Chapter 7.1 - Grassed Underdrained Soil Filters

Vegetated underdrained soil filters capture and retain runoff and pass it through a soil filter media. The media consists of a silty sand and organic matter mixture to remove a wide range of pollutants, including suspended solids, phosphorus, nitrogen, metals, hydrocarbons, and some dissolved pollutants. Once through the soil media, the runoff is collected in a perforated underdrain pipe system and discharged downstream. The filter structure provides for the slow release of smaller storm events, minimizing stream channel erosion, and cooling of the discharge. Vegetated soil filters are usually located in close proximity to the origin of the stormwater runoff and should be scattered throughout a residential area or along the downhill edge of smaller parking areas.

Basin Siting: The following criteria apply to all underdrained soil filters:

- *Drainage Area:* The size of the underdrained soil filter and storage capacity over the filter is based on the size and land use within the area draining to the structure. Upgradient areas should be directed around the filter basin if they are not to be treated by the filter.
- *Subsurface Investigation:* Subsurface explorations (test pits or borings) should be made within the basin area to identify depths to seasonal high groundwater and bedrock. Explorations should extend to below the proposed basin bottom elevation.
- *Separation from Seasonal High Water table and Bedrock:* The bottom of the underdrained soil filter should be a minimum of 18 inches above the seasonal high groundwater table or bedrock, unless an impermeable liner (not clay) or other design elements are employed.
- *Permeable Soils:* Vegetated soil filters can be designed to infiltrate water into the groundwater below. In hydrologic soil groups A and B, an underdrained filter basin should be designed as an infiltration basin provided that the design and siting criteria for infiltration can be met. Otherwise, an impermeable liner (not clay) may be required.

Basin Plan: When used to meet the Chapter 500 Phosphorus Standard, the sizing of the underdrain filter structures needs to be adjusted in accordance with Volume II of this BMP manual.

- *Treatment Volume:* An underdrained soil filter must detain and filter a runoff volume equal to 1.0 inch times the subcatchment's impervious area plus 0.4 inch times the subcatchment's landscaped developed area. Other upgradient areas should be directed away from the filter basin if they are not being treated by the filter.
- *Filter Area and Thickness*: The surface area of the filter must be no less than the sum of 5% of the impervious area and 2% of the landscaped area draining to the filter. The soil filter media must be at least 18 inches thick.
- *Basin Size:* The filter area should not exceed 3000 square feet or have more than 2.5 acres of subwatershed draining to the structure. Larger basins are difficult to construct and maintain
- *Drain Time:* A filter basin must drain dry in no less than 24 and no more than 48 hours.
- *Impoundment Depth*: The peak water quality storage depth may not exceed 18 inches over a grass filter. Storage over the treatment volume may be provided to control peak flows from the 2, 10 and 25 year storms and meet the flooding standards.
- *Sediment Pretreatment:* A pretreatment device such as a forebay, grassed swale, filter strip, and sediment trap should be provided to minimize the discharge of sediment to the filter basin. The pretreatment structure should be sized to hold an annual sediment volume as follow:

Assuming an average of 10 storm events per year, the volume of a sediment trap should be calculated as follow:

$$\text{10 storms per year} \times \text{Sanded Area (acres)} \times \frac{\text{500 lbs.}}{\text{per acre-storm}} : \frac{\text{90 lbs.}}{\text{ft}^3} = \text{annual cubic feet of collected sediment}$$

