunities for BMPs. Update the plan with new protocol and train staff and contractors accordingly.

Winter Road Materials BMPs

Salt, sand and chemical storage
Provide cover and impervious pads for salt, sand and chemical storage areas. This will reduce the possibility for contamination of downstream water bodies while preventing formation of lumpy salt that is difficult to handle and reducing salt loss through dissolving and runoff. It is also important to collect runoff from storage areas.

Image Courtesy of Emmons & Olivier Resources, Inc.

Ideally, all mixing of salt/sand mixes and all loading should also be done under cover. If space and cost factors do not allow for total inside operation, runoff collection and post-operation clean-up should be standard procedures. No mixed salt/sand piles should be left exposed between operations.

For additional information on proper storage and handling of these materials see the Hazardous Material Storage and Handling fact sheet.

Anti-icing techniques
Liquid anti-icing chemicals are applied to the pavement before a storm in order to prevent or minimize the bonding of snow and ice with the pavement surface. This reduces the salt application required after the storm event. The liquid is contained within tanks on the application vehicle and can include any of a number of products or mixes available (see the Additional Resources section).

Application BMPs
Application BMPs for the state of Minnesota are provided in two manuals. The Minnesota Snow and Ice Control: Field Handbook for Snowplow Operators was developed by the University of Minnesota Center for Transportation Studies, the Minnesota Department of Transportation, and the Minnesota Local Road Research Board.

The Winter Parking Lot and Sidewalk Maintenance Manual was developed by the MPCA and others providing a tool for training snowplow operators, based on the research conducted for the Field Handbook.

The following topics are a subset of those covered in The Winter Parking Lot and Sidewalk Maintenance Manual:

- Selection and use of materials
- Practical melting temperature of deicers
- Materials testing
- Spreader calibration
- Measuring pavement temperature
- Weather conditions
- Snow removal
- Loading/hauling materials
- Prewetting and pretreating salt and sand
- Deicing and anti-icing guidelines
- Deicing and anti-icing application rates
- Documentation
- Case Studies from application of the guidelines

Treatment and recycling of salt truck wash water
Salt truck wash water and runoff from salt storage facilities can contain high levels of sodium, chloride, cyanide, and other associated pollutants. Capture, treat, and recycle salt-containing wash water or storage facility runoff for use as

salt-brine in salt pre-wetting and anti-icing materials, or properly route the collected runoff to a wastewater treatment facility. For additional information regarding wash water containment and recycling see the Vehicle Washing fact sheet.

Training
As part of the MPCA Road Salt Education Program, a road salt applicator training program is offered based on the Winter Parking Lot and Sidewalk Maintenance Manual. Over 1,500 road salt applicators have received certification. Entities with certified personnel include, but are not limited to, cities, public works, private companies, counties and MnDOT.

Snow Management Plans and Private Operations

Each MS4 should examine its approach to managing the accumulation, removal and potential collection of snow so that procedures are in place for both during and after a snowfall event. This plan should not only address MS4 operations, but also examine how commercial entities are conducting their operations. Many commercial applicators apply excessive salt to assure the public's safety in well traveled areas. Education or possible regulation of these applicators could help reduce pollutants entering the MS4 community drainage system that eventually flow to sensitive receiving waters.

The Minnesota Stormwater Manual (Chapter 9) contains recommendations on the potential content of a snow management plan.

Maintenance Considerations

All application equipment must be well maintained and calibrated in order to operate effectively. Proper documentation should be part of this maintenance program, as described previously. Inspection and maintenance of storage areas should be provided to minimize contact of stored or spilled materials with stormwater. Details on this topic are well covered in the material referenced in the Additional Resources section.

Typical Cost

The Winter Parking Lot and Sidewalk Maintenance Manual identifies the cost savings experienced by those who underwent the road salt applicator training program. Rather than creating an additional expense, implementation of BMPs reduced material usage by 33 percent to 51 percent. Materials reductions translated directly into cost savings. Increased efficiencies from operator training can similarly save an MS4 both staff and materials costs.

Storm Drain Stenciling

Developing a storm drain stenciling program

Storm drains are gateways that allow pollutants in stormwater to flow untreated from local streets to lakes, rivers and streams. Residual oil, grease, solids, antifreeze, cigarette butts, yard waste, plastic and other wastes found on roads, parking lots and driveways pollute downstream waters by increasing phosphorus levels, reducing oxygen levels and ultimately impairing aquatic habitat for fish and other organisms as well as drinking water sources.

An unfortunate, yet still common, misperception is that storm drains discharge to water treatment plants. Stenciling is one public education tool that helps dispel this misperception. This fact sheet provides guidance on implementing a storm drain stenciling program to increase public awareness of the direct connectivity between storm drains and water resources.

Benefits / Pollution Reduction

Storm drain stenciling will help the people in your community understand what happens to polluted stormwater. When people are aware of the negative environmental impacts of their actions, they are more likely to stop dumping pollutants down storm drains. Reduction in the discharge of pollutants into storm drains results in cleaner downstream lakes, streams and wetlands. It contributes to improved water clarity, coloration and odor as well as fish and wildlife habitat.

Program Development & Implementation

Programs designed to increase public awareness through volunteer efforts have the benefit of educating both the general public and the volunteer. The extent of an MS4's storm drain stenciling program is dependent upon several factors including the MS4's available resources, size of staff, and degree and character of its illicit storm drain discharges. Many pollution prevention awareness phrases can be effective: "No Dumping. Drains to River," "No Dumping. Drains to <Insert Water Source>," "You Dump It, You Drink It," "No Waste Here," and "Only Rain in the Drain." For more information regarding other methods to trace and prevent illicit discharges see the Potential Discharge Identification and Risk Reduction fact sheet.

Unrestricted flickr ® Image

Storm Drain Stenciling Techniques

Storm drain 'stenciling' can be done with paint and stencils, medallions, pre-stamped grates or stamped concrete.

Paint

Painting or spray painting with a paper, plastic or metal stencil as a guide is an inexpensive application for storm drain stenciling and easily implemented by volunteers. However, the lifetime of the paint may not exceed two years. Stenciling can be done on the street in front of the storm drain, on the adjacent sidewalk, or on the curb. Spray paint is the easiest to apply neatly, but contains air polluting propellants. Consider using environmentally-friendly paints free of heavy metals and low in volatile organic compounds.

Medallions

Plastic, ceramic or metal medallions, typically 4 inches round, can be glued with a strong epoxy or embedded in concrete and bolted down. Gluing medallions is easily transferrable to volunteer programming.

Pre-stamped grates

Pre-stamped grates will last a long time (until the metal is worn down) and are an effective means to implement a city-wide storm drain stenciling initiative.

Stamped concrete

While concrete is still wet, stamp an impression of the selected 'no dumping' slogan. Stamped concrete will last longer than paint or medallions. In addition, concrete stamps allow versatility in design since, unlike medallions, long-term stability is not based on size of the design.

Volunteer Recruiting

Encourage organization-sponsored stenciling

Storm drain stenciling is a great activity for all types of organizations including service clubs, neighborhood associations and scout groups. Stenciling does not require extensive volunteer participation. A few trained volunteers can thoroughly mark storm drains within a single neighborhood. However, the educational nature of the activity facilitates greater understanding among participants of the value of water resources.

MS4s can provide brochures and guidance documents identifying how to stencil and recruiting organizations to get involved. The City of Lakeville, MN, provides an online sign-up form for individuals and organizations to get involved. The City of Woodbury, MN, recruits community groups for storm drain stenciling projects. Volunteers also distribute informational door hangers to homes in the project area. A single project area is a commitment of one to two hours of work. In all cases of recruiting volunteers, the City provides materials and instructions. Friends of the Mississippi River, University of Minnesota Extension Service and North Carolina State University are just a few of the entities that provide detailed guidelines on volunteer safety, protection of public and private property, MS4 liability, painting quality and stenciling effectiveness.

Adopt A Street integration

The City of Ashland, Oregon, has instituted a storm drain stenciling program in collaboration with their Adopt a Street Program. They encourage participants in the existing Adopt a Street Program to stencil storm drains as well. The same collector or arterial street adopted for quarterly trash pick-up by businesses, organizations or schools can serve as the site to conduct storm drain stenciling with City resources.

Be prepared

The EPA suggests that organizers be prepared with the following at all volunteer stenciling events:

- Kits containing all necessary materials and tools
- A map of the storm drains to be marked
- Safety training on the technique for using stencils or affixing signs including the use of masks or goggles, gloves, traffic safety equipment such as traffic cones, safety vests
- Incentives and rewards (e.g. badges, t-shirts, certificates).

Standard Specifications and/or Ordinances

Require that all new and repaired storm drains be outfitted with storm grates that have a pre-stamped pollution prevention message such as "No Dumping, Drains to River." The City of South Jordan, Utah provides a good example of engineering specifications for storm drain stenciling:

Developments must provide theft-resistant permanent installation of a City-approved storm drain marker at each stormwater inlet. The marker is part #STDM-9131-SSP, a 4" Stainless Steel Green Painted Marker with Custom Tree Logo with ¼" square hole made by Almetek Industries, Inc. Installation requires Drive Rivet and approved adhesive. Lettering on the marker as appropriately follows:

- "Only Rain in the Drain" markers installed anywhere stormwater discharges to a retention or detention pond
- "No Dumping, Drains to River" markers installed anywhere stormwater discharges to the Jordan River
- "No Dumping, Drains to Creek" markers installed anywhere stormwater discharges to a Creek in the City
- "No Dumping, Drains to Lake" markers installed anywhere stormwater discharges to a lake in the City

Specifications such as this could be contained in MS4 drainage manuals, stormwater design manuals, engineering guidelines, or stormwater management ordinances and permitting.

Maintenance Considerations

In order to maintain the visibility of the storm drain stenciling, re-application may be necessary. Painting lasts about 2 years while medallions would not require replacement for many years, depending on the application.

Typical Cost

The EPA indicates that plastic stencils that can last 25 to 500 uses, depending on paint application (spray, brush, or roller), cost $10 to $15.50. Metal stencils have the benefit of lasting longer and can cost $100 or more. Medallions range from $1 to $3 for 4-inch diameter plastic markers, $2 to $5 for metal and up to $7 for ceramic. Costs vary based on custom versus standard designs. Glue is only a fraction of the cost. A one-time set-up fee of $200 to $1,000 for pre-cast drain inlets with custom pollution prevention messages is applicable above the cost of the structures based on the text and or imagery of the message. Concrete stamps cost around $100 depending on size and custom versus standard designs.

Residential Waste Collection & Clean-up Programs

Developing municipal programs for non-hazardous household waste and yard waste collection and clean-up

Illegal dumping of non-hazardous household waste and improper dumping of yard waste in streets, storm drains, wetlands, lakes, and other water bodies pollutes surface waters. Non-hazardous household waste includes items such as tires, furniture, common household appliances and other bulk items. Yard waste includes any organic debris such as grass clippings, leaves, and tree branches.

Although yard waste is composed of natural materials that will eventually decompose, the debris releases nutrients and uses up oxygen that is necessary for a healthy aquatic ecosystem. Non-hazardous household materials should be recycled or disposed of at a proper facility and yard waste is best minimized and composted. This fact sheet provides guidance on implementing non-hazardous residential waste and yard waste clean-up and collection programs in order to increase public awareness about the environmental impacts of these wastes to encourage proper disposal.

Benefits / Pollution Reduction

Waste collection and clean-up programs can positively change the actions of residents by decreasing the dumping of household materials and yard waste into local surface waters. Yard waste such as grass clippings and leaves, when carried through storm drains or dumped directly into a waterbody, contribute excess amounts of phosphorus to the water, resulting in an increase in the likelihood and severity of noxious algae blooms. Reductions in these pollutants entering surface waters will contribute to improved water clarity, coloration, odor, and fish and wildlife habitat, leading to a more inviting lake for community recreation and enjoyment.

Program Development & Implementation

Encouraging citizens to responsibly dispose of non-hazardous residential waste and yard waste can be accomplished through:

- Ordinances prohibiting harmful disposal
- Education on why dumping is harmful to water resources
- Efforts to connect citizens with local resources to form a sense of ownership and value
- Organized clean-up and waste collection programs

MS4s can combine education with clean-up and waste collection programs for optimal results. For additional program development information regarding illicit discharges, see the Potential Discharge Identification and Risk Reduction fact sheet and for information on preventing disposal of waste in storm drains see the Storm Drain Stenciling fact sheet.

Waste Collection Programs

Offering designated waste drop off locations or curbside yard and bulk non-hazardous household waste collection provides residents with an environmentally friendly alternative to illegal and illicit dumping of waste. There are a variety of options to look into before choosing the best option for your community. These programs can be set-up and implemented by a municipality which will result in a direct cost up front for additional staffing. Coordination of these programs can be contracted out to a private collection service. Additionally, these programs can be offered free of charge, through pay-as-you-throw fees, or by implementing a seasonal or year-round flat fee added to utility billings.

Curbside yard waste collection

Many waste haulers in the Metro Area will pick up yard waste for an extra fee. The city of Columbus, Ohio has contracted with a private hauling service to provide a subscription based yard waste collection service to its residents. The resident is responsible for paying a fee for the six month service. Waste is accepted in biodegradable paper bags, rigid reusable containers labeled with "YARD WASTE" or bundles of twigs tied with twine. Residents can place up to 15 bags, bundles or containers of yard waste curbside for a weekly pick-up. If the limit of 15 is exceeded, additional waste can be collected for a fee. Some communities identify a size limit for yard waste that can be picked up curbside. Waste that exceeds the size limit, must be dropped off at a waste facility by the homeowner.

Yard waste drop off

Designated drop off facilities can be established for yard waste collection. Ramsey County, MN has seven yard waste drop off sites. The sites are open for residents from April through November to drop off yard waste free of charge. Taxes cover the costs of operation and the sites are only available to residents.

The County composts a portion of the material and offers it back to residents free of charge. The majority of compost is trucked by vendors to high- capacity compost sites or to farming operations for soil amendments. The County website identifies what wastes are accepted and available at each site.

Image Courtesy of Emmons & Olivier Resources, Inc.

Residents can bring yard waste to a community drop off site in Ramsey County.

Bulk residential waste collection

Bulk waste such as furniture, tires, appliances and other large items have, unfortunately, been found in wetlands and other water resources. A bulk waste collection program can prevent the illicit disposal of these items. The City of Bloomington, MN, has organized a large item and appliance collection program called Citywide Curbside Cleanup where items not routinely collected by weekly hauling services can be placed on the curb for pickup. Residents pay approximately $20/year to participate. A similar program in Grand Rapids, Michigan is administered by selling stickers which are attached to the bulk waste that can then be placed for curbside pickup on designated days. The stickers cost $7.50 and $12.50 respectively.

Annual waste collection event

Designate a specific day and location for community members to drop-off bulk waste. This event could be coupled with other Earth Day activities in April. Residential hazardous waste collection could also be coupled with this event by working with county hazardous waste departments. St. Louis Park, MN sponsors an annual Spring Clean-up Day. City residents can bring large items such as furniture, tires, remodeling supplies, and appliances to a centralized site. A disposal fee is charged depending on the item. Some items in good condition are collected and redistributed to others for reuse. Other cities offer free disposal service to residents during annual waste collection days.

Awareness Campaigns

Awareness campaigns inform the public of the harm caused to surface waters by illegal dumping of residential waste and yard waste. Through awareness campaigns, an emphasis can be made on changing behaviors, stressing the importance of valuing natural resources. Suggested educational methods include:

Brochures

Develop informative brochures and guidance for specific audiences such as homeowners, landowners, businesses, and garden clubs regarding the yard waste program. The brochure could include supplemental yard waste handling tips. Brochures can be made available at public establishments such as libraries and other municipal buildings, gardening and landscaping stores, and hardware stores. In addition, any of this information could be distributed directly via door hangers, utility bills, or mass-mailed. The information on the brochure could also be made available on a municipality or community website. Suggested topics in education materials may include:

- An explanation of why these disposal practices could harm the environment
- Local yard waste clean-up programs including curbside pickup programs and local collection site locations, hours and materials accepted
- Local burning restrictions for yard waste
- How to compost your own waste (e.g. in bins, worm bins or piles)
- Proper handling of yard waste such as: sweeping up grass clippings and leaves on the sidewalk, driveway, alley or street; leaving grass clippings on your yard; avoid blowing grass clippings and leaves into adjacent water bodies; sweeping up excess fertilizer that lands on your driveway, sidewalk, or in the street; avoiding washing cars with soapy water in driveways that discharge to a storm drain and instead, washing your car on the lawn or at a commercial car wash.

Signage

Position "No Dumping" signage with information about natural resource protection near common dumping sites, wetlands, and storm sewer inlets.

Composting education

Provide workshops and educational materials on backyard composting of leaves, grass clippings and other yard waste. Workshops can provide the technical assistance needed to get homeowners started with a backyard compost bin.

Clean-up Programs

Community wide clean-up event

Organize an annual event for volunteers to come together to clean-up wetlands and other water resources through-out the community. The annual event could coordinate with other Earth Day activities in April.

Adopt-A-Wetland

The City of Oakdale, MN has an Adopt-A-Wetland program encouraging individuals, families, school groups, youth groups, businesses and civic organizations to get involved. The program includes an initial education session, spring and fall trash clean-up of the adopted wetland, annual buckthorn removal, monitoring of invasive species and annual feedback to the City. The local watershed district is involved as an additional resource for program participants. The program helps keep wetlands throughout the city clean year-round and participants gain a sense of pride and ownership in their local water resource.

Image Courtesy of Emmons & Olivier Resources, Inc.

This wetland is enrolled in Oakdale's Adopt-a-Wetland program and is cleaned-up twice a year by volunteers.

Maintenance Considerations

Maintenance considerations will vary depending upon the type of program implemented. If a municipality decides to implement a yard waste collection program, maintenance will need to be considered for additional trucks, residential yard waste bins, and other pick-up equipment. Signs posted in public areas will need to be monitored for graffiti, destruction, and natural wear and fading.

Typical Cost

Costs will vary depending upon the type of program that is implemented. The implementation of a waste collection program will take time and effort on the part of municipal staff and may demand the need for additional staff. In order to implement a municipally run program, collection trucks and equipment as well as a composting facility will need to be acquired. This could result in a significant cost up front. However if a fee is being charged to residents for the service, the cost of maintaining the service could be covered. Costs for educational materials and community wide events could be offset by local business sponsorships while encouraging the participation of additional community members.

Potential Discharge Identification & Risk Reduction

Potential illicit discharge identification and risk reduction techniques

Illicit discharges are those wastes and wastewaters from non-stormwater sources which MS4s cannot legally discharge down storm drains. Sources include:

- Sanitary wastewater illegally connected to the storm drain system
- Residential laundry washwaters
- Effluent from septic tanks
- Industrial wastewaters
- Auto and household toxics such as used motor oil
- Liquid fertilizers and pesticides
- Pet waste
- Drained pool water
- Spills from roadways
- Paint waste
- Anything that isn't rain down the storm drain is a potential illicit discharge.

The result of illicit discharges entering the storm drain is untreated discharges to receiving water, contributing high levels of pollutants including heavy metals, toxics, oil and grease, solvents, nutrients, viruses, and bacteria. Pollutant levels from these illicit discharges have been shown in EPA studies (see Additional Resources) to be high enough to significantly degrade receiving water quality and threaten aquatic, wildlife and human health. This fact sheet provides guidance on identification of potential illicit stormwater discharges and techniques to reduce the risk of illicit discharges.

Benefits / Pollution Reduction

Reduction of illicit discharges results in minimization of the discharge of pollutants down storm drains or water conduits and, ultimately to downstream lakes, streams and wetlands. Reducing discharge of pollutants improves water clarity, coloration and odor, as well as fish and wildlife habitat.

Program Development & Implementation

Programs designed to identify illicit discharges and reduce the risk of such discharges are dependant upon several factors including the MS4's available resources, size of staff, and degree and character of its illicit discharges. Ultimately, effective source control is dependent upon applying a mixture of education, incentives and regulation.

The Center for Watershed Protection identifies some strategies for education and incentives: passive education, active training, provision of direct MS4 services, subsidies and discounts, home/business-owner recognition programs, stewardship group formation. Regulations might include: adoption of a local ordinance, notifications/signs /hotlines, restrictions or bans, enforcement, utility pricing. An effective program applies some combination of the above strategies, many of which are discussed below. For greater detail, see the Additional Resources section.

