

Stormwater runoff from new development and redevelopment projects can significantly impact receiving water quality due to both an increase in stormwater runoff quantity and a decrease in water quality. The main cause of these impacts is due to an increase in impervious surfaces and necessitates the implementation of long-term stormwater management after construction is complete. Long-term stormwater management includes implementation of best management practices (BMPs) and routine maintenance.

An increase in impervious surfaces causes stormwater runoff to be conveyed directly to a receiving water, disrupting the natural processes of infiltration and percolation. Consequently, larger volumes of runoff cause streambank scouring and downstream flooding. This often leads to a loss of aquatic habitat and property damage. Stormwater pollutants increase in developed areas as runoff flows over altered areas, picks up harmful pollutants and carries these to receiving waters. These pollutants can alter habitat and may be toxic to aquatic life.

Salt Lake County implements a Stormwater Management Plan that includes a Long-term Stormwater Management Program (previously referred to as the Post-Construction Stormwater Management in New Development and Redevelopment Program). This program is in the development stage.

The primary users of this guidance document will be property owners, developers, contractors, engineers, and public agencies who are involved in construction and land disturbance activities. Municipal departments that oversee these activities will also find this guidance document useful. The Industrial and Municipal chapters should also be referenced as applicable.

The primary sources of information for this section include EPA (http://cfpub1.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=min_measure&min_measure_id=5), the Urban Drainage and Flood Control District (Denver, CO <http://www.udfcd.org/>) and the California Stormwater Quality Association

(<http://www.casqa.org/Home/tabid/36/Default.aspx>).

Contact the Salt Lake County Department of Engineering and Flood Control for more information.

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POLLUTANTS OF CONCERN

The pollutants of concern in developed areas are similar to those caused by construction activities and include sediment, nutrients, pesticides, heavy metals, and oil and grease. These pollutants are primarily due both to an increase in impervious surfaces and other human activities such as landscape maintenance. The following sections address stormwater runoff from developed areas and the associated impacts to receiving waters.

Sediment

Sediment is one of the most common pollutants in stormwater runoff (Shaver, et al., 2007). Sediment in stormwater runoff typically comes from the transport of particulate material from impervious surfaces, particularly streets and parking lots, as well as from active construction sites. Sediment can also be transported from lawns and landscaped areas.

Excessive sediment in water can cause increased turbidity and reduced light penetration, resulting in impaired vision for aquatic life, clogging of fish gills, and a reduction in aesthetic values. In addition, other substances such as nutrients, heavy metals, and hydrocarbons tend to attach to sediment and in turn are transported with the sediment.

Nutrients

While nutrients, such as nitrogen and phosphorus, are essential elements in aquatic ecosystems, excessive levels of nutrients are found in stormwater runoff and can be detrimental to lakes, rivers and streams. The main source of these pollutants comes from fertilizers used in landscape maintenance. Other

sources of nutrients in stormwater include failing septic systems and atmospheric deposition from industrial facilities. Excessive discharge of nutrients into waterways may result in algae growth which can cause odor problems and reduce the dissolved oxygen available to fish and other aquatic life.

Chlorides

Chlorides are salt compounds that are found in runoff due to road de-icing operations. High chloride levels can cause human illness and can be toxic to plants and animals.

Metals

Metals are another common pollutant found in stormwater runoff. These pollutants include chromium, copper, lead and zinc, and are associated with industrial activities and vehicle maintenance. Metals tend to be associated with fine particulate matter and are deposited on rooftops, roads and parking lots. Elevated levels of metals can be harmful to aquatic life.

Oils and Greases

Oil and grease contain a wide array of hydrocarbon compounds, some of which are toxic to aquatic organisms at low concentrations. The main source of these pollutants in urban areas is from cars (vehicle fluids) in parking lots or on streets. Additional hydrocarbon sources include gas stations and industrial activities.

Bacteria

Bacteria are also a common pollutant in stormwater runoff in urban areas. Sources include failing septic systems and pet waste. Some bacteria can be harmful to human health, preventing recreational activities and fish consumption.

Organic Pollutants

These pollutants include pesticides and herbicides that are commonly used in landscape maintenance. Some of these compounds are known carcinogens and can be toxic to humans and aquatic life.

Table 1 presents a list of common stormwater

pollutants.

WATER RESOURCES IMPACTS

As mentioned above, development results in an increase in impervious surfaces, disrupting the natural runoff cycle of infiltration. In addition to an increase in stormwater pollutants, changes to stream hydrology and habitat occur. Some of these changes are identified in Table 2.

Table 2 Summary of Development Impacts on Water Resources

Increases in:	Decreases in:
Impervious cover, compacted soils, managed turf, and other land covers that contribute pollutants	Health and safety of receiving waters
Stormwater volume	Groundwater recharge
Stormwater velocity	Stream channel stability
Pollutant loads	Health, safety, and integrity of water supplies, reservoirs, streams and biological communities
Stream channel erosion	Stream habitat

EPA, 2008

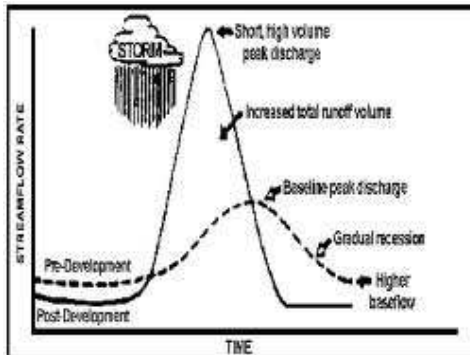
Urban development can also impact stream hydrographs. Post-development stormwater discharges can increase runoff volume, increase peak discharges and decrease the infiltration of stormwater, which results in decreases in baseflow in headwater streams. These changes impact channel stability and the health of aquatic habitats. Common problems include bank scouring and erosion, increased downstream flooding and loss of habitat (Figure 1).

Table 1 Common Urban Runoff Pollutant Sources

Pollutant Category Source	Solids	Nutrients	Pathogens	Dissolved Oxygen Demands	Metals	Oils	Synthetic Organics
Soil erosion	X	X		X	X		
Cleared vegetation	X	X		X			
Fertilizers		X	X	X			
Human waste	X	X	X	X			
Animal waste	X	X	X	X			
Vehicle fuels & fluids	X			X	X	X	X
Fuel combustion						X	
Vehicle wear	X			X	X	X	X
Industrial & household chemicals	X	X		X	X	X	X
Industrial processes	X	X		X	X	X	X
Paints & preservatives					X	X	X
Pesticides				X	X	X	X
Stormwater facilities w/out proper maintenance	X	X	X	X	X	X	X

Adapted from Horner, et al., 1994

Figure 1 Urban Development Impacts to Stream Hydrology



POLICY

Communities are beginning to view stormwater management as an opportunity to improve the environment, create attractive public and private spaces, and engage the community in environmental stewardship. While in the past, municipal flood control departments focused on adequate drainage, the current trend involves more sophisticated programs that incorporate

channel protection, groundwater recharge, protection of receiving waters, and control of runoff. Some communities are implementing ordinances specifically relating to stormwater, both quality and quantity, and in some cases, are requiring post-development hydrology to mimic that of pre-development.

Salt Lake County ordinance, Title 17, Chapter 17.22 was developed for the purpose of minimizing stormwater impacts caused by construction, residential and municipal activities, and new development and redevelopment. Long-term stormwater management requirements in this ordinance include submittal of as-built plans, landscaping and stabilization requirements, and provides the County access to inspect facilities and take enforcement actions.

Salt Lake County implements a Stormwater Management Plan (SWMP) as required by the Utah Division of Water Quality. This SWMP

contains numerous BMPs to be implemented in accordance with the Utah Pollutant Discharge Elimination System (UPDES) stormwater discharge permit. The SWMP includes a Long-term Stormwater Management Program that requires plan review and approval by the County, as well as BMP maintenance requirements.

Salt Lake County encourages the use of low impact development (LID) approaches to long-term stormwater management. The goal of

LID strategies is to control stormwater at its source and to restore the natural ability of an urban site to infiltrate stormwater. Examples of LID strategies include rain gardens, rainwater harvesting, green roofs, porous pavement, and many more. These techniques are described in more detail in the information sheets at the end of this chapter.

SITE PERFORMANCE STANDARDS

Site performance standards are required by permit and are intended to ensure that the site hydrology associated with new development mirrors the pre-development hydrology; or to improve hydrology at a redevelopment site, and to reduce the discharge of stormwater. EPA is developing performance standards for long-term BMPs, however, these standards will not be finalized until the end of 2012. In the meantime, the County recommends consideration of the options listed below in order to meet the intent of this requirement. These options may be used in combination, depending on the site conditions. This section will be modified once the performance standards are finalized by EPA.

- 1) Design, construct and maintain stormwater BMPs that manage rainfall on-site, and prevent the off-site discharge of precipitation from the first one inch of rainfall from a 24-hour storm preceded by 48 hours of no measurable precipitation.
- 2) Design, construct and maintain stormwater BMPs that manage rainfall on-site, and prevent off-site discharge of the precipitation

from all rainfall events less than or equal to the 90th percentile rainfall event. In Salt Lake County, the 90th percentile rainfall event is 0.6 inches.

- 3) Design, construct and maintain stormwater BMPs that preserve the pre-development runoff conditions following construction. The post-construction rate, volume, duration and temperature of discharges must not exceed the pre-development rates and the pre-development hydrograph for 1, 2, 10, 25, 50 and 100 year storms must be replicated through site design and other appropriate practices.
- 4) The project must comply with one of the following two groundwater recharge requirements:
 - a. Demonstrate through hydrologic and hydraulic analysis that the site and its stormwater management measures maintain 100 percent of the average annual pre-construction groundwater recharge volume for the site; or
 - b. Demonstrate through hydrologic and hydraulic analysis that the increase of stormwater discharges volume from pre-construction to post-construction for the two-year storm is infiltrated.
- 5) Minimize total impervious cover resulting from new development and redevelopment to 10% of disturbed land cover and/or limit total amount of effective impervious surface to no more than 5% of the landscape.

BEST MANAGEMENT PRACTICES

Implementation and maintenance of long-term Best Management Practices (BMPs) following construction activities is critical to minimizing impacts caused by stormwater runoff and for watershed protection. The purpose of the BMPs in this chapter is to reduce the volume of runoff and the pollutants entrained in the runoff.

It is important to recognize that there are techniques to reduce stormwater impacts before it is generated and pollutants are conveyed to the storm drain system. These BMPs are relatively simple and can decrease costs

associated with stormwater treatment and problems caused by the change in stream hydrology.

EPA recommends a hierarchy of stormwater treatment methods for consideration:

- 1) **Reduce runoff through design:** Use site planning and design techniques to reduce impervious cover, disturbed soils and stormwater impacts. Techniques such as conservation design, protecting critical open space and natural drainage features and disconnecting a site’s impervious cover will serve to reduce the generation of runoff.
- 2) **Reduce pollutants carried by runoff:** Use source control and pollution prevention practices to reduce the exposure of pollutants to rainfall. Examples include cleaning impervious surfaces, homeowner education, proper handling and storage of chemicals, and collecting and recycling hazardous chemicals.
- 3) **Capture and treat runoff:** Design and implement stormwater BMPs to collect and treat runoff. BMPs can be both large and small-scale practices and should incorporate low impact development techniques.

Stormwater BMPs are often classified into two categories: source controls and treatment controls. Typically, no one BMP can provide the necessary stormwater controls, and are implemented as a “treatment train”, providing several techniques to achieve a particular goal in stormwater management.

SOURCE CONTROLS

Controlling pollutants at their source is fundamental to effective stormwater quality management. Typically, it is easier and more cost-effective to prevent stormwater pollution than to remove contaminants once they have entered the storm drain system or receiving water.

A source control BMP can be a structural component of a planned site (e.g. low impact design) or a procedural BMP (e.g. public

education, staff training, ordinances). The intent is to prevent or minimize the discharge of stormwater pollutants at the source as opposed to removing stormwater pollutants through treatment. Many of these BMPs have been implemented nationwide, are recommended by EPA, and are included in the County’s Stormwater Management Plan.

TREATMENT CONTROLS

Engineered and constructed systems are designed to improve the quality and/or control the quantity of runoff. Such systems incorporate infiltration, filtration, or retention/detention to provide necessary treatment or quantity control.

Structural BMPs are used to treat stormwater at either the point of generation or the point of discharge to a storm drain system or a receiving water. Examples of these include infiltration basins, detention ponds, constructed wetlands, bioretention, sand filters, and many more.

BMP SELECTION

The selection of long-term BMPs is a complex process and should be incorporated into a comprehensive stormwater management program. Without proper selection, design, installation and maintenance, stormwater BMPs will not be effective.

The selection process is similar to that for construction sites: a three step process as shown below. Refer to “Use of BMP Information Sheets” at the end of this section for specific selection information.

Define BMP Objectives: Determine what performance standard will be utilized at the site and determine necessary requirements.

Identify BMP Design Specifications: Select the appropriate category or categories of BMPs which address the objectives and take into consideration site constraints and other considerations.

Select the appropriate BMPs: BMPs are often selected from each category based on site

constraints, maintenance requirements, and cost-effectiveness considerations.

Define BMP Objectives

The State of Utah Division of Water Quality issues permits for the discharge of municipal stormwater. This permit requires the implementation of a Long-term Stormwater Management Program with the goal of maintaining pre-development runoff conditions. Consequently, a thorough understanding of each site is necessary to select appropriate BMPs. BMP objectives should be based on the Site Selection Standards discussed above.

Table 3 provides general guidance on evaluating appropriate BMPs.

Identify BMP Design Specifications

The identification of BMP specifications is an important component of a long-term stormwater management program. These specifications influence BMP performance, appearance, safety, maintenance requirements and community benefits. Applying these specifications will serve to ensure the right stormwater BMPs are implemented. Specifications applicable to long-term BMPs include (EPA, 2008):

- *Site Requirements/Feasibility:* Ensure the selected BMP is used in the appropriate setting: consider contributing drainage area,

slope, available head, soil infiltration rate, depth to groundwater & depth to bedrock.

- *Conveyance:* Consider plumbing into and out of the BMP and its connection to the storm drain system. Prevent erosion at inlets and outlets, provide safe overflow and adequate conveyance for storms that exceed the water quality volume.
- *Pretreatment:* Pretreatment is necessary for all types of structural BMPs to ensure adequate pollutant removal and to minimize maintenance requirements.
- *Treatment:* Evaluate treatment requirements including water quality volume, geometry, flow path, media and residence time.
- *Landscaping:* Consider the community benefits of enhancing the appearance of the BMP. Landscaping plans and maintenance requirements should be developed where applicable.
- *Safety:* Evaluate safety hazards of BMPs and mitigate appropriately.
- *Maintenance:* Consider methods to reduce the maintenance burden of BMPs and make maintenance tasks easier to perform.

Select Appropriate BMPs

Many BMPs can be utilized in various

Table 3 BMP Selection Considerations

Provide reliable pollutant removal performance	The BMP should employ a sequence of pollutant removal mechanisms that maximize the removal of key pollutants of concern. BMP performance can be evaluated on the basis of removal efficiency, effluent concentration, and the documentation of pollutant removal design features (e.g., pretreatment, filtering, settling).
Have a sustainable maintenance burden	Both routine and non-routine maintenance tasks should promote longevity, and the life cycle costs should be manageable so that future owners can maintain the BMP.
Be acceptable to the public	The BMP should be viewed by adjacent residents and business owners as an attractive community amenity and/or landscape feature that adds to rather than detracts from property values.
Confer multiple community benefits	The BMP should do more than just treat stormwater; it should also promote community greening, recreation, and stormwater education.
Creatively use vegetation	The BMP should use trees and vegetation to promote cooling, shading, screening, and other landscape functions and should avoid the extensive use of irrigated turf.
Create habitat but reduce nuisances	The BMP should create both aquatic and terrestrial habitat and should be designed to avoid nuisance problems such as resident geese and mosquito breeding.
Have no unanticipated negative impacts on the environment	The BMP should not create any negative environmental impacts, such as stream warming or groundwater contamination.

EPA, 2008

applications and are often used in treatment trains (linear flow through multiple BMPs). This should be taken into consideration when selecting BMPs to achieve maximum cost-effectiveness, while at the same time, minimizing maintenance costs.

MONITORING BMP PERFORMANCE

Once the BMPs have been selected and implemented, it is important to routinely monitor how well the BMPs work and to evaluate whether additional BMPs are required.

Routine inspections and maintenance are necessary to ensure proper BMP operation and protection of surface water quality. The Utah municipal stormwater discharge permit requires inspections by County employees at least once during installation and on an annual basis thereafter, or every five years if the property owner or operator is conducting BMP maintenance. In this case, the owner/operator must conduct annual inspections. Maintenance must be conducted in accordance with BMP specifications. A maintenance agreement must be developed in cases where the owner/operator will be conducting BMP maintenance.

REGULATORY PERMITS

Stormwater discharges and storm drainage systems are regulated and permitted by various agencies. These agencies control design of systems, discharge quantities and locations and other aspects of stormwater runoff. Below is a brief description of permits and regulations which apply to stormwater discharges.

Stormwater discharges from construction activities. A Utah Pollutant Discharge Elimination System (UPDES) Permit is required from the Utah Division of Water Quality.

Stormwater discharges to Salt Lake County Flood Control System. Prior to construction of a stormwater drainage system, approval of a Salt Lake County Flood Control permit is required from Salt Lake County Engineering Division.

Outfalls into Waters of the U.S. For system outfalls which discharge stormwater into waters of the U.S., a stream alteration/404 joint permit may be required from the Utah State Engineer's Office.

Local Municipalities Approval. Site drainage is approved at the local level by the municipality who maintains jurisdiction over the site. Generally, drainage design, system and discharge requirements are approved prior to construction.

REFERENCES

California Stormwater Quality Association, 2004. *Stormwater Best Management Practice (BMP) Handbooks*.

EPA website:

http://cfpub1.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=min_measure&min_measure_id=5

Environmental Protection Agency, 2001. *Storm Water Technology Fact Sheet On-Site Underground Retention/Detention*. Office of Water. EPA 832-F-01-005.

Environmental Protection Agency, 2008. *Managing Stormwater in Your Community A Guide for Building an Effective Post-Construction Program*. Developed by Center for Watershed Protection. EPA Publication No: 833-R-08-001.

Environmental Protection Agency, 2010. *MS4 Permit Improvement Guide*. Office of Wastewater Management Water Permits Division. EPA 833-R-10-001.

Horner, R.R., J.J. Skupien, E.H. Livingston and H.E. Shaver, 1004. *Fundamentals of Urban Runoff Management: Technical and Institutional Issues*. Washington, DC: Terrene Institute and EPA.

Shaver, et. al., 2007. *Fundamentals of Urban Runoff Management: Technical and Institutional Issues*. EPA.

Urban Drainage and Flood Control District, 2010. *Urban Storm Drainage Criteria Manual Volume 3, Best Management Practices*.

Van Metre, P.C. and Mahler, B.J., 2003. *The contribution of particles washed from rooftops to contaminant loading to urban streams*. In: *Chemosphere* 52 (2003), pages 1727 – 1741.

USE OF BEST MANAGEMENT PRACTICE (BMP) INFORMATION SHEETS

The BMP Information Sheets attached are compiled from research and review of existing documents. These BMPs are presented as accepted practices currently in use nationwide. Variations from BMPs described herein will be acceptable, provided implemented controls meet the intent of Best Management Practices for controlling stormwater pollution.

Each information sheet is organized into three main sections:

- Heading
- Fast Facts
- Main Body

HEADING

The title of the BMP is provided in the upper left-hand corner.

FAST FACTS

This section identifies the objectives of the BMP, installation information, pollutants

targeted by the BMP, and an indication of the level of effort and costs to implement.

MAIN BODY

The main body in each BMP sheet contains the following information:

- description of the BMP;
- applications;
- implementation;
- limitations; and
- maintenance.

DECISION MATRIX

The BMPs for long-term stormwater management are listed in Table 4. This matrix is provided to give the user a relatively easy way to identify applicable BMPs. The user should understand that the matrix is only a guide and should not be used in place of sound engineering judgment.

