



Standard Operating Procedure (SOP)
For
Porous Landscape Detention (PLD)
Inspection and Maintenance

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ACRONYMS

PBMP	Permanent Best Management Practice
GIS	Geographic Information System
O&M	Operation and Maintenance
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
SOP	Standard Operating Procedure
EPA	U.S. Environmental Protection Agency
CDPHE	Colorado Department of Public Health and Environment
CDPS	Colorado Discharge Permit System
WQCD	Water Quality Control Division of the CDPHE
CWA	Clean Water Act
EDB	Extended Detention Basin
PLD	Porous Landscape Detention
GS/GB	Grass Swale/Grass Buffer
WQCV	Water Quality Capture Volume

PLD-1 BACKGROUND

Porous Landscape Detention (PLD) is one of the most common types of Stormwater Management Facilities utilized within the Front Range of Colorado. PLDs consist of a low-lying vegetated area underlain by a sand bed with an underdrain pipe. A shallow surcharge zone exists above the PLD for temporary storage of the Water Quality Capture Volume (WQCV). During a storm, accumulated runoff ponds in the vegetated zone and gradually infiltrates into the underlying sand bed, filling the void spaces of the sand. The underdrain gradually dewateres the sand bed and discharges the runoff to a nearby channel, swale, or storm sewer. The PLD provides for filtering, adsorption, and biological uptake of constituents in stormwater¹. The popularity of PLDs has increased because they allow the WQCV to be provided on a site that has little open area available for stormwater management.

PLD-2 INSPECTING POROUS LANDSCAPE DETENTION (PLD)

PLD-2.1 Access and Easements

Inspection or maintenance personnel may utilize the stormwater facility map located in Appendix B containing the locations of the access points and maintenance easements of the PLDs within this development.

PLD-2.2 Stormwater Management Facilities Locations

Inspection or maintenance personnel may utilize the stormwater facility map located in Appendix B containing the locations of the PLDs within this development.

PLD-2.3 Porous Landscape Detention (PLD) Features

PLDs have a number of features that are designed to serve a particular function. Many times the proper function of one feature depends on another. It is important for maintenance personnel to understand the function of each of these features to prevent damage to any feature during maintenance operations:

¹ Design of Stormwater Filtering Systems, Centers for Watershed Protection, December 1996

**Table PLD-1
Typical Inspection & Maintenance Requirements Matrix**

	Sediment Removal	Mowing Weed control	Trash & Debris Removal	Erosion	Overgrown Vegetation Removal	Removal/ Replacement	Structure Repair
Inflow Points	X		X				X
Landscaping	X	X	X	X	X		
Filter Media	X	X	X	X	X	X	
Underdrain System						X	
Overflow Outlet Works	X		X				X
Embankment		X	X	X	X		

PLD-2.3.1 Inflow Points

Inflow points or outfalls into PLDs are the point of stormwater discharge into the facility. An inflow point is commonly a curb cut with a concrete or riprap rundown. In limited cases a storm sewer pipe outfall with a flared end section may be the inflow point into the PLD.

An energy dissipater (riprap or concrete wall) is typically immediately downstream of the discharge point into the PLD to protect the PLD from erosion. In some cases, the storm sewer outfall can have a toe-wall or cut-off wall immediately below the structure to prevent undercutting of the outfall from erosion.

The typical maintenance items that are required at inflow points are as follows:

a. Riprap Displaced – Many times, because of, the repeated impact/force of water, the riprap can shift and settle. If any portion of the riprap rundown or apron appears to have settled, soil is present between the riprap, or the riprap has shifted, maintenance may be required to ensure future erosion is prevented.

b. Erosion Present/Outfall Undercut – In some situations, the energy dissipater may not have been sized, constructed, or maintained appropriately and erosion has occurred. Any erosion within the vicinity of the inflow point will require maintenance to prevent damage to the structure(s) and sediment transport within the facility. It is imperative that material utilized to correct erosion problems within the filter media meets the requirements for filter media as shown on the approved construction drawings.

d. Sediment Accumulation – Because of the turbulence in the water created by the energy dissipater, sediment often deposits immediately downstream of the inflow point. To prevent a loss in performance of the upstream infrastructure, sediment that accumulates in this area must be removed on a timely basis.

e. Structural Damage – Structural damage can occur at anytime during the life of the facility. Typically for an inflow, the structural damage occurs to the concrete or riprap rundown or pipe flared end section (concrete or steel). Structural damage can lead to additional operating problems with the facility, including loss of hydraulic performance.

