CHAPTER 6

Post Construction Best Management Practices

6.1 Introduction

BMPs are "schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States" (40 CFR 122.2). BMPs include, but are not limited to, "treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage" (40 CFR 122.2). BMPs also include measures for the control of erosion and sedimentation, and for the treatment of stormwater runoff (including highway runoff). Chapter 5 discussed BMPs related to construction activities. This chapter deals with post construction or permanent BMPs (PC BMPs) intended to function after construction BMPs have been removed.

Implementation of PC BMPs for stormwater treatment is required by the CPDS stormwater regulations, and other regulatory guidance (see Section 2). PC BMPs are to be included in the permanent drainage improvement plans for construction projects (see Section 4).

6.2 Planning

Planning for the inclusion of appropriate PC BMPs should occur early in the project development process. The details of where PC BMPs enter into the planning process is discussed in the New Development Chapter of the CDOT Drainage Design Manual. The Permanent BMP Checklist included in that chapter is a useful tool which highlights the key decision points related to each of the major steps in the project development process. Another key part of the checklist is the sign off column where appropriate planners, maintenance supervisors, and designers, acknowledge that the key steps and decisions have occurred.

6.3 Elements of Post Construction Best Management Practices

The objective of post construction or permanent BMPs is to limit the amount of pollutants that could potentially be discharged to a receiving water. The mechanism by which pollutants are removed from storm runoff is through either a filtering process or by allowing sediment to settling out of the runoff. A water quality capture volume is used to provide adequate volume for sediment to settle.

Table 6.1 provides a summary of the post construction/permanent stormwater quality management BMPs to consider included in this Guide.

TABLE 6.1
Post Construction Stormwater Quality Management BMPs

Post Construction BMP Name	BMP Number, Page
Extended Detention Pond with Micropool	PC 1, Page 6-4
Wet Pond	PC 2, Page 6-6
Wet Extended Detention Pond	PC 3, Page 6-8
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Pond/Wetland System	PC 6, Page 6-14
Pocket Wetland	PC 7, Page 6-16
Infiltration Trench	PC 8, Page 6-18
Infiltration Basin	PC 9, Page 6-20
Surface Sand Filter	PC 10, Page 6-22
Subsurface Sand Filter	PC 11, Page 6-24
Perimeter Sand Filter	PC 12, Page 6-26
Organic Filter	PC 13, Page 6-28
Pocket Sand Filter	PC 14, Page 6-30
Bioretention	PC 15, Page 6-32
Dry Swale	PC 16, Page 6-34
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Sheet Flow to Buffers	PC 18, Page 6-38
Catch Basin Inserts	PC 19, Page 6-40
Water Quality Inlet with Oil/Grit Separator	PC 20, Page 6-42
Street Sweeping	PC 21, Page 6-44
Deep Sump Catch Basins	PC 22, Page 6-45
On-line Storage in Storm Drain Network (Vaults)	PC 23, Page 6-47
Porous Pavements	PC 24, Page 6-49
Proprietary/Manufactured Systems	PC 25, Page 6-51

6.4 Selection of Controls

Implementation of PC BMPs will be successful if used appropriately, taking into account a number of factors. The information on the BMP fact sheets in section 6.5 include application guidelines to assist the planner and designer in determining which PC BMP is appropriate for a given location.

6.5 Post Construction BMP Fact Sheets

The BMP fact sheets provide the planner and designer with basic application guidelines and design criteria to be able to perform preliminary selection and design of permanent BMPs. The fact sheets include information on other resources that provide the detailed design procedures and are updated periodically. This approach was taken for two reasons. First, enough information is provided to be useful in performing planning level evaluation and understanding of the BMPs. Second, the detailed design procedures are evolving, and the designer is encouraged to research the latest available information to design the BMP.

The BMP fact sheets may evolve over time and it is expected that the state of the art will improve and change. The New Development Program seeks to utilize current accepted BMPs but is a living document that will also evolve over time. Therefore the following fact sheets should periodically be reviewed and updated as BMPs improve and evolve.

Extended Detention Pond with Micropool

Description

A structural BMP used to capture and treat a specific volume of stormwater runoff. Because of a smaller outlet, the pond releases stored flows over a period of a few days and drains totally dry sometime after the storm ends. The pond is considered dry, although the formation of small wetland marshes or shallow pools in the bottom can enhance the effectiveness of the pond.
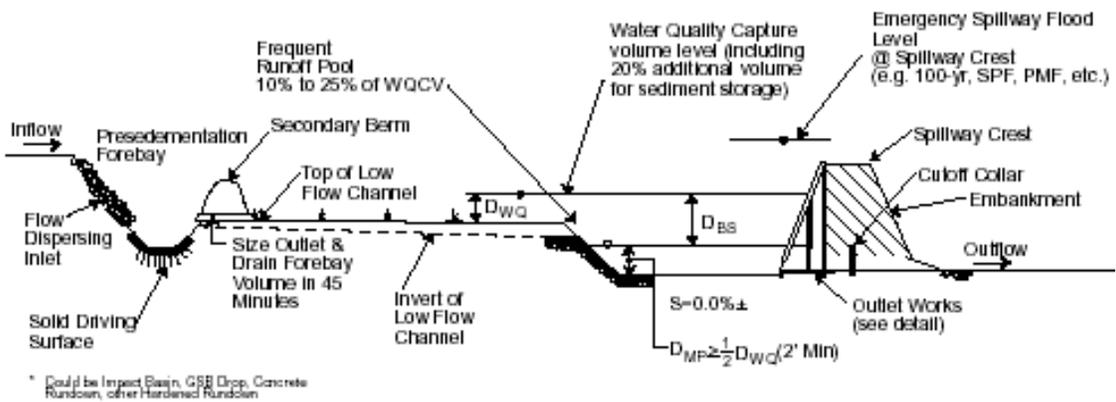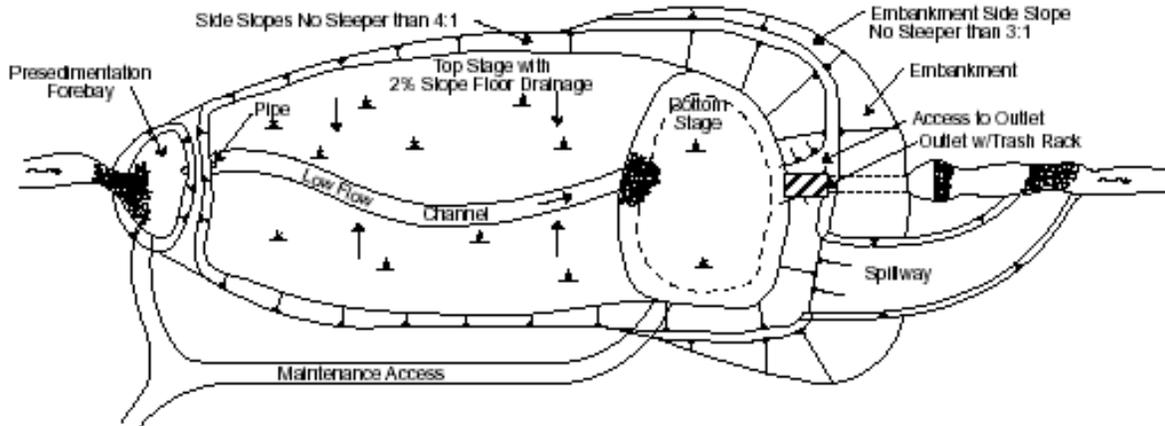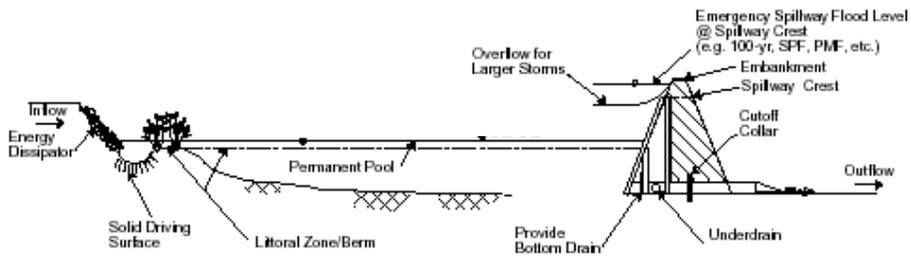

Application Guidelines

Pond can be used to enhance stormwater quality and reduce peak discharges,

Most applicable in residential, commercial, and industrial areas,

If constructed early in development of a particular site, the pond becomes an effective means of trapping sediment from construction activities,

Ponds can be retrofitted into existing flood control facilities,

Ponds are used to improve quality of urban runoff,

Used for regional and/or follow-up water quality treatment but are also effective as an "on-site" BMP,

Pond also works well in conjunction with other BMP's used to control upstream and downstream sediments,

Ponds can be effective if they are combined with BMP's that attenuate peak stormwater discharges or reduce runoff volumes. If needed, flood routing detention volume can be designed and captured by the pond, above volume used for water quality treatment,

Pond size can be reduced if effectively combined with other BMP's,

Pond can also be used for recreation and open space and in some cases, wildlife habitat if wetlands or shallow pools are incorporated into the design.

Basic Design Criteria

If possible, pond should be incorporated into existing facility or flood control basin,

Consider other urban uses such as recreation, open space, and/or wildlife habitat,

Generally, minimum drain time of 40 hours is recommended to allow finer particulates found in urban stormwater runoff to settle,

Generally, land required is approximately 0.5 to 2.0% of tributary development area,

Account for groundwater elevations in the design and construction of the basin,

Review State Engineer's regulatory requirements for dam embankments and storage volumes if minimum dam heights and volumes are exceeded.

Extended Detention Pond with Micropool

Reference: Denver Urban Drainage and Flood Control District, Volume 3 Criteria Manual.

SECTION
NOT TO SCALE

Wet Pond

Description

A structural BMP used to capture and treat a specific volume of stormwater runoff. This structure has a permanent pool and runoff from each rain event is detained and treated in the pond until it is displaced by runoff from the next storm. The permanent pool enhances the effectiveness of the pond by promoting biological uptake.
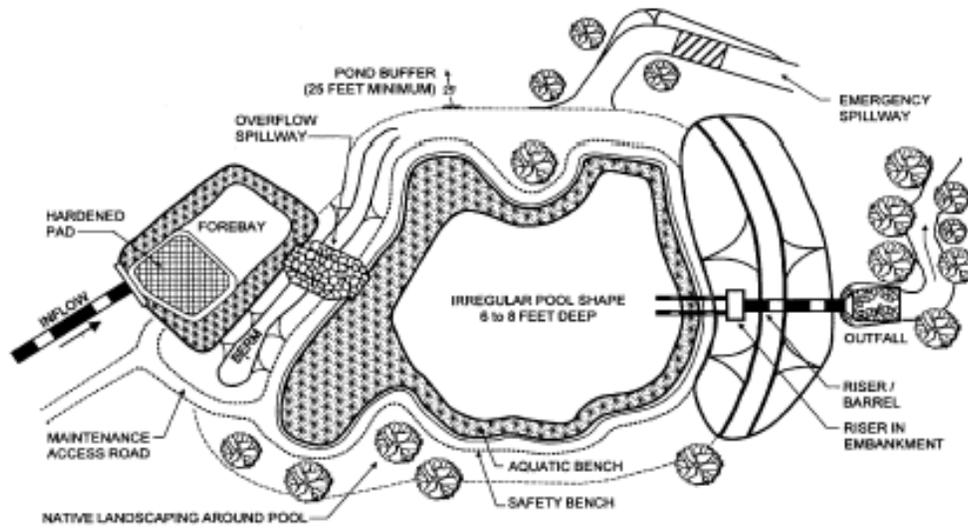

Application Guidelines

Pond can be used to enhance stormwater quality and reduce peak discharges,
Most applicable in residential, commercial, and industrial areas,
If constructed early in development of a particular site, the pond becomes an effective means of trapping sediment from construction activities,
Pond can be retrofitted into existing flood control facilities,
Ponds are used to improve quality of urban runoff,
Basins are used for regional and/or follow-up water quality treatment but are also effective as an "on-site" BMP,
Pond also works well in conjunction with other BMP's used to control upstream and downstream sediments,
Basins can be effective if they are combined with BMP's that attenuate peak stormwater discharges or reduce runoff volumes. If needed, flood routing detention volume can be designed and captured by the pond, above volume used for water quality treatment,
Pond size can be reduced if effectively combined with other BMP's,
Basins can also be used for recreation and open space and in some cases, wildlife habitat if wetlands or shallow pools are incorporated into the design.

Basic Design Criteria

Generally, water quality flows require a minimum drain time of 40 hours to allow finer particulates found in urban stormwater runoff to settle,
If possible, pond should be incorporated into existing facility or flood control basin,
Consider other urban uses such as recreation, open space, and/or wildlife habitat,
Generally, land required is approximately 0.5 to 2.0% of tributary development area,
Account for groundwater elevations in the design and construction of the basin,
Review State Engineer's regulatory requirements for dam embankments and storage volumes if minimum dam heights and volumes are exceeded.

Wet Pond

Reference: Maryland Stormwater Design Manual.

Wet Extended Detention Pond

Description

A structural BMP used to capture and treat a specific volume of stormwater runoff. This structure is generally the same as a wet pond. However, this BMP provides water quality treatment through a combination of a permanent pool and extended detention storage. The permanent pool enhances the effectiveness of the pond by promoting biological uptake.


Application Guidelines

Pond can be used to enhance stormwater quality and reduce peak discharges,

Water in permanent pool mixes with initial runoff from storm event,

Most applicable in residential, commercial, and industrial areas,

If constructed early in development of a particular site, the pond becomes an effective means of trapping sediment from construction activities,

Basins can be retrofitted into existing flood control facilities,

Basins are used for regional and/or follow-up water quality treatment but are also effective as an "on-site" BMP,

Pond also works well in conjunction with other BMP's used to control upstream and downstream sediments,

Basins can be effective if they are combined with BMP's that attenuate peak stormwater discharges or reduce runoff volumes. If needed, flood routing detention volume can be designed and captured by the pond, above volume used for water quality treatment,

Pond size can be reduced if effectively combined with other BMP's,

Basins can also be used for recreation and open space and in some cases, wildlife habitat if wetlands or shallow pools are incorporated into the design.

Basic Design Criteria

Generally, minimum drain time of 40 hours is recommended for the extended storage volume to allow finer particulates found in urban stormwater runoff to settle,

If possible, pond should be incorporated into existing facility or flood control basin,

Consider other urban uses such as recreation, open space, and/or wildlife habitat,

Generally, land required is approximately 0.5 to 2.0% of tributary development area,

Account for groundwater elevations in the design and construction of the basin,

Review State Engineer's regulatory requirements for dam embankments and storage volumes if minimum dam heights and volumes are exceeded.