Awareness Campaigns

Awareness campaigns inform public employees, businesses, property owners, and elected officials of the ways to detect and eliminate illicit discharges and the hazards associated with illegal discharges and improper disposal of waste. Illicit discharge education actions may include programs to promote, publicize and facilitate public reporting of illicit connections or discharges, distribution of outreach materials and storm drain stenciling. Suggested educational methods include:

Brochures

Develop informative brochures, guidance for specific audiences (i.e. carpet cleaning businesses that might dump their wastewater into a convenient manhole) and school curricula. Tips might include:

- Direct wash water onto your lawn to soak up soap when washing your car or truck
- Fertilize established lawns with phosphorous-free fertilizer and don't overspray fertilizer into the street
- Rake leaves and sweep grass clippings away from curbs. Clean curbs mean clean water.
- Dispose of all spent auto fluids properly; recycle where programs exist

Public watch campaign

Design a program to publicize and facilitate public reporting of illicit discharges. Establish a 24-hour call-in line for pollution complaints.

Volunteer storm drain inspections and stenciling

Coordinate volunteers for locating and visually inspecting outfalls or to stencil storm drains (see the Storm Drain Stenciling fact sheet).

Detect and Address Illicit Discharges

A program to detect and address illicit discharges is central to the ultimate elimination of illicit discharges. EPA recommends (see Additional Resources) that the program include the following four components:

Locate problem areas

Some methods that can be used to locate problem areas include: public complaints, visual screening, routine or targeted water sampling from manholes and outfalls during dry weather, and use of infrared and thermal photography. EPA recommends visually screening outfalls during dry weather and conducting field tests of selected pollutants (such as total solids, chlorine, nutrients, metals) as part of the procedures for locating priority areas. The Center for Watershed Protection and the University of Alabama recommend conducting an Outfall Reconnaissance Inventory (ORI) (see Additional Resources).

An ORI is a field screening technique that entails a stream walk to inventory and measure storm drain outfalls to identify continuous and intermittent discharges without in-depth laboratory analysis. The Center for Watershed Protection's Urban Subwatershed Restoration Manual No. 8 (see Additional Resources) identifies three additional field methods to identify individual pollution source areas: the Neighborhood Source Assessment (NSA), the Hotspot Site Investigation (HSI) and the Discharge Prevention Investigation (DPI).

Hotspot facilities produce higher levels of stormwater pollutants and/or present a higher potential risk for spills, leaks or illicit discharges. Common hotspot facilities are those that handle solid waste, wastewater, road and vehicle maintenance, and yard waste.

Find the source

Once a problem area or discharge is found, additional efforts should be made to determine the source of the problem. Some methods include dye-testing buildings in problem areas; dye or smoke testing buildings at the time of sale; tracing the discharge upstream in the storm sewer; employing a certification program that shows that buildings have been checked for illicit connections; implementing an inspection program of existing septic systems; and using video to inspect the storm sewers.

Remove/correct illicit connections

Once the source is identified, the offending discharger should be notified and directed to correct the problem. Education efforts and working with the discharger can be effective in resolving the problem before taking legal action (see Awareness Campaigns above).

Document actions taken

Documenting actions illustrates that progress is being made to eliminate illicit connections and discharges. Actions should be documented in the MS4 annual report and should include the following: number of outfalls screened, any complaints received and corrected, the number of discharges and quantities of flow eliminated, and the number of dye or smoke tests conducted.

Recycling Program

Initiate recycling programs for commonly dumped wastes, such as motor oil, antifreeze and pesticides. Provide sufficient public notification of any newly established programs or increase public awareness of existing programs. For more detailed information on ways to keep yard debris out of the street, see the Residential Waste Collection & Clean-up Programs fact sheet.

Maintenance Considerations

Recycling collection services may be provided in a recycling program (see Recycling Program above), but are not necessary if the public is properly notified of recycling drop-off locations and materials accepted. For maintenance associated with storm drain stenciling, see the Storm Drain Stenciling fact sheet.

Typical Cost

The cost of detecting and reducing the risk of illicit discharges will vary depending on the intensity of the effort and the approach(es) chosen. Costs attributable to detection and correction of illicit discharges are based on the total staff involvement driven by the problem area identification methods employed and the number and extent of discharge incidences. Public education program costs are determined by the type of materials produced and the method of distribution selected. Volunteer efforts can reduce program costs, as determined by staff hours required for program implementation and leadership of volunteers. An important consideration is that prevention of illicit discharges is much less costly than detection and subsequent correction.

Hazardous Material Storage & Handling

Proper storage and handling of hazardous materials

A hazardous material is any biological, chemical, or physical material with properties that make it dangerous or potentially harmful to human health or the environment. Hazardous materials can be released to the environment in a variety of ways.

When hazardous material comes into contact with rain or snow, the pollutants are washed into the storm sewer system and, ultimately, to surface water bodies and/or ground water. Hazardous materials have negative impacts on fish habitat, ground water drinking water sources, and recreational uses of Minnesota's lakes and streams.

A spill of only one gallon of oil can contaminate one million gallons of water. Hazardous materials associated with MS4s and their operations include, but are not limited to, oil, gasoline, antifreeze, fertilizers, pesticides, and de-icing agents and additives. This fact sheet provides guidance on storage and handling of hazardous materials.

Benefits / Pollution Reduction

Minimizing or eliminating contact of hazardous materials with stormwater can significantly reduce pollution of downstream waters. Proper hazardous material handling and storage also contributes to employee health, an organized work place, and efficient operation.

Program Development & Implementation

Potential Hotspots

Hotspot facilities are facilities that produce higher levels of stormwater pollutants and/or present a higher potential risk for spills, leaks or illicit discharges. Hazardous material storage and handling is of particular concern in these areas. Common MS4 owned or managed hotspot facilities are those that handle solid waste, wastewater, road and vehicle maintenance, and yard waste, such as:

- Composting facilities
- Equipment storage and maintenance yards
- Hazardous waste disposal facilities
- Hazardous waste handling and transfer facilities
- Incinerators
- Landfills
- Materials storage yards
- Public buildings (e.g. schools, libraries, police and fire departments)
- Public golf courses
- Public swimming pools
- Public works yards
- Solid waste handling and transfer facilities
- Vehicle storage and maintenance yards
- Water and wastewater treatment facilities

Hazardous Material Handling, Loading, and Unloading Pollution Prevention Practices

- Avoid loading/unloading materials in the rain and/or provide cover for the activity
- Retrace areas where materials have been transferred to identify spills and immediately clean them up
- Time delivery and handling of materials during favorable weather conditions whenever possible (e.g. avoid receiving loads of sand during windy weather)
- Inspect containers for material compatibility and structural integrity prior to loading/unloading any raw or waste materials
- Use dry cleanup methods (e.g. squeegee and dust pan, sweeping, and absorbents as a last step) in case of spillage rather than hosing down surfaces
- If your MS4 operates loading docks, provide cover and provide grading or berming to prevent run-on of stormwater

Material Storage Pollution Prevention Practices

- Confine material storage indoors to the greatest extent feasible, and plug or disconnect floor drains that lead to the stormwater system

- Confine outdoor material storage to designated areas that are covered, away from high traffic areas, outside of drainage pathways, and on impervious surfaces
- Store containers on pallets or equivalent structures to facilitate leak inspection and to prevent contact with wet floors that can cause corrosion. This technique also reduces incidences of container damage by insects, rodents, and etc.
- Store materials and waste in materially compatible containment units
- Keep hazardous materials in their original container
- If not in their original container (e.g. used motor oil), clearly label all storage containers with the name of the chemical, expiration date and handling instructions
- Maintain an inventory of all raw and waste materials to identify leakage and order new materials only when needed
- Provide secondary containment for storage tanks and drums with sufficient volume to store 110 percent of the volume of the material
- Provide sufficient aisle space to allow for routine inspections and access for spill cleanup
- Inspect storage areas for spills or leaks and containment units for corrosion or other failures

Vehicle and Equipment Maintenance Pollution Prevention Practices

- Implement good housekeeping including emptying and cleaning drip pans and containers rather than leaving them full and open around the shop
- Dispose of greasy rags, oil filters, air filters, batteries, spent coolant, and degreasers following MPCA or county hazardous waste guidelines
- Use drip pans, drain boards, and drying racks to direct drips back to a fluid holding tank for reuse or proper disposal
- Avoid hosing down areas that would result in polluted runoff discharging to a stormwater system
- Do not pour liquid waste into sinks, floor drains, outdoor storm drain inlets or other storm drains or sewer connections
- Clean equipment and vehicles regularly to remove accumulated dust and residue
- Perform all cleaning operations indoors or under cover when possible
- If washing vehicles outdoors see the Vehicle Washing fact sheet for more information.

Vehicle and Equipment Fueling Pollution Prevention Practices

- Fuel vehicles only in designated areas that are covered
- Avoid topping off fuel tanks to prevent spills from overfilling
- Prevent run-on of stormwater into fueling areas using diversion dikes, berms, curbing, surface grading or other measures or use catch basin inserts to prevent discharge into storm drains
- Provide barriers around fuel pumps to prevent collisions with vehicles
- Use fueling hoses with check valves to prevent hose drainage after filling

Waste Treatment, Disposal, and Cleanup Pollution Prevention Practices

- Adopt a regular schedule for the pick up and disposal of waste materials
- Recycle leftover materials whenever possible
- Substitute nonhazardous or less hazardous materials for hazardous materials wherever possible

Specific Materials Control

Other fact sheets developed for this guidance document provide hazardous material storage and handling procedures for specific materials.

Winter road salt and de-icing additives - see Winter Road Materials Management fact sheet

Equipment and vehicle wash water – see Vehicle Washing factsheet

Fertilizers and pesticides - See Park & Open Space Fertilizer/Chemical Application Programs factsheet

Spill Prevention, Control and Countermeasure (SPCC) Plan

Spill prevention plans are created for prevention as opposed to after-the-fact reactive measures. Specifically, SPCC Plans are required by the EPA for oil spill prevention at facilities that meet the following three criteria: non-transportation-related, having an aggregate aboveground storage capacity greater than 1,320 gallons or a complete buried storage capacity greater than 42,000 gallons, and have a reasonable expectation of a discharge into or upon navigable waters of the United States. Remember that a spill of only one gallon of oil can contaminate a million gallons of water. Even if an SPCC is not required at your facility, spill prevention plans for any and all hazardous materials can be an effective preventive measure and training tool (see Employee Training below), and SPCC Plans provide a good framework for any type of spill prevention plan. For details on what to include in spill prevention plans see the EPA and MPCA guidance documents in the Additional Resources.

Employee Training

Municipalities and other regulated MS4s can greatly reduce potential water quality impacts by creating chemical application programs and training all full time and seasonal employees that are responsible for handling hazardous wastes. Consider registering city staff into existing training programs or providing in-house training. In-house training could include the development of guidance documents for trainees to keep with them on the job site.

Maintenance Considerations

Maintenance of loading/unloading areas, storage areas and containers, and equipment, as described above, is inherent for proper storage and handling of hazardous materials.

Typical Cost

Pollution prevention measures are not inherently costly and are more a matter of culture. However, providing cover over hazardous materials stored outdoors can be equivalent to the cost of a pole building ($5 to $12 per square foot) and a concrete slab ($3 to $6 per square foot). If waste reduction measures are taken, an accurate inventory is maintained, and regular waste disposal is implemented, MS4s can minimize the amount of materials stored onsite, decreasing costs.

Reducing Pet Waste

Pet waste management activities

Pet waste left uncollected is unsanitary and disagreeable for users. It contains pathogenic bacteria and other parasites. When pet waste is washed into our lakes and rivers it decays in the water, depleting oxygen levels and releasing ammonia, which can be harmful to fish and other aquatic organisms. Pet waste also contains nutrients that foster weed and algae growth. Elevated bacteria levels in lakes and rivers caused by Escherichia coli (E. coli) can cause unsafe conditions for swimming and recreational activities. This fact sheet provides guidance on developing a community pet waste management program.

Benefits / Pollution Reduction

Pet waste management results in cleaner parks and neighborhoods, with improved aesthetics and lowered potential for diseases to spread. Reducing the amount of uncollected pet waste reduces a significant cause of stormwater pollution.

Program Development & Implementation

Programs designed to combat poor management of pet waste fall into three broad categories. Municipalities often create programs that overlap these categories for optimal results.

Awareness Campaigns (Pet Owner-based)

Programs are designed to overcome educational barriers. Owners are educated about the health risks and natural resource impacts associated with not cleaning up their animal's waste and are informed of their responsibility for finding suitable methods to pick up after their pet. The City of Minneapolis has implemented the "Canines for Clean Water" awareness campaign. Throughout the summer, the city sponsors dog oriented activities and education about keeping their waterways clean.

Brochures/fact sheets

Informational sheets are mass-mailed to educate residents of the health risks, natural resource impacts and applicable ordinances/fines. The brochure should also outline the proper handling and disposal of pet waste. Brochures could be provided at public kiosks or city offices, attached to park signage (see below) as well as displayed at pet supply outlets and veterinarian offices.

Image Courtesy of Emmons & Olivier Resources, Inc.

Park signage

Located at park entrances to alert residents of the proper disposal techniques and/or park design features for pet droppings.

Pet Waste Control Ordinances (Management-based)

A municipality may introduce a law that requires pet owners to pick up after their pets or risk receiving a fine.

Park Design Features (Management-based)

Collection systems

The simplest addition to a dog-friendly park are pet waste collection systems, which hold plastic bags for owners to use to pick up waste, and which have garbage cans placed in close proximity to bag dispensers and park exits. Bag dispensers should also include educational signage.

Doggy loos

Pet feces disposal units are placed in the ground, which operate by foot-activated lids. Decomposition is quick, and messy cleanup is avoided.

Pooch patch

Upon entrance into the park, the dog is introduced to a telegraph pole, surrounded by a scattering of sand. Dogs are encouraged to defecate on the patch, and bins are close by for owners to dispose of their dog's waste.

Long-grass principle

Parks can have areas where grass is not mowed where pet owners can take their dogs to defecate. A height of around 4 inches is necessary for the feces to disintegrate naturally without stormwater runoff. Long grass areas, however, should not be placed in close proximity to overland flow paths, stream channels, lakes, drinking water wells, and stormwater drainage inlets.

Maintenance Considerations

Collection Systems: Regular refuse collection and resupply of pickup bags. Doggy Loos: These disposal units are installed in the ground and decomposition occurs within the unit. Minimal maintenance is required (occasionally add water and non-toxic digester powder for continuous break down of waste).

Typical Cost

The cost of reducing pet waste varies on the intensity of the program and control activities implemented. The most popular control method is via ordinance, but municipalities must consider the cost of enforcement, including staff and equipment requirements. Awareness campaign costs are determined by the quality of materials produced and the frequency and method of distribution. Park signage may have higher initial capital costs, but can last for many years. Signs may also be more effective, since they act as on-site reminders to dog owners to clean up in parks. Collection systems can cost anywhere between $60 and $400. The pickup bags purchased in bulk cost 5¢–15¢ each.

Septic System Maintenance Programs

Development of an effective management program for decentralized wastewater treatment systems

Septic systems, also known as onsite/decentralized wastewater treatment systems and subsurface sewage treatment systems (SSTS), treat sewage from homes and businesses that are not connected to a centralized wastewater treatment plant. Septic systems can vary in size and the number of dwellings served and include individual and cluster SSTS. Septic systems can be of conventional design (heavily relying on the soil for treatment along with dispersal) or use pre-soil treatment technologies like constructed wetlands, media filters, or aerobic treatment tanks followed by dispersal (with limited final treatment) in the soil. Soil treatment and dispersal options include in-ground trenches or beds or above ground at-grade or mound systems. The type of soil dispersal system is chosen based on the treatment abilities of the native soil in combination with the effectiveness of any pre-soil treatment that may be employed. SSTS can be protective of public health and water quality if properly planned, sited, designed, constructed, installed, operated, and maintained.

This fact sheet summarizes a step-by-step approach to developing a community management program for SSTS. It also provides an overview of the five management models outlined in EPA's Voluntary National Guidelines for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems. While this factsheet, based on EPA guidance, provides direction to MS4's, Minnesota Statutes 115.55 and 115.56, which regulate SSTS, must also be consulted in the development of a comprehensive management program.

Benefits / Pollution Reduction

Although some management programs are effective, many existing rules that regulate septic systems are not adequate to ensure proper operation and maintenance. Failure of septic systems is a term subject to much debate. Based on local units of government estimates, approximately 10 percent of all systems back up into homes or have wastewater emerging on the ground surface, and approximately 25% of the systems in Minnesota fail to protect groundwater.

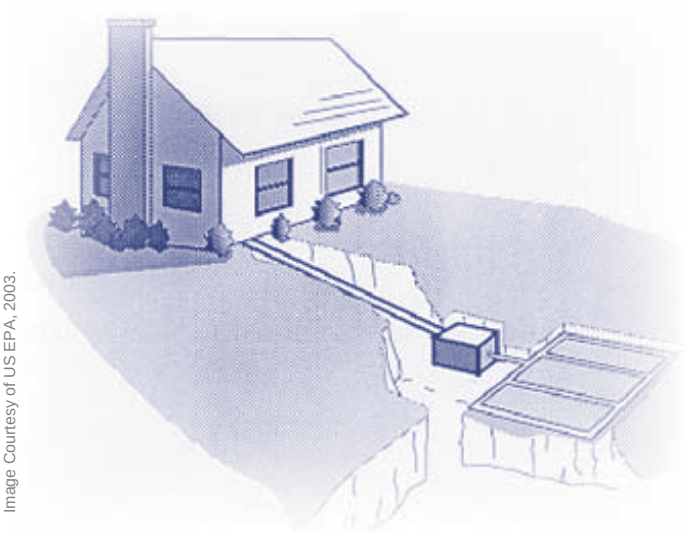


Image Courtesy of US EPA, 2003.

Systems may not receive proper maintenance because owners are either unaware of the need for maintenance, or believe it to be unnecessary or too costly. Improper operation and maintenance will result in premature clogging of the soil's infiltrative surface which may result in system back-up or seepage on the ground surface. Generally improper maintenance does not result in groundwater contamination; improper operation of SSTS (such as the discharge of hazardous waste or other non-treatable wastes into the system) will result in groundwater contamination. The MPCA's Detailed Assessment of Phosphorus Sources to Minnesota Watersheds has identified a method to quantify the phosphorus discharging from nonconforming or failing septic systems (MPCA, 2004) and could be used by an MS4 to estimate the phosphorus loads coming from local systems.

The study states that throughout Minnesota, failing septic systems have relatively direct connections to surface waters resulting in the increased potential that phosphorus from the systems will contribute to water quality problems and create an imminent threat to public health and safety and the environment. Ultimately, it is the absence of a fully implemented, comprehensive management program addressing each of these issues that limits the reliability and effectiveness of such systems. The potential for health and water quality problems from poorly managed systems is increased.

Benefits of a management program are accrued by both the municipality and the property owners. They include the following:

Protection of Public Health and Local Water Resources

Although currently not quantified, SSTS failures resulting in yard backups have been recognized as a public health hazard and water quality issue for many years. Improved management practices will minimize the occurrence of failures by ensuring that pollutants are adequately managed and treated.

Ground Water Conservation and Water Quality

A properly functioning SSTS contributes to ground water recharge and protect the quality of ground water and nearby water resources. Due to the number of failing septic systems still in operation, conversion to regional sanitary services can often result in improved water quality within nearby water resources.

Preservation of Tax Base

A series of well-managed SSTS can prevent small communities from needing to finance the high cost of centralized sewers. If small communities exhaust their tax base, at the expense of other public safety and education programs, to pay for sewers, they may then need to encourage growth in an effort to pay for the systems.

Life-cycle Cost Savings

There is indication that in many cases management may pay for itself in terms of lower failure rates and alleviation of the need for premature system replacement. This payoff will depend on the types of systems employed and the management program chosen.