PLD-2.3.2 Landscaping

The landscaped area consists of specific plant materials and associated landscaping mulch in the bottom of the PLD. These plantings provide several functions for the PLD. Planting not only provides an aesthetic value for the PLD, but in many cases assists with biological uptake or removal of pollutants.

The plants are carefully selected for use in the PLDs. Plants utilized in PLDs must be able to grow in dry sandy soils but also be able to withstand frequent inundation by stormwater runoff. These plants also must be able to withstand a variety of pollutants commonly found in stormwater runoff. In addition, plants utilized in PLDs cannot have a deep extensive root system that may cause maintenance difficulty or damage to the facility.

The typical maintenance activities that are required within the landscape areas are as follows:

a. Woody Growth/Weeds Present – Undesirable vegetation can grow in and around the landscaped area in the PLD that can significantly impact the performance of the facility. This type of vegetation includes dense areas of shrubs (willows), grasses and noxious weeds. If undesired vegetation is not routinely mowed/removed, the growth can cause debris/sediment to accumulate, resulting in blockage of the filter media. Also, shrub, grass and weed roots can cause damage to the filter media and underdrain system. Routine management is essential to prevent more extensive and costly future maintenance.

b. General Landscape Care – The landscape elements of the PLD are the same as any other landscape area and need to be provided with regular care. Landscape mulch will need to be removed and replaced to ensure the aesthetics of the PLD.

PLD-2.3.3 Filter Media

The filter media is the main pollutant removal component of the PLD. The filter media consists of 18-inches of a mixture of washed sand and peat. The filter media removes pollutants through several different processes, including sedimentation, filtration, absorption, infiltration and microbial uptake.

Sedimentation is accomplished by the slow release of stormwater runoff through the filter media. This slow release allows for sediment particles to be deposited on the top layer of the filter media where they are easily removed through routine maintenance. Other pollutants are also removed through this process because many pollutants utilize sediment as a transport mechanism.

Filtration is the main pollutant removal mechanism of PLDs. When the stormwater runoff migrates down through the filter media many of the particulate pollutants are physically strained out as they pass through the filter bed of sand and are trapped on the surface or among the pores of the filter media.²

Absorption results from the peat utilized in the filter media. Organic materials have a natural ability to attach to soluble nutrients, metals and organic pollutants. This attachment then prevents these pollutants from leaving the PLD.

PLDs that are not lined with an impervious liner allow for infiltration into the native soils. This process also allows for additional pollutant removal.

Microbes that naturally occur in the filter media can assist with pollutant removal by breaking down organic pollutants.

The typical maintenance activities that are required within the filter media areas are as follows:

a. Infiltration Rate Check – The infiltration rate of the PLD needs to be checked in order to ensure proper functioning of the PLD. Generally, a PLD should drain completely within 12-hours of a storm event. If drain times exceed the 12-hour drain time then maintenance of the filter media shall be required.

b. Sediment Removal – Although PLDs should not be utilized in areas where large concentrations of sediment may enter the PLD, it is inevitable that some sediment will enter the PLD.

² Design of Stormwater Filtering Systems, Centers for Watershed Protection, December 1996

c. Filter Replacement - The top layers of the filter media are the most susceptible to pollutant loading and therefore may need to be removed and disposed of properly on a semi-regular basis when infiltration rates slow.

PLD-2.3.4 Underdrain System

The underdrain system consists of a layer of geotextile fabric, gravel storage area and perforated PVC pipes. The geotextile fabric is utilized to prevent the filter media from entering the underdrain system. The gravel storage area allows for storage of treated stormwater runoff prior to the discharge of the runoff through the perforated PVC pipe.