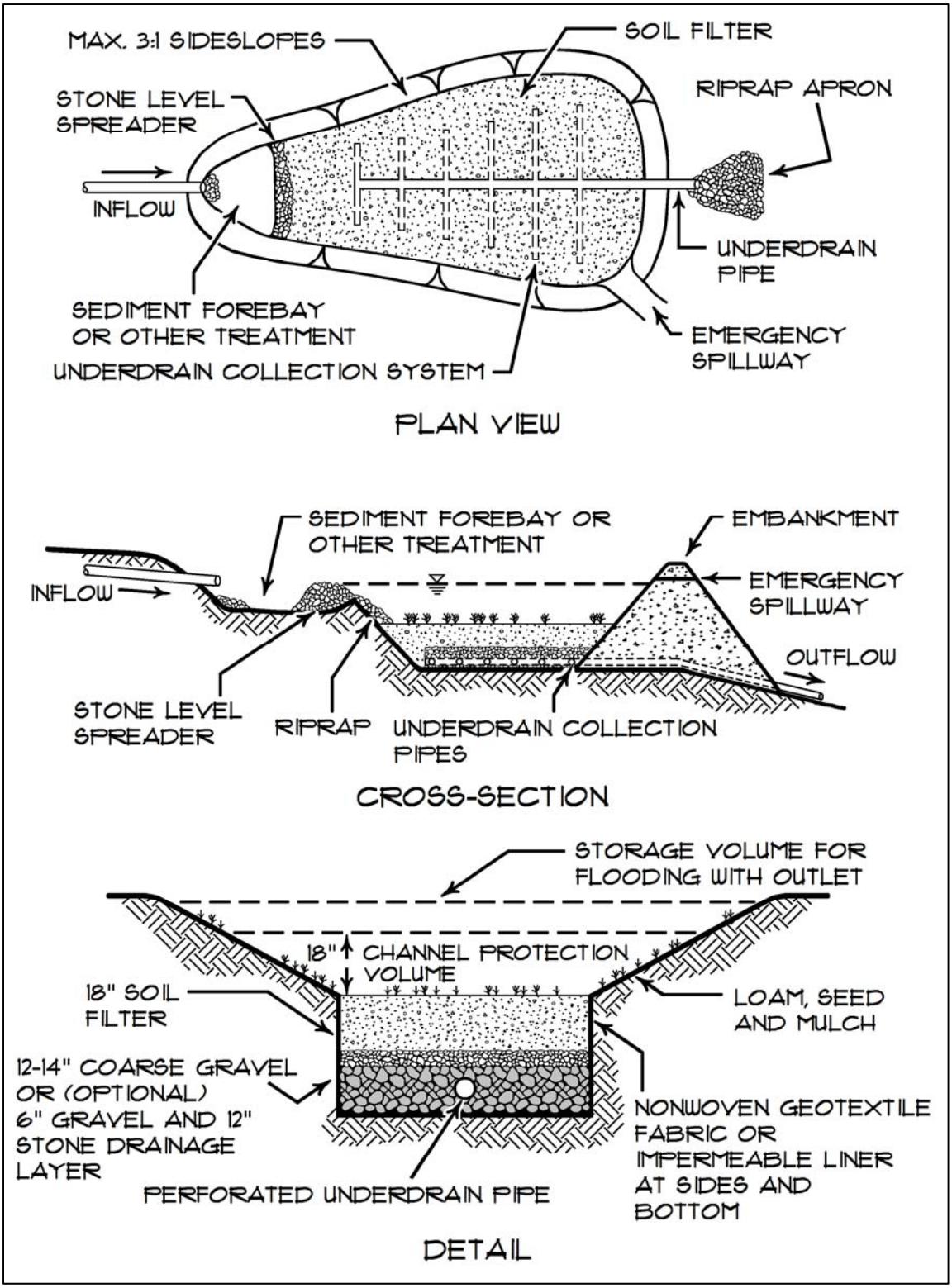

Figure 7.1.1 – Grassed Underdrained Soil Filter

- *Sediment Forebay:* A rock forebay is recommended to reduce flow velocity into the basin. All sediment should be removed after construction and the upgradient tributary area is fully stabilized.
- *Access:* Where needed, a maintenance access should be provided and maintained that is at least 10 feet wide with a maximum slope of 15% and a maximum cross slope of 3%. This access should never cross the emergency spillway, unless the spillway has been designed for that purpose. An easement for long-term access may be needed.
- *Vegetation:* The soil filter surface should be planted with a grass species that is tolerant of frequent inundation and well drained soils. Upon seeding, the soil filter should be mulched with hay or an erosion control mixture. A conservation type seed mixture is appropriate (or a 48 lbs/acre mixture containing 20 lbs/acre of Creeping red fescue and Tall fescue each plus 8 lbs/acre of Birdsfoot trefoil).