Table 4 BMP Decision Matrix

Source Control BMPs	Pg.	BMP Applicability				
		Residential	Commercial Activities	Industrial Activities	Municipal Activities	Illegal Discharge
Alternative Turnarounds	S-1	X	X	X	X	
BMP Inspection and Maintenance	S-2	X	X	X	X	
Conservation Easements	S-3	X	X	X		
Development Districts	S-4	X	X	X		
Efficient Irrigation	S-5	X	X		X	
Eliminating Curbs and Gutters	S-6	X				
Green Parking	S-7		X	X	X	
Green Roofs	S-8		X	X	X	
Infrastructure Planning	S-9	X	X	X	X	
Landscape Planning	S-10	X	X		X	
Landscape Maintenance	S-11	X	X		X	
Low Impact Development	S-12	X	X	X	X	
Narrower Residential Streets	S-13	X				
Open Space Design	S-14	X	X	X	X	
Pesticides, Herbicides & Fertilizers	S-15	X	X	X	X	X
Post-construction Plan Reviews	S-16	X	X	X	X	
Protection of Natural Features	S-17	X	X	X	X	
Redevelopment	S-18	X	X	X	X	
Riparian/Forested Buffer	S-19	X	X	X	X	
Roof Runoff	S-20	X	X	X	X	
Storm Drain Signs	S-21					X
Street Design and Patterns	S-22	X				
Urban Forestry	S-23		X	X	X	
Zoning	S-24	X	X	X	X	

Treatment Control BMPs	Pg.	BMP Criteria						
		Soils	Area Required	Slope	Water Availability	Aesthetics	Hydraulic Head	Environmental Side Effects
Alum Injection	T-1		X					
Bioretention	T-2	X		X	X	X	X	X
Catch Basin Inserts	T-3	X		X	X	X	X	X
Constructed Wetland Channels	T-4	X	X	X	X	X		
Constructed Wetlands	T-5	X	X	X	X	X		
Dry Detention Ponds	T-6	X	X	X			X	X
Grass Buffer	T-7	X	X	X	X	X		
Grassed Swales	T-8	X	X	X	X	X	X	X
Infiltration Basin	T-9	X	X	X			X	X
Infiltration Trench	T-10	X	X	X			X	X
In-line Storage	T-11			X				
Manufactured Products	T-12						X	
On-lot Treatment	T-13	X						
On-site Underground Retention/Detention	T-14	X					X	
Outlet Structures	T-15							
Permeable Pavement Systems	T-16	X				X		X
Sand and Organic Filters	T-17	X		X		X	X	X
Vegetated Filter Strip	T-18	X				X		
Wet Ponds	T-19	X	X	X		X		

SOURCE CONTROL BMP Alternative Turnarounds



DESIGN OBJECTIVES

- | | |
|---|---|
| <input type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

Alternative turnarounds are end-of-street vehicle turnarounds that reduce impervious cover in neighborhoods by replacing the more traditional cul-de-sacs. Cul-de-sacs create a large impervious area; some have more than a 40-foot radius, thus increasing the amount of runoff. Reducing the size of cul-de-sacs, either by alternative turnarounds or by elimination, can reduce the amount of impervious cover created at the site. Examples of alternatives include reducing the radius of the cul-de-sac, hammerhead or loop roads, and pervious islands in the cul-de-sac's center.

APPLICATIONS:

- ▶ Alternative turnarounds can be applied to residential, commercial and mixed-use developments.

IMPLEMENTATION:

- ▶ Consider necessary turnaround area.
- ▶ Costs may be lower than traditional cul-de-sacs due to the decrease in pavement required.

LIMITATIONS:

- ▶ May be limited by local regulations due to the requirements of emergency vehicles.

MAINTENANCE:

- ▶ If a center island is constructed, vegetation maintenance is necessary.

SOURCE CONTROL BMP BMP Inspection and Maintenance

DESIGN OBJECTIVES

- | | |
|--|---|
| <ul style="list-style-type: none"> <input checked="" type="checkbox"/> Maximize Infiltration <input checked="" type="checkbox"/> Provide Retention <input checked="" type="checkbox"/> Slow Runoff <input checked="" type="checkbox"/> Minimize Impervious Cover | <ul style="list-style-type: none"> <input type="checkbox"/> Prohibit Dumping of Improper Materials <input type="checkbox"/> Contain Pollutants <input type="checkbox"/> Collect and Convey |
|--|---|

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

- High Medium Low



DESCRIPTION:

Regular inspections and maintenance of post-construction BMPs are critical to the performance and effectiveness of these measures. Without this, captured stormwater pollutants can be re-entrained or pass through the BMP. This BMP refers to routine maintenance to ensure proper operation, and repair maintenance to fix problems prior to the next storm event.

APPLICATIONS:

- ▶ Applicable to owners and operators of small municipal separate storm sewer system (MS4) facilities that are responsible for implementing BMP inspection and maintenance programs and having penalties in place to deter infractions.

IMPLEMENTATION:

- ▶ All stormwater BMPs should be inspected on a regular basis for continued effectiveness and structural integrity.
- ▶ Some structural BMPs may require more frequent inspection to ensure proper operation.
- ▶ All BMPs should be checked after each storm event. In some cases, such as vegetative or infiltration BMPs, the after storm inspection should occur after the expected drawdown period to allow the inspector to see if the BMPs are draining properly.
- ▶ Inspections and follow-up actions should be documented. Development of inspection checklists would be beneficial.

LIMITATIONS:

- ▶ Most tools necessary for BMP maintenance are readily available; however, some materials necessary for emergency structural repairs may be more difficult. Consideration should be given to stockpiling essential materials for this purpose.

MAINTENANCE:

- ▶ Routine maintenance and non-routine repair should be conducted according to a schedule or as soon as a problem is identified, as many BMPs are ineffective if not installed and maintained properly.

SOURCE CONTROL BMP Conservation Easements



DESIGN OBJECTIVES

- | | |
|---|---|
| <input type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

Conservation easements are voluntary agreements that allow individuals or groups to limit the type or amount of development on their property. A conservation easement can cover all or just a portion of a property and it can either be permanent or temporary. Easements typically describe the resource they are designed to protect (e.g., agricultural, forest, historic, or open space easements), and they explain and mandate the restrictions on the uses of the particular property. An important benefit to an easement is to relieve property owners of the burden of managing these areas; the responsibility can be a private organization (land trust) or government agency, which would be better equipped to handle maintenance and monitoring issues. In addition, tax benefits might be given to property owners who place conservation easements on some or all of their property.

An easement can act as a vegetated buffer that filters-out pollutants from stormwater runoff. The ability of a conservation easement to function as a stream buffer depends on the width of the easement and in what vegetated state the easement is maintained.

APPLICATIONS:

- ▶ This BMP is typically aimed at preserving agricultural lands and natural areas threatened by development.
- ▶ May be a way to preserve open space before land prices make the purchase of land impractical.

IMPLEMENTATION:

- ▶ Determine feasibility of conservation easement agreement: consider natural resource value, uniqueness of property, size of property, financial issues, perpetuity, and mission of land trust.
- ▶ Address easement holder responsibilities: language is clear and enforceable, develop maps and property descriptions, have easement listed on property deed, monitor the use of the land, provide easement information to new property owners, establish review and approval process for land activities, maintain easement-related records.

LIMITATIONS:

- ▶ Usually not an option in highly urbanized areas due to the lack of available space and the high cost of undeveloped land.

MAINTENANCE:

- ▶ Responsibility for the property maintenance may be either the land trust agency or the property owners.

SOURCE CONTROL BMP

Development Districts



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DESIGN OBJECTIVES

- | | |
|---|---|
| <input type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

■ High ☒ Medium □ Low

DESCRIPTION:

Development Districts are special zoning districts created for the purpose of permitting property development. These districts are generally larger in size (5 or more acres), with the intent to concentrate development to a smaller footprint than would otherwise be necessary. In addition, these districts require complex and coordinated rezoning, transportation and planning efforts. This compact development tends to reduce transportation needs, so that not only is there less impervious cover, but there is also a reduction of some sources of stormwater pollutants.

APPLICATIONS:

- ▶ This BMP is applicable on a regional level, in ultra-urban areas and as a stormwater retrofit.

IMPLEMENTATION:

- ▶ When considering a development district for stormwater quality attributes, take into account: compact project and community design, street design and transportation options, and mixed uses.

LIMITATIONS:

- ▶ Subdivision regulations or drainage district requirements may impede plans to establish a mix of uses or higher densities.

MAINTENANCE:

- ▶ Maintenance plans will vary with design elements.

SOURCE CONTROL BMP

Efficient Irrigation

DESIGN OBJECTIVES

- | | |
|---|---|
| <ul style="list-style-type: none"> <input checked="" type="checkbox"/> Maximize Infiltration <input checked="" type="checkbox"/> Provide Retention <input checked="" type="checkbox"/> Slow Runoff <input type="checkbox"/> Minimize Impervious Cover | <ul style="list-style-type: none"> <input type="checkbox"/> Prohibit Dumping of Improper Materials <input type="checkbox"/> Contain Pollutants <input type="checkbox"/> Collect and Convey |
|---|---|

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low



DESCRIPTION:

Irrigation water provided to landscaped areas may result in excess irrigation water being conveyed into stormwater drainage systems. Development plans should include careful consideration of irrigation systems to minimize runoff of excess irrigation water into the stormwater conveyance systems. This BMP also serves to conserve water usage.

APPLICATIONS:

- ▶ Applicable to residential, commercial and industrial areas planned for development or redevelopment.

IMPLEMENTATION:

- ▶ Use rain-triggered shutoff devices to prevent irrigation after precipitation.
- ▶ Design irrigation systems to each landscaped area's specific water requirements.
- ▶ Implement water conservation plans that may include water sensors, programmable irrigation times, etc.
- ▶ Group plants with similar water requirements; use plants with low irrigation requirements.
- ▶ Park strips are difficult to irrigate without waste of water; consider alternative landscape techniques for these areas.

LIMITATIONS:

- ▶ Must be in compliance with local regulations.

MAINTENANCE:

- ▶ Maintenance of vegetation as appropriate.

SOURCE CONTROL BMP Eliminating Curb and Gutters



DESIGN OBJECTIVES

- | | |
|---|---|
| <input checked="" type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High
 Medium
 Low

DESCRIPTION:

This BMP utilizes grass swales as an alternative to the typical curb and gutter design. Curbs and gutters are only designed to convey stormwater and can also be a source of stormwater pollutants. Whereas grass swales provide an opportunity for infiltration of stormwater.

APPLICATIONS:

- ▶ Most applicable in low- and medium-density residential zones where soils, slope and housing density permit its use.

IMPLEMENTATION:

- ▶ Siting and design must consider the contributing drainage area, slope, soils, depth to groundwater, and development density.

LIMITATIONS:

- ▶ May require a revision to existing regulations that require the use of curb and gutters.
- ▶ Not feasible in areas with high traffic volumes or extensive on-street parking demand.
- ▶ Reduced applicability in arid or semi-arid climates where irrigation would be necessary.

MAINTENANCE:

- ▶ Vegetation maintenance.
- ▶ Sediment deposits may need to be removed from the swale approximately once every 10 years.

SOURCE CONTROL BMP Green Parking

DESIGN OBJECTIVES

- | | |
|--|--|
| <input checked="" type="checkbox"/> Maximize Infiltration
<input type="checkbox"/> Provide Retention
<input type="checkbox"/> Slow Runoff
<input checked="" type="checkbox"/> Minimize Impervious Cover | <input type="checkbox"/> Prohibit Dumping of Improper Materials
<input checked="" type="checkbox"/> Contain Pollutants
<input type="checkbox"/> Collect and Convey |
|--|--|

IMPLEMENTATION REQUIREMENTS

-
- Capital Costs
-
-
- O&M Costs
-
-
- Maintenance
-
-
- Training

High Medium Low



DESCRIPTION:

Green parking refers to several techniques that are intended to reduce the amount of impervious cover. Examples of these techniques include: setting maximums for the number of parking lots created; minimizing the dimensions of parking lot spaces; utilizing alternative pavers in overflow parking areas; using bioretention areas to treat stormwater; encouraging shared parking; and providing economic incentives for structured parking.

APPLICATIONS:

- ▶ These techniques can be applied in new developments and in redevelopment projects.

IMPLEMENTATION:

- ▶ Parking lot designs should be based on the average parking demand instead of the maximum demand to minimize impervious cover.
- ▶ Reducing parking stall size reduces the overall size of the lot.
- ▶ Use of alternative pavers reduces runoff volumes and can provide a water quality benefit.
- ▶ Bioretention areas provide treatment when the runoff is directed into a shallow, landscaped area, where it is temporarily detained.
- ▶ Shared and structured parking can reduce impervious cover by 1) sharing a lot instead of constructing two lots which typically works well when peak demand is different, and 2) structured parking minimizes the need for surface parking.

LIMITATIONS:

- ▶ Limitations include applicability, cost and maintenance.

MAINTENANCE:

- ▶ Alternative pavers require cleaning.
- ▶ Vegetation maintenance in bioretention areas.

SOURCE CONTROL BMP

Green Roofs



DESIGN OBJECTIVES

- | | |
|---|---|
| <input checked="" type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input checked="" type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

Green roofs can be effectively used to reduce stormwater runoff from rooftops. In contrast to traditional asphalt or metal roofing, green roofs absorb, store, and later evapotranspire initial precipitation, thereby acting as a stormwater management system and reducing overall peak flow discharge to the drainage system. These roofs serve to reduce impervious areas associated with building footprints, and may absorb up to 50% of rainfall. Furthermore, conventional roofing can act as a source for numerous toxic pollutants including lead, zinc, pyrene, and chrysene (Vane Metre and Mahler, 2003).

APPLICATIONS:

- ▶ Can be utilized for commercial, industrial and residential buildings.
- ▶ Can be applied to new construction or retrofitted to existing construction.
- ▶ Applicable in all parts of the country – green roofs provide additional building insulation in areas with extreme temperatures.

IMPLEMENTATION:

- ▶ The slope of green roofs can range from 0 to 40 degrees.
- ▶ May be designed to provide public access.
- ▶ Roof must be able to support the loading from a saturated roof.
- ▶ Materials for green roofs include a waterproofing layer, a soil or substrate layer, and a plant layer.
- ▶ Selected plants for planting need to be suited for local climate conditions.

LIMITATIONS:

- ▶ In most climates, green roofs will need to have drought tolerant plant species or an irrigation system.

MAINTENANCE:

- ▶ Upon completion of roof, regular monitoring of the vegetation is necessary to ensure plantings are successful.
- ▶ Watering is required during the first season if precipitation is not sufficient.
- ▶ Following the first season, vegetation should be inspected and fertilized approximately once/year.
- ▶ Occasional weeding and watering may be necessary.
- ▶ Repair leaks.

SOURCE CONTROL BMP Infrastructure Planning

DESIGN OBJECTIVES

- | | |
|---|---|
| <ul style="list-style-type: none"> <input type="checkbox"/> Maximize Infiltration <input type="checkbox"/> Provide Retention <input type="checkbox"/> Slow Runoff <input checked="" type="checkbox"/> Minimize Impervious Cover | <ul style="list-style-type: none"> <input type="checkbox"/> Prohibit Dumping of Improper Materials <input type="checkbox"/> Contain Pollutants <input type="checkbox"/> Collect and Convey |
|---|---|

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low



DESCRIPTION:

Infrastructure planning involves changes in the regional growth planning process to contain the more typical 'sprawl' development. Sprawl development requires local governments to extend public services to new residential communities whose tax payments often do not cover the cost of providing those services. Whereas, infrastructure planning makes decisions to locate utilities and other services in the suburban fringe and discourage low-density development. Generally, this is done by drawing a boundary around a community, beyond which major public infrastructure investments are discouraged or not subsidized. In addition, economic and other incentives are provided within the boundary to encourage growth in existing neighborhoods. By encouraging housing growth in areas that are already provided with public services, communities not only save infrastructure development costs, but reduce the impacts of sprawl development on urban streams and water quality. The main reason for this reduction is due to a decrease in impervious cover.

APPLICATIONS:

- ▶ Applicable in all areas of the nation.

IMPLEMENTATION:

- ▶ Examples of techniques to manage urban growth include Urban Growth Boundaries (planning tool that defines where a growth limit is to occur and where agricultural or rural land is to be preserved), and Infill/Community Redevelopment (encourages new development in unused or underutilized urban areas through tax breaks of other incentives).

LIMITATIONS:

- ▶ Requires a coordinated effort between impacted communities in order to be successful.

MAINTENANCE:

- ▶ Not applicable.

SOURCE CONTROL BMP Landscape Maintenance



DESIGN OBJECTIVES

- | | |
|--|--|
| <input type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Collect and Convey |
| <input type="checkbox"/> Provide Retention | <input type="checkbox"/> Prohibit Illicit Discharges |
| <input type="checkbox"/> Slow Runoff | <input checked="" type="checkbox"/> Contain Pollutants |
| <input type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

■ High ☒ Medium □ Low

DESCRIPTION:

Proper landscape maintenance is important to reduce nutrient and chemical loading to the storm drain system, reduce nuisance flows and standing water in stormwater BMPs, and to maintain healthy vegetation. Examples of maintenance activities that will serve to minimize stormwater pollutants include mowing, aeration, fertilization and irrigation.

APPLICATIONS:

- ▶ Applicable to residential, commercial, municipal, and some industrial areas.

IMPLEMENTATION:

- ▶ Public education regarding landscape maintenance should include the following key points:
 - Keep lawn clipping and debris out of the gutters; mulch-mowing turf at a height of 2.5 to 3 inches to help develop deeper root systems; minimize thatch development by mowing at appropriate frequencies and heights for the grass type, avoid overwatering and over fertilization, and aerating the turf.
 - Lawn aeration reduces soil compaction and serves to move water and fertilizer into the root zone; aerate once or twice/year, but not when it is extremely hot and dry; don't use spike-type aerators, holes should be 2 to 3 inches deep and no more than 2 to 4 inches apart; thoroughly water day before.
 - Only apply nutrients that the plants can use; follow manufacturer's directions; conduct soil testing to determine needs; utilize split applications of slow-release fertilizers; keep fertilizers off hard surfaces (streets and sidewalks); water turf following fertilization; avoid fertilizing before heavy rainfall forecast; don't fertilize near wells or waterbodies (6 to 10 feet away).
 - Determine water needs to supplement normal rainfall; irrigate lawn uniformly until soil is moist to a depth of 4 to 6 inches; maintain irrigation system to prevent waste; consider use of "Smart" irrigation controllers and weather sensors;

LIMITATIONS:

- ▶ Must be in compliance with local regulations.

SOURCE CONTROL BMP Landscape Planning



DESIGN OBJECTIVES

- | | |
|---|---|
| <input checked="" type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input checked="" type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input checked="" type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

Landscape Planning takes into consideration land suitability for urban uses, as well as community goals and projected growth. The intent is to conserve natural areas, maximize natural water storage and infiltration opportunities and protect slopes and channels. This BMP may be integrated with other source control BMPs and serves to minimize surface and groundwater contamination from stormwater pollution.

APPLICATIONS:

- ▶ Applicable to residential, commercial and industrial areas planned for development or redevelopment.

IMPLEMENTATION:

- ▶ Map and assess land suitability for urban uses.
- ▶ Maintain natural storage reservoirs and drainage corridors.
- ▶ Evaluate infiltration opportunities.
- ▶ Avoid disturbance of steep or unstable slopes

LIMITATIONS:

- ▶ Must be in compliance with local regulations.

MAINTENANCE:

- ▶ Maintenance of vegetation.

SOURCE CONTROL BMP

Low Impact Development

DESIGN OBJECTIVES

- | | |
|---|---|
| <input checked="" type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input checked="" type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input checked="" type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- | |
|---|
| <input checked="" type="checkbox"/> Capital Costs |
| <input type="checkbox"/> O&M Costs |
| <input checked="" type="checkbox"/> Maintenance |
| <input type="checkbox"/> Training |

■ High Medium Low



DESCRIPTION:

Low impact development and other green design strategies refers to a number of methods designed to mimic natural hydrology prior to development, and is intended to control stormwater at its source.

APPLICATIONS:

- ▶ Can be applied across the nation.
- ▶ Integrates small-scale measures scattered throughout the development site to reduce peak runoff through infiltration, evaporation or collection.

IMPLEMENTATION:

- ▶ Examples of techniques to manage urban growth include Urban Growth Boundaries (planning tool that defines where a growth limit is to occur and where agricultural or rural land is to be preserved, and Infill/Community Redevelopment (encourages new development in unused or underutilized urban areas through tax breaks or other incentives).
- ▶ Methods include minimizing the distance between land uses to decrease infrastructure requirements, conserve forests and green spaces, protect stream buffers, narrow roads and sidewalk widths, reducing parking lot sizes, minimize or remove cul-de-sacs, etc.

LIMITATIONS:

- ▶ Some methods may be restricted by local codes (e.g. cul-de-sac turning radius for emergency vehicles).

MAINTENANCE:

- ▶ Some methods will require maintenance, such as bioretention systems, green roofs, porous pavement, grassed swales, etc.

SOURCE CONTROL BMP

Narrower Residential Streets



DESIGN OBJECTIVES

- | | |
|---|---|
| <input type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

This method promotes the narrowing of streets to reduce the amount of impervious cover created by new residential development, which serves to reduce runoff volume and pollutant loading. Typical residential street widths provide two parking lanes and two moving lanes, but they provide more parking than is necessary. Whereas, designing narrower streets will reduce the amount of impervious surface without sacrificing emergency access, on-street parking, or vehicular and pedestrian safety.