Wet Extended Detention Pond

Reference: Maryland Stormwater Design Manual.
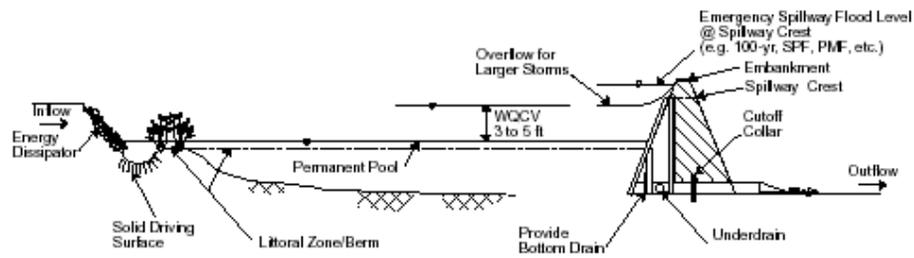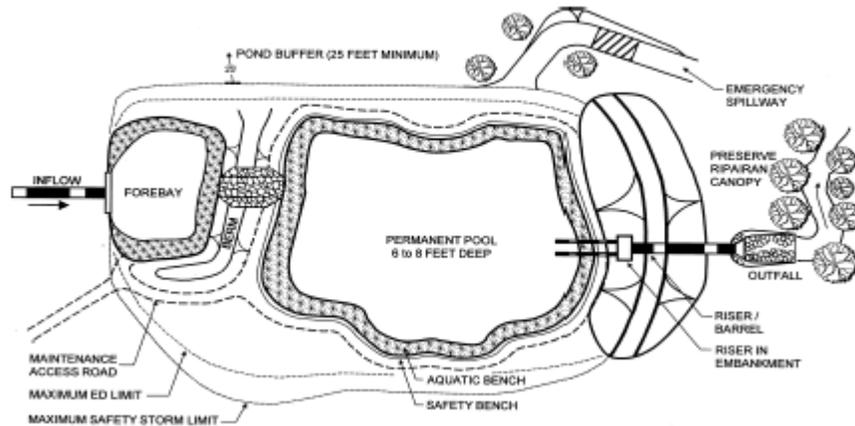
Shallow Wetland

Description

A structural BMP used to capture and treat a specific volume of stormwater runoff. This structure is similar to a stormwater pond. However, wetland vegetation is added to the bottom of the pond to enhance the pollutant removal capability of the structure. A perennial base flow is needed to promote wetland vegetation and water quality treatment is provided in the shallow pool.
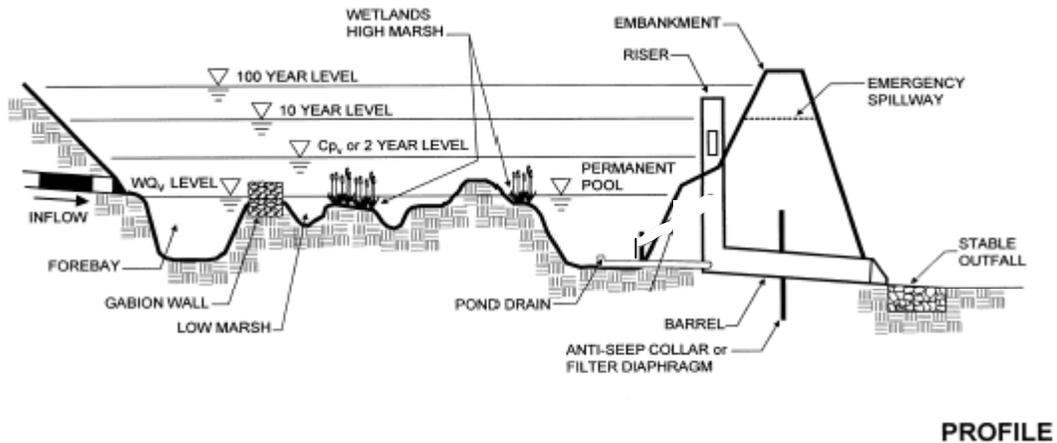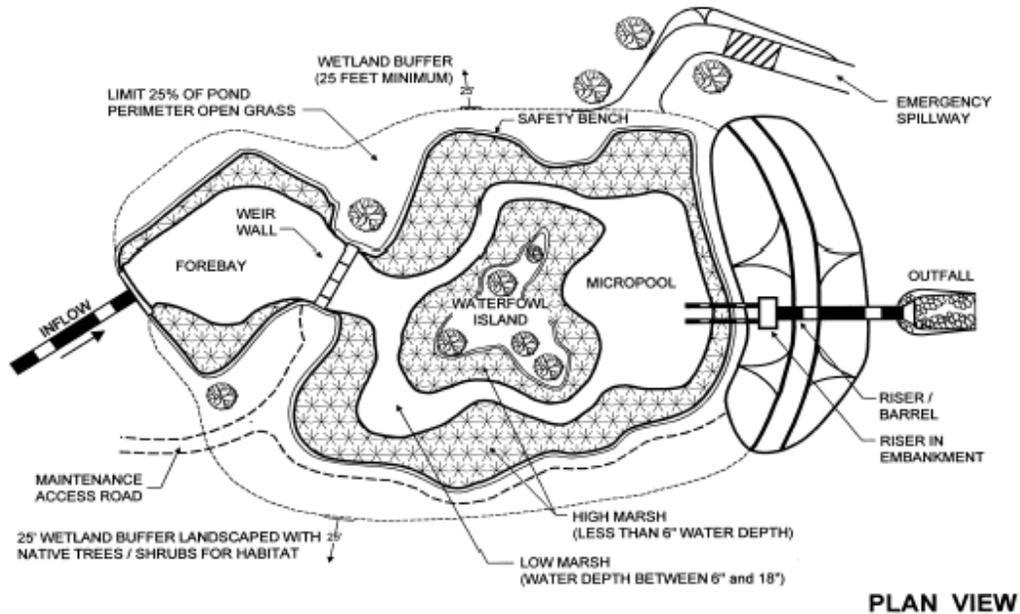
Application Guidelines

Wetland can be used to reduce peak discharges,

Can be used as a follow-up structural BMP or as a stand-alone facility,

Small existing wetlands can be enlarged and incorporated into constructed wetland (requires state and federal permits),

Requires an area sufficiently large for impounding stormwater in shallow basins,

Wetland cells can be arranged in a series of terraces,

If needed, flood storage can be provided above volume used for water quality treatment,

Wetlands can provide effective follow-up treatment to on-site and other basin BMP's,

State and Federal regulations protecting natural wetlands recognize classification of wetlands constructed for water quality treatment,

Constructed wetlands generally not allowed on receiving waters and cannot be used to mitigate loss of natural wetlands,

Advantage is in aesthetics and creation of wildlife habitat, disadvantage is need for continuous base flow to maintain wetland growth.

Basic Design Criteria

Generally, minimum drain time of 24 hours is recommended,

Wetlands constructed outside of the Waters of the U.S. and explicitly designed for stormwater management, are not subject to the provisions of the Clean Water Act (Sections 401 and 404). When abandoned, they may be regulated as natural wetlands,

Consider other urban uses such as recreation, open space, and/or wildlife habitat,

Loamy soils are required in the wetland bottom to sustain plant growth,

Perennial base flow is needed and is determined through a water budget analysis,

Exfiltration through pond bottom is not reliable because of low permeability soils and/or high ground water elevations,

Review State Engineer's regulatory requirements for dam embankments and storage volumes if minimum dam heights and volumes are exceeded.

Shallow Wetland

Reference: Maryland Stormwater Design Manual.

PLAN VIEW

PROFILE

Extended Detention Shallow Wetland

Description

A structural BMP used to capture and treat a specific volume of stormwater runoff. This structure is a shallow wetland with additional detention storage provided for water quality treatment. Wetland species are added to the bottom of the pond to enhance the pollutant removal capability and a perennial base flow is required to maintain and promote wetland vegetation.
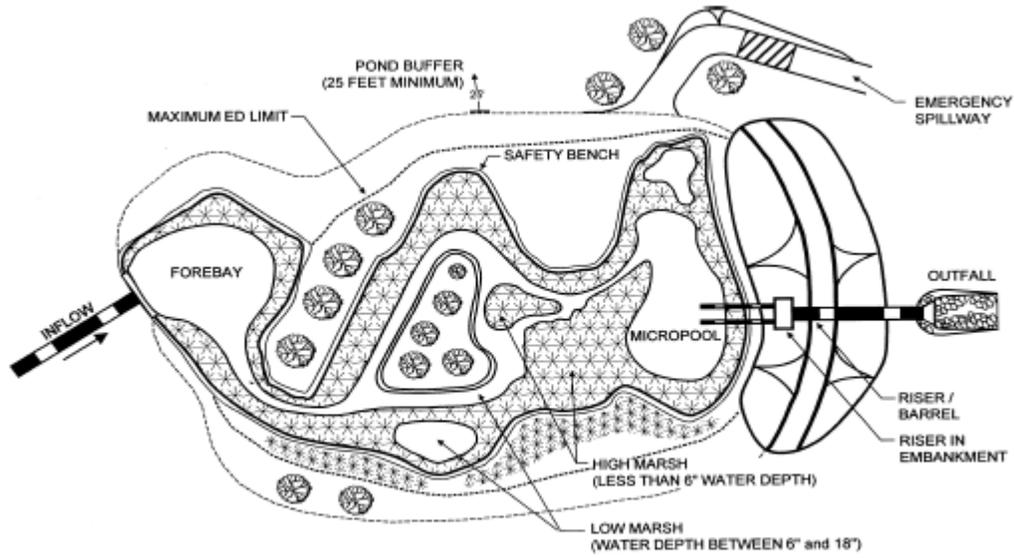

Application Guidelines

Wetland can be used to reduce peak discharges,

Can be used as a follow-up structural BMP or as a stand-alone facility,

Small existing wetlands can be enlarged and incorporated into constructed wetland (requires state and federal permits),

Requires an area sufficiently large for impounding stormwater in shallow basins,

Wetland cells can be arranged in a series of terraces,

If needed, flood storage can be provided above volume used for water quality treatment,

Wetlands can provide effective follow-up treatment to on-site and other basin BMP's,

State and Federal regulations protecting natural wetlands recognize classification of wetlands constructed for water quality treatment,

Constructed wetlands generally not allowed on receiving waters and cannot be used to mitigate loss of natural wetlands,

Advantage is in aesthetics and creation of wildlife habitat, disadvantage is need for continuous base flow to maintain wetland growth.
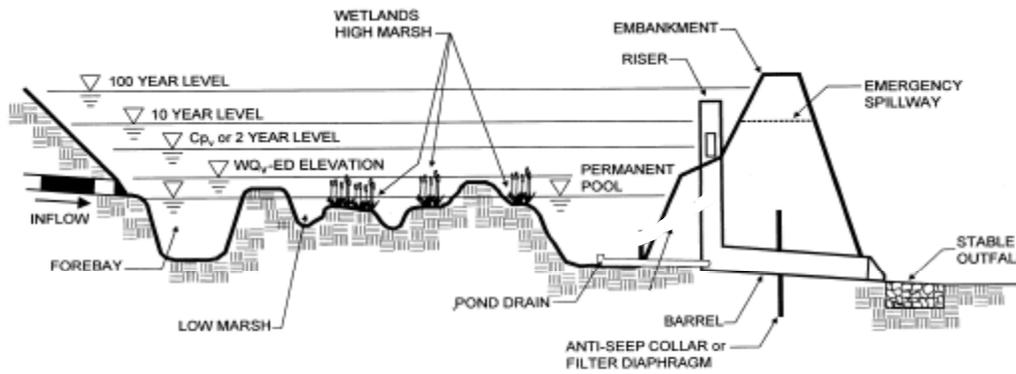
Basic Design Criteria

Generally, minimum drain time of 24 hours is recommended,

Wetlands constructed outside of the Waters of the U.S. and explicitly designed for stormwater management, are not subject to the provisions of the Clean Water Act (Sections 401 and 404). When abandoned, they may be regulated as natural wetlands,

Perennial base flow is needed and is determined through a water budget analysis,

Consider other urban uses such as recreation, open space, and/or wildlife habitat,

Loamy soils are required in the wetland bottom to sustain plant growth,

Exfiltration through pond bottom is not reliable because of low permeability soils and/or high ground water elevations,

Review State Engineer's regulatory requirements for dam embankments and storage volumes if minimum dam heights and volumes are exceeded.

Extended Detention Shallow Wetland

Reference: Maryland Stormwater Design Manual.

PLAN VIEW

PROFILE

Pond/Wetland System

Description

A structural BMP used to capture and treat a specific volume of stormwater runoff. This structure is a shallow wetland with a deep permanent pool placed upstream of the pond. Wetland species are added to the bottom of the pond to enhance the pollutant removal capability and a perennial base flow is required to maintain and promote wetland vegetation.
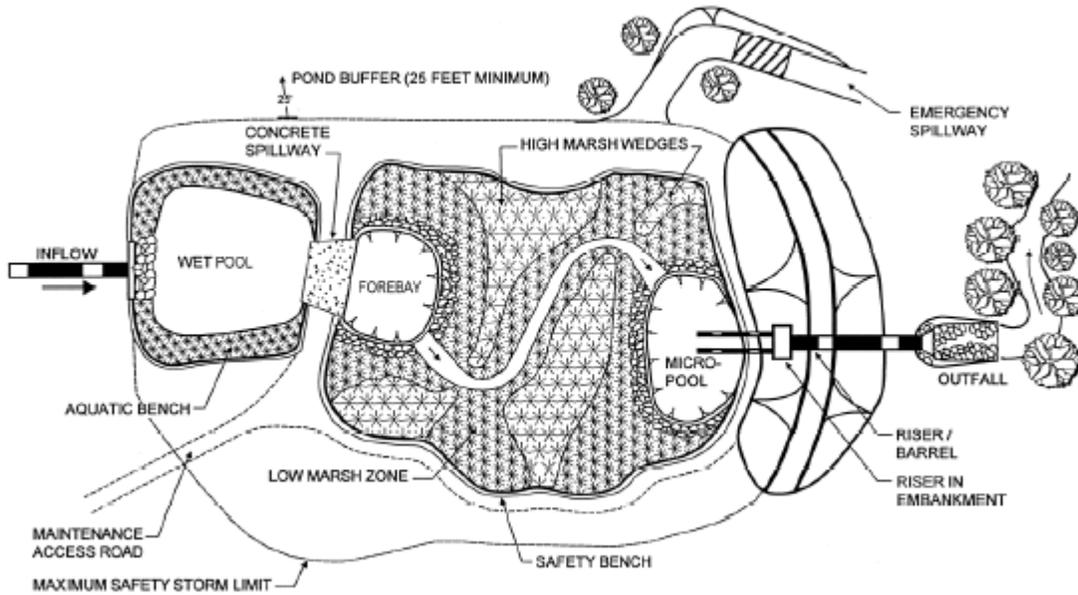

Application Guidelines

Wetland can be used to reduce peak discharges,
Can be used as a follow-up structural BMP or as a stand-alone facility,
Small existing wetlands can be enlarged and incorporated into constructed wetland (requires state and federal permits),
Requires an area sufficiently large for impounding stormwater in shallow basins,
Wetland cells can be arranged in a series of terraces,
If needed, flood storage can be provided above volume used for water quality treatment,
State and Federal regulations protecting natural wetlands recognize classification of wetlands constructed for water quality treatment,
Wetlands can provide effective follow-up treatment to on-site and other basin BMP's,
Constructed wetlands generally not allowed on receiving waters and cannot be used to mitigate loss of natural wetlands,
Advantage is in aesthetics and creation of wildlife habitat, disadvantage is need for continuous base flow to maintain wetland growth.