The typical maintenance activities that are for the underdrain system are as follows:

With proper maintenance of the landscape areas and filter media there should be a minimum amount of maintenance required on the underdrain system. Generally the only maintenance performed on the underdrain system is jet-vac cleaning.

PLD-2.3.5 Overflow Outlet Works

Generally, the initial runoff (“first flush”) or WQCV during the storm event contains the majority of the pollutants. PLDs are designed to treat only the WQCV and any amount over the WQCV is allowed to go to a detention facility without water quality treatment. The overflow outlet works allows runoff amounts over the WQCV to exit the PLD to the detention facility. The outlet works is typically constructed of a reinforced concrete box in the embankment of the PLD. The concrete structure typically has a steel grate to trap litter and other debris from entering the storm sewer system. Proper inspection and maintenance of the outlet works is essential in ensuring the long-term operation of the PLD.

The most typical maintenance items that are found with inflow points are as follows:

a. Structural Damage - The overflow outlet structure is primarily constructed of concrete, which can crack, spall, and settle. The steel grate on the overflow outlet structure is also susceptible to damage.

b. Woody Growth/Weeds Present – The presence of plant material not part of the original landscaping, such as wetland plants or other woody growth, can clog the overflow outlet works during a larger storm event, causing flooding damage to adjacent areas. This

plant material also may indicate a clogging of the filter media than may require additional investigation.

c. Trash Debris – Trash and debris can accumulate in the upper area after large events, or from illegal dumping. Over time, this material can clog the PLD outlet works.

PLD-2.3.6 Embankments

Some PLDs utilize irrigated turf grass embankment to store the WQCV.

The typical maintenance activities that are required with the embankments areas are as follows:

a. Vegetation Sparse – The embankments are one of the most visible parts of the PLD, and therefore aesthetics are important. Adequate and properly maintained vegetation can greatly increase the overall appearance of the PLD. Vegetation can reduce the potential for erosion and subsequent sediment transport to the filter media, thereby reducing the need for more costly maintenance.

b. Erosion – Inadequate vegetative cover may result in erosion of the embankments. Erosion that occurs on the embankments can cause clogging of the filter media.

PLD-2.3.7 Miscellaneous

There are a variety of inspection/maintenance issues that may not be attributed to a single feature within the PLD. This category on the inspection form is for maintenance items that are commonly found in the PLD, but may not be attributed to an individual feature.

a. Encroachment in Easement Area – Private lots/property can sometimes be located very close to the PLDs, even though the County requires that PLDs be located in tracts with drainage easements. Property owners may place landscaping, trash, fencing, or other items within the easement area that may impact maintenance or the operation of the facility.

b. Graffiti/Vandalism – Vandals can cause damage to the PLD infrastructure. If criminal mischief is evident, the inspector should forward this information to the Douglas County Sheriff's Office

c. Public Hazards – Public hazards include items such as containers of unknown/suspicious substances, and exposed metal/jagged concrete on structures. **If any hazard is found within the facility area that poses an immediate threat to public**

safety, contact the Douglas County Sheriff's Office at 911 immediately!

d. Other – Any miscellaneous inspection/maintenance items not contained on the form should be entered here.

PLD-3 MAINTAINING POROUS LANDSCAPE DETENTIONS (PLDs)

PLD-3.1 Maintenance Personnel

Maintenance personnel must be experienced to properly maintain PLDs. Inadequately trained personnel can cause additional problems resulting in additional maintenance costs.

PLD-3.2 Equipment

It is imperative that the appropriate equipment and tools are taken to the field with the operations crew. The types of equipment/tools will vary depending on the task at hand. Below is a list of tools, equipment, and material(s) that may be necessary to perform maintenance on a PLD:

- 1.) Mowing Tractors
- 2.) Trimmers (extra string)
- 3.) Shovels
- 4.) Rakes
- 5.) All Surface Vehicle (ASVs)
- 6.) Skid Steer
- 7.) Back Hoe
- 8.) Track Hoe/Long Reach Excavator
- 9.) Dump Truck
- 10.) Jet-Vac Machine
- 11.) Engineers Level (laser)
- 12.) Riprap
- 13.) Geotextile Fabric
- 14.) Erosion Control Blanket(s)
- 15.) Sod
- 16.) Illicit Discharge Cleanup Kits
- 17.) Trash Bags
- 18.) Tools (wrenches, screw drivers, hammers, etc)
- 19.) Confined Space Entry Equipment

- 20.) Approved Stormwater Facility Operation and Maintenance Manual
- 21.) ASTM C-33 Sand
- 22.) Peat
- 23.) Wood Landscaping Mulch

Some of the items identified above may not be needed for every maintenance operation. However, this equipment should be available to the maintenance operations crews should the need arise.

