Permanent Stormwater Quality Best Management Practice

INSPECTION AND MAINTENANCE FIELD GUIDE

COLORADO STORMWATER CENTER

COLORADO STATE UNIVERSITY

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Stormwater Problems and Best Management Practices

Water that runs off the urban land surface during rain storms ("stormwater runoff") is typically collected in storm drains and eventually ends up in nearby lakes, rivers and streams ("receiving waters"). Left uncontrolled, stormwater runoff can cause flooding, stream erosion and pollution problems in receiving waters. Over the past 20-30 years, cities have started to require that permanent stormwater quality best management practices ("BMPs") be installed in urban areas to reduce the impacts of stormwater runoff by removing pollutants and the amount of stormwater runoff that enters receiving waters.

About This Field Guide

BMPs require frequent inspection and maintenance (“I&M”) in order to continue operating properly. If BMPs are not properly inspected and maintained, the pollutant removal and stormwater runoff reduction benefits they are designed to provide may be diminished. BMP owners, which may include cities, towns, schools, homeowner’s associations, businesses, etc. are required by state and national law to ensure that BMPs remain operating properly by providing regular inspection and maintenance.

There are many different types of BMPs used in Colorado (and throughout the US) and each type uses different mechanisms to remove pollutants and reduce runoff. This field guide presents typical inspection and maintenance activities that are required for the most common types of BMPs used in Colorado.

This field guide is intended for persons who may inspect and/or maintain BMPs; including stormwater inspectors, landscape and construction contractors, stormwater maintenance personnel, engineers, and private BMP owners.

QR Codes

Throughout this field guide, we have included QR codes that link directly to online resources that may be useful to users. Scan the QR codes using a barcode scanner app on your smartphone to access those resources.

Example QR Code that links to Colorado Stormwater Center website

Acknowledgements

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Disclaimer

This field guide is intended for educational and informational purposes only. Although every attempt has been made to provide complete and accurate information regarding proper BMP inspection and maintenance in a concise format, the developers and sponsors of this field guide make no implicit or explicit guarantees that following this guide will ensure regulatory compliance and/or prevent any other problems associated with the operation of BMPs.

Extended Detention Basins

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YouTube Video
Scan the QR Code to view a short video on Extended Detention Basin maintenance

EXTENDED DETENTION BASINS

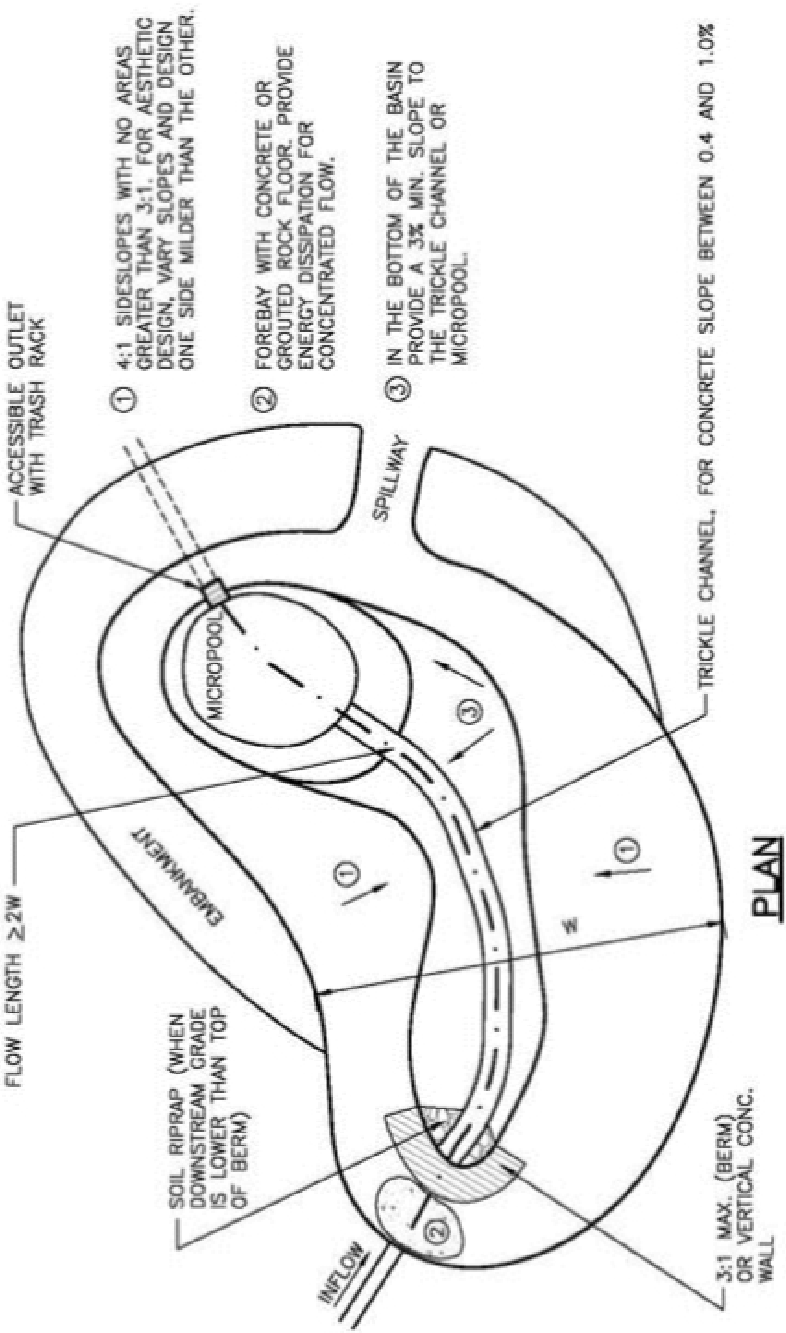
Introduction

Extended Detention Basins (EDBs) capture and temporarily store stormwater runoff long enough for most pollutants to settle out on the bottom of the basin. EDBs should be dry most of the time (with the exception of the micropool), but will hold water throughout the basin for up to 72 hours after a rain event.