APPLICATIONS:

- ▶ Can be used in residential developments generating less than 500 or fewer average daily trips, or for streets generating 500 to 1,000 average daily trips.

IMPLEMENTATION:

- ▶ Designing narrower streets requires a balancing of different objectives, such as design, speed traffic volume, emergency access, etc.

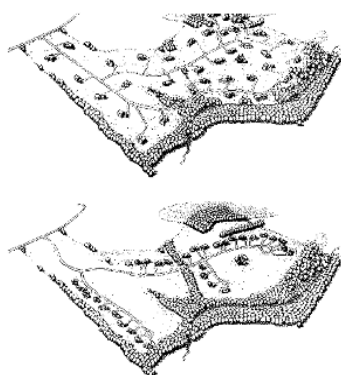
LIMITATIONS:

- ▶ Most communities require wide residential streets as a standard element of their local road and zoning standards.

MAINTENANCE:

- ▶ Maintenance is reduced due to the smaller surface area to maintain and repair.

SOURCE CONTROL BMP Open Space Design



DESIGN OBJECTIVES

- | | |
|---|---|
| <input type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

Open space design, also known as conservation development or cluster development, is a design technique that concentrates residential units in a compact area of the development site in exchange for providing open space and natural areas elsewhere on the site. The minimum lot sizes, setbacks and frontage distances for the residential zone are relaxed in order to create the open space at the site. These designs have several benefits, such as reducing impervious cover, stormwater pollutants, construction costs, grading, and the loss of natural areas.

APPLICATIONS:

- ▶ Applicable to most forms of residential development.
- ▶ Can be implemented across the nation.

IMPLEMENTATION:

- ▶ Should develop ordinances for open space areas.
- ▶ Typically reserves 25 to 50 percent of the development site as green space.

LIMITATIONS:

- ▶ May be necessary to revise local codes to allow for smaller lot sizes.

MAINTENANCE:

- ▶ Maintenance of open space vegetation.

SOURCE CONTROL BMP

Pesticides, Herbicides and Fertilizers



DESIGN OBJECTIVES

- | | |
|--|---|
| <input type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Collect and Convey |
| <input type="checkbox"/> Provide Retention | <input checked="" type="checkbox"/> Prohibit Illicit Discharges |
| <input type="checkbox"/> Slow Runoff | <input checked="" type="checkbox"/> Contain Pollutants |
| <input type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

Various chemicals used for landscape maintenance must be properly applied, stored, handled and disposed of to prevent contamination of surface and ground waters. These chemicals include pesticides, herbicides, fertilizers, fuel, etc. Misuse of pesticides and herbicides can result in adverse impacts to aquatic life, even at low concentrations. Misuse of fertilizer can result in increased algae growth in waterbodies due to excessive phosphorus and nitrogen loading.

APPLICATIONS:

- ▶ Applicable to residential, commercial and municipal areas.

IMPLEMENTATION:

- ▶ Public education regarding the use of these chemicals is necessary to ensure proper application and to minimize the release of these chemicals into storm drains or groundwater. Some of the key education points include:
 - Application of fertilizers, pesticides, and other chemicals according to manufacturer's directions.
 - Application of pesticides and herbicides only when needed and use in a manner to minimize off-target effects.
 - Accurately diagnose the pest; know characteristics of the application site, including soil type and depth to groundwater.
 - Employ application techniques that increase efficiency and allow the lowest effective application rate.
 - Keep pesticide and fertilizer equipment properly calibrated according to the manufacturer's instructions and in good repair.
 - All mixing and loading operations must occur on an impervious surface.
 - Do not apply pesticides or herbicides during high temperatures, windy conditions or immediately prior to heavy rainfall or irrigation.
 - Storage areas should be secure and covered, preventing exposure to rain and unauthorized access.
 - Store chemicals in their original containers, tightly closed, with labels intact. Regularly inspect them for leaks. Storage and maintenance areas, and vehicle refueling and maintenance areas should be located away from wells and surface waterbodies in accordance with local regulations, typically at least 50 to 100 feet away.

LIMITATIONS:

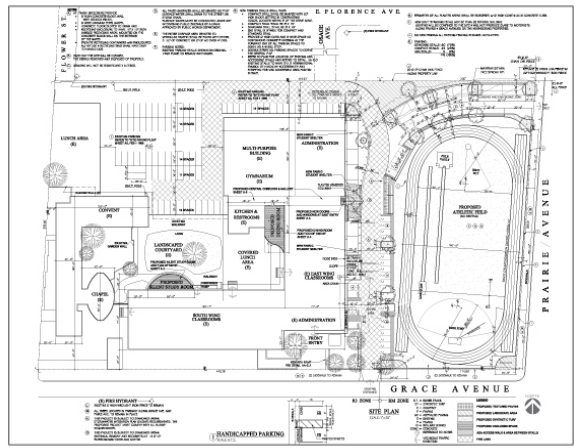
- ▶ Must be in compliance with local regulations.

MAINTENANCE:

- ▶ Should be in compliance with manufacturer's instructions.

SOURCE CONTROL BMP

Post-construction Plan Review



DESIGN OBJECTIVES

- Maximize Infiltration
- Provide Retention
- Slow Runoff
- Minimize Impervious Cover
- Prohibit Dumping of Improper Materials
- Contain Pollutants
- Collect and Convey

IMPLEMENTATION REQUIREMENTS

- Capital Costs
 - O&M Costs
 - Maintenance
 - Training
- High Medium Low

DESCRIPTION:

Considering water quality impacts early in the design process of a development project can provide long-term water quality benefits. A thorough review of development plans that incorporates both structural and non-structural stormwater BMPs is essential to minimizing impacts to stormwater quality caused by development. Ensuring proper installation and long-term operation and maintenance of stormwater BMPs is an important component to a stormwater management plan.

APPLICATIONS:

- ▶ Provide training with regards to low impact development and post-construction BMPs.
- ▶ Require pre-submittal meetings with developers/engineers.
- ▶ Review conceptual and design plans.

IMPLEMENTATION:

- ▶ Include a pre- and post-development hydrologic analysis.
- ▶ Identify low impact development opportunities.
- ▶ Identify pollutants of concern and pollution prevention measures.
- ▶ Identify controls that provide treatment and reduce stormwater volume and velocity.
- ▶ Ensure provisions are made for long-term operation and maintenance of controls .

LIMITATIONS:

- ▶ Difficult to implement without staff training.

MAINTENANCE:

- ▶ Routine maintenance and non-routine repair should be conducted according to a schedule or as soon as a problem is identified, as many BMPs are ineffective if not installed and maintained properly.

SOURCE CONTROL BMP

Protection of Natural Features

DESIGN OBJECTIVES

- | | |
|---|---|
| <input checked="" type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low



DESCRIPTION:

Protection of natural features such as wetlands, riparian areas and floodplains during the development of a site serves to provide environmental, aesthetic, and recreational benefits. Protection of natural areas can also occur in property redevelopment. Protection of these features can be considered an amenity to the development.

APPLICATIONS:

- ▶ Applicable to most forms of residential development.

IMPLEMENTATION:

- ▶ Use a combination of site planning techniques, construction site BMPs, and measures employed after the site is in use.
- ▶ Utilize techniques such as clustering buildings and using smaller lots, shared driveways, and narrower streets.
- ▶ Developers should implement prohibitions and training to ensure these areas are not impacted during construction.
- ▶ May consider use of conservation easements.

LIMITATIONS:

- ▶ Local zoning codes might restrict the use of clustering, reduced road widths, and other techniques for natural area preservation.

MAINTENANCE:

- ▶ Maintenance of natural features specific to the area.

SOURCE CONTROL BMP Redevelopment

DESIGN OBJECTIVES

- | | |
|---|---|
| <input checked="" type="checkbox"/> Maximize Infiltration
<input type="checkbox"/> Provide Retention
<input checked="" type="checkbox"/> Slow Runoff
<input checked="" type="checkbox"/> Minimize Impervious Cover | <input type="checkbox"/> Prohibit Dumping of Improper Materials
<input type="checkbox"/> Contain Pollutants
<input type="checkbox"/> Collect and Convey |
|---|---|

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low



DESCRIPTION:

Redevelopment of existing properties with impervious surfaces can be a key opportunity to reduce impervious surfaces. In watersheds that are experiencing growth, the reuse of impervious surface mitigates developmental impacts that would be experienced elsewhere. Redevelopment can occur on individual sites, and can also be part of a larger effort of revitalize older properties, thereby protecting undeveloped areas from development. Redevelopment also provides the opportunity to retrofit stormwater BMPs.

APPLICATIONS:

- ▶ Applicable in urban, suburban and rural areas.

IMPLEMENTATION:

- ▶ Consideration should be given to economic factors, such as location to amenities and proximity to transit.

LIMITATIONS:

- ▶ Typically requires larger, regional cooperation.

MAINTENANCE:

- ▶ Maintenance of stormwater BMPs.

SOURCE CONTROL BMP Riparian/Forested Buffer



DESIGN OBJECTIVES

- | | |
|---|---|
| <input checked="" type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input type="checkbox"/> Provide Retention | <input checked="" type="checkbox"/> Contain Pollutants |
| <input checked="" type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

These buffers refer to an area along a waterbody or wetland in which development is restricted or prohibited. Buffers vary in size, and protect and separate the area from future disturbance or encroachment, and provide protection of the ecosystems and habitats. There are three types of buffers: water pollution hazard setbacks, vegetated buffers, and engineered buffers. All of these buffer types are designed to protect the waterbody and/or provide stormwater treatment.

APPLICATIONS:

- ▶ Can be implemented in any area of the country.
- ▶ Benefits are increased if managed in a forested condition.

IMPLEMENTATION:

- ▶ Buffers can be applied to new developments by establishing specific preservation areas; maintenance can be conducted through easements or community associations.
- ▶ For existing developed areas, an easement may be needed from adjoining landowners. A local ordinance can help set specific criteria for buffers to achieve stormwater management goals.
- ▶ Generally, a 100 foot buffer is recommended to provide adequate stream protection.
- ▶ Establishing a three-zone buffer system, consisting of inner, middle, and outer zones, distinguished by function, width, vegetative target and allowable uses is recommended.

LIMITATIONS:

- ▶ Buffers must be engineered correctly to prevent channel flow, otherwise stormwater treatment is reduced.

MAINTENANCE:

- ▶ Develop a buffer management plan to establish, manage and make distinctions of allowable and prohibited uses within the zones.
- ▶ Buffer boundaries should be well defined and visible before, during and after construction.
- ▶ Vegetation maintenance as applicable.

SOURCE CONTROL BMP

Roof Runoff Controls



DESIGN OBJECTIVES

- | | |
|---|---|
| <input checked="" type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input checked="" type="checkbox"/> Provide Retention | <input checked="" type="checkbox"/> Contain Pollutants |
| <input checked="" type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

Roof runoff controls refers to a variety of methods used to address stormwater that drains off rooftops. The objective is to reduce the total volume and rate of runoff and retain the pollutants on site that may be picked up from roofing materials and atmospheric deposition. Roof runoff controls consist of directing the roof runoff away from paved areas and mitigating flow to the storm drain system.

APPLICATIONS:

- ▶ Applicable to residential (single and multi-family homes), commercial and industrial areas planned for development or redevelopment.

IMPLEMENTATION:

- ▶ Runoff can be redirected from impervious surfaces by utilizing: cisterns or rain barrels, dry wells, pop-up emitters, and foundation planting.
- ▶ Collected water can be reused for irrigation purposes, which also serves as a water conservation measure.

LIMITATIONS:

- ▶ Must be in compliance with local regulations.
- ▶ Implement methods for vector control (e.g. minimizing standing water).

MAINTENANCE:

- ▶ Maintenance of vegetation as appropriate.

SOURCE CONTROL BMP Storm Drain System Signs



DESIGN OBJECTIVES

- | | |
|--|---|
| <input type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Collect and Convey |
| <input type="checkbox"/> Provide Retention | <input checked="" type="checkbox"/> Prohibit Illicit Discharges |
| <input type="checkbox"/> Slow Runoff | <input type="checkbox"/> Contain Pollutants |
| <input type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

Identifying storm drain system inlets can serve to discourage illegal or illicit discharges into the system. Signs can be stenciled or may be stickers designed to inform the public that these are drains for stormwater that may impact surface water quality.

APPLICATIONS:

- ▶ Applicable to residential, commercial and industrial areas planned for development or redevelopment.

IMPLEMENTATION:

- ▶ Could be part of the project design.
- ▶ Some cities encourage signs as part of volunteer efforts, for example, Boy Scout projects.
- ▶ Marker or sign should be placed in clear sight facing toward anyone approaching the inlet from either side.
- ▶ Salt Lake County has information packets available for residents where signs are placed providing general stormwater information.

LIMITATIONS:

- ▶ Type of sign needs to take into consideration snow plows and street sweepers.

MAINTENANCE:

- ▶ Stencils may need to be repainted on a periodic basis.
- ▶ Stickers or markers will need to be replaced every few years.

SOURCE CONTROL BMP Street Design and Patterns

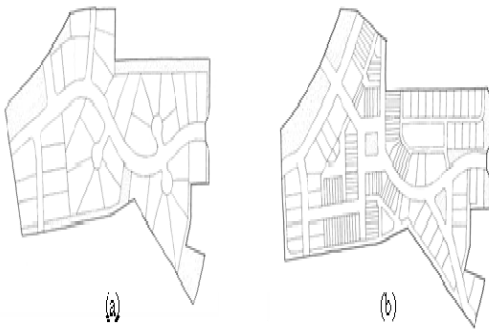
DESIGN OBJECTIVES

- | | |
|---|---|
| <input type="checkbox"/> Maximize Infiltration
<input type="checkbox"/> Provide Retention
<input type="checkbox"/> Slow Runoff
<input checked="" type="checkbox"/> Minimize Impervious Cover | <input type="checkbox"/> Prohibit Dumping of Improper Materials
<input type="checkbox"/> Contain Pollutants
<input type="checkbox"/> Collect and Convey |
|---|---|

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low



DESCRIPTION:

This BMP refers to street designs and patterns that take into consideration stormwater by reducing the amount of impervious surface in residential and commercial areas. An example of this concept is “Smart Growth Street Designs” which are based on a network of well-connected streets that support multiple transportation modes. Some smart growth approaches to street design include decreasing street widths, adjusting the vehicular level of service (LOS), creating LOS for other modes of transportation, and designing connected street networks to support multiple uses.

APPLICATIONS:

- ▶ Applicable to residential and mixed-use land uses, both in new developments and as a retrofit.
- ▶ Also applicable on a regional level.

IMPLEMENTATION:

- ▶ Coordination with local transportation department is necessary to ensure design meets code.
- ▶ Need to consider requirements of emergency vehicles.

LIMITATIONS:

- ▶ Developers are more accustomed to traditional street patterns and may resist changes.
- ▶ Storage of accumulated snow should be taken into consideration.

MAINTENANCE:

- ▶ Typical street maintenance requirements.
- ▶ Maintenance of stormwater BMPs incorporated into the design.

SOURCE CONTROL BMP

Urban Forestry



DESIGN OBJECTIVES

- | | |
|---|---|
| <input checked="" type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input checked="" type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

The purpose of this BMP is to break up a landscape of impervious cover by providing small green spaces, and to link walkways and trails. Successful urban forestry requires a conservation plan for individual trees as well as forests of a designated size. An ordinance is one technique for achieving conservation and should include specific measures to protect and manage these areas. These areas can help reduce stormwater management needs in urban areas.

APPLICATIONS:

- ▶ Applicable in urban and suburban areas.

IMPLEMENTATION:

- ▶ Tree preservation areas need to be clearly marked; delineating lines along a critical root zone is preferable to a straight line.
- ▶ Ordinance should include a requirement to develop an urban forestry plan with measures to establish, conserve or re-establish preservation areas.
- ▶ Utilize native vegetation.

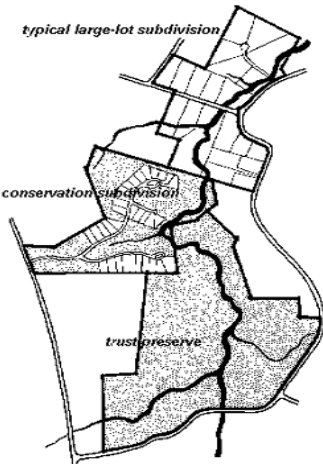
LIMITATIONS:

- ▶ Pressure to develop these areas is the main issue with this BMP.
- ▶ Attraction of undesirable insects and other pests.

MAINTENANCE:

- ▶ Fringe landscaping and trash pick-up.

SOURCE CONTROL BMP Zoning



DESIGN OBJECTIVES

- | | |
|---|---|
| <input checked="" type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input checked="" type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input checked="" type="checkbox"/> Slow Runoff | <input checked="" type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

■ High ☒ Medium □ Low

DESCRIPTION:

Incorporating better site design into land use planning zoning can serve to mitigate runoff problems. By applying the right zoning technique, development can be targeted at specific areas, limiting development in and providing protection for the most important land conservation areas. Examples of zoning techniques for better site design include watershed-based zoning, overlay zoning, floating zones, incentive zoning, performance zoning, urban growth boundaries, etc.

APPLICATIONS:

- ▶ The type of zoning will depend on management goals. Watershed-based zoning can provide a comprehensive approach if water or land quality is the primary goal, whereas, incentive zoning, performance zoning and transfer of development rights can be used for specific conservation areas.

IMPLEMENTATION:

- ▶ Steps for implementation are dependent on the zoning type. For example, for watershed-based zoning, a comprehensive stream inventory should be conducted; for impervious overlay zoning, the environmental impacts of future impervious cover is estimated and a limit is set for the maximum imperviousness.

LIMITATIONS:

- ▶ Some zoning techniques may be limited by economic and political acceptance.

MAINTENANCE:

- ▶ Review of the estimates and projections should be conducted periodically.

TREATMENT CONTROL BMP

Alum Injection



CONSIDERATIONS

- Soils
- Area Required
- Slope
- Water Availability

- Aesthetics
- Hydraulic Head
- Environmental Side Effects

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High
 Medium
 Low

DESCRIPTION:

Alum injection is the process of adding aluminum sulfate salt – alum, to stormwater, which allows for the removal of fine particles. This process can remove other pollutants that are adhered to particles, such as phosphorus. Alum treatment systems generally consist of three parts, a flow-weighted dosing system that fits inside a storm sewer manhole, remotely located storage tanks that provide alum to the doser, and a downstream pond that allows the alum, pollutants and sediments to settle out. When injected into stormwater, alum forms the harmless precipitates aluminum phosphate and aluminum hydroxide. These precipitates combine with heavy metals and phosphorus and sink into the sediment in a stable, inactive state (EPA website).

APPLICATIONS:

- ▶ Due to the high installation and operation costs, alum injection is most effective when applied to large volumes of water stored in one area.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Requires a doser system, and chemical storage tanks.
- ▶ Dosage rates are determined on a flow-weighted basis during storm events.
- ▶ Requires a downstream settling basin, as well as a separate floc collection pump-out facility.
- ▶ Disposal of floc may include the sanitary sewer system (with approval by the treatment plant), a nearby upland area, or a sludge drying bed.

LIMITATIONS:

- ▶ This BMP requires ongoing operation, unlike most other post-construction stormwater treatment practices.
- ▶ Does not control flows or prevent channel erosion.
- ▶ Chemicals added during the alum injection process may have negative effects on downstream waters.
- ▶ Requires disposal of the accumulated floc.

MAINTENANCE:

- ▶ Routine inspection and repair of equipment, including the doser and pump-out facility.
- ▶ A trained operator should be on-site to adjust the dosage of alum and other chemicals, and possibly to regulate flows through the basin.
- ▶ Floc stored on-site in drying beds will need to be disposed of regularly.
- ▶ The settling basin must be dredged periodically to dispose of accumulated floc.



TREATMENT CONTROL BMP

Bioretention



CONSIDERATIONS

- Soils
- Area Required
- Slope
- Water Availability
- Aesthetics
- Hydraulic Head
- Environmental Side Effects

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

■ High Medium Low

DESCRIPTION:

Bioretention areas, or rain gardens, are landscaping features adapted to provide on-site treatment of stormwater runoff. They are commonly located in parking lot islands or within small pockets of residential land uses. Surface runoff is directed into shallow, landscaped depressions, which are designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. During storms, runoff filters through the vegetation, mulch and prepared soil mix prior to infiltration or collection and conveyance by means of an underdrain.

