

BEST MANAGEMENT PRACTICES MANUAL



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CHAPTER 5 POST-CONSTRUCTION

5.1 Introduction

Permanent erosion and sediment control best management practices (BMPs) are long-term measures that survive the design life of a project. The area where permanent BMPs have been applied should remain permanently stabilized until the area is disturbed again due to construction or in the case of maintenance, slides or floods. Permanent BMPs are designed to reduce or control erosion and are put in place during construction with beneficial results extending over a period of years.

Permanent erosion control is the prime consideration in a soil-disturbing project and, in contrast to temporary erosion control, is designed and planned for long-term benefits.

5.2 Post-Construction Management Goals

Permanent erosion and sediment control goals consist of:

1. Perimeter Controls

- a. Ensure that no sediment is leaving the project area.

2. Controls within the Project

- a. Use erosion and sediment controls that perform properly.
- b. Minimize or eliminate erosion.
- c. Complete stabilization of the site.

3. Final Product

- a. Complete stabilization and no erosion prior to final acceptance.
- b. Achieve Notice of Termination.

5.3 Best Management Practices (BMP)

Post-construction involves the use of the following BMPs:

- *PC-1 Channel Protection–Check Dams*
- *PC-2 Sheet Flow to Buffers*
- *PC-3 Channel Protection–Flexible Liners*
- *PC-4 Channel Protection–Rigid Channel Liner*
- *PC-5 Dikes and Berms*
- *PC-6 Dry Swale*
- *PC-7 Wet Swale*
- *PC-8 Geosynthetics*
- *PC-9 Surface Sand Filter*
- *PC-10 Subsurface Sand Filter*
- *PC-11 Perimeter Sand Filter*
- *PC-12 Organic Filter*
- *PC-13 Pocket Sand Filter*

- *PC-14 Bioretention*
- *PC-15 Inlet/Outlet Protection*
- *PC-16 Interceptor Ditches*
- *PC-17 Retaining Walls*
- *PC-18 Stormwater Basins*
- *PC-19 Extended Detention Basin with Micropool*
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- *PC-24 Pond/Wetland System*
- *PC-25 Pocket Wetland*
- *PC-26 Sediment Control Box*
- *PC-27 Infiltration Trench*
- *PC-28 Infiltration Basin*
- *PC-29 Slope Drains/Chutes/Flumes*
- *PC-30 Rock Armor/Rock Mulch/Turf Reinforcement Mats*
- *PC-31 Serrations and Roughening*
- *PC-32 Terraces and Benches*
- *PC-33 Top Soil Management*
- *PC-34 Vegetation/Seeding*
- *PC-35 Vegetation/Planting*
- *PC-36 Water Quality Inlet Oil/Grit Separator*
- *PC-37 Street Sweeping*
- *PC-38 Deep Sump Catch Basin*
- *PC-39 On-Line Storage in Storm Drain Network (Vaults)*
- *PC-40 Porous Pavements*
- *PC-41 Proprietary/Manufactured Systems*

PC-1 CHANNEL PROTECTION—CHECK DAMS

Refer to: ITD Standard Specifications, Section 212.
ITD Standard Drawing P-2-B.



BMP Objectives	
<input type="checkbox"/>	Perimeter Control
<input type="checkbox"/>	Slope Protection
<input type="checkbox"/>	Borrow and Stockpiles
<input checked="" type="checkbox"/>	Drainage Areas
<input checked="" type="checkbox"/>	Sediment Trapping
<input type="checkbox"/>	Stream Protection
<input checked="" type="checkbox"/>	Temporary Stabilizing
<input checked="" type="checkbox"/>	Permanent Stabilizing

Definition and Purpose

A check dam is a small dam constructed in an open channel, swale, or drain way to reduce or prevent excessive bank and bottom erosion by reducing the gradient or runoff velocity. Check dams are normally made of rock; however, other materials may be used. (Rock check dams are often used with channel liners to prevent formation of rills and gullies, or to interrupt their growth, and/or to provide grade control in the channel.)

Bank barbs are similar to rock check dams in construction and materials. Bank barbs are a measure to guide the force of the stream or channel flow away from the bank to reduce bank erosion. Bank barbs may be required under an Idaho Department of Water Resources Stream Alteration Permit, are beyond the scope of this manual, and require guidance from a Professional Engineer.

Appropriate Applications

Check dams are often used in channels or ditches where adequate vegetation cannot be established for controlling erosion and may be used below small drainage structures or culverts.

Limitations

- Check dams are not to be used in live streams, except with proper permitting in place (Idaho Department of Water Resources, U.S. Army Corps of Engineers).
- Use of check dams below the high water mark of a stream or other water body (waters of the U.S.) should be carefully evaluated due to Section 404 permit requirements.
- Section 404 permitting and an Idaho Department of Water Resources Stream Alteration Permit may be required. These are required for the use of bank barbs in live streams.

Design Parameters

- Maximum height should be 24 inches. The center of the check dam must be 6 inches lower than either edge, to form a weir at the overflow.
- The sides should also be lower than the adjoining banks, roadway, or backslope. The top of the outside edges should be 6 inches lower than the roadway surface to prevent water from flowing onto the roadway or undercutting the banks.
- The drainage area above the check dam should not exceed 10 acres.
- The dams must be spaced so that the toe of the upstream dam is never lower than the overflow of the downstream dam. Excavating a sediment basin immediately upstream from the check dam improves its effectiveness.
- Check dams composed of rock may be placed on erosion control geotextile to avoid undercutting. Be sure to check that the overflow will handle large volumes of water and that the sides are high enough to form a weir.
- Within the safety clear zone, all rock check dam face slopes shall be 6H:1V or flatter relative to the roadway grade. Overflow channel slopes may be 3H:1V or flatter.
- Outlet stabilization should be provided below each check dam, and the use of channel liners or protection such as riprap should be considered where there is potential for significant erosion or prolonged submergence.

Materials

- Rock size should vary from 1 to 8 inches with the 8-inch material making up approximately 30 percent of the mix.
- Erosion control geotextile shall meet the requirements of the Standard Specifications.

Construction Guidelines

- The rock check dams shall be constructed according to the plans and specifications.
- The rock shall be placed on erosion control geotextile either by hand or using appropriate equipment. Rock shall not be dumped directly on the geotextile.
- The upstream side of the dam shall be lined with a layer of 0.75- to 2-inch Coarse Aggregate for concrete 6 inches deep if necessary for additional channel protection.
- Riprap and erosion control geotextile may be necessary on the downstream side of the dam to protect the streambed channel from scour.
- Rock check dams within the safety clear zone shall have a slope of 6H:1V or flatter relative to the roadway grade.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.

- Make any repairs necessary to ensure the measure is operating properly.
- Remove accumulated debris and sediment from behind the dam when the debris or sediment reaches a depth of one-half the original height of the dam. Properly dispose in an approved location.
- Restore rock as necessary to maintain the correct dam height.

PC-2 SHEET FLOW TO BUFFERS

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



BMP Objectives

- | | |
|-------------------------------------|-----------------------|
| <input type="checkbox"/> | Perimeter Control |
| <input checked="" type="checkbox"/> | Slope Protection |
| <input type="checkbox"/> | Borrow and Stockpiles |
| <input checked="" type="checkbox"/> | Drainage Areas |
| <input checked="" type="checkbox"/> | Sediment Trapping |
| <input checked="" type="checkbox"/> | Stream Protection |
| <input type="checkbox"/> | Temporary Stabilizing |
| <input checked="" type="checkbox"/> | Permanent Stabilizing |

Definition and Purpose

This is a structural BMP used to filter pollutants as stormwater runoff moves to a swale, stream, or other flow area. It 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 drainage way.

Appropriate Applications

- Zones 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.

Design Parameters

- 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 percent.

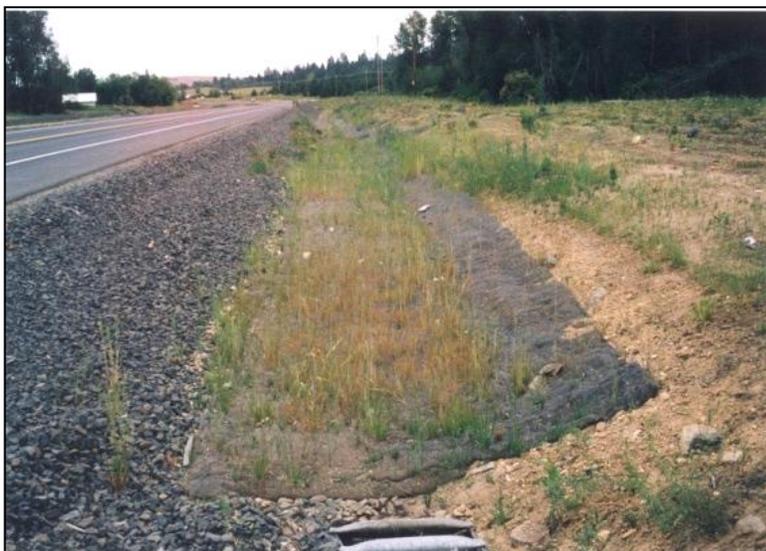
- Buffer is not applicable where rooftop or non-rooftop disconnections are already in place.
- Buffers should be located within accepted easements, right-of-way, or other enforceable areas that will ensure protection of the buffer area.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- If observations show concentrated surface flow occurs after installation, utilize other BMPs in the areas of concentrated flow to direct and spread the flow.

PC-3 CHANNEL PROTECTION—FLEXIBLE LINERS

Refer to: ITD Standard Specifications, Sections 212 and 624.
ITD Standard Drawings P-2-A and P-2-C.



BMP Objectives

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

Flexible channel protection uses a flexible material as a lining to stabilize and prevent erosion in open drainage channels.

Appropriate Applications

Flexible liners may be applied as a continuous sheet covering an open channel or may be used in conjunction with rock check dams installed in a trench perpendicular to the direction of flow.

The most commonly used liners are as follows:

- Riprap is composed of large angular stones placed along the stream bank or shore where water is turbulent and fast flowing and/or where soil may erode under design conditions. Riprap forms a dense, flexible, self-healing cover that adapts well to uneven surfaces.
- Riprap and gabions are usually placed over a filter blanket (a gravel layer of erosion control geotextile).
- Revet mattresses are rock-filled wire cages that are used to protect a channel bank or bed.
- Matting is useful as a protective measure when seeding for permanent, grassed waterways. Turf reinforcement and jute are two common types of matting used for channel protection.
- Jute matting is a type of temporary, biodegradable erosion control blanket that can be used to promote post-construction revegetation.

Limitations

- Turf Reinforcement Mats (TRM) should not be used where their presence or appearance is aesthetically unacceptable.

- Effectiveness of matting may be reduced if not properly selected, designed, or installed. Matting is for use on minor channels with low-flow velocities, or for intermittent channels or drainages that do not normally contain water other than during snowmelt or stormwater runoff. A channel’s optimum configuration for this type of control is a low-gradient, shallow, U-shaped swale without physical instability.
- Matting is not suitable for channels with steep sides or erodible, uncompacted soil. Riprap orrevet mattresses should be used for these situations.
- Riprap andrevet mattress are of limited suitability if the channel is to be revegetated. 1H:1V or flatter channel side slopes are required for riprap lining. Typical channel side slopes forrevet mattresses are 1½ H:1V or flatter.
- The use of flexible liners below the high water mark of a stream or other water body (waters of the U.S.) should be carefully evaluated due to Section 404 permit requirements. A Section 404 permit (401 Certification) and an Idaho Department of Water Resources Stream Alteration Permit may be required.

Design Parameters

- **Channel configuration:** Open channels lined with flexible mat channel liners should have side slopes of 3H:1V or flatter and an anticipated low-flow velocity. Determination of hydraulic capacity should include evaluation of limitations imposed by mature vegetation.
- The following table offers suggested guidance in the selection of flexible channel protection linings. Values for an unlined earth ditch are included for reference.

<i>Channel Type</i>	<i>Velocity (meter/second)</i>	
	<i>Low</i>	<i>Maximum</i>
<i>Unlined earthen ditch</i>	<i>0.3</i>	<i>0.6</i>
<i>Riprap lining</i>	<i>1.0</i>	<i>3.0</i>
<i>Vegetation</i>	<i>0.6</i>	<i>1.2</i>
<i>Revet mattress lining</i>	<i>0.6</i>	<i>4.5</i>
<i>Jute or Turf Reinforcement Mat*</i>	<i>0.3</i>	<i>1.0</i>

** Refer to design characteristics of the individual products being considered for further information. If individual products are identified in the specification, three products or approved equals should be specified.*

- **Riprap:** Riprap protects soil from erosion and is often used on steep slopes built with fill materials and that are subject to harsh weather or seepage. Riprap can also be used for flow channel liners, inlet and outlet protection at culverts, stream bank protection, and protection of shorelines subject to wave action.

- Riprap is used where water is turbulent and fast flowing and where soil may erode under the design flow conditions. Riprap is either a uniform size or graded (different sizes) and is usually applied in an even layer. Riprap has the advantage of adjusting to differential settlement along the channel while protecting against erosion.
- Riprap that is utilized for channel lining should consist of a well-graded layer about 1.5 times or more as thick as the dimensions of the largest rock, with a bulk specific gravity of 2.5 or greater. Rock fragments should be large enough to provide surface protection from erosion during the peak design flows. Riprap lining should be placed over a filter layer and extended to an elevation of at least 12 inches above the design waterline. The graded filter layer should be erosion control geotextile or crushed base material at least 6 inches thick with a gradation sized to preclude erosion through the riprap.
- Riprap andrevet mattresses are usually placed over a filter blanket (a gravel layer or erosion control geotextile).
- **Revet Mattress:** Revet mattresses permit higher flow capacity than other types of liners. The revet mattress requires a firm, compacted, stable foundation and must be carried below the channel bed to prevent undercutting and at least 12 inches above the design waterline. Side slopes should be 1½H:1V or flatter.
- Refer to the Materials Phase Reports for sizing of the filter material, or obtain a recommendation from the District Materials Engineer.
- **Turf Reinforcement Mat:** TRM is a long-term, non-degradable, rolled erosion control product composed of UV-stabilized synthetic fibers, nettings, and/or filaments processed into three-dimensional reinforcement matrices designed for permanent and critical hydraulic applications where design discharges exert velocities and shear stresses that exceed the limits of mature, natural vegetation. TRM provides sufficient thickness, strength, and void space to permit soil filling and/or retention and development of vegetation within the matrix.

Construction Guidelines

- Use flexible, long-lasting mats or membranes of geosynthetics or rock with erosion control geotextile. Allow for an overlap of 3 feet where one roll of material ends and another begins. Construction guidelines for rock for riprap, rock for revet mattress, wire for revet mattress, and gabion revetment construction are included in the Standard Specifications.
- **Turf Reinforcement Mat:** Shape and grade the waterway or channel as required by plans and specifications. Remove rocks, clods, sticks, and other material that will prevent contact of the liner with the soil surface. Protect the outlet in the same manner as in the main channel. Apply the liner for the tributary first, and overlap the matting in the main channel. Apply the liner from the upper end of the channel, and continue downgrade. Install matting in accordance with the manufacturer's recommendations.
- After completing the job, check that the matting is in contact with the soil in all places and critical areas are securely stapled. Complete contact of the matting with the underlying soil surface is vital to keep water flow over (not under) the matting.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- If the desired vegetation has not become established through a mat, reseed as necessary.
- Do not disturb any areas of established vegetation.
- Clean and remove debris as necessary.