PLD-3.3 PLD Maintenance Categories and Activities

A typical PLD Maintenance Program will consist of three broad categories of work: Routine, Minor and Major. Within each category of work, a variety of maintenance activities can be performed on a PLD. A maintenance activity can be specific to each feature within the PLD, or general to the overall facility. This section of the SOP explains each of the categories and briefly describes the typical maintenance activities for a PLD.

Douglas County Department of Public Works Engineering has identified a variety of maintenance activities that are typical of PLDs. The maintenance activities range in magnitude from routine trash pickup to the reconstruction of the PLD filter media or underdrain system. Below is a description of each maintenance activity, the objectives, and frequency of actions:

PLD-3.4 ROUTINE MAINTENANCE ACTIVITIES

The majority of this work consists of scheduled mowings, trash and debris pickups and landscape care for the PLD during the growing season. It also includes activities such as weed control. These activities normally will be performed numerous times during the year. These items **do not** require any prior approval by Douglas County, however, completed inspection forms shall be reviewed and retained by the property owner and/or manager.

The Routine Maintenance Activities are summarized below, and further described in the following sections.

**Table PLD-2
Summary of Routine Maintenance Activities**

Maintenance Activity	Minimum Frequency	Look for:	Maintenance Action
Mowing	Twice annually	Excessive grass height/aesthetics	2"-4" grass height
Trash/Debris Removal	Twice annually	Trash & debris in PLD	Remove and dispose of trash and debris
Overflow Outlet Works Cleaning	As needed - after significant rain events – twice annually minimum	Clogged outlet structure; ponding water above outlet elevation	Remove and dispose of debris/trash/sediment to allow outlet to function properly
Weed Control	Minimum twice annually	Noxious weeds; Unwanted vegetation	Treat w/herbicide or hand pull; consult Douglas County Weed Inspector

PLD-3.4.1 Mowing

Routine mowing of the turf grass embankments is necessary to improve the overall appearance of the PLD. Turf grass should be mowed to a height of 2 to 4- inches and shall be bagged to prevent potential contamination of the filter media.

Frequency – Routine - Minimum of twice annually or depending on aesthetics.

PLD-3.4.2 Trash/Debris Removal

Trash and debris must be removed from the entire PLD area to minimize outlet clogging and to improve aesthetics. This activity must be performed prior to mowing operations.

Frequency – Routine – Prior to mowing operations and minimum of twice annually.

PLD-3.4.3 Overflow Outlet Works Cleaning

Debris and other materials can clog the overflow outlet works' grate. This activity must be performed anytime other maintenance activities are conducted to ensure proper operation.

Frequency - Routine – After significant rainfall event or concurrently with other maintenance activities.

PLD-3.4.4 Weed Control

Noxious weeds and other unwanted vegetation must be treated as needed throughout the PLD. This activity can be performed either through mechanical means (mowing/pulling) or with herbicide. Consultation with the Douglas County Weed Inspector is highly recommended prior to the use of herbicide. Herbicides should be utilized sparingly and as a last resort. All herbicide applications should be in accordance with the manufacturer's recommendations.

Frequency – Routine – As needed based on inspections.