Program Development & Implementation

EPA's Handbook for Managing Onsite and Clustered (Decentralized) Wastewater Treatment Systems describes a step-by-step approach to developing a community management program for decentralized wastewater systems. The handbook is intended to improve the performance of individual and clustered treatment systems through better planning, design, siting, installation, operation, maintenance and other activities. It includes specific community examples, gives an overview of the elements essential for sound management of these systems, and provides links to extensive resources (articles, publications, web sites, databases, software, and government programs) for more thorough investigation of particular topics or elements of management. The handbook also includes the necessary steps for developing or enhancing a decentralized wastewater management program.

Management Models

EPA's Voluntary National Guidelines for Management of Onsite/Decentralized Wastewater Systems (Guidelines) are a set of practices recommended to raise the level of performance of onsite/decentralized wastewater systems through improved management programs. Five separate model programs are presented as a progressive series. Management requirements of wastewater systems become more rigorous as the system technologies become more complex or as the sensitivity of the environment increases. Each model program shares the common goal of protecting human health and the environment. Each model approach includes program elements and activities needed to achieve the management objectives. The Guidelines address the sensitivity of the environment in the community and the complexity of the system used. An overview of the management models are summarized below:

<u>Management Model 1 Homeowner Awareness</u>

Individual property owners in areas of low environmental sensitivity must be aware of their treatment systems and understand proper maintenance schedules. This program is adequate where treatment technologies are limited to conventional systems that require little owner attention. To help ensure that timely maintenance is performed the regulatory authority mails maintenance reminders to owners at appropriate intervals. This model is a starting point for enhancing management programs because it provides communities with a good database of systems and their application for determining whether increased management practices are necessary. In Minnesota all owners of new systems receive a specific and detailed management plan for their system. These management plans are developed by the system designer.

<u>Management Model 2 Maintenance Contracts</u>

This model focuses on the need for maintenance contracts for systems with complex designs and systems employed to enhance the capacity of conventional systems to accept and treat wastewater. Contracts with qualified technicians can be used to ensure proper and timely maintenance of all types of systems, but most commonly are used for large complex systems.

<u>Management Model 3 Operating Permits</u>

Sustained performance of treatment systems is critical to protect public health and water quality. Limited-term operating permits are issued to the owner and are renewable for another term if the owner demonstrates that the system is in compliance with the terms and conditions of the permit. Performance-based designs may be

incorporated into programs with management controls at this level. In Minnesota, management model 3 is used for all new systems that incorporate pre-soil treatment devices.

Management Model 4 Responsible Management Entity (RME) Operations and Maintenance
Under this model, the operating permit is issued to an RME instead of the property owner to provide the needed assurance that the appropriate maintenance is performed. The property owner is responsible for system operations.

Management Model 5 RME Ownership
In contrast to model 4, under this model, treatment systems are not only operated and maintained by the RME, but also owned by the RME, which removes the property owner from responsibility for the system. This program is comparable to central sewerage and provides the greatest assurance of system performance in the most sensitive of environments. Some sanitary districts in Minnesota are operating SSTS under this management level.

Maintenance Considerations

Initial adoption of a management program requires an investment in training for the plan developer (or fee for a consultant). MS4's must also consider the enforcement, including staff training and equipment maintenance requirements. In addition, periodic review and update of the management program would be required.

Typical Cost

MS4s must recognize the likelihood that both the regulatory authority and the property owner will face increased costs in improving management practices and programs. The cost impacts may increase as the level of management increases; however, trade-offs exist. Costs incurred by the regulatory authority and/or management entity may be offset by increased permit fees and more efficient data management tools, while the costs to the property owner may be offset by reduced repair and replacement costs, avoidance of environmental restoration costs, and increased property values and quality of life.

Open Space Design

Open space design and ordinance development

Open space design is a form of residential development that concentrates development in a compact area of the site to allow for greater conservation of natural areas. This form of development may also be called cluster design, conservation design, or low impact development (LID). Many of the typical management practices associated with open space design and LID including Reducing Impervious Surfaces, Pervious Pavements, Green Roofs, Rainwater Harvesting, Urban Forestry, Vegetated Swales and Buffers, and Establishing an Infiltration Standard are presented within this guidance document. This fact sheet presents guidance on the development of an ordinance to encourage the use of open space design and LID.

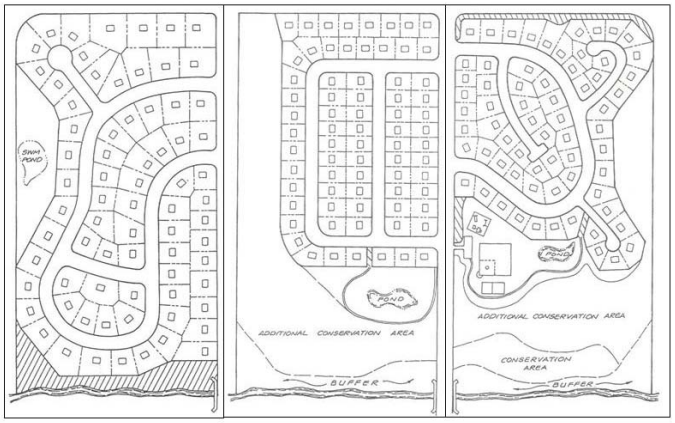


Image Courtesy of Schueler, 1995

Conventional subdivision (left) with 72 lots, an alternative layout (center) using open space design with the same number of lots, and another alternative layout (right) using open space design with 66 lots.

Benefits / Pollution Reduction

Research has shown that open space designs can more effectively reduce a site's overall impervious cover compared to conventional subdivisions, and command higher prices and more rapid sales because of the attraction of open space and preserved natural features (Zielinski, 2001). Other benefits include lower costs for grading, erosion control, stormwater and site infrastructure, as well as greater land conservation, without the loss of developable lots.

Increased open space and less runoff directly translates into lower pollutant loads to downstream waters, protecting lakes, streams and wetlands. This is especially true when the preserved open space is tied into a well designed overall site runoff management plan. Open space design can revitalize city centers, increase the quality of life of its citizens and attract tax-paying businesses and residents to the area.

Program Development & Implementation

Open Space Design Techniques

Open space design is a form of development that allows for greater conservation of natural areas. Approaches include relaxed minimum lot sizes, setbacks and frontage distances in order to maintain the same number of dwelling units at the site while creating more open space.

A mixed-use approach that integrates usable grassed park space with a trail system among restored native ecosystems and preserved drainageways and wetlands can be a very effective approach. Shared driveways and utilities is one example of impervious surface reduction that can facilitate the preservation of open space.

The residential development Fields of St. Croix, in Lake Elmo, MN, was completed in 2004 and is an example of open space design. The development includes 113 single family homes and 12 attached single family homes with lot sizes ranging from 0.35- to 1-acre. The 241-acre site leaves 144 acres (60 percent) as open space. The development maximized open space using cluster development techniques. Street widths are sized appropriate to their function ranging from 14-foot one-way lanes to 24-foot two-way lanes. More than 90 acres of farmland are preserved and functions as a community-supported agricultural farm with paying members. Additional open space consists of prairie and oak savanna and a pond and associated preserved shoreland. The site also uses a constructed wetland wastewater treatment system for the entire development.

For additional design techniques that identify ways to preserve more open space (e.g. smaller parking lots, slimmer sidewalks and streets), see the Reducing Impervious Surfaces fact sheet.


Image Courtesy of Emmons & Olivier Resources, Inc.

Field's of St. Croix Conservation Development, Lake Elmo, MN.

Open space design and LID practices are not limited to new construction. Most of the techniques can be done on existing developed land. For example, the cities of Maplewood and Burnsville both successfully incorporated a rain garden network into existing neighborhoods to capture street runoff, reducing the amount of runoff generated locally. In the case of Maplewood, this approach was chosen over more traditional curb and gutter installation. The LID approach can also be employed to comply with local regulations governing the volume, rate, and quality of runoff. See the Retrofitting: Infiltration, Filtration & Bioretention fact sheet for more information.

Open Space Development Rules and Ordinances

Development rules can be in conflict with alternate design standards that maximize the amount of open space associated with a development. Development rules can refer to subdivision codes, zoning regulations, parking and street standards and other local ordinances that regulate development. These rules will likely require review and adjustment to allow for open space design. Municipal fire, police and public works operations (ex. snow plowing) must be an integral part of the rule/ordinance planning so that their perspective is incorporated into any changes being considered. Material provided in the Additional Resources can help to address some of the concerns (fire truck access, snow storage) often raised by these departments.

The open space ordinance in the City of Inver Grove Heights' Northwest Area requires 20 percent of upland buildable area (excluding area dedicated to stormwater treatment, protected wetlands, and other non-buildable space) to be maintained as undisturbed, natural area. In addition, the code allows an increased mixture of housing types for each zoning district in order to promote and enable cluster development to facilitate open space design.

Most local codes contain front yard setback requirements that dictate driveway length. In many communities, front yard setbacks for certain residential zoning categories may extend 50 or 100 feet or even longer, which increases driveway length well beyond what is needed for adequate parking and access to the garage. Shorter setbacks reduce the length and impervious cover for individual driveways. The Northwest Area of Inver Grove Heights, MN, allows a 20 foot setback.

The City of Lake Elmo city code introduces an option for additional units in its large lot residential zoning district. Additional units are allowed if total preserved open space represents at least 50 percent of the total buildable land area. Qualified preserved open space includes agricultural lands, natural habitat, pedestrian corridors, or neighborhood or community recreational areas. All preserved open space must be subject to a conservation easement.

Open Space Development in High Density Neighborhoods

One of the arguments against open space development is that it can only occur as part of high end, low density neighborhoods. Although new development with low density does offer the luxury of more options, it is not essential for open space development. EPA's 2006 report entitled Protecting Water Resources with Higher-Density Development (see Additional Resources) shows that high density development can actually lower per unit runoff because of such practices as shared infrastructure and multiple units under a single roof.

The City of Farmington, MN, incorporated open space stormwater drainage design into a unique development with moderate densities. The development incorporates a prairie waterway in which open drainage ways were preserved in roadway medians, which route runoff to an adjacent stream while filtering it and allowing it to soak into the soil.

Maintenance Considerations

Compared with natural open space, if lawn is preferred for open space, more maintenance is typically needed. Alternatively, open space can be easily maintained if planted with native grasses, forbs, shrubs and/or trees. If the latter approach is taken, the first two to three years will require weed control, but maintenance requirements will decrease with time.

Once a LID best management practice is designed and installed properly, maintenance becomes essential to ensure that designed stormwater management performance and other benefits continue over the full life cycle of the installation. Maintenance and determining the

responsible party(ies) for maintenance can be a stumbling block for LID. Responsible parties for maintenance should be mutually agreed upon by the homeowner and the MS4 early in the design process. The Minnesota Stormwater Manual contains advisory information on maintenance, as well as checklists (see Appendix D Operation and Maintenance Checklists). Some of the maintenance agreements and activities associated with LID practices are similar to those performed for conventional landscapes and stormwater systems; however, the scale, location, and the nature of an LID approach will require new maintenance strategies. Studies have shown that maintenance costs associated with LID are similar to traditional landscapes (Lakeville LID Study, 2006).

Typical Cost

Open space development, having lower built acreage and imperviousness than conventional development, results in lower costs for grading, erosion control, stormwater and site infrastructure (Mohamed, 2006). Research has shown that on average, lots in subdivisions applying open space design (conservation subdivisions) carry a premium, are less expensive to build, and sell more rapidly than lots in conventional subdivisions (Mohamed, 2006; Zielinski 2001). Mohamed (2006) quantified the average savings at $7,400 per lot based on the results of 169 subdivisions.

A cost/benefit analysis was done in 2006 in the City of Lakeville, MN, on three alterative site designs: low impact development (LID), a conventionally designed development, and the actual built development which contained some LID components. Though the LID design was most profitable because of lower costs for stormwater infrastructure and thirty-year maintenance, the difference in profitability was not statistically significant. Therefore, both installation and long term maintenance costs can be said to be equal between the three designs.

The Green Values® Stormwater Calculator (see Additional Resources) is a cost calculator that can help MS4s conduct cost/benefit analyses to optimize implementation of some of the open space design techniques discussed above.

Reducing Impervious Surfaces

Reducing stormwater runoff through the use of alternative design standards and ordinance development

Impervious areas such as road and parking pavement, building surfaces, and walkways/driveways significantly increase stormwater runoff volumes, which in turn causes flooding and streambank erosion. Impervious surfaces also facilitate the wash-off and transport of pollutants like oil, grease and sediment into downstream rivers, lakes and wetlands. This fact sheet identifies methods and design standards used to achieve a reduction in the total runoff volume from impervious surfaces and gives examples of municipal ordinances that foster the reduction of impervious surfaces.

Benefits / Pollution Reduction

Reduced imperviousness results in smaller stormwater discharges which enhances flood control, reduces erosion and increases infiltration. Any reduction in runoff volume translates into reduced pollutant loads to downstream waters. Reduced runoff can also reduce the size and cost of stormwater management systems. Increased greenspace can facilitate recreational and community activities that enhance the quality of life of residents/employees.

Program Development & Implementation

Managing the extent of impervious area of buildings, roads and parking pavements occurs through the site planning and design process. Example methods to reduce imperviousness include but are not limited to, narrower road sections, alternative road layouts, reduced application of sidewalks and on-street parking, cul-de-sac design, parking lot design, house setbacks, structure/building impervious area limits and driveway designs. These methods are a component of design methodologies such as low impact development, design with nature, sustainable development and conservation design, and could become a part of standard building codes.

Design for Reducing Imperviousness

This strategy relies on several techniques to reduce the total area of rooftops, parking lots, streets, sidewalks and other types of impervious cover created at a development site. The basic approach is to reduce each type of impervious cover by downsizing the required minimum geometry specified in current local codes, keeping in mind that there are minimum requirements that must be met for fire, snowplow and school bus operation.

Image Courtesy of Emmons & Olivier Resources, Inc.

Trees and vegetation in the landscape of a cul-de-sac.

Impervious area can also be effectively removed by routing runoff flow to an area that will absorb the water, such as a yard, swale or bioretention area. Below are several techniques that can be used to reduce imperviousness. The City of Inver Grove Heights, MN, has implemented several of these techniques in its ordinance for the Northwest Area.

Narrower streets

Many communities require residential streets that are much wider than needed to support travel lanes, on-street parking, and emergency access. Some communities currently require residential streets as wide as 32 to 40 feet, which provide two parking lanes and two moving lanes.

Local experience has shown that residential streets can have pavement widths as narrow as 22 to 26 feet, and still accommodate all access and parking needs (ITE, 1997). Even narrower access streets or shared driveways can be used when only a handful of homes are served. The City of Inver Grove Heights Northwest Area requires a 28 foot paved local public street in addition to a sidewalk or trail on one side of the street. Local private streets have a 24-foot width requirement. Narrower streets help reduce traffic speeds in residential neighborhoods which, in turn, improve pedestrian safety.

Local public works, police and fire departments might object to narrower streets. Referring to the documents in the Additional Resources section can help identify how to address some of their concerns.

Slimmer sidewalks

Many communities require sidewalks that are excessively wide or are located adjacent to the street where the pedestrians are at risk from vehicles. A better site design technique modifies the width and location of sidewalks to promote safer pedestrian mobility. Impervious cover is reduced when sidewalks are reduced in width and located away from the street. Sidewalks can also be disconnected so they drain to lawns or landscaping instead of the gutter and storm drain system, or they can be constructed with permeable concrete, asphalt or blocks.

Sidewalk that drains to adjacent vegetation and provides common walkways linking pedestrian areas.

Smaller cul-de-sacs

Impervious cover can be reduced by minimizing the diameter of residential street cul-de-sacs and/or incorporating landscaped islands. Many communities require cul-de-sacs that have a greater diameter than needed to allow emergency and large vehicles to adequately turn around. Alternatives to the traditional 80 foot diameter cul-de-sac include 60 foot diameter cul-de-sacs, hammerhead turnarounds and loop roads. The Northwest Area zoning ordinance requires an outside roadway radius of 35 feet and a street property line (right-of-way) of 50 feet.

In addition, the inside of the turnaround can be landscaped as a bioretention area to further reduce impervious cover and improve stormwater treatment. Trees and vegetation planted in landscaped islands can be used to intercept rain water and treat stormwater runoff from surrounding pavement. Each of these alternative turnaround options produces a more attractive and safe environment for residents.

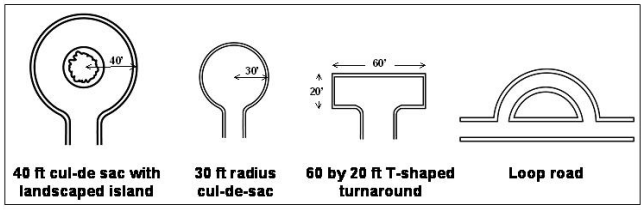


Image Adapted from Center for Watershed Protection. 1997.

Turnaround options for residential streets.

Smaller parking lots

In many communities, parking lots are over-sized and under-designed. Local parking and landscaping codes can be modified to allow the following techniques to be applied within parking lots:

- Minimize standard stall dimensions for regular spaces
- Provide compact car spaces
- Use pervious pavement (asphalt, concrete, pavers, sand amendments, vegetation) particularly for light-use or overflow parking
- Incorporate efficient, narrow parking lanes
- Reduce minimum parking demand ratios for certain land uses
- Treat the parking demand ratio as a maximum limit
- Create hydraulically designed stormwater "islands" or landscaping areas to treat runoff using bioretention, filter strips or other practices
- Encourage shared parking arrangements with adjacent land uses
- Enable owners/developers to provide proof of parking for required number of parking spaces while constructing only those that the owner/developer demonstrates are necessary

The Inver Grove Heights Northwest Area ordinance encourages joint parking arrangements and requires multi-family and mixed-use development to provide 50 percent of total parking underground, under the principal structure or as tuck-under parking. In addition, the ordinance includes incentives for pervious parking if more than the minimum parking requirement is desired.

Parking lot landscaping makes the lot more attractive to customers, and promotes safety for both vehicles and pedestrians. In addition, trees and other landscaping help screen adjacent land uses, shade people and cars, reduce summertime temperatures, improve air quality and bird habitat, reduce runoff volume and improve water quality.

Shorter Driveways

Most local codes contain front yard setback requirements that dictate driveway length. In many communities, front yard setbacks for certain residential zoning categories may extend 50 or 100 feet or even longer, which increases driveway length well beyond what is needed for adequate parking and access to the garage. Shorter setbacks reduce the length and impervious cover for individual driveways. The Northwest Area of Inver Grove Heights, MN, allows a 20 foot setback. In addition, driveway widths can be reduced and more permeable driveway surfaces can be allowed such as porous pavers, porous asphalt or porous concrete. Another way to reduce impervious cover is to allow shared driveways that provide street access for more than a single home. The Northwest Area zoning ordinance allows and encourages shared driveways.

Reduced Imperviousness Development Rules

Development rules are frequently in conflict with alternate design standards that limit the amount of impervious surface associated with a development. Development rules can refer to subdivision codes, zoning regulations, parking and street standards and other local ordinances that regulate development. Section 515.80 Subd. 39 of the City of Inver Grove Heights City Code is a good example of an ordinance facilitating reduced imperviousness (see Additional Resources).

The Center for Watershed Protection (see Additional Resources) recommends the following four step process to adapt local development rules to more closely conform to reduced imperviousness principles and related conservation design principles.

Step 1

Identify the development rules in your MS4. Locate all MS4 rules that have a potential impact on the way land is developed. Consider zoning ordinances, subdivision codes, street standards, covenants, fire codes and standards, parking requirements, building regulations/standards, stormwater management ordinances, buffer or floodplain regulations and environmental regulations.

Step 2

See how the rules stack up to the development principles of interest. Rate development rules on a scale of 1 to 10 (or similar) for how favorably they compare with the reduced imperviousness techniques giving a higher score for more favorable comparisons. If out of the maximum points possible, 80 percent or less are received, consider a systematic reform of imperviousness development rules.

Step 3

Consider which development rules might be changed. Given the difficulty and effort in changing development rules, prioritize proposed changes. Consider all the factors that contribute to established development rules. A low rate from Step 2 does not necessarily imply the rule should be or can be changed. In prioritizing, consider how changes will impact development costs, liability, property values, public safety and any other elements.