EDBs have many different components that each serve a special function and have different inspection and maintenance needs. EDB components include:

- Inflow point (inlets)
- Forebays
- Trickle Channels
- Micropools
- Outlet Structure
- Embankments

Typical extended detention basin during a storm. The EDB is designed to drain within 48-72 hours



ACCESSIBLE OUTLET WITH TRASH RACK
① 4:1 SIDESLOPES WITH NO AREAS GREATER THAN 3:1. FOR AESTHETIC DESIGN, VARY SLOPES AND DESIGN ONE SIDE MILDER THAN THE OTHER.
② FOREBAY WITH CONCRETE OR GROUTED ROCK FLOOR. PROVIDE ENERGY DISSIPATION FOR CONCENTRATED FLOW.
③ IN THE BOTTOM OF THE BASIN PROVIDE A 3% MIN. SLOPE TO THE TRICKLE CHANNEL OR MICROPOOL.
SPILLWAY
MICROPOOL
TRICKLE CHANNEL, FOR CONCRETE SLOPE BETWEEN 0.4 AND 1.0%
FLOW LENGTH ≥2W
EMBANKMENT
W
SOIL RIPRAP (WHEN DOWNSTREAM GRADE IS LOWER THAN TOP OF BERM)
3:1 MAX. (BERM) OR VERTICAL CONC. WALL
INFLOW
PLAN
NTS

INFLOW POINT (INLET)

The inflow point is where runoff enters the EDB through a storm sewer pipe, surface drainage channel or ditch.

Sediment/Trash/Debris Removal

- Remove any sediment, trash or other debris that has accumulated near the inlet.
- Dispose of sediment, trash and debris in landfill.

Clean inlet after proper maintenance

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Inlet with sediment, trash and other debris that needs to be removed.

✘

Vegetation Removal

Excess vegetation near the inlet can limit flow into the EDB and cause damage to the inlet structure.

- Remove excess vegetation (especially large, woody vegetation) from the area around the inlet.
- Do not wait for vegetation to get too large. It is much easier and less expensive to remove vegetation when it is small.

Large, woody vegetation near the outlet will eventually damage the concrete inlet pipe.

INFLOW POINT (INLET)

Erosion/Structure Damage

Identifying early signs of erosion and fixing the problem can prevent more expensive repairs later.

- Look for erosion and structure damage near the inlet.
- Minor erosion/structure repair may be performed by a qualified contractor. These repairs may include adding riprap to provide energy dissipation and minor concrete patching.
- Major erosion/structure repair may require consultation with an engineer and/or the local stormwater authority.

Example of major structure damage to inlet. The inlet pipe has separated from the wing wall

✗

Concrete chase-type inlet with major damage due to erosion.

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FOREBAY

The forebay is located below the inflow point and is designed to remove large particles, trash and other debris. It is typically made of concrete and has a flat bottom for easier maintenance. Frequent (2-4 times per year) forebay maintenance is much less expensive than removing sediment from other parts of the EDB.

Sediment/Trash/Debris Removal

- Remove any sediment, trash or other debris that has accumulated in the forebay.
- For large forebays, heavy machinery (skid-steer, long-reach excavator, front-end loader) may be used.
- Dispose of sediment, trash and debris in landfill.
- Wet sediment may need to dry several days before the landfill will accept it.

Clean forebay in working condition after recent maintenance. A small amount of sediment is noticeable from a recent storm, but there is no trash or other debris present.

✔

Forebay with excess sediment that needs to be removed. Vegetation growing in the forebay is a typical sign that maintenance is needed.

Roll off bin used to dry sediment prior to taking to the landfill.

Drain Pipe/Weir Clogging
Runoff exits the forebay through a drain pipe or weir.

- Make sure the forebay drain pipe or weir is not clogged so that runoff will flow through the forebay properly.

TRICKLE CHANNEL

The trickle channel conveys small flows from the forebay (or inlet) to the micropool (or outlet structure). Trickle channels are typically concrete, but may also be constructed of rock.

Sediment/Trash/Debris Removal

Sediment and debris that is left to accumulate in the trickle channel will eventually block the flow of water. Water that is diverted out of the trickle channel will cause damage to nearby vegetation and erosion within the EDB.

- Remove any sediment, trash or other debris that has accumulated in the trickle channel.
- Dispose of sediment, trash and debris in landfill.

Trickle channel that needs maintenance. Standing water in the trickle channel is a sign that sediment and other debris are blocking the flow of water.

Clean trickle channel with no sediment, debris or woody vegetation nearby.

Woody Vegetation Removal

Left unmanaged, woody vegetation can damage the trickle channel. It is easier and cheaper to remove when it is small.

- Remove woody vegetation growing near the trickle channel.

Example of woody vegetation growing near trickle channel. This vegetation should be removed to prevent future damage.

Erosion/Structure Damage

- Look for erosion and structure damage near the trickle channel.
- Major erosion/structure repair may require consultation with an engineer and/or the local stormwater authority.

Structure damage to trickle channel resulting from overgrown woody vegetation.

MICROPOOL

The micropool is a small area of standing water (about 2-3 feet deep) just in front of the outlet structure. It is designed to prevent the outlet structure from clogging by maintaining a constant pool of water and is the only area in an EDB where standing water is not a problem. Note that not all EDBs have micropools.

Micropools examples

Sediment Removal

- Measure depth of sediment in the micropool.
- Remove sediment once 12 inches of sediment has accumulated.
- Sediment removal may require a vacuum truck that is capable of removing both sediment and water.
- Dispose of sediment in a landfill.
- Wet sediment may need to dry several days before the landfill will accept it.