APPLICATIONS:

- ▶ For use in small sites (5 acres or less), and highly urbanized areas.
- ▶ Can be used as a retrofit BMP.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Evaluate potential contaminants and depth to groundwater.
- ▶ Best applied to areas with shallow slopes (~5%).
- ▶ Pretreatment recommended to remove coarse sediment particles.
- ▶ Provide a soil bed, mulch layer and appropriate vegetation.
- ▶ Usually designed with an underdrain system to collect filtered runoff at the bottom of the filter bed and convey runoff to the storm drain system.
- ▶ Provide overflow structure to bypass bioretention BMP.
- ▶ Area should be designed to drain within 72 hours.

LIMITATIONS:

- ▶ Potential for groundwater contamination.
- ▶ Additional design and construction steps are necessary when BMP is placed near or upgradient from a building foundation to avoid adverse impacts to these structures.

MAINTENANCE:

- ▶ Vegetation maintenance.
- ▶ Inspect soil and repair eroded areas.
- ▶ Remove litter and debris.

TREATMENT CONTROL BMP Catch Basin Inserts



CONSIDERATIONS

- Soils
- Area Required
- Slope
- Water Availability

- Aesthetics
- Hydraulic Head
- Environmental Side Effects

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High
 Medium
 Low

DESCRIPTION:

Catch basins, also known as storm drain inlets, curb inlets or drain inserts, are inlets to the storm drain system. A grate or curb inlet and a sump to capture sediment, debris, and pollutants are typically part of a catch basin. The effectiveness of catch basins, their ability to remove sediments and other pollutants, depends on its design (e.g., the size of the sump) and on maintenance procedures to regularly remove accumulated sediments from its sump.

APPLICATIONS:

- ▶ Typically used as pretreatment for other BMPs.
- ▶ Can be used as a retrofit BMP.
- ▶ Good for use in areas where land is limited.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Should be designed to accommodate the volume of sediment that enters the system.
- ▶ Design should incorporate a hooded outlet to prevent floatable materials and trash from entering the storm drain system.
- ▶ Catch basin maintenance training for operators is recommended.

LIMITATIONS:

- ▶ Catch basins are not as efficient at removing pollutants as other BMPs.
- ▶ Must be frequently maintained to prevent resuspension of sediments.
- ▶ Some landfills may not be able to accept sediment; testing may be necessary particularly in industrial or hot spot areas.

MAINTENANCE:

- ▶ Frequent removal of trash and sediment.

TREATMENT CONTROL BMP Constructed Wetland Channel



CONSIDERATIONS

- Soils
- Area Required
- Slope
- Water Availability

- Aesthetics
- Hydraulic Head
- Environmental Side Effects

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

■ High Medium Low

DESCRIPTION:

Wetland channels are similar to constructed wetlands in that the wetlands are designed to provide treatment of stormwater, however, this BMP is considered to be a conveyance BMP. These channels use dense vegetation to slow down runoff and allow time for biological uptake and settling of sediment.

APPLICATIONS:

- ▶ Appropriate in areas where a baseflow is anticipated.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Requires a net influx of water to maintain vegetation and microorganisms.
- ▶ Loamy soils are needed to permit plants to take root.
- ▶ Requires a near-zero longitudinal slope.
- ▶ Pretreatment may be necessary if influent pollutant concentrations are high.

LIMITATIONS:

- ▶ Safety concerns associated with open water.
- ▶ Improper design can result in the accumulation of salts and scum that are flushed out during larger storms.
- ▶ High solids in influent will reduce the wetlands capacity and increase maintenance requirements.
- ▶ Due to the standing water, abatement for mosquitoes may be needed.

MAINTENANCE:

- ▶ Vegetation maintenance.

TREATMENT CONTROL BMP Constructed Wetlands



CONSIDERATIONS

- Soils
- Area Required
- Slope
- Water Availability

- Aesthetics
- Hydraulic Head
- Environmental Side Effects

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High
 Medium
 Low

DESCRIPTION:

These wetlands, also referred to as stormwater wetlands, incorporate wetland plants into the design. Stormwater pollutants are removed as stormwater flows through the wetland through settling and biological uptake. Wetlands are the most effective practice at pollutant removal and can also provide habitat and aesthetic value. There are several different designs of wetlands for consideration; shallow marsh, extended detention wetland, pond/wetland system or a submerged gravel wetland.

APPLICATIONS:

- ▶ Applicable in most areas with the exception of highly urbanized setting and in arid climates.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Need sufficient drainage area to maintain the permanent pool.
- ▶ The slope for the wetland area should be relatively shallow.
- ▶ Pretreatment should be incorporated to remove coarse particles.
- ▶ The surface area of the wetland should be at least 1% of the drainage area.
- ▶ Wetlands should have a length-to-width ratio of at least 1.5:1.
- ▶ Wetlands should be designed to include two depth zones to encourage plant diversity.
- ▶ Stabilize the outfall to prevent scour.
- ▶ Install a non-clogging outlet or include a trash rack to minimize maintenance requirements.
- ▶ Landscaping plan to ensure the establishment and survival of plants.

LIMITATIONS:

- ▶ Requires a relatively large area.
- ▶ Consideration must be given to groundwater contamination if used at a stormwater hot spot (e.g. gas stations).
- ▶ Pollutant removal is reduced when groundwater contributes substantially to the pool volume.

MAINTENANCE:

- ▶ Inspect and maintain inlet/outlet.
- ▶ Repair undercut or eroded areas.
- ▶ Vegetation maintenance, including removal of invasive species.
- ▶ Monitor sediment accumulation in pond and forebay and remove as necessary.

TREATMENT CONTROL BMP

Dry Detention Ponds



CONSIDERATIONS

- | | |
|---|--|
| <input checked="" type="checkbox"/> Soils | <input type="checkbox"/> Aesthetics |
| <input checked="" type="checkbox"/> Area Required | <input checked="" type="checkbox"/> Hydraulic Head |
| <input checked="" type="checkbox"/> Slope | <input checked="" type="checkbox"/> Environmental Side Effects |
| <input type="checkbox"/> Water Availability | |

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

Dry detention ponds, also referred to as dry ponds, extended detention basins, detention ponds or extended detention ponds, are basins whose outlets have been designed to detain stormwater runoff for some minimum time (e.g., 24 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool of water. However, they are often designed with small pools at the inlet and outlet of the basin. They can also be used to provide flood control by including additional flood detention storage.

APPLICATIONS:

- ▶ Requires a large area, consequently may not be applicable in densely developed areas.
- ▶ Soils information is needed to ensure proper infiltration rates.
- ▶ Consideration must be given to potential for groundwater contamination. Evaluate potential contaminants and depth to groundwater.
- ▶ Can be applicable as a retrofit measure.
- ▶ Potential for increase in water temperature should be considered during design for discharges to cold water streams.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Size pond to detain the volume of runoff to be treated for between 12 and 48 hours.
- ▶ Elevation drop from the pond inlet to the pond outlet sufficient to ensure that flow can move through the system
- ▶ Design ponds with a high length-to-width ratio (i.e., at least 1.5:1),
- ▶ Provide hard-bottom forebay for easier removal of sediment.
- ▶ Place energy dissipaters at the entrance to minimize bottom erosion and resuspension.
- ▶ Install trash rack.
- ▶ Include a vegetated buffer around pond.

LIMITATIONS:

- ▶ Not applicable in areas with greater than 15% slope.
- ▶ Limitation of the orifice diameter may preclude use in small watersheds.
- ▶ Should be used in conjunction with street sweeping on adjacent public right-of-way.
- ▶ Moderate pollutant removal provided by these ponds and they are ineffective at removing soluble pollutants.

MAINTENANCE:

- ▶ Pretreatment will reduce maintenance costs.
- ▶ Inspect pond banks and bottom for erosion.
- ▶ Check inlet and outlet devices for clogging.
- ▶ Manage vegetation, pesticide and herbicide use, and litter and debris.
- ▶ Remove sediment from forebay.
- ▶ Remove sediment when the pond volume has been reduced by 25 percent.

TREATMENT CONTROL BMP

Grass Buffer



CONSIDERATIONS

- | | |
|--|---|
| <input checked="" type="checkbox"/> Soils | <input checked="" type="checkbox"/> Aesthetics |
| <input checked="" type="checkbox"/> Area Required | <input type="checkbox"/> Hydraulic Head |
| <input checked="" type="checkbox"/> Slope | <input type="checkbox"/> Environmental Side Effects |
| <input checked="" type="checkbox"/> Water Availability | |

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training
- Low

DESCRIPTION:

Grass buffers are densely vegetated strips of grass designed to provide flow control and filtration of stormwater from upgradient development. These buffers differ from grassed swales in that these are designed to provide overland sheet flow rather than concentrated or channelized flow.

APPLICATIONS:

- ▶ Easily incorporated into development settings.
- ▶ Often used in conjunction with other BMPs and landuses.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Install the top of the buffer 1 to 3 inches below the adjacent pavement.
- ▶ Amend soils to encourage deep roots, reduce irrigation and promote infiltration.
- ▶ Avoid soil compaction during construction.
- ▶ Provide irrigation.
- ▶ Slope should not exceed 10%; 2% slope or more is adequate to facilitate drainage.
- ▶ Prevent vehicular traffic from these areas.
- ▶ Provide a means for downstream conveyance.

LIMITATIONS:

- ▶ Low nutrient removal rates.
- ▶ Damage caused by vehicles.
- ▶ High loadings of solids, trash and debris requires pretreatment

MAINTENANCE:

- ▶ Vegetation maintenance

TREATMENT CONTROL BMP

Grassed Swales



CONSIDERATIONS

- | | |
|--|--|
| <input checked="" type="checkbox"/> Soils | <input checked="" type="checkbox"/> Aesthetics |
| <input checked="" type="checkbox"/> Area Required | <input checked="" type="checkbox"/> Hydraulic Head |
| <input checked="" type="checkbox"/> Slope | <input checked="" type="checkbox"/> Environmental Side Effects |
| <input checked="" type="checkbox"/> Water Availability | |

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

A grassed swale refers to densely vegetated trapezoidal or triangular channels with low-pitched side slopes designed to convey runoff slowly. These are also referred to as grassed channels, dry swales, wet swales and biofilters. As stormwater runoff flows into these channels, it is treated by means of flowing through vegetation which slows the flow to allow sedimentation, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Designs for these swales incorporate modified geometry and other features for use of the swale as a treatment and conveyance practice.

APPLICATIONS:

- ▶ Can be applied in most situations.
- ▶ Well suited for treating highway and parking lot runoff.
- ▶ Good BMP as part of a treatment train.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Generally used to treat runoff from small drainage areas (less than 5 acres).
- ▶ Site should have low to moderate slopes (less than 4% slope). Check dams may be necessary for areas with larger slopes.
- ▶ Evaluate potential contaminants and depth to groundwater.
- ▶ Small forebay installed to trap incoming sediments.
- ▶ Typical designs allow the runoff from a 2-year storm to flow through the swale.

LIMITATIONS:

- ▶ Cannot treat large drainage areas.
- ▶ Improper drainage may lead to mosquito problems.
- ▶ If designed improperly, little pollutant removal will be achieved.
- ▶ Irrigation may be necessary during dry periods to maintain vegetation.

MAINTENANCE:

- ▶ Routine inspections for erosion and clogging.
- ▶ Remove trash and debris.
- ▶ Rototill or cultivate the surface if infiltration does not occur within 48 hours.
- ▶ Remove sediment build-up once it has accumulated to 25% of the design volume.
- ▶ Maintain vegetation.

TREATMENT CONTROL BMP

Infiltration Basin



CONSIDERATIONS

- | | |
|---|--|
| <input checked="" type="checkbox"/> Soils | <input type="checkbox"/> Aesthetics |
| <input checked="" type="checkbox"/> Area Required | <input checked="" type="checkbox"/> Hydraulic Head |
| <input checked="" type="checkbox"/> Slope | <input checked="" type="checkbox"/> Environmental Side Effects |
| <input type="checkbox"/> Water Availability | |

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High
 Medium
 Low

DESCRIPTION:

An infiltration basin is a shallow impoundment designed to infiltrate stormwater into the soil. This practice includes infiltration systems such as vaults, trenches, dry wells, porous pavement and concrete grids. This practice is efficient at pollutant removal, but can be challenging to implement due to soil requirements. These systems are typically designed to only intercept a certain volume of runoff, any excess volume is bypassed. Some studies have shown relatively high failure rates compared with other management practices.

APPLICATIONS:

- ▶ Suitable site soils and geologic conditions; low potential for long-term erosion in the watershed.
- ▶ Provides for groundwater recharge.
- ▶ Most effective for small sites (less than 5 acres).
- ▶ Typically designed as an off-line BMP, diverting small flows to the basin.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Area needs to be relatively flat.
- ▶ Requires appropriate soils for infiltration.
- ▶ Inclusion of a forebay will increase pond efficiency and reduce maintenance requirements.
- ▶ Evaluate potential contaminants and depth to groundwater.
- ▶ Include energy dissipation at the inlet.

LIMITATIONS:

- ▶ Potential for groundwater contamination.
- ▶ Problems associated with clogging soils.
- ▶ Delayed infiltration may cause mosquito problems.
- ▶ Limited application as a stormwater retrofit.

MAINTENANCE:

- ▶ Regular inspections for signs of wetness or damage to structures
- ▶ Vegetation maintenance
- ▶ Stabilize eroded banks
- ▶ Disc or aerate bottom and dethatch basin bottom on an annual basis
- ▶ Scrape bottom and remove sediment and restore ground cover approximately every 5 years

TREATMENT CONTROL BMP

Infiltration Trench



CONSIDERATIONS

- | | |
|--|---|
| <ul style="list-style-type: none"> <input checked="" type="checkbox"/> Soils <input checked="" type="checkbox"/> Area Required <input checked="" type="checkbox"/> Slope <input type="checkbox"/> Water Availability | <ul style="list-style-type: none"> <input type="checkbox"/> Aesthetics <input checked="" type="checkbox"/> Hydraulic Head <input checked="" type="checkbox"/> Environmental Side Effects |
|--|---|

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High
 Medium
 Low

DESCRIPTION:

An infiltration trench, also referred to as an infiltration galley, is a rock-filled trench with no outlet that receives stormwater runoff. Stormwater runoff passes through some combination of pretreatment measures, such as a swale and detention basin, and into the trench. There, runoff is stored in the void space between the stones and infiltrates through the bottom and into the soil matrix. The primary pollutant removal mechanism of this practice is filtering through the soil, fine sediment and associated pollutants are removed through infiltration.

APPLICATIONS:

- ▶ Most effective for small sites (less than 5 acres).
- ▶ Provides for groundwater recharge.
- ▶ Not appropriate in extremely cold climates.
- ▶ Good use for thin, linear areas.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Sites should be flat, but area draining to the trench can be as steep as 15%.
- ▶ Evaluate potential contaminants and depth to groundwater.
- ▶ Pretreatment to remove large particles should be implemented to ease maintenance burden.
- ▶ Size trench to drain within 24 hours.
- ▶ Typically designed as an off-line system, conveying small storms to the trench.
- ▶ Sides of trench should be lined with a geotextile fabric to prevent erosion on the sides of the trench.
- ▶ Installation of an observation well to monitor the drawdown rate.
- ▶ Installation of an underdrain provides a means of drainage in case of clogging in the trench.

LIMITATIONS:

- ▶ High failure rate due to unsuitable soils.
- ▶ Not appropriate for industrial sites.
- ▶ Not suitable on fill sites or steep slopes.

MAINTENANCE:

- ▶ Check observation wells.
- ▶ Inspect pretreatment systems.
- ▶ Remove sediment and oil and grease from pretreatment systems and overflow structures.
- ▶ Total rehabilitation necessary to maintain storage capacity within 2/3 of the design treatment volume.
- ▶ Excavate trench walls to expose clean soil.

TREATMENT CONTROL BMP In-line Storage

CONSIDERATIONS

- | | |
|---|---|
| <input type="checkbox"/> Soils | <input type="checkbox"/> Aesthetics |
| <input type="checkbox"/> Area Required | <input type="checkbox"/> Hydraulic Head |
| <input checked="" type="checkbox"/> Slope | <input type="checkbox"/> Environmental Side Effects |
| <input type="checkbox"/> Water Availability | |

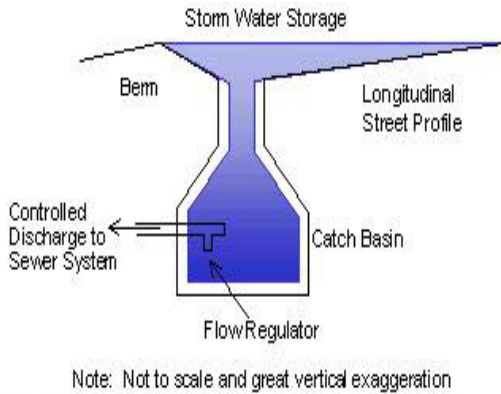
TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

■ High Medium Low



DESCRIPTION:

In-line refers to practices designed to use the storage within the storm drain system to detain flows. These practices serve to reduce peak flows, but do not provide treatment and or protection of downstream channels. This practice utilizes flow restriction devices placed in the storm drain system, which serve to slow the rate of flow.

APPLICATIONS:

- ▶ Can be used when available space for aboveground storage is an issue.

INSTALLATION/APPLICATION CRITERIA:

- ▶ May not be feasible in older areas where storm drain pipes are not oversized, causing upstream flooding.
- ▶ Must have adequate slope for the pipes to prevent upstream flooding, however, steep slopes do not allow for use of the available storage capacity.

LIMITATIONS:

- ▶ Use of these devices should include water quality BMPs since this practice only controls flow.
- ▶ Can cause upstream flooding if not designed properly.

MAINTENANCE:

- ▶ Little maintenance required.
- ▶ Designed to be "self cleaning".

TREATMENT CONTROL BMP Manufactured Products



- Soils
- Area Required
- Slope
- Water Availability

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

CONSIDERATIONS

- Aesthetics
- Hydraulic Head
- Environmental Side Effects

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

■ High Medium Low

DESCRIPTION:

Manufactured products are treatment systems such as swirl separators or hydrodynamic structures. These systems contain an internal component that creates a swirling motion as stormwater flows through a cylindrical chamber. As stormwater moves into this swirling path, sediments settle out. Additional compartments or chambers are sometimes present to trap oil and other floatables. There are several different types of proprietary separators, each incorporating slightly different design variations, such as off-line application. Catch basin inserts are also examples of manufactured products (refer to the Catch Basin Insert fact sheet).

APPLICATIONS:

- ▶ Good for use in highly pervious areas.
- ▶ Best use is as a pretreatment BMP.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Design and sizing is based upon the manufacturer's recommendations.

LIMITATIONS:

- ▶ Very little pollutant removal data; independent sources indicate moderate removal rates.
- ▶ Disposal of captured solids may be difficult.

MAINTENANCE:

- ▶ Frequent removal of captured solids is necessary to prevent resuspension.
- ▶ Vactor trucks are typically used to remove captured solids; proper disposal of solids.

TREATMENT CONTROL BMP

On-lot Treatment



CONSIDERATIONS

- | | |
|---|---|
| <input checked="" type="checkbox"/> Soils | <input type="checkbox"/> Aesthetics |
| <input type="checkbox"/> Area Required | <input type="checkbox"/> Hydraulic Head |
| <input type="checkbox"/> Slope | <input type="checkbox"/> Environmental Side Effects |
| <input type="checkbox"/> Water Availability | |

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

On-lot treatment refers to a range of practices designed to treat runoff from residential lots. The intent is to control runoff from impervious surfaces, including roofs, driveways and sidewalks. These practices work in several ways: infiltration of stormwater, diversion of stormwater into pervious areas, or runoff storage for later use. Examples of these include drywells (infiltration), redirect rooftop runoff to a vegetated surface (diversion) or rain barrels (storage).

APPLICATIONS:

- ▶ Can be used in residential and commercial areas.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Soils must be able to infiltrate.
- ▶ Infiltration requires some type of pretreatment to prevent clogging
- ▶ Diversion of runoff must meet siting requirements.
- ▶ Storage requires a use for the collected water and must accommodate overflow and freezing conditions.
- ▶ Infiltration and storage should incorporate some type of bypass to direct heavy runoff flows away from homes.

LIMITATIONS:

- ▶ Infiltration practices should be located at least 10 feet away from buildings.
- ▶ May be impracticable in small lots with no or little landscaping.
- ▶ Pollutant removal considered to be minimal mainly due to low levels of pollutants from these sources initially. In addition, these areas are small in relation to the entire watershed.

MAINTENANCE:

- ▶ Vegetation maintenance.
- ▶ Sediment removal in infiltration practices.
- ▶ Rain barrels or cisterns should be cleaned once/year, and the seal checked periodically to prevent mosquito breeding.