Step 4

Start a local roundtable process. Utilize a consensus process such as a local site planning roundtable to proceed with the desired development rule changes. The process allows for systematic review of existing rules and determination of whether or not changes can or should be made. Ultimately, the roundtable will come to agreement on the changes to be made to codes, engineering standards, guidelines, regulations and ordinances. Include key players in the roundtable, especially those agencies or personnel with authority for development review. Consider planning agencies/commissions, public works department, road/highway department, developers, fire officials, health department, land use lawyers, real estate brokers, chamber of commerce, elected officials, residents/land owners, stormwater management authority and any other potential stakeholders. In addition, consider utilizing an outside facilitator to guide and structure the roundtable process.

Maintenance Considerations

Narrower roads, sidewalks and cul-de-sacs, smaller parking lots and shorter driveways reduce maintenance needs, but the nature of the maintenance requirements is no different than that for existing features. Among others, these will include repair of failed structure or surface, periodic sweeping to remove accumulated debris, cleanout of sump manholes, and inspection of drainage paths to make sure structures are operable. There are a variety of pervious pavements with respective maintenance needs that compare to those of impervious pavements but may require annual vacuum cleaning. Pervious pavements can reduce winter maintenance needs including less salting, plowing and sanding due to the textured and porous nature of the pavement.

Typical Cost

Reducing imperviousness surfaces reduce maintenance and construction costs. In addition, reduced imperviousness reduces the size and cost of both the stormwater conveyance system and stormwater management practices. Additional resources may be required at the planning stages until familiarity with the design concepts and standards are established. The adoption of new ordinances requires an investment in training for the plan reviewer, the consultant, and possibly the public. MS4s must also consider the cost of enforcement, including staff and equipment requirements.

Pervious Pavements

Using pervious pavements in roadway and parking lot construction

When rainfall hits impervious pavements such as conventional concrete and asphalt, the water runs off, collecting pollutants along the way and ends up in stormdrains and waterways. Pervious pavements allow water to pass through the surface and infiltrate into the soil below rather than running off impervious surfaces and into surface water.

Pervious pavements include pervious asphalt, pervious concrete, pervious interlocking concrete pavers, plastic grid systems and amended soils. These pavements have the dual benefit of serving as a parking or drive surface and a stormwater management BMP. This fact sheet provides an overview of the benefits associated with pervious pavements. In addition, examples of municipal ordinances and programs that incorporate pervious pavement into development and roadway reconstruction projects are provided.

Image Courtesy of the Chicago Green Alley Handbook. CDOT.

Left: Alley with impervious pavement and poor drainage. Right: Alley with pervious pavement resulting in no standing water.

Benefits / Pollution Reduction

Whether soil conditions favor infiltration or filtration, peak runoff rates are reduced and water quality treatment is afforded by using pervious pavements. Runoff volumes are reduced and ground water is recharged where underlying soils are suitable for infiltration. Numerous analyses of discharge from pervious pavement under-drains show that concentrations of suspended solids, total solids, phosphorus and nitrogen were lower than typical discharges from impervious surfaces, and that concentrations of copper, zinc and lead were also reduced. Two long-term monitoring studies conducted in Rockville, MD, and Prince William, VA indicate removal efficiencies of 82 to 95 percent for sediment, 65 percent for total phosphorus, and 80 to 85 percent of total nitrogen (EPA, 1999). Removal efficiency is a function of introduced load/concentration, depth of filtration and materials used to filter.

When installed over a drainage storage bed, pervious pavements allow runoff to be stored and infiltrated into the surrounding soils or filtered, and collected by an under-drain system that discharges to the storm sewer system or directly to receiving waters. Pervious paving can reduce the size of engineered stormwater treatment facilities by reducing the amount of runoff needing treatment. Currently, the General Construction Permit will allow site designers to reduce the water quality volume sizing required when using pervious pavement, up to a maximum of ½ acre of new impervious surface.

During the winter months, water does not accumulate on the surface of pervious pavements unlike traditional impervious pavements preventing ice build-up. This decreases the need for using deicing agents such as sand and salt saving a municipality time and money. In addition, there is a decreased chance of a public safety hazard in pedestrian areas.

Program Development & Implementation

Types of Pervious Pavements

Pervious asphalt

Pervious asphalt consists of fine and course aggregate stone bound by a bituminous-based binder. The amount of fine aggregate is reduced to allow for a larger void space of typically 15 to 20 percent. The installation at the Ramsey Washington Metro Watershed District offices in Little Canada, MN installed pervious asphalt in their parking lot.

Pervious concrete

Pervious concrete is a mixture of Portland cement, fly ash, washed gravel, and water. Unlike conventional concrete, pervious concrete usually contains a void content of 15 to 25 percent which is achieved by the addition of a fine, washed gravel.

Image Courtesy of Emmons & Olivier Resources, Inc.

Pervious concrete installation in Mound, MN.

Pervious interlocking concrete pavers

These pavers, when installed, form patterns that create openings through which rainfall can infiltrate. These openings, generally 8 to 20 percent of the surface area, are typically filled with pea gravel aggregate. Pervious pavers have been used as an asphalt alternative in cul-du-sacs in Woodbury, MN.

Plastic grid systems

Plastic grid systems, sometimes referred to as geocells, consist of flexible plastic interlocking units that allow for infiltration through large gaps filled with gravel or topsoil planted with turf grass. Empty grids are usually at least 90 percent open space, so void space depends on the fill media.

Image Courtesy of Emmons & Olivier Resources, Inc.

Plastic grid system installed at offices of Rehbein Company in Blaine, MN.

Amended soils

Soil amendments add fiber or artificial media to soil to maintain soil structure and prevent compaction (see the Volume Control Using Compost Materials Soil Amendments fact sheet). The Minnesota Landscape Arboretum has designated an area of the parking lot for testing infiltration rates of several different installations of pervious pavements. This exhibit includes information to educate the public on how the various surfaces work.

Example Ordinances and Initiatives

Typical applications for permeable paving include commercial and light industrial parking lots, sidewalks, trails, driveways, residential access roads and emergency and facility maintenance roads. Examples of municipal ordinances and initiatives, which encourage the use of pervious pavements include:

City of Inver Grove Heights, Northwest Area Ordinance

For all development within this nearly 3,000 acre area of the city, pervious pavements must be used for the portion of parking over the minimum required off-street parking spaces. If proposed parking exceeds the maximum required off-street parking spaces, 50 percent of all parking spaces shall be pervious pavement.

Chicago Green Alleyway Program

The program began as a pilot in 2006, and through 2008, more than 80 green alleys have been installed. Of the four design approaches piloted, three incorporate pervious pavements with underlying infiltration or filtration.

Seattle Green Streets

Permeable pavements can be used to achieve City of Seattle water quality requirements and flow control requirements. While street surface demonstrations are currently being studied, at this time, pervious pavements are limited to non-street surfaces, such as sidewalks and driveways.

City of Vancouver Country Lane Projects

With the first "country lane" project, various types of road surfaces were incorporated in combination to create an environmentally friendly lane. The design of the first lane included the use of pervious pavers, plastic mats and formed concrete driving strips.

State of North Carolina

In 2007, the North Carolina Legislature enacted a law (Bill H1473) that requires 20 percent of a parking lot to be made of pervious pavement or a suitable, environmentally-friendly alternative stormwater management practice.

Maintenance Considerations

Permeable pavement maintenance should include vacuum sweeping annually at a minimum. Additional vacuuming is needed if sediment is visibly accumulating and clogging the pores of the surface. High-pressure washing may also be necessary to free pores in the top layer from clogging. Potholes and cracks can be filled with patching mixes unless more than 10 percent of the surface area needs

repair. Some restriction on the use of sand or anti-skid material might be needed if repeated use shows an accumulation is problematic.

Typical Cost

Construction costs of pervious pavements should be viewed with caution, given the wide range of site conditions and design requirements. It is recommended that each potential application be evaluated on a site-by-site basis. However, a range of cost estimates for the basic installation of pervious paver materials (including minimum base requirements) is given in the table below for comparison purposes. These costs should not be compared directly to the cost of conventional pavements because pervious pavements are also stormwater management systems. An accurate price comparison would include the costs for full stormwater management and paving systems; that is, curbs, gutters, piping and storage

Paver System	Cost Per Square Foot Installed (2009 $)
Permeable Asphalt	$4.00 to $9.00
Permeable Concrete	$6.00 to $12.00
Pavers	$7.00 to $15.00
Plastic Grid System	$3.00 to $9.00
Amended Soils	$12.00 to $16.00

Green Roofs

The benefits of green roofs and examples of successful programs

Green roofs are becoming commonly accepted and installed across the Upper Midwest on buildings of all shapes and sizes. Green roofs are being utilized as a means to reduce costs associated with the life-cycle of conventional roofs, and heating and cooling. In addition, they are being used to address stormwater management and large green roofs are being used to create spaces for public benefit in urban settings. This fact sheet focuses on the benefits of green roofs and provides examples of municipal programs and resolutions for municipal buildings.

Benefits / Pollution Reduction

Green roofs offer several benefits such as reduced runoff, increased evapo-transpiration, prolonged roof life, reduced roof temperature, decreased energy costs, reduction of the urban heat island, habitat for birds and insects, carbon sequestration, improved air quality, and enjoyment and increased productivity for adjacent building occupants. Green roofs also have aesthetic qualities which help to meet landscaping requirements, and they create additional living space if constructed properly. The possibilities of so many benefits, particularly in urban high-density environments such as downtown Minneapolis and St. Paul, have triggered the use of green roofs.

Program Development & Implementation

Types of Green Roofs

A green roof typically consists of the following components listed from the bottom upward: roof deck; a waterproof membrane to protect the building from leaks; a root barrier to prevent roots from penetrating the waterproof membrane; an insulation layer; a drainage layer, usually made of lightweight gravel or plastic; a geotextile or filter mat that allows water to soak through but prevents erosion of fine soil particles; a growing medium; plants; and, sometimes, an erosion control blanket.

There are two general types of green roofs: extensive and intensive. Structural load capacity, that is, how much weight the roof can hold, is a significant factor in determining whether an extensive or intensive green roof should be considered from a design and liability standpoint.

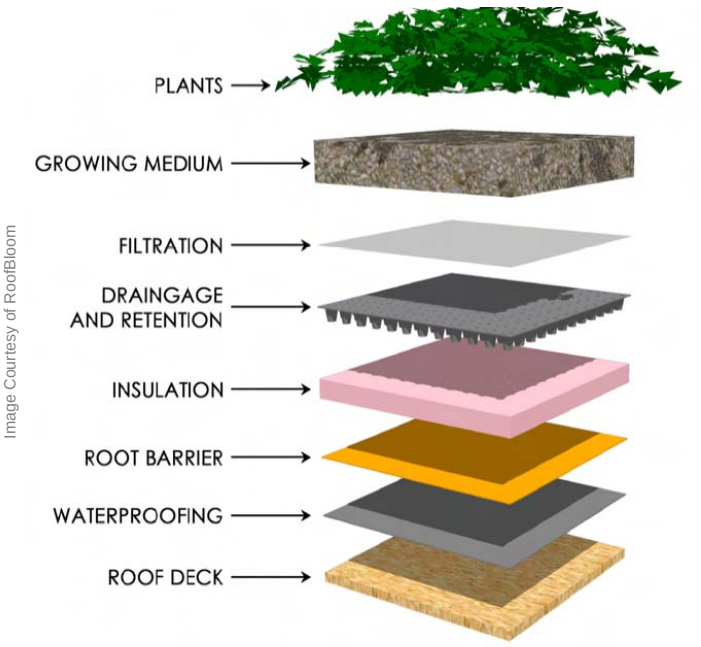


Image Courtesy of RoofBloom

Cross-section of a typical green roof.

Extensive green roofs

Comprise a lower-maintenance design with groundcover in shallow soil, which in relationship to an intensive green roof adds significantly less (14-35 lbs/ sq. ft) to the roof's dead load (Dunnett and Kingsbury, 2004). This roof type is covered in engineered soil medium that is 70-90 percent inorganic and generally 3 to 6 inches deep.

Extensive green roofs support a limited palette of vegetation that is generally low-lying and designed for maximum groundcover, water retention, transpiration, and erosion protection. An extensive green roof is generally much less expensive to construct than an intensive green roof and requires less maintenance. Maintenance on extensive green roofs is usually performed in bulk – similar to a lawn. Extensive green roofs are generally designed to support limited traffic for building and green roof maintenance.

Intensive green roofs

These are garden-like installations with deeper, more organic soils that can potentially support more diverse plantings. Intensive green roofs can increase dead loads from 59-199 lbs/ sq. ft. (Dunnett and Kingsbury 2004). The range of plantings is dependent on a combination of the soil type and depth, as well as the maintenance availability – including watering and fertilization. Native plants and several traditional garden plants are available in

the planting palette as the depth and organic content of the soil medium is increased. In several cases intensive green roofs are designed to support pedestrian traffic because of their higher structural load capacity. They typically require more intense maintenance, such as irrigation and fertilization. Intensive green roof maintenance is generally more specific – similar to a garden. Intensive green roofs often cover underground parking decks, such as the installation in Minneapolis at Brit's Pub.

Example Incentives and Initiatives

City of Minneapolis
One of the many green initiatives being taken on by the City of Minneapolis is promoting green roofs. Minneapolis has set the goal of completing 150 green roofs around the city by the year 2015. Currently the city has 39 green roofs in place through the collaboration with local businesses, organizations, and other government agencies. In 2008, the city finished the over 5,000 square foot green roof a top the Minneapolis City Hall and Courthouse.

City of Chicago – Green Roof & Cool Roof Grants Programs
In 2005, the City of Chicago launched its green roofs grant program, offering twenty $5,000 grants to residents and small businesses to help finance planning and installation. In 2006, forty $5,000 grants were awarded. Nearing the end of 2006, there were more than 250 public and private green roofs totaling more than 1 million square feet that are under design or construction in Chicago, a true testament to the efficacy of the grant program.

City of Toronto – Green Roof Bylaw & Eco-Roof Incentive Program
In May of 2009, Toronto became the first city in North America to adopt a bylaw to require and govern the construction of green roofs on new development. The bylaw will apply to all new building permit applications made after January 31, 2010 (residential, commercial and institutional) and January 31, 2011 for all new industrial development. The new bylaw will be required on all new development above 2,000 m² of gross floor area and have a graduated coverage requirement ranging from 20-60 percent.

Toronto's Eco-Roof Incentive Program
The scope of polices now available in Toronto to encourage green roof implementation include: 1) Incentives through the Green Roof Incentive Pilot Program with a $200,000 budget for the first year (2009) providing a $10/sq.ft. financial incentive up to a maximum of $20,000 per project, and 2) green procurement by government facilities requiring that green roofs be installed on new City owned buildings and on retrofit projects where feasible.

City of Seattle – The Green Factor
The Green Factor is a landscape requirement designed to increase the quantity and quality of planted areas in Seattle while allowing flexibility for developers and designers to meet development standards. Permit applicants in affected zones must demonstrate that their projects meet the Green Factor by using the Green Factor Score Sheet. The scoring system is designed to encourage larger plants, permeable paving, green roofs, vegetated walls, preservation of existing trees, and layering of vegetation along streets and other areas visible to the public.


Image Courtesy of Emmons & Olivier Resources, Inc.
Green Roof at Edgewater Condominiums, Minneapolis.

Maintenance Considerations

Once a properly installed green roof is well established, maintenance requirements are usually minimal. However, of the two basic types of green roofing systems, extensive and intensive, the latter requires more maintenance due to the increased organic material in the soil (more weeds), ongoing irrigation and/ or fertilization of vegetation, and increased human traffic & activities. Maintenance considerations for both systems include inspection of the roof membrane, the most crucial element of a green roof, as well as routine inspection and as needed maintenance of the drainage layer flow paths.

Regardless, for any kind of green roof, initial watering and occasional fertilization are required until the plants have fully established themselves. Supplemental irrigation in addition to natural precipitation at least once a week is most likely required during the vegetation establishment period. Ongoing irrigation will be required for intensive green roofs, and will be needed during prolonged dry periods for intensive and extensive green roofs. In addition, maintenance activities should include hand pulling weedy species every growing season.

Because of the nature of rooftop installations, a certain number of green roof plants can be expected to die-off. This number will be higher in initial roof establishment, but will decrease as the plants become established. It is

critical that the dead plants be replaced to regain the design plant coverage.

Typical Cost

Cost data indicates that green roof pricing varies from $8/square foot to $28/square foot for eight-inch extensive roof systems. Most cost references quote $10 to $12 per square foot (Chicago Dept. of Planning & Development). These costs include all aspects of green roof development, from the waterproofing membrane to soil substrate creation to planting. By far the highest costs associated with green roof creation are the soil substrate/growth medium and the plant components associated with it.

While a green roof may cost 2-3 times that of a conventional roof, life expectancy is commonly estimated to be at least twice as long. In addition, when evaluating the cost effectiveness of green roofs, all related cost reductions should be tabulated. For example, these could include the reduced energy costs of the building under the roof, the runoff credits possible through local regulatory programs and the carbon sequestration that could be credited as part of local CO2 monitoring.

Image Courtesy Philips Green Institute

Green roof at the Philips Green Institute.

Rainwater Harvesting/Stormwater Reuse & Rain Barrel Programs

Development of rainwater harvesting and stormwater reuse concepts and programs

High intensity land use patterns and increasing pressure on water resources require effective stormwater management solutions in tight spaces. Rainwater harvesting programs collect runoff from rooftops, parking lots and other surfaces and reuse the water for such things as irrigation of gardens and municipal ballparks, washing patio furniture and lawn watering. Additionally, harvested rainwater when approved could be used indoors for non-potable uses such as toilet and urinal flushing. Indoor use designs are subject to review by the Plumbing Plan Review Program of the MN Department of Labor and Industry in accordance with the MN Plumbing Code, Chapter 4715 and would require pretreatment practices including filtration and disinfection. The effect is volume control, reduced flooding and erosion, and less demand for treated potable water. This fact sheet discusses the benefits of rainwater harvesting, highlights existing programs and provides conceptual designs for a variety of effective rainwater harvesting systems.

Benefits / Pollution Reduction

Rainwater harvesting programs serve multiple benefits. The collected rainwater can be used for purposes that would otherwise require potable, tap water. This reduces the cost of tap water to the owner and conserves potable water resources. All of the water captured and subsequently infiltrated (e.g. used for irrigation) removes 100 percent of the solids, nutrients, metals, pathogens and toxins that would otherwise have washed off, drained to the storm sewer, and then reached downstream waterbodies.

Harvesting and re-using rainwater decreases the impact of stormwater runoff to our lakes and streams; it protects the environment and minimizes localized flooding and erosion. It has additional benefits in urban areas, including, but not limited to, an increase in soil moisture levels for urban greenery. In addition, it can be used to meet regulatory requirements for stormwater volume control and water quality.

Image Courtesy of Emmons & Olivier Resources, Inc.

Wall garden to capture rooftop runoff.

Program Development & Implementation

Programs designed to promote rainwater harvesting and reuse can incorporate any combination of the elements below.

Rain Barrels

Rainwater harvesting can be accomplished using rain barrels and/or cisterns. Rain barrels are typically small scale (25-100 gallons) and located at the downspout of a gutter system. They can also be linked to expand the overall storage volume (right). They are used to collect and store rainwater for watering landscapes and gardens or washing patio furniture. The simplest method of delivering water is by the force of gravity. However, more complex systems can be designed to deliver the water from multiple barrels connected in a series with pumps and flow control devices.

The total volume of storage available from rain barrels represents roof runoff from relatively small rainfall events, typically substantially less than one inch of rain over the surface. This is a small volume for a single rain barrel, but cumulative effects of rain barrels installed across a watershed include volume reduction and water quality treatment since typically the first half to one-inch of runoff contains the dirtiest water. During wet weather, there will likely be little or no storage available because of prior filling and little demand for irrigation water. If the ground can absorb it, consider discharging collected water onto vegetated areas between rainfall events to maximize rainwater capture and infiltration even if unnecessary for irrigation.

Rain barrel design, installation and operation guidance

The following general guidance provides an overview of the items to consider in rain barrel design, installation and operation. Specific design guidance for installation and construction can be found in many of the resources in the Additional Resources section.