Basic Design Criteria

Generally, minimum drain time of 24 hours is recommended,
Wetlands constructed outside of the Waters of the U.S. and explicitly designed for stormwater management, are not subject to the provisions of the Clean Water Act (Sections 401 and 404). When abandoned, they may be regulated as natural wetlands,
Perennial base flow is needed and is determined through a water budget analysis,
Exfiltration through pond bottom is not reliable because of low permeability soils and/or high ground water elevations,
Review State Engineer's regulatory requirements for dam embankments and storage volumes if minimum dam heights and volumes are exceeded.

Pond/Wetland System

Reference: Maryland Stormwater Design Manual.

PLAN VIEW
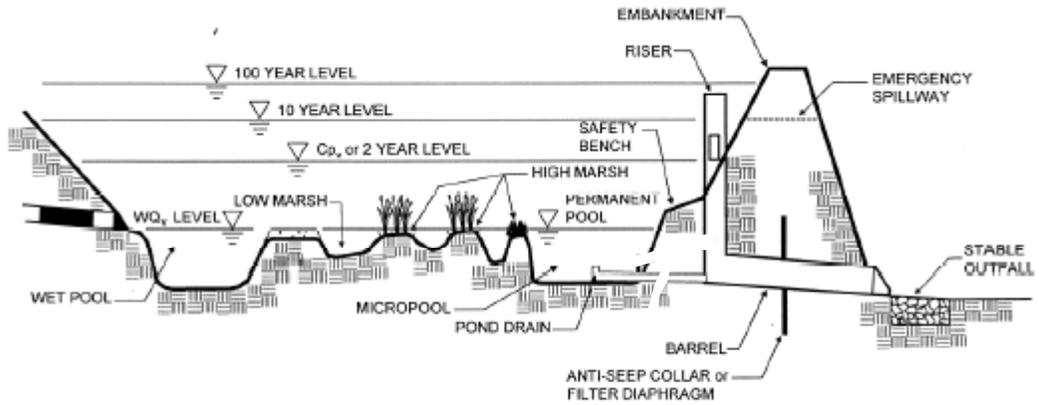
PROFILE

Pocket Wetland

Description

A structural BMP used to capture and treat a specific volume of stormwater runoff. This structure is a shallow wetland with a permanent pool and wetland species added to the bottom to enhance the pollutant removal capability. For this BMP, a high groundwater table is used to maintain the shallow pool and wetland vegetation.


Application Guidelines

Wetland can be used to reduce peak discharges,
Can be used as a follow-up structural BMP or as a stand-alone facility,
Small existing wetlands can be enlarged and incorporated into constructed wetland (requires state and federal permits),
Requires an area sufficiently large for impounding stormwater in shallow basins,
Wetland cells can be arranged in a series of terraces,
If needed, flood storage can be provided above volume used for water quality treatment,
State and Federal regulations protecting natural wetlands recognize classification of wetlands constructed for water quality treatment,
Constructed wetlands generally not allowed on receiving waters and cannot be used to mitigate loss of natural wetlands,
Wetlands can provide effective follow-up treatment to on-site and other basin BMP's,
Advantage is in aesthetics and creation of wildlife habitat, disadvantage is need for continuous base flow to maintain wetland growth.

Basic Design Criteria

Generally, minimum drain time of 24 hours is recommended,
Wetlands constructed outside of the Waters of the U.S. and explicitly designed for stormwater management, are not subject to the provisions of the Clean Water Act (Sections 401 and 404). When abandoned, they may be regulated as natural wetlands,
Perennial base flow is needed and is determined through a water budget analysis,
Consider other urban uses such as recreation, open space, and/or wildlife habitat,
Loamy soils are required in the wetland bottom to sustain plant growth,
Exfiltration through pond bottom is not reliable because of low permeability soils and/or high ground water elevations,
Review State Engineer's regulatory requirements for dam embankments and storage volumes if minimum dam heights and volumes are exceeded.

Pocket Wetland

Reference: Maryland Stormwater Design Manual.
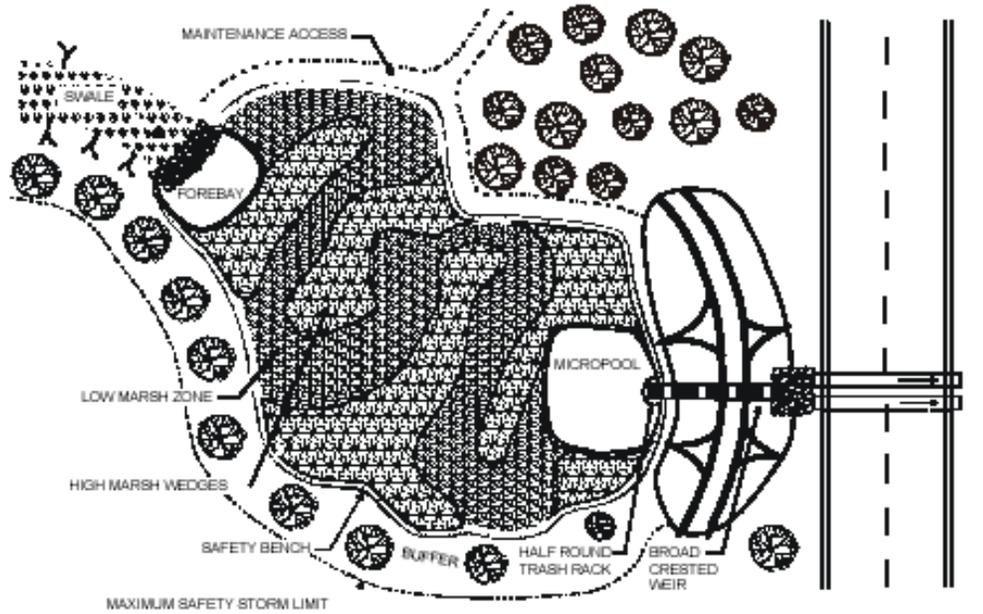
PLAN VIEW
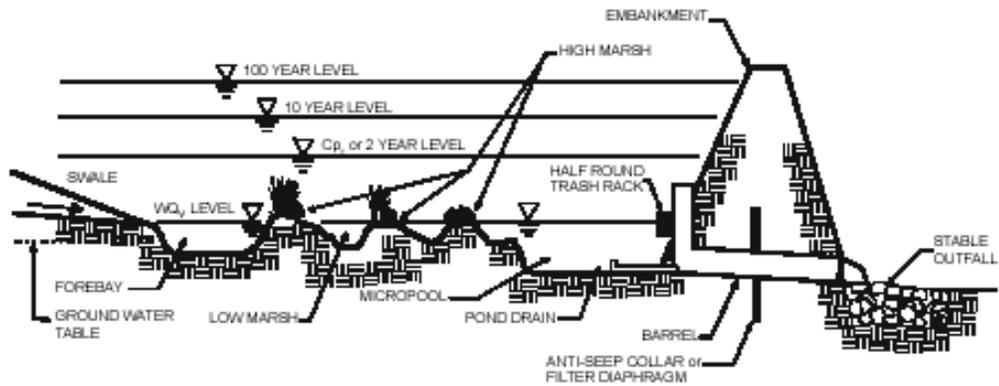
PROFILE

Infiltration Trench

Description
A structural BMP used to capture and treat a volume of stormwater runoff. This BMP consists of a stone-filled trench in which runoff is collected and percolated to the surrounding soils. Grass channels, filter strips, or forebays can be used to reduce sediments entering the trench. Generally, the trench is 3 to 8 feet deep and filled with 1.5 to 2.5 inch diameter clean stone or bank run gravel.

Application Guidelines
Trenches can be used to enhance stormwater quality, reduce peak discharges, and recharge groundwater,

Structures are prone to clogging by suspended solids and are best used in conjunction with other BMP's that are more effective in removing suspended solids,

They should not be used on or adjacent to steep slopes and are typically used for drainage areas less than 5 acres,

Trenches should only be used in well-drained soils of Hydrologic Soil Groups A or B. However, they can be used in Hydrologic Soil Groups C and D soils if used for a very small drainage area, such as the backyard of a single family residence,

Bottom of trench should be 4 feet higher than the seasonal high water table or bedrock,

Trenches recharge surface runoff directly to groundwater and they should not be used in areas where there are concerns about contamination of surface runoff with dissolved pollutants,

Trenches should not be installed in highly permeable sand or gravel seams that are directly connected to aquifers,

Trenches can be connected to parking lot drains, roof downspouts, or inlet structures.

Basic Design Criteria
Generally, trenches are designed to infiltrate retained runoff within a 48-hour period,

Accumulated sediments render the trench ineffective and regular inspections are needed. These sediments must be controlled to lengthen the effective life span,

De-watering methods need to be designed in the event of a failure,

No vehicular traffic and minimal pedestrian traffic should be allowed over the trench,

Observations should be made to determine the time needed for water to infiltrate into the soil after a storm event,

Periodic observations should also be made to monitor any decrease in performance.

Infiltration Trench

Reference: Maryland Stormwater Design Manual.

PLAN VIEW
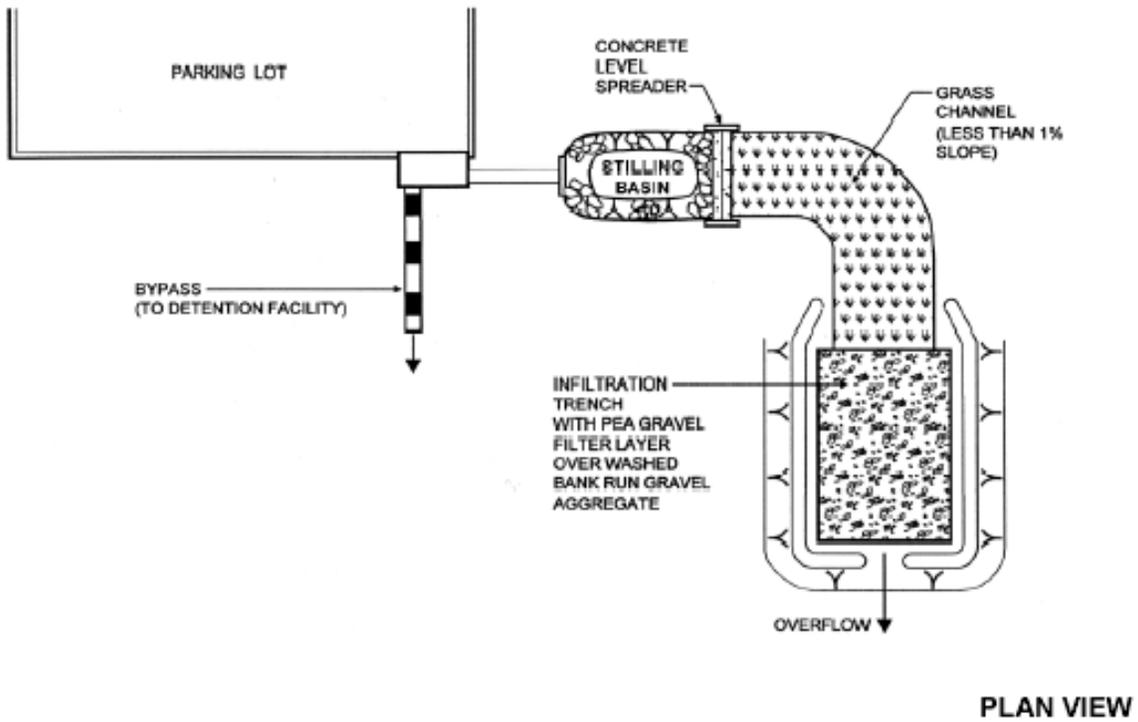
Infiltration Basin

Description

A structural BMP used to capture and treat a volume of stormwater runoff. This BMP consists of an excavated basin (sometimes rock-filled) in which runoff is collected and percolated to the surrounding soils. Grass channels, filter strips, or forebays can be used to reduce sediments entering the basin. The basin has a flat floor with an underdrain system and an outfall to drain higher volumes of flow.

Application Guidelines

Basin can be used to enhance stormwater quality, reduce peak discharges, and recharge groundwater,

Basins should not be used on or adjacent to steep slopes and should not be used within fill soils,

Upstream stilling basins can be used to pre-treat portions of the water quality volume,

Typically used for drainage areas less than 5 acres,

Basins should only be used with well-drained soils of Hydrologic Soil Groups A or B,

Bottom of the basin should be 4 feet higher than the seasonal high water table or bedrock,

Basins should not be installed in highly permeable sand or gravel seams that are directly connected to aquifers,

Basins can be directly connected to parking lot drains, roof downspouts, or other inlet structures.

Basic Design Criteria

Generally, basins are designed to infiltrate retained runoff within a 48-hour period,

Regular inspections are necessary and accumulated sediments will need to be removed periodically,

A dense vegetative cover needs to be established over all contributing pervious areas before runoff can be conveyed to the basin,

De-watering methods need to be designed in the event of a failure. For the basin, underdrain pipe systems will accommodate excess flows,

Observations should be made to determine the time needed for water to infiltrate into the soil after a storm event,
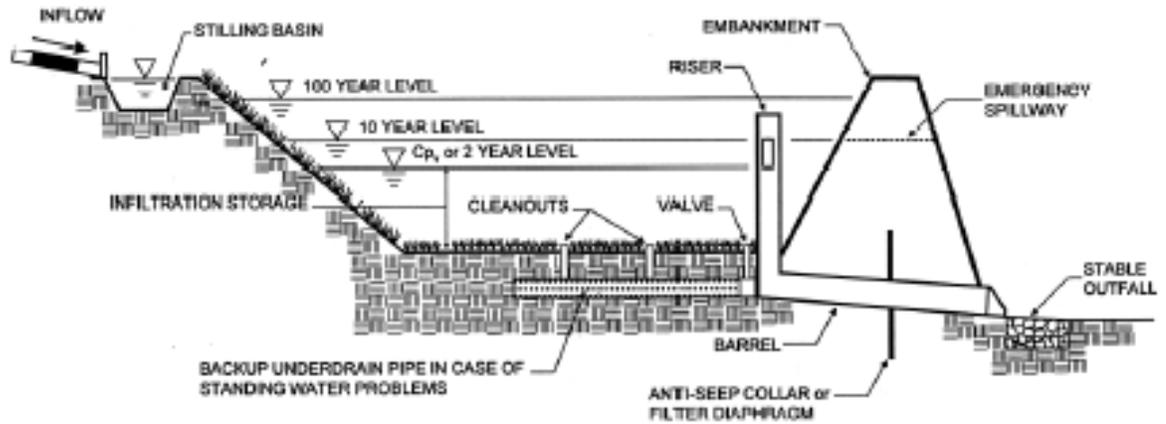
Periodic observations should also be made to monitor any decrease in performance.