PLD-3.5 MINOR MAINTENANCE ACTIVITIES

This work consists of a variety of isolated or small-scale maintenance/operational problems. Most of this work can be completed by a small crew, hand tools, and small equipment. **All of this work requires notification, at least 14 days prior to the start of work, to the Douglas County Engineering Permits and Inspections Department at 303-660-7487.** In the event that the PLD needs to be dewatered, care should be given to ensure sediment, filter material and other pollutants are not discharged. **All dewatering activities shall be coordinated with Douglas County Engineering Permits and Inspections Department at 303-660-7487.**

**Table PLD-3
Summary of Minor Maintenance Activities**

Maintenance Activity	Minimum Frequency	Look for:	Maintenance Action
Sediment/Pollutant Removal	As needed; Based on infiltration test	Sediment build-up; decrease in infiltration rate	Remove and dispose of sediment
Erosion Repair	As needed, based upon inspection	Eroded areas on embankments	Repair eroded areas & revegetate; address cause
Jet Vac/Cleaning underdrain system	As needed, based upon inspection	Sediment build-up /non draining system	Clean drains; Jet-Vac if needed

PLD-3.5.1 Sediment/Pollutant Removal

Sediment/Pollutant removal is necessary to ensure proper function of the filter media. The infiltration rate of the PLD needs to be checked in order to ensure proper functioning of the PLD. Generally, a PLD should drain completely within 12-hours of a storm event. If drain times exceed the 12-hour drain time then maintenance of the filter media shall be required.

Generally the top 3-inches of filter media should be removed at each removal period. Additional amounts of filter media may need to be removed if deeper sections of the filter media are contaminated. New filter media will need to replace the removed filter media. It is critical that only sand that meets the American Society for Testing and Materials (ASTM) C-33 standard be utilized in the replacement of the filter media.

**Table PLD-4
ASTM C-33 Sand Standard**

US Standard Sieve Size (Number)	Total Percent Passing (%)
9.5 mm (3/8 inch)	100
4.75 mm (No. 4)	95-100
2.36 mm (No. 8)	80-100
1.18 mm (No. 16)	50-85
600µm (No. 30)	25-60
300µm (No. 50)	10-30
150µm (No. 100)	2-10

**Table PLD-5
Peat Moss Specifications for Filter Media**

pH (Units)	7.6
Total Salts (MMHOS/CM, 1:5)	2.28
Organic Matter (%)	20.22
Moisture (%)	21.43
Dry Matter Basis:	
Nitrogen - Total (%)	0.780
Nitrogen - Organic (%)	0.773
Nitrogen - Ammonia (PPM)	46.8
Nitrogen - Nitrate (PPM)	31.3
Total Phosphorus (%) as P	0.103
(%) as P₂O₅	0.237
Total Potassium (%) as K	0.138
(%) as K₂O	0.166
Carbon / Nitrogen Ratio	13.6

Other types of sand or soil material may lead to clogging of the PLD. The minor sediment removal activities can typically be addressed with shovels and rakes and smaller equipment. Major sediment removal activities will require larger and more specialized equipment. Extreme care should be taken when utilizing motorized or heavy equipment to ensure damage to the underdrain system does not occur. The major sediment removal activities will also require surveying with an engineer's level, and consultation with the Douglas County Engineering Staff to ensure design volumes/grades are achieved.

Stormwater sediments removed from PLDs do not meet the regulatory definition of "hazardous waste". However, these sediments can be contaminated with a wide array of organic and inorganic pollutants and handling must be done with care. Sediments should be transported by motor vehicle only after they are dewatered. All sediments must be taken to a licensed landfill for proper disposal. Should a spill occur during transportation, prompt and thorough cleanup and disposal is imperative.

Frequency – Non-routine – As necessary, based upon inspections and infiltration tests. Sediment removal in the forebay and trickle channel may be necessary as frequently as every 1-2 years.

PLD-3.5.2 Erosion Repair

The repair of eroded areas is necessary to ensure the proper functioning of the PLD, to minimize sediment transport, and to reduce potential impacts to other features. Erosion can vary in magnitude from minor repairs to filter media and embankments, to rills and gullies in the embankments and inflow points. The repair of eroded areas may require the use of excavators, earthmoving equipment, riprap, concrete, and sod. Extreme care should be taken when utilizing motorized or heavy equipment to ensure damage to the underdrain system does not occur. Major erosion repair to the pond embankments, spillways, and adjacent to structures will require consultation with Douglas County Engineering Staff.

Frequency – Non-routine – As necessary, based upon inspections.