- The system should be watertight, have a smooth interior surface, be located on level and stable ground, have a tight-fitting lid, durable screens on the inlet and outlet and have an emergency overflow device
- Barrel material should withstand the pressure of water over long periods of time
- The barrel should include an overflow deflection and routing feature to keep water away from the foundation of your home
- Rain barrels should not be used for the following roof types: tar and gravel, asbestos shingle and treated cedar shakes because of the high potential for polluting the captured water
- To prevent the breeding of mosquitoes, water in the rain barrel should be emptied in less than five days or enclosed with a fine screen over all openings
- Rain barrels and cisterns should be disconnected and drained in the winter to prevent freezing and deformation of the rain water harvesting system. When emptied, they can be reconnected to collect spring meltwater.

Image Courtesy of Emmons & Olivier Resources, Inc.

Regional rain barrel programs and initiatives

The utilities of Austin, Rochester and Owatonna, MN, teamed up to offer a $10 rebate to water customers for rain barrel purchases of over 40 gallons in volume. Martin County SWCD in Fairmont, MN, coordinated with Hormel Foods Corporation to salvage their 55 gallon food-grade drums to recycle for use in its Rain Barrel Program. St. Croix County, Wisconsin, runs a program retrofitting food-grade barrels into rain barrels and selling them for $30. Many cities provide a limited supply of rain barrels to residents at a reduced cost.

In the past, Nine Mile Creek Watershed District has sponsored a Rain Barrel Decorating Event with optional art competition in Bloomington and Hopkins, MN, for residents living in the District. The District supplied rain barrels at discounted price and free painting supplies for decorating the barrels onsite.

In 2007, the City of Minneapolis supplied 2,000 rain barrels to residents at the reduced cost of $45. The barrels were available through a $100,000 grant from the Environmental Protection Agency and in partnership with Minneapolis/Metro Blooms and the Green Institute. Monitoring was conducted by the City of Minneapolis to determine the volume control and water quality benefits of rain barrels (Neighborhood Rain Barrel Partnership Project, 2008). Data indicated that the average 50-gallon rain barrel could capture a 0.26-inch precipitation event, or 64 percent of the 28 precipitation events monitored. Additional benefits could be realized by increasing available storage to limit overflow (e.g. plumbing barrels in series).

Cisterns

Cisterns have a greater storage capacity than rain barrels and may be located above or below ground. Due to their size and storage capacity, these systems (often large polyethylene drums) typically collect runoff from areas larger than residential rooftops such as commercial parking lots.

Collected water is typically used to irrigate landscapes, gardens, and ballparks on a regular basis (e.g. feeding an automated irrigation system) reducing the strain on municipal water supplies during peak summer months. Again, cisterns may be used in series and water is typically delivered using a pump system. Pump systems in cisterns can be designed with a floating level that shuts off the pump and converts the water source to a municipal supply when cistern levels are too low.

St. Anthony Village, MN, constructed an underground cistern that collects stormwater runoff from adjacent roadways and filters backwash from the adjacent water treatment plant for reuse. The cistern is designed to hold 500,000 gallons of water which is used to water the adjacent City Park and City Hall. A surface stormwater pond can also overflow to the cistern and be used for irrigation. The $1.5 million project was designed and

installed in conjunction with an adjacent road project making connection to storm sewer easier; the cistern overflows to storm sewer when full.

Image Courtesy of Chesapeake Bay Foundation

Rainwater is filtered and stored in these large cisterns; the water is used for non-potable uses such as cleaning equipment, mop sinks, and irrigation.

Cistern and Rain Barrel Sizing

The storage capacity of a rain barrel or cistern is a function of the catchment area, the depth of rainfall required to fill the system and the volume and timing of water use. A general rule of thumb in sizing rain barrels or cisterns is that one inch of rainfall on a 1,000 square foot roof will yield approximately 600 gallons of runoff. The website, Rainwaterharvesting.org, provides additional design guidance. More complicated rainwater harvesting designs entailing 5,000+ gallon cisterns and pumps for irrigation require a more thorough investigation of regional rainfall patterns and irrigation rates.

Rainwater Harvesting Ordinances

A rainwater harvesting ordinance may be an option for MS4s. The City of Tuscan, Arizona requires that commercial developments provide at least 50 percent of their irrigation needs with harvested rainwater.

Hotspot Awareness

Hotspots are facilities, activities or landuses that historically or currently produce higher levels of stormwater pollutants and/or present a higher potential risk for spills, leaks or illicit discharges of stormwater pollutants. Caution must be exercised to avoid collection of stormwater from hotspots when routing the saved water to a pervious area. For more information on hotspots identification and awareness, see Chapter 3.1 Potential Stormwater Hotspots (PSHs) of the Minnesota Stormwater Manual.

Maintenance Considerations

Rain barrels and cisterns require inspection and minor maintenance to ensure the structures are leak-proof and have not been compromised by weathering or puncture. Rain barrel hoses, spigots and seals can require upkeep. Irrigation pumps and electronic management systems associated with large stormwater reuse systems require regular inspection and maintenance. Inspection is needed as a result of sediment and debris wash-off from roof and other impervious surfaces; it can accumulate if not filtered prior to discharge to the rain barrel or cistern.

Typical Cost

Rain barrels typically cost between $50 and $230 dollars for a 55 gallon drum depending on the manufacturer and inclusion of accessories and/or installation (Rain Barrels: More Than a Drop in the Bucket). Rain barrels can be easily constructed by residents using a standard food-grade plastic 55-gallon barrel which can be obtained for approximately $15 to $20. The Low Impact Design Urban Design Tools website, designed by the Low Impact Development Center (see Additional Resources), provides additional cost guidelines.

Cisterns are considerably more expensive than rain barrels ranging from $200 to $10,000 due to size, materials, and structural requirements. Very large scale stormwater reuse systems (e.g. at public buildings or commercial sites) vary in cost based on complexity of the system, the scale of the system and the existing land use prior to installation. The reuse system in the Village of St. Anthony (see Cisterns above) was particularly costly due to size and connectivity with the filter backwash from the adjacent water treatment plant, which added an additional layer of complexity.

Urban Forestry & Stormwater Management

Using trees to enhance stormwater management efforts

High intensity land use patterns and increasing pressure on water resources demands creative stormwater management. Trees dissipate the energy of falling raindrops to help prevent erosion and buffer intense rainfalls. Urban tree roots have the potential to penetrate compacted soils and increase infiltration rates in open space areas, stormwater basins and subsurface stormwater storage (structured soil). Uptake of water from trees limits the volume of runoff discharged downstream, and their canopies offer interception of rainfall and shading (cooling) in an urban environment. Trees also absorb nutrients that could otherwise run off to local receiving waters.

This fact sheet provides an overview of the benefits of protecting existing trees and planting new trees in stormwater treatment practices of new development or redevelopment sites and includes activities that can be implemented by an MS4.

Benefits / Pollution Reduction

Urban forestry strategies can help satisfy many of the MS4 stormwater management requirements in a cost effective manner. Trees, forests, and other natural areas effectively manage water through interception, evapotranspiration, and infiltration. Together, these processes can significantly reduce peak stormwater rates and volumes, naturally filter runoff, enhance ground water recharge, stabilize base flows and reduce erosion in streams.

Trees also take up nutrients and various pollutants through their root systems. A study of the City of Fayetteville, Arkansas, estimated that increasing tree canopy from 27 percent to 40 percent would reduce stormwater runoff by 31 percent (American Forests, UEA of Benton and Washington Counties, Arkansas, 2002).

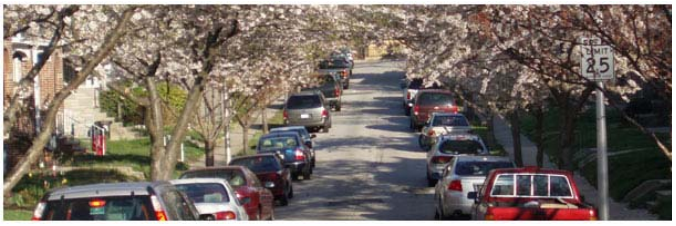


Image Courtesy of Center for Watershed Protection

A study at University of California at Davis evaluated pollutant removals for structural soils, soils designed to meet requirements for pavement support while still allowing sufficient pore space to support tree roots. Three soil types averaged 73-77 percent removal of nitrate, 52-58 percent of phosphorus, 75-80 percent of zinc and 78-92 percent of chromium (see Managing Stormwater for Urban Sustainability Using Trees and Structural Soils in Additional Resources). The term "phytoremediation" has been used to describe the ability of certain trees to take up and alter contaminants that occur in soil and shallow ground water. This has become an effective and low cost remediation approach for brownfield restoration.

Program Development & Implementation

Preventing Tree Loss during Development and Redevelopment

Regulatory tools can be adopted, perhaps as part of a tree ordinance, to reduce forest clearing during development, as well as to prevent inadvertent injury to trees. Some of these techniques include:

- Bonus or incentive zoning – provides the right to build more intensely on a portion of the property in exchange for conserving forested areas
- Clearing and grading requirements – set limits on the amount of clearing that may occur onsite
- Forest conservation and protection regulations – establish the criteria by which trees are identified for conservation, including buffer and fencing requirements
- Open space design – a compact form of development that relaxes minimum lot sizes, setbacks, road widths and other ordinances to provide common open space (also see the Open Space Design fact sheet)
- Overlay zoning – or the stacking of additional standards onto existing development criteria
- Performance-based zoning – designed to ensure an acceptable level of performance is met with a development, in this case, for protection of specified percentage of forest land
- Stormwater credits – may be granted for the conservation of forested areas (also see the Minnesota Stormwater Manual)
- Stream buffer ordinances – specify protection of existing forest cover or may even specify reforestation along corridors lacking tree cover

Trees and Stormwater Management BMPs

Urban development and redevelopment sites provide many opportunities (e.g. during the installation of stormwater treatment practices) to plant new trees that provide water quality treatment and storage of stormwater runoff from impervious surfaces. Many stormwater treatment practices such as roadside rain gardens have not traditionally been considered appropriate locations for planting trees. Research on the benefits of trees, however, shows they have enormous potential to improve the efficiency of these practices through nutrient uptake and runoff reduction.

To encourage tree planting in stormwater treatment practices, detailed guidance has been developed by the Center for Watershed Protection (CWP) (see Additional Resources) for the selection of appropriate species, identification of areas suitable for planting, and modification of the design or planting environment. The CWP resource also provides conceptual designs for the following stormwater management features:

- Wooded wetland
- Bioretention and biofiltration facilities
- Alternating side slope plantings (swale)
- Tree check dams (swale)
- Forested filter strip
- Multi-zone filter strip
- Linear stormwater tree pit

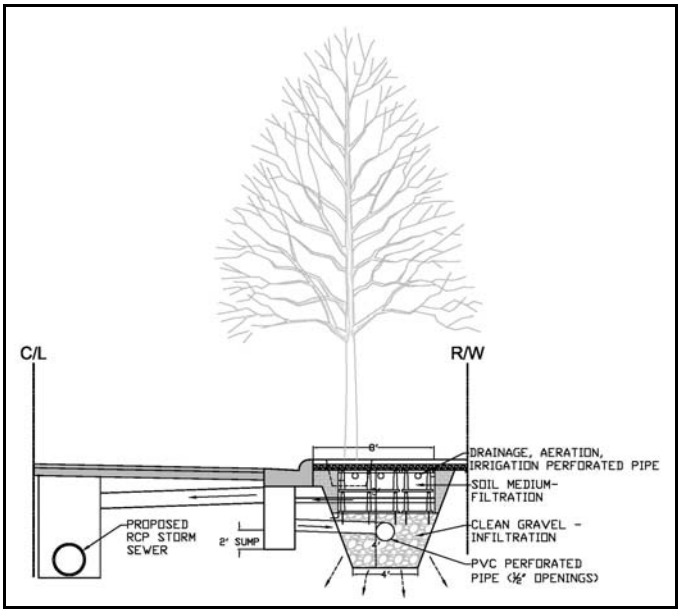
The Minnesota Stormwater Manual (Appendix E) contains recommendations for trees suitable for Minnesota conditions such as salt tolerance. Proprietary devices are available that consist of the structural framework into which the soil medium and tree is installed and above which the sidewalk is constructed. For examples, see Additional Resources.

Tree Credits for Stormwater Management

Incentives for implementing trees for stormwater management can include providing stormwater management credit in development or redevelopment rules. Some metro watershed districts are considering allowing credit for the interception of rainfall by trees. For example, the Capitol Region Watershed District is considering a volume reduction credit equal to 0.15 inches over the area of the tree canopy. Other credits have been established in municipalities across the country. Pine Lake, Georgia site runoff requirements are lessened by 10 gallons/inch for trees less than 12 inches diameter at breast height (DBH) and those greater than 12 inches DBH are credited 20 gallons/inch. The following table presents this and other stormwater credit approaches.

Municipality	Credit	Website
Pine Lake, GA	Saved trees contribute to site runoff requirements: < 12 inches DBH = 10 gal/in; > 12 inches DBH = 20 gal/in	http://pinelakega.com/environment-green-space/waterfirst-plan/
Sacramento, CA	A portion of impervious cover underneath the canopy of new or existing interceptor trees from approved species list may be subtracted from the site's overall impervious cover: New deciduous = 100 ft^2; New evergreen = 200 ft^2 Existing = ½ existing canopy	2007 Stormwater Quality Design Manual: http://www.sacramentostormwater.org/SSQP/documents/DesignManual/SWQ_DesignManual_May07_062107.pdf
Portland, OR	A portion of impervious cover underneath the canopy of new or existing trees from approved species list and within 25 feet of impervious surfaces may be subtracted from the site's overall impervious cover.	2004 Stormwater Management Manual: http://www.portlandonline.com/BES/index.cfm?c=35122
Indianapolis, IN	100 ft^2 impervious area reduction for each new tree within 20 feet of impervious surfaces and from approved species list.	http://www.indygov.org/eGov/City/DPW/Pages/Supplemental%20Green%20Infrastructure%20Document%20(Draft).aspx

Adapted from the Center for Watershed Protection Stormwater Credits



Typical cross-section of a tree box filter adjacent to a parking lot or roadway.

Financial Incentives for Tree Planting

In addition to regulatory tools and design detail modifications for development and redevelopment, financial incentives can encourage private landowners to plant trees on their property. These incentives can take many forms, ranging from free or low cost seedlings or other native tree stock to financial rebates or reduced fees offered by utilities or local governments. Tree seedling giveaways may be coupled with educational programs and may also coincide with nationally recognized days such as Arbor Day. Various utilities across the country offer incentives to preserve or plant trees in certain areas of the yard to maximize their cooling benefits.

Maintenance Considerations

Every urban tree planting site requires regular inspection and maintenance such as watering, weed control, pruning, and pest management. Fertilization is usually not needed for newly planted trees, but may be beneficial later, depending on soil and growing conditions. The Tree Care Industry Association (2004) provides guidance on tree fertilization. Inspection, replacement, and removal of tree shelters and stakes should also be part of a maintenance plan.

Typical Cost

The cost of preventing tree loss during development and redevelopment and the incorporation of trees into stormwater management BMPs will largely be at the expense of developers, except for staff time for ordinance and detail development. The cost for incentivizing planting of trees in existing development will vary depending on the intensity of the effort and the set maximum cost-share or rebate. Cost savings as a result of increasing tree cover in urban areas was studied in Fayetteville, Arkansas where increasing tree canopy from 27 percent to 40 percent was estimated to reduce stormwater runoff by 31 percent. This runoff reduction was estimated to result in a savings of $43 million in capital improvement based on a $2/cubic ft. cost for stormwater management (American Forests, UEA of Benton and Washington Counties, Arkansas, 2002). A similar study on Portland's declining tree canopy found that tree replacement would cost at least $5 billion, but the volume reduction and pollutant removal benefits from the trees were estimated to save the city $11 million per year in stormwater management costs. Volume and pollutant removal benefits increase with the age of the trees. Trees planted for stormwater management are planted in uncompacted soils to maximize the stormwater management benefits; this practice increases the lifetime of the tree as compared to the general practice of planting trees in compacted soil.

Vegetated Swales & Buffer Strips

Utilizing vegetated swales and buffer strips to prevent pollution

Stormwater runoff from residential, commercial, industrial and agricultural land uses contains pollutants that can contaminate water bodies. Stormwater runoff from impervious surfaces also can increase runoff velocities and contribute to streambank erosion. Swales and buffer strips are a type of stormwater treatment composed of vegetation and a porous subsoil medium. Buffer strips are vegetated areas adjacent to a waterway that prohibit stormwater runoff from flowing directly into a water body.

The vegetation catches pollutants carried by stormwater, decreases the rate of flow and volume of runoff, and stabilizes the soil on the shoreline or bank, lessening erosion caused by runoff. A swale is a long, vegetated depression often used as a water conveyance system which is also designed to infiltrate water and remove sediment and pollutants from runoff. A swale, therefore, assists in recharging ground water and managing stormwater runoff quantity and quality. This fact sheet provides guidance on the design, implementation and maintenance of vegetated swales and buffer strips and on programs to educate the public and decision makers about installing them.

Benefits / Pollution Reduction

Properly designed swales and buffers protect and separate a stream, lake or wetland from future disturbance or encroachment and sustain the integrity of stream ecosystem habitats. Maintaining a buffer or swale upstream of surface waters reduces pollutant impacts from sediment, phosphorus, nitrogen and high temperature waters. Additional benefits include ground water recharge, channel protection, erosion control, aquatic and terrestrial riparian habitat, flood control and recreational and educational opportunities.

Swales and buffer, when constructed properly, can remove a series of pollutants from stormwater runoff. Water quality removal rates for are variable and depend on a number of factors including slope, width, and vegetation. The Minnesota Stormwater Manual contains relevant data on pollutant removal efficiencies.

Program Development & Implementation

Programs designed to facilitate the installation of swales and buffers for water quality protection take into account both the mechanism of implementation and the ideal design characteristics for maximum effectiveness. For additional information on developing a buffer ordinance see the Establishing a Buffer Ordinance fact sheet. The following elements can be implemented in a vegetated swale and buffer initiative.

Awareness Campaigns

Awareness campaigns inform businesses, developers, and property owners of the benefits of vegetated swales and buffers. Efforts can contribute to encouraging individuals and organizations to implement buffers on a voluntary basis, educating individuals on proper installation and maintenance. Suggested educational methods include:

Brochures

Develop informative brochures, and guidance for specific audiences such as businesses, contractors, developers, homeowners associations and garden clubs.

Signage at municipal installations

Locate signage at parks, government buildings, and parking lots identifying swales and buffers and explaining their functions and benefits.

Workshops and seminars

Workshops and seminars can be used to provide needed technical assistance to homeowners, property owners and citizens for establishing a swale or buffer on their property.

Vegetated Swale Design

Vegetated swales are linear, channel-like surface depressions that can be utilized as conveyance to direct stormwater away from or around a structure, for treatment to remove pollutants from stormwater, to promote infiltration of runoff into the ground and as volume control for stormwater runoff. Vegetated swales can also be landscaped to provide an aesthetic appeal and provide natural habitat within an urban setting.

Applications

- Natural drainage on a residential lot
- Along local roads in place of curb and gutter
- Parking lot islands and medians

- Highway medians
- First line of defense upstream of the stormwater system
- Aesthetic amenity at civic, commercial or residential sites
- Low flow conveyance in place of structural conveyance
- Pretreatment prior to discharge to open water or stormwater treatment facilities such as infiltration basins

Design considerations

The size of the swale including length, width, and depth is dependent upon soil conditions, ground water level, the area discharging stormwater, the amount of impervious area discharging stormwater, and the topography of the contributing area. The recommendations below are from Chapter 12 of the Minnesota Stormwater Manual.

- Size the bottom width, depth, length, and slope necessary to store the water quality volume with less than 18 inches of ponding at the downstream end
- Slope should not exceed 5 percent (1 to 2 percent recommended)
- Bottom width should range from 2 to 8 feet
- Ensure that side slopes are no greater than 3:1 (4:1 recommended)
- The maximum drainage area should be five acres with a maximum site slope of 20 percent
- Swales are designed to meet a runoff velocity target for a water quality storm as well as the peak discharge from a 2-year design storm. The runoff velocity should not exceed one foot-per-second during the water quality storm.
- Swales can be designed to pass larger storms and serve as conveyance tools
- Pre-treatment can be created by placing checkdams across the channel below pipe inflows, and at various other points along the channel
- Provide a 30-inch deep filter bed of amended soil in the swale if check dams are used to promote infiltration
- The swale's ability to infiltrate is dependant upon the soils. In addition a swale will not function optimally in an area where the ground water table meets the bottom of the swale. Soils and ground water table level should be evaluated before installation. Provide a minimum 3-foot depth to bedrock or the seasonally high water table.