PC-4 CHANNEL PROTECTION—RIGID CHANNEL LINER

Refer to: ITD Standard Specifications, Sections 209 and 623.

ITD Standard Drawing P-2-D.

For assistance, contact the Hydraulics Engineer at the ITD Headquarters Roadway Design Section.



BMP Objectives

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

Rigid channel liners are non-erosive structures or surfaces placed in a channel or ditch that may be used to prevent erosion resulting from high velocities of water. Typical measures include the following:

- Portland Cement Concrete: Rigid concrete liners that cover channel or ditch banks and create a non-erosive surface.
- Grid pavers: Pre-cast or cast-in-place concrete units that are placed along the channel or ditch banks to stabilize the bank and leave open spaces where vegetation can be established.
- Asphalt: Asphalt concrete (plant mix) that is placed along the channel or ditch bank to create a non-erosive surface.

Appropriate Applications

- Rigid channel protection is used where vegetative stabilization practices are not practical and where the channel or ditch banks are subject to heavy erosion from high flows. Rigid liners are preferable to mat-type linings or unlined channels where high-flow velocities are anticipated.
- When deciding which method to use, consider cost and availability of materials, aesthetic concerns, the need to protect vegetation or wildlife habitat, velocity and turbulence of the flow, and the disturbance involved in installing the control measure. For instance, many channel protection structures can be designed to allow revegetation to establish along the bank; however, a rigid liner will most likely preclude most vegetation.

Limitations

- Rigid liners may preclude their use in some situations. Consider the following disadvantages or limitations of rigid liners before selecting a channel protection technique. Rigid liners may:
 - Not provide the water quality or aesthetic benefits that vegetative practices provide.
 - Require design by qualified professional engineers.
 - Be more expensive than other erosion control methods.
 - Require additional permits for installation.
 - Alter stream dynamics, causing changes in the channel downstream.
 - Cause negative impacts to wildlife habitats.
- The use of rigid channel liners below the high water mark of a stream or other water body (waters of the U.S.) should be carefully evaluated due to Section 404 permit requirements. A Section 404 permit (401 Certification) and an Idaho Department of Water Resources Stream Alteration Permit may be required.

Design Parameters

- Applicable federal, state, and local requirements should be followed in designing the rigid liner. Permanent rigid channel liners must be designed to handle expected flood conditions.
- The following table offers suggested guidance in selection of rigid channel protection liners. Values for unlined and vegetation lined channels are included for reference.

<i>Channel Liner Type</i>	<i>Velocity (meter/second)</i>	
	<i>Low</i>	<i>Maximum</i>
<i>Unlined earthen ditch</i>	<i>0.3</i>	<i>0.6</i>
<i>Asphalt or concrete lined</i>	<i>0.6</i>	<i>4.5</i>
<i>Vegetation</i>	<i>0.6</i>	<i>1.2</i>
<i>Grid pavers lining</i>	<i>1.0</i>	<i>3.5</i>

- If allowed by permit, grade control measures may be required to reduce the gradient of open channels. Check dams, drop structures, or other structures may be located in a reasonably straight channel section. They must be constructed of durable materials (such as cast-in-place concrete, rock, or gabions) that are adapted for use in hydraulic structures. The banks should be stabilized upstream and downstream at sufficient distances with riprap or other lining to prevent scour and bank erosion.

- Reinforced concrete structures may require drainage behind the bulkhead or retaining wall to mitigate freeze/thaw effects and erosion around the structure. Grid pavers should be designed and installed according to manufacturers' recommendations.
- Concrete and asphalt-concrete permit maximum flow capacity due to their low roughness coefficients. Bank liners require a firm, compacted, stable foundation and must be carried below channel bed (to prevent undercutting) and at least 6 inches above the design waterline. Side slopes should be 1H:1V or flatter.

Construction Guidelines

- Place materials for rigid linings to provide:
 - Asphalt plant mix: 2.5 inches minimum thickness.
 - Concrete liner: 4 inches minimum thickness.
- Install channel liners or other protection structures immediately after channel construction. Construct as directed or as specified in the contract.
- Provide compacted, firm, stable foundations as required for Portland Cement Concrete and asphalt plant mix liners.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Maintain the rigid liners and structures as installed.
- Repair liner damage as soon as possible to prevent further damage or erosion to the channel bank or bed.
- Clean and remove debris as necessary.

PC-5 *DIKES AND BERMS*

Refer to: ITD Standard Specifications, Sections 205, 209, and 212.
ITD Standard Drawings P-1-E and P-1-F.



BMP Objectives

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

A permanent dike or berm is a ridge constructed of compacted soil, loose gravel, stone, or crushed rock that intercepts and prevents stormwater runoff from entering a sensitive area, and diverts or directs the water to a controlled or stabilized drainage outlet. Dikes or berms can be located or placed immediately along the top or bottom of cut or fill slopes, along the perimeter of an area, or adjacent to streams to prevent high stream flows from entering a site, or runoff from a site entering a stream or waterway.

Appropriate Applications

- Directs water to slope drains, ditches, channels, sediment trap basins, retention ponds, or swales.
- Serves both as a temporary and later as a permanent erosion control that is left in place for the life of the project.
- Prevents runoff water from entering or overflowing slopes or intercepts and diverts overflow water after coming off a slope.
- Intercepts runoff from upland undisturbed areas and diverts to a sediment trap basin or slope drain.
- Intercepts runoff from a road or slope and directs the water to a slope drain or a sediment trap basin.
- Prevents off-site stormwater from entering the area when installed around the perimeter.
- Prevents high water from entering a project when installed next to live streams, ponds, or lakes.

- Prevents runoff from a site entering a live body of water.
- Slows the velocity of water when used in ditches as a water bar.

Limitations

- Shall not be used in streambeds and should not be used to filter water.
- Should be used for anticipated minor runoff or for small drainage areas.
- Must be properly keyed and compacted to avoid washout.
- Must be designed and constructed to avoid erosion or washout due to diversion of the water and/or creation of a concentrated flow of high velocity runoff.

Design Parameters

- Dikes or berms are constructed of soil, gravel, stone or crushed rock, or a combination of these materials. If soil is used for dikes or berms, the soil should be of a silt or clay type, intermixed with gravel or rock.
- The height of dikes or berms comprised of soil or rock should be sufficient to prevent water from overtopping the structure. The width at the top of the dike or berm should be approximately twice the height, with 2H:1V or flatter slopes. Maximum height should not exceed 5 feet.
- A permanent ditch or channel liner may be placed on the uphill or upstream side and properly anchored to prevent erosion or washout of the dikes or berms.
- If used as an interceptor/diversion structure, the dike or berm should be built on contour with a consistent but gradual gradient to a stabilized outlet.
- A channel or ditch may be constructed directly uphill from a dike or berm to aid in diverting and carrying water to a stabilized outlet.

Construction Guidelines

- Use permanent dikes and berms to intercept and divert water to sediment traps or stabilized outlets. Used in conjunction with channels or ditches and liners, they can be very effective in handling runoff water. Space, degree of slope, and access can be limiting or prohibitive factors in installing dikes or berms.
- Grade all dikes and berms as flat as possible to prevent erosion and drain to a stabilized outlet or other area.
- Compact the dike or berm material in accordance with the Standard Specifications, and if for any reason this cannot be done, ditch or channel liners are required to avoid erosion and washout.
- Make field adjustments as necessary to ensure proper performance.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.

- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Repair immediately if erosion or damage is observed.

PC-6 DRY SWALE

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

**BMP Objectives**

- Perimeter Control**
- Slope Protection**
- Borrow and Stockpiles**
- Drainage Areas**
- Sediment Trapping**
- Stream Protection**
- Temporary Stabilizing**
- Permanent Stabilizing**

Definition and Purpose

Dry swales are used to filter pollutants as stormwater runoff moves through them. This BMP is constructed as an open-channel drainage way with grass or other vegetation to provide conveyance, reduce velocity, 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.

Appropriate Applications

- Runoff sources can be overland flow from impervious areas or discharges from drainage pipes.
- Swale depressions can be used in place of aboveground islands in large parking lots.
- Flows that infiltrate into the channel soil are conveyed by an underdrain system.
- Dry swales:
 - Can be used to enhance stormwater quality and reduce peak runoff.
 - Are efficient for removing a wide variety of pollutants including suspended solids and nutrients.
 - Work best in conjunction with other BMPs and can be used as an alternative to or enhancement of a conventional storm sewer.
 - Are used for impervious areas, generally less than 10 acres.
 - Can be used in early post-construction when stabilizing vegetation is not established and principal consideration is preventing erosion in unvegetated channels.
 - Are well-suited for flat or rolling terrain.

Design Parameters

- Generally, swales are designed to temporarily store the water quality volume for a maximum of 48 hours.
- 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.
- Excavated area is lined with layers of filter fabric around the permeable soil.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Regular maintenance is necessary to remove surface sediment, trash, debris, leaf litter, and dead or diseased plant material.
- Routine mowing is required.

PC-7 WET SWALE

Reference: Maryland Stormwater Design Manual.

**BMP Objectives**

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

Wet swales are used to filter pollutants as stormwater runoff moves through them. This BMP is constructed as an open-channel drainage way 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.

Appropriate Applications

- 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 aboveground islands in large parking lots.
- Wet swales:
 - Can be used to enhance stormwater quality and reduce peak runoff.
 - Are efficient for removing a variety of pollutants including suspended solids and nutrients.
 - Are ideal for treating highway runoff in flat terrain areas.
 - 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 vector problems.

Standards and Specifications

- Generally, swales are designed to temporarily store the water quality volume for a maximum of 48 hours.
- A vegetative cover needs to be established as soon as possible to prevent erosion and scour. This 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.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Regular maintenance is necessary to remove surface sediment, trash, debris, leaf litter, and dead or diseased plant material.
- Frequent mowing is not required.

PC-8 GEOSYNTHETICS

Refer to: ITD Standard Specifications, Sections 640 and 718.

For assistance, contact the Geotechnical Engineer at the ITD Headquarters Materials Section.



BMP Objectives

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|-------------------------------------|-----------------------|
| <input type="checkbox"/> | Perimeter Control |
| <input checked="" type="checkbox"/> | Slope Protection |
| <input checked="" type="checkbox"/> | Borrow and Stockpiles |
| <input checked="" type="checkbox"/> | Drainage Areas |
| <input type="checkbox"/> | Sediment Trapping |
| <input type="checkbox"/> | Stream Protection |
| <input checked="" type="checkbox"/> | Temporary Stabilizing |
| <input checked="" type="checkbox"/> | Permanent Stabilizing |

Definition and Purpose

Geosynthetic is defined as a planar product manufactured from a polymeric material that is used with soil, rock, or other geotechnical-related material as an integral part of a civil engineering project, structure, or system. Most geosynthetics are made from synthetic polymers of polypropylene, polyester, or polyethylene. Geosynthetic products available today include, but are not limited to, geoweb, geogrids, geonets, geomeshes, geocomposites, and geotextiles.

Geotextile is a permeable geosynthetic made of textile materials. Geotextile type is determined by the method used to combine the filaments or tapes into the planar structure.

Appropriate Applications

Geosynthetic applications are normally defined by the primary function of the following:

- **Filtration:** Geosynthetics can be used as filters to prevent soils from migrating into the adjacent material, such as drainage aggregate, while allowing water to flow through the system (e.g., the use of geotextile in trench drains, silt fence, etc.).
- **Drainage:** Geotextiles or geocomposites can be used as drainage, or conduit, by allowing water to drain from or through low-permeability soils.
- **Separation:** Geosynthetics can be used as a separator to separate the two dissimilar materials and prevent them from mixing, such as the use of geotextile between fine-grained subgrade and granular base course below a roadway.
- **Reinforcement:** Geogrids or geotextiles can be used as reinforcement to increase shear strength of soils, thereby providing a more competent structural material. Examples of this application include the use of geogrid to reinforce a steep slope, or to strengthen a base course in a pavement system.

- Erosion control: Geosynthetics can be used to minimize the movement of soil particles due to flow of water. An example of this application is geotextile used between riprap and the stream bank to minimize erosion of soil below the riprap.

The primary advantages of geosynthetics are:

- Relatively low cost for many applications
- Ease and convenience for many applications
- Quick and effective protection against erosion problems
- Design methodologies are available for many uses
- Wide variety of geosynthetic products are available to meet specific needs
- May be removed and reused if economically feasible

Limitations

- Effectiveness may be reduced drastically if the geosynthetic is not properly selected, designed, or installed.
- Many geosynthetics are sensitive to light degradation and must be protected prior to installation.
- Geosynthetics that are not degradable should not be used where their presence or appearance is aesthetically unacceptable.

Design Parameters

- For geotextiles used in applications such as drainage, erosion control, silt fence, or separation, refer to the Standard Specifications for material property requirements.
- For other geosynthetic materials, follow manufacturers' recommendations.
- Call the Geotechnical Engineer at ITD Headquarters for help in selecting geosynthetics for appropriate design and application.

Construction Guidelines

- For geosynthetic materials, follow manufacturers' recommendations.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- If geosynthetic is damaged or missing, repairs or replacements shall be made immediately to restore full protection.
- Geosynthetics used for temporary erosion control may be removed and reused, if this can be done without leaving the area susceptible to erosion.

PC-9 SURFACE SAND FILTER

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



BMP Objectives

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

Surface sand filters are 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 dewateres the sand bed and flows are conveyed to a nearby swale or storm sewer. An outfall is used to drain higher volumes of flow.

Appropriate Applications

- Can be used to enhance stormwater quality and reduce peak discharges.
- 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.
- Is 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 base flow.
- Can also be used in areas of thin soil and high evaporation rates.
- 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.
- Is useful in watersheds where groundwater quality is a concern or where low-permeability soils prevent infiltration.
- Should not be located close to building foundations or in areas where expansive soils are a concern.

Design Parameters

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

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Regular maintenance is necessary to remove surface sediment, trash, debris, and leaf litter.

PC-10 SUBSURFACE SAND FILTER

Reference: Maryland Stormwater Design Manual.

**BMP Objectives**

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

Subsurface sand filters are used to capture and treat a volume of stormwater runoff. The 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.

Appropriate Applications

Upstream grass channels, grass filter strips, or other BMPs can be used to help remove sediments and particulates before they enter the filter. A subsurface sand filter is:

- Used to enhance stormwater quality.
- 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.
- Particularly useful at sites with limited space for water quality treatment or in high-value real estate areas. Filter vaults can be installed under parking lots and streets, but maintenance access needs to be considered.
- Most effective in treating runoff from small storms or early stages of larger storms.
- Generally used in areas where sediment loads are low and there is no base flow.
- 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.

Design Parameters

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

- 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 inches.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Regular maintenance is necessary to remove surface sediment, trash, debris, and leaf litter.
- Outlets and chambers need to be cleaned/repared when drawdown times in the filter exceed 36 hours.
- In certain cases, layers of sand may need to be replaced every 3 to 5 years.

PC-11 PERIMETER SAND FILTER

Reference: Maryland Stormwater Design Manual.

Definition and Purpose

Perimeter sand filters are 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.