Infiltration Basin

Reference: Maryland Stormwater Design Manual.
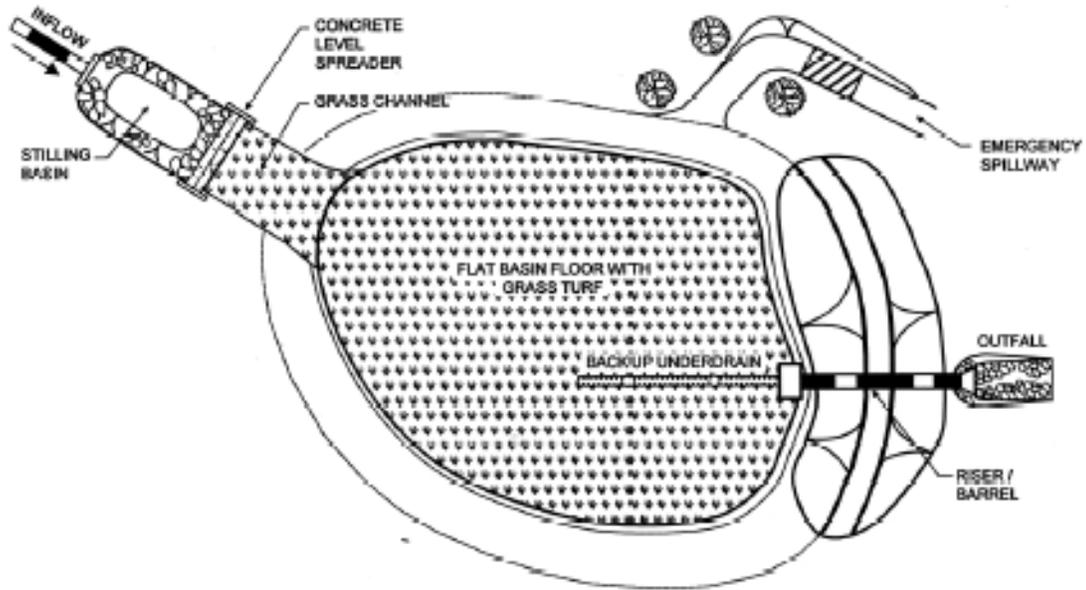
PLAN VIEW

PROFILE

Surface Sand Filter

Description

A structural BMP used to capture and treat a volume of stormwater runoff. This BMP is an excavated basin underlain by a sand filter bed with an underdrain system. Runoff collects in the basin and gradually infiltrates into the sand bed. The underdrain then de-waters the sand bed and flows are conveyed to a nearby swale or storm sewer. An outfall is used to drain higher volumes of flow.
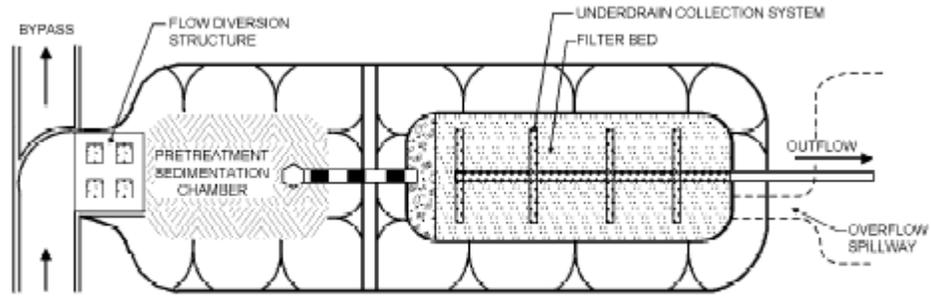

Application Guidelines

Filter can be used to enhance stormwater quality and reduce peak discharges,

Filter is subject to clogging if moderate to high levels of silts and clays flow into facility and should not be used while construction is occurring in the upstream catchment. Facility is most effective if used with a pre-treatment basin to filter out finer materials,

Most effective in treating runoff from small storms or early stages of larger storms.

Upstream grass channels or grass filter strips can also be used to help protect the integrity of the basin,

Generally suited to tributary, on-site drainages and most development sites where sediment loads are low and there is no baseflow,

Filter can also be used in areas of thin soil and high evaporation rates,

Surface Sand Filters can treat the largest drainage area of all filtering systems. Upper limit of drainage area is 50 acres although most applications are for areas between 0.5 and 10 acres,

Useful in watersheds where groundwater quality is a concern or where low permeability soils prevent infiltration,

Filter should not be located close to building foundations or in areas where expansive soils are a concern,

Basic Design Criteria

Generally, basins are designed to infiltrate retained runoff within a 40-hour period,

Regular inspection and maintenance is necessary to remove surface sediment, trash, debris, and leaf litter,

A dense vegetative cover needs to be established over all contributing pervious areas before runoff can be conveyed to the filter,

Screens/grated inlets should be considered in design to keep debris out of filter chambers,

Maximum design volume depth is generally 3 feet,

Filter bed typically has a minimum depth of 18".

Surface Sand Filter

Reference: Denver Urban Drainage and Flood Control District, Volume 3 Criteria Manual.

PLAN VIEW
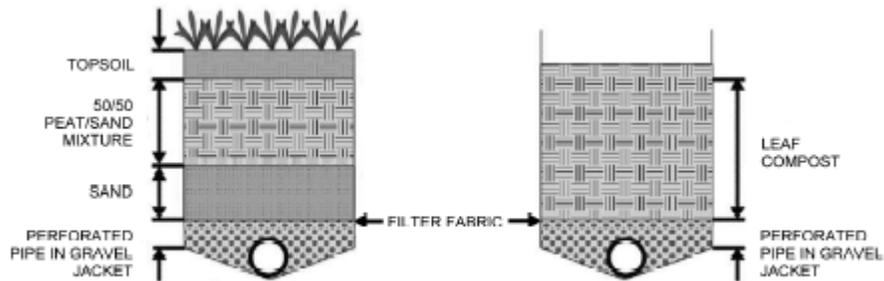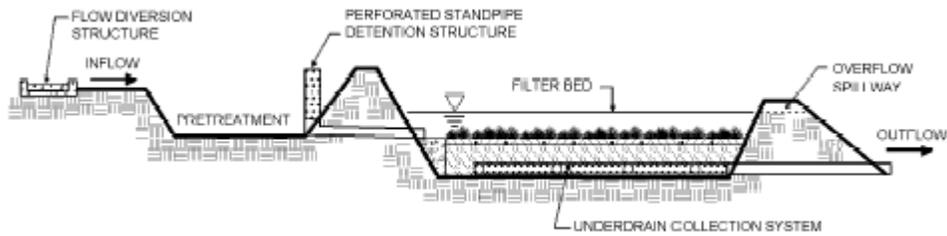
TYPICAL SECTIONS

Subsurface Sand Filter

Description

A structural BMP used to capture and treat a volume of stormwater runoff. This structure consists of an underground concrete vault with distinct chambers designed for various levels of treatment. Flows enter and exit the structure through underground pipes and flows from the filter are conveyed into a storm sewer or open channel.
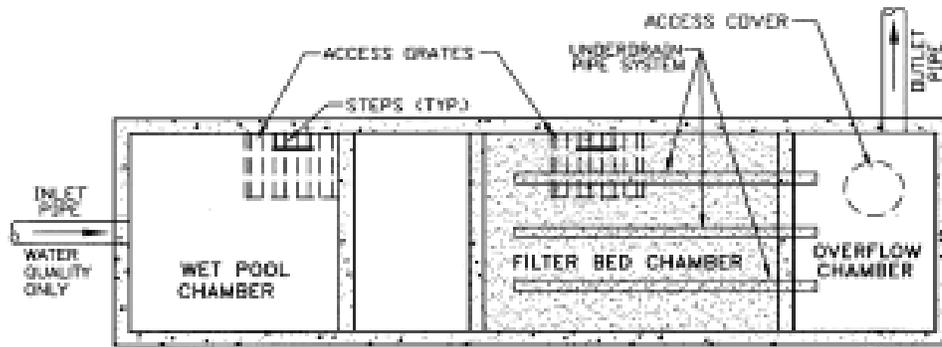
Application Guidelines

Filter is used to enhance stormwater quality,

Filter is subject to clogging if moderate to high levels of silts and clays flow into facility and should not be used while construction is occurring in the upstream catchment,

Upstream grass channels, grass filter strips, or other BMP's can be used to help remove sediments and particulates before they enter the filter,

Particularly useful at sites with limited space for water quality treatment or in high-value real estate areas. Filter vault can be installed under parking lots and streets,

Most effective in treating runoff from small storms or early stages of larger storms.

Filters are generally used in areas where sediment loads are low and there is no baseflow,

Subsurface sand filters are used to treat drainage areas of 5 acres or less,

Useful in watersheds where groundwater quality is a concern or where low permeability soils prevent infiltration.

Basic Design Criteria

Generally, basins are designed to infiltrate retained runoff within a 40-hour period,

Regular inspection and maintenance is necessary to remove surface sediment, trash, debris, and leaf litter,

A dense vegetative cover needs to be established over all contributing pervious areas before runoff can be conveyed to the filter,

Screens/grated inlets should be considered in design to keep debris out of filter chambers,

Filter bed typically has a depth of between 18" and 30",

In certain cases, layers of sand will need to be replaced every 3 to 5 years,

Outlets and chambers will be cleaned/repaired when drawdown times in the filter exceed 36 hours.
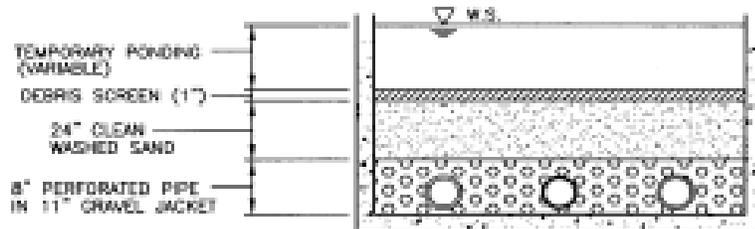
Subsurface Sand Filter

Reference: Maryland Stormwater Design Manual.

PLAN VIEW
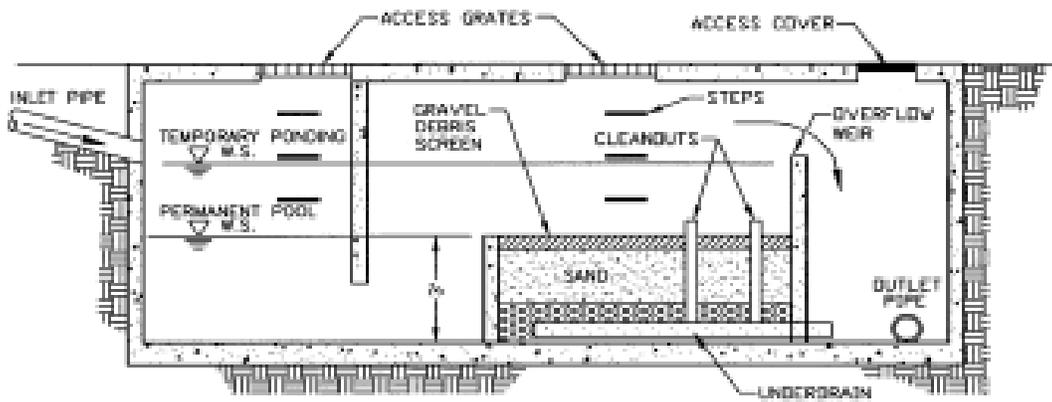
PROFILE

FILTER SECTION

Perimeter Sand Filter

Description

A structural BMP used to capture
and treat a volume of stormwater
runoff. This BMP consists of an
underground concrete vault with
distinct chambers designed for
various levels of treatment. Flows
enter the structure through surface
grates and exit the structure
through underground pipes.
Generally, one chamber collects
sediments while the other chamber
filters runoff.


Application Guidelines

Filter is used to enhance stormwater quality,

Filter is subject to clogging if moderate to high levels of silts and clays flow into facility and
should not be used while construction is occurring in the upstream catchment,

Upper chamber filters out finer materials and sediments. Flows percolate through a sand
filter in the lower chamber and into an underdrain system,

Upstream grass channels, grass filter strips, or other BMP's can be used to help remove
sediments and particulates before they enter the filter,

Most effective in treating runoff from small storms or early stages of larger storms,

Particularly useful at sites with limited space for water quality treatment such as parking
lots or in high-value real estate areas. Filter vault can be installed under parking lots and
streets,

Also practical for small sites with flat terrain or a high water table,

Filters are generally used where sediment loads are low and there is no baseflow,

Subsurface sand filters are used to treat drainage areas of 5 acres or less,

Useful in watersheds where groundwater quality is a concern or where low permeability
soils prevent infiltration.

Basic Design Criteria

Generally, basins are designed to infiltrate retained runoff within a 40-hour period,

Regular inspection and maintenance is necessary to remove surface sediment, trash, debris,
and leaf litter,

A dense vegetative cover needs to be established over all contributing pervious areas before
runoff can be conveyed to the filter,

Screens/grated inlets should be considered in design to keep debris out of filter chambers,

In certain cases, layers of sand will need to be replaced every 3 to 5 years,

Outlets and chambers will be cleaned/repaired when drawdown times in the filter exceed
36 hours.