Using vacuum truck to remove sediment from the micropool

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Mosquito/Algae Treatment

- Micropools are designed with deep water depths (2-3 feet) to limit mosquito breeding. If large amounts of mosquitos are present during inspection, appropriate amounts of “insecticide” may be applied by certified mosquito control applicators.
- Algae consume stormwater pollutants and are beneficial to stormwater quality treatment. Excess algae in the micropool may be removed mechanically (and disposed of in a landfill) if it is clogging the track rack. Use of “algaecides” to control algae is not encouraged.

Oil/Chemical Sheens

- The presence of oil/chemical sheens in the micropool indicate a possible illicit discharge upstream on the EDB.
- If an oil/chemical sheen is present, report this to the local stormwater authority to assist with proper removal/disposal.

OUTLET STRUCTURE

The outlet structure controls the rate that stored runoff is discharged from the EDB. It includes several different components (well screen, orifice plate, trash rack) that each require frequent maintenance. Inadequate maintenance of these components can cause severe problems with EDB performance; including standing water, inadequate pollutant removal and downstream flooding.

Well Screen /Trash Rack Clogging

- The well screen and trash rack will clog with grass and other debris very frequently.
- Gently scrape the debris off the well screen/trash rack using a rake and dispose of the material in a landfill. Do not leave the material on site.
- If the well screen/trash rack is not cleaned frequently, the EDB will have standing water problems.

Well screen that is clogged with debris. Maintenance is required to prevent standing water.

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Cleaning the well screen gently using a garden rake.

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Well Screen and/or Orifice Plate Missing/Removed

When the well screen and/or orifice plate becomes clogged creating standing water issues, owners/citizens may remove those components to allow water to flow through the EDB. This is NOT an acceptable solution as it prevents pollutants from being removed within the EDB.

- If the well screen and/or orifice plate is removed, it should be re-installed.
- If the well screen and/or orifice plate are missing, contact the local stormwater authority who may provide information for the installation of a new one.

Picture of outlet structure with orifice plate removed. Orifice plate must be re-installed.

Sediment/Trash/Debris Removal

- Remove any sediment, trash or other debris that has accumulated within or in front of the outlet structure.
- Dispose of sediment, trash and debris in a landfill.
- Wet sediment may need to dry several days before the landfill will accept it.
- Frequent (2-4 times per year) removal of these materials will limit clogging of the outlet structure.
- Note: pictures below show EDBs without micropools.

Sediment, debris and vegetation built up in front of outlet structure.

Picture of a well-maintained outlet structure.

Wet Ponds and Constructed Wetlands

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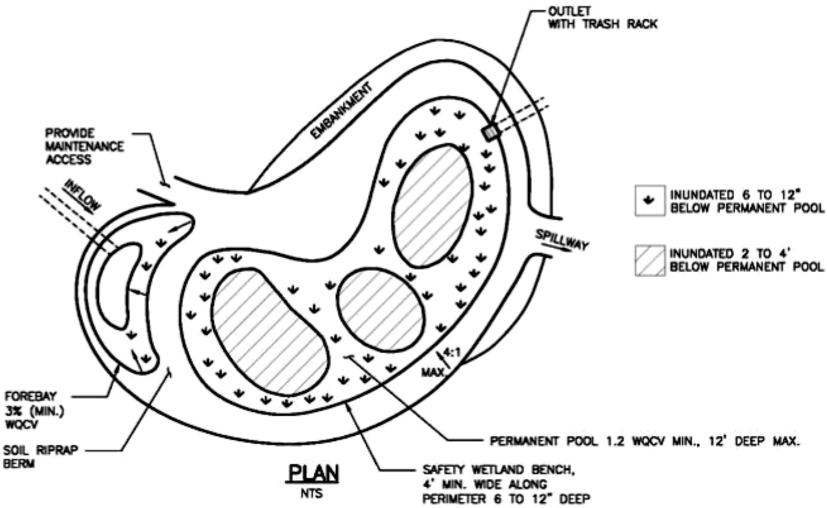
WET PONDS AND CONSTRUCTED WETLANDS

Introduction

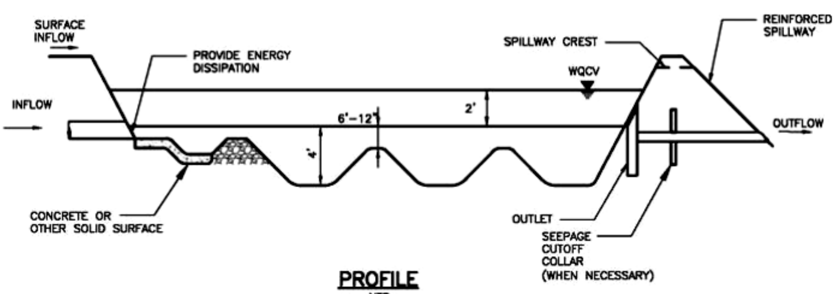
Wet ponds and constructed wetlands are BMPs designed to retain runoff for long periods of time (typically several weeks or more) so that natural processes have additional time to remove pollutants. Both types of BMPs have a "permanent pool" of water that can range in depth from 1-6 feet or more. Components of these BMPs include:

- Inflow point (inlets)
- Forebays
- Permanent Pool
- Outlet Structure
- Embankments

Typical wet pond with permanent pool.