Appropriate Applications

Upstream grass channels, grass filter strips, or other BMPs can be used to help remove sediments and particulates before they enter the filter. Upper chamber filters out finer materials and sediments. Flows percolate through a sand filter in the lower chamber and into an underdrain system. A perimeter sand filter is:

- Used to enhance stormwater quality.
- 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.
- 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 vaults can be installed under parking lots and streets, but maintenance access needs to be considered.
- Also practical for small sites with flat terrain or a high water table.
- Generally used where sediment loads are low and there is no base flow.
- 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.

Design Parameters

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

BMP Objectives

- | | |
|-------------------------------------|------------------------------|
| <input checked="" type="checkbox"/> | Perimeter Control |
| <input type="checkbox"/> | Slope Protection |
| <input type="checkbox"/> | Borrow and Stockpiles |
| <input checked="" type="checkbox"/> | Drainage Areas |
| <input checked="" type="checkbox"/> | Sediment Trapping |
| <input checked="" type="checkbox"/> | Stream Protection |
| <input type="checkbox"/> | Temporary Stabilizing |
| <input type="checkbox"/> | Permanent Stabilizing |

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Regular maintenance is necessary to remove surface sediment, trash, debris, and leaf litter.
- Outlets and chambers need to be cleaned/repared when drawdown times in the filter exceed 36 hours.
- In certain cases, layers of sand will need to be replaced every 3 to 5 years.

PC-12 ORGANIC FILTER

Reference: Maryland Stormwater Design Manual.

Photograph to come.

BMP Objectives

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

Organic filters are used to capture and treat a volume of stormwater runoff. This BMP is identical to a Surface Sand Filter (PC-10).

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.

Appropriate Applications

Upstream grass channels or filter strips can be used to protect the integrity of the basin. An organic filter:

- Can be used to enhance stormwater quality and reduce peak discharges.
- Is most effective in treating runoff from small storms or early stages of larger storms.
- 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.
- Is generally suited to tributary, on-site drainages and most development sites where sediment loads are low and there is no base flow.
- Can also be used in areas of thin soil and high evaporation rates.
- Has an upper limit drainage area of 50 acres, although most applications are for areas between 0.5 and 10 acres.
- Should be located in a flat or only slightly depressed area.
- Is useful in watersheds where groundwater quality is a concern or where low permeability soils prevent infiltration.
- Should not be located close to building foundations or in areas where expansive soils are a concern.

Design Parameters

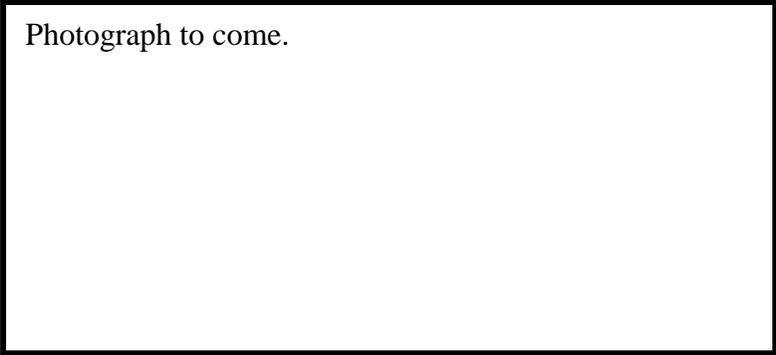
- Generally, basins are designed to infiltrate retained runoff within a 40-hour period.
- A dense vegetative cover needs to be established over all contributing pervious areas before runoff can be conveyed to the filter.
- Screens/grated inlets should be considered in design to keep debris out of filter chambers.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Regular maintenance is necessary to remove surface sediment, trash, debris, and leaf litter.
- In certain cases, layers of sand or peat will need to be replaced every 3 to 5 years.

PC-13 POCKET SAND FILTER

Reference: Maryland Stormwater Design Manual.



Photograph to come.

BMP Objectives

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

Pocket sand filters are 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.

Appropriate Applications

- The underdrain dewateres the sand bed and discharges runoff to a nearby swale or storm sewer.
- Upstream grass channels or grass filter strips can be used to help protect the integrity of the basin.
- Pocket sand filters:
 - Can be used to enhance stormwater quality.
 - 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.
 - Is generally suited to small sites (5 acres or less) where sediment loads are expected to be moderate to low and where there is no base flow.
 - Should be located in a flat or only slightly depressed area.
 - Is useful in watersheds where groundwater quality is a concern or where low permeability soils prevent infiltration.
 - Should not be located close to building foundations or in areas where expansive soils are a concern.

Design Parameters

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

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Regular maintenance is necessary to remove surface sediment, trash, debris, and leaf litter.
- In certain cases, layers of sand will need to be replaced every 3 to 5 years.

PC-14 BIORETENTION

Reference: Maryland Stormwater Design Manual.

**BMP Objectives**

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

Bioretention is 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.

Appropriate Applications

- Upstream grass channels or grass filter strips can be used to help protect the integrity of the basin.
- Excavated area is lined with layers of filter fabric.
- Runoff sources can be overland flow from impervious areas or discharges from drainage pipes.
- Bioretention:
 - Can be used to enhance stormwater quality, reduce peak runoff, and recharge groundwater.
 - Can be used in residential and non-residential development areas.
 - Is efficient for removing a wide variety of pollutants including suspended solids and nutrients.
 - 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.

- Is generally suited for drainage areas of 10 acres or less.
- Is most effective if the retention area can be located as close as possible to the runoff source.

Design Parameters

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

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Regular maintenance is necessary to remove surface sediment, trash, debris, and leaf litter, and dead or diseased plant material.

PC-15 INLET/OUTLET PROTECTION

Refer to: ITD Standard Specifications, Sections 212, 608, 609, 640, 711,04, and 718.
ITD Standard Drawings D-1-A, D-1-B, P-1-A, P-1-H, and P-2-F.



BMP Objectives

- Perimeter Control**
- Slope Protection**
- Borrow and Stockpiles**
- Drainage Areas**
- Sediment Trapping**
- Stream Protection**
- Temporary Stabilizing**
- Permanent Stabilizing**

Definition and Purpose

Inlet/outlet protection is placed around an inlet to trap sediment and debris and prevent it from entering a storm drain system or water body, or placed at the outlet to reduce the erosive effect of water at the outfall.

Appropriate Applications

Inlet

- Inlet protection serves to prevent scour, piping, or the silting-in of inlets, storm drainage systems, or receiving channels. Inlet protection may be composed of riprap and erosion control geotextile; masonry block, aggregate, and wire mesh; or permanent vegetation.
- Masonry block, aggregate, and wire mesh filters can be used where velocities are high and may be used with most types of inlets where overflow capability is needed and in areas of heavy flows (0.53 cubic feet/second or greater).
- Permanent vegetation inlet filters are usually used where sediments in the stormwater runoff are low, and provide additional stabilization to the site.
- Inlet protection measures may be used in conjunction with sediment trap basins. The sediment trap basins should be located upstream from the inlet protection measures.

Outlet

- Outlet protection should be installed at the outlets of all pipes or culverts, retention basins, dikes and berms, grassed swales, or channels and ditches where the velocity of flow may cause scouring or erosion.

- Outlet protection should also be used where the velocity of flow may require a basin (plunge pool) to dissipate the water velocity and prevent erosion.

Limitations

- Work involving disturbance of stream channels will require a Section 404 permit (401 Certification) and an Idaho Department of Water Resources Stream Alteration Permit.
- Silt fence inlet protection cannot be used.
- Straw bales are not to be used for inlet protection.
- There may be high maintenance requirements associated with inlet protection.
- Outlet treatment measures require the right size of riprap to be effective, depending on flow velocity, soil conditions, and location.

Design Parameters

Inlet

- The area immediately surrounding the inlet should be flat.
- Where possible, an inlet protection measure should be provided with a sediment trap basin. The sediment trap basin should be constructed upstream from the inlet to assist in ponding the water, allowing sediment to settle.
- Masonry block can be installed upstream to the inlet to provide added strength and stability. The block should be laid on its flat side so water can pass through the openings in the block. Wire mesh with a 0.4- to 0.6-inch opening should be installed between the masonry block and the aggregate. The aggregate should be coarse concrete aggregate or similar material 0.75 to 4 inches in size.

Outlet

- Unless otherwise specified, all riprap used in an outlet should be 6 inches or larger. An erosion control geotextile should be installed prior to the placement of the riprap, with the riprap placed directly on top of the geotextile. A basin on the discharge side of the outlet may be needed to dissipate water velocity and prevent erosion.
- For berm and dike outlets, the minimum length of the crest of the rock outlet structure should be determined by a hydraulic analysis.
- Maximum allowable flow-through rate is 30 liters per second per square meter of the outlet opening.
- The outlet structure should be located so as to discharge onto a stabilized area or into a stable watercourse.

Construction Guidelines

Inlet

- Riprap and erosion control geotextile:
 - Clear area where the desired protection measure is to be installed, making sure that the area is free of rocks and other debris.

- Place erosion control geotextile on the ground. Embed the edges of the geotextile a minimum of 6 inches into the soil.
- Place the riprap on the geotextile.
- Masonry block, aggregate, and woven wire mesh:
 - Use wire mesh with 0.4- to 0.6-inch openings.
 - Use masonry blocks 4 to 12 inches wide.
 - Use coarse concrete aggregate or other similar material 0.75 to 4 inches in size.
 - Remove any obstructions to excavating and grading. Excavate sediment trap basin if required; grade slopes, and properly dispose of excavated material.
 - Secure the inlet grate.
 - Place concrete masonry blocks in a single row lengthwise on their sides along the sides of the inlet. Excavate the foundation a minimum of 2 inches below the crest of the inlet. The bottom row of blocks should be against the edge of the structure for lateral support
 - Place the block barrier such that it is at least 6 inches high and up to a maximum of 18 inches high.
 - Place the open ends of the block such that they face outward, not upward, and the ends of adjacent blocks abut.
 - Place wire mesh against the outside of the masonry blocks so the wire will be flush with the top of the masonry block. The woven wire mesh should also extend over the area where the aggregate will be placed. Overlap the strips of mesh if more than one is necessary.
 - Place the aggregate over the woven wire mesh so the aggregate and woven wire mesh are flush with the top of the masonry block.

Outlet

- Place outlet protection measures in such a manner that the flow from the conveyance is not restricted.
- Construct outlet and outlet protection measures concurrently with pipe, culvert, dike, berms, and inlets before allowing water flows to pass over or through the outlet.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
-

- Remove accumulated sediment when it has accumulated to half the design depth of the trap, and restore the sediment trap basin to its original dimensions.
- Properly dispose of all sediments at an approved location.
- On masonry block, aggregate, and woven wire mesh devices, clean the filter if it becomes clogged.

PC-16 INTERCEPTOR DITCHES

Refer to: ITD Standard Specifications, Section 208 and 209.



BMP Objectives

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

An interceptor ditch is a small ditch or channel constructed to intercept and convey water to an area where it can be safely discharged.

Appropriate Applications

- Interceptor (diversion) ditches are used above the top of cut slopes, at the toe of embankments, in materials sources, and at waste sites to divert runoff from an exposed area. Interceptor ditches can also be used along benches on slope faces to prevent collected runoff from flowing onto slope faces below and to reduce the length of the uninterrupted slope face on unbenched slopes.
- The interceptor ditch may be constructed with or without a supporting berm or dike on the downslope side.

Limitations

- For grades in excess of 5 percent or steeper, for highly erodible soils, or for large flows, the interceptor ditch may require stabilization with a permanent channel liner.
- Flows concentrated by an interceptor ditch should be conveyed from the slope using a slope drain.

Design Parameters

- The interceptor ditch must discharge to a heavily vegetated area, a stabilized area, or to a slope drain. The diverted runoff should not overtop the dike or berm, or lip of the ditch.
- General considerations include:
 - Soil characteristics
 - Depth (1.6 feet or greater)

- Compaction in accordance with the Standard Specifications
- Graded to drain, although the grade depends upon topography

Construction Guidelines

- The interceptor ditch normally consists of a ditch and may have an associated dike or berm. Other sediment control measures may be required to filter or trap sediment before the runoff leaves the construction area.
- The construction of the interceptor ditch at the crown of a slope shall be accomplished prior to the excavation of the cut section.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Locate any damaged areas and repair as necessary. Remove any channel obstructions.

PC-17 *RETAINING WALLS*

Refer to: ITD Standard Specifications, Sections 210 and 512.

For assistance, contact the Geotechnical Engineer at ITD Headquarters.

**BMP Objectives**

- Perimeter Control**
- Slope Protection**
- Borrow and Stockpiles**
- Drainage Areas**
- Sediment Trapping**
- Stream Protection**
- Temporary Stabilizing**
- Permanent Stabilizing**

Definition and Purpose

Retaining walls are structures that are constructed to support almost vertical (steeper than 70 degrees) or vertical slopes of earth masses. All walls over 5 feet in height shall be engineered.

Different common retaining wall types include the following:

- **Rigid Gravity and Semi-Gravity Walls:** These walls are often constructed of reinforced concrete, un-reinforced concrete, or stone masonry. The rigid gravity walls develop their soil retaining capacity from their dead weights. The semi-gravity walls, such as cast-in-place concrete cantilever walls, develop resistance to overturning and sliding from self-weight and weight of soil above the wall footing.
- **Prefabricated Modular Gravity Walls:** These walls include crib walls, bin walls, and gabion walls. A crib wall, concrete or timber, is a gravity retaining structure that consists of interlocking concrete or timber elements. Each crib unit is filled with compacted granular soil. A bin wall, concrete or metal, is constructed of adjoining closed-face or open-face bins. Each bin unit is filled with compacted granular soil. Gabion walls consist of baskets made of galvanized steel mesh or PVC coated wire mesh. The baskets are filled with durable rock ranging in size from 4 to 8 inches.
- **Non-Gravity Cantilevered Walls:** These walls develop lateral resistance through the embedment of vertical wall elements and support retained soil with wall-facing elements. Vertical wall elements are normally extended deep in the ground to provide lateral and vertical support. The vertical wall elements can be piles, drilled shafts, steel sheet piles, etc. Wall faces can be reinforced concrete, metal, or timber. Cantilevered walls are generally limited to a maximum height of about 20 feet.
- **Anchored Walls:** These walls typically consist of the same elements as the non-gravity cantilevered walls but derive additional lateral resistance from one or more tiers of anchors.

The anchored walls are typically used in the cut situation, in which the construction proceeds from the top to the base of the wall.

- **Mechanically Stabilized Earth (MSE) Walls:** These walls normally include a facing element and a reinforcement element embedded in the backfill behind the facing. The facing element can be concrete, panel or segmental block, or steel wire mesh. The reinforcement element can be either metallic (strip, grid, wire mesh) or geosynthetic (geotextile, geogrid). MSE walls are often used to support fills and when substantial total and differential settlement are anticipated. Most of the MSE walls are proprietary, and a list of pre-approved MSE walls for use can be obtained from the Geotechnical Engineer at ITD Headquarters Resources Center.

Appropriate Applications

Retaining walls are often used near the toe of a cut or fill slope, so that a flatter slope can be constructed to prevent or minimize slope erosion or failure. They can also be used to keep a toe of a slope from encroaching into a wetland area or into a stream and thus prevent potential undercutting of the toe by flowing water.

Limitations

Retaining walls, in most instances, are considered a permanent measure. Cost and site-specific design requirements limit their use to situations where other stabilization measures would be ineffective or aesthetically unacceptable.