PLD-3.5.3 Jet-Vac/Clearing Drains

A PLD contains an underdrain system that allows treated stormwater runoff to exit the facility. These underdrain systems can develop blockages that can result in a decrease of hydraulic capacity and also create standing water. Many times the blockage to this infrastructure can be difficult to access and/or clean. Specialized equipment (jet-vac machines) may be necessary to clear debris from these difficult areas.

Frequency – Non-routine – As necessary, based upon inspections.

PLD-3.6 MAJOR MAINTENANCE ACTIVITIES

This work consists of larger maintenance/operational problems and failures within the stormwater management facilities. **All of this work requires notification, at least 14 days prior to the start of work, to the Douglas County Engineering Permits and Inspections Department at 303-660-7487.** This work requires that Engineering Staff review the original design and construction drawings to assess the situation and assign the necessary maintenance. This work may also require more specialized maintenance equipment, design/details, surveying, or assistance through private contractors and consultants.

**Table PLD-6
Summary of Major Maintenance Activities**

Maintenance Activity	Minimum Frequency	Look for:	Maintenance Action
Major Sediment/Pollutant Removal	As needed – based upon scheduled inspections	Large quantities of sediment; reduced pond capacity	Remove and dispose of sediment. Repair vegetation as needed
Major Erosion Repair	As needed – based upon scheduled inspections	Severe erosion including gullying, excessive soil displacement, areas of settlement, holes	Repair erosion – find cause of problem and address to avoid future erosion
Structural Repair	As needed – based upon scheduled inspections	Deterioration and/or damage to structural components – broken concrete, damaged pipes & outlet works	Structural repair to restore the structure to its original design
PLD Rebuild	As needed – due to complete failure of PLD	Removal of filter media and underdrain system	Contact Douglas County Engineering

PLD-3.6.1 Major Sediment/Pollutant Removal

Major sediment removal consists of removal of large quantities of pollutants/sediment/filter media/landscaping material. Extreme care should be taken when utilizing motorized or heavy equipment to ensure damage to the underdrain system does not occur. Some PLDs also contain an impermeable liner that can be easily damaged if care is not taken when removing the filter media. Stormwater sediments removed from PLDs do not meet the regulatory definition of “hazardous waste”. However, these sediments can be contaminated with a wide array of organic and inorganic pollutants and handling must be done with care to ensure proper removal and disposal. Sediments should be transported by motor vehicle only after they are dewatered. All sediments must be taken to a licensed landfill for proper disposal. Should a spill occur during transportation, prompt and thorough cleanup and disposal is imperative. Vegetated areas need special care to ensure design volumes and grades are preserved or may need to be replaced due to the removal activities.

Frequency – Non-routine – Repair as needed, based upon inspections.

PLD-3.6.2 Major Erosion Repair

Major erosion repair consists of filling and revegetating areas of severe erosion. Determining the cause of the erosion as well as correcting the condition that caused the erosion should also be part of the erosion repair. Care should be given to ensure design grades and volumes are preserved. Extreme care should be taken when utilizing motorized or heavy equipment to ensure damage to the underdrain system does not occur.

Frequency – Non-routine – Repair as needed, based upon inspections.

PLD-3.6.3 Structural Repair

A PLD generally includes a concrete overflow outlet structure that can deteriorate or be damaged during the service life of the facility. These structures are constructed of steel and concrete that can degrade or be damaged and may need to be repaired or re-constructed from time to time. Major repairs to structures may require input from a structural engineer and specialized contractors. Consultation with Douglas County Engineering Staff shall take place prior to all structural repairs.

Frequency – Non-routine – Repair as needed, based upon inspections.

PLD-3.6.4 PLD Rebuild

In very rare cases a PLD may need to be rebuilt. Generally, the need for a complete rebuild is a result of improper construction, improper maintenance resulting in structural damage to the underdrain system, or extensive contamination of the PLD. Consultation with Douglas County Engineering Staff shall take place prior to any rebuild project.

Frequency – Non-routine – As needed, based upon inspections.

Reference:

This Manual is adapted from the Douglas County, Colorado, Standard Operating Procedure for Extended Detention Basin (EDB) Inspection and Maintenance, July 2005