Perimeter Sand Filter

Reference: Maryland Stormwater Design Manual.
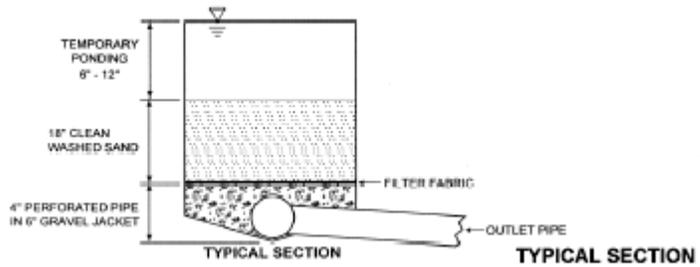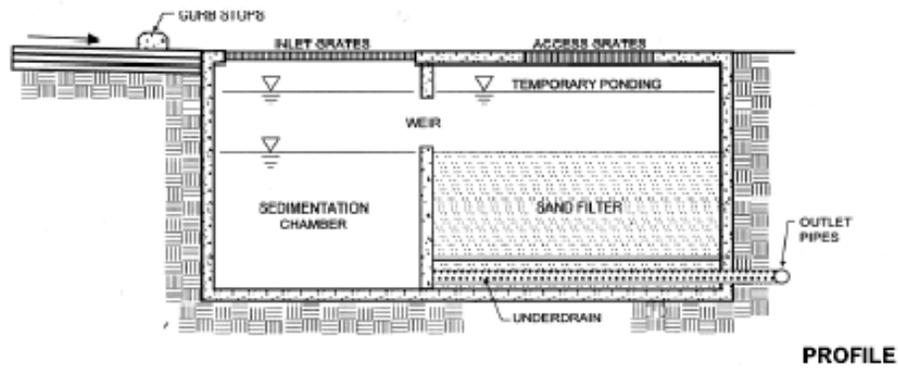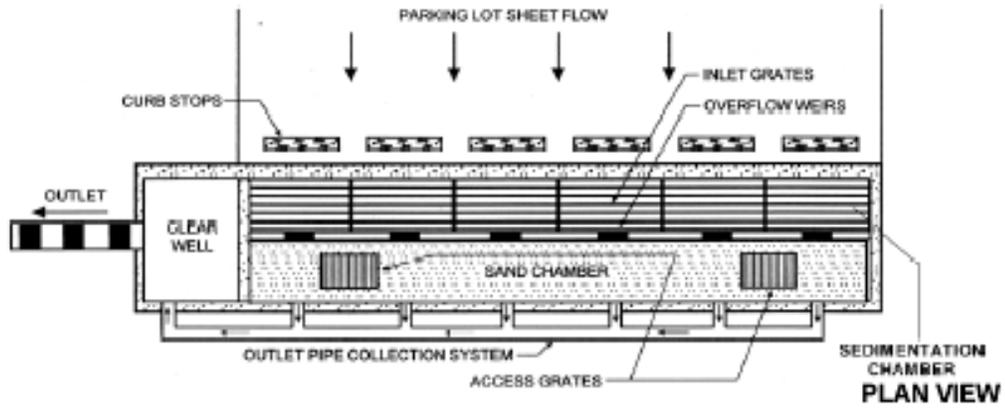
Organic Filter

Description

A structural BMP used to capture and treat a volume of stormwater runoff. This BMP is identical to a Surface Sand Filter. However, the runoff storage zone is underlain by a 50/50 peat and sand mixture filter bed with an underdrain system. This filter is used in areas where maximum nutrient or trace metal removals are desired. The underdrain system then conveys flows to a swale or storm sewer.
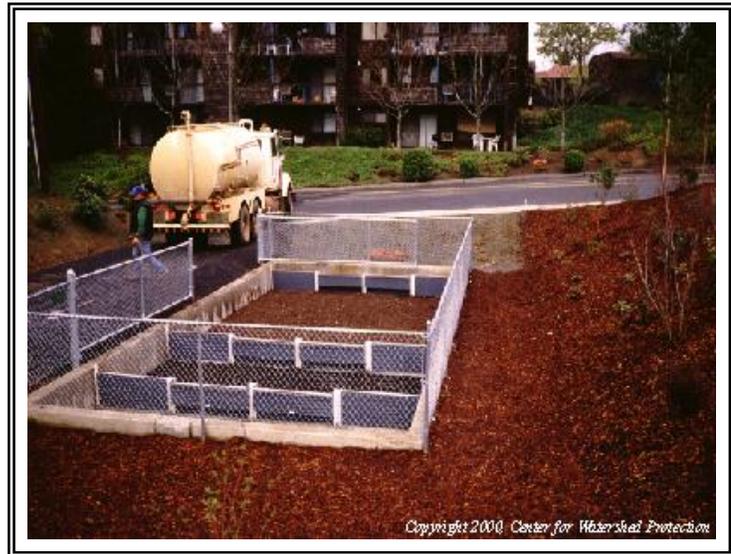
Copyright 2000 Center for Watershed Protection

Application Guidelines

Filter can be used to enhance stormwater quality and reduce peak discharges,

Upstream grass channels or filter strips can be used to protect the integrity of the basin,

Most effective in treating runoff from small storms or early stages of larger storms.

Filter is subject to clogging if moderate to high levels of silts and clays flow into facility and should not be used while construction is occurring in the upstream catchment. Pre-treatment basin can be used to filter out finer materials and prevent the filter bed from clogging,

Generally suited to tributary, on-site drainages and most development sites where sediment loads are low and there is no baseflow,

Filter can also be used in areas of thin soil and high evaporation rates,

Upper limit of drainage area is 50 acres although most applications are for areas between 0.5 and 10 acres,

Area for filter should be flat or only slightly depressed,

Useful in watersheds where groundwater quality is a concern or where low permeability soils prevent infiltration,

Filter should not be located close to building foundations or in areas where expansive soils are a concern.

Basic Design Criteria

Generally, basins are designed to infiltrate retained runoff within a 40-hour period,

Regular inspection and maintenance is necessary to remove surface sediment, trash, debris, and leaf litter,

A dense vegetative cover needs to be established over all contributing pervious areas before runoff can be conveyed to the filter,

Screens/grated inlets should be considered in design to keep debris out of filter chambers.

Organic Filter

Reference: Maryland Stormwater Design Manual.

PLAN VIEW

PROFILE

TYPICAL SECTIONS
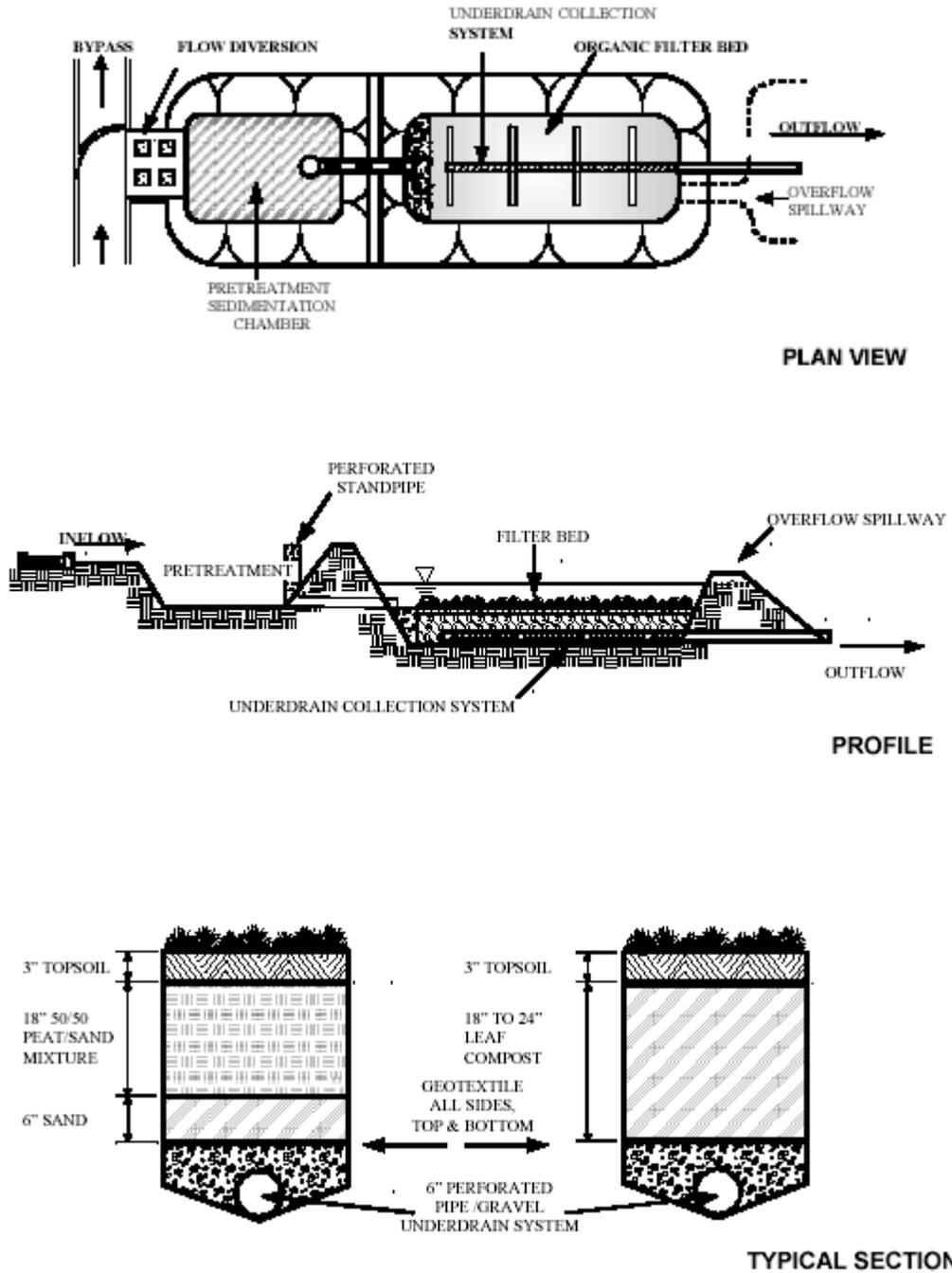
Pocket Sand Filter

Description

A structural BMP used to capture and treat a volume of stormwater runoff. This BMP is similar to a Surface Sand Filter. The filter consists of a small excavated basin with a runoff storage zone underlain by a sand filter bed. For this BMP, the lower portion of the sand bed has a pea gravel 'window' on the surface that allows runoff into the filter if the surface becomes clogged.

Copyright 2000 Center for Watershed Protection

Application Guidelines

Filter can be used to enhance stormwater quality,

Filter is subject to clogging if moderate to high levels of silts and clays flow into facility and should not be used while construction is occurring in the upstream catchment. Pre-treatment basin can be used to filter out finer materials and prevent the sand filter bed from clogging,

Underdrain dewaters the sand bed and discharges runoff to a nearby swale or storm sewer,

Generally suited to small sites (5 acres or less) where sediment loads are expected to be moderate to low and where there is no baseflow,

Upstream grass channels or grass filter strips can be used to help protect the integrity of the basin,

Area for filter should be flat or only slightly depressed,

Useful in watersheds where groundwater quality is a concern or where low permeability soils prevent infiltration,

Filter should not be located close to building foundations or in areas where expansive soils are a concern.

Basic Design Criteria

Generally, basins are designed to infiltrate retained runoff within a 40-hour period,

Regular inspection and maintenance is necessary to remove surface sediment, trash, debris, and leaf litter,

A dense vegetative cover needs to be established over all contributing pervious areas before runoff can be conveyed to the filter,

Screens/grated inlets should be considered in design to keep debris out of filter chambers,

Filter bed typically has a depth of approximately 1.5 feet, with 3 inches of topsoil.

Pocket Sand Filter

Reference: Maryland Stormwater Design Manual.

PLAN VIEW

PROFILE
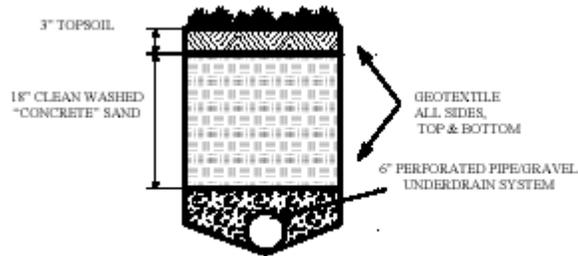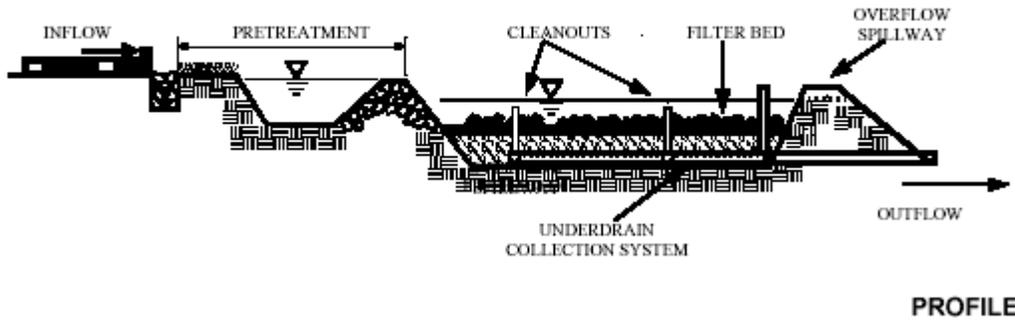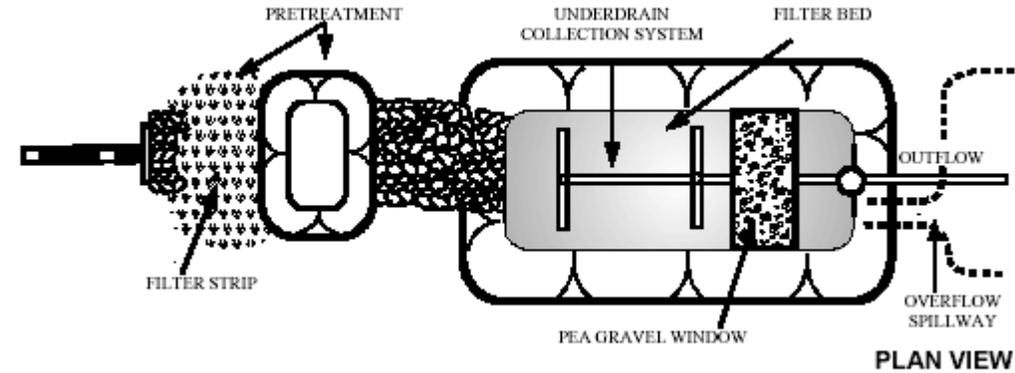
TYPICAL SECTION

Bioretention

Description

A structural BMP used to capture and treat a volume of stormwater runoff. The Bioretention area is an excavated pit filled with planting soil or a sand/planting soil mix. Runoff ponds in the depression on top of the bioretention area and percolates through the sand/soil later. Flows are then conveyed by an underdrain system connected to a storm sewer, open channel, or stream.

Application Guidelines

Structure can be used to enhance stormwater quality, reduce peak runoff, and recharge groundwater,

Can be used in residential and non-residential development areas,

Excavated area is lined with layers of filter fabric,

Efficient for removing a wide variety of pollutants including suspended solids and nutrients,

Structure can be off-line, receiving runoff from overland flow or other structures in a traditional drainage system, or on-line, where structures are located in grass swales or other conveyance systems that have been modified to enhance pollutant removal,

Upstream grass channels or grass filter strips can be used to help protect the integrity of the basin,

Generally suited for drainage areas of 10 acres or less,

Runoff sources can be overland flow from impervious areas or discharges from drainage pipes,

Most effective if the retention area can be located as close as possible to the runoff source.