TREATMENT CONTROL BMP

On-site Underground Retention/Detention



- Soils
- Area Required
- Slope
- Water Availability

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

CONSIDERATIONS

- Aesthetics
- Hydraulic Head
- Environmental Side Effects

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High
 Medium
 Low

DESCRIPTION:

Underground stormwater BMPs include a variety of devices that are installed underground to provide flow control and/or treatment. Treatment can be provided through sedimentation, screening, filtration and other processes. These systems typically consist of large pipes designed for capture and storage of stormwater runoff. Runoff can either be discharged through an outlet pipe or released into the subsoil.

APPLICATIONS:

- ▶ Primarily used in newly-developed areas where land cost and/or availability is an issue.
- ▶ Applicable for use in highly urbanized areas.
- ▶ Frequently used in "treatment trains" to provide both treatment and storage.
- ▶ Provides groundwater recharge.
- ▶ Not usually designed for retrofit applications.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Perforated underground retention systems must be installed in areas with well-drained soils.
- ▶ Pretreatment should be considered when installing perforated systems to avoid system clogging.
- ▶ In some cases, it may be necessary to pump the runoff to a discharge outfall.

LIMITATIONS:

- ▶ Because this BMP is not visible, maintenance tends to be overlooked.
- ▶ Maintenance is more difficult due to access issues.
- ▶ Depth to groundwater can be an issue when installing perforated systems.
- ▶ Potential odor problems if anoxic conditions occur in accumulated materials.

MAINTENANCE:

- ▶ Must be cleaned periodically to remove accumulated trash, grit, sediment and other debris.

TREATMENT CONTROL BMP Outlet Structures



CONSIDERATIONS

- | | |
|---|---|
| <input type="checkbox"/> Soils | <input type="checkbox"/> Aesthetics |
| <input type="checkbox"/> Area Required | <input type="checkbox"/> Hydraulic Head |
| <input type="checkbox"/> Slope | <input type="checkbox"/> Environmental Side Effects |
| <input type="checkbox"/> Water Availability | |

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High
 Medium
 Low

DESCRIPTION:

This BMP is used primarily in conjunction with sedimentation BMPs. The most common types of outlets can be categorized into three groups: orifice-type, weir-type, and riser-pipe structures.

APPLICATIONS:

- ▶ Used for regulation of flow in detention basins, retention ponds and constructed wetlands.

INSTALLATION/APPLICATION CRITERIA:

- ▶ These structures should include a partially submerged orifice plate with a screen (or grate) protecting the orifice plate from clogging, and an overflow weir for flows exceeding the water quality capture volume.
- ▶ Design orifice plate to pass the baseflow while detaining the water quality capture volume for appropriate length of time.
- ▶ Maximize the area of each orifice to avoid clogging.
- ▶ Maximize the width of the trash rack to the geometry of the outlet to reduce clogging and maintenance requirements associated with cleaning the trash rack.
- ▶ Set outlet into the embankment of the pond for better access.
- ▶ Consider safety, aesthetics and maintenance when designing outlet structure.

LIMITATIONS:

- ▶ Sizing must be appropriate to needs for flood control and water quality control, as well as the size of the contributing area.

MAINTENANCE:

- ▶ Clearing trash rack.
- ▶ Sediment removal.
- ▶ Vegetation maintenance.

References:

- <http://www.ctre.iastate.edu/pubs/stormwater/documents/2C-12DetentionBasinOutletStructures.pdf>
- <http://www.knoxcounty.org/stormwater/pdfs/vol2/3-3%20Outlet%20Structures.pdf>

TREATMENT CONTROL BMP

Permeable Pavement Systems



CONSIDERATIONS

- | | |
|---|--|
| <input checked="" type="checkbox"/> Soils | <input checked="" type="checkbox"/> Aesthetics |
| <input type="checkbox"/> Area Required | <input type="checkbox"/> Hydraulic Head |
| <input type="checkbox"/> Slope | <input checked="" type="checkbox"/> Environmental Side Effects |
| <input type="checkbox"/> Water Availability | |

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High
 Medium
 Low

DESCRIPTION:

Permeable pavement systems describe any one of several pavements that allow movement of water into the layers below the pavement surface. Depending on the design, permeable pavements can be used to promote volume reduction and provide treatment. These systems temporarily stores water prior to infiltration or drainage to a controlled outlet and may consist of porous pavement that allows water to infiltrate across the entire surface of the material (e.g., grass and gravel surfaces, porous concrete and porous asphalt), or permeable paving where impermeable blocks are separated by spaces and joints, through which the water can drain.

APPLICATIONS:

- ▶ Used for most pedestrian and vehicular applications except high-volume/high-speed roadways.
- ▶ Provides for groundwater recharge.
- ▶ Use of road salt may be reduced.
- ▶ May help reduce urban temperatures.
- ▶ Can obtain LEED credits.
- ▶ Less likely to form ice on surface than conventional pavements.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Evaluate potential contaminants and depth to groundwater.
- ▶ Installation of subsurface components (bedding course, base reservoir, underdrain, geotextile, etc.) should be evaluated.
- ▶ Pretreatment may be necessary to prevent high sediment loads (e.g. swales, filter strips).
- ▶ Terracing of the soil subgrade base may be necessary in areas with slopes greater than 2%.
- ▶ Ensure compliance with ADA regulations.
- ▶ Cannot use sand for roadway treatment.
- ▶ May require protection measures when BMP is located adjacent to structures, hardscape or conventional pavement areas.
- ▶ Include observation well to monitor drain time.

LIMITATIONS:

- ▶ Not appropriate for stormwater hotspots (e.g. hazardous materials storage).
- ▶ Snow pile should not be placed on these systems due to potential for clogging.
- ▶ Freeze/thaw cycles may cause damage to porous pavements.

MAINTENANCE:

- ▶ Routine vacuum sweeping to remove sediment.
- ▶ Aggregate replacement between pavers may be necessary when substantial clogging has occurred.
- ▶ Cleaning or replacement of subsurface materials as necessary.

TREATMENT CONTROL BMP

Sand and Organic Filters



CONSIDERATIONS

- | | |
|---|--|
| <input checked="" type="checkbox"/> Soils | <input checked="" type="checkbox"/> Aesthetics |
| <input type="checkbox"/> Area Required | <input checked="" type="checkbox"/> Hydraulic Head |
| <input checked="" type="checkbox"/> Slope | <input checked="" type="checkbox"/> Environmental Side Effects |
| <input type="checkbox"/> Water Availability | |

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

■ High ☒ Medium □ Low

DESCRIPTION:

Sand filters are usually designed as two-chambered units, a settling chamber, and a filter bed filled with sand or another filtering media. Large particles settle out in the first chamber and then finer particles and other pollutants are removed as stormwater flows through the filtering medium. There are several modifications of the basic sand filter design, including the surface sand filter, underground sand filter, perimeter sand filter, organic media filter, and Multi-Chamber Treatment Train. All of these filtering practices operate on the same basic principle.

APPLICATIONS:

- ▶ Good application in urban areas where space is limited.
- ▶ Good for use in hot spot areas.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Most applicable for small drainages (e.g. less than 10 acres).
- ▶ Can be used on sites with slopes up to about 6 percent.
- ▶ Can be used as a pretreatment BMP.
- ▶ Evaluate depth to groundwater.
- ▶ Usually designed as an off-line system.
- ▶ Should include underdrain below filter bed.
- ▶ Filter bed should be sized to discharge capture volume within 48 hours.
- ▶ Include a maintenance ramp in design for maintenance.
- ▶ Include energy dissipation in inlet design.

LIMITATIONS:

- ▶ More expensive relative to other BMPs.
- ▶ Requires frequent maintenance.
- ▶ Cannot treat large drainage basins.
- ▶ Requires more hydraulic head to operate properly.

MAINTENANCE:

- ▶ Routine trash removal.
- ▶ Inspect and remove sediment as necessary.
- ▶ Inspect inlets, outlets and overflow structures for evidence of erosion; repair as necessary.
- ▶ Inspect chambers for evidence of deterioration, repair as necessary.

TREATMENT CONTROL BMP Vegetated Filter Strip



CONSIDERATIONS

- | | |
|---|---|
| <input checked="" type="checkbox"/> Soils | <input checked="" type="checkbox"/> Aesthetics |
| <input type="checkbox"/> Area Required | <input type="checkbox"/> Hydraulic Head |
| <input type="checkbox"/> Slope | <input type="checkbox"/> Environmental Side Effects |
| <input type="checkbox"/> Water Availability | |

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High
 Medium
 Low

DESCRIPTION:

Vegetated filter strips (grassed filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants, and by providing some infiltration into underlying soils.

APPLICATIONS:

- ▶ Filter strips are best suited to treating runoff from roads and highways, roof downspouts, very small parking lots, and pervious surfaces.
- ▶ Good for use as a pretreatment BMP.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Slopes should not exceed 15%.
- ▶ Width of strip should be the same as the contributing area.
- ▶ Select low growing, drought tolerant, native vegetation.

LIMITATIONS:

- ▶ May not be appropriate in industrial or hot spot areas.
- ▶ Cannot treat a large drainage area.
- ▶ Does not provide flow or volume attenuation.

MAINTENANCE:

- ▶ Routine inspections for erosion, damage to vegetation, or standing water.
- ▶ Vegetation maintenance.
- ▶ Trash removal.
- ▶ Inspect inlets, outlets and overflow structures for evidence of erosion; repair as necessary.
- ▶ Inspect chambers for evidence of deterioration, repair as necessary.

TREATMENT CONTROL BMP

Wet Ponds



CONSIDERATIONS

- Soils
- Area Required
- Slope
- Water Availability

- Aesthetics
- Hydraulic Head
- Environmental Side Effects

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High
 Medium
 Low

DESCRIPTION:

Wet ponds are also referred to as stormwater ponds, wet retention ponds and wet extended detention ponds, and are constructed basins that have a permanent pool of water. Stormwater runoff is treated through settling and algal uptake of nutrients. There are several different pond designs, including wet extended detention ponds and water reuse ponds.

APPLICATIONS:

- ▶ Limited applicability in highly urbanized setting and in arid climates.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Requires significant separation from groundwater if used in a stormwater hotspot.
- ▶ Requires sufficient drainage area to maintain the permanent pool.
- ▶ The local slope should be relatively shallow.
- ▶ Pretreatment recommended to minimize pool maintenance.
- ▶ Ponds should have a length-to-width ratio of at least 1.5:1.
- ▶ Design should incorporate features to lengthen the flow path through the pond.
- ▶ Install a non-clogging outlet or include a trash rack to minimize maintenance requirements.
- ▶ Preserve a vegetated buffer around pond to protect the banks from erosion.
- ▶ Incorporate an aquatic bench around the edge of the pond to stabilize the soil at the pond edge.

LIMITATIONS:

- ▶ Requires a relatively large area.
- ▶ May pose safety hazards

MAINTENANCE:

- ▶ Inspect and maintain inlet/outlet.
- ▶ Repair undercut or eroded areas.
- ▶ Vegetation maintenance, including removal of invasive species.
- ▶ Monitor sediment accumulation in pond and forebay and remove as necessary.

SOURCE CONTROL BMP Alternative Turnarounds



DESIGN OBJECTIVES

- | | |
|---|---|
| <input type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

Alternative turnarounds are end-of-street vehicle turnarounds that reduce impervious cover in neighborhoods by replacing the more traditional cul-de-sacs. Cul-de-sacs create a large impervious area; some have more than a 40-foot radius, thus increasing the amount of runoff. Reducing the size of cul-de-sacs, either by alternative turnarounds or by elimination, can reduce the amount of impervious cover created at the site. Examples of alternatives include reducing the radius of the cul-de-sac, hammerhead or loop roads, and pervious islands in the cul-de-sac's center.

APPLICATIONS:

- ▶ Alternative turnarounds can be applied to residential, commercial and mixed-use developments.

IMPLEMENTATION:

- ▶ Consider necessary turnaround area.
- ▶ Costs may be lower than traditional cul-de-sacs due to the decrease in pavement required.

LIMITATIONS:

- ▶ May be limited by local regulations due to the requirements of emergency vehicles.

MAINTENANCE:

- ▶ If a center island is constructed, vegetation maintenance is necessary.

SOURCE CONTROL BMP

BMP Inspection and Maintenance

DESIGN OBJECTIVES

- | | |
|--|---|
| <ul style="list-style-type: none"> <input checked="" type="checkbox"/> Maximize Infiltration <input checked="" type="checkbox"/> Provide Retention <input checked="" type="checkbox"/> Slow Runoff <input checked="" type="checkbox"/> Minimize Impervious Cover | <ul style="list-style-type: none"> <input type="checkbox"/> Prohibit Dumping of Improper Materials <input type="checkbox"/> Contain Pollutants <input type="checkbox"/> Collect and Convey |
|--|---|

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

- High Medium Low



DESCRIPTION:

Regular inspections and maintenance of post-construction BMPs are critical to the performance and effectiveness of these measures. Without this, captured stormwater pollutants can be re-entrained or pass through the BMP. This BMP refers to routine maintenance to ensure proper operation, and repair maintenance to fix problems prior to the next storm event.

APPLICATIONS:

- ▶ Applicable to owners and operators of small municipal separate storm sewer system (MS4) facilities that are responsible for implementing BMP inspection and maintenance programs and having penalties in place to deter infractions.

IMPLEMENTATION:

- ▶ All stormwater BMPs should be inspected on a regular basis for continued effectiveness and structural integrity.
- ▶ Some structural BMPs may require more frequent inspection to ensure proper operation.
- ▶ All BMPs should be checked after each storm event. In some cases, such as vegetative or infiltration BMPs, the after storm inspection should occur after the expected drawdown period to allow the inspector to see if the BMPs are draining properly.
- ▶ Inspections and follow-up actions should be documented. Development of inspection checklists would be beneficial.

LIMITATIONS:

- ▶ Most tools necessary for BMP maintenance are readily available; however, some materials necessary for emergency structural repairs may be more difficult. Consideration should be given to stockpiling essential materials for this purpose.

MAINTENANCE:

- ▶ Routine maintenance and non-routine repair should be conducted according to a schedule or as soon as a problem is identified, as many BMPs are ineffective if not installed and maintained properly.

SOURCE CONTROL BMP Conservation Easements



DESIGN OBJECTIVES

- | | |
|---|---|
| <input type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

Conservation easements are voluntary agreements that allow individuals or groups to limit the type or amount of development on their property. A conservation easement can cover all or just a portion of a property and it can either be permanent or temporary. Easements typically describe the resource they are designed to protect (e.g., agricultural, forest, historic, or open space easements), and they explain and mandate the restrictions on the uses of the particular property. An important benefit to an easement is to relieve property owners of the burden of managing these areas; the responsibility can be a private organization (land trust) or government agency, which would be better equipped to handle maintenance and monitoring issues. In addition, tax benefits might be given to property owners who place conservation easements on some or all of their property.

An easement can act as a vegetated buffer that filters-out pollutants from stormwater runoff. The ability of a conservation easement to function as a stream buffer depends on the width of the easement and in what vegetated state the easement is maintained.

APPLICATIONS:

- ▶ This BMP is typically aimed at preserving agricultural lands and natural areas threatened by development.
- ▶ May be a way to preserve open space before land prices make the purchase of land impractical.

IMPLEMENTATION:

- ▶ Determine feasibility of conservation easement agreement: consider natural resource value, uniqueness of property, size of property, financial issues, perpetuity, and mission of land trust.
- ▶ Address easement holder responsibilities: language is clear and enforceable, develop maps and property descriptions, have easement listed on property deed, monitor the use of the land, provide easement information to new property owners, establish review and approval process for land activities, maintain easement-related records.

LIMITATIONS:

- ▶ Usually not an option in highly urbanized areas due to the lack of available space and the high cost of undeveloped land.

MAINTENANCE:

- ▶ Responsibility for the property maintenance may be either the land trust agency or the property owners.

SOURCE CONTROL BMP

Development Districts



Traditional and Conventional

DESIGN OBJECTIVES

- Maximize Infiltration
- Provide Retention
- Slow Runoff
- Minimize Impervious Cover
- Prohibit Dumping of Improper Materials
- Contain Pollutants
- Collect and Convey

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

■ High Medium Low

DESCRIPTION:

Development Districts are special zoning districts created for the purpose of permitting property development. These districts are generally larger in size (5 or more acres), with the intent to concentrate development to a smaller footprint than would otherwise be necessary. In addition, these districts require complex and coordinated rezoning, transportation and planning efforts. This compact development tends to reduce transportation needs, so that not only is there less impervious cover, but there is also a reduction of some sources of stormwater pollutants.

APPLICATIONS:

- ▶ This BMP is applicable on a regional level, in ultra-urban areas and as a stormwater retrofit.

IMPLEMENTATION:

- ▶ When considering a development district for stormwater quality attributes, take into account: compact project and community design, street design and transportation options, and mixed uses.

LIMITATIONS:

- ▶ Subdivision regulations or drainage district requirements may impede plans to establish a mix of uses or higher densities.

MAINTENANCE:

- ▶ Maintenance plans will vary with design elements.

SOURCE CONTROL BMP

Efficient Irrigation

DESIGN OBJECTIVES

- | | |
|---|---|
| <ul style="list-style-type: none"> <input checked="" type="checkbox"/> Maximize Infiltration <input checked="" type="checkbox"/> Provide Retention <input checked="" type="checkbox"/> Slow Runoff <input type="checkbox"/> Minimize Impervious Cover | <ul style="list-style-type: none"> <input type="checkbox"/> Prohibit Dumping of Improper Materials <input type="checkbox"/> Contain Pollutants <input type="checkbox"/> Collect and Convey |
|---|---|

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low



DESCRIPTION:

Irrigation water provided to landscaped areas may result in excess irrigation water being conveyed into stormwater drainage systems. Development plans should include careful consideration of irrigation systems to minimize runoff of excess irrigation water into the stormwater conveyance systems. This BMP also serves to conserve water usage.

APPLICATIONS:

- ▶ Applicable to residential, commercial and industrial areas planned for development or redevelopment.

IMPLEMENTATION:

- ▶ Use rain-triggered shutoff devices to prevent irrigation after precipitation.
- ▶ Design irrigation systems to each landscaped area's specific water requirements.
- ▶ Implement water conservation plans that may include water sensors, programmable irrigation times, etc.
- ▶ Group plants with similar water requirements; use plants with low irrigation requirements.
- ▶ Park strips are difficult to irrigate without waste of water; consider alternative landscape techniques for these areas.

LIMITATIONS:

- ▶ Must be in compliance with local regulations.

MAINTENANCE:

- ▶ Maintenance of vegetation as appropriate.

SOURCE CONTROL BMP Eliminating Curb and Gutters



DESIGN OBJECTIVES

- | | |
|---|---|
| <input checked="" type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High
 Medium
 Low

DESCRIPTION:

This BMP utilizes grass swales as an alternative to the typical curb and gutter design. Curbs and gutters are only designed to convey stormwater and can also be a source of stormwater pollutants. Whereas grass swales provide an opportunity for infiltration of stormwater.

APPLICATIONS:

- ▶ Most applicable in low- and medium-density residential zones where soils, slope and housing density permit its use.

IMPLEMENTATION:

- ▶ Siting and design must consider the contributing drainage area, slope, soils, depth to groundwater, and development density.

LIMITATIONS:

- ▶ May require a revision to existing regulations that require the use of curb and gutters.
- ▶ Not feasible in areas with high traffic volumes or extensive on-street parking demand.
- ▶ Reduced applicability in arid or semi-arid climates where irrigation would be necessary.

MAINTENANCE:

- ▶ Vegetation maintenance.
- ▶ Sediment deposits may need to be removed from the swale approximately once every 10 years.

SOURCE CONTROL BMP Green Parking

DESIGN OBJECTIVES

- | | |
|--|--|
| <input checked="" type="checkbox"/> Maximize Infiltration
<input type="checkbox"/> Provide Retention
<input type="checkbox"/> Slow Runoff
<input checked="" type="checkbox"/> Minimize Impervious Cover | <input type="checkbox"/> Prohibit Dumping of Improper Materials
<input checked="" type="checkbox"/> Contain Pollutants
<input type="checkbox"/> Collect and Convey |
|--|--|

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low



DESCRIPTION:

Green parking refers to several techniques that are intended to reduce the amount of impervious cover. Examples of these techniques include: setting maximums for the number of parking lots created; minimizing the dimensions of parking lot spaces; utilizing alternative pavers in overflow parking areas; using bioretention areas to treat stormwater; encouraging shared parking; and providing economic incentives for structured parking.

APPLICATIONS:

- ▶ These techniques can be applied in new developments and in redevelopment projects.

IMPLEMENTATION:

- ▶ Parking lot designs should be based on the average parking demand instead of the maximum demand to minimize impervious cover.
- ▶ Reducing parking stall size reduces the overall size of the lot.
- ▶ Use of alternative pavers reduces runoff volumes and can provide a water quality benefit.
- ▶ Bioretention areas provide treatment when the runoff is directed into a shallow, landscaped area, where it is temporarily detained.
- ▶ Shared and structured parking can reduce impervious cover by 1) sharing a lot instead of constructing two lots which typically works well when peak demand is different, and 2) structured parking minimizes the need for surface parking.