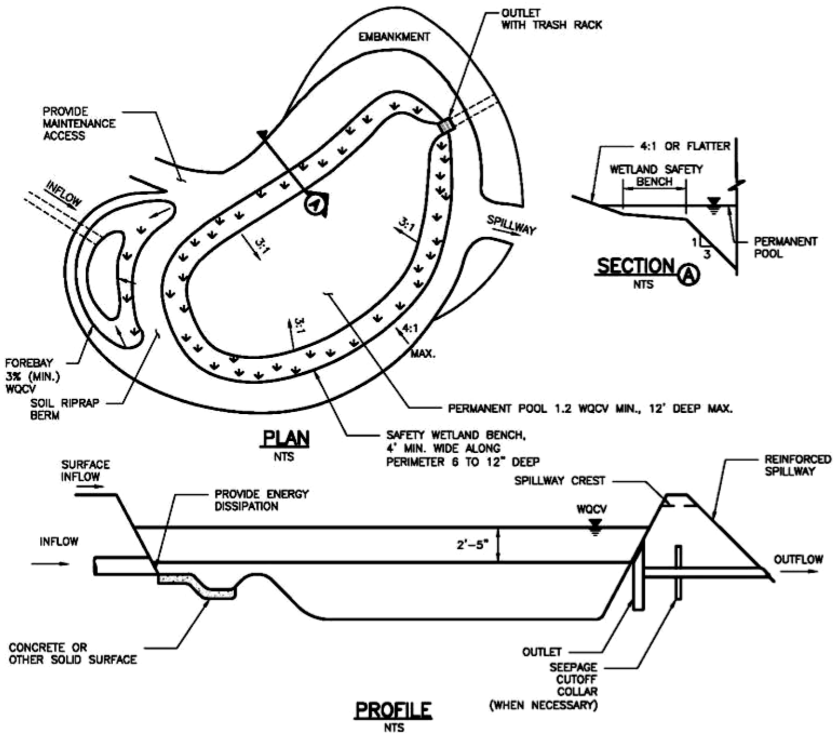


Plan view diagram of typical constructed wetland basin showing locations of components. Note that vegetation is dispersed throughout the entire basin.



Profile view diagram of typical constructed wetland basin. Note that the permanent pool depth is variable throughout the basin to promote vegetation growth.

Wet Ponds and Constructed Wetlands



Plan and profile view diagrams of typical wet pond showing locations of components.

Vegetation lines the perimeter of the pond to serve as a safety barrier to open water in the middle.

Wet pond permanent pools have a constant depth throughout

INLET, FOREBAY, OUTLET STRUCTURE

Maintenance of inlets, forebays and outlet structures for wet ponds and constructed wetlands are similar to extended detention basins. Follow maintenance procedures for those components as provided in the Extended Detention Basin section of this field guide. For wetland specific components please see below.

PERMANENT POOL

Trash and Debris Removal

Frequently remove any trash or other debris that has accumulated in the permanent pool to prevent the outlet structure from clogging Dispose of trash and debris in a landfill.

Remove trash and debris from permanent pool to prevent outlet structure clogging

Mosquito Control
If large amounts of mosquitos are present during inspection, appropriate amounts of "insecticide" may be applied by certified mosquito control applicators.

Algae Control
- Algae consume stormwater pollutants and are beneficial to stormwater quality treatment. If necessary, excess algae should be removed mechanically and disposed of in a landfill.
- Use of "algaecides" to control algae is not encouraged because it adds to stormwater pollution.

Algae in wet ponds are OK as they remove pollutants from stormwater

Oil/Chemical Sheens
- The presence of oil/chemical sheens in the permanent pool indicate a possible illicit discharge upstream of the BMP.
- If an oil/chemical sheen is present, report this to the local stormwater authority to assist with proper removal/disposal.

Wetland Vegetation Removal

Wetland vegetation may need to be removed/thinned every few years to preserve the storage volume of the BMP and remove pollutants that have been absorbed by plants.

- Excess vegetation can be cut below the water level or removed mechanically
- Vegetation removal is often easier during the dry season (November-February)
- Check with the local office of the Army Corps of Engineers to determine if a 404 permit is needed for wetland maintenance at each facility.

Major Sediment Removal

Wet ponds and constructed wetlands are very effective at removing sediment from stormwater. Sediment will accumulate on the bottom and must be removed every 10-20 years.

- Major sediment removal requires heavy machinery
- Ponds and wetlands may need to be drained first. Check for drain valve near the outlet structure.
- Sediment must be dewatered prior to disposal in a landfill.
- Major sediment removal is often easier during the dry season (November-February).
- An engineer should verify final grading elevations after major sediment removal.

Bioretention and Sand Filters

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BIORETENTION AND SAND FILTER BASINS

Introduction

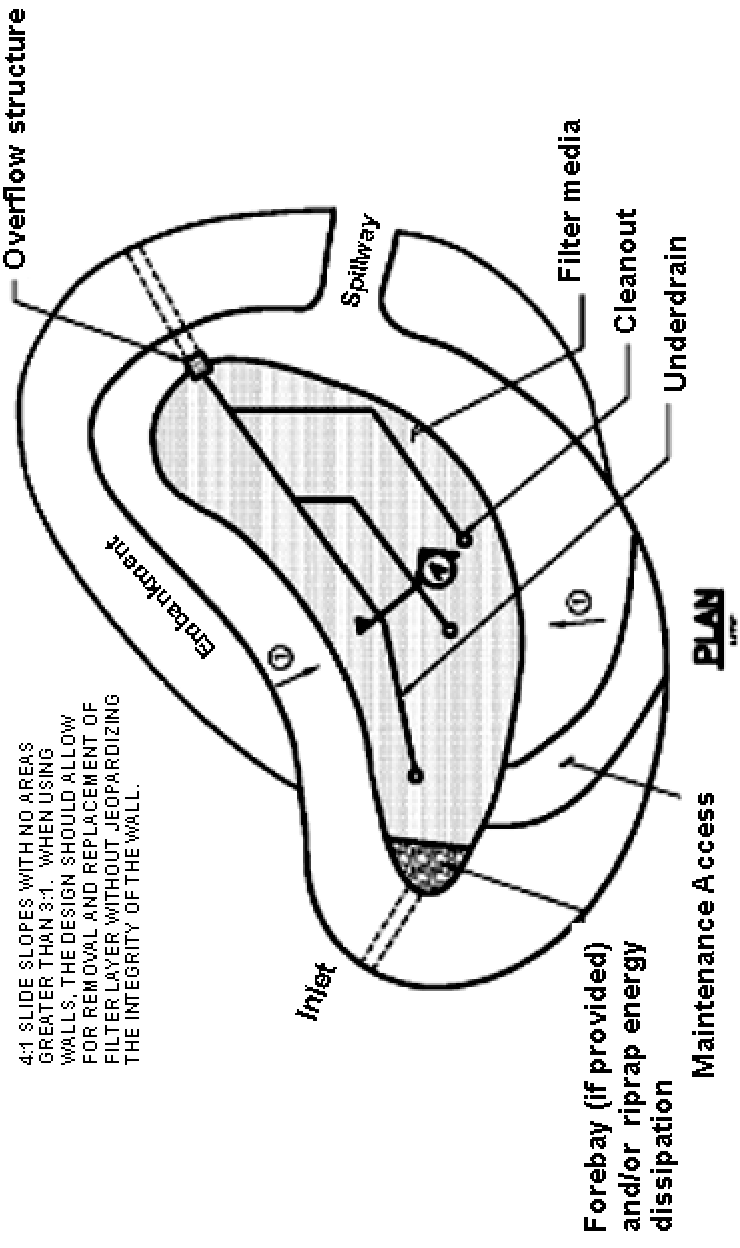
Bioretention and sand filter basins are BMPs that remove pollutants by filtering runoff through specialized filter media. During rainfall events, runoff is temporarily ponded on top of the BMP as it slowly infiltrates downward through the filter media.