Basic Design Criteria

Generally, basins are designed to infiltrate retained runoff within a 40-hour period,

Regular inspection and maintenance is necessary to remove surface sediment, trash, debris, and leaf litter, and dead or diseased plant material,

A dense vegetative cover needs to be established over all contributing pervious areas before runoff can be conveyed to the filter,
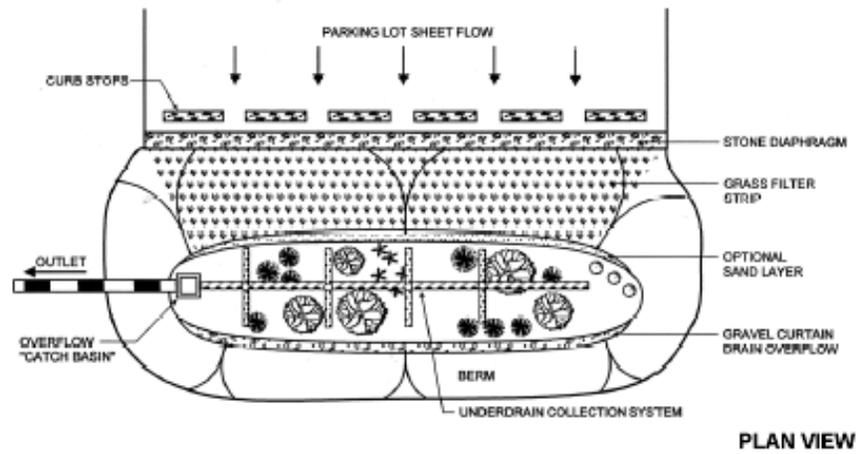
Screens/grated inlets should be considered in design to keep debris out of filter chambers,

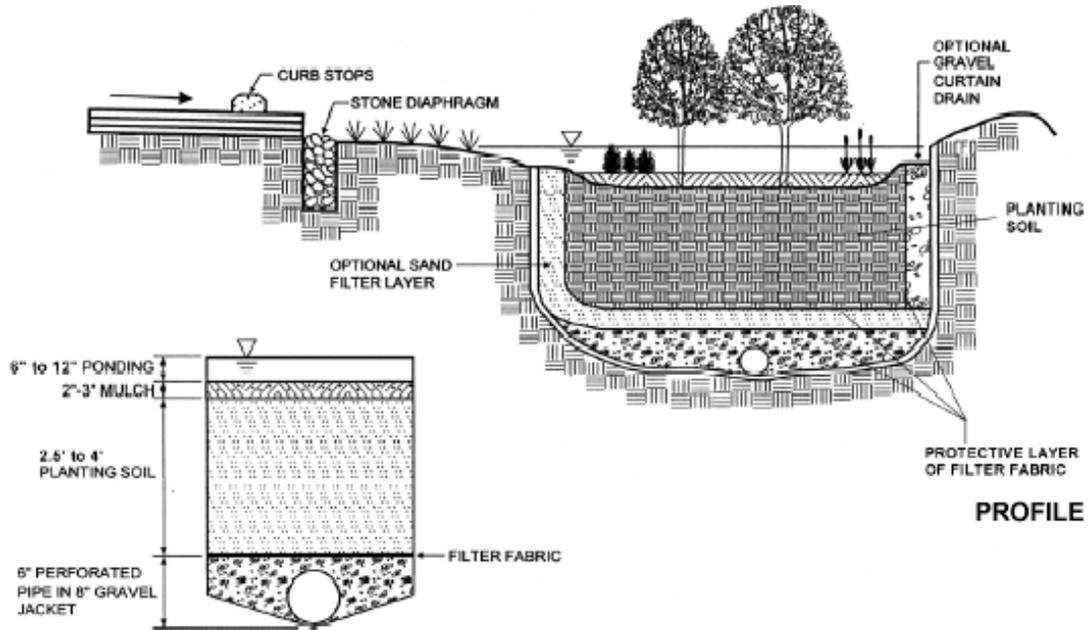Filter bed typically has a depth of approximately 2.5 to 4 feet,

The top of the bioretention area is depressed to allow for 6 to 12 inches of stormwater ponding.

Bioretention

Reference: Maryland Stormwater Design Manual.

PLAN VIEW

PROFILE

TYPICAL SECTION

Dry Swale

Description

A structural BMP used to filter pollutants as stormwater runoff moves through the swale. This BMP is constructed as an open-channel drainageway with grass or other vegetation to provide conveyance and to filter pollutants. Other features such as check dams, pre-treatment forebays, gravel pads, and riprap can be used to temporarily inhibit stormwater runoff and enhance treatment.

Application Guidelines

Structure can be used to enhance stormwater quality and reduce peak runoff,
Efficient for removing a wide variety of pollutants including suspended solids and nutrients.
Swales work best in conjunction with other BMP's and can be used as an alternative to or enhancement of a conventional storm sewer,
Excavated area is lined with layers of filter fabric around the permeable soil,
Flows that infiltrate into the channel soil are conveyed by an underdrain system,
Swales are used in low density residential areas or for very small impervious areas, generally less than 10 acres,
Runoff sources can be overland flow from impervious areas or discharges from drainage pipes,
Swales can be used in early post-construction when stabilizing vegetation is not established and principal consideration is preventing erosion in unvegetated channels,
Well suited for flat or rolling terrain,
Swale depressions can be used in place of above-ground islands in large parking lots.

Basic Design Criteria

Generally, swales are designed to temporarily store the water quality volume for a maximum of 48 hours,
Regular inspection and maintenance is necessary to remove surface sediment, trash, debris, and leaf litter, and dead or diseased plant material. Routine mowing is required,
A vegetative cover needs to be established as soon as possible to prevent erosion and scour. They should also be constructed early in the construction schedule before grading and paving increase runoff rates,
The maximum ponding depth is generally no greater than 1.5 feet at the outlet,
Longitudinal slope should be as flat as possible, to minimize velocities and enhance pollutant filtering.

Dry Swale

Reference: Denver Urban Drainage and Flood Control District, Volume 3 Criteria Manual.
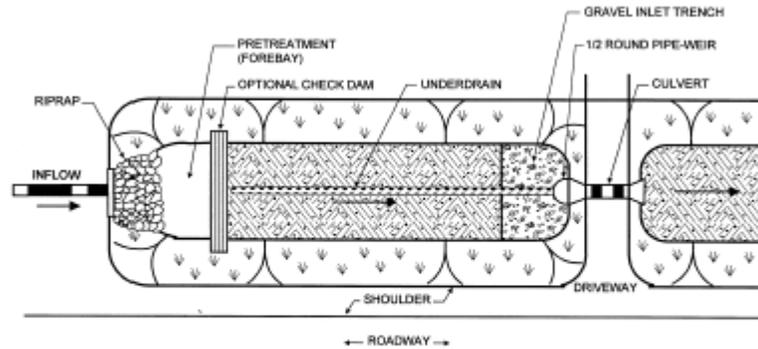
PLAN VIEW
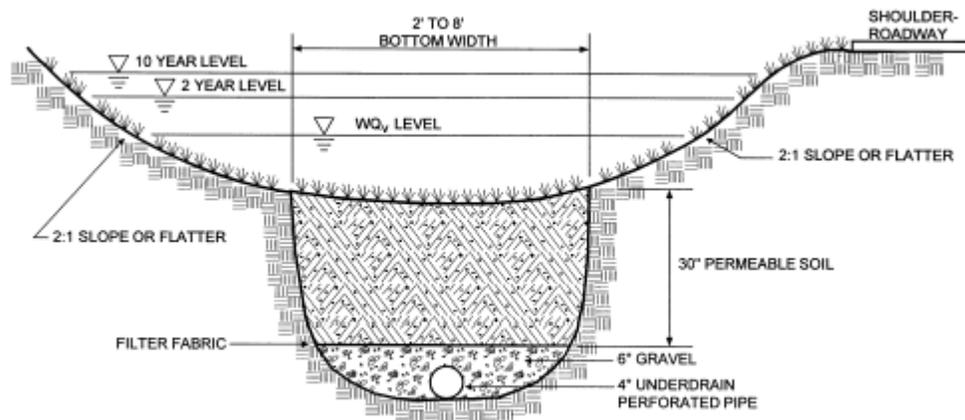
SECTION

Wet Swale

Description

A structural BMP used to filter pollutants as stormwater runoff moves through the swale. This BMP is constructed as an open-channel drainageway with grass or other wetland vegetation to filter pollutants. Other features such as check dams, pre-treatment forebays, gravel pads, and riprap can be used to temporarily inhibit stormwater runoff and enhance treatment.

Application Guidelines

Structure can be used to enhance stormwater quality and reduce peak runoff,
Efficient for removing a variety of pollutants including suspended solids and nutrients.
Wet swales are ideal for treating highway runoff in flat terrain areas,
Wet swales can be used in residential areas if ponded water can be flushed frequently and wetland vegetation in the bottom of the channel can be established and maintained.
Extended periods of standing water may result in nuisance conditions and mosquito problems,
Flows from wet swales are generally conveyed through a surface outlet structure to an open channel or stream, or directly into a storm sewer,
Drainage areas are generally less than 10 acres,
If designed with check dams and/or depression storage, the swale can satisfy site runoff capture storage requirements,
Runoff sources can be overland from impervious areas or flows from drainage pipes,
Swale depressions can be used in place of above-ground islands in large parking lots.

Basic Design Criteria

Generally, swales are designed to temporarily store the water quality volume for a maximum of 48 hours,
Regular inspection and maintenance is necessary to remove surface sediment, trash, debris, and leaf litter, and dead or diseased plant material,
A vegetative cover needs to be established as soon as possible to prevent erosion and scour. They should also be constructed early in the construction schedule before grading and paving increase runoff rates,
The maximum ponding depth is generally no greater than 1.5 feet at the outlet,
Longitudinal slope should be as flat as possible, to minimize velocities and enhance pollutant filtering, while still allowing for periodic flushing of standing water,
Frequent mowing is not required.

Wet Swale

Reference: Maryland Stormwater Design Manual.
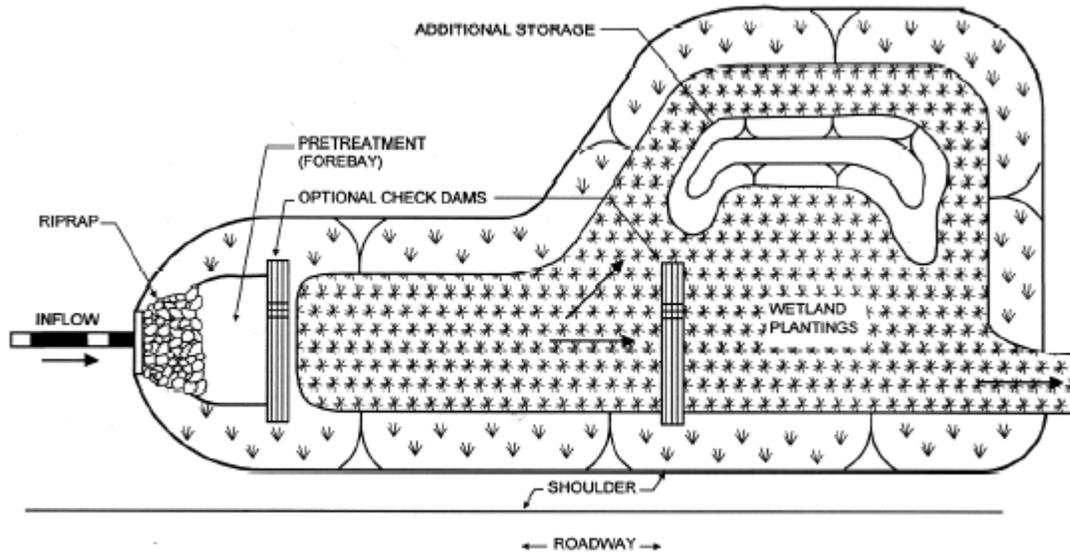
PLAN VIEW
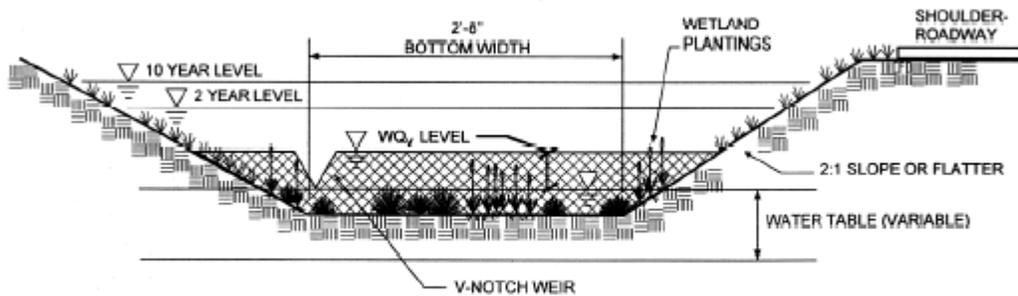
PROFILE

Sheet Flow to Buffers

Description

A structural BMP used to filter pollutants as stormwater runoff moves to a swale, stream, or other flow area. This BMP protects streams, lakes, and/or wetlands from high concentrations of sediment in runoff. The flows are discharged over the buffer zone where sediments and other pollutants can be filtered out before the flows reach the natural drainageway.


Application Guidelines

Zone where stormwater runoff is treated by a natural buffer before it enters a stream or forested area,
Runoff from pervious and impervious areas is discharged through buffer,
Buffer generally consists of grass, meadow, forest or a mix,
Generally used to treat overland flow in the green space of a development site,
Level spreader or similar BMP can be used along upstream edge of buffer zone to enhance treatment.

Basic Design Criteria

Minimum buffer width is 50 feet and is measured from the bank elevation of the stream,
Maximum contributing length is 150 feet for pervious surfaces and 75 feet for impervious surfaces,
Runoff will enter the buffer as sheet flow. If sheet flow cannot be achieved at the edge of the buffer, a level spreader or similar BMP will be used to establish sheet flow,
Contributing overland slope should be less than 5%,
Buffer is not applicable where rooftop or non-rooftop disconnections are already in place,
Buffers should be located within accepted conservation easements or other enforceable areas that will ensure protection of the buffer area.