- Non-engineered walls should not be used where traffic is expected near the top of the wall.
- Rock retaining walls have a maximum height of about 10 feet.
- Railroad tie retaining walls require a firm foundation to anchor the wall.
- Some MSE walls have height restrictions. Backfill must meet specific materials property requirements to avoid corrosion of the backfill metallic reinforcements. MSE walls should not be used when utilities will be located within the reinforced backfill zone unless access is provided to those utilities.

The use of retaining walls below the high water mark of a stream or other water body (waters of the U.S.) should be carefully evaluated due to Section 404 permit requirements. A Section 404 permit and an Idaho Department of Water Resources Stream Alteration Permit may be required.

Design Parameters

- Most retaining walls require a site-specific design. Wall heights, requirements for drainage, and suitable materials must be determined through on-site investigation. MSE walls are normally designed by the manufacturer.
- An engineered retaining structure is a designed structure that is supported by plans and specifications signed and sealed by a Professional Engineer licensed in the State of Idaho.
- Non-engineered retaining structures may be designed by an engineer; however, if the design is not supported by the seal and signature, the retaining structure is not considered to be engineered. Non-engineered walls should not be used when traffic is expected near the top of the wall.

- Concrete retaining wall: An engineered concrete wall designed to stabilize a slope and retain the rock or soil behind it.
- Masonry retaining wall: A structure similar to a concrete retaining wall but using masonry blocks of specific design for aesthetic appeal. A masonry block wall consists of prefabricated segmental blocks that are stacked, keyed into or interlocked with each other. A masonry block wall may or may not include soil reinforcement. When soil reinforcement is included, a masonry block wall system is considered an MSE wall system.
- Rock retaining wall: A gravity wall constructed of rock materials to provide an aesthetically attractive method of supporting a soil mass. A rock retaining wall is suitable in situations where the wall is up to about 10 feet and where the slope is 2H:1V or flatter behind the wall.
- Railroad tie retaining wall: A retaining wall constructed of railroad ties. The wall must be securely anchored to the rock base or firm subsoil.
- Gabions: Single- or multi-celled rectangular wire mesh baskets that are filled with rock and wired together to form a retaining structure. Gabions can be used as retaining walls to mechanically stabilize over-steep slopes and are particularly useful where seepage is anticipated. Refer to the Standard Specifications for property requirements for gabions. Erosion control geotextile is often placed behind gabion baskets to prevent the fine material of the retained soil from entering the basket.
- Geosynthetic retaining wall: A flexible retaining wall constructed of geosynthetics, often a geotextile or geogrid. A geosynthetic wall is constructed by placing successive layers of fill material, each on a geosynthetic layer with the geosynthetic folded over and covering the face of the wall. The weight of the next layer of fill material then holds the folded geosynthetic from the previous layer in place.
- MSE retaining wall: These wall systems are normally used in a fill situation. Many of these wall systems can sustain large differential settlement.

Construction Guidelines

Rock retaining wall guidelines:

-
- A footing trench shall be excavated at the location of the proposed wall.
- The largest rocks in the footing trench shall be placed with their longitudinal axis normal to the wall face. Subsequent rock layers shall be arranged so that each rock above the foundation course has a firm seating on the underlying rocks.
- The batter of the wall face shall be between $\frac{1}{2}$ H:1V and vertical, depending upon the height of the wall, the height of the slope, the width of the right-of-way, or other limitations on space.
- Fill material shall be placed behind the rock wall. The slope above the wall shall be maintained at 2H:1V or flatter. The footing trench shall be backfilled with excavated material.

- If a roadway is located at the toe of the wall, the roadway shall be paved up to the base of the rock wall and roadway curbs shall be provided for water transport. If a roadway is not located at the toe of the retaining wall, the backfilled material shall be sloped away from the wall.
- The stabilized slope shall be revegetated with a method applicable to the particular site.

Railroad tie retaining wall guidelines:

- Prepare the site by rough grading the ground surface. Set the bottom course of railroad ties onto a rigid base foundation material, and secure with pinning or metal collars.
- Place fill material behind the wall.
- Place next layer of railroad ties and fasten it to the lower layer.
- Place backfill and compact.
- Proceed in a similar fashion to the desired height.
- Revegetate the backfill behind the walls according to procedures applicable to the specific site.

Geosynthetic retaining walls:

- Do not allow equipment to operate directly on the geosynthetic.
- Contact ITD Headquarters Geotechnical Engineer for further guidance.
- All other walls should be constructed as designed by a Professional Engineer or as shown on the plans. A Special Provision for MSE retaining walls can be obtained from the Geotechnical Engineer at the Headquarters Resources Center.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.

PC-18 **STORMWATER BASINS**

Refer to: ITD Standard Specifications, Sections 205 and 212.
ITD Standard Drawings P-1-C and P-4-A.



BMP Objectives

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

Configurations may include retention and detention basins.

A retention basin is an impoundment created by a dam or an excavation for the purpose of storing water and settling sediment and other pollutants from surface runoff. A retention basin is designed to hold a specific amount of water until the water can evaporate or infiltrate. Usually the basin is designed to have overflows drain to a receiving conveyance system when the water level exceeds the basin capacity.

A detention basin is designed to temporarily hold, or detain, a specified volume of runoff while slowly releasing flows at a controlled rate to a receiving conveyance system. By detaining water and controlling release rates, detention basins can be designed to reduce peak runoff rates.

Typically, detention basins are designed with an orifice invert level with the bottom of the basin so that all of the water eventually drains out of the basin following a rainfall event.

Appropriate Applications

- Basins can be constructed in series to provide greater holding capacity for surface runoff.
- Small extended detention basins can be used in conjunction with other measures to trap sediment in runoff. In such applications, the outlet orifice size is reduced to maximize settling time and sediment capture.
- Large basins can provide substantial reduction of peak runoff rates when incorporated into the design of a storm drainage system.
- A retention basin typically consists of a dam or embankment, a storage basin, a riser discharge, and an emergency spillway.

- A detention basin typically consists of a dam or embankment, a storage basin, an outlet orifice, and an emergency spillway. If a detention basin is designed as an extended detention basin for water quality purposes, then a riser discharge may be an appropriate outlet control.

Limitations

- Not suitable for drainage areas exceeding 150 acres.
- Not suitable if the water depth will exceed 10 feet when measured from the original bed of the drainage channel to the crest elevation of the riser discharge. For safety purposes, fencing is required around all detention/retention facilities when the ponded water would create a drowning risk.
- If basins do not drain properly, resulting nuisance problems such as vegetation overgrowth, insects/vectors, erosion or rubbish accumulations, and fire hazards can complicate basin maintenance activities. It is recommended that water detention times be less than 96 hours to prevent vector/mosquito breeding.
- Side slopes should be gentle (3H:1V or flatter). Steep slopes will increase runoff rates and create greater potential for erosion.
- “Waste Disposal and Injection Wells” (Title 42, Chapter 39, Idaho Code; IDAPA 37.03.03; or any local jurisdiction) regulations shall be checked before completion of final design of basins.
- Federal and local requirements shall be checked if the basin is designed to retain water more than 2 feet deep.

Design Parameters

Retention Basins

- Retention basin design should be based on the total contributing drainage area. Locate the dam to provide maximum volume capacity. The structure becomes part of the permanent drainage system for the area.
- Retention basins should be designed by a professional engineer.

Detention Basins

- Detention basin design should be based on the total contributing drainage area. The release of runoff water must be at a non-erosive rate. Proper energy dissipation must be provided at the detention basin outfall location if discharging to an unlined conveyance system.
- Detention basins should be designed by a professional engineer.

Storage and Discharge Capacity

- Select a site that can provide adequate storage for not less than 1.25 inches of runoff per 2.5 acres of drainage area. For trap efficiency calculations, use the volume below the emergency spillway crest (or the riser discharge crest if there is no emergency spillway). If necessary, excavate additional storage capacity to meet these storage requirements, and plan for periodic basin clean out to maintain capacity requirements. If no available sites can meet

these design criteria, seek approval (from the permit issuing authority) to design and install a basin with less storage.

- Perform runoff calculations based on soil cover conditions expected to prevail during the anticipated effective life of the structure. Discharge risers and emergency spillways together should be able to handle requirements as specified by local jurisdiction design standards.
- Design the storage area such that it does not produce a public nuisance (vegetation overgrowth, vector issues associated with standing water, etc.).

Embankment

- The embankment should have a minimum top width of 8 feet. Side slopes should be 3H:1V or flatter.
- Minimum freeboard should be 12 inches for retention or detention basins with an emergency spillway and 3 feet for retention or detention basins with no emergency spillway. (Freeboard is the difference in elevation between design high water and the top of the compacted embankment.) The emergency spillway should be designed 1 foot above the local design storm standard surface elevation in the basin (based on hydraulics from the principal outlet structure). The emergency spillway should also convey the local design flow standard in the event of principal outlet clogging or back-to-back storm events.
- Vegetation should be established on all disturbed embankment slopes, borrow areas, or any other areas suitable for vegetative growth. Non-vegetative stabilization should be utilized where vegetation cannot be established.
- Foundation soils should be reviewed by the ITD Geotechnical Engineer for potential settlement.

Discharge Riser

- All riser discharge retention basins should have an emergency spillway.
- Design the discharge to handle not less than 5 inches runoff from the drainage area for 24 hours. The discharge riser will consist of a perforated vertical pipe or box-type riser joined to a horizontal conduit (barrel) that will extend through the embankment. The horizontal pipe conduit (barrel) should be a minimum of 12 inches in diameter. The riser should be a minimum of 30 inches in diameter with a cross-sectional area of at least 1.5 times the cross-sectional area of the horizontal conduit.
- Crest Elevation: When used in combination with emergency spillways, the crest elevation of the riser should be at least 12 inches below the elevation of the control section of the emergency spillway. If no emergency spillway is provided, the crest elevation of the riser should be at least 3 feet below the crest elevation of the embankment.
- Perforated Riser: The upper portion of the riser should be perforated with 1.5- to 4-inch-diameter holes staggered and spaced 8 inches vertically and 10 to 12 inches horizontally. The perforated portion should be the top one-half to two-thirds of the riser. The whole pipe length should be perforated if a gravel filter cone is placed around the bottom one-third of the riser. Perforations should be small enough to prevent the passage of filter material.

- **Antivortex Device:** Install an antivortex device on the top of the riser. An approved antivortex device is a thin, vertical plate normal to the centerline of the dam and firmly attached to the top of the riser. The plate dimensions are: length = diameter of the horizontal pipe.
- **Base:** The riser should have a base attached with a watertight connection and should have sufficient weight to prevent flotation of the riser. Two approved bases are (1) a concrete base 18 inches thick with the riser embedded 6 inches into the base (the base should be square with each side 24 inches greater than the riser diameter), and (2) a 0.2-inch minimum thickness steel plate welded all around the base of the riser to form a watertight connection (the plate should be square with each side equal to two times the riser diameter and should have 24 inches of stone, gravel, or tamped earth placed on it to prevent flotation).
- **Trash Rack:** A trash rack consisting of #4 (#10M) reinforcing bars, 6 inches on center, should be welded across the top of the riser.
- **Antiseep Collars:** Conduits through embankments should be provided with antiseep collars. All basins should have a minimum of one antiseep collar that is rectangular, blocking all potential flow through the backfilled material and extending to the sides of the barrel trench. The horizontal dimension should be at least 24 inches larger than the barrel diameter. The bottom side of the antiseep collar should extend a minimum of 24 inches below the grade line, and the top side should extend 12 inches above the barrel.

Spillways

- The spillway should be at least 1.6 feet deep with 1H:1.5V side slopes. Two designs are (1) rigid channel liner protected spillway with discharge over the top of dam or embankment, and (2) spillway protected from erosion by riprap and erosion control geotextile or other appropriate material. The design width and entrance/exit channel slopes are critical to the ability of the spillway to successfully protect the dam with a minimum of erosion hazard to the receiving channel.
- **Minimum Capacity:** The spillway must be able to pass 150 percent of the peak flow from the design storm. Where emergency spillways are used, the channel bottom should have a minimum width of 8 inches.
- **Maximum Allowable Velocity:** Allow a maximum discharge velocity of 6 feet per second in the exit channel, based on the design frequency storm.
- **Vegetative Protection:** Provide appropriate vegetative cover or other suitable means of protecting the embankment and spillway.

Basin Information to Be Submitted in Final Design Plans

- Specific location of the basin.
- Plan view of dam and the storage basin.
- Cross-section of the dam, storage basin, spillway, and/or emergency spillway and profile of the emergency spillway.
- Runoff calculations including storage volumes and required capacity for local design storm standard.

- Calculations showing design of riser discharge and emergency spillway.
- An inspection and maintenance schedule including sediment removal and disposal procedures.

Construction Guidelines

The following construction criteria are critical to successful installation and operation of basins.

- Preparation
 - Prepare the dam site by clearing vegetation and removing topsoil before beginning dam construction. To facilitate cleanout and restoration, the pool area (measured at the top of the riser discharge) should also be cleared of all brush, trees, and other debris.
- Riser Discharge
 - Level the bed for the riser discharge to provide uniform support throughout its entire length under the dam.
 - Make sure there is a watertight bottom on the riser and that all pipe joints are watertight.
 - Locate the outlet invert of the riser discharge unit no more than 12 inches above the streambed and provide outlet protection measures.
 - Place the barrel on a firm foundation according to the lines and grades shown on the plans, and compact.
 - Backfill with material of the type and quality specified or with an approved equal.
- Embankment
 - Obtain material from approved materials sources.
- Spillway
 - Construct a spillway or an emergency spillway, as specified in the plans.
- Stabilization
 - Stabilize the embankment and emergency spillway using slope stabilization and re-vegetation measures.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications.
- Prepare an inspection and maintenance schedule including sediment removal and disposal procedures.
- Cleanout the basin when its effective storage capacity drops below 0.6 inches per 2.5 acres of drainage area. The elevation corresponding to this level should be determined and given in the design data as a distance below the top of the riser.

- Dispose of accumulated sediments in an approved area. Location of the disposal site should prevent sediments from returning to the basin or to downstream areas during storm events or snowmelt.

PC-19 EXTENDED DETENTION BASIN WITH MICROPOOL

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

**BMP Objectives**

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

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

Appropriate Applications

- Can be used to enhance stormwater quality and reduce peak discharges.
- Are most applicable in residential, commercial, and industrial areas.
- If constructed early in development of a particular site, become an effective means of trapping sediment from construction activities.
- Can be retrofitted into existing flood control facilities.
- Are used to improve quality of urban runoff.
- Are used for regional and/or follow-up water quality treatment but are also effective as an “on-site” BMP.
- Work well in conjunction with other BMPs used to control upstream and downstream sediments.
- Can be effective if they are combined with BMPs that attenuate peak stormwater discharges or reduce runoff volumes. If needed, flood routing detention volume can be designed and captured by the basin, above volume used for water quality treatment. If combined effectively with other BMPs, the size of the basin can be reduced.
- 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.

Design Parameters

- If possible, basin should be incorporated into existing facility or flood control basin.
- Other urban uses such as recreation, open space, and/or wildlife habitat should be considered.
- 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 percent of tributary development area.
- Groundwater elevations should be accounted for in the design and construction of the basin.
- If minimum dam heights and volumes are exceeded, regulatory requirements should be reviewed for dam embankments and storage volumes.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Regular maintenance is necessary to remove surface sediment, trash, debris, and leaf litter, and dead or diseased plant material.