Components of bioretention and sand filter BMPs include:

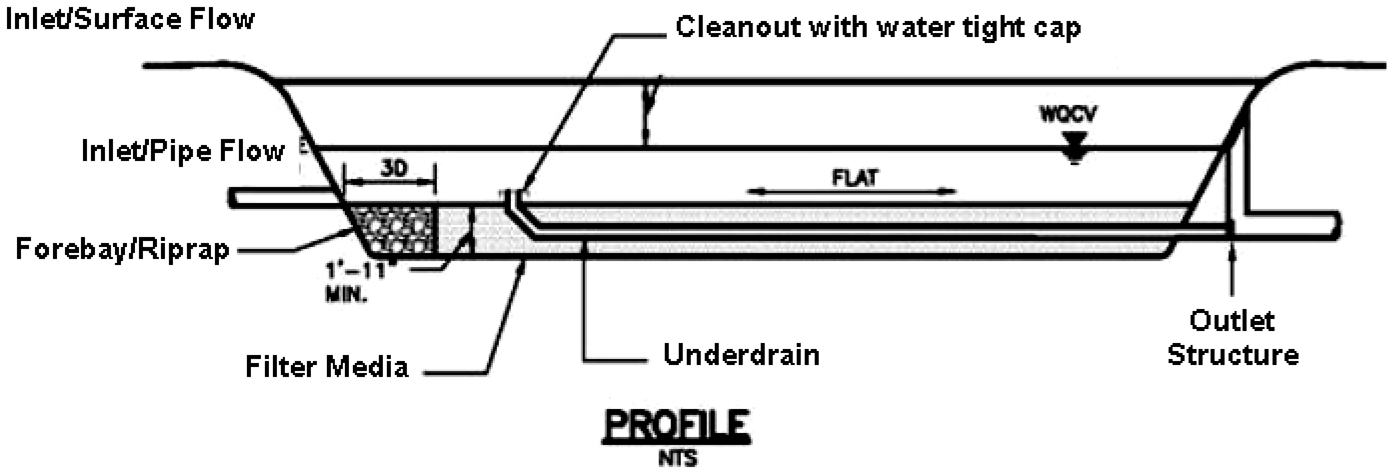
- Inflow point (inlets)
- Forebay/Energy Dissipater
- Filter Media
- Underdrain
- Outlet Structure
- Embankments/Containment Walls

Typical bioretention with ponded runoff during rain event

Typical sand filter



Plan view diagram of typical bioretention/sand filter



Profile view diagram of typical bioretention/sand filter

Note: Some biorention/sand filters will not have an underdrain system if local soils provide adequate infiltration. Always refer to original drawings to determine if underdrain system is present

INFLOW (INLETS)

Runoff can enter bioretention/sand filters through a pipe, roof downspout, surface channel, curb-cut or as “distributed” surface overflow.

Check Inlet Elevation

Runoff must be allowed to flow freely into the BMP, however the flow path can be obstructed by sediment, debris and landscape materials

- Check that inflow point is at least 3 inches above the top of the filter media.
- Remove sediment/debris from the inlet and dispose of it in a landfill.
- If landscape materials are higher than the inflow point, remove materials so that there is a 3 inch drop into the BMP.

“Curb-cut” inlet with debris blocking the flow path. Landscape material is higher than the inlet elevation, preventing flow from entering the BMP. The excess landscape material near the inlet should be removed to 3 inches below the inlet.

Bioretention and Sand Filters

INFLOW (INLETS)

Bioretention with curb-cut inlet. Landscape material (downstream of forebay) is placed too high and runoff cannot enter the BMP. Landscape material should be lowered about 3 inches below the inlet elevation.

Bioretention with curb-cut inlet showing 3 inches of "fall" into BMP.

FOREBAY/RIP-RAP ENERGY DISSIPATION

The forebay or riprap energy dissipater (if present) will be located directly downstream of the inflow point. The forebay is designed to remove large sediment and debris prior to runoff entering the filter media. Riprap serves as an energy dissipater to reduce erosion of the filter media near the inflow point.

Sediment/Trash/Debris Removal

- Remove any sediment, trash or other debris that has accumulated within the forebay or riprap.
- Dispose of sediment, trash and debris in landfill.
- Most forebays are small and can be maintained using a shovel.
- Sediment removal from rip-rap and larger forebays may require use of vacuum truck.

Sand filter with rip-rap energy dissipater. Sediment that has accumulated near the riprap should be removed periodically. If maintenance of riprap is difficult, the owner may consider installing a forebay for easier maintenance.