Sheet Flow to Buffers

Reference: Denver Urban Drainage and Flood Control District, Volume 3 Criteria Manual.
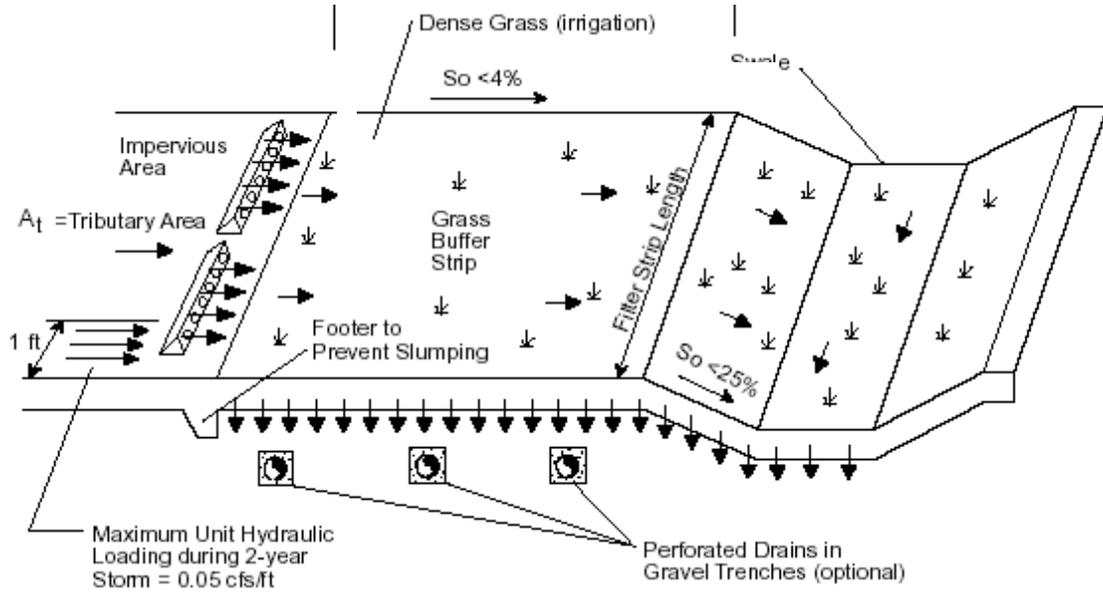
SHEET FLOW CONTROL
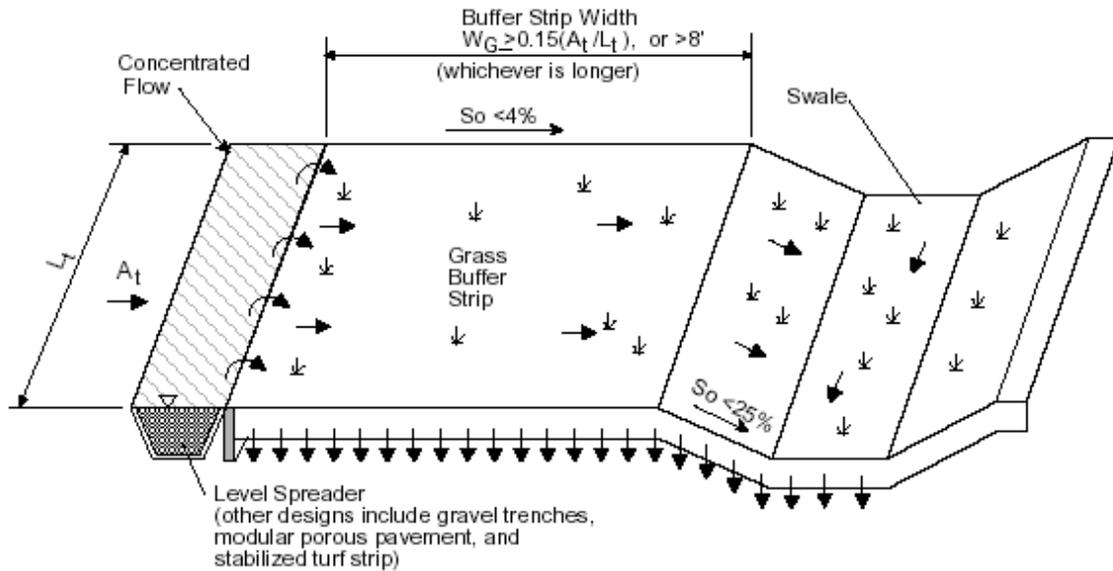
CONCENTRATED FLOW CONTROL

Catch Basin Inserts

Description

Catch basin inserts hang from the opening of a curb inlet or below the grate of an area inlet. These inserts catch debris and other sediment and pollutant particles before they can enter the inlet structure. Some inserts have more than one treatment mechanism (i.e. oil absorption) and are generally placed in areas where oil/grit separators cannot be used.

Application Guidelines

Generally, inserts are not suitable for removal of fine particulates such as metals, clays, silts, or nutrients,

Some inserts are designed with more than one treatment mechanism. One such method is an inner component that contains oil absorbent materials,

Can be used in areas where coarse sediments or materials are expected in stormwater,

Suitable for sites where substantial amounts of debris are found in stormwater,

Can be used in areas of unpaved roads or parking areas, construction sites, unpaved industrial sites, and lumber yards,

Inserts can be used in areas where oil/grit separators cannot be used,

Some inserts are designed with a high-flow bypass to prevent re-suspension and washout,

Inserts have limited ability to remove pollutants and should be used in conjunction with other BMP's,

Best suited as pre-treatment for sediment and debris removal before flows are conveyed to downstream BMP's.

Basic Design Criteria

Inserts should be designed for a reasonable design storm (i.e. 2-year), based on the characteristics of the site,

Inserts should not interfere with storm events greater than or equal to the 10-year storm,

Regular inspection and maintenance is required,

Inserts should be cleaned after every two or three major storms,

Maintenance is more intensive for inserts configured to remove oil and grease,

Street sweeping can be used in conjunction with inserts to reduce maintenance frequency.

Catch Basin Inserts

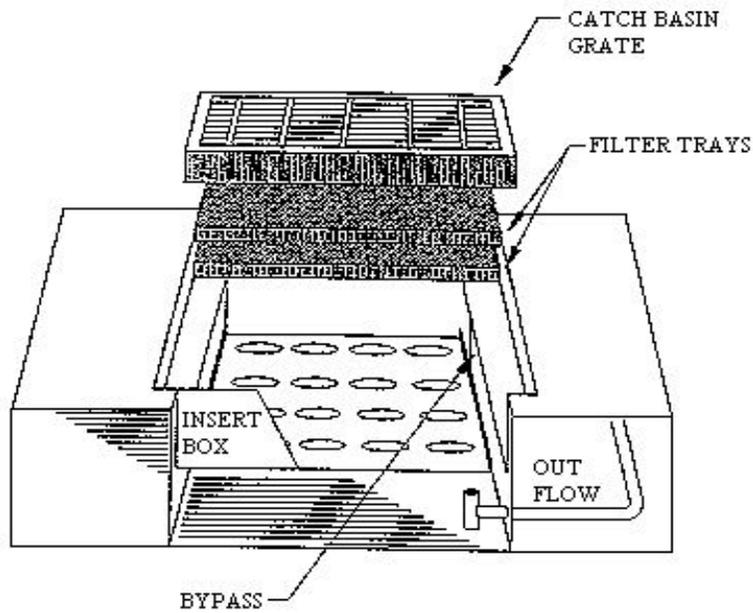Reference: Pierce County, Washington Public Works and Utilities

Figure T.4.4 CATCH BASIN FILTER
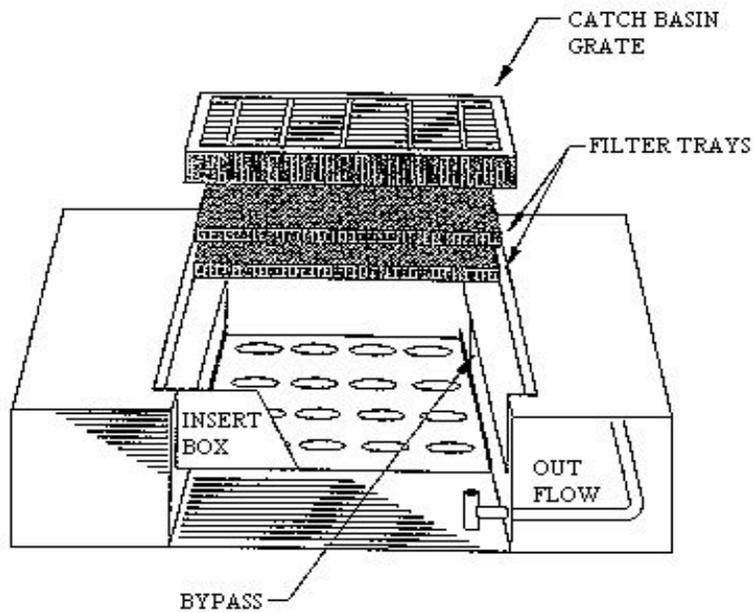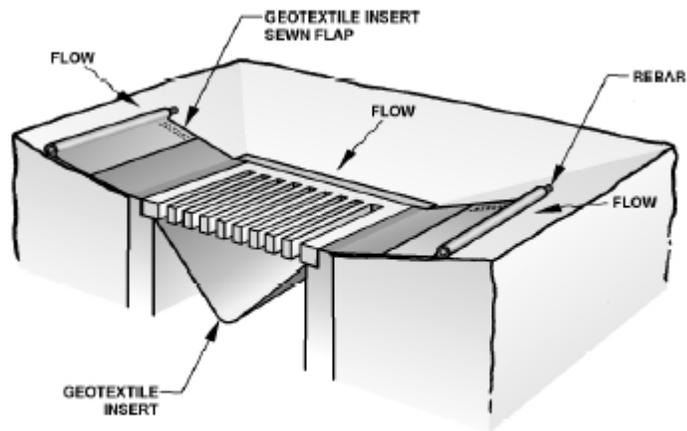N.T.S.

Figure T.4.4 CATCH BASIN FILTER
N.T.S.

Inlet Protection - Prefabricated Filter Insert

Water Quality Inlet with Oil/Grit Separator

Description

This structural BMP is similar to a standard curb inlet with modifications made to the underground portion of the structure to separate oil and grit into discrete chambers. Generally this BMP consists of a three chamber system designed to remove heavy particulates and absorb hydrocarbons from stormwater runoff.


Application Guidelines

Generally used at sites expected to receive heavy vehicular traffic,

Also used at sites where oils, grease, and petroleum products could be carried by stormwater,

Inlets are often placed in parking lots, service stations, or in truck loading areas,

Inlets can be used to reduce the maintenance required at downstream BMP's,

Multi- stage underground retention system,

Upstream chamber traps sediments, center chamber traps oils and other heavy substances, downstream chamber discharges flows,

Since flows are only detained for a short time, pollutants not removed as effectively as facilities that retain runoff for longer periods,

Although flows are only detained for a short time, inlet can be used as an effective first stage of treatment by removing oil, grease, and sediments from stormwater before the flows enter a larger BMP such as a pond,

Inlets can be installed in most areas and drainage area to inlet is generally less than one acre.

Basic Design Criteria

Inlets can be installed in any soil or terrain and are best used when they are installed at or near the impervious area that generates stormwater runoff,

Area above inlet needs to be large enough for maintenance access,

The inlet should be designed with a permanent pool approximately 4 feet deep with a total chamber volume of 400 cubic feet of water per acre of contributing drainage area,

Higher levels of pollutants can be removed by incorporating surface skimmers in the structure,

Structure should be inspected regularly and cleaned at least twice per year to remove sediment, oil, grease, and other pollutants.

Water Quality Inlet with Oil/Grit Separator

Reference: Georgia Stormwater Management Manual
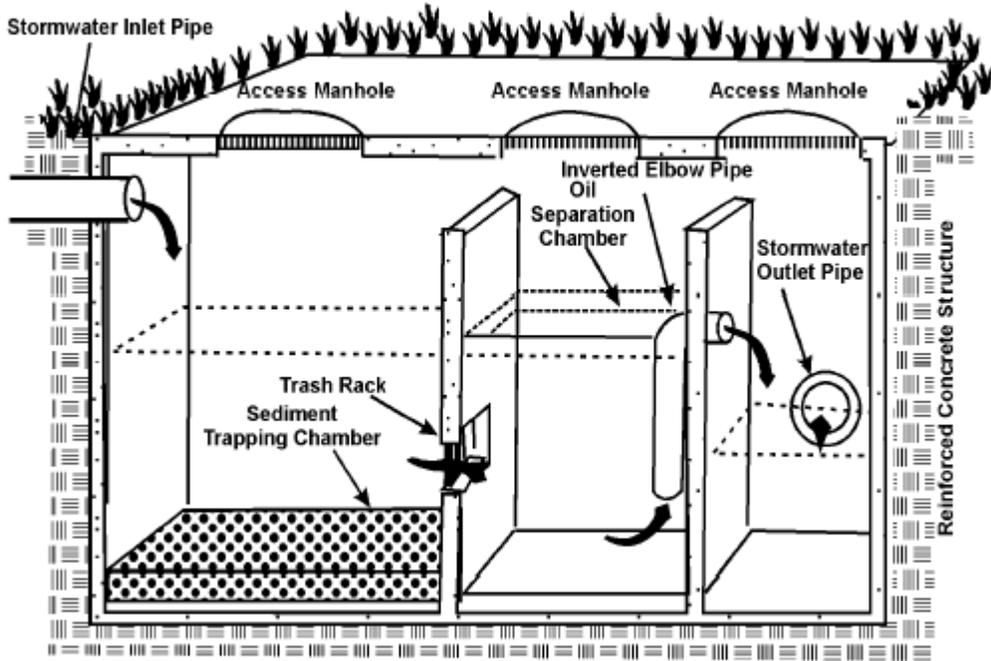
Street Sweeping

Description

In this BMP, mechanical vehicles are used to physically remove solids and other pollutants from impervious surfaces. New street sweeping technologies, including vacuum assisted sweeping, can potentially reduce total annual suspended solids and pollutants up to 80%.

Application Guidelines

Well suited in urban environments where little land is available for structural or sediment controls,

Can be used in commercial districts and industrial sites, and in intensely developed areas near receiving waters,

Consider for highway applications along road shoulders, rest stops, parking areas, or maintenance yards,

Best results when most sophisticated sweepers are used at a weekly to bimonthly frequency, depending on local regulations and conditions,

Not a good application in removing oil and grease,

Older mechanical sweepers are limited in their ability to remove fine sediment

Types of sweepers and practices include: Vacuum-assisted, Mechanical sweepers, Regenerative air sweepers, vacuum-assisted dry sweepers, and Tandem sweeping.

Basic Design Criteria

Sweepers need to be operated at optimum speeds and sweeping patterns, with brushes properly adjusted, for maximum particulate removal from surfaces,

Generally, 50% of particulates can be removed if sweeping is done at least once between storms with two passes per run. Depending on local traffic conditions and storm frequencies, sweeping may need to be done at more frequent intervals to achieve desired particulate removal,

Maintenance requirements are greater for certain types of sweepers,

Ensure that arrangements are made for the disposal of collected wastes,

Street sweeping is more effective if upstream erosion control and stormwater BMP's are implemented, especially at construction sites.

Deep Sump Catch Basins

Description

This structural BMP is designed to capture and treat runoff. This structure is a modified drainage inlet that removes debris, oil, grease, and sediment from storm flows. Runoff enters the top of the structure and flows through screened orifices to a treatment chamber. Stormwater flows out of the chamber through an inverted pipe. Because the pipe is inverted, pollutants are trapped in the basin.