LIMITATIONS:

- ▶ Limitations include applicability, cost and maintenance.

MAINTENANCE:

- ▶ Alternative pavers require cleaning.
- ▶ Vegetation maintenance in bioretention areas.

SOURCE CONTROL BMP

Green Roofs



DESIGN OBJECTIVES

- | | |
|---|---|
| <input checked="" type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input checked="" type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

Green roofs can be effectively used to reduce stormwater runoff from rooftops. In contrast to traditional asphalt or metal roofing, green roofs absorb, store, and later evapotranspire initial precipitation, thereby acting as a stormwater management system and reducing overall peak flow discharge to the drainage system. These roofs serve to reduce impervious areas associated with building footprints, and may absorb up to 50% of rainfall. Furthermore, conventional roofing can act as a source for numerous toxic pollutants including lead, zinc, pyrene, and chrysene (Vane Metre and Mahler, 2003).

APPLICATIONS:

- ▶ Can be utilized for commercial, industrial and residential buildings.
- ▶ Can be applied to new construction or retrofitted to existing construction.
- ▶ Applicable in all parts of the country – green roofs provide additional building insulation in areas with extreme temperatures.

IMPLEMENTATION:

- ▶ The slope of green roofs can range from 0 to 40 degrees.
- ▶ May be designed to provide public access.
- ▶ Roof must be able to support the loading from a saturated roof.
- ▶ Materials for green roofs include a waterproofing layer, a soil or substrate layer, and a plant layer.
- ▶ Selected plants for planting need to be suited for local climate conditions.

LIMITATIONS:

- ▶ In most climates, green roofs will need to have drought tolerant plant species or an irrigation system.

MAINTENANCE:

- ▶ Upon completion of roof, regular monitoring of the vegetation is necessary to ensure plantings are successful.
- ▶ Watering is required during the first season if precipitation is not sufficient.
- ▶ Following the first season, vegetation should be inspected and fertilized approximately once/year.
- ▶ Occasional weeding and watering may be necessary.
- ▶ Repair leaks.

SOURCE CONTROL BMP Infrastructure Planning

DESIGN OBJECTIVES

- | | |
|---|---|
| <input type="checkbox"/> Maximize Infiltration
<input type="checkbox"/> Provide Retention
<input type="checkbox"/> Slow Runoff
<input checked="" type="checkbox"/> Minimize Impervious Cover | <input type="checkbox"/> Prohibit Dumping of Improper Materials
<input type="checkbox"/> Contain Pollutants
<input type="checkbox"/> Collect and Convey |
|---|---|

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

- High Medium Low



DESCRIPTION:

Infrastructure planning involves changes in the regional growth planning process to contain the more typical 'sprawl' development. Sprawl development requires local governments to extend public services to new residential communities whose tax payments often do not cover the cost of providing those services. Whereas, infrastructure planning makes decisions to locate utilities and other services in the suburban fringe and discourage low-density development. Generally, this is done by drawing a boundary around a community, beyond which major public infrastructure investments are discouraged or not subsidized. In addition, economic and other incentives are provided within the boundary to encourage growth in existing neighborhoods. By encouraging housing growth in areas that are already provided with public services, communities not only save infrastructure development costs, but reduce the impacts of sprawl development on urban streams and water quality. The main reason for this reduction is due to a decrease in impervious cover.

APPLICATIONS:

- ▶ Applicable in all areas of the nation.

IMPLEMENTATION:

- ▶ Examples of techniques to manage urban growth include Urban Growth Boundaries (planning tool that defines where a growth limit is to occur and where agricultural or rural land is to be preserved), and Infill/Community Redevelopment (encourages new development in unused or underutilized urban areas through tax breaks of other incentives).

LIMITATIONS:

- ▶ Requires a coordinated effort between impacted communities in order to be successful.

MAINTENANCE:

- ▶ Not applicable.

SOURCE CONTROL BMP Landscape Maintenance



DESIGN OBJECTIVES

- | | |
|--|--|
| <input type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Collect and Convey |
| <input type="checkbox"/> Provide Retention | <input type="checkbox"/> Prohibit Illicit Discharges |
| <input type="checkbox"/> Slow Runoff | <input checked="" type="checkbox"/> Contain Pollutants |
| <input type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

■ High ☒ Medium □ Low

DESCRIPTION:

Proper landscape maintenance is important to reduce nutrient and chemical loading to the storm drain system, reduce nuisance flows and standing water in stormwater BMPs, and to maintain healthy vegetation. Examples of maintenance activities that will serve to minimize stormwater pollutants include mowing, aeration, fertilization and irrigation.

APPLICATIONS:

- ▶ Applicable to residential, commercial, municipal, and some industrial areas.

IMPLEMENTATION:

- ▶ Public education regarding landscape maintenance should include the following key points:
 - Keep lawn clipping and debris out of the gutters; mulch-mowing turf at a height of 2.5 to 3 inches to help develop deeper root systems; minimize thatch development by mowing at appropriate frequencies and heights for the grass type, avoid overwatering and over fertilization, and aerating the turf.
 - Lawn aeration reduces soil compaction and serves to move water and fertilizer into the root zone; aerate once or twice/year, but not when it is extremely hot and dry; don't use spike-type aerators, holes should be 2 to 3 inches deep and no more than 2 to 4 inches apart; thoroughly water day before.
 - Only apply nutrients that the plants can use; follow manufacturer's directions; conduct soil testing to determine needs; utilize split applications of slow-release fertilizers; keep fertilizers off hard surfaces (streets and sidewalks); water turf following fertilization; avoid fertilizing before heavy rainfall forecast; don't fertilize near wells or waterbodies (6 to 10 feet away).
 - Determine water needs to supplement normal rainfall; irrigate lawn uniformly until soil is moist to a depth of 4 to 6 inches; maintain irrigation system to prevent waste; consider use of "Smart" irrigation controllers and weather sensors;

LIMITATIONS:

- ▶ Must be in compliance with local regulations.

SOURCE CONTROL BMP Landscape Planning



DESIGN OBJECTIVES

- | | |
|---|---|
| <input checked="" type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input checked="" type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input checked="" type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

Landscape Planning takes into consideration land suitability for urban uses, as well as community goals and projected growth. The intent is to conserve natural areas, maximize natural water storage and infiltration opportunities and protect slopes and channels. This BMP may be integrated with other source control BMPs and serves to minimize surface and groundwater contamination from stormwater pollution.

APPLICATIONS:

- ▶ Applicable to residential, commercial and industrial areas planned for development or redevelopment.

IMPLEMENTATION:

- ▶ Map and assess land suitability for urban uses.
- ▶ Maintain natural storage reservoirs and drainage corridors.
- ▶ Evaluate infiltration opportunities.
- ▶ Avoid disturbance of steep or unstable slopes

LIMITATIONS:

- ▶ Must be in compliance with local regulations.

MAINTENANCE:

- ▶ Maintenance of vegetation.

SOURCE CONTROL BMP

Low Impact Development

DESIGN OBJECTIVES

- | | |
|---|---|
| <input checked="" type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input checked="" type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input checked="" type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- | |
|---|
| <input checked="" type="checkbox"/> Capital Costs |
| <input type="checkbox"/> O&M Costs |
| <input checked="" type="checkbox"/> Maintenance |
| <input type="checkbox"/> Training |

■ High Medium Low



DESCRIPTION:

Low impact development and other green design strategies refers to a number of methods designed to mimic natural hydrology prior to development, and is intended to control stormwater at its source.

APPLICATIONS:

- ▶ Can be applied across the nation.
- ▶ Integrates small-scale measures scattered throughout the development site to reduce peak runoff through infiltration, evaporation or collection.

IMPLEMENTATION:

- ▶ Examples of techniques to manage urban growth include Urban Growth Boundaries (planning tool that defines where a growth limit is to occur and where agricultural or rural land is to be preserved, and Infill/Community Redevelopment (encourages new development in unused or underutilized urban areas through tax breaks or other incentives).
- ▶ Methods include minimizing the distance between land uses to decrease infrastructure requirements, conserve forests and green spaces, protect stream buffers, narrow roads and sidewalk widths, reducing parking lot sizes, minimize or remove cul-de-sacs, etc.

LIMITATIONS:

- ▶ Some methods may be restricted by local codes (e.g. cul-de-sac turning radius for emergency vehicles).

MAINTENANCE:

- ▶ Some methods will require maintenance, such as bioretention systems, green roofs, porous pavement, grassed swales, etc.

SOURCE CONTROL BMP Narrower Residential Streets



DESIGN OBJECTIVES

- | | |
|---|---|
| <ul style="list-style-type: none"> <input type="checkbox"/> Maximize Infiltration <input type="checkbox"/> Provide Retention <input type="checkbox"/> Slow Runoff <input checked="" type="checkbox"/> Minimize Impervious Cover | <ul style="list-style-type: none"> <input type="checkbox"/> Prohibit Dumping of Improper Materials <input type="checkbox"/> Contain Pollutants <input type="checkbox"/> Collect and Convey |
|---|---|

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

This method promotes the narrowing of streets to reduce the amount of impervious cover created by new residential development, which serves to reduce runoff volume and pollutant loading. Typical residential street widths provide two parking lanes and two moving lanes, but they provide more parking than is necessary. Whereas, designing narrower streets will reduce the amount of impervious surface without sacrificing emergency access, on-street parking, or vehicular and pedestrian safety.

APPLICATIONS:

- ▶ Can be used in residential developments generating less than 500 or fewer average daily trips, or for streets generating 500 to 1,000 average daily trips.

IMPLEMENTATION:

- ▶ Designing narrower streets requires a balancing of different objectives, such as design, speed traffic volume, emergency access, etc.

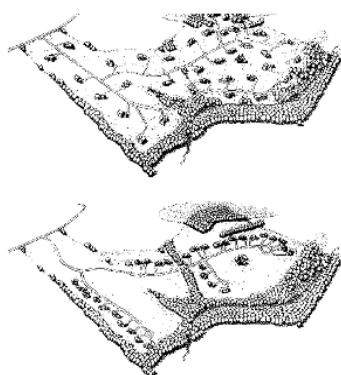
LIMITATIONS:

- ▶ Most communities require wide residential streets as a standard element of their local road and zoning standards.

MAINTENANCE:

- ▶ Maintenance is reduced due to the smaller surface area to maintain and repair.

SOURCE CONTROL BMP Open Space Design



DESIGN OBJECTIVES

- | | |
|---|---|
| <input type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

Open space design, also known as conservation development or cluster development, is a design technique that concentrates residential units in a compact area of the development site in exchange for providing open space and natural areas elsewhere on the site. The minimum lot sizes, setbacks and frontage distances for the residential zone are relaxed in order to create the open space at the site. These designs have several benefits, such as reducing impervious cover, stormwater pollutants, construction costs, grading, and the loss of natural areas.

APPLICATIONS:

- ▶ Applicable to most forms of residential development.
- ▶ Can be implemented across the nation.

IMPLEMENTATION:

- ▶ Should develop ordinances for open space areas.
- ▶ Typically reserves 25 to 50 percent of the development site as green space.

LIMITATIONS:

- ▶ May be necessary to revise local codes to allow for smaller lot sizes.

MAINTENANCE:

- ▶ Maintenance of open space vegetation.

SOURCE CONTROL BMP

Pesticides, Herbicides and Fertilizers



DESIGN OBJECTIVES

- | | |
|--|---|
| <input type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Collect and Convey |
| <input type="checkbox"/> Provide Retention | <input checked="" type="checkbox"/> Prohibit Illicit Discharges |
| <input type="checkbox"/> Slow Runoff | <input checked="" type="checkbox"/> Contain Pollutants |
| <input type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

Various chemicals used for landscape maintenance must be properly applied, stored, handled and disposed of to prevent contamination of surface and ground waters. These chemicals include pesticides, herbicides, fertilizers, fuel, etc. Misuse of pesticides and herbicides can result in adverse impacts to aquatic life, even at low concentrations. Misuse of fertilizer can result in increased algae growth in waterbodies due to excessive phosphorus and nitrogen loading.

APPLICATIONS:

- ▶ Applicable to residential, commercial and municipal areas.

IMPLEMENTATION:

- ▶ Public education regarding the use of these chemicals is necessary to ensure proper application and to minimize the release of these chemicals into storm drains or groundwater. Some of the key education points include:
 - Application of fertilizers, pesticides, and other chemicals according to manufacturer's directions.
 - Application of pesticides and herbicides only when needed and use in a manner to minimize off-target effects.
 - Accurately diagnose the pest; know characteristics of the application site, including soil type and depth to groundwater.
 - Employ application techniques that increase efficiency and allow the lowest effective application rate.
 - Keep pesticide and fertilizer equipment properly calibrated according to the manufacturer's instructions and in good repair.
 - All mixing and loading operations must occur on an impervious surface.
 - Do not apply pesticides or herbicides during high temperatures, windy conditions or immediately prior to heavy rainfall or irrigation.
 - Storage areas should be secure and covered, preventing exposure to rain and unauthorized access.
 - Store chemicals in their original containers, tightly closed, with labels intact. Regularly inspect them for leaks. Storage and maintenance areas, and vehicle refueling and maintenance areas should be located away from wells and surface waterbodies in accordance with local regulations, typically at least 50 to 100 feet away.

LIMITATIONS:

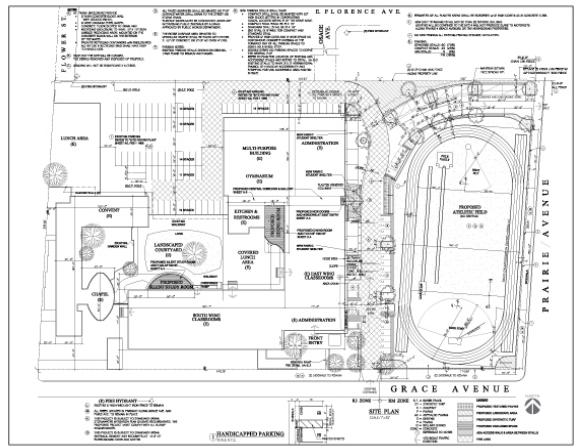
- ▶ Must be in compliance with local regulations.

MAINTENANCE:

- ▶ Should be in compliance with manufacturer's instructions.

SOURCE CONTROL BMP

Post-construction Plan Review



DESIGN OBJECTIVES

- | | |
|---|---|
| <input checked="" type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input checked="" type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input checked="" type="checkbox"/> Slow Runoff | <input checked="" type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- | | | | |
|--|-------------------------------|--|------------------------------|
| <input type="checkbox"/> Capital Costs | <input type="checkbox"/> High | <input checked="" type="checkbox"/> Medium | <input type="checkbox"/> Low |
| <input type="checkbox"/> O&M Costs | | | |
| <input type="checkbox"/> Maintenance | | | |
| <input checked="" type="checkbox"/> Training | | | |

DESCRIPTION:

Considering water quality impacts early in the design process of a development project can provide long-term water quality benefits. A thorough review of development plans that incorporates both structural and non-structural stormwater BMPs is essential to minimizing impacts to stormwater quality caused by development. Ensuring proper installation and long-term operation and maintenance of stormwater BMPs is an important component to a stormwater management plan.

APPLICATIONS:

- ▶ Provide training with regards to low impact development and post-construction BMPs.
- ▶ Require pre-submittal meetings with developers/engineers.
- ▶ Review conceptual and design plans.

IMPLEMENTATION:

- ▶ Include a pre- and post-development hydrologic analysis.
- ▶ Identify low impact development opportunities.
- ▶ Identify pollutants of concern and pollution prevention measures.
- ▶ Identify controls that provide treatment and reduce stormwater volume and velocity.
- ▶ Ensure provisions are made for long-term operation and maintenance of controls .

LIMITATIONS:

- ▶ Difficult to implement without staff training.

MAINTENANCE:

- ▶ Routine maintenance and non-routine repair should be conducted according to a schedule or as soon as a problem is identified, as many BMPs are ineffective if not installed and maintained properly.

SOURCE CONTROL BMP

Protection of Natural Features

DESIGN OBJECTIVES

- | | |
|---|---|
| <input checked="" type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

■ High Medium Low



DESCRIPTION:

Protection of natural features such as wetlands, riparian areas and floodplains during the development of a site serves to provide environmental, aesthetic, and recreational benefits. Protection of natural areas can also occur in property redevelopment. Protection of these features can be considered an amenity to the development.

APPLICATIONS:

- ▶ Applicable to most forms of residential development.

IMPLEMENTATION:

- ▶ Use a combination of site planning techniques, construction site BMPs, and measures employed after the site is in use.
- ▶ Utilize techniques such as clustering buildings and using smaller lots, shared driveways, and narrower streets.
- ▶ Developers should implement prohibitions and training to ensure these areas are not impacted during construction.
- ▶ May consider use of conservation easements.

LIMITATIONS:

- ▶ Local zoning codes might restrict the use of clustering, reduced road widths, and other techniques for natural area preservation.

MAINTENANCE:

- ▶ Maintenance of natural features specific to the area.

SOURCE CONTROL BMP Redevelopment

DESIGN OBJECTIVES

- | | |
|---|---|
| <input checked="" type="checkbox"/> Maximize Infiltration
<input type="checkbox"/> Provide Retention
<input checked="" type="checkbox"/> Slow Runoff
<input checked="" type="checkbox"/> Minimize Impervious Cover | <input type="checkbox"/> Prohibit Dumping of Improper Materials
<input type="checkbox"/> Contain Pollutants
<input type="checkbox"/> Collect and Convey |
|---|---|

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low



DESCRIPTION:

Redevelopment of existing properties with impervious surfaces can be a key opportunity to reduce impervious surfaces. In watersheds that are experiencing growth, the reuse of impervious surface mitigates developmental impacts that would be experienced elsewhere. Redevelopment can occur on individual sites, and can also be part of a larger effort of revitalize older properties, thereby protecting undeveloped areas from development. Redevelopment also provides the opportunity to retrofit stormwater BMPs.

APPLICATIONS:

- ▶ Applicable in urban, suburban and rural areas.

IMPLEMENTATION:

- ▶ Consideration should be given to economic factors, such as location to amenities and proximity to transit.

LIMITATIONS:

- ▶ Typically requires larger, regional cooperation.

MAINTENANCE:

- ▶ Maintenance of stormwater BMPs.

SOURCE CONTROL BMP Riparian/Forested Buffer



DESIGN OBJECTIVES

- | | |
|---|---|
| <input checked="" type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input type="checkbox"/> Provide Retention | <input checked="" type="checkbox"/> Contain Pollutants |
| <input checked="" type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

These buffers refer to an area along a waterbody or wetland in which development is restricted or prohibited. Buffers vary in size, and protect and separate the area from future disturbance or encroachment, and provide protection of the ecosystems and habitats. There are three types of buffers: water pollution hazard setbacks, vegetated buffers, and engineered buffers. All of these buffer types are designed to protect the waterbody and/or provide stormwater treatment.

APPLICATIONS:

- ▶ Can be implemented in any area of the country.
- ▶ Benefits are increased if managed in a forested condition.

IMPLEMENTATION:

- ▶ Buffers can be applied to new developments by establishing specific preservation areas; maintenance can be conducted through easements or community associations.
- ▶ For existing developed areas, an easement may be needed from adjoining landowners. A local ordinance can help set specific criteria for buffers to achieve stormwater management goals.
- ▶ Generally, a 100 foot buffer is recommended to provide adequate stream protection.
- ▶ Establishing a three-zone buffer system, consisting of inner, middle, and outer zones, distinguished by function, width, vegetative target and allowable uses is recommended.

LIMITATIONS:

- ▶ Buffers must be engineered correctly to prevent channel flow, otherwise stormwater treatment is reduced.

MAINTENANCE:

- ▶ Develop a buffer management plan to establish, manage and make distinctions of allowable and prohibited uses within the zones.
- ▶ Buffer boundaries should be well defined and visible before, during and after construction.
- ▶ Vegetation maintenance as applicable.

SOURCE CONTROL BMP

Roof Runoff Controls



DESIGN OBJECTIVES

- | | |
|---|---|
| <input checked="" type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input checked="" type="checkbox"/> Provide Retention | <input checked="" type="checkbox"/> Contain Pollutants |
| <input checked="" type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

Roof runoff controls refers to a variety of methods used to address stormwater that drains off rooftops. The objective is to reduce the total volume and rate of runoff and retain the pollutants on site that may be picked up from roofing materials and atmospheric deposition. Roof runoff controls consist of directing the roof runoff away from paved areas and mitigating flow to the storm drain system.

APPLICATIONS:

- ▶ Applicable to residential (single and multi-family homes), commercial and industrial areas planned for development or redevelopment.