Bioretention and Sand Filters

FOREBAY/RIP-RAP ENERGY DISSIPATION

Bioretention forebay that needs sediment and debris removed

Bioretention forebay that has been properly cleaned

FILTER MEDIA

The filter media is generally 18-36 inches deep and removes pollutants as runoff flows downward through it. For sand filters, the filter media is a specified type of sand. For bioretention, the filter media is a specified mix of sand, silt/clay, shredded mulch, or other materials.

Infiltration Testing

Filter media removes sediment from runoff and that sediment will eventually clog the filter. An infiltration test should be conducted during each inspection to determine if the filter is too clogged. Several infiltration testing methods are described below.

Method 1:

- Visit the site within 24 hours of 0.5 inches (or more) of rainfall. If water is still ponded on top of the filter media, the filter media may be clogged.

Method 2:

- Obtain round, metal cylinder at least 12 inches long
- Insert (pound) cylinder 2-3 inches into filter media
- Fill cylinder with 10 inches of water
- After 1 hour, measure depth of water remaining in the cylinder
- If depth is greater than 5 inches, then filter may be clogged

Method 3:

- Use infiltration testing tool (such as “TURF-TEC” Infiltrometer) to measure infiltration rate
- If infiltration rate is less than 1 inch/hour, then filter media may be clogged.

Bioretention and Sand Filters

Filter Clogging

If infiltration tests suggest the filter media is clogged, then maintenance to restore adequate infiltration rates must be performed.

- First, scarify (rake) the top 2-3 inches of media to loosen sediment at the surface. Perform additional infiltration tests to see if infiltration rates have been restored.
- If there is an obvious "cake-layer" of sediment on top of the filter media, remove the top 1-2 inches of sediment and filter media and dispose of materials in a landfill.
- Once 3-6 inches of filter media have been removed over time (perhaps after 5-10 years), add additional filter media back to original elevation. (See filter media material specifications on next page).

Sand filter with obvious "cake-layer" of sediment built up over time. This sand filter needs to be maintained by removing 1-2 inches of filter media and sediment throughout the entire BMP.

Filter Media Replacement
If filter media needs to be replaced, make sure to obtain and install the appropriate materials.

Sand Filters
- Sand filter media must be washed and clean
- Use AASHTO C-33 or CDOT Class B material

Bioretention
- Check with local stormwater design criteria for bioretention media specification
- DO NOT USE 100% topsoil or clay-grown sod

Filter Media Grading
The filter media should be flat to allow for even distribution of runoff throughout the BMP
- Check for uneven drainage/erosion
- If filter media is not flat, manually re-grade using rakes or lightweight equipment

Bioretention with uneven filter media grading. Maintenance is required to re-grade so that filter media is flat.

Note of Heavy Equipment Use
Never drive heavy equipment onto the filter media. This will compact the filter media and reduce infiltration rates.

Filter Media/Final Landscaping Elevation
It is common for final landscaping (mulch, rock, etc.) to be placed higher than the inlet elevation in bioretention BMPs. This prevents runoff from entering the BMP and should be corrected.

- Verify that final landscaping is at least 3 inches below the inlet.
- If landscaping is higher than the inlet, maintenance is necessary to remove landscaping material to the correct elevation.

Snow Storage
Storing snow on top of sand filters/bioretention can clog the filter media.

- Look for indications of snow storage on filter media
- If snow is being stored on filter media, contact the snow plowing company to discuss alternative snow storage areas
- It may also be beneficial to install a sign indicating “No Snow Storage” near the BMP

Snow should not be stored on bioretention/sand filter BMPs

UNDERDRAIN

Underdrains are used in areas where infiltration of runoff into groundwater beneath the BMP is low or not allowed. Underdrains are designed to completely drain the BMP within 12-24 hours and discharge into the outlet structure. NOTE: not all BMPs will have underdrains.

- Underdrains should be inspected to verify they are not clogged.
- During runoff event, check to see if water is flowing freely out of the underdrain, OR
- Use pipe inspection TV to see if debris is clogging underdrain
- If underdrain clogging is suspected, the underdrain should be cleaned using a jet-vac truck

Cleanouts

- Verify that cleanout caps are installed and water tight

Orifice plate

- Verify that the orifice plate (as shown in picture above) is installed on the end of the underdrain to control rate of discharge.

Water flowing freely from the underdrain discharge point within the outlet structure.

Bioretention and Sand Filters

OUTLET STRUCTURE

The outlet structure is where runoff that exceeds the BMP's storage capacity discharges back to the storm sewer system untreated. It is also the location where the underdrain (if present) will discharge into.

Outlet Overflow Elevation

It is important that the overflow elevation of the outlet structure is correct so that water can pond within the BMP until it infiltrates through the filter media.

- Measure the distance between the filter media and overflow elevation and compare to the "water quality capture volume" (WQCV) depth on the design drawings
- If measured depth is less than design depth, the outlet structure must be modified

Sand filter overflow elevation equal to elevation of the filter media. This BMP will not store water on top of the filter media. Original design showed distance of 9 inches between filter media and overflow elevation.

EMBANKMENTS/CONTAINMENT WALLS

Embankments and containment walls allow runoff to pond within the BMP to a specific design depth, and also provide protection against pedestrian and vehicle traffic that may compact the filter media over time. Embankments are generally vegetated, while containment walls are generally formed with concrete.

Embankment Erosion

- Check for signs of sparse vegetation and/or erosion on embankments. Erosion can add excess sediment to the filter media, resulting in clogging.
- Areas with sparse vegetation should be re-seeded. Temporary erosion control matting and irrigation may be necessary until vegetation is re-established.

Sand filter with sparse vegetation on embankment.

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Bioretention and Sand Filters

Containment Walls

- Check that containment walls fully enclose the entire BMP and are not damaged.
- Modifications should be made to repair or install new containment walls if these requirements are not met.

Bioretention cell with partial, concrete containment wall. Runoff will not pond to the proper design depth because the containment wall is not complete.