Table 7.1.1 - Maine DOT Specifications for Underdrain Backfill (MEDOT #703.22)

Sieve #	% Passing by Weight
UNDERDRAIN - TYPE B	
1”	95-100
½”	75-100
No. 4	50-100
No. 20	15-80
No. 50	0-15
No. 200	0-5.0
UNDERDRAIN - TYPE C	
1”	100
¾”	90-100
3/8”	0-75
No. 4	0-25
No. 10	0-5

Filter Outlet: The channel protection volume must be discharged solely through a network of underdrain pipe having a single outlet with a diameter that is no greater than eight inches.

- *Downgradient Discharge Area:* Each underdrain system must discharge to an area capable of withstanding concentrated flows and saturated conditions without eroding.
- *Underdrain Pipe:* A proper layout of the pipe underdrain system is necessary to effectively drain the entire filter area. The pipes within the basin must be placed no further apart than 15 feet and should have a positive slope. The underdrain should be 4" to 6" diameter perforated, rigid schedule 40 PVC or SDR 35 pipe. Structure joints should be sealed and watertight.
- *Outlet Discharge*: Outflow of the filter basin underdrain can be controlled by a constrictive orifice or a valve (2” plastic ball valve, type 346, with a ball valve handle extension, type 615, with a three-piece valve box installed over the valve). Upon completion of the installation of the soil filter media and the establishment of 90% of grass cover over the filter media, the contractor should flood the vegetated basin to the design elevation with clean water and adjust the outflow to obtain the 24 to 48 hour release time.

Underdrain Layer: The perforated piping in the underdrain layer should be bedded in 12 inches of material, with at least 4 inches of material beneath the pipe and 4 inches above. Two options for the underdrain layer are provided below, but Option 1 is preferred by the DEP:

- *Drainage Layer - OPTION 1*: The underdrain material consists of well-graded, clean, coarse gravel meeting the Maine DOT specification 703.22 Underdrain Backfill for Type B Underdrain (see Table 7.1.1). This design is acceptable for areas where the depth to seasonal high groundwater is close to the bottom of the drainage layer.
- *Drainage Layer with Transition Layer - OPTION 2:* The underdrain material consists of 12 inches of crushed stone meeting the Maine DOT specification 703.22 Underdrain Backfill for Type C Underdrain (see Table 7.1.1). As a transition zone, a 6 inch layer of well graded, clean, coarse gravel meeting the Maine DOT specification 703.22 Underdrain Backfill for Type B Underdrain (Table 7.1.1) is needed above the bedding.

Soil Filter Bed: The soil filter over the gravel underdrain pipe bedding must be at least 18 inches deep and must extend across the entire filter area. This soil mixture should be a uniform mix, free of stones, stumps, roots, or other similar objects larger than two inches. No materials or substances that may be harmful to plant growth can be mixed within the filter. Except for agricultural sources, most organic sources may be acceptable for the organic component of the media. The soil filter may be omitted if the permeability of the in-situ soils is greater than the permeability of the soil filter and mounding will not be an issue. However, the basin will need to meet the requirements for infiltration per Chapter 6. Two options are available for the soil filter portion of the basin:

- *Optional Hay Layer:* A layer of hay can be placed to separate the drainage layer from the filter layer above to prevent subsidence or plugging of the sand/gravel/stone layer and/or pipe.
- *Soil Filter Media - OPTION 1:* Soil filter media consists of a silty sand soil or soil mixture combined with a mature, moderately fine shredded bark or wood fiber mulch 20% to 25% by volume (no less than 10% by dry weight). The resulting mixture should have 8% to 12% passing the No. 200 sieve and a clay content of less than 2%. The proportions of the mixture can be adjusted so it will contain sufficient fines and organic matter.
  - *As an example, the soil filter media may contain the following (by volume):*
    - *50% of sand (Maine DOT specification #703.01 is close but it contains insufficient fine material for the filter media)*
    - *20% of sandy loam to fine sandy loam (Table 7.1.2).*
    - *30 % of mature composted woody fibers and fine shredded bark, superhumus or equivalent (adjusted for mineral soil content).*
- *Layered System with Topsoil - OPTION 2 :* Option 2 provides for a layered system that takes advantage of the characteristics of natural soils. A filter media mixed from different sources may lack nutrients, may be unable to retain moisture (because of its coarseness), and may be devoid of micro-organisms (such as fungus, bacteria and nematodes) which are found in a natural soil and which benefit the germination and establishment of vegetation. Natural soils contain these important organisms and provide superior filtration. The different layers from the bottom up are:
  - *Filter Layer:* A 12-inch layer of loamy coarse sand which is loosely installed and meets the grain size specification of Table 7.1.3.
  - *Topsoil:* The surface of the basin should be covered with 6 inches of non-clayey, loamy topsoil such as USDA loamy sand topsoil with 5 to 8% humified organic content. Topsoil from the development site may be appropriate but should be tested for organic content and clay content (hydrometer test). The soil must be screened, loose, friable, and shall be free from admixtures of subsoil, refuse, stones (greater than 2 inches in diameter), clumps, root and other undesirable foreign matter. The topsoil should be gently mixed within the filter layer to provide continuity for deep root penetration. The teeth of a backhoe, a hand rake, a shovel or rototilling 2-3 inches may be used to create a loosened transition.

Table 7.1.2 - Sandy Loam to Fine Sandy Loam Specifications

Sieve #	% Passing by Weight
No. 4	75-95
No. 10	60-90
No. 40	35-85
No. 200	20-70
200 (clay size)	< 2.0

Table 7.1.3 - Loamy Coarse Sand Specifications

Sieve #	% Passing by Weight
No. 10	85-100
No. 20	70-100
No. 60	15-40
No. 200	8-15
200 (clay size)	<2.0

- *Clay Content:* The media mixture should have very little or no clay content as tested via hydrometer test. Soils with more than 2% clay content could cause failure of the system.
- *Filter Permeability:* The filter must be permeable enough to insure drainage within 24 to 48 hours, yet have sufficient fines to insure the filtration of fine particles and the removal of dissolved pollutants. The design may either rely on the soil permeability, if known, to provide the slow release of the water treatment volume, or may insure this rate by installing a constrictive orifice or valve on the underdrain outlet. In determining the permeability of the media, the amount of fines of the mixture and the level of compaction should be considered.
- *Gradation testing:* Gradation tests, including hydrometer testing for clay content, and permeability testing of the soil filter material, should be performed by a qualified soil testing laboratory and submitted to the DEP for review before placement.
- *Seeding and Mulching:* The filter bed should be seeded with a drought tolerant grass mix and mulched. Watering is recommended to establish a healthy vegetation base.

Geotextile Fabric: A geotextile fabric may be placed between the sides of the filter layer and adjacent soil to prevent the surrounding soil from migrating into and clogging the filter or clogging the outlet. Seams should be overlapped a minimum of 12 inches. Do not wrap fabric over the pipe bedding as it may clog and prevent flows out of the filter. The geotextile fabric should be Mirafi 170N or equivalent.

Impermeable Liner: An impermeable liner may be required if the basin is located over highly permeable soils or with less than 18 inches of separation between the bottom of the underdrain and the top of bedrock or the high seasonal water table, if the basin drains an impervious area that is greater than one acre or greater than 2 acres of developed area, and the impervious area is considered a hot spot (public road, fuel handling facility, high use parking and drive-through lanes, industrial facility, vehicle maintenance facility, etc.). The liner must seamlessly extend up the sides of the basin and be anchored into the subgrade.

Construction: Erosion and sedimentation from unstable construction areas is the most common reason for filter failure. The soil filter media should not be installed until the area that drains to it has been permanently stabilized or unless the runoff is diverted around the filter