Vegetation

Vegetation can range from tall plants and grasses to a short turf grass depending upon the desired application of the swale. Any vegetation used should be water tolerant. Native vegetation is preferred with its ability to uptake water and filter pollutants like phosphorus and sediment. Roots of native vegetation grow deep to stabilize the soil and promote infiltration, and native vegetation does not require irrigation after the first year of establishment.

Image Courtesy of Emmons & Olivier Resources, Inc.

Buffer Design

Review of a cross section of peer-reviewed studies identifies the following buffer characteristics that are most effective at filtering runoff and treating stormwater.

Width

The determination of buffer widths on individual wetlands could be based on the following minimum guidelines:

50 feet for reduction of human impact

50 – 100 feet for overall water quality protection

50 – 200 feet for habitat protection and species diversity

Use the high end of the range for sensitive water bodies, steep slopes and surrounding land uses that could adversely impact the water body. Add buffer width to off-set the adverse impacts of slope, poor soils, human land use pressures, or to add extra protection for sensitive aquatic organisms or wildlife. Flexibility in application of buffer width requirements can be achieved through buffer width averaging, variances and conservation easements. Overall, the U.S. Fish and Wildlife Service, the MNDNR and the Center for Watershed Protection agree that bigger is better in terms of many factors including water quality treatment, erosion control and habitat.

Vegetation

A vegetative mix of trees, shrubs and groundcover are recommended to provide several layers of protection. Consider native prairie planting for the groundcover

portion of any buffer. The deep roots, hardiness, aesthetic appeal, unique habitat character and filtering ability all make prairies an ideal vegetative ecosystem for a conservation buffer. Trees and shrubs can also be used as a vegetative transition from the water body. Trees and shrubs can provide for enhanced infiltration and nutrient uptake while stabilizing soil and dissipating rainfall. Specific plantings will depend upon your application and area within the state. Take care to assure that vegetation and grading of any buffer area enables runoff to occur as sheet flow rather than forming channels and rills.

Structure

The Center for Watershed Protection recommends designing a structure that includes the following elements:

- The outer zone should provide a stormwater depression area designed to capture storm runoff from small storm events
- Runoff from larger storm events should overflow the depression and spread across a grass filter designed for sheet flow and infiltration referred to as the middle zone
- The grass filter should discharge into a wider forest buffer designed to infiltrate and treat remaining runoff, the riparian zone

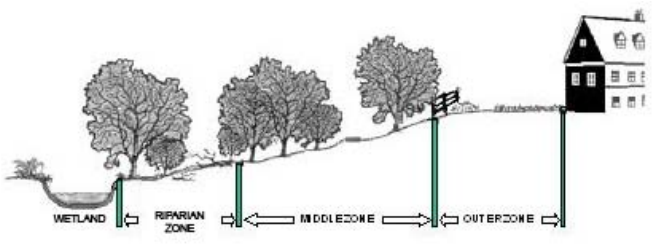


Image Adapted from Welsch (1991) by US EPA

Recommended buffer zones.

Maintenance Considerations

Maintenance is essential to ensure a swale functions properly over time. Maintenance suggestions include:

- Regular mowing of grass swales
- Removal of garbage, debris, and dead plant material at least once a year
- Regularly inspect for erosion and proper infiltration.
- Remove sediment build-up as needed
- Replace any damaged or dead plants as needed

Typical buffer maintenance activities include:

- Remediation of any channelization that may develop
- Removal of accumulated pollutants or trash
- Weed control or other tasks to maintain healthy vegetation
- Aeration or other mitigation to maintain the high pervious quality of the soil

Typical Cost

The cost of installation of a vegetated swale or buffer strip varies greatly based on width, soil amendments, the use of check dams and vegetation. The cost of the installation of a vegetated swale is estimated at $0.50 per square foot, according to a 2004 study done by the Army Corps of Engineers. There will also be costs associated with labor and supplies for necessary maintenance. Financial help may be available through cost share programs and grants to offset the cost of installation.

Establishing a Buffer Ordinance

Ordinance framework, awareness and assessment

Conservation buffers are small areas or strips of land in permanent vegetation, designed to intercept pollutants and manage other environmental concerns. Examples of buffers include: riparian/wetland buffers, filter strips, grassed waterways and vegetative barriers. An ordinance that requires buffers around water resources can effectively remove additional pollutants and protect downstream resources, as well as provide aquatic and terrestrial habitat. This fact sheet provides guidance on developing and implementing a buffer ordinance.

Benefits / Pollution Reduction

Buffers can provide many different environmental and economic benefits, including:

- Reduced small drainage problems and complaints
- Reduced risk of flood damage
- Reduced stream bank erosion
- Increased adjacent property values
- Enhanced pollutant removal
- Location for greenways and trails
- Sustained integrity of stream ecosystems and habitat
- Protection of wetlands associated with the stream corridor
- Prevention of disturbance of steep slopes
- Mitigation of stream warming
- Protection of important stream corridor habitat for wildlife

Water quality improvement and protection will vary based on the ordinance developed. An ordinance that requires a 100-foot buffer versus a 20 foot buffer will have higher pollutant removals. Pollutant removal studies have determined a 63-89 percent removal of TSS and 41-78 percent removal of TP for buffers that are between 4.6 and 26 meters wide (Aquatic Buffers Fact Sheet: Buffer Zones, Center for Watershed Protection).

Program Development & Implementation

Buffer Ordinance

MS4s can adopt regulations wherein owners or developers are required to implement buffers under certain conditions. Conditions could be based on proximity to streams, lakes and wetlands, to waters of the United States, to DNR public waters or based on the functions and values of water bodies as identified by the MS4. The EPA provides model ordinance guidance for buffers and recommends the ordinance framework adapted below.

Background
Identify the functions and benefits of buffers.

Intent
Establish the intent to require the design and implementation of buffer installations.

Definitions
Define key terms.

Applications
Identify the activities and applications to which the ordinance applies.

Plan requirements
Identify the content and submittal requirement for the buffer plan.

Design standards
Define the design standards including width or area, slope and vegetative cover. Establish a minimum width that would apply to all buffers, and then customize requirements according to functions, values, and perhaps size of the water body. Determine how areas are to be calculated and identify any flexibility in the standard, such as using an average buffer width to meet the standard. This would also allow changes to be made to adjust for such factors as steep slopes, poor soils, encroaching land uses or sensitivity of the water body. A State of Minnesota Stormwater Advisory Group document provides thorough guidance on wetland susceptibility which could provide a basis for required characteristics of wetland buffers (see Additional References). Standards should also provide specifications for different vegetative mixes based on a set of site conditions (e.g. slope, soils and climatic region), require signage, and specify a minimum spacing of signage (ex. every 50 feet) to identify the buffer and prevent encroachment. Especially in early spring, the untrained eye can mistake buffers for lawn.

See the Vegetated Swales and Buffer Strips fact sheet for additional design information.


Image Courtesy of Center for Watershed Protection

A wide forested buffer protects this small stream from nearby development.

Buffer management and maintenance
Define the management and maintenance standards. Maintenance of buffer areas is essential to their proper long-term operation. Special attention should be paid to preventing concentrated stormwater discharges, maximizing distribution of runoff as sheet flow, removing accumulations of pollutants, keeping vegetation healthy and keeping soils porous. An annual maintenance for buffer areas would help to assure continued success as an integral part of the overall stormwater management program. Buffers that are kept healthy will maintain their physical filtering and chemical uptake characteristics.

Enforcement procedures:
Identify the penalties for violations and the program responsible for detecting violations.

Waivers and variances
Specify the conditions under which waivers or variances apply. Flexibility could be introduced through buffer averaging, clustering or conservation easements.

Conflicts with other regulations
Identify that the more restrictive regulation applies when the ordinance conflicts with other regulations.

References
Site all references used to develop the ordinance or rule.

Awareness Campaigns

Awareness campaigns inform public employees, businesses, property owners, and elected officials on the benefits of buffers. Efforts can contribute to generating acceptance of the new ordinance or encouraging individuals and organizations to implement buffers on a voluntary basis. Suggested educational methods include:

Brochures
Develop informative brochures, and guidance for specific audiences such as businesses, homeowners associations and garden clubs.

Signage at MS4 installations
Locate signage at parks and government buildings identifying the conservation buffer and its functions and benefits.

Workshops and seminars
Workshops and seminars can be used to provide the technical assistance that developers, staff and consultants will need in order to meet the new buffer ordinance.

Monitoring and Assessment

The MS4, or the municipality in cooperation with other buffer interests, could engage in documenting the effectiveness of its buffer approach by conducting monitoring to see what water quality and other benefits are accomplished. Findings could provide feedback for maintenance requirements and ordinance revisions. Buffer monitoring could include the following activities: identification or measurement of encroachment by adjacent property owners, water quantity and quality monitoring (e.g. nutrients, temperature, heavy metals) at various locations in downstream water bodies, botanical surveys including identification of species cover and composition, and mapping of overall acreage of buffers implemented through the buffer ordinance.

Maintenance Considerations

Maintenance of a buffer ordinance requires periodic review and revision based on new technology, new research or feedback from implementation of the ordinance. Typical buffer maintenance activities include remediation of any channelization that may have developed, removal of accumulated pollutants or trash, weed control or other tasks that maintain healthy vegetation, and aeration or other mitigation to maintain the high pervious quality of the soil.

Typical Cost

The adoption of a buffer ordinance requires an investment in training for the plan reviewer, the consultant, and possibly the public. Time consuming elements include research, functions and values assessments, and educating decision makers. MS4s must also consider the cost of enforcement, including staff and equipment requirements. Awareness campaign costs are determined by the type of materials produced and the method of distribution selected. Signs at public buffer installations may initially have a higher cost than printed materials, but can serve as a more effective tool for increasing public understanding. Assessments should include the reasonable cost of the land used to establish buffers.

Retrofitting: Infiltration, Filtration & Bioretention

Integrating stormwater management practices into developed sites

Retrofitting can be used to achieve highly effective stormwater management that reduces runoff volume, increases ground water recharge, improves surface water quality, provides thermal benefits and helps mimic pre-development hydrology. Retrofits such as rain gardens and swales are versatile because they can be constructed in small areas and easily integrated into existing residential and commercial sites. This fact sheet provides a list of practices and applications for small-scale sites and includes discussion on the associated benefits and costs. Links to example municipal cost-share and incentive programs for stormwater retrofitting are provided in the Additional Resources section.

Image Courtesy of Emmons & Olivier Resources, Inc.

Bioretention facility in St. Paul, MN.

Benefits / Pollution Reduction

Retrofitting is a way to rehabilitate watersheds that have a significant amount of imperviousness and little stormwater treatment. When properly designed, constructed, and maintained, BMP retrofits, as discussed here, increase the aesthetics of an area by providing green space and/or stormwater educational opportunities. Retrofitting has the potential to help achieve nondegradation requirements and TMDL allocations for impaired waters as well as protect resources that may be experiencing increased pressure from other areas of the watershed. Stormwater retrofits are generally employed to:

- Fix past mistakes and maintenance problems
- Solve chronic flooding problems
- Serve as stormwater demonstration and education opportunities
- Trap trash and floatables
- Reduce runoff volumes to combined sewers
- Restore stream corridors
- Reduce specific pollutants
- Reduce downstream channel erosion
- Support stream restoration efforts
- Recharge shallow ground water

The preceding list was adapted from the manual: Urban Stormwater Retrofit Practices created by the Center for Watershed Protection (see Additional Resources) which has tables listing retrofit objectives and implementation options, including pollutant removal capabilities of retrofit options.

Program Development & Implementation

Retrofit programs can be effectively implemented on both public and private properties. Municipally driven projects can be used as examples to encourage private landowner participation. MS4s can also encourage landowners to install retrofit practices using a variety of methods such as those identified below. Using a MS4 directed approach along with a program that encourages landowner retrofits will generally realize the greatest benefits.

Retrofit Designs

Through appropriate planning and BMP selection, almost any type of BMP can be used in retrofitting existing infrastructure. BMP selection depends on site location and characteristics. The existing land use and site objectives can be indicators of which BMPs are more likely to be successful in a retrofit situation.

The following list of retrofit BMPs are examples categorized based on the likely application of each. These lists are not meant to exclude BMPs from particular land uses but rather provide a guide to identifying the best BMPs for your MS4. Individual project constraints will dictate which BMP is the most appropriate in a given situation. Descriptions of these practices and design recommendations can be found in the Minnesota Stormwater Manual or the Center for Watershed Protection Manual 3: Urban Stormwater Retrofit Practices Version 1.0.

Intensive land use retrofit BMPs

- Cisterns
- Stormwater tree pits
- Permeable pavers
- Extensive or intensive green rooftops
- Underground sand filters
- Impervious cover conversion
- Stormwater planter
- Sub-grade storage/infiltration

Residential retrofit BMPs

- Pond (new or alteration of existing system)
- French drains
- Rain barrels
- Rain gardens
- Small and large bioretention
- Water quality swale
- Structural sand filter

MS4 Directed Retrofits

Retrofit projects that are directly implemented or cost-shared by the MS4 usually include larger practices or systematic implementation of smaller retrofits. Public waters, ditches and infrastructure usually provide the greatest opportunities for MS4 directed stormwater BMP retrofits. Care should be taken to locate BMPs where they provide the best water quality benefit.

The City of Burnsville rain gardens are one example of a municipality installing retrofits to protect a waterbody. The city identified 17 locations in a neighborhood and worked with the homeowners to construct, plant, and monitor the rain gardens. This project is a great example of using city and homeowner resources and collaborating with conservation districts to create a great product that reduces downstream runoff volumes and associated phosphorus loading.

Another example is the City of Maplewood. The City constructed their first rain garden in 1996 and has since launched an aggressive installation campaign. Today they have 450 home rain gardens and over 30 rain gardens on public land. Their policies incorporate rain gardens into street reconstructions, residential retrofits and business developments.

On a much larger scale, the City of Seattle, Washington took on 32 acres and 15 residential blocks for the Street Edge Alternatives project (SEA Streets). This project incorporated networks of stormwater BMP features. Surface runoff discharges to vegetated swales, amended soils, and rain gardens. Swales with permeable weirs were used in steeper areas to help control runoff velocity and volumes, while rain gardens were installed in flatter terrain.

Image Courtesy of Emmons & Olivier Resources, Inc.

Pervious pavers in Minneapolis, MN.

Individual Landowner Directed Retrofits

In addition to taking on retrofits directly, MS4s can use stormwater programs that encourage private party retrofits. These programs work by providing financial incentives for homeowners and businesses to make stormwater improvements to their properties.

Grants and cost-share programs

These types of programs are offered by many government agencies to address water quality issues. The specifics of programs vary by grantor but all are based on the idea of providing financial assistance to private parties to incentivize retrofit installations. Generally, this funding will need to be matched and can be used for design, installation and materials to construct water quality features. Many local examples exist in Minnesota; some that may be helpful to review include the following:

- Minnehaha Creek Watershed District Cost-Share Program – This program is available to neighborhood associations, lake and stream associations, schools, cities, businesses and other groups to do projects that have an environmental benefit and an educational component.
- Rice Creek Watershed District Grant Programs – Three different grant programs are available through the RCWD: 1) Grants for up to 50 percent of the project cost are available for residential and municipal projects that improve water quality; 2) The Landscaping for Clean Water rebate program provides funds to individuals that want to plant native grasses; and 3) The Urban Stormwater Remediation cost-share program assists public entities with improving stormwater in redevelopment and infrastructure improvement processes. This program is implemented through conservation districts.
- Any of many local grant opportunities listed on the Blue Thumb: Planting for Clean Water website: http://www.bluethumb.org/grants/.

Stormwater utility credit programs

These programs involve accounting for stormwater management costs in the same manner that other city services are counted, with a line item on a bill. Funds are generated through per-plot fees based on the amount of runoff leaving each plot that enters the MS4's stormwater conveyance system. The fee payer is given methods to reduce this fee, such as infiltrating or treating a volume of runoff from their property. This method has been applied locally and throughout the nation; two Minnesota examples follow.

- Minneapolis Stormwater Utility Credit Program – This program provides stormwater credits to people who use onsite tools to improve the quantity and/or quality of runoff leaving their property. The amount of fee reduction can be up to 100 percent for designs certified by a Minnesota registered professional engineer.
- Baxter, MN, Stormwater Utility Credits – The city provides commercial properties the chance to install stormwater BMPs with a maximum possible reduction of 30 percent off the total utility fee bill.

Maintenance Considerations

Retrofit BMP maintenance considerations can be substantial, vary considerably based on the type of practice installed, and are paramount to the short and long term success of the BMP function. See fact sheets on Pervious Pavements, Green Roofs and Rainwater Harvesting/ Stormwater Reuse and Rain Barrel Programs for maintenance regarding each of these practices. In particular, refer to Chapter 12 of the Minnesota Stormwater Manual for advisory information on maintenance; also look for associated checklists (see Appendix D Operation and Maintenance Checklists).

Some of the maintenance agreements and activities associated with BMP retrofits are similar to those performed for conventional landscapes and stormwater systems; however, the scale, location, and the nature of a BMP approach will require new maintenance strategies. Studies have shown that maintenance costs associated with LID are similar to traditional landscapes (Lakeville LID Study, 2006). Maintenance responsibilities may be taken on by the MS4 whether on MS4 or private property.

Legal documentation providing for the latter scenario is recommended to facilitate proper maintenance of the installation in perpetuity. Likewise, retrofit BMP programs should provide a legal document template to be completed and recorded with the city by private landowners in the case where the MS4 will not be conducting maintenance. At a minimum, annual inspections of the BMPs should be conducted, and a plan should be in place for any necessary repairs that are discovered through routine inspections.

Maintenance considerations of a retrofit program, whether it is MS4 or individual directed, vary depending on the intensity of the program implemented; but at a minimum maintenance should include periodic review and revision based on research studies, new technology, and feedback from implementation of past retrofits.

Typical Cost

The cost of implementing a retrofit program varies significantly based on the scope of the program. Programs will have costs for administration, marketing and implementation.

Typical costs for BMP retrofits are higher (1.5-4 times) than the cost of BMPs in new development. This is largely due to site constraints and having a greater number of interested parties involved in the project. The approximate costs for BMPs are reported in the CWP's manual: Urban Stormwater Retrofit Practice. Each site cost will vary based on complexity and size of the project. Generally speaking, the intensive land use retrofit BMPs require less land but may have higher costs associated with them, whereas the residential retrofit BMPs require more land but can often be installed for a lower cost.

Establishing An Infiltration Standard

Creating an infiltration standard for development and redevelopment

Infiltration is a highly effective stormwater practice that reduces runoff volume, increases ground water recharge, improves surface water quality, provides thermal benefits and helps to mimic predevelopment hydrology. While other practices may address stormwater quality and rate control, limiting increased volumes of runoff from development and redevelopment is the most effective way to reduce the cumulative impacts on downstream water resources.

This fact sheet addresses effective tools and strategies to assess existing ordinances and develop consensus for the adoption of an infiltration standard. In addition, this fact sheet includes discussion on the importance of mimicking natural or predevelopment hydrology, and provides a range of example infiltration standards adopted across the state with links to example municipal ordinances and watershed district rules.

Benefits / Pollution Reduction

The main goal of an infiltration standard is to mimic the natural hydrology of the landscape by allowing water to soak into the ground close to where it falls. This generally means defining an infiltration standard that limits post-development runoff volume to pre-development runoff volume. The multiple objectives that can be realized with infiltration (volume control) as part of a stormwater management plan include:

- Reduced stormwater pollutants
- Increased ground water recharge
- Decreased runoff volume and peak flow rates
- Preserved base flow in streams
- Reduced thermal impacts of runoff
- Lowered infrastructure costs

Image Courtesy of Emmons & Olivier Resources, Inc.

Rain garden used to infiltrate street runoff.