IMPLEMENTATION:

- ▶ Runoff can be redirected from impervious surfaces by utilizing: cisterns or rain barrels, dry wells, pop-up emitters, and foundation planting.
- ▶ Collected water can be reused for irrigation purposes, which also serves as a water conservation measure.

LIMITATIONS:

- ▶ Must be in compliance with local regulations.
- ▶ Implement methods for vector control (e.g. minimizing standing water).

MAINTENANCE:

- ▶ Maintenance of vegetation as appropriate.

SOURCE CONTROL BMP Storm Drain System Signs



DESIGN OBJECTIVES

- | | |
|--|---|
| <input type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Collect and Convey |
| <input type="checkbox"/> Provide Retention | <input checked="" type="checkbox"/> Prohibit Illicit Discharges |
| <input type="checkbox"/> Slow Runoff | <input type="checkbox"/> Contain Pollutants |
| <input type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

■ High ☒ Medium □ Low

DESCRIPTION:

Identifying storm drain system inlets can serve to discourage illegal or illicit discharges into the system. Signs can be stenciled or may be stickers designed to inform the public that these are drains for stormwater that may impact surface water quality.

APPLICATIONS:

- ▶ Applicable to residential, commercial and industrial areas planned for development or redevelopment.

IMPLEMENTATION:

- ▶ Could be part of the project design.
- ▶ Some cities encourage signs as part of volunteer efforts, for example, Boy Scout projects.
- ▶ Marker or sign should be placed in clear sight facing toward anyone approaching the inlet from either side.
- ▶ Salt Lake County has information packets available for residents where signs are placed providing general stormwater information.

LIMITATIONS:

- ▶ Type of sign needs to take into consideration snow plows and street sweepers.

MAINTENANCE:

- ▶ Stencils may need to be repainted on a periodic basis.
- ▶ Stickers or markers will need to be replaced every few years.

SOURCE CONTROL BMP Street Design and Patterns

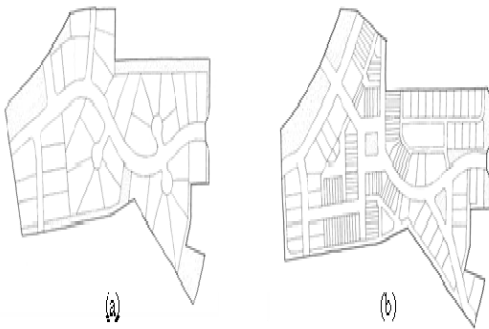
DESIGN OBJECTIVES

- | | |
|---|---|
| <input type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

■ High Medium Low



DESCRIPTION:

This BMP refers to street designs and patterns that take into consideration stormwater by reducing the amount of impervious surface in residential and commercial areas. An example of this concept is “Smart Growth Street Designs” which are based on a network of well-connected streets that support multiple transportation modes. Some smart growth approaches to street design include decreasing street widths, adjusting the vehicular level of service (LOS), creating LOS for other modes of transportation, and designing connected street networks to support multiple uses.

APPLICATIONS:

- ▶ Applicable to residential and mixed-use land uses, both in new developments and as a retrofit.
- ▶ Also applicable on a regional level.

IMPLEMENTATION:

- ▶ Coordination with local transportation department is necessary to ensure design meets code.
- ▶ Need to consider requirements of emergency vehicles.

LIMITATIONS:

- ▶ Developers are more accustomed to traditional street patterns and may resist changes.
- ▶ Storage of accumulated snow should be taken into consideration.

MAINTENANCE:

- ▶ Typical street maintenance requirements.
- ▶ Maintenance of stormwater BMPs incorporated into the design.

SOURCE CONTROL BMP

Urban Forestry



DESIGN OBJECTIVES

- | | |
|---|---|
| <input checked="" type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input checked="" type="checkbox"/> Slow Runoff | <input type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

The purpose of this BMP is to break up a landscape of impervious cover by providing small green spaces, and to link walkways and trails. Successful urban forestry requires a conservation plan for individual trees as well as forests of a designated size. An ordinance is one technique for achieving conservation and should include specific measures to protect and manage these areas. These areas can help reduce stormwater management needs in urban areas.

APPLICATIONS:

- ▶ Applicable in urban and suburban areas.

IMPLEMENTATION:

- ▶ Tree preservation areas need to be clearly marked; delineating lines along a critical root zone is preferable to a straight line.
- ▶ Ordinance should include a requirement to develop an urban forestry plan with measures to establish, conserve or re-establish preservation areas.
- ▶ Utilize native vegetation.

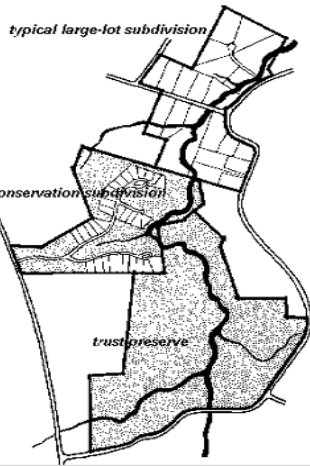
LIMITATIONS:

- ▶ Pressure to develop these areas is the main issue with this BMP.
- ▶ Attraction of undesirable insects and other pests.

MAINTENANCE:

- ▶ Fringe landscaping and trash pick-up.

SOURCE CONTROL BMP Zoning



DESIGN OBJECTIVES

- | | |
|---|---|
| <input checked="" type="checkbox"/> Maximize Infiltration | <input type="checkbox"/> Prohibit Dumping of Improper Materials |
| <input checked="" type="checkbox"/> Provide Retention | <input type="checkbox"/> Contain Pollutants |
| <input checked="" type="checkbox"/> Slow Runoff | <input checked="" type="checkbox"/> Collect and Convey |
| <input checked="" type="checkbox"/> Minimize Impervious Cover | |

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

■ High ☒ Medium □ Low

DESCRIPTION:

Incorporating better site design into land use planning zoning can serve to mitigate runoff problems. By applying the right zoning technique, development can be targeted at specific areas, limiting development in and providing protection for the most important land conservation areas. Examples of zoning techniques for better site design include watershed-based zoning, overlay zoning, floating zones, incentive zoning, performance zoning, urban growth boundaries, etc.

APPLICATIONS:

- ▶ The type of zoning will depend on management goals. Watershed-based zoning can provide a comprehensive approach if water or land quality is the primary goal, whereas, incentive zoning, performance zoning and transfer of development rights can be used for specific conservation areas.

IMPLEMENTATION:

- ▶ Steps for implementation are dependent on the zoning type. For example, for watershed-based zoning, a comprehensive stream inventory should be conducted; for impervious overlay zoning, the environmental impacts of future impervious cover is estimated and a limit is set for the maximum imperviousness.

LIMITATIONS:

- ▶ Some zoning techniques may be limited by economic and political acceptance.

MAINTENANCE:

- ▶ Review of the estimates and projections should be conducted periodically.

TREATMENT CONTROL BMP

Alum Injection



CONSIDERATIONS

- Soils
- Area Required
- Slope
- Water Availability

- Aesthetics
- Hydraulic Head
- Environmental Side Effects

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High
 Medium
 Low

DESCRIPTION:

Alum injection is the process of adding aluminum sulfate salt – alum, to stormwater, which allows for the removal of fine particles. This process can remove other pollutants that are adhered to particles, such as phosphorus. Alum treatment systems generally consist of three parts, a flow-weighted dosing system that fits inside a storm sewer manhole, remotely located storage tanks that provide alum to the doser, and a downstream pond that allows the alum, pollutants and sediments to settle out. When injected into stormwater, alum forms the harmless precipitates aluminum phosphate and aluminum hydroxide. These precipitates combine with heavy metals and phosphorus and sink into the sediment in a stable, inactive state (EPA website).

APPLICATIONS:

- ▶ Due to the high installation and operation costs, alum injection is most effective when applied to large volumes of water stored in one area.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Requires a doser system, and chemical storage tanks.
- ▶ Dosage rates are determined on a flow-weighted basis during storm events.
- ▶ Requires a downstream settling basin, as well as a separate floc collection pump-out facility.
- ▶ Disposal of floc may include the sanitary sewer system (with approval by the treatment plant), a nearby upland area, or a sludge drying bed.

LIMITATIONS:

- ▶ This BMP requires ongoing operation, unlike most other post-construction stormwater treatment practices.
- ▶ Does not control flows or prevent channel erosion.
- ▶ Chemicals added during the alum injection process may have negative effects on downstream waters.
- ▶ Requires disposal of the accumulated floc.

MAINTENANCE:

- ▶ Routine inspection and repair of equipment, including the doser and pump-out facility.
- ▶ A trained operator should be on-site to adjust the dosage of alum and other chemicals, and possibly to regulate flows through the basin.
- ▶ Floc stored on-site in drying beds will need to be disposed of regularly.
- ▶ The settling basin must be dredged periodically to dispose of accumulated floc.



TREATMENT CONTROL BMP

Bioretention



CONSIDERATIONS

- Soils
- Area Required
- Slope
- Water Availability
- Aesthetics
- Hydraulic Head
- Environmental Side Effects

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

■ High Medium Low

DESCRIPTION:

Bioretention areas, or rain gardens, are landscaping features adapted to provide on-site treatment of stormwater runoff. They are commonly located in parking lot islands or within small pockets of residential land uses. Surface runoff is directed into shallow, landscaped depressions, which are designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. During storms, runoff filters through the vegetation, mulch and prepared soil mix prior to infiltration or collection and conveyance by means of an underdrain.

APPLICATIONS:

- ▶ For use in small sites (5 acres or less), and highly urbanized areas.
- ▶ Can be used as a retrofit BMP.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Evaluate potential contaminants and depth to groundwater.
- ▶ Best applied to areas with shallow slopes (~5%).
- ▶ Pretreatment recommended to remove coarse sediment particles.
- ▶ Provide a soil bed, mulch layer and appropriate vegetation.
- ▶ Usually designed with an underdrain system to collect filtered runoff at the bottom of the filter bed and convey runoff to the storm drain system.
- ▶ Provide overflow structure to bypass bioretention BMP.
- ▶ Area should be designed to drain within 72 hours.

LIMITATIONS:

- ▶ Potential for groundwater contamination.
- ▶ Additional design and construction steps are necessary when BMP is placed near or upgradient from a building foundation to avoid adverse impacts to these structures.

MAINTENANCE:

- ▶ Vegetation maintenance.
- ▶ Inspect soil and repair eroded areas.
- ▶ Remove litter and debris.

TREATMENT CONTROL BMP Catch Basin Inserts



CONSIDERATIONS

- Soils
- Area Required
- Slope
- Water Availability

- Aesthetics
- Hydraulic Head
- Environmental Side Effects

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High
 Medium
 Low

DESCRIPTION:

Catch basins, also known as storm drain inlets, curb inlets or drain inserts, are inlets to the storm drain system. A grate or curb inlet and a sump to capture sediment, debris, and pollutants are typically part of a catch basin. The effectiveness of catch basins, their ability to remove sediments and other pollutants, depends on its design (e.g., the size of the sump) and on maintenance procedures to regularly remove accumulated sediments from its sump.

APPLICATIONS:

- ▶ Typically used as pretreatment for other BMPs.
- ▶ Can be used as a retrofit BMP.
- ▶ Good for use in areas where land is limited.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Should be designed to accommodate the volume of sediment that enters the system.
- ▶ Design should incorporate a hooded outlet to prevent floatable materials and trash from entering the storm drain system.
- ▶ Catch basin maintenance training for operators is recommended.

LIMITATIONS:

- ▶ Catch basins are not as efficient at removing pollutants as other BMPs.
- ▶ Must be frequently maintained to prevent resuspension of sediments.
- ▶ Some landfills may not be able to accept sediment; testing may be necessary particularly in industrial or hot spot areas.

MAINTENANCE:

- ▶ Frequent removal of trash and sediment.

TREATMENT CONTROL BMP Constructed Wetland Channel



CONSIDERATIONS

- Soils
- Area Required
- Slope
- Water Availability

- Aesthetics
- Hydraulic Head
- Environmental Side Effects

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

■ High ☒ Medium □ Low

DESCRIPTION:

Wetland channels are similar to constructed wetlands in that the wetlands are designed to provide treatment of stormwater, however, this BMP is considered to be a conveyance BMP. These channels use dense vegetation to slow down runoff and allow time for biological uptake and settling of sediment.

APPLICATIONS:

- ▶ Appropriate in areas where a baseflow is anticipated.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Requires a net influx of water to maintain vegetation and microorganisms.
- ▶ Loamy soils are needed to permit plants to take root.
- ▶ Requires a near-zero longitudinal slope.
- ▶ Pretreatment may be necessary if influent pollutant concentrations are high.

LIMITATIONS:

- ▶ Safety concerns associated with open water.
- ▶ Improper design can result in the accumulation of salts and scum that are flushed out during larger storms.
- ▶ High solids in influent will reduce the wetlands capacity and increase maintenance requirements.
- ▶ Due to the standing water, abatement for mosquitoes may be needed.

MAINTENANCE:

- ▶ Vegetation maintenance.

TREATMENT CONTROL BMP Constructed Wetlands



CONSIDERATIONS

- Soils
- Area Required
- Slope
- Water Availability

- Aesthetics
- Hydraulic Head
- Environmental Side Effects

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

These wetlands, also referred to as stormwater wetlands, incorporate wetland plants into the design. Stormwater pollutants are removed as stormwater flows through the wetland through settling and biological uptake. Wetlands are the most effective practice at pollutant removal and can also provide habitat and aesthetic value. There are several different designs of wetlands for consideration; shallow marsh, extended detention wetland, pond/wetland system or a submerged gravel wetland.

APPLICATIONS:

- ▶ Applicable in most areas with the exception of highly urbanized setting and in arid climates.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Need sufficient drainage area to maintain the permanent pool.
- ▶ The slope for the wetland area should be relatively shallow.
- ▶ Pretreatment should be incorporated to remove coarse particles.
- ▶ The surface area of the wetland should be at least 1% of the drainage area.
- ▶ Wetlands should have a length-to-width ratio of at least 1.5:1.
- ▶ Wetlands should be designed to include two depth zones to encourage plant diversity.
- ▶ Stabilize the outfall to prevent scour.
- ▶ Install a non-clogging outlet or include a trash rack to minimize maintenance requirements.
- ▶ Landscaping plan to ensure the establishment and survival of plants.

LIMITATIONS:

- ▶ Requires a relatively large area.
- ▶ Consideration must be given to groundwater contamination if used at a stormwater hot spot (e.g. gas stations).
- ▶ Pollutant removal is reduced when groundwater contributes substantially to the pool volume.

MAINTENANCE:

- ▶ Inspect and maintain inlet/outlet.
- ▶ Repair undercut or eroded areas.
- ▶ Vegetation maintenance, including removal of invasive species.
- ▶ Monitor sediment accumulation in pond and forebay and remove as necessary.

TREATMENT CONTROL BMP

Dry Detention Ponds



CONSIDERATIONS

- | | |
|---|--|
| <input checked="" type="checkbox"/> Soils | <input type="checkbox"/> Aesthetics |
| <input checked="" type="checkbox"/> Area Required | <input checked="" type="checkbox"/> Hydraulic Head |
| <input checked="" type="checkbox"/> Slope | <input checked="" type="checkbox"/> Environmental Side Effects |
| <input type="checkbox"/> Water Availability | |

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High
 Medium
 Low

DESCRIPTION:

Dry detention ponds, also referred to as dry ponds, extended detention basins, detention ponds or extended detention ponds, are basins whose outlets have been designed to detain stormwater runoff for some minimum time (e.g., 24 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool of water. However, they are often designed with small pools at the inlet and outlet of the basin. They can also be used to provide flood control by including additional flood detention storage.

APPLICATIONS:

- ▶ Requires a large area, consequently may not be applicable in densely developed areas.
- ▶ Soils information is needed to ensure proper infiltration rates.
- ▶ Consideration must be given to potential for groundwater contamination. Evaluate potential contaminants and depth to groundwater.
- ▶ Can be applicable as a retrofit measure.
- ▶ Potential for increase in water temperature should be considered during design for discharges to cold water streams.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Size pond to detain the volume of runoff to be treated for between 12 and 48 hours.
- ▶ Elevation drop from the pond inlet to the pond outlet sufficient to ensure that flow can move through the system
- ▶ Design ponds with a high length-to-width ratio (i.e., at least 1.5:1),
- ▶ Provide hard-bottom forebay for easier removal of sediment.
- ▶ Place energy dissipaters at the entrance to minimize bottom erosion and resuspension.
- ▶ Install trash rack.
- ▶ Include a vegetated buffer around pond.

LIMITATIONS:

- ▶ Not applicable in areas with greater than 15% slope.
- ▶ Limitation of the orifice diameter may preclude use in small watersheds.
- ▶ Should be used in conjunction with street sweeping on adjacent public right-of-way.
- ▶ Moderate pollutant removal provided by these ponds and they are ineffective at removing soluble pollutants.

MAINTENANCE:

- ▶ Pretreatment will reduce maintenance costs.
- ▶ Inspect pond banks and bottom for erosion.
- ▶ Check inlet and outlet devices for clogging.
- ▶ Manage vegetation, pesticide and herbicide use, and litter and debris.
- ▶ Remove sediment from forebay.
- ▶ Remove sediment when the pond volume has been reduced by 25 percent.

TREATMENT CONTROL BMP

Grass Buffer



CONSIDERATIONS

- | | |
|--|---|
| <input checked="" type="checkbox"/> Soils | <input checked="" type="checkbox"/> Aesthetics |
| <input checked="" type="checkbox"/> Area Required | <input type="checkbox"/> Hydraulic Head |
| <input checked="" type="checkbox"/> Slope | <input type="checkbox"/> Environmental Side Effects |
| <input checked="" type="checkbox"/> Water Availability | |

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training
- Low

DESCRIPTION:

Grass buffers are densely vegetated strips of grass designed to provide flow control and filtration of stormwater from upgradient development. These buffers differ from grassed swales in that these are designed to provide overland sheet flow rather than concentrated or channelized flow.

APPLICATIONS:

- ▶ Easily incorporated into development settings.
- ▶ Often used in conjunction with other BMPs and landuses.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Install the top of the buffer 1 to 3 inches below the adjacent pavement.
- ▶ Amend soils to encourage deep roots, reduce irrigation and promote infiltration.
- ▶ Avoid soil compaction during construction.
- ▶ Provide irrigation.
- ▶ Slope should not exceed 10%; 2% slope or more is adequate to facilitate drainage.
- ▶ Prevent vehicular traffic from these areas.
- ▶ Provide a means for downstream conveyance.

LIMITATIONS:

- ▶ Low nutrient removal rates.
- ▶ Damage caused by vehicles.
- ▶ High loadings of solids, trash and debris requires pretreatment

MAINTENANCE:

- ▶ Vegetation maintenance

TREATMENT CONTROL BMP

Grassed Swales



CONSIDERATIONS

- | | |
|--|--|
| <input checked="" type="checkbox"/> Soils | <input checked="" type="checkbox"/> Aesthetics |
| <input checked="" type="checkbox"/> Area Required | <input checked="" type="checkbox"/> Hydraulic Head |
| <input checked="" type="checkbox"/> Slope | <input checked="" type="checkbox"/> Environmental Side Effects |
| <input checked="" type="checkbox"/> Water Availability | |

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

A grassed swale refers to densely vegetated trapezoidal or triangular channels with low-pitched side slopes designed to convey runoff slowly. These are also referred to as grassed channels, dry swales, wet swales and biofilters. As stormwater runoff flows into these channels, it is treated by means of flowing through vegetation which slows the flow to allow sedimentation, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Designs for these swales incorporate modified geometry and other features for use of the swale as a treatment and conveyance practice.

APPLICATIONS:

- ▶ Can be applied in most situations.
- ▶ Well suited for treating highway and parking lot runoff.
- ▶ Good BMP as part of a treatment train.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Generally used to treat runoff from small drainage areas (less than 5 acres).
- ▶ Site should have low to moderate slopes (less than 4% slope). Check dams may be necessary for areas with larger slopes.
- ▶ Evaluate potential contaminants and depth to groundwater.
- ▶ Small forebay installed to trap incoming sediments.
- ▶ Typical designs allow the runoff from a 2-year storm to flow through the swale.

LIMITATIONS:

- ▶ Cannot treat large drainage areas.
- ▶ Improper drainage may lead to mosquito problems.
- ▶ If designed improperly, little pollutant removal will be achieved.
- ▶ Irrigation may be necessary during dry periods to maintain vegetation.

MAINTENANCE:

- ▶ Routine inspections for erosion and clogging.
- ▶ Remove trash and debris.
- ▶ Rototill or cultivate the surface if infiltration does not occur within 48 hours.
- ▶ Remove sediment build-up once it has accumulated to 25% of the design volume.
- ▶ Maintain vegetation.