PC-20 WET BASIN

Reference: Maryland Stormwater Design Manual.

**BMP Objectives**

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

A wet basin is 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 basin until it is displaced by runoff from the next storm. The permanent pool enhances the effectiveness of the basin by promoting biological uptake.

Appropriate Applications

- Can be used to enhance stormwater quality and reduce peak discharges.
- Are most applicable in residential, commercial, and industrial areas.
- If constructed early in development of a particular site, become an effective means of trapping sediment from construction activities.
- Can be retrofitted into existing flood control facilities.
- Are used to improve quality of urban runoff.
- Are used for regional and/or follow-up water quality treatment but are also effective as an “on-site” BMP.
- Also work well in conjunction with other BMPs used to control upstream and downstream sediments.
- Can be effective if they are combined with BMPs that attenuate peak stormwater discharges or reduce runoff volumes. If needed, flood routing detention volume can be designed and captured by the basin, above volume used for water quality treatment. Basin size can be reduced if effectively combined with other BMPs.

- 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.

Design Parameters

- 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, basin should be incorporated into existing facility or flood control basin.
- Other urban uses such as recreation, open space, and/or wildlife habitat should be considered.
- Generally, land required is approximately 0.5 to 2.0 percent of tributary development area.
- Groundwater elevations should be accounted for in the design and construction of the basin.
- If minimum dam heights and volumes are exceeded, regulatory requirements should be reviewed for dam embankments and storage volumes.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Regular maintenance is necessary to remove surface sediment, trash, debris, and leaf litter, and dead or diseased plant material.

PC-21 WET EXTENDED DETENTION BASIN

Reference: Maryland Stormwater Design Manual.

**BMP Objectives**

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

A wet extended detention basin is used to capture and treat a specific volume of stormwater runoff. This structure is generally the same as a wet basin. However, this BMP provides water quality treatment through a combination of a permanent pool and extended detention storage. Water in the permanent pool mixes with initial runoff from storm events. The permanent pool enhances the effectiveness of the basin by promoting biological uptake.

Appropriate Applications

- Can be used to enhance stormwater quality and reduce peak discharges.
- Are most applicable in residential, commercial, and industrial areas.
- If constructed early in development of a particular site, become an effective means of trapping sediment from construction activities.
- Can be retrofitted into existing flood control facilities.
- Are used for regional and/or follow-up water quality treatment but are also effective as an “on-site” BMP.
- Also work well in conjunction with other BMPs used to control upstream and downstream sediments.
- 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 basin, above volume used for water quality treatment. Basin size can be reduced if effectively combined with other BMPs.
- 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.

Design Parameters

- 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, basin should be incorporated into existing facility or flood control basin.
- Other urban uses such as recreation, open space, and/or wildlife habitat should be considered.
- Generally, land required is approximately 0.5 to 2.0 percent of tributary development area.
- Groundwater elevations should be accounted for in the design and construction of the basin.
- If minimum dam heights and volumes are exceeded, regulatory requirements should be reviewed for dam embankments and storage volumes.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Regular maintenance is necessary to remove surface sediment, trash, debris, and leaf litter, and dead or diseased plant material.

PC-22 SHALLOW WETLAND

Reference: Maryland Stormwater Design Manual.

**BMP Objectives**

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

A shallow wetland is used to capture and treat a specific volume of stormwater runoff. This structure is similar to a stormwater basin; however, wetland vegetation is added to the bottom of the basin 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.

Appropriate Applications

- Shallow wetlands:
 - Can be used to reduce peak discharges.
 - Can be used as a follow-up structural BMP or as a stand-alone facility.
 - Can be incorporated with small existing wetlands (requires state and federal permits).
 - Require an area sufficiently large for impounding stormwater in shallow basins.
 - Can be arranged in a series of terraces.
 - Can provide effective follow-up treatment to on-site and other basin BMPs.
- 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.
- The advantage is in aesthetics and creation of wildlife habitat, and the disadvantage is the need for continuous base flow to maintain wetland growth.

Design Parameters

- Generally, minimum drain time of 24 hours is recommended.

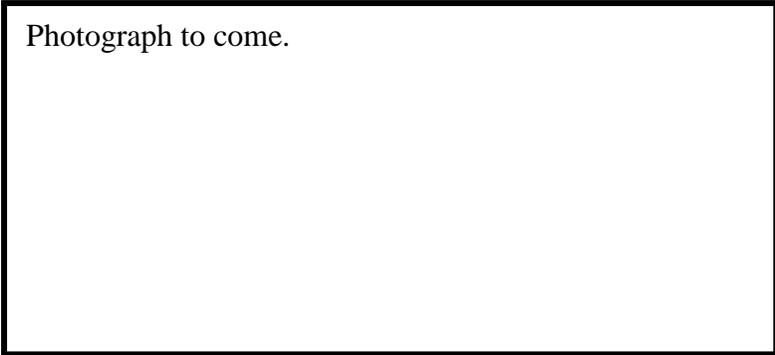
- Wetlands constructed outside of the Waters of the U.S. and explicitly designed for stormwater management are not subject to the provisions of the Clean Water Act (Sections 401 and 404). When abandoned, they may be regulated as natural wetlands.
- Other urban uses such as recreation, open space, and/or wildlife habitat should be considered.
- 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 basin bottom is not reliable because of low permeability soils and/or high ground water elevations.
- If minimum dam heights and volumes are exceeded, regulatory requirements should be reviewed for dam embankments and storage volumes.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Regular maintenance is necessary to remove surface sediment, trash, debris, and leaf litter, and dead or diseased plant material.

PC-23 EXTENDED DETENTION SHALLOW WETLAND

Reference: Maryland Stormwater Design Manual.



Photograph to come.

BMP Objectives

- Perimeter Control**
- Slope Protection**
- Borrow and Stockpiles**
- Drainage Areas**
- Sediment Trapping**
- Stream Protection**
- Temporary Stabilizing**
- Permanent Stabilizing**

Definition and Purpose

An extended detention shallow wetland is 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 basin to enhance the pollutant removal capability, and a perennial base flow is required to maintain and promote wetland vegetation.

Appropriate Applications

- Extended detention shallow wetland:
 - Can be used to reduce peak discharges.
 - Can be used as a follow-up structural BMP or as a stand-alone facility.
 - Can be incorporated with small existing wetlands (requires state and federal permits).
 - Require an area sufficiently large for impounding stormwater in shallow basins.
 - Can be arranged in a series of terraces.
 - Can provide effective follow-up treatment to on-site and other basin BMPs.
- 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.
- The advantage is in aesthetics and creation of wildlife habitat, and the disadvantage is the need for continuous base flow to maintain wetland growth.

Design Parameters

- 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.
- Other urban uses such as recreation, open space, and/or wildlife habitat should be considered.
- Loamy soils are required in the wetland bottom to sustain plant growth.
- Exfiltration through basin bottom is not reliable because of low permeability soils and/or high ground water elevations.
- If minimum dam heights and volumes are exceeded, regulatory requirements should be reviewed for dam embankments and storage volumes.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Regular maintenance is necessary to remove surface sediment, trash, debris, and leaf litter, and dead or diseased plant material.

PC-24 POND/ WETLAND SYSTEM

Reference: Maryland Stormwater Design Manual.

**BMP Objectives**

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

A pond/wetland system is 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.

Appropriate Applications

- Pond/wetland systems:
 - Can be used to reduce peak discharges.
 - Can be used as a follow-up structural BMP or as a stand-alone facility.
 - Can be incorporated with small existing wetlands (requires state and federal permits).
 - Require an area sufficiently large for impounding stormwater in shallow basins.
 - Can be arranged in a series of terraces.
 - Can provide effective follow-up treatment to on-site and other basin BMPs.
- 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.
- The advantage is in aesthetics and creation of wildlife habitat, and the disadvantage is the need for continuous base flow to maintain wetland growth.

Design Parameters

- 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.

If minimum dam heights and volumes are exceeded, regulatory requirements should be reviewed for dam embankments and storage volumes.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Regular maintenance is necessary to remove surface sediment, trash, debris, and leaf litter, and dead or diseased plant material.

PC-25 POCKET WETLAND

Reference: Maryland Stormwater Design Manual.

**BMP Objectives**

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

A pocket wetland is 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.

Appropriate Applications

- Pocket wetlands:
 - Can be used to reduce peak discharges.
 - Can be used as a follow-up structural BMP or as a stand-alone facility.
 - Can be incorporated with small existing wetlands (requires state and federal permits).
 - Require an area sufficiently large for impounding stormwater in shallow basins.
 - Can be arranged in a series of terraces.
 - Can provide effective follow-up treatment to on-site and other basin BMPs.
- 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.
- The advantage is in aesthetics and creation of wildlife habitat, and the disadvantage is the need for continuous base flow to maintain wetland growth.

Design Parameters

- 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.
- If minimum dam heights and volumes are exceeded, regulatory requirements should be reviewed for dam embankments and storage volumes.

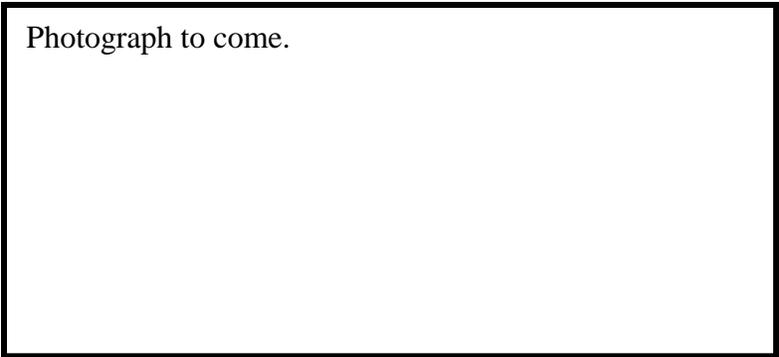
Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Regular maintenance is necessary to remove surface sediment, trash, debris, and leaf litter, and dead or diseased plant material.

PC-26 SEDIMENT CONTROL BOX

Refer to: ITD Standard Specifications, Sections 605 and 609.

ITD Standard Drawings E-6-A through F, P-1-H, P-3-A, P-3-B, and P-3-D.



BMP Objectives	
<input type="checkbox"/>	Perimeter Control
<input type="checkbox"/>	Slope Protection
<input type="checkbox"/>	Borrow and Stockpiles
<input checked="" type="checkbox"/>	Drainage Areas
<input checked="" type="checkbox"/>	Sediment Trapping
<input type="checkbox"/>	Stream Protection
<input type="checkbox"/>	Temporary Stabilizing
<input type="checkbox"/>	Permanent Stabilizing

Definition and Purpose

A sediment control box is a structure constructed from reinforced concrete or corrugated metal pipe (underground tank) that receives runoff from drainage areas or facilities and stores or conveys the runoff into an underground system.

Sediment control boxes consist of catch basins, oil/water separators, and wet vaults/tanks.

Appropriate Applications

- Catch basins capture sediment and convey runoff to a pipe system so that ditch flow or gutter flow capacity is not exceeded. A catch basin can also dissipate flow energy. Catch basins may be used along roadways or other paved surfaces as needed. If local conditions and permit restrictions allow, dry wells may be incorporated into the catch basin design.
- Oil/water separators are multi-chambered devices designed to remove trace metals and petroleum hydrocarbons from stormwater runoff as it moves through the device. The primary use of oil/water separators will be in areas where oil spills dripping from vehicles or parking lot residues are an issue.
- Wet vaults and tanks are underground facilities used for the collection of surface water and are designed to provide runoff treatment and sediment capture by settling pools or baffles.

Limitations

- Catch basins may not be as effective in reducing sediment loading or pollutants as other sediment control box measures.
- Oil/water separators have limited application in stormwater treatment because their treatment mechanisms are not well suited to the characteristics of stormwater runoff (high variable flow with high discharge rates, turbulent flow regime, low oil concentration, high suspended solids concentration). Oil/water separators require intensive maintenance.

- Wet vaults/tanks cannot provide the equivalent level of treatment accomplished by retention (wet) basins and constructed wetlands. Wet vaults and tanks are difficult to monitor and maintain.
- Sediment control boxes that are within a separate municipal storm sewer system must satisfy all requirements of that system. The municipality shall be notified before installing devices that will affect the quantity or quality of runoff discharging into the municipal storm sewer system. An NPDES Permit is required for this application.

Design Parameters

Catch Basins

- Spacing shall be determined so that catch basins will intercept all drainage and inlet capacity will not be exceeded.
- The design shall be completed in accordance with the Hydrology Section in the ITD Design Manual.
- Catch basins shall be located at all low spots in a street gutter and at abrupt grade changes. The gutter flowline may be depressed at inlet points to permit increased gutter grades and to reduce ponding.
- Hydraulic grade line should be a minimum of 6 inches below the bottom of the inlet grade elevation for the design storm.
- The length of a rectangular inlet should be at least two times as long as the inside diameter of the inlet/outlet pipes. The width of the inlet should be at least equal to the pipe diameter with a minimum of 24 inches. Circular inlets should be at least two times as wide as the pipe diameter. Determine the capacity by assuming that one-half of the grate is blocked by debris.
- Several catch basin designs are available. Consult the ITD Design section for standardized or previously accepted drawings.

Oil/Water Separators

- Oil/water separators may require design by a professional engineer licensed in the State of Idaho.
- For roadway projects, refer to the Standard Specifications. If treatment that is more extensive is necessary or required, refer to oil/water separators as described in the IDEQ Catalog of Stormwater Best Management Practices for design parameters.

Wet Vaults/Tanks

- May require design by a professional engineer licensed in the State of Idaho.
- Design notes are provided in the Standard Specifications.

Construction Guidelines

- Dispose excavated soils at an approved location.

- Compact the area around the sediment control box to the appropriate standards as specified in the plans and specifications.

Catch Basins

- Construct according to contract plans and specifications.
- Install and operate when construction of the drainage system is completed.
- Install outlet protection for all pipe outfalls.

Oil/Water Separators

- Construct or install according to design and manufacturer's recommendations.

Wet Vaults/Tanks

- Construct according to plans and specifications.
- Seal all construction joints watertight by an approved method.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Remove any debris trapped on the grate or in the inlet.
- Make sure that street sweeping occurs frequently enough to prevent clogging of inlets.
- Clean oil/water separators frequently to keep accumulated oil from escaping during a storm event or snowmelt.
- Replace oil absorbent pads as necessary in pad type separators.
- Dispose waste oil and residues in accordance with 40 Code of Federal Regulations 279.

PC-27 INFILTRATION TRENCH

Reference: Maryland Stormwater Design Manual.

**BMP Objectives**

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

An infiltration trench is 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.

Appropriate Applications

- Structures are prone to clogging by suspended solids and are best used in conjunction with other BMPs that are more effective in removing suspended solids.
- Bottom of the trench should be 4 feet higher than the seasonal high water table or bedrock.
- Trenches:
 - Can be used to enhance stormwater quality, reduce peak discharges, and recharge groundwater.
 - Should not be used on or adjacent to steep slopes and are typically used for drainage areas less than 5 acres.
 - 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.

- 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.
- Should not be installed in highly permeable sand or gravel seams that are directly connected to aquifers.
- Can be connected to parking lot drains, roof downspouts, or inlet structures.