Application Guidelines
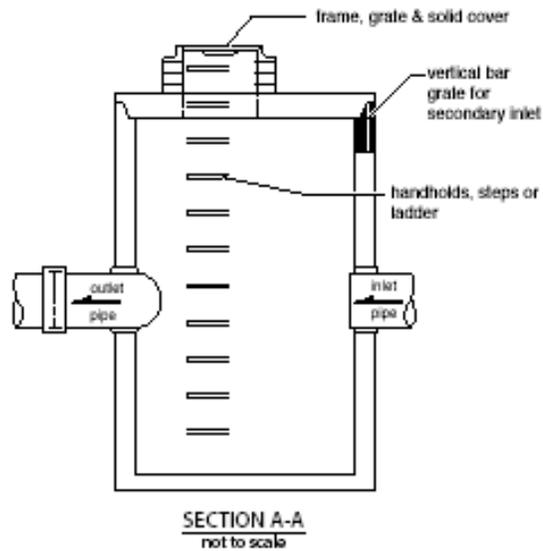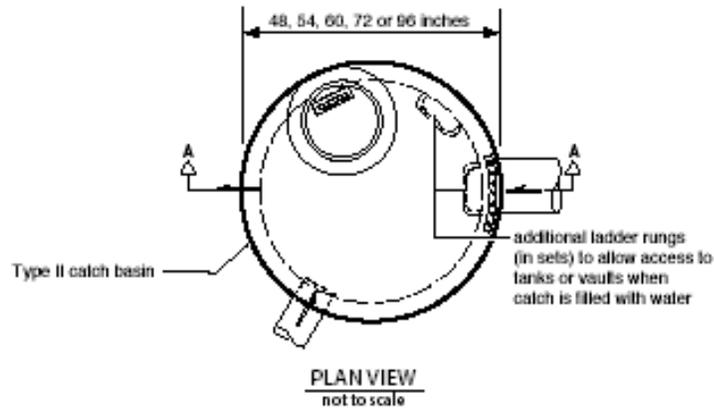
Structure can be used to provide pre-treatment for other BMP's,
Can be retrofitted to provide water quality treatment for small urban lots where larger BMP's cannot be used due to site constraints,
Located underground so lot size is not a factor,
Structure can be used as part of a storm drain system with a circular manhole or rectangular box,
Structure can be easily accessed for maintenance,
Sump has limited pollutant removal capabilities and is expensive to maintain,
Generally used for parking lots, gas stations, convenience stores, or other areas with substantial vehicle traffic.
Contributing area is expected to generate high sediment and hydrocarbon loadings,
Contributing area to a single structure should be limited to one acre or less,

General Design Criteria

Structure discharge point is located at least 4 feet below the inflow point,
Regular maintenance is required to ensure effectiveness of structure,
Inflow pipe is designed to pass the design storm volume directly into the sump. Excess flows are routed to another BMP of sufficient capacity to meet water quality requirements,
The volume of the permanent pool in the chamber should be maximized to achieve a consistent removal of pollutants,
The chamber volume should equal 400 cubic feet (or more) per acre of contributing impervious area,
Vertical baffles can be placed at the bottom of the structure to minimize sediment re-suspension,
Outlet pipe should be covered with a trash rack or screen to keep suspended pollutants out of downstream discharges.

Deep Sump Catch Basins

Reference: King County Washington, Department of Natural Resources and Parks, Stormwater Pollution Control Manual

48, 54, 60, 72 or 96 inches

Type II catch basin

additional ladder rungs (in sets) to allow access to tanks or vaults when catch is filled with water

PLAN VIEW
not to scale

frame, grate & solid cover

vertical bar grate for secondary inlet

handholds, steps or ladder

outlet pipe

inlet pipe

SECTION A-A
not to scale

On-Line Storage in Storm Drain Network (Vaults)

Description

This structural BMP is designed to capture and treat runoff. This structure generally consists of an underground box culvert that treats flows at or near the end of a storm sewer system. Called a Wet Vault or Sedimentation Vault, the structure has more volume for treatment that a grit chamber and removes debris, trash, and sediment from storm flows.


Application Guidelines

Structure provides temporary water quality storage for a specified storm event,

Wet vaults have a permanent pool which dissipates energy and improves the settling of particulates,

Sedimentation vaults use a weir to block flows and allow for particulate settlement. Flows are drained through a gravel/pipe riser structure behind the weir,

Vaults are typically used for commercial, industrial, or roadway projects in areas where space limitations preclude the use of other BMP's,

Stormwater flows into and out of the vault through a storm sewer pipe,

The primary pollutant removal mechanism is sedimentation,

Vaults are considerably more expensive than other BMP's,

Sediment removal schedule is less frequent than other water quality BMP's,

Maintenance requires special equipment although easily accessed for maintenance,

Vaults should be constructed in the early phases of a development project,

General Design Criteria

Wet vault volume should be maximized to increase efficiency of particulate removal,

For design, water quality volume is assumed to flow into vault all at once, rather than over the course of several hours or days,

Because the structure is underground, biological activity cannot be used for treatment in these structures,

Structure length to width from the inlet to the outlet should be a minimum of 3:1,

Outlet pipe can be covered with a trash rack or screen to keep suspended pollutants out of downstream discharges,

Gravel filter and vertical pipe riser in sedimentation vault should be designed for a retention time of 40 hours.

On-Line Storage in Storm Drain Network (Vaults)

Reference: King County Washington, Department of Natural Resources and Parks, Stormwater Pollution Control Manual
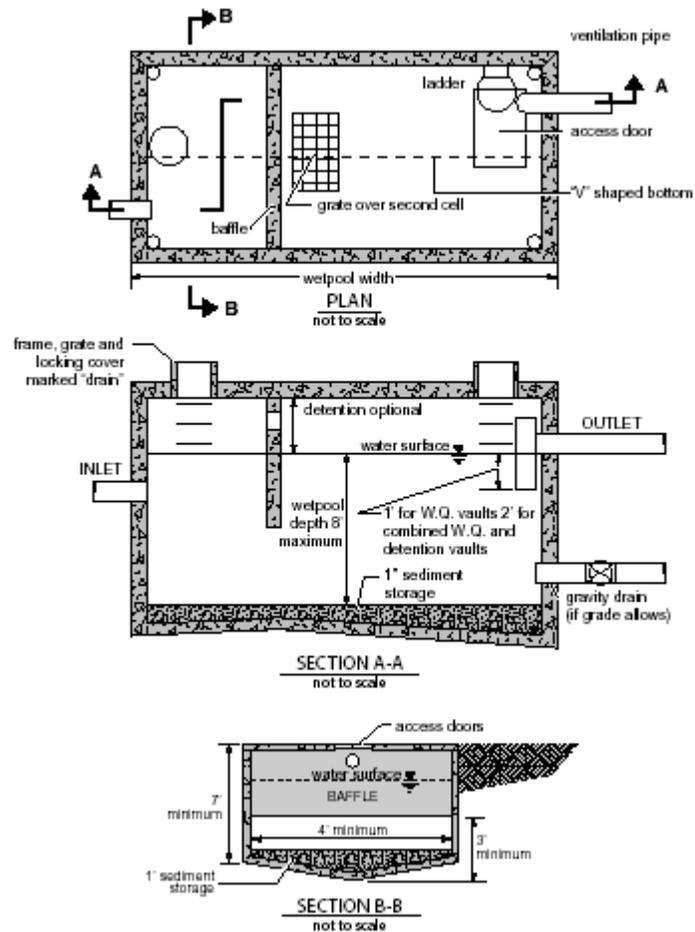
Porous Pavements

Description

This structural BMP consists of porous asphalt, concrete, lattice pavers, concrete blocks, or stones. The surface material is laid on a gravel subgrade and the surface voids are filled with sand or a sandy loam turf. Stormwater flows percolate through the pavement into the underlying soil. Using this BMP, streets, parking lots, sidewalks, and other impervious surfaces retain infiltration capacity.

Application Guidelines

Best used in areas of low traffic volumes and loads,
Alternate approach is to use grass turf reinforced with plastic rings and filter fabric underlain by gravel,
Porous pavements function to decrease the effective imperviousness of a project site,
Most often used in the construction of parking lots for office buildings and shopping centers. Other uses include traffic islands, emergency stopping areas, road shoulders, residential driveways, airport parking aprons, and maintenance roads,
Structural and functional characteristics of the surfaces they replace are maintained,
Potential for high particulate pollutant removal,
Can be used to reduce flooding by infiltrating or slowing down stormwater runoff,
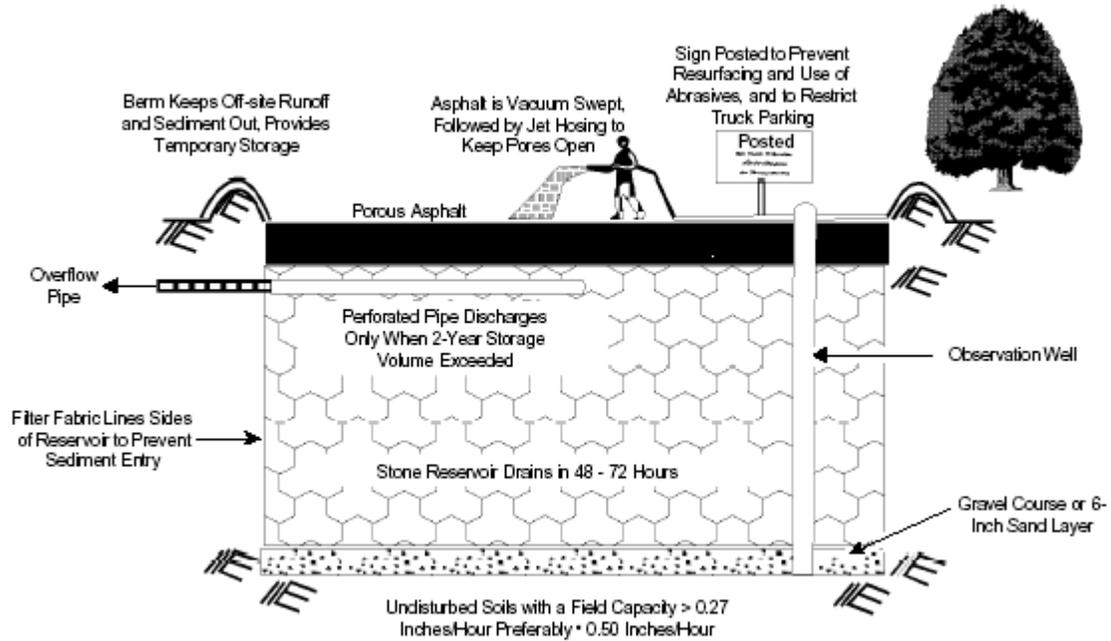Lattice pavers, blocks, or stones can enhance site aesthetics.

General Design Criteria

Initial pollutant removal rates are high but decrease as the porous materials become clogged. Careful attention to maintenance is necessary to reduce clogging. Maintenance should include vacuum sweeping and jet hosing,
Suitable sites are generally limited to low traffic areas with a minimum soil infiltration capacity of 0.5 inches/hour,
Porous pavements should not be used in areas of high contaminant loads such as gas stations and the proximity of the pavement to groundwater needs to be considered,
Pavement thickness should be sufficient to protect the subgrade,
Quality base and subbase materials should be used to support the applied loads,
Underdrain system can be used if sub-soils cannot adequately infiltrate the expected flows,
Adjacent unpaved areas should be stabilized to prevent sediment from washing into the porous pavement area,

Porous Pavements

Reference: Denver Urban Drainage and Flood Control District, Volume 3 Criteria Manual.

Sign Posted to Prevent Resurfacing and Use of Abrasives, and to Restrict Truck Parking

Posted

Berm Keeps Off-site Runoff and Sediment Out, Provides Temporary Storage

Asphalt is Vacuum Swept, Followed by Jet Hosing to Keep Pores Open

Porous Asphalt

Overflow Pipe

Perforated Pipe Discharges Only When 2-Year Storage Volume Exceeded

Observation Well

Filter Fabric Lines Sides of Reservoir to Prevent Sediment Entry

Stone Reservoir Drains in 48 - 72 Hours

Gravel Course or 6-Inch Sand Layer

Undisturbed Soils with a Field Capacity > 0.27 Inches/Hour Preferably • 0.50 Inches/Hour

Proprietary/Manufactured Systems

Description

This BMP consists of pre-manufactured stormwater treatment devices for circular and rectangular structures. The devices use vortex-motion and/or particulate setting treatment mechanisms. Popular brand names include *Stormceptor, Vortechs, BaySaver, StormFilter, StormTreat, Stormvault,* and the *Downstream Defender*.

Application Guidelines

Used primarily for runoff from impervious surfaces in ultra-urban settings,

Systems are precast and some can be retrofitted to existing sewer systems or can replace a portion of the system,

Minimal space is required since systems are installed underground,

Structures can only treat a portion of the flow that enters the storm drain system,

Generally, stormwater and pollutants enter various chambers designed to allow oils and floatable particulates to rise to the top while sediments settle to the bottom. In a cylindrical system, runoff spirals down perimeter of structure where larger sediments settle out. Internal components trap oils, grease, and other floatables,

Systems are designed to prevent re-suspension of particulates, providing removal during every storm event.

Structures are commonly used for new developments, streets and roadways, parking lots, and industrial/commercial facilities,

Best used at the beginning of a storm drain line for maximum treatment efficiency,

Drainage areas generally limited to a few acres or less.

General Design Criteria

Vendors often provide services to build, install, and maintain systems,

Maintenance is one of biggest concerns,

Access manholes are placed where they can be easily accessed by vacuum trucks,

Generally, systems require cleaning annually but should be inspected more frequently to ensure proper function,

If not maintained properly, oils, grease, sediments, and other particulates can be washed out of the system and conveyed to downstream components of the storm sewer system,

Adjacent unpaved areas should be stabilized to prevent sediment from washing into the treatment system.

Proprietary/Manufactured Systems

Reference: Vortechnics Inc,
                  Stormceptor, (Carder Concrete Products)
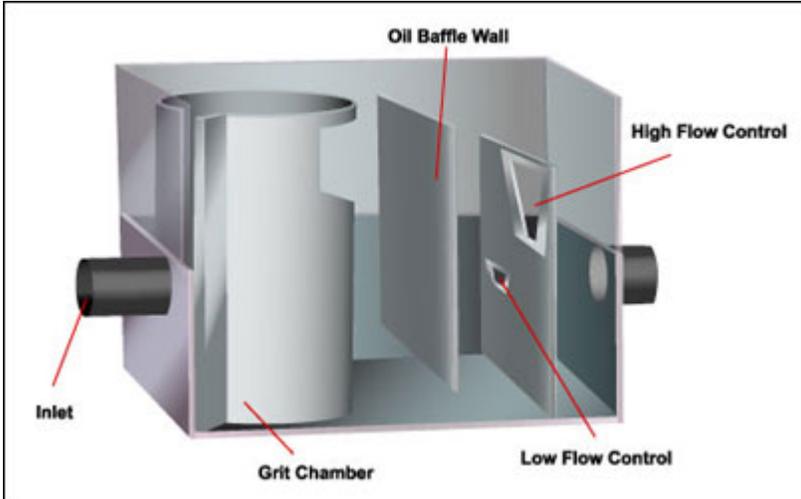
Vortechs System

Stormceptor System