Program Development & Implementation

The Right Infiltration Standard for Your MS4

The infiltration standard of your MS4 should be based primarily on the local geology/soils, existing and planned land use, stormwater goals and stakeholder interests. Attaining a balance among these sometimes competing interests will determine what infiltration standard is feasible.

- Geology/soils – Defines the infiltration rates and connectivity of the predevelopment landscape. MS4s that contain diverse geology should implement a pre-to-post development event standard. Homogeneous landscapes may be able to implement a flat standard for the entire MS4. Note that although some level of infiltration can occur in any soil, other volume reduction techniques might be better when extremely low infiltration rates prevent achieving a community's volume reduction goal.
- Existing and planned land use – A fully developed MS4 will want to focus on retrofit and redevelopment stormwater standards, whereas new construction infiltration standards should be the focus of a developing MS4.
- Stormwater goals –Stormwater issues need to be defined and the infiltration requirement should be tailored to address these issues. Water quality and quantity can be addressed partially, if not fully, through infiltration practices.
- Stakeholder Interests – Working with all stakeholders in the MS4 to garner support for any ordinance is very important to its success. The best approach is to get feedback early and often and work through any issues or misconceptions that may exist.

Infiltration Standard Categories

Infiltration standards vary across the state based on the factors previously discussed. Watershed Districts, Municipalities and Water Management Organizations all enact standards that are designed to protect their waters. The standards generally fall into two categories: flat standards and pre-to-post standards.

Flat standards

Flat standards are typically expressed as the volume of runoff generated by a certain rainfall depth, typically 0.5- or 1.0-inch. These standards are usually applied only to

impervious surfaces, either net additional impervious or total impervious. Net additional impervious is calculated by subtracting the total area of existing impervious area from the impervious area under post construction conditions. Total impervious is the total impervious area under post construction conditions. Some standards may also only apply to areas draining to special water such as trout streams, or may include rainfall over the pervious areas of the site as well as the impervious areas.
Flat standards do not mimic existing condition hydrology as precisely as a pre-to-post standard, but are considered by most practitioners to be more easily implemented.

Pre-to-post standards
Pre-to-post standards require modeling of existing runoff volumes and hold post-development runoff volumes to existing conditions for a return frequency rainfall event, typically the 1- or 2-year storm event. In other words, pre-to-post standards restrict the volume that leaves the site after development, keeping it equal to predevelopment conditions. This requires more in-depth development review, but also provides a better analysis of the land than a flat standard. This method more reliably mimics existing conditions, better protects downstream resources and avoids over- or under-applying a flat infiltration standard.

Example Infiltration Standards

The following table is a sampling of infiltration requirements for development/redevelopment within the Twin Cities Metropolitan Area (2009). Flat standards are the most prevalent due to the ease of application. Pre-to-post standards are also utilized, particularly in locales that have unique geologic setting and resources of high value.

Example Infiltration Requirements in the Twin Cities Metro Area (2009)

Municipalities		
Entity	Infiltration Requirement	Requirement Applies To
Afton	0.6”	Impervious area
Inver Grove Heights NWA	3.6” Pre-Post	Entire site
Lakeville	1.5”	Impervious area (within areas draining to trout waters)
Woodbury	0.5”	Entire site
Maplewood	1”	Entire site
Watershed Districts		
Entity	Infiltration Requirement	Requirement Applies To
Brown's Creek	2.8” Rainfall Event Pre-Post, 3.6” Rainfall Event if Landlocked	Entire site
Capitol Region	1”	Impervious area
Comfort Lake-Forest Lake	2.8” Rainfall Event Pre-Post, 3.6” Rainfall Event if Landlocked	Entire site
Minnehaha Creek	1”	Impervious area
Nine Mile Creek	1”	Impervious area
Prior Lake-Spring Lake	0.5”	New Impervious
Ramsey-Washington Metro	1”	Impervious area
Watershed Management Organizations		
Entity	Infiltration Requirement	Requirement Applies To
Scott County	0.5”	New impervious area
Vermillion River	2.8” Rainfall Event Pre-Post	Entire site
Shingle Creek	0.5”	Impervious area
West Mississippi	0.5”	Impervious area
Upper Rum River	0.5”	New impervious area

Existing Ordinance Compatibility with Infiltration Standards

It is possible that existing ordinances and regulations currently being used by a community or by another regulatory entity within a community, such as a watershed organization, could work contrary to infiltration concepts or to each other. For example, a community might not recognize the importance of infiltration while a watershed organization's rules require it. Or a community might have subdivision requirements that mandate an extra-wide street that generates more runoff and consumes land that could be used for infiltration. Or the street design standards of a community may preclude the use of ribbon curb, flat curb or curb cuts to convey runoff surficial to adjacent infiltration features such as rain gardens.

The above examples indicate the need for MS4s to review all of their existing regulations when considering the adoption of infiltration requirements. The community should also review the rules of other entities operating within its borders. Additional resources can be found in the Center for Watershed Protection's A Handbook for Changing Development Rules in Your Community and in the Minnesota Stormwater Manual (Ch. 12).

Contamination Caution

Whenever runoff is directed to an infiltration BMP, there is a danger of ground water contamination by the pollutants being carried in the runoff. Chapter 13 of the Minnesota Stormwater Manual discusses the ways in which potential pollution "hotspots" can be identified and runoff from them diverted from infiltration areas. In short, any surface runoff source that exposes or generates toxic or highly contaminating material should not be routed to an infiltration device unless some form of pretreatment is provided to remove the contaminant. Example hotspots include: chemical storage (including salt), vehicle maintenance facilities, gasoline service stations, airports (de-icing agents), waste disposal facilities and scrap yards. The Minnesota Department of Health also provides guidance on the suitability of locating infiltration features within vulnerable wellhead protection areas.

Maintenance Considerations

The maintenance of infiltration features can be the responsibility of the private sector or of the MS4. Generally speaking, larger stormwater infiltration features are considered part of the regional stormwater system and maintenance is conducted by the MS4s. Small rain gardens may be maintained privately with agreements in place that assign responsibility when BMPs are being poorly maintained.

Infiltration BMPs initially obtained a bad reputation because of the lack of proper design, installation and/or maintenance. Any one of these three factors could easily lead to system failure. Substantial progress has been made on guidance for each. The element of maintenance is absolutely essential to long-term infiltration BMP success. Appendix D of the Minnesota Stormwater Manual contains guidance on inspection and maintenance of infiltration facilities. Some key factors to keep in mind include: adequate pretreatment to remove particles that could clog the infiltration surface; inspection of system overflow to assure free flow around the facility when needed; monitoring of sub-surface water levels to assure proper and timely drainage; and rapid removal of any sediment accumulation on the infiltration surface.

Typical Cost

The costs to set an infiltration requirement will vary based on the complexity of the situation. Costs will include time for MS4 staff to create, propose and implement any requirement. Additional expenditures may include engineering costs to analyze the local geology and determine reasonable standards, legal fees and inspection costs.

Volume Control Using Compost Materials / Soil Amendments

Soil amendment techniques, standards and ordinances

Land development including landscaping practices damage soil structure and function by removing or compacting topsoil. These practices can impact water resources by decreasing infiltration, increasing erosion, impairing fish habitat, and increasing the need for permanent stormwater management.

These practices also create chemically dependent landscapes which are difficult and expensive to maintain and contribute to polluted runoff. Soil compaction also reduces the water retention capacity of soil which requires additional irrigation and increased public water supply demand. This fact sheet provides guidance on soil amendment practices and implementation of soil amendment standards and ordinances.

Benefits / Pollution Reduction

Compost, an organic material, absorbs and infiltrates rainwater, reduces flooding and soil erosion and filters out pollutants typically associated with stormwater runoff. Compost also stores water and nutrients for plants to use during drought conditions, promoting healthy plants and better looking lawns that require less irrigation, pesticides and fertilizers. In addition, healthy amended soils that require less irrigation reduce municipal water demand.

Program Development & Implementation

Programs developed to provide volume control through soil amendments may include MS4 standards and/or ordinances. Soil amendment guidelines as well as guidelines for standards and ordinance development are identified below. The program is ultimately dependent upon several factors including the MS4's available resources, extent of development and/or redevelopment opportunities, and character of its soil and stormwater runoff.

Awareness Campaigns

Awareness campaigns inform the public, public employees, businesses, property owners, and elected officials of the negative effects of soil compaction and the benefits of soil amendments. Efforts can also contribute to generating acceptance of a new ordinance and encouraging individuals and organizations to implement soil amendments on a voluntary basis.

Brochures

Develop informative brochures, and guidance for specific audiences such as developers, businesses, homeowners and local development permitting authorities.

Signage at MS4 installations

Locate signage at parks and government buildings identifying compost-amended sites and the associated functions and benefits.

Workshops and seminars

Workshops and seminars can be used to provide the technical assistance that developers, city staff and consultants will need in order to meet a new soil amendment ordinance.

Compost delivery to a project site.

Soil Amendment Application Guidelines

Design variants are summarized below to provide guidance appropriate for implementing soil amendments within various site constraints and conditions. A good design approach will likely apply a combination of techniques at a single site based on the local conditions. There are soil and compost calculator worksheets in the Additional Resources section.

General guidance

Unless soils are native and can be left undisturbed, the following guidance applies to techniques implemented:

- Minimum final soil depth of 8 inches
- Avoiding plowing or tilling within drip line of trees
- Soil pH testing, and if necessary, adjusting proposed suite of plants

Undisturbed native soil

Areas of the site that do not need to be disturbed should be identified to protect areas of native vegetation. Fence off these areas to protect them from compaction during the construction phase.

Amend existing soil in-place

Where the soil has been compacted or the organic layer (e.g. forest duff or upper soil horizon) removed, the simplest way to restore soil quality is to rototill compost into the existing soil. Apply a 2.5-inch deep layer of compost to the existing soil. Rototill compost into the soil to a depth of at least 8 inches. Tilling to this depth will require repeated passes with a large machine, such as a tractor-mounted or heavy rear-tine rototiller.

Unrestricted flickr ® Image

Rototilling compost into the soil.

Import topsoil mix

Where subsoil is too rocky, compacted or poorly drained to amend effectively, a topsoil mix with 8-13 percent soil organic matter can be imported and placed on the surface. The topsoil mix should contain 30-40 percent compost by volume and clean sand or sandy soil to promote adequate drainage. The soil depth should be 8 inches and the pH suitable for proposed plants. Ask topsoil suppliers for test results of their product to verify the material contains the desired organic matter content and pH. For best results, plow or till compacted subsoil at least 2 inches deep before applying topsoil mix and/or rototill some of the newly applied topsoil into the subsoil.

Native soil

Sites that contain original, undisturbed native soils (most often applicable to forested land) may be stockpiled and reapplied without compost amendments after grading or other construction disturbances are completed. Remove forest duff layer and topsoil and stockpile separately prior to grading. Cover soil and duff piles with woven weed barrier (available from nursery supply stores) that sheds moisture yet allows air flow. Reapply topsoil to landscape areas to a minimum 8-inch depth after grading and other disturbances are completed. For best results, plow or till compacted subsoil at least 2 inches deep before replacing stockpiled topsoil, and/or rototill some of the replaced topsoil into the subsoil. Apply a 2-inch layer of stockpiled duff as mulch after planting.

Disturbed soil

Stockpile topsoil, reapply and amend in place. This design variant is only applicable to sites where the soil is not the original, undisturbed native soil. Topsoil and forest duff excavated for structures and paved areas or removed before site grading can be stockpiled and reapplied after grading and amended.

Remove soil and stockpile prior to grading. Cover soil with woven weed barrier (available from nursery supply stores) that sheds moisture yet allows air flow. Reapply stockpiled soil to landscape areas to a minimum 8-inch depth after grading and other disturbances are completed. In some cases, purchasing additional topsoil will be needed to achieve the 8-inch depth. Plow or till compacted subsoil at least 2 inches deep before replacing stockpiled soil, and/or rototill some of the replaced soil into the subsoil. Apply a layer of compost to the reapplied soil at a depth of 2.5 inches. Rototill compost into the soil to a depth of at least 8 inches. Tilling to this depth will require repeated passes with a large machine, such as a tractor or heavy rear-tine rototiller.

Scarification

The Minnesota Stormwater Manual recommends plowing or tilling (scarifying) compacted subsoil more than the 2 inches recommended in the above applications. For high-traffic areas, the recommended depth of scarification is 10 inches. For all other areas within the construction limits, the recommended depth of scarification is four inches.

Planting areas vs. turf areas

The Minnesota Stormwater Manual recommends a greater depth of compost, 3 inches, for planting areas than for turf areas which may be adequately amended with only 1.75 inches of compost. In all cases, the recommended minimum depth of the resulting topsoil layer with the incorporated compost is 8 inches.

Compost Specifications

When purchasing compost to be incorporated into the soil as a volume control soil amendment, look for specifications presented in the following table, adapted from Table 1 of Chapter 12-3 Runoff Volume Minimization of the Minnesota Stormwater Manual.

Parameter	Parameter Definition	Range
Source material/ Nutrient content	Typically biosolids/animal manure, source separated compostable materials or sorted yard wastes	Nitrogen: 0.5 – 3 Phosphorus: 0.5 – 1.5 Potassium: 0.5 – 1
Maturity	Level of completeness of the composting process	Seed emergence and seed vigor = minimum 80% relative to positive control
Stability	Biological activity in the composted material	CO_2 evolution rate: < 8 milligrams CO_2-C per grams organic matter per day
pH	Acidity/alkalinity	5.5 – 8.5
Soluble salts	The amount of soluble ions in a solution of compost and water	Varies widely according to source materials for compost, but should be < 10 deciSiemen per meter (millimhos per centimeter)
Organic matter	The amount of carbon-based materials	30-65% dry weight basis
Particle size	Size of particles	Pass through 1-inch screen or less
Biological contaminants	Pathogens (disease causing organisms) and weed seeds	Meet or exceed US EPA Class A standards, 40 CFR Section 503.32(2) levels
Physical contaminants	Man-made materials (like pieces of plastic or glass) that do not compose, also called 'inerts'	< 1% dry weight basis
Trace metals	Elements that can be toxic to humans, animals or plants	Meet or exceed standards for Class I compost set in Minn.R. 7035.2836, Subp. 6, (A)

Soil Amendment Ordinances

Introduce regulations whereby property owners and developers are required to provide soil amendments to any development or redevelopment site. King County, Washington, may have been the first local government to institute a clearing and grading ordinance that includes soil amendment requirements. The ordinance was first introduced in 2005 and was updated in December 2008. It serves as a good starting point for an MS4 ordinance.

"The topsoil layer shall be a minimum of eight inches thick, unless the applicant demonstrates that a different thickness will provide conditions equivalent to the soil moisture-holding capacity native to the site. The topsoil layer shall have an organic matter content of between five to ten percent dry weight and a pH suitable for the proposed landscape plants. When feasible, subsoils below the topsoil layer should be scarified at least four inches with some incorporation of the upper material to avoid stratified layers. Compost used to achieve the required soil organic matter content must meet the definition of "composted materials" in WAC 173-350-220."

Rice Creek Watershed District water quality and volume control rules are designed to account for loss of infiltration due to soil compaction during construction. As an incentive for soil amendments, the water quality and volume control benefits of compost amended soils are given credit in the rules. The District provides a corresponding soil amendment guidelines worksheet for permit applicants.

Monitoring and Assessment

The MS4 could engage in documenting the effectiveness of its soil amendment standards by conducting monitoring to see what water quality and other benefits are accomplished. Findings could provide feedback for standards/ordinance revisions.

Maintenance Considerations

Compost amended sites are maintained no differently than sites that have not been amended. However, less watering and fertilizer may be required, as well as less runoff management.

Typical Cost

Amending with compost is often the most economical way to uncompact and bring soils up to the desired soil organic matter content. On sites with the original, undisturbed, native soil and where space permits, stockpiling and reapplying topsoil may be less costly. Importing topsoil usually costs more than amending existing soil, although it may be easier where subsoil conditions make cultivation difficult. Reductions in the need for irrigation and fertilizer can provide payback for up front costs in the range of 2 to 7 years. Implementation of amended soils can also result in a cost savings due to reduced detention ponding requirements.

The adoption of a soil amendment ordinance requires an investment in training for the plan reviewer, the consultant, and possibly the public. MS4s must also consider the cost of enforcement, including staff and equipment requirements. Awareness campaign costs are determined by the type of materials produced and the method of distribution selected. Signs at city buffer installations may initially have a higher cost than printed materials, but can serve as a more effective tool for increasing public understanding.

Environmentally Preferable Purchasing

Municipal environmentally preferable purchasing

Environmentally preferable purchasing (EPP) is the conscious identification and selection of goods and services that have a lesser or reduced impact on human health and the environment when compared to similar goods and services that serve the same purpose. EPP practices can be utilized when purchasing any product utilized by a municipality in various departments from landscaping and construction materials to office supplies and food services. This fact sheet provides guidance on developing and implementing an EPP program.

Benefits / Pollution Reduction

Purchasing environmentally preferable products and services improves worker's health and safety, can reduce energy and waste disposal costs for a municipality, and keeps the environment cleaner through benefits such as lower carbon dioxide emissions, preservation of land and natural resources, and decreased waste production. EPP can protect water resources and even improve water quality in a number of ways.

Traditional products such as cleaning supplies and landscaping management supplies may contain harsh chemicals and toxins that make it to our water ways through normal use and improper dumping. Nontoxic products benefit an MS4 as they do not have associated disposal costs that toxic materials have. Additionally, some commonly used appliances such as dishwashers and fixtures such as faucets are designed to use less water thereby lessening the demand on our natural water supplies and decreasing utility bills.

By purchasing environmentally preferable products that contain little to no toxic chemicals and conserve water, you will protect your local waters as well as save on water bills and material disposal costs.

Program Development & Implementation

Purchasing Criteria

Many of the products purchased by an MS4 can impact stormwater such as pesticides, herbicides and other landscape management materials, deicing agents, and other chemicals. Stormwater friendly alternatives are available and can be sought out by an MS4. Set up criteria for your MS4 that establishes how purchasing staff should select products.

The Solid Waste Management Coordinating Board (SWMCB) has established a set of seven categories to classify how a product or service is environmentally friendly. The categories are:

- Contains less hazardous content
- Conserves energy
- Contains recycled content
- Prevents waste
- Contains low amounts of volatile organic compounds (VOCs)
- Conserves water
- Incorporates end of life management

In addition, a MS4 may want to include in their purchasing criteria items that are produced, manufactured and/or sold locally and organically, items that are fair trade and items not produced using child labor in support of social and economic sustainability. For more information and guidance on setting EPP criteria, visit the MPCA's EPP webpage: http://www.pca.state.mn.us/oea/epp/criteria.cfm.

Product Procurement

Resources are available to investigate stormwater friendly product alternatives and other items that fall under an MS4's EPP criteria. On the SWMCB Think Recycling website, there is an EPP guide specifically for government agencies with information about commonly purchased products, green alternatives, performance ratings, costs, and links to vendors. Visit the SWMCB Think Recycling website: http://www.rethinkrecycling.com/for-government.

Establish an EPP Resolution

A resolution can outline specific reasons, goals, benchmarks, criteria and policies surrounding EPP. A resolution can act as a formal guideline for municipal officials and staff when making purchasing decisions as well as provide documentation for vendors on the guidelines they must meet in order to be considered supplier of products and services. Washington County, MN, has passed board resolutions to specifically address EPP as well as sustainable building. Recycled paint and

recycled manufactured scrap shingles have been used in various asphalt applications within county operations.

Staff Training

An annual training session could be organized for staff responsible for purchasing materials and products. Training topics could include:

- EPP best practices and new EPP initiatives state wide
- Purchasing criteria and/or resources for preferred vendors
- Comparisons of purchased products and their performance
- Updates on municipal cooperative purchasing agreements
- Coordination processes between departments to facilitate bulk purchases

Dakota County, in partnership with Dakota Valley Recycling, organizes EPP workshops once a year to work with local cities and schools to incorporate EPP practices in the workplace. The MPCA also holds regular workshops about EPP.