Design Parameters

- Generally, trenches are designed to infiltrate retained runoff within a 48-hour period.
- Dewatering 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.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Accumulated sediments render the trench ineffective. These sediments must be controlled to lengthen the effective life span.

PC-28 INFILTRATION BASIN

Reference: Maryland Stormwater Design Manual.

**BMP Objectives**

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

An infiltration basin is 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.

Appropriate Applications

- Can be used to enhance stormwater quality, reduce peak discharges, and recharge groundwater.
- Should not be used on or adjacent to steep slopes and should not be used within fill soils.
- Can be used to pre-treat portions of the water quality volume if used as an upstream stilling basin.
- Typically used for drainage areas less than 5 acres.
- Should only be used with well-drained soils of Hydrologic Soil Groups A or B.
- Should not be installed in highly permeable sand or gravel seams that are directly connected to aquifers.
- Can be directly connected to parking lot drains, roof downspouts, or other inlet structures.

Design Parameters

- The bottom of the basin should be 4 feet higher than the seasonal high water table or bedrock.
- Generally, basins are designed to infiltrate retained runoff within a 48-hour period.

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

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Periodic observations should also be made to monitor any decrease in performance.
- Regular maintenance is necessary to remove surface sediment, trash, debris, and leaf litter, and dead or diseased plant material.

PC-29 SLOPE DRAINS/CHUTES/FLUMES

Refer to: ITD Standard Specifications, Sections 208, 212, 409, 606, 607, and 609.
ITD Standard Drawings D-1-A, D-1-B, and P-2-D.

**BMP Objectives**

- | | |
|-------------------------------------|------------------------------|
| <input type="checkbox"/> | Perimeter Control |
| <input checked="" type="checkbox"/> | Slope Protection |
| <input type="checkbox"/> | Borrow and Stockpiles |
| <input checked="" type="checkbox"/> | Drainage Areas |
| <input checked="" type="checkbox"/> | Sediment Trapping |
| <input type="checkbox"/> | Stream Protection |
| <input type="checkbox"/> | Temporary Stabilizing |
| <input checked="" type="checkbox"/> | Permanent Stabilizing |

Definition and Purpose

A slope drain is a device used to carry concentrated runoff from the top to the toe of a slope that has already been damaged by erosion or is at high risk for erosion. The slope drain may be used to convey runoff from offsite around a disturbed portion of the site or may be used to drain around or over saturated slopes that have the potential for slides.

- Pipe slope drains are made of flexible tubing or rigid pipe and may have prefabricated inlet and outlet sections. The drain discharges into a stabilized watercourse, sediment trap, or stabilized area. Pipe slope drains can be either temporary or permanent, depending on the method of installation and the material used.
- Chutes and flumes are channels that are designed to conduct runoff down a slope face and discharge the water to a stable outlet area without causing erosion. Chutes and flumes may be constructed of rock, concrete or asphalt liners, or half-round pipe. Chutes and flumes can convey runoff from diversion dikes, infiltration trenches, slope steps, benches, or other runoff control facilities. Chutes and flumes discharge into a stabilized watercourse, sediment trap, or stabilized area.

Appropriate Applications

- Pipe slope drains are used whenever it is necessary to convey water down a slope without causing erosion. Pipe slope drains may be used with other devices, including diversion dikes or swales, sediment traps, and level spreaders. Permanent slope drains may be placed on or beneath the ground surface.
- Pipe slope drains are appropriate in the following general locations:
 - On cut or fill slopes where permanent stormwater drainage structures are to be installed.

- Where earth dikes or other diversion measures have been used to concentrate flows.
- On any slope where concentrated runoff crossing the face of the slope may cause gullies, channel erosion, or saturation of slide-prone soils.
- As an outlet for a natural drainage way.
- Chutes and flumes may be used on slopes 2H:1V or flatter to convey water down the face of erodible slopes, usually from runoff collection devices at the top to stable discharge areas at the bottom. Chutes and flumes are permanent structures that are effective in many situations where concentrated runoff would otherwise cause slope erosion.

Limitations

- Pipe slope drains are not suitable for drainage areas greater than 10 acres.
- Chutes and flumes must be 2H:1V or flatter.

Design Parameters

- All designs should handle the peak runoff for the 50-year storm event. Detailed design, that includes a hydraulic analysis by a licensed professional engineer, is required.
- Dikes or other diversion devices should be graded to direct water to the invert at the inlet structure.
 - Slope drains drainage area may be up to 10 acres for each slope drain. Accessories to the slope drain (inlets, outlets, and collars, etc.) shall be specified in accordance with the manufacturer's recommendations.
 - Chutes and flumes must be placed on undisturbed soil or well-compacted fill. Energy dissipaters within the chute or flume or at the outlet end should be provided to protect against scour when necessary. Riprap at the outlet may be needed as appropriate. Slopes should be no steeper than 2H:1V or flatter.

Construction Guidelines

Pipe Slope Drains

Install slope drains with inlets at points where water is discharged from ditches, berms, or other points of concentrated flow. Anchor all pipe slope drains to the slope to prevent disruption by water or other forces. Install the inlet section of the drain to properly funnel the flow into the drain. Cross berms may be necessary to direct the flow into the inlet.

- Place pipe slope drains that are located on the surface on firm well-compacted soil.
- Compact soil around and under the inlet section to prevent piping failure or undercutting around the inlet.
- Position erosion control geotextile under the inlet, extend it 3 to 6.5 feet in front of the inlet, and key it in 6 inches on all sides to prevent erosion. Secure the pipe slope drain to the slope at intervals of 10 feet or less. The method of accomplishing this should be as specified or as approved by the Professional Engineer. Securely fasten all slope drain sections together with watertight fittings.

- Extend the pipe beyond the toe of the slope if possible. Discharge water into a stabilized area or to a sedimentation trap or basin. Use riprap outlet protection or energy dissipaters if necessary. Another option is to “tee” the pipe slightly up from the toe to disperse and dissipate the flow.
- Situate the finished grade at the inlet a minimum of 6 inches above the top of the slope drain.
- Protect the outlet structure against scour with energy dissipaters and/or riprap.
- Stabilize all areas disturbed by the installation of the slope drain.

Chutes and Flumes

- Locate the chute or flume on soil compacted in accordance with the Standard Specifications with the discharge going only to a stabilized area or stable drainage system.
- Coordinate installation of the chutes and flumes with construction of the slope and completion of upslope runoff collection devices. Locate control measures so that exposed slopes are not damaged by concentrated flows from gullies or drainage outlets above the slope.
- Compact suitable aggregate around the inlet to ensure that good contact is attained at the interface of the structure and diversion dikes to prevent failure. Refer to the Standard Specifications for further information on inlet structures.
- Protect the outlet structure against scour with energy dissipaters and/or riprap.

Maintenance and Inspection

Pipe Slope Drains

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- If a sediment trap has been provided, clean when the sediment level reaches one-half the design volume.

Chutes and Flumes

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Repair all damage promptly, as needed.

PC-30 ROCK ARMOR/ROCK MULCH/TURF REINFORCEMENT MATS

For assistance, contact the Geotechnical Engineer in ITD Headquarters

**BMP Objectives**

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

Protection of a slope by using angular shot rock, or Turf Reinforcement Mats (TRM).

- Rock Armoring: Angular shot rock placed on a slope surface to prevent or reduce erosion.
- Rock Mulch: When topsoil and soil amendments are included to facilitate vegetative growth, the material is referred to as rock mulch. Rock mulch is considered topsoil material with angular rock included to inhibit erosion.
- TRM: A long-term, non-degradable rolled erosion control product composed of UV-stabilized synthetic fibers, nettings, and/or filaments processed into three-dimensional reinforcement matrices designed for permanent applications where discharges exert velocities and shear stresses that exceed the limits of mature, natural vegetation. The TRM provides sufficient thickness, strength, and void space to permit soil filling and/or retention and the development of vegetation within the matrix.

Appropriate Applications

- Rock armoring and/or rock mulch is normally used to protect fine-grained soil slopes and steep soil slopes from erosion due to high surface runoff, strong wind, and surface sloughing.
- TRM is used for surface erosion control on bare slopes to be revegetated.

Limitations

- Rock armoring should not be used on slopes 1.25H:1V or steeper. Extra measures are required to place rock armor on slopes 2H:1V or steeper. Rock mulch is not generally recommended on slopes 2H:1V or steeper.
- A minimum application of 12 inches thickness is the most effective, and for rock armoring, revegetation efforts may be of limited effectiveness.

- The TRM should not be used where the presence or appearance is aesthetically unacceptable. Aesthetics may be less of a limitation for rock armoring.
- The effectiveness of TRM may be reduced if not properly selected, designed, or installed.

Design Parameters

- Rock armoring/rock mulch should be placed on a roughened slope to help key and stabilize the material on the slope.
- Material for rock armoring should meet the requirements of the Standard Specifications and should consist of 6-inch-minus rippable or shot rock with 20 to 40 percent passing the 4.75 mm (No. 4) sieve.
- Rounded rock is not acceptable for use as rock armoring on steep slopes. Rounded rock for rock mulch is of limited value.
- A lined ditch at the toe is appropriate to inhibit erosion (undercutting) under the rock-armored slope.
- For 3H:1V or flatter slopes, rock mulch may consist of 60 percent coarse rock armoring material and 40 percent minus 4.75 mm (No. 4) rock armoring fines, topsoil, and soil amendments. Soil amendments should include organic material such as compost, log yard waste, bark, or wood chips if available.
- For steeper slopes, added topsoil and soil amendments should be limited to no more than 10 percent.
- If the TRM is used, additional erosion control methods are generally recommended. Fiber wattles may be appropriate at regular intervals under the TRM to further reduce surface runoff velocity. Appropriate seeding measures should be included.
- TRM products intended for surface stabilization of slopes as steep as 1H:1V are available.

Construction Guidelines

- Rock armoring/rock mulch should be keyed into a roughened surface to prevent slippage, and the rock armoring/rock mulch should also be keyed into the toe of the slope to enhance long-term stability.
- A lined ditch at the toe is appropriate to inhibit erosion (undercutting) under the rock-armored slope.
- The TRM should be installed in accordance with the plans, specifications, and manufacturer's recommendations. The TRM requires a smooth surface for installation to avoid tenting or gaps under the mat.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.

- Make any repairs necessary to ensure the measure is operating properly.

PC-31 SERRATIONS AND ROUGHENING

Refer to: ITD Standard Specifications, Section 205.
ITD Design Manual, Section 5.6.

**BMP Objectives**

- | | |
|-------------------------------------|-----------------------|
| <input type="checkbox"/> | Perimeter Control |
| <input checked="" type="checkbox"/> | Slope Protection |
| <input type="checkbox"/> | Borrow and Stockpiles |
| <input checked="" type="checkbox"/> | Drainage Areas |
| <input checked="" type="checkbox"/> | Sediment Trapping |
| <input type="checkbox"/> | Stream Protection |
| <input checked="" type="checkbox"/> | Temporary Stabilizing |
| <input checked="" type="checkbox"/> | Permanent Stabilizing |

Definition and Purpose

A rough surface is added to a slope by serrations, horizontal grooves, furrows, or depressions running parallel to the slope contour over the entire face of a slope.

Appropriate Applications

- Serration or roughening reduces the velocity of surface runoff, increases infiltration, traps sediment, and provides simple, inexpensive, and immediate erosion control for bare soil where vegetative cover is not yet established. Serrating or roughening a smooth slope prior to application of topsoil will assist in retaining the topsoil in place. In some cases, leaving the slope in a roughened condition will help control erosion and provide suitable rooting areas for plant seedlings.
- Serration or roughening is appropriate for most slopes, although different methods are used depending on the steepness of the slope, the type of slope (cut or fill), soil and rock characteristics, and future maintenance requirements.

Limitations

- When serration or roughening is improperly applied, erosion may increase rather than be reduced.
- Serration shall be limited to slopes in medium to highly cohesive soils (i.e., clays) or in soft rock that can be excavated without ripping.
- Slope angle must be 2H:1V or flatter to allow access by heavy equipment.
- If the serration or roughening is damaged, the surface must be reworked and roughened.

- Serration or roughening alone is not a sufficient control measure for some locations. For these areas, this measure must be implemented in conjunction with other soil stabilization measures.

Design Parameters

- Different methods can be used to roughen the slope surface, including grooving, tracking, or ripping. The selection of an appropriate method depends upon the grade of the slope, soil type, and whether the slope is a cut or fill slope.
- Slopes 2H:1V or steeper should be constructed to include a roughened surface of the embankment or cut materials, in conjunction with additional appropriate measures. Slopes with a gradient steeper than 3H:1V but flatter than 2H:1V should be roughened or serrated prior to placing topsoil.
- Surface roughening or serrating can be done by any equipment that can be safely operated on the slope. Grooves should not be less than 4 inches deep or more than 16 inches apart.
- Excessive compacting of the topsoil surface must be avoided, because soil compaction inhibits vegetation growth and causes higher runoff velocity.
- Cut or fill slopes that may require mowing should have a gradient 3H:1V or flatter. Such a slope can be roughened with shallow grooves parallel to the slope contour by using normal tilling. Grooves should be close together, less than 10 inches wide and not less than 1 inch deep.

Construction Guidelines

- Apply surface roughening after grading activities have ceased in an area. Equipment of various kinds (disks, harrows, or teeth) can be successfully used for slope roughening and serration. Ripper shanks or scarifiers can be used to roughen the slope surface. For rippers and scarifiers, serration intervals should be at 3-foot spacing and 12 inches in depth.
- Operate a crawler tractor up and down the slope to make cleat imprints parallel to the slope contour.
- Construct the serrations approximately horizontal or parallel to the roadway grade if its profile grade is less than 4 percent.
- Construct each series of serrations in the opposite direction from the preceding series to minimize buildup of loose material.
- Remove loose material collected at the ends of the slope and blend the slope ends into the natural ground surface.
- If rock that is too hard to roughen is encountered, blend the serrations into the rock.
- Remove materials that fall into the roadway ditch or roadway.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.

- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Any rills or gullies that appear should be promptly filled, and the slope should be re-roughened or serrated and adequately protected.

PC-32 TERRACES AND BENCHES

Refer to: ITD Standard Specifications, Section 205.
ITD Design Manual, Section 5.6.

**Definition and Purpose**

A permanent berm and channel arrangement either constructed along the face of a slope at regular intervals or constructed as a continuous series of horizontal steps on the face of a slope.

Appropriate Applications

- Reduce erosion damage by capturing or slowing down surface runoff and directing it to a stable outlet at a velocity that minimizes erosion. On long, steep slopes that have a water erosion problem or where it is anticipated that water erosion will be a problem, terraces or benches are particularly effective.
- Trap and retain sediments from the slope above, and the revegetation process on bare slopes can be enhanced. Moisture is held better than smooth slopes, and the sediment loading of surface runoff is minimized.
- May be used on new slopes to minimize erosion.
- May be suitable for slopes in soils and soft rock that can be excavated by ripping.

Limitations

- Terraces and benches should not be constructed on slopes or cuts:
 - With sandy or rocky soils, non-cohesive or highly erodible soils, or decomposing rock including moraines and other depositional materials.
 - With soft-rock laminations in thin layers oriented so that the strike is approximately parallel to the slope face and the dip approximates the staked slope line.
- Terraces and benches may cause sloughing if too much water infiltrates the soil and are effective only where suitable runoff outlets are available.
- Avoid benching, if possible, in areas where there is potential for rockfall problems.