- *Construction Components:* Underdrained filters consist of (from bottom up):
  - A geotextile fabric to separate the filter basin from the natural soils. An impermeable membrane may be required if groundwater impact or contamination is a concern, or if it may influence the effectiveness of the basin.
  - A 12-inch base of coarse clean stone or coarse gravel in which a 4-inch to 6- inch perforated underdrain pipe system is bedded.
  - A gravel transition layer, if necessary.
  - An 18-inch layer of uncompacted soil filter media.
  - A surface cover of grass and mulch.
- *Basin Excavation:* The basin area may be excavated for underdrain installation and can be used as a sediment trap during construction. After excavation of the basin, the outlet structure and piping system may be installed if protected with a sediment barrier.
- *Sacrificial Mulch cover:* If the basin will be used as a sediment trap, the sides of the embankments must be stabilized and maintained to prevent erosion. The basin will need to be restored for its planned purpose after construction. Before final stabilization of the drainage area to the basin, a 2-inch to 3-inch layer of sandy loam (with less than 2% clay content) may be spread on the surface of the soil filter media as a sacrificial protection layer. The sacrificial layer will need to be removed at the end of construction, and the soil filter media will need to be seeded and mulched.
- *Compaction of Soil Filter:* Filter soil media and underdrain bedding material should be applied to reach a bulk density of between 90% and 92% standard proctor. The soil filter media should be installed in at least two lifts of 9 inches to prevent pockets of loose media.
- *Remedial Loam Cover:* If vegetation is not established within the first year, the basin may be rototilled, reseeded and protected with a well-anchored erosion control blanket. Or, a 2-inch to 3-inch layer of fine sandy loam may be applied before seeding and mulching.
- *Construction Oversight:* Inspection of the filter basin must be provided for each phase of construction by the design engineer with required reporting to the DEP. All material intended for the filter basin must be approved by the design engineer after tests by a certified laboratory show that the material conforms to all DEP specifications. At a minimum, inspections will occur:
  - After the preliminary construction of the filter grades and once the underdrain pipes are installed (not backfilled);
  - After the drainage layer is constructed and prior to the installation of the soil filter media;
  - After the soil filter media has been installed, seeded and mulched; and
  - After one year, to inspect vegetation and make corrections.

Testing and Submittals: The source of each component of the soil filter media needs to be identified prior to construction. All results of field and laboratory testing must be submitted to the DEP for approval.

- *Media Source:* Samples of each type of material should be blended for the mixed filter media and underdrain bedding material. Samples must be a composite of three different locations (grabs) from the stockpile or pit face. Sample size requirements will be determined by the testing laboratory.
- *Sieve Analysis:* A sieve analysis conforming to ASTM C136 should be performed on each type of the sample material.
- *Permeability Testing:* Testing the permeability of the soil filter media mixture is recommended with the mixture at a measured bulk dry density of 90-92% based on ASTM D698.

Maintenance: The basin should be inspected semi-annually and following major storm events. Debris and sediment buildup should be removed from the forebay and basin as needed. Any bare area or erosion rills should be repaired with new filter media, seeded and mulched.

- *Maintenance Agreement:* A legal entity should be established with responsibility for inspecting and maintaining any underdrained filter. The legal agreement establishing the entity should list specific maintenance responsibilities (including timetables) and provide for the funding to cover long-term inspection and maintenance.
- *Drainage:* The filter should within 24 to 48 hours following a one-inch storm or greater. If the system drains too fast, an orifice may need to be added on the underdrain outlet or may need to be modified if already present.
- *Sediment Removal:* Sediment and plant debris should be removed from the pretreatment structure at least annually.
- *Mowing:* If mowing is desired, only hand-held string trimmers or push-mowers are allowed on the filter (no tractor) and the grass bed should be mowed no more than 2 times per growing season to maintain grass heights of no less than 6 inches.
- *Fertilization:* Fertilization of the underdrained filter area should be avoided unless absolutely necessary to establish vegetation.
- *Harvesting and Weeding:* Harvesting and pruning of excessive growth should be done occasionally. Weeding to control unwanted or invasive plants may also be necessary.
- *Grass cover:* Maintaining a healthy cover of grass will minimize clogging with fine sediments. If ponding exceeds 48 hours, the top of the filter bed should be rototilled to reestablish the soil's filtration capacity.
- *Soil Filter Replacement:* The top several inches of the filter can be replaced with fresh material if water is ponding for more than 72 hours, or the basin can be rototilled, seeded and mulched. Once the filter is mature, adding new material (a 1-inch to 2-inch cover of mature compost) can compensate for subsidence.