Sand filter (with rockscape cover) with partial "curb" containment wall. Tracks indicate vehicles are parking/ driving on top of the sand filter which can cause compaction to filter media.

VEGETATION (BIORETENTION ONLY)

Adequate vegetation in bioretention cells provides several important benefits including aesthetic appeal, increased runoff and pollutant reduction and reduced clogging due to root penetration.

- Check that vegetation is healthy and well-dispersed.
- If vegetation is sparse, contact a landscape company to re-vegetate. Temporary erosion control matting and irrigation may be necessary until vegetation is re-established.
- Minimize the use of fertilizers and pesticides on bioretention vegetation. Manually remove weeds when necessary.

Bioretention with sparse vegetation.

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Recommended Bioretention Plant Mix
The Urban Drainage and Flood Control District (Denver, CO) recommends a native seed mix for bioretention cells constructed on the Colorado Front Range.
Scan the QR code for details

VEGETATION (BIORETENTION ONLY)

Dead/Unhealthy Vegetation

- Dead or unhealthy vegetation may be caused by standing water problems in the BMP
- Standing water problems may be caused by clogging of the filter media and/or underdrain system.
- Perform filter media and underdrain tests and maintenance prior to re-vegetating.

Bioretention with dead vegetation. At this site, the wrong filter media was installed which led to rapid clogging.

Bioretention with healthy and well-dispersed vegetation

Bioretention and Sand Filters

Permeable Pavement

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PERMEABLE PAVEMENT

Introduction

Permeable pavement (PP) is a type of BMP used in parking lots and roadways that allows rainfall to flow directly through the pavement instead of running off into the storm sewer.

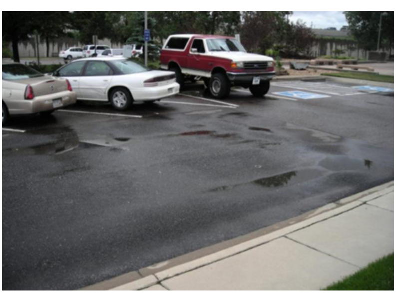
The primary components of PP systems that require inspection and maintenance include the pavement section and underdrain. Note: not all systems will have underdrains.

There are several types of PP typically used:

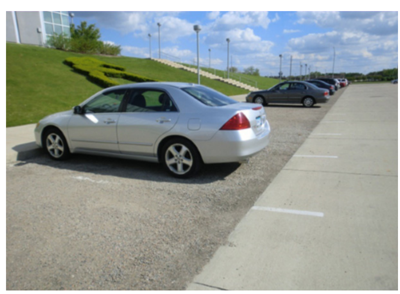
- Permeable Interlocking Concrete Pavement (PICP)
- Concrete Grid Pavement (CGP)
- Pervious Concrete
- Porous Asphalt

Concrete Grid Pavement

PICP



Porous Asphalt



Pervious Concrete

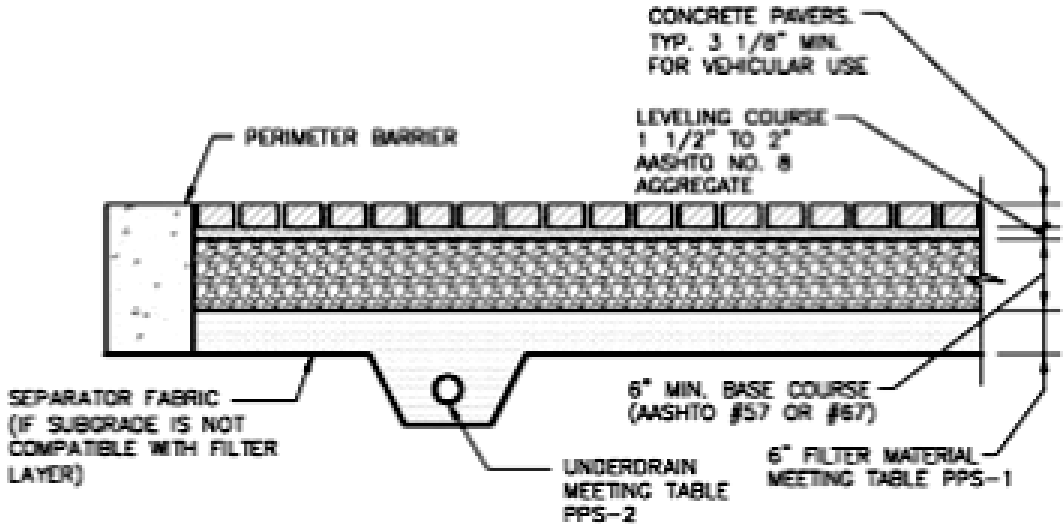


Diagram of typical permeable pavement cross-section

Note: Some PP systems will not have an underdrain system if local soils provide adequate infiltration. Always refer to the original drawings to determine if an underdrain system is present.

PAVEMENT SECTION

The pavement section is a 3-6 inch (typical) layer at the top of the PP system on which vehicles drive and park. Stormwater infiltrates through this section into additional PP layers below before it discharges into the groundwater or underdrain.

The pavement section is where the majority of sediment and other pollutants are trapped as stormwater infiltrates through the PP system. Eventually, these materials will clog the pavement section if they are not removed frequently.

Proactive Maintenance

Unlike most other BMPs where maintenance can be recommended based on visual inspection, it is not possible to see the accumulation of sediment within the pavement section over time. Frequent (proactive) maintenance is required to ensure that PP systems remain properly functioning over time.

- All PP systems should be vacuumed at least one time per year using a regenerative air sweeper or pure vacuum sweeper
  - On small sites where vacuum trucks cannot access, walk-behind vacuums may be used.
- Vacuuming may be necessary more than one time per year under the following conditions:
  - High number of trees near PP system
  - Unstable (exposed soil) areas nearby
  - High impervious run-on ratio

Improper Maintenance Methods

Do not use the following methods for maintenance:

- Broom/mechanical sweepers: these are ineffective at removing sediment and debris from pavement section
- Pressure washing: this method pushes sediment further into the pavement section, making future removal more difficult

Regenerative air sweeper performing maintenance. Many (but not all) private companies have regenerative air sweepers.