Design Parameters

- The design of terraces and benches should be determined by an engineering survey and layout.

BMP Objectives

- | | |
|-------------------------------------|-----------------------|
| <input type="checkbox"/> | Perimeter Control |
| <input checked="" type="checkbox"/> | Slope Protection |
| <input type="checkbox"/> | Borrow and Stockpiles |
| <input checked="" type="checkbox"/> | Drainage Areas |
| <input checked="" type="checkbox"/> | Sediment Trapping |
| <input type="checkbox"/> | Stream Protection |
| <input checked="" type="checkbox"/> | Temporary Stabilizing |
| <input checked="" type="checkbox"/> | Permanent Stabilizing |

- The upper step should begin immediately below the top of the cut or fill. Continue constructing terraces or benches down to the toe of the slope.
- Terraces or benches should have approximately vertical back slopes and may vary from 2 to 4 feet vertically. The tread (level area) should be approximately horizontal but may parallel the roadway grade if it is less than 4 percent.
- Slopes 2H:1V or steeper may be stair-stepped with terraces or benches at sufficient width to retain sediment eroded from the slope above.
- The terraces and benches **must be** designed with adequate outlets, such as a grassed waterway, vegetated area, or other suitable outlet. Slope drains may be needed to convey surface runoff from the terraces or benches to the toe of the slope without causing erosion. Analysis of the local site conditions should determine the needed outlets.
- Terraces and benches may be constructed with liners to carry water to the outlet.
- Interceptor ditches may be needed at the top of the slope to prevent or reduce the surface water from running down the slope face.
- Stabilize or revegetate the slope with methods applicable to the particular site.

Construction Guidelines

- Construct terraces and benches using equipment that is capable of meeting the specifications established in the plans. Drain to a stabilized area. In cut slopes, begin terrace or bench construction at the top of the slope and work downward.
- Remove the loose material that collects at the end of terraces or benches and blend the ends of each terrace or bench into the natural ground surface. If encountering rock that is too hard to rip (within a cut), blend the terraces or benches into the rock.
- Scale the benched and terraced slopes to remove rock that may fall into the roadway ditch or onto the roadway.
- Install interceptor ditches prior to beginning the construction of the cut section.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- During the construction phase, maintenance of the terraces and benches will be the responsibility of the Contractor to ensure that these measures are properly functioning.
- Damaged benching and terracing areas shall be repaired immediately and reseeded as soon as possible. If excessive seepage or surface runoff is a problem, the seepage/runoff shall be controlled with appropriate drainage facilities.

- Prompt action shall be taken as needed to ensure proper drainage and slope stability. Rills shall be prepared and damaged areas shall be reseeded as they develop.
- Substantial maintenance of the newly planted or seeded vegetation may be required.

PC-33 TOPSOIL MANAGEMENT

Refer to: ITD Standard Specifications, Sections 213 and 711.09.

**BMP Objectives**

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

Topsoil is that uppermost layer of soil capable of growing and supporting vegetation. Topsoil contains the essential microorganisms, nutrients, organic matter, and physical characteristics necessary to grow and sustain permanent vegetation. Stripping, stockpiling, and reusing topsoil on construction projects is essential for proper reclamation of disturbed areas.

Appropriate Applications

Topsoil is recommended on all disturbed sites and slopes 2H:1V or flatter, or as a planting medium for plantings or nursery stock. Topsoil may be added to a rock mulch to enhance slope protection and provide soil medium for seed germination and plant growth. Topsoil can be mixed with organic material such as compost or manufactured soil amendments to improve the growing capability of seeded and planted vegetation.

Limitations

- Topsoil normally should not be used on slopes steeper than 2H:1V or on sandy or silty slopes steeper than 3H:1V. Topsoil should not be placed on frozen, extremely wet, or smooth slopes.
- Stockpiling topsoil will result in the disruption and loss of beneficial soil microorganisms, and if stockpiled over a length of time (+/-6 months), may result in total or partial loss of soil microorganisms.
 - If topsoil is stockpiled prior to placement, the top 1 foot of the stockpile material should be mixed with the remainder of the stockpile to ensure that living organisms are distributed throughout the topsoil material at the time of final placement.
 - The use of microorganism inoculates may be necessary to reestablish microorganisms in topsoil material that has been stockpiled for more than 9 months.

Design Parameters

- Additional design information is provided in the ITD Roadside Revegetation Guidebook.
- To the extent practicable, aboveground vegetation, including litter, should be mixed or otherwise incorporated into the topsoil prior to excavation. Topsoil should be excavated from the existing roadway shoulder to a depth of 6 inches. For new alignments, topsoil should be excavated to the depth it exists and stockpiled.
- The topsoil shall be placed into stockpiles at locations designated on the plans. Stockpiles should be treated with temporary soil stabilization and erosion control measures as per SWPPP. Topsoil stockpile height should not exceed 10 feet.
- Topsoil should be used on all disturbed sites (2H:1V or flatter) that will be permanently seeded.
- After final slope grading and prior to placement, cut slopes should be cross-rippled horizontal to the slope to assist in anchoring the topsoil. The spacing of the ripping shanks should be 3 feet, and penetration should not exceed 12 inches in depth. Where embankments are constructed, offsetting lifts of material to create an uneven surface prior to topsoil placement should be considered. Smooth slopes are not acceptable.
- Following construction, stockpiled topsoil should be uniformly redistributed (placement) to a depth of 6 inches. Placed topsoil should be cat-tracked vertically to the slope to compact the topsoil and to create horizontal pockets (safe sites) to hold seed and water.
- Where quantities of topsoil are limited, it is recommended to cover the more critically disturbed areas to the proper depth, rather than cover all areas. If necessary, the more favorable sites may be left without topsoil.
- Approved compost and/or manufactured organic soil amendments can be added to the topsoil to increase the organic content of the soil and assist in rebuilding soil microorganism populations. Topsoil can be added to rock mulch for added slope protection, to reduce the potential of erosion and to enhance vegetative growth.
- Organic material such as wood bark or fiber, grass hay, or grain straw shall not be mixed in topsoil unless nitrogen fertilizer is included. (Organic material uses nitrogen to break down and decompose the fibers.)
- Compost derived from livestock or green urban waste (trees, leaves, lawn clippings) is far superior to non-composted manure or wood fiber.
- Topsoil can be placed on benched slopes to assist in vegetation establishment. The topsoil is especially valuable on rocky benches or benches with south- or west-facing exposure (aspect). Placement of too much topsoil on the benches may destroy the benching value.

Construction Guidelines

- The Design Parameters provide procedures for stripping, stockpiling, and placing topsoil.
- If topsoil is stockpiled prior to placement, the top 1 foot of the stockpile material should be mixed with the remainder of the stockpile to ensure that living organisms are distributed throughout the topsoil material at the time of final placement.

- A temporary soil stabilization and erosion control treatment shall be applied to the exposed topsoiled areas to protect the topsoil prior to permanent seeding.
- The topsoil surface shall be left in a roughened condition to reduce erosion and facilitate establishment of permanent vegetation. The roughening establishes safe sites for seed to germinate and grow.
- **Smooth slopes or surfaces are not acceptable.**

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Repair and reseed if necessary to control erosion and loss of topsoil. This periodic maintenance procedure applies to either temporary soil stabilization or permanent seeding application.

PC-34 VEGETATION/SEEDING

Refer to: ITD Standard Specifications, Sections 621, 711.05 to 711.12, and 711.16.
 For assistance, contact the Roadside Vegetation Manager at ITD Headquarters.



BMP Objectives	
<input type="checkbox"/>	Perimeter Control
<input checked="" type="checkbox"/>	Slope Protection
<input checked="" type="checkbox"/>	Borrow and Stockpiles
<input checked="" type="checkbox"/>	Drainage Areas
<input checked="" type="checkbox"/>	Sediment Trapping
<input checked="" type="checkbox"/>	Stream Protection
<input checked="" type="checkbox"/>	Temporary Stabilizing
<input checked="" type="checkbox"/>	Permanent Stabilizing

Definition and Purpose

Permanent seeding is the process of growing from seed a long-term or permanent vegetative cover (plants) on disturbed area or areas that need additional assistance for soil stabilization or erosion control. Vegetation/seeding uses prescribed and preferably native perennial grasses, forbs, legumes, and shrubs, including a nurse crop when appropriate (see the temporary BMP for Vegetation Seeding [EC-12]) to hold soils in place and prevent erosion.

Permanent seeding, with the objective of establishing diverse (variable root depth) vegetation, is the key component and the most cost-effective method for slope and surface erosion control. Vegetation provides added benefits in the form of competitive ground cover, aesthetics, wildlife habitat, and ease of roadside maintenance. A desirable, diverse, well-established permanent seeding will capture or filter (bio-filtration) stormwater runoff and sediment, preventing pollution of streams, rivers, and lakes.

The permanent vegetation advantages are:

- Excellent soil stabilization
- Soil erosion and sedimentation prevention
- Containment and filtration of stormwater runoff
- Valuable ground cover and wildlife habitat
- Competition with undesirable vegetation and noxious weeds
- Aesthetic qualities

- Maintenance cost reduction

Appropriate Applications

- Permanent vegetation should be considered and planned for all disturbed areas and where construction or maintenance soil-disturbing activities have been completed or finalized.
- Typical permanent vegetative cover sites are all areas disturbed by new construction, reconstruction, maintenance, landscape, materials source site(s), slope failures, and areas in need of revegetation.
- Good seed-to-soil contact with adequate seed coverage is critical. A light incorporation of the seed using a harrow or drill seeding is preferable to establish safe sites for seed germination and growth.
- Permanent seed should only be applied (dormant seeding) during the season of seeding, usually between October 1 and April 31.
- Reusing topsoil whenever practical is recommended and greatly assists the establishment of permanent vegetation.

Limitations

Permanent vegetation (except turf) is not an immediate or short-term solution for compliance with NPDES requirements. Permanent vegetative ground cover takes several years before sufficient establishment is achieved. Establishment occurs quicker in high-precipitation areas, usually over 20 inches, as opposed to the arid or semi-arid regions.

Permanent seeding should be conducted in conjunction with soil amendments, soil biological stimulants, and fertilizers, with various erosion control measures such as mulching, matting, or erosion blanket, and with an annual nurse crop such as annual rye, spring barley, wheat, oats, or sterile hybrid grains.

Other factors contribute to the success or failure of permanent seeding, such as the following:

- Proper species selection is critical to fit the site conditions and precipitation zone.
- The rate of seeding for each species, either in pounds per acre or number of seeds per square foot, to ensure that the area is not over- or under-seeded.
- The correct mean annual precipitation (MAP) zones to ensure that the plant species selected fit within the prescribed precipitation region.
- The proper season of seeding (proper time of year) to allow germination and growth.
- Fertilization, soil amendments, or soil biological stimulants as prescribed may contribute to the success of the seeding.
- Establishment water may reduce the risk of seeding failure in low precipitation areas (arid/semi-arid) and enhance establishment.
- Proper planting methods (seed must be in contact with the soil and partially covered) for optimum germination and establishment (drill-seeding, where practical, is preferable).

Design Parameters

- All permanent vegetation, soil amendments, or fertilizer shall be applied in accordance with the ITD Design Manual Final Design Section and the Standard Specifications.
- The materials (grass species, etc.), site preparation, slope, rate and season of seeding, installation methods, and other vegetation procedures are all important factors that require advance planning.
- Topsoil stripping, stockpiling, and placement shall be included whenever possible.
- Additional information can be obtained from TN Plant Materials No. 24, Improved Grass, Forb, Legume, and Wood Seed Species for The Intermountain West (USDA–Natural Resources Conservation Service) or the ITD Roadside Revegetation Guidebook.
- The ITD Roadside Vegetation Manager in the ITD Headquarters can provide assistance in developing project-specific special provisions.

Construction Guidelines

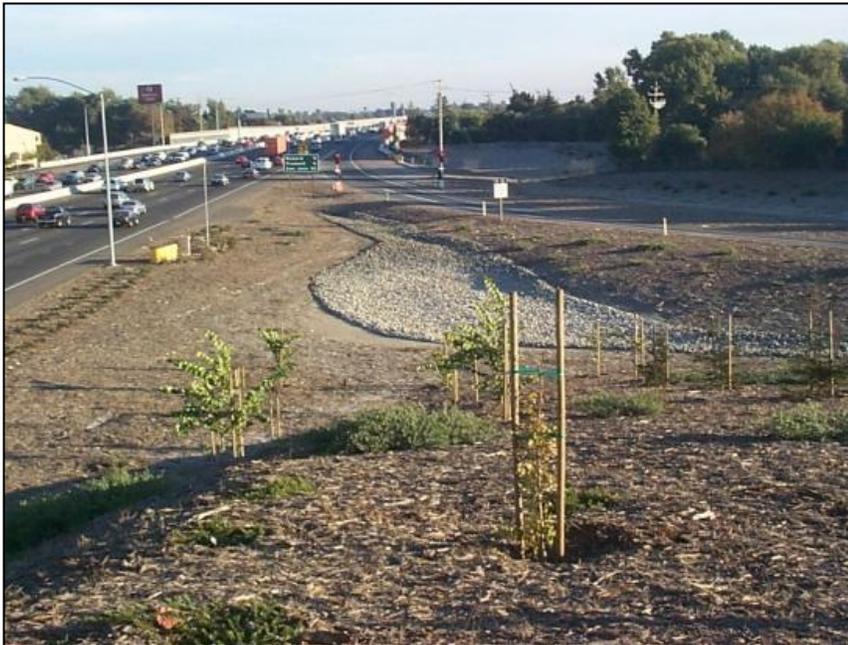
- Apply permanent vegetation as the last phase of reclaiming any disturbed soils. Check the requirements of your contract, the NPDES stormwater permit, or SWPPP for establishing permanent vegetation.
- Check that all other erosion control measures, such as dikes, basins, and surface control measures, have been installed before planting seed.
- Perform seedbed preparation, if required, in accordance with the Standard Specifications. The season of seeding will also be in accordance with the Standard Specifications. Most seed, unless otherwise specified, will be furnished by ITD.
- Select and apply fertilizer or soil amendment in accordance with the Design Manual Final Design chapter.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Indicate which areas need to be reseeded or where other remedial actions are necessary to ensure establishment of permanent vegetation.
- Monitor the seeded area annually following successful establishment of permanent vegetation.

PC-35 VEGETATION/PLANTING

Refer to: ITD Standard Specifications, Sections 620 and 711.06.
 For assistance, contact the Roadside Vegetation Manager in ITD Headquarters.