TREATMENT CONTROL BMP

Infiltration Basin



CONSIDERATIONS

- | | |
|---|--|
| <input checked="" type="checkbox"/> Soils | <input type="checkbox"/> Aesthetics |
| <input checked="" type="checkbox"/> Area Required | <input checked="" type="checkbox"/> Hydraulic Head |
| <input checked="" type="checkbox"/> Slope | <input checked="" type="checkbox"/> Environmental Side Effects |
| <input type="checkbox"/> Water Availability | |

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High
 Medium
 Low

DESCRIPTION:

An infiltration basin is a shallow impoundment designed to infiltrate stormwater into the soil. This practice includes infiltration systems such as vaults, trenches, dry wells, porous pavement and concrete grids. This practice is efficient at pollutant removal, but can be challenging to implement due to soil requirements. These systems are typically designed to only intercept a certain volume of runoff, any excess volume is bypassed. Some studies have shown relatively high failure rates compared with other management practices.

APPLICATIONS:

- ▶ Suitable site soils and geologic conditions; low potential for long-term erosion in the watershed.
- ▶ Provides for groundwater recharge.
- ▶ Most effective for small sites (less than 5 acres).
- ▶ Typically designed as an off-line BMP, diverting small flows to the basin.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Area needs to be relatively flat.
- ▶ Requires appropriate soils for infiltration.
- ▶ Inclusion of a forebay will increase pond efficiency and reduce maintenance requirements.
- ▶ Evaluate potential contaminants and depth to groundwater.
- ▶ Include energy dissipation at the inlet.

LIMITATIONS:

- ▶ Potential for groundwater contamination.
- ▶ Problems associated with clogging soils.
- ▶ Delayed infiltration may cause mosquito problems.
- ▶ Limited application as a stormwater retrofit.

MAINTENANCE:

- ▶ Regular inspections for signs of wetness or damage to structures
- ▶ Vegetation maintenance
- ▶ Stabilize eroded banks
- ▶ Disc or aerate bottom and dethatch basin bottom on an annual basis
- ▶ Scrape bottom and remove sediment and restore ground cover approximately every 5 years

TREATMENT CONTROL BMP

Infiltration Trench



CONSIDERATIONS

- | | |
|---|--|
| <input checked="" type="checkbox"/> Soils | <input type="checkbox"/> Aesthetics |
| <input checked="" type="checkbox"/> Area Required | <input checked="" type="checkbox"/> Hydraulic Head |
| <input checked="" type="checkbox"/> Slope | <input checked="" type="checkbox"/> Environmental Side Effects |
| <input type="checkbox"/> Water Availability | |

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

An infiltration trench, also referred to as an infiltration galley, is a rock-filled trench with no outlet that receives stormwater runoff. Stormwater runoff passes through some combination of pretreatment measures, such as a swale and detention basin, and into the trench. There, runoff is stored in the void space between the stones and infiltrates through the bottom and into the soil matrix. The primary pollutant removal mechanism of this practice is filtering through the soil, fine sediment and associated pollutants are removed through infiltration.

APPLICATIONS:

- ▶ Most effective for small sites (less than 5 acres).
- ▶ Provides for groundwater recharge.
- ▶ Not appropriate in extremely cold climates.
- ▶ Good use for thin, linear areas.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Sites should be flat, but area draining to the trench can be as steep as 15%.
- ▶ Evaluate potential contaminants and depth to groundwater.
- ▶ Pretreatment to remove large particles should be implemented to ease maintenance burden.
- ▶ Size trench to drain within 24 hours.
- ▶ Typically designed as an off-line system, conveying small storms to the trench.
- ▶ Sides of trench should be lined with a geotextile fabric to prevent erosion on the sides of the trench.
- ▶ Installation of an observation well to monitor the drawdown rate.
- ▶ Installation of an underdrain provides a means of drainage in case of clogging in the trench.

LIMITATIONS:

- ▶ High failure rate due to unsuitable soils.
- ▶ Not appropriate for industrial sites.
- ▶ Not suitable on fill sites or steep slopes.

MAINTENANCE:

- ▶ Check observation wells.
- ▶ Inspect pretreatment systems.
- ▶ Remove sediment and oil and grease from pretreatment systems and overflow structures.
- ▶ Total rehabilitation necessary to maintain storage capacity within 2/3 of the design treatment volume.
- ▶ Excavate trench walls to expose clean soil.

TREATMENT CONTROL BMP In-line Storage

CONSIDERATIONS

- | | |
|---|---|
| <input type="checkbox"/> Soils | <input type="checkbox"/> Aesthetics |
| <input type="checkbox"/> Area Required | <input type="checkbox"/> Hydraulic Head |
| <input checked="" type="checkbox"/> Slope | <input type="checkbox"/> Environmental Side Effects |
| <input type="checkbox"/> Water Availability | |

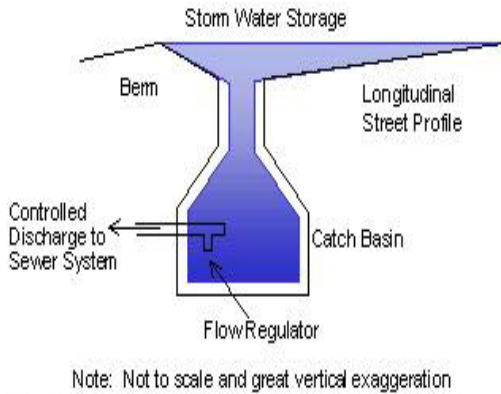
TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High
 Medium
 Low



DESCRIPTION:

In-line refers to practices designed to use the storage within the storm drain system to detain flows. These practices serve to reduce peak flows, but do not provide treatment and or protection of downstream channels. This practice utilizes flow restriction devices placed in the storm drain system, which serve to slow the rate of flow.

APPLICATIONS:

- ▶ Can be used when available space for aboveground storage is an issue.

INSTALLATION/APPLICATION CRITERIA:

- ▶ May not be feasible in older areas where storm drain pipes are not oversized, causing upstream flooding.
- ▶ Must have adequate slope for the pipes to prevent upstream flooding, however, steep slopes do not allow for use of the available storage capacity.

LIMITATIONS:

- ▶ Use of these devices should include water quality BMPs since this practice only controls flow.
- ▶ Can cause upstream flooding if not designed properly.

MAINTENANCE:

- ▶ Little maintenance required.
- ▶ Designed to be "self cleaning".

TREATMENT CONTROL BMP Manufactured Products



- Soils
- Area Required
- Slope
- Water Availability

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

CONSIDERATIONS

- Aesthetics
- Hydraulic Head
- Environmental Side Effects

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

■ High Medium Low

DESCRIPTION:

Manufactured products are treatment systems such as swirl separators or hydrodynamic structures. These systems contain an internal component that creates a swirling motion as stormwater flows through a cylindrical chamber. As stormwater moves into this swirling path, sediments settle out. Additional compartments or chambers are sometimes present to trap oil and other floatables. There are several different types of proprietary separators, each incorporating slightly different design variations, such as off-line application. Catch basin inserts are also examples of manufactured products (refer to the Catch Basin Insert fact sheet).

APPLICATIONS:

- ▶ Good for use in highly pervious areas.
- ▶ Best use is as a pretreatment BMP.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Design and sizing is based upon the manufacturer's recommendations.

LIMITATIONS:

- ▶ Very little pollutant removal data; independent sources indicate moderate removal rates.
- ▶ Disposal of captured solids may be difficult.

MAINTENANCE:

- ▶ Frequent removal of captured solids is necessary to prevent resuspension.
- ▶ Vactor trucks are typically used to remove captured solids; proper disposal of solids.

TREATMENT CONTROL BMP

On-lot Treatment



CONSIDERATIONS

- | | |
|---|---|
| <input checked="" type="checkbox"/> Soils | <input type="checkbox"/> Aesthetics |
| <input type="checkbox"/> Area Required | <input type="checkbox"/> Hydraulic Head |
| <input type="checkbox"/> Slope | <input type="checkbox"/> Environmental Side Effects |
| <input type="checkbox"/> Water Availability | |

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High Medium Low

DESCRIPTION:

On-lot treatment refers to a range of practices designed to treat runoff from residential lots. The intent is to control runoff from impervious surfaces, including roofs, driveways and sidewalks. These practices work in several ways: infiltration of stormwater, diversion of stormwater into pervious areas, or runoff storage for later use. Examples of these include drywells (infiltration), redirect rooftop runoff to a vegetated surface (diversion) or rain barrels (storage).

APPLICATIONS:

- ▶ Can be used in residential and commercial areas.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Soils must be able to infiltrate.
- ▶ Infiltration requires some type of pretreatment to prevent clogging
- ▶ Diversion of runoff must meet siting requirements.
- ▶ Storage requires a use for the collected water and must accommodate overflow and freezing conditions.
- ▶ Infiltration and storage should incorporate some type of bypass to direct heavy runoff flows away from homes.

LIMITATIONS:

- ▶ Infiltration practices should be located at least 10 feet away from buildings.
- ▶ May be impracticable in small lots with no or little landscaping.
- ▶ Pollutant removal considered to be minimal mainly due to low levels of pollutants from these sources initially. In addition, these areas are small in relation to the entire watershed.

MAINTENANCE:

- ▶ Vegetation maintenance.
- ▶ Sediment removal in infiltration practices.
- ▶ Rain barrels or cisterns should be cleaned once/year, and the seal checked periodically to prevent mosquito breeding.

TREATMENT CONTROL BMP

On-site Underground Retention/Detention



- Soils
- Area Required
- Slope
- Water Availability

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

CONSIDERATIONS

- Aesthetics
- Hydraulic Head
- Environmental Side Effects

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High
 Medium
 Low

DESCRIPTION:

Underground stormwater BMPs include a variety of devices that are installed underground to provide flow control and/or treatment. Treatment can be provided through sedimentation, screening, filtration and other processes. These systems typically consist of large pipes designed for capture and storage of stormwater runoff. Runoff can either be discharged through an outlet pipe or released into the subsoil.

APPLICATIONS:

- ▶ Primarily used in newly-developed areas where land cost and/or availability is an issue.
- ▶ Applicable for use in highly urbanized areas.
- ▶ Frequently used in "treatment trains" to provide both treatment and storage.
- ▶ Provides groundwater recharge.
- ▶ Not usually designed for retrofit applications.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Perforated underground retention systems must be installed in areas with well-drained soils.
- ▶ Pretreatment should be considered when installing perforated systems to avoid system clogging.
- ▶ In some cases, it may be necessary to pump the runoff to a discharge outfall.

LIMITATIONS:

- ▶ Because this BMP is not visible, maintenance tends to be overlooked.
- ▶ Maintenance is more difficult due to access issues.
- ▶ Depth to groundwater can be an issue when installing perforated systems.
- ▶ Potential odor problems if anoxic conditions occur in accumulated materials.

MAINTENANCE:

- ▶ Must be cleaned periodically to remove accumulated trash, grit, sediment and other debris.

TREATMENT CONTROL BMP Outlet Structures



CONSIDERATIONS

- | | |
|---|---|
| <input type="checkbox"/> Soils | <input type="checkbox"/> Aesthetics |
| <input type="checkbox"/> Area Required | <input type="checkbox"/> Hydraulic Head |
| <input type="checkbox"/> Slope | <input type="checkbox"/> Environmental Side Effects |
| <input type="checkbox"/> Water Availability | |

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High
 Medium
 Low

DESCRIPTION:

This BMP is used primarily in conjunction with sedimentation BMPs. The most common types of outlets can be categorized into three groups: orifice-type, weir-type, and riser-pipe structures.

APPLICATIONS:

- ▶ Used for regulation of flow in detention basins, retention ponds and constructed wetlands.

INSTALLATION/APPLICATION CRITERIA:

- ▶ These structures should include a partially submerged orifice plate with a screen (or grate) protecting the orifice plate from clogging, and an overflow weir for flows exceeding the water quality capture volume.
- ▶ Design orifice plate to pass the baseflow while detaining the water quality capture volume for appropriate length of time.
- ▶ Maximize the area of each orifice to avoid clogging.
- ▶ Maximize the width of the trash rack to the geometry of the outlet to reduce clogging and maintenance requirements associated with cleaning the trash rack.
- ▶ Set outlet into the embankment of the pond for better access.
- ▶ Consider safety, aesthetics and maintenance when designing outlet structure.

LIMITATIONS:

- ▶ Sizing must be appropriate to needs for flood control and water quality control, as well as the size of the contributing area.

MAINTENANCE:

- ▶ Clearing trash rack.
- ▶ Sediment removal.
- ▶ Vegetation maintenance.

References:

- <http://www.ctre.iastate.edu/pubs/stormwater/documents/2C-12DetentionBasinOutletStructures.pdf>
- <http://www.knoxcounty.org/stormwater/pdfs/vol2/3-3%20Outlet%20Structures.pdf>

TREATMENT CONTROL BMP

Permeable Pavement Systems



CONSIDERATIONS

- | | |
|---|--|
| <input checked="" type="checkbox"/> Soils | <input checked="" type="checkbox"/> Aesthetics |
| <input type="checkbox"/> Area Required | <input type="checkbox"/> Hydraulic Head |
| <input type="checkbox"/> Slope | <input checked="" type="checkbox"/> Environmental Side Effects |
| <input type="checkbox"/> Water Availability | |

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High
 Medium
 Low

DESCRIPTION:

Permeable pavement systems describe any one of several pavements that allow movement of water into the layers below the pavement surface. Depending on the design, permeable pavements can be used to promote volume reduction and provide treatment. These systems temporarily stores water prior to infiltration or drainage to a controlled outlet and may consist of porous pavement that allows water to infiltrate across the entire surface of the material (e.g., grass and gravel surfaces, porous concrete and porous asphalt), or permeable paving where impermeable blocks are separated by spaces and joints, through which the water can drain.

APPLICATIONS:

- ▶ Used for most pedestrian and vehicular applications except high-volume/high-speed roadways.
- ▶ Provides for groundwater recharge.
- ▶ Use of road salt may be reduced.
- ▶ May help reduce urban temperatures.
- ▶ Can obtain LEED credits.
- ▶ Less likely to form ice on surface than conventional pavements.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Evaluate potential contaminants and depth to groundwater.
- ▶ Installation of subsurface components (bedding course, base reservoir, underdrain, geotextile, etc.) should be evaluated.
- ▶ Pretreatment may be necessary to prevent high sediment loads (e.g. swales, filter strips).
- ▶ Terracing of the soil subgrade base may be necessary in areas with slopes greater than 2%.
- ▶ Ensure compliance with ADA regulations.
- ▶ Cannot use sand for roadway treatment.
- ▶ May require protection measures when BMP is located adjacent to structures, hardscape or conventional pavement areas.
- ▶ Include observation well to monitor drain time.

LIMITATIONS:

- ▶ Not appropriate for stormwater hotspots (e.g. hazardous materials storage).
- ▶ Snow pile should not be placed on these systems due to potential for clogging.
- ▶ Freeze/thaw cycles may cause damage to porous pavements.

MAINTENANCE:

- ▶ Routine vacuum sweeping to remove sediment.
- ▶ Aggregate replacement between pavers may be necessary when substantial clogging has occurred.
- ▶ Cleaning or replacement of subsurface materials as necessary.

TREATMENT CONTROL BMP

Sand and Organic Filters



CONSIDERATIONS

- | | |
|---|--|
| <ul style="list-style-type: none"> <input checked="" type="checkbox"/> Soils <input type="checkbox"/> Area Required <input checked="" type="checkbox"/> Slope <input type="checkbox"/> Water Availability | <ul style="list-style-type: none"> <input checked="" type="checkbox"/> Aesthetics <input checked="" type="checkbox"/> Hydraulic Head <input checked="" type="checkbox"/> Environmental Side Effects |
|---|--|

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High
 Medium
 Low

DESCRIPTION:

Sand filters are usually designed as two-chambered units, a settling chamber, and a filter bed filled with sand or another filtering media. Large particles settle out in the first chamber and then finer particles and other pollutants are removed as stormwater flows through the filtering medium. There are several modifications of the basic sand filter design, including the surface sand filter, underground sand filter, perimeter sand filter, organic media filter, and Multi-Chamber Treatment Train. All of these filtering practices operate on the same basic principle.

APPLICATIONS:

- ▶ Good application in urban areas where space is limited.
- ▶ Good for use in hot spot areas.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Most applicable for small drainages (e.g. less than 10 acres).
- ▶ Can be used on sites with slopes up to about 6 percent.
- ▶ Can be used as a pretreatment BMP.
- ▶ Evaluate depth to groundwater.
- ▶ Usually designed as an off-line system.
- ▶ Should include underdrain below filter bed.
- ▶ Filter bed should be sized to discharge capture volume within 48 hours.
- ▶ Include a maintenance ramp in design for maintenance.
- ▶ Include energy dissipation in inlet design.

LIMITATIONS:

- ▶ More expensive relative to other BMPs.
- ▶ Requires frequent maintenance.
- ▶ Cannot treat large drainage basins.
- ▶ Requires more hydraulic head to operate properly.

MAINTENANCE:

- ▶ Routine trash removal.
- ▶ Inspect and remove sediment as necessary.
- ▶ Inspect inlets, outlets and overflow structures for evidence of erosion; repair as necessary.
- ▶ Inspect chambers for evidence of deterioration, repair as necessary.

TREATMENT CONTROL BMP

Vegetated Filter Strip



CONSIDERATIONS

- | | |
|---|---|
| <input checked="" type="checkbox"/> Soils | <input checked="" type="checkbox"/> Aesthetics |
| <input type="checkbox"/> Area Required | <input type="checkbox"/> Hydraulic Head |
| <input type="checkbox"/> Slope | <input type="checkbox"/> Environmental Side Effects |
| <input type="checkbox"/> Water Availability | |

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High
 Medium
 Low

DESCRIPTION:

Vegetated filter strips (grassed filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants, and by providing some infiltration into underlying soils.

APPLICATIONS:

- ▶ Filter strips are best suited to treating runoff from roads and highways, roof downspouts, very small parking lots, and pervious surfaces.
- ▶ Good for use as a pretreatment BMP.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Slopes should not exceed 15%.
- ▶ Width of strip should be the same as the contributing area.
- ▶ Select low growing, drought tolerant, native vegetation.

LIMITATIONS:

- ▶ May not be appropriate in industrial or hot spot areas.
- ▶ Cannot treat a large drainage area.
- ▶ Does not provide flow or volume attenuation.

MAINTENANCE:

- ▶ Routine inspections for erosion, damage to vegetation, or standing water.
- ▶ Vegetation maintenance.
- ▶ Trash removal.
- ▶ Inspect inlets, outlets and overflow structures for evidence of erosion; repair as necessary.
- ▶ Inspect chambers for evidence of deterioration, repair as necessary.

TREATMENT CONTROL BMP Wet Ponds



CONSIDERATIONS

- Soils
- Area Required
- Slope
- Water Availability

- Aesthetics
- Hydraulic Head
- Environmental Side Effects

TARGETED POLLUTANTS

- Sediment
- Nutrients
- Heavy Metals
- Toxic Materials
- Oxygen Demanding Substances
- Oil & Grease
- Bacteria
- Floatable Materials
- Other Waste

IMPLEMENTATION REQUIREMENTS

- Capital Costs
- O&M Costs
- Maintenance
- Training

High
 Medium
 Low

DESCRIPTION:

Wet ponds are also referred to as stormwater ponds, wet retention ponds and wet extended detention ponds, and are constructed basins that have a permanent pool of water. Stormwater runoff is treated through settling and algal uptake of nutrients. There are several different pond designs, including wet extended detention ponds and water reuse ponds.

APPLICATIONS:

- ▶ Limited applicability in highly urbanized setting and in arid climates.

INSTALLATION/APPLICATION CRITERIA:

- ▶ Requires significant separation from groundwater if used in a stormwater hotspot.
- ▶ Requires sufficient drainage area to maintain the permanent pool.
- ▶ The local slope should be relatively shallow.
- ▶ Pretreatment recommended to minimize pool maintenance.
- ▶ Ponds should have a length-to-width ratio of at least 1.5:1.
- ▶ Design should incorporate features to lengthen the flow path through the pond.
- ▶ Install a non-clogging outlet or include a trash rack to minimize maintenance requirements.
- ▶ Preserve a vegetated buffer around pond to protect the banks from erosion.
- ▶ Incorporate an aquatic bench around the edge of the pond to stabilize the soil at the pond edge.

LIMITATIONS:

- ▶ Requires a relatively large area.
- ▶ May pose safety hazards

MAINTENANCE:

- ▶ Inspect and maintain inlet/outlet.
- ▶ Repair undercut or eroded areas.
- ▶ Vegetation maintenance, including removal of invasive species.
- ▶ Monitor sediment accumulation in pond and forebay and remove as necessary.