Walk-behind vacuums may be available from landscape and sidewalk cleaning companies.

Pressure washing is not acceptable maintenance method. It can make clogging worse and lead to total failure of the PP system

PICP Joint Aggregate
PICP systems have small openings (joints) between each paver to allow rainfall to infiltrate through. These openings are filled with special aggregate to capture sediments close to the surface so that they can be removed using methods discussed in the previous section. Keeping joints properly filled also reduces tripping hazards.

- During each inspection, and after proactive maintenance, measure distance between the top of the paver and top of the fill aggregate between pavers
- If fill aggregate is more than 1/2 inch below the top of the paver, additional aggregate should be added.

Adding aggregate to PICP joints after maintenance.

PICP Joint Aggregate
PICP joint aggregate must meet specific requirements, which should be verified in the field prior to placement.

- ASTM No. 8, 9 or 89 aggregate
- Aggregate must be washed
- Aggregate must be angular, not rounded

Infiltration Testing

Infiltration tests should be conducted to assure that proactive maintenance is working properly.

- During inspection, test the infiltration rate of the PP system using the procedure outlined below.
- Perform several tests on each site, as the infiltration rate can vary considerably from one test to another.
- If the infiltration test fails, then restorative maintenance actions may be necessary (see next section)

Permeable Pavement Infiltration Test

- Pour 1 gallon of water onto the PP over approximately 30 seconds
- The water will infiltrate through the surface creating a "wetted area"
- Measure the diameter of the wetted area using a tape measure
- If wetted area is longer than 10 feet, then maintenance is necessary

"Wetted area" after infiltration test on PP system.

Standing water on PP system during rainfall event is another indication that restorative maintenance is necessary.

Restorative Maintenance

Restorative maintenance is required when excessive clogging of the PP system has occurred due to ineffective or infrequent proactive maintenance. Restorative maintenance requires methods that aim to remove sediments from deep (2+ inches) below the PP surface. Different types of PP systems require different types of restorative maintenance methods.

NOTE: The procedures described in this section may be very expensive and are not guaranteed to restore PP systems.

Neglected PICP with "caked" sediment. This system requires restorative maintenance.

Vacuum Sweeper Restorative Maintenance

- Pure vacuum sweepers (such as Elgin Whirlwind) are difficult to find. Most private companies will not own these, but some large municipalities may.
- These sweepers only cover about 3 feet on each pass and maintenance of entire PP system may take several days.

Restorative Maintenance of Porous Concrete/Asphalt
Two different methods may be used to restore clogged porous asphalt and concrete.

- Method 1: "Vacuum Hydro Scrubber"
  This technology is used by sidewalk cleaning companies and is available from several vendors in Colorado.
- Method 2: Pure Vacuum Sweeper
  This type of street sweeper (e.g. Elgin Whirlwind) is not very common and it may be difficult to find one available.

Restorative maintenance of a porous asphalt site using "vacuum hydro scrubber" technology.

The bottom of the "vacuum hydro scrubber" device.

Restorative Maintenance of PICP/CGP by Complete Bedding Course Removal and Replacement

Sediment that is not removed by proactive maintenance will accumulate deep within the bedding/leveling course of PICP and CGP systems. To complete restorative maintenance, pavers and existing bedding course may have to be removed. New bedding course must then be placed and the original pavers can be reinstalled.

- Only a certified PICP/CGP installer should provide this service
- Maintenance of an entire PP system may take multiple days

Sediment accumulated in bedding layer below pavers of a PICP system. This system was not maintained for 6 years and became fully clogged with sediment.

Manual removal of PICP pavers during restorative maintenance.

Weed and Stain Removal

- Kill weeds using thermal treatment (flame torch) or small amounts of biodegradable, non-toxic chemical treatment
- Do not pull weeds manually as the roots may also dislodge the pavers.
- Remove stains using spot treatments of a biodegradable, non-toxic degreaser. Wipe up degreaser using cloth towels and dispose in the landfill. Do not wash degreaser away using water.

CGP system with weeds growing between pavers.

Weeds In Permeable Pavement Systems

Weeds growing from PP systems are an indication that excess sediment has accumulated within the system and that restorative maintenance may be necessary.

Snow and Ice Control

- Snow removal on PP systems should be done using plows with rubber blades. Metal blades can damage PICP/CGP systems.
- Never apply sand to any PP system. Sand is full of small sediments that will clog the system rapidly.
- Never use chemical deicers on porous concrete. The chemicals will cause the concrete to crack and fail.
- Snow should not be stored directly on PP systems. Excess sediment in snow piles will clog the PP system rapidly.
- If inspection reveals any of these violations, contact the snow plowing company to discuss alternatives
- It may also be beneficial to install a sign indicating “No Snow Storage” near the BMP

PICP that was sanded during recent snowstorm. Sediment within the sand material will clog the PP system rapidly.

UNDERDRAIN

Underdrains are used in areas where infiltration of runoff into groundwater beneath the BMP is low or not allowed. Underdrains are designed to completely drain the BMP within 12-24 hours and discharge into the outlet structure. NOTE: Not all BMPs will have underdrains.

- Underdrains should be inspected to verify they are not clogged.
- During runoff event, check to see if water is flowing freely out of the underdrain OR
- Use pipe inspection TV to see if debris is clogging underdrain
- If underdrain clogging is suspected, the underdrain should be cleaned using a jet-vac truck

Cleanouts

- Cleanouts will be located within a valve box
- Verify that cleanout caps are installed and water tight

Typical valve box cleanout for PP system

Orifice plate

- Verify that the orifice plate is installed at end of underdrain to control the rate of discharge according to design.

Permeable Pavement

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