BMP Objectives	
<input checked="" type="checkbox"/>	Perimeter Control
<input checked="" type="checkbox"/>	Slope Protection
<input type="checkbox"/>	Borrow and Stockpiles
<input checked="" type="checkbox"/>	Drainage Areas
<input type="checkbox"/>	Sediment Trapping
<input checked="" type="checkbox"/>	Stream Protection
<input checked="" type="checkbox"/>	Temporary Stabilizing
<input checked="" type="checkbox"/>	Permanent Stabilizing

Definition and Purpose

- Permanent vegetation/planting is the process of using live plants, plant parts (stem cuttings), roots, or cut sod for long-term or permanent vegetative cover (shrubs, trees, grass, or forbs) on disturbed areas or areas that need additional assistance for soil/slope stabilization and erosion control. The plants can be potted in containers, tublings, bare rootstock, cuttings, rhizomes, stolons, shoots, sprouts, or rolled or cut sod.
- Plantings can serve various soil stabilization and erosion control functions, and in a planted area will usually grow rapidly and large enough to provide quicker benefits than plant species grown from seed.
- The use of live plants (trees, shrubs, grass, or forbs) provides greater aesthetic and biological diversity by quickly establishing deeper root depth and aboveground growth.
- Stem cuttings from woody plants, such as willows, cottonwoods, or similar plants placed in holes in the ground aid in providing slope, water barb, or stream bank stabilization.
- Bundles of stem cuttings (wattles) from growing willows, alders, or similar plants, placed and secured in horizontal trenches, aid in providing slope and stream bank stabilization.
- Plant roots, stolons, rhizomes, sprouts, or shoots (sprigging), mechanically or manually incorporated into the top layer of soil, provide quicker plant growth, especially in wet/moist areas.
- The placement of continuous sod (turf) cuts or patch pieces (plugs) is a form of permanent planting that provides, where needed, immediate ground cover with established vegetation.

Appropriate Applications

Planting live trees and shrubs is a preferable method for roadside revegetation and, in combination with permanent seeding, can provide very effective soil/slope stabilization and erosion control.

Vegetation/planting applications may include:

- Finished and permanently seeded slopes that remain undisturbed for a long period.
- Areas adjacent to forests, wetlands, or other naturally occurring woody and non-woody vegetation.
- Slopes where a large quantity of rocks are present.
- Slopes subject to shallow-seated (slide) failure.
- Abandoned or closed roads or source sites.
- All types of landscaping projects.
- Stream bank restoration, wetlands, wildlife habitat, or riparian areas.
- Buffer strips, grassy swales, or berms.
- Areas where moisture in the soil is removed through transpiration by plant growth.
- Using cuttings to construct bundles (wattles), installed horizontally in the soil in riparian, moist, or wetland areas.
- Using the root systems of some species of plants to incorporate or sprig into the soil.
- Using sod or turf to provide a more rapid form of erosion control.
- In combination with other erosion control measures, such as riprap, gabions, rock mulch, and temporary or permanent seeding.
- Vegetative buffer strips which reduce surface water runoff, provide biofiltration, reduce noise pollution, or act as a screen for viewing purposes.

Limitations

Vegetation/planting limitations include:

- Live native plant species may be required, although they may be hard to establish.
- Limited availability of some species.
- Higher purchase and installation costs.
- Water application may be necessary to assure plant survival.
- Season of planting may be more restrictive to assure survival.
- Cannot be substituted for retaining walls or similar structures to stabilize over-steepened, raveling, or unstable slopes.
- Sight distance may be restricted by plantings.
- Overgrowth of plants into safe or recovery zone.

- Plants restrict snow removal and storage.
- Plants shade an area of the roadway, causing slick and unsafe conditions in the winter.
- Plants may perform as a living snow fence and cause drifting of either snow or dust onto the roadway, creating unsafe driving conditions.
- Plants may shield or harbor wildlife, creating unsafe conditions for both the public and the wildlife.
- Sod or turf requires irrigation (landscape) availability.

Design Parameters

- Planted shrubs and trees are appropriate tools in reestablishing vegetation in sensitive areas or areas that require a quicker stand of vegetation than the normal procedures of either seeding or allowing adjacent vegetation to volunteer onto disturbed sites.
- Wetlands and other various projects must consider plant species that are healthy, preferably native, and adapted to the disturbed site and climate. The planting process requires proper site preparation, fertility and soil amendments. The plant material shall conform to the Standard Specifications concerning care, condition, identification (species), and inspection.
- Provisions for continued maintenance and care of plants after planting should be considered, along with watering during the required establishment period.
- Plants should be specified as to container size, balled and burlaped, bare root, cuttings (length or size), and, in the case of containers, tublings, etc., caliper, or height.
- Additional requirements, such as the use of amended topsoil, fertilizer, and inoculation of beneficial soil microorganisms, should be considered.
- More detailed specifications of nursery-grown plant material are provided in the current edition of the American Standard for Nursery Stock (ANSI Z 60.1).
- Additional information can be obtained from TN Plant Materials No. 32, A User's Guide to Description, Propagation and Establishment of Native Shrubs and Trees for Riparian Areas in the Intermountain West (USDA–Natural Resource Conservation Service) and the Practical Streambank Bioengineering Guide, A User's Guide for Natural Streambank Stabilization Techniques in the Arid and Semi-arid Great Basin and Intermountain West (USDA–Natural Resources Conservation Service), and the ITD Roadside Revegetation Guidebook.
- Technical assistance regarding plant species selection, planting, and spacing requirements can be obtained by contacting the ITD District Environmental Planner or the Roadside Vegetation Manager in ITD Headquarters.

Construction Guidelines

- Make sure that planting sites are adequately graded, soil conditions are acceptable, and tree locations and planting areas for shrubs, vines, and ground covers are marked and approved before planting begins. Check the requirements of the contract.

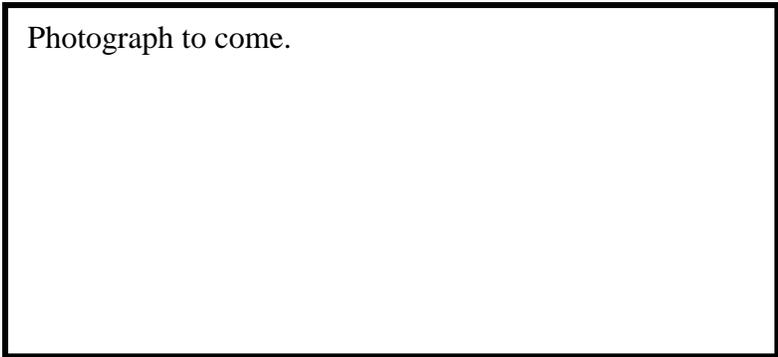
- Examine plant materials before use to ensure that species, species health, container sizes, and roots are acceptable.
- Store bundled bare root planting stock and cuttings, whether tree or shrub species, in a cool, moist place from time of receipt until time of planting. This time should not exceed 10 days unless refrigerated.
- Store planting stock (not bare root) in shade, out-of-doors, and lightly sprinkle with water to maintain a moist soil from the time of receipt to the time of planting. The storage time should not exceed 30 days.
- Construction Planting Procedures:
 - Voluntary or unskilled labor may be used in planting. However, a supervisor skilled in proper planting techniques should direct the labor.
 - Plants should be carefully removed from the containers, if any, and placed in the planting holes so that the crown of the plant is at the surface of the soil. No air space should be allowed around the roots, nor should the roots be folded under. Plants in individual containers made of decomposable material can be planted without removing them from the container.
 - Fertilizer or soil amendments should be applied at the rate specified.
 - Soil should be wetted to field capacity at the time of planting and each time the soil moisture level drops below the permanent wilting point.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Irrigation of the plantings during the first 2 years following planting is recommended to increase the survival rate. Water as often as necessary during periods of intense heat or lack of rain.
- Remove and replace dead plants to restore the prescribed number of living plants per acre.
- Check for and correct areas where protective measures may have to be made.

PC-36 WATER QUALITY INLET OIL/GRIT SEPARATOR

Reference: Georgia Stormwater Management Manual.



BMP Objectives	
<input type="checkbox"/>	Perimeter Control
<input type="checkbox"/>	Slope Protection
<input type="checkbox"/>	Borrow and Stockpiles
<input type="checkbox"/>	Drainage Areas
<input checked="" type="checkbox"/>	Sediment Trapping
<input checked="" type="checkbox"/>	Stream Protection
<input type="checkbox"/>	Temporary Stabilizing
<input type="checkbox"/>	Permanent Stabilizing

Definition and Purpose

A water quality inlet oil/grit separator 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. This BMP generally consists of a three-chamber system designed to remove heavy particulates and absorb hydrocarbons from stormwater runoff.

Appropriate Applications

- This BMP is generally used at sites expected to receive heavy vehicular traffic. It is 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 BMPs.
- The BMP consists of a multi-stage underground retention system: upstream chamber traps sediments, center chamber traps oils and other heavy substances, downstream chamber discharges flows.
- Although flows are only detained for a short time, the 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 basin.
- Inlets can be installed in most areas, and the drainage area to inlet is generally less than 1 acre.

Limitations

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

Design Parameters

- 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.

- The area above the 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.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- The structure should be cleaned at least twice per year to remove sediment, oil, grease, and other pollutants.

PC-37 STREET SWEEPING



BMP Objectives

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

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 percent.

Appropriate Applications

- 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.
- Should be considered 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.
- Types of sweepers and practices include: vacuum-assisted sweepers, mechanical sweepers, regenerative air sweepers, vacuum-assisted dry sweepers, and tandem sweeping.

Limitations

- Not a good application in removing oil and grease.
- Older mechanical sweepers are limited in their ability to remove fine sediment.

Design Parameters

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

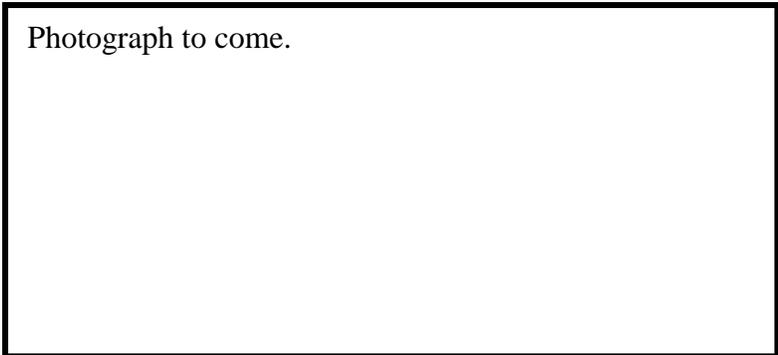
- Generally, 50 percent of particulates can be removed if sweeping is done at least once between storms with two passes per run. Depending on local traffic conditions and storm frequencies, sweeping may need to be done at more frequent intervals to achieve desired particulate removal.
- Arrangements shall be made for the disposal of collected wastes.
- Street sweeping is more effective if upstream erosion control and stormwater BMPs are implemented, especially at construction sites.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Maintenance requirements are greater for certain types of sweepers.

PC-38 DEEP SUMP CATCH BASIN

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



BMP Objectives	
<input type="checkbox"/>	Perimeter Control
<input type="checkbox"/>	Slope Protection
<input type="checkbox"/>	Borrow and Stockpiles
<input checked="" type="checkbox"/>	Drainage Areas
<input checked="" type="checkbox"/>	Sediment Trapping
<input type="checkbox"/>	Stream Protection
<input type="checkbox"/>	Temporary Stabilizing
<input type="checkbox"/>	Permanent Stabilizing

Definition and Purpose

A deep sump catch basin 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.

Appropriate Applications

- Can be used to provide pre-treatment for other BMPs.
- Can be retrofitted to provide water quality treatment for small urban lots where larger BMPs cannot be used due to site constraints.
- Located underground so lot size is not a factor.
- Can be used as part of a storm drain system with a circular manhole or rectangular box.
- Can be easily accessed for maintenance.
- 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.

Limitations

Has limited pollutant removal capabilities and is expensive to maintain.

Design Parameters

- Structure discharge point is located at least 4 feet below the inflow point.
- 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.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Regular maintenance is required to ensure effectiveness of structure.

PC-39 ON-LINE STORAGE IN STORM DRAIN NETWORK (VAULTS)

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

Photograph to come.

BMP Objectives

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

On-line storage in storm drain network (vaults) 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 than a grit chamber and removes debris, trash, and sediment from storm flows.

Appropriate Applications

- 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 BMPs.
- Stormwater flows into and out of the vault through a storm sewer pipe.
- The primary pollutant removal mechanism is sedimentation.
- Sediment removal schedule is less frequent than other water quality BMPs.
- Vaults should be constructed in the early phases of a development project.

Limitations

- Vaults are considerably more expensive than other BMPs.
- Because the structure is underground, biological activity cannot be used for treatment in these structures.

Design Parameters

- 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.
- 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.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Maintenance requires special equipment although easily accessed for maintenance.

PC-40 POROUS PAVEMENTS

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



BMP Objectives

- Perimeter Control
- Slope Protection
- Borrow and Stockpiles
- Drainage Areas
- Sediment Trapping
- Stream Protection
- Temporary Stabilizing
- Permanent Stabilizing

Definition and Purpose

Porous pavement 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.

Appropriate Applications

- 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.

Limitations

- 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.

Standards and Specifications

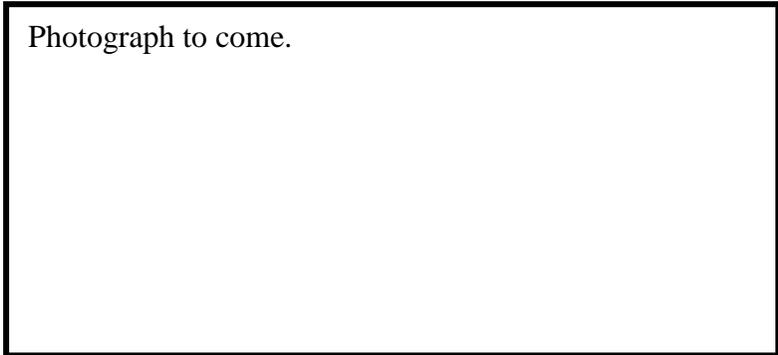
- Initial pollutant removal rates are high but decrease as the porous materials become clogged.
- Pavement thickness should be sufficient to protect the subgrade.
- Quality base and subbase materials should be used to support the applied loads.
- Underdrain system can be used if sub-soils cannot adequately infiltrate the expected flows.
- Adjacent unpaved areas should be stabilized to prevent sediment from washing into the porous pavement area.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Careful attention to maintenance is necessary to reduce clogging. Maintenance should include vacuum sweeping and jet hosing.

PC-41 PROPRIETARY/ MANUFACTURED SYSTEMS

Reference: Vortech Inc.; Stormceptor, (Carder Concrete Products)



BMP Objectives	
<input type="checkbox"/>	Perimeter Control
<input type="checkbox"/>	Slope Protection
<input type="checkbox"/>	Borrow and Stockpiles
<input checked="" type="checkbox"/>	Drainage Areas
<input checked="" type="checkbox"/>	Sediment Trapping
<input type="checkbox"/>	Stream Protection
<input type="checkbox"/>	Temporary Stabilizing
<input type="checkbox"/>	Permanent Stabilizing

Definition and Purpose

A proprietary/manufactured system 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.

Appropriate Applications

- This BMP is 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.
- 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 the perimeter of the 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.

Limitations

- Structures can only treat a portion of the flow that enters the storm drain system.
- Drainage areas generally limited to a few acres or less.
- Maintenance requirements can be a significant limitation.

Design Parameters

- Vendors often provide services to build, install, and maintain systems.
- Access manholes are placed where they can be easily accessed by vacuum trucks.
- Adjacent unpaved areas should be stabilized to prevent sediment from washing into the treatment system.

Maintenance and Inspection

- Conduct inspections as required by the NPDES permit or contract specifications during construction.
- Periodic inspection and maintenance will be required based on post-construction site conditions.
- Make any repairs necessary to ensure the measure is operating properly.
- Generally, systems require cleaning annually at a minimum.
- 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.