Awareness Campaigns

In addition to changing the purchasing practices of municipal officials and staff, awareness campaigns can be focused on the purchasing practices of local businesses, institutions, and residents within a community. Through educating purchasers on environmentally preferable purchasing criteria, conscious consumers are produced that will have a great influence on the local marketplace. By demanding environmentally, socially, and economically sustainable products, manufacturers, producers, and vendors will begin to develop and sell these sought after products resulting in a more sustainable community overall. Suggested educational methods include:

Brochures

Develop informative brochures, and guidance for specific audiences such as residents, tourists, businesses, and institutions. Brochures can be made available at public establishments such as libraries and other municipal buildings, businesses and institutions. In addition, brochures can be distributed via door hangers, mailed within utility bills, or mass-mailed. The information on the brochure could also be made available on a municipality or community website. The brochures could include, but are not limited to, information about your MS4's EPP initiatives, suggested EPP criteria and practices, the environmental, social and economic benefits of EPP, and resources for additional information and potential vendors. Brochures for businesses and institutions could include information about potential cooperative purchasing agreements.

EPP workshops

Similar to the workshops organized for municipal purchasing staff discussed above, workshops could be organized for community members, business owners, and purchasing staff of local institutions. The workshops could include the training elements listed above under staff training. The workshops could be turned into product fairs that allow local vendors to highlight their environmentally preferred products.

Maintenance Considerations

A staff person could be assigned to continually investigate new products available on the market, research performance reviews of existing products, and remain knowledgeable of current EPP trends and practices.

Typical Cost

An environmentally preferable purchasing program will have development and training costs associated with it. The cost of purchasing environmentally preferable products will vary. Some products are more expensive than conventional products, however suggestions to keep the cost of these products down include:

- Entering into a cooperative purchasing agreement. The state of Minnesota has a cooperative purchasing venture (CPV) that allows certain government entities such as cities, towns and counties, to purchase goods and services through established contracts. Cities can subscribe to the CPV through the State. Alternatively, a municipality can look into forming their own cooperative purchasing agreements with environmentally preferable vendors.
- Support and train staff to coordinate product needs between departments to facilitate purchasing items in bulk.

Additional Resources

Erosion & Sediment Control Training

Training Programs

Minnesota Erosion Control Association. http://www.mnerosion.org/

South St. Louis SWCD Construction Stormwater. http://www.southstlouisswcd.org/ConstructionSW.html

University of Minnesota Erosion and Sediment Control Certification Program. http://www.erosion.umn.edu/

University of Minnesota Stormwater U. http://www.extension.umn.edu/Stormwater/stormwaterU.html

Erosion & Sediment Control

Erosion and Sediment Control Certification Training Manual – MECA, MNDOT
http://www.dot.state.mn.us/environment/pdf_files/TrnManCl.pdf

Metro Watershed Partners – MS4 Toolkit – Construction Site Stormwater Runoff Control
http://www.cleanwatermn.org/MS4-Toolkit/Construction-Site-Stormwater-Runoff-Control.aspx

Minnesota Stormwater Manual- Chapter 12 – Temporary Construction Erosion and Sediment Control Fact Sheet
http://www.pca.state.mn.us/publications/wq-strm9-01.pdf

MPCA Protecting Water Quality in Urban Areas Manual. http://www.pca.state.mn.us/water/pubs/sw-bmpmanual.html

Urban Small Sites Best Management Practice Manual – Metropolitan Council
http://www.metrocouncil.org/environment/Watershed/bmp/manual.htm

Best Management Practice (BMP) References

Erosion and Sediment Control Certification Training Manual – MECA, MnDOT
http://www.dot.state.mn.us/environment/pdf_files/TrnManCl.pdf

Metro Watershed Partners – MS4 Toolkit – Construction Site Stormwater Runoff Control
http://www.cleanwatermn.org/MS4-Toolkit/Construction-Site-Stormwater-Runoff-Control.aspx

Minnesota Department of Transportation Approved Products List.
www.mrr.dot.state.mn.us/materials/ApprovedProducts/appchart.asp#ipl

Minnesota Stormwater Manual. http://www.pca.state.mn.us/publications/wq-strm9-01.pdf

MPCA Construction Inspection Guide. http://www.pca.state.mn.us/publications/wq-strm2-10.pdf

MPCA Protecting Water Quality in Urban Areas Manual. http://www.pca.state.mn.us/water/pubs/sw-bmpmanual.html

Urban Small Sites Best Management Practice Manual – Metropolitan Council
http://www.metrocouncil.org/environment/Watershed/bmp/manual.htm

USEPA National Pollutant Discharge Elimination System (NPDES) Menu of BMPs- Construction Site Stormwater Runoff Control. http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=min_measure&min_measure_id=4

Vehicle Washing

Case Study: Equipment Wash Rack Upgrade, Prairie Dunes Country Club, Hutchinson, Kansas. http://www.audubonintemational.org/PDFs/PrairieDunesHighlight.pdf and http://www.eifg.org/portal/portal/item_download.aspx?item_id=350

City of Centralia, Washington. http://www.centraliaguide.com/centralia/departments.php?src=11

Concrete Washout Guidance. MPCA. http://www.pca.state.mn.us/publications/wq-strm2-24.pdf

Vehicle Equipment Cleaning. California Stormwater Quality Association. http://www.cabmphandbooks.com/Documents/Industrial/SC-21.pdf

Street & Parking Lot Sweeping

Deriving Reliable Pollutant Removal Rates for Municipal Street Sweeping and Storm Drain Cleanout Programs in the Chesapeake Bay Basin. Center for Watershed Protection. http://www.cwp.org/Resource_Library/Center_Docs/municipal/CBStreetSweeping.pdf

Managing Street Sweepings. MPCA. http://www.pca.state.mn.us/waste/pubs/4_54.pdf

Municipal Operation Profile Sheet MO-4: Street Sweeping. Urban Subwatershed Restoration Manual No. 9: Municipal Pollution Prevention/Good Housekeeping Practices, Version 1.0. Center for Watershed Protection. http://www.cwp.org/Store/usrm.htm#9

Pollution Prevention Fact Sheet: Parking Lot and Street Cleaning. Center for Watershed Protection. http://www.stormwatercenter.net/Pollution_Prevention_Factsheets/ParkingLotandStreetCleaning.htm

Putting Research into Practice: Resource for Implementing a Street Sweeping Best Practice. Minnesota Local Road Research Board's Research Implementation Committee (LRRB-RIC). http://www.lrrb.org/detail.aspx?productid=2254

Resource for Implementing a Street Sweeping Best Practice. Minnesota Local Road Research Board's Research Implementation Committee (LRRB-RIC). http://www.lrrb.org/detail.aspx?productid=2159

Runoff Pollution Prevention: Housekeeping: Pavement Management. Urban Small Sites Best Management Practice Manual. Metropolitan Council. http://www.metrocouncil.org/environment/water/BMP/manual.htm

Selbig, W. R and Bannerman, R. T. (2007). Evaluation of Street Sweeping as a Stormwater-Quality-Management Tool in Three Residential Basins in Madison, Wisconsin. USGS Scientific Evaluation. http://www.cityofmadison.com/engineering/stormwater/documents/FinalReport1.pdf

Urban Subwatershed Restoration Manual No. 11: Unified Subwatershed and Site Reconnaissance: A User's Manual, Version 2.0. Center for Watershed Protection. http://www.cwp.org/Store/usrm.htm#11

Park & Open Space Fertilizer/Chemical Application Programs

Pesticides

Pesticides and Aquatic Animals: A Guide to Reducing Impacts on Aquatic Systems. Virginia Cooperative Extension. http://www.ext.vt.edu/pubs/waterquality/420-013/420-013.html#L18

Pesticide Applicator Licensing. MDA. http://www.mda.state.mn.us/licensing/pestfert/pesticideapplicator.htm

Pesticide Environmental Stewardship Program (PESP). EPA. http://www.epa.gov/oppbppd1/pesp/

Pesticide Resources. University of Minnesota Extension.
http://www.extension.umn.edu/pesticides/pesticides/pesticideresources.html

Pesticide Safety and Environmental Education. University of Minnesota Extension.
http://www.extension.umn.edu/PESTICIDES/commercial.html

Urban Subwatershed Restoration Manual No. 8: Pollution Source Control Practices, Version 2. Chapter 5, Neighborhood Stewardship Profile Sheet N-2: Reduced Pesticide Use. Center for Watershed Protection.
http://www.cwp.org/Store/usrm.htm#8

Fertilizers

Fertilizer Licensing. MDA. http://www.mda.state.mn.us/licensing/pestfert/fertilizer.htm

Urban Subwatershed Restoration Manual No. 8: Pollution Source Control Practices, Version 2. Chapter 5, Neighborhood Stewardship Profile Sheet N-1: Reduced Fertilizer Use. Center for Watershed Protection.
http://www.cwp.org/Store/usrm.htm#8

Yard Care and the Environment: Lawn and Garden Fertilizers. Wisconsin Department of Natural Resources and University of Wisconsin-Extension. http://www.epa.gov/nps/toolbox/other/wiexfertilizer.pdf

Winter Road Materials Management

Minnesota Snow and Ice Control: Field Handbook for Snowplow Operators. University of Minnesota Center for Transportation Studies, Minnesota Department of Transportation, Minnesota Local Road Research Board.
http://www.mnltap.umn.edu/pdf/snowicecontrolhandbook.pdf

Minnesota Stormwater Manual, Chapter 9 Cold Climate Impact on Runoff Management.
http://www.pca.state.mn.us/water/stormwater/stormwater-manual.html

MPCA Road Salt Education Program. MPCA. http://www.pca.state.mn.us/programs/roadsalt.html

Primer: Road Salt and Snow and Ice Control. Transportation Association of Canada.
http://www.tac-atc.ca/english/resourcecentre/readingroom/pdf/saltprimer.pdf

Road Salt Advocacy Project. Canadian Public Works Association. http://www.cpwa.net/advocacy.asp?mode=cat&cat=21

Salt Institute™ Education Center. http://www.saltinstitute.org/Education-Center

Synthesis of Best Practices Road Salt Management, Chapter 1.0 Salt Management Plans. Transportation Association of Canada. http://www.tac-atc.ca/english/resourcecentre/readingroom/pdf/roadsalt-1.pdf

Understanding Water Quality Impacts: Road Salt. Lakesuperiorstreams.
http://www.lakesuperiorstreams.org/understanding/impact_salt.html

Winter Parking Lot and Sidewalk Maintenance Manual. MPCA and Others.
http://www.pca.state.mn.us/publications/parkinglotmanual.pdf

Storm Drain Stenciling

Supplies: The MPCA does not endorse or promote any the companies listed below. This information is provided as a courtesy. There may be others that provide these same services.

C&R Stencils. http://www.crstencils.com/

Cast Iron Messages. East Jordan Iron Works. http://www.ejiw.com/construction-and-municipal-castings-19/

das Curb Markers®. Das Manufacturing, Inc. http://www.dasmanufacturing.com/storm_drain.html

Storm Drain Markers. Almetek Industries, Inc. http://www.almetek.com/

Program Guidance

Delaware Storm Drain Marking Program. State of Delaware.
http://www.swc.dnrec.delaware.gov/Drainage/Pages/StormDrainMarking.aspx

North Carolina Storm Drain Stenciling Project. North Carolina State University.
http://www.bae.ncsu.edu/bae/programs/extension/wqg/smp-18/stormdrain/

Storm Drain Marking. EPA.
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=browse&Rbutton=detail&bmp=15

Storm Drain Marking: Preventing Water Pollution in Your Community. Texas Commission on Environmental Quality.
http://www.tceq.state.tx.us/files/gi-212.pdf_4447189.pdf

Storm Drain Stenciling. Friends of the Mississippi River. http://www.fmr.org/participate/ongoing/stenciling

Storm Drain Stenciling. Water Action Volunteers, University of Wisconsin Extension.
http://watermonitoring.uwex.edu/wav/stenciling/index.html

Storm Drain Stenciling Guide and Waiver of Liability Form. University of Minnesota Extension Service.
http://www.cleanwatermn.org/app_themes/cleanwater/pdfs/GetInvolved_InNeighborhood/StormDrainStencilingGuide.pdf

Storm Drain Stenciling: How You Can Prevent Water Pollution. University of Wisconsin-Extension.
http://clean-water.uwex.edu/pubs/pdf/storm.drain.pdf

Storm Drain Stenciling in North Carolina: A Local Government's Guide to Storm Drain Stenciling. North Carolina Sea Grant and North Carolina State University. http://www.bae.ncsu.edu/bae/programs/extension/wqg/smp-18/stormdrain/localgov.html

Urban Subwatershed Restoration Manual No. 8: Pollution Source Control Practices, Version 2. Chapter 5, Neighborhood Stewardship Profile Sheet N-21: Storm Drain Marking. Center for Watershed Protection.
http://www.cwp.org/Store/usrm.htm#8

Residential Waste Collection and Clean-Up Programs

Waste Collection

City of Bloomington, MN, Citywide Curbside Cleanup
http://www.ci.bloomington.mn.us/cityhall/dept/pubworks/mainten/garbage/curbside/curbside.htm

Pay-as-you-throw Recycling and Other Complimentary Programs- EPA
http://www.epa.gov/epawaste/conserve/tools/payt/top16.htm

Ramsey County, MN, Yard Waste Collection. http://www.co.ramsey.mn.us/ph/rt/brush_compost_yardwaste.htm

Awareness Campaigns

Managing Leaves and Yard Trimmings – UW Extension. http://clean-water.uwex.edu/pubs/pdf/home.managlt.pdf

Metro Watershed Partners- MS4 Toolkit – Lawn Care and Landscaping for Clean Water
http://www.cleanwatermn.org/MS4-Toolkit/Public-Education-and-Outreach/Landscaping-for-Clean-Water.aspx

Spring Tips for Lawns and Lakes – Metro Watershed Partners
http://www.cleanwatermn.org/app_themes/cleanwater/pdfs/GetInvolved_AtHome/Lawn_care_article.pdf

Clean-up Programs

Carter Lake Preservation Society Annual Lake Clean-up. http://www.carterlakepreservation.org/id12.html

City of Oakdale, MN, Adopt-A-Wetland Program. http://www.ci.oakdale.mn.us

Potential Discharge Identification & Risk Reduction

Additional Rouge River illicit discharge elimination materials related to this study.
http://cfpub.epa.gov/npdes/stormwater/casestudies_specific.cfm?case_id=8

Illicit Discharge Detection and Elimination Guidance Manual. Center for Watershed Protection and University of Alabama.
http://www.cwp.org/Resource_Library/Controlling_Runoff_and_Discharges/idde.htm

Illicit Discharge Detection and Elimination Program Development. EPA.
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=browse&Rbutton=detail&bmp=111&minmeasure=3

Model Illicit Discharge and Connection Stormwater Ordinance. The Stormwater Manager's Resource Center of the Center for Watershed Protection.
http://www.stormwatercenter.net/Model%20Ordinances/Final%20Illicit%20Connection%20Ordinances/illicit_discharge_model_ordinanc.htm

The Rouge River Project: Overview Description of Illicit Discharge Elimination Program. Michigan.
http://www.rougeriver.com/techtop/illicit/overview.html

Urban Subwatershed Restoration Manual No. 8: Pollution Source Control Practices, Version 2. Chapter 3: Finding Pollution Sources in Your Subwatershed. Center for Watershed Protection. http://www.cwp.org/Store/usrm.htm#8

Hazardous Material Storage & Handling

Hazardous Materials Storage. EPA.
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=browse&Rbutton=detail&bmp=105

Secondary Containment for Aboveground Storage Tanks. MPCA. http://www.pca.state.mn.us/publications/t-a4-01.pdf

Spill Prevention, Control and Countermeasure (SPCC) Regulation, 40 CFR 112. EPA.
http://www.epa.gov/emergencies/docs/oil/spcc/spccbluebroch2002.pdf

Spill Prevention and Planning. MPCA. http://www.pca.state.mn.us/publications/c-er1-02.pdf

The Hazardous Waste Compliance Guide. MPCA. http://www.pca.state.mn.us/publications/w-hw5-25.pdf

Urban Subwatershed Restoration Manual No. 8: Pollution Source Control Practices, Version 2. Center for Watershed Protection. http://www.cwp.org/Store/usrm.htm#8

Urban Subwatershed Restoration Manual No. 9: Municipal Pollution Prevention/ Good Housekeeping Practices, Version 1. Center for Watershed Protection. http://www.cwp.org/Store/usrm.htm#8

Reducing Pet Waste

EPA National Menu of Stormwater Best Management Practices. Pet Waste Management.

http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=4

EPA Source Water Protection Practices Bulletin**:** Managing Pet and Wildlife Waste to Prevent Contamination of Drinking Water. http://www.epa.gov/safewater/sourcewater/pubs/fs_swpp_petwaste.pdf

San Diego County, CA – Pet Waste Brochure.
http://www.co.san-diego.ca.us/dpw/watersheds/watershedpdf/pet_waste.pdf

Stormwater Center – Pollution Prevention Fact Sheet: Animal Waste Collection
http://www.stormwatercenter.net/Pollution_Prevention_Factsheets/AnimalWasteCollection.htm

Septic System Maintenance Programs

Brown, Laurie, et al. *Septic System Owner's Guide*. Minnesota Extension Service, University of Minnesota. St. Paul, MN. Revised 2008. http://www.extension.umn.edu/distribution/naturalresources/DD6583.html

Handbook for Managing Onsite and Clustered (Decentralized) Wastewater Treatment Systems, US EPA, December 2005.
http://cfpub.epa.gov/owm/septic/septic.cfm?page_id=289

How to Manage and Maintain your Septic System – University of MN, Water Resource Center
http://septic.umn.edu/owners/maintenance/index.htm

MPCA (2004), Detailed Assessment of Phosphorus Sources to Minnesota Watersheds. Prepared by Barr Engineering.
http://www.pca.state.mn.us/hot/legislature/reports/phosphorus-report.html

MPCA Webage – Minnesota's Subsurface Sewage Treatment Systems Program.
http://www.pca.state.mn.us/programs/ists/index.html

MN Statute 115.55 INDIVIDUAL SEWAGE TREATMENT SYSTEMS.
https://www.revisor.leg.state.mn.us/statutes/?id=115.55

SMRC – Pollution Prevention Fact Sheet: Septic System Controls
http://www.stormwatercenter.net/Pollution_Prevention_Factsheets/SepticSystemControls.htm

US EPA, 2003. Voluntary National Guidelines for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems, March 2003. http://www.epa.gov/owm/septic/pubs/septic_guidelines.pdf

Open Space Design

Better Site Design: A Handbook for Changing Development Rules in Your Community. Center for Watershed Protection (CWP). http://www.cwp.org/Resource_Library/Better_Site_Design/

Design Open Space: the Fields of St. Croix. Robert Engstrom Companies. http://www.engstromco.com/prev_fields

Environmental Protection Agency (EPA), 2007. Reducing Stormwater Cost through Low Impact Development (LID) Strategies and Practices. EPA publication number 841-F-07-006. http://www.epa.gov/owow/nps/lid/costs07/

Green Values® Stormwater Calculator. Green Values® Stormwater Toolbox. http://greenvalues.cnt.org/

Lakeville Low Impact Development Study (2006), Friends of the Mississippi River, Dakota County and the Minnesota Department of Natural Resources. http://www.fmr.org/projects/lakeville_lid_study

Low Impact Development. EPA. http://www.epa.gov/nps/lid/

Low Impact Development Center, Inc. http://www.lowimpactdevelopment.org

Low Impact Development for Businesses. MPCA. http://www.pca.state.mn.us/programs/sbeap-lid.html

Minnesota Stormwater Manual, Chapter 4: Better Site Design. Minnesota Stormwater Steering Committee, Minnesota Pollution Control Agency. http://www.pca.state.mn.us/water/stormwater/stormwater-manual.html

Mohamed, R. 2006. The Economics of Conservation Subdivisions: Price Premiums, Improvement Costs, and Absorption Rates. Urban Affairs Review, 41(3): 376-399. http://www.greenerprospects.com/EconomicsOfConservationSubdivisions-1.pdf

Prince George's County, Maryland, Department of Environmental Resources
http://www.goprincegeorgescounty.com/Government/AgencyIndex/DER/index.asp

Protecting Water Resources with Higher-Density Development. Environmental Protection Agency.
http://www.epa.gov/dced/water_density.htm

Schueler, T. 1995. Site Planning for Urban Stream Protection. Center for Watershed Protection. Ellicott City, MD.
http://www.cwp.org/Resource_Library/Better_Site_Design/

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