Chapter 7.3 - Subsurface Sand Filters

A chamber system and surrounding aggregate over a subsurface sand filter is designed to store, and discharge the stormwater at an attenuated rate to reduce the thermal impacts downstream of the system. The stormwater rises in the chambers and is filtered vertically out of the open bottom through the filter and to the storage and treatment area of adjacent chambers, sand filter and underdrain.

Subsurface soil filters with a detention/retention chamber system require much more care in their design, construction and maintenance than a vegetated filter basin as it does not provide a source of organic matter for filtration, long-term permeability and evapotranspiration. Thus, a pretreatment structure must be provided to ensure the long-term effectiveness of a subsurface sand filter. As an example, a fabric wrapped row of chambers will provide the necessary pre-treatment as it can provide an initial settlement and filtration of contaminants if it is accessible for cleaning. As an alternative, a pre-treatment manufactured flow-through box may be provided if approved by the Department of Environmental Protection. Approval and all design specifics concerning a proprietary pretreatment structure for its siting, sizing, construction or maintenance is provided in a letter to the manufacturer. The letters are provided in Appendix B.

Structure Siting: The following criteria apply to all underdrained subsurface sand filters:

- *Drainage Area:* The size of the subsurface underdrained sand filter and chamber system is based on its storage capacity and the drainage area contributing to the structure.
- *Subsurface Investigation:* Subsurface explorations (test pits or borings) should be made within the filter area to identify depths to seasonal high groundwater and bedrock. Explorations should extend to below the proposed filter bottom elevation.
- *Separation from Seasonal High Watertable:* The bottom of the underdrained sand filter should be at a minimum one (1) foot above the seasonal high groundwater table, unless an impermeable liner or other design elements are employed.
- *Separation from Bedrock:* The bedrock surface may be no closer than 1 foot from the bottom of the underdrained sand filter, unless an impermeable liner or other design elements are employed.
- *Permeable Soils:* Underdrained subsurface sand filters can be designed to infiltrate in hydrologic soil groups A and B (sand and gravel) provided that the design and siting criteria for infiltration can be met. Otherwise, an impermeable liner (not clay) or other design elements may be necessary. The structure will not need a liner and will not need to be designed as an infiltration system if its drainage area of the project:
    - Contains less than one acre of imperious area,
    - Consists only of roof,
    - Is a single family residential subdivision,
    - Is not a facility that has high turnover parking, stocks hazardous products, or provides vehicle services and maintenance,
    - Is not an industrial facility.

  However, a minimum one (1) foot separation distance should be maintained from the bottom of the sand filter to seasonal high groundwater or bedrock.

Structure Design: The following criteria apply to all underdrained subsurface sand filters:

- *Phosphorus:* When used to meet the phosphorus allocation in lake watersheds, the sizing of the underdrain filter structures needs to be adjusted in accordance with Volume II of this BMP manual.
- *Treatment Volume:* An underdrained sand 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 system.
- *Impoundment Depth:* The temporary ponding depth within the chamber system for the water quality volume should not exceed 18 inches. Additional storage with more depth may be provided to detain runoff for flooding control.
- *Filter Area*: 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 system.

- *Drain Time:* A filter basin should drain dry in no less than 24 and no more than 48 hours
- *Construction Components:* An underdrained chamber system is installed in an excavated area that is at least 5 feet deep; and is layered as follow:
  - A geotextile fabric between the natural subbase soils and constructed media. It may be omitted over clean soils (little or no fines) or if the seasonal high groundwater table is 3 or more feet below the bottom of the drainage layer.
  - A 12-14 inches of coarse clean stone with a piping system of 4 to 6-inch perforated pipes,
  - A layer of well compacted sand filter media at least 18 inches thick, and
  - Any transition layer necessary to separate the different layers (geotextiles may clog).
- *Hydrocarbon Pretreatment:* A sump skimmers, sorbent boom, or other similar device should be provided in catchbasins draining to the subsurface chamber system to minimize the discharge of hydrocarbons when the draining area is a likely source of hydrocarbons (i.e. parking lots, roads, etc.).

Drainage Layer Components:

- *Underdrain Pipe:* The pipe underdrain must be properly laid out to drain the entire filter area. At least one line of underdrain pipe should be provided for every eight feet of the filter area's width. The underdrain piping should be 4" to 6" slotted, rigid schedule 40 PVC or SDR35. An orifice may be needed to control the release of the water quality volume over 24 to 48 hours.
- *Pipe Bedding and Transition Zone:* The underdrain pipe(s) should be bedded in a minimum of 12 inches of underdrain aggregate with at least 4 inches of material beneath the pipe and 4 inches above. The underdrain bedding material should consist of a clean gravel meeting the MEDOT specification 703.22 Underdrain Type C for Underdrain Backfill Material. Crushed stone bedding material may be used; however it will need 6-inch transition layer of well graded, clean, coarse gravel meeting the MEDOT specification 703.22 Underdrain Type B for Underdrain Backfill Material. Fines passing the #200 sieve in the gravel should be no more than 5% (preferably 2%). The gradation for these materials is shown on Table 7.3.1.
- *Inspection Ports:* Inspection ports to the underdrain gravel layer should be provided with at least one port per 500 square feet of subsurface filter area. The system should be inspected after every major storm in the first few months to ensure proper function and annually thereafter.

Table 7.3.1 - Maine DOT Specifications for Underdrains (MEDOT #703.22)

Sieve Size	% by Weight
UNDERDRAIN - TYPE B	
1”	90-100
½”	75-100
#4	50-100
#20	15-80
#50	0-15
#200	0-5
UNDERDRAIN - TYPE C	
1”	100
¾”	90-100
3/8”	0-75
#4	0-25
#10	0-5

Table 7.3.2 - Maine DOT Specifications for Aggregate (MEDOT #703.01)

Sieve Size	% by Weight
3/8”	100
#4	95-100
#8	80-100
#16	50-85
#30	25-60
#60	10-30
#100	2-10
#200	0-5 (8-10% is preferred)

Sand Filter:

- *Sand Filter Bed:* The sand filter should be at least 18 inches thick over the gravel underdrain bedding and should extend across the bottom of the entire filter area. This material should be uniform, free of stones, stumps, roots, or other objects larger than two inches. The preferred material should meet the specifications of MEDOT # 703.01 aggregate as shown on Table 7.3.2. However, more fines would be preferable (between 8% and 10% fines passing the #200 sieve).
- *Compaction:* The material should be compacted and tested to insure adequate permeability at the desired level of compaction (92 to 95% Proctor). The material should drain within 24 and 48 hours after compaction.
- *Clay Content:* The filter material should have very little or no clay content as tested by hydrometer. 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 48 hours maximum, yet be able to filter fine particles and retain dissolved pollutants. The filter's permeability can be used to provide the slow release of the water treatment volume, or the discharge rate may be controlled with 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.
- *Aggregate Backfill around Flexible Chambers:* Clean, crushed, angular stone with a nominal size distribution of ¾ to 2 inches, or as suggested by the manufacturer, should support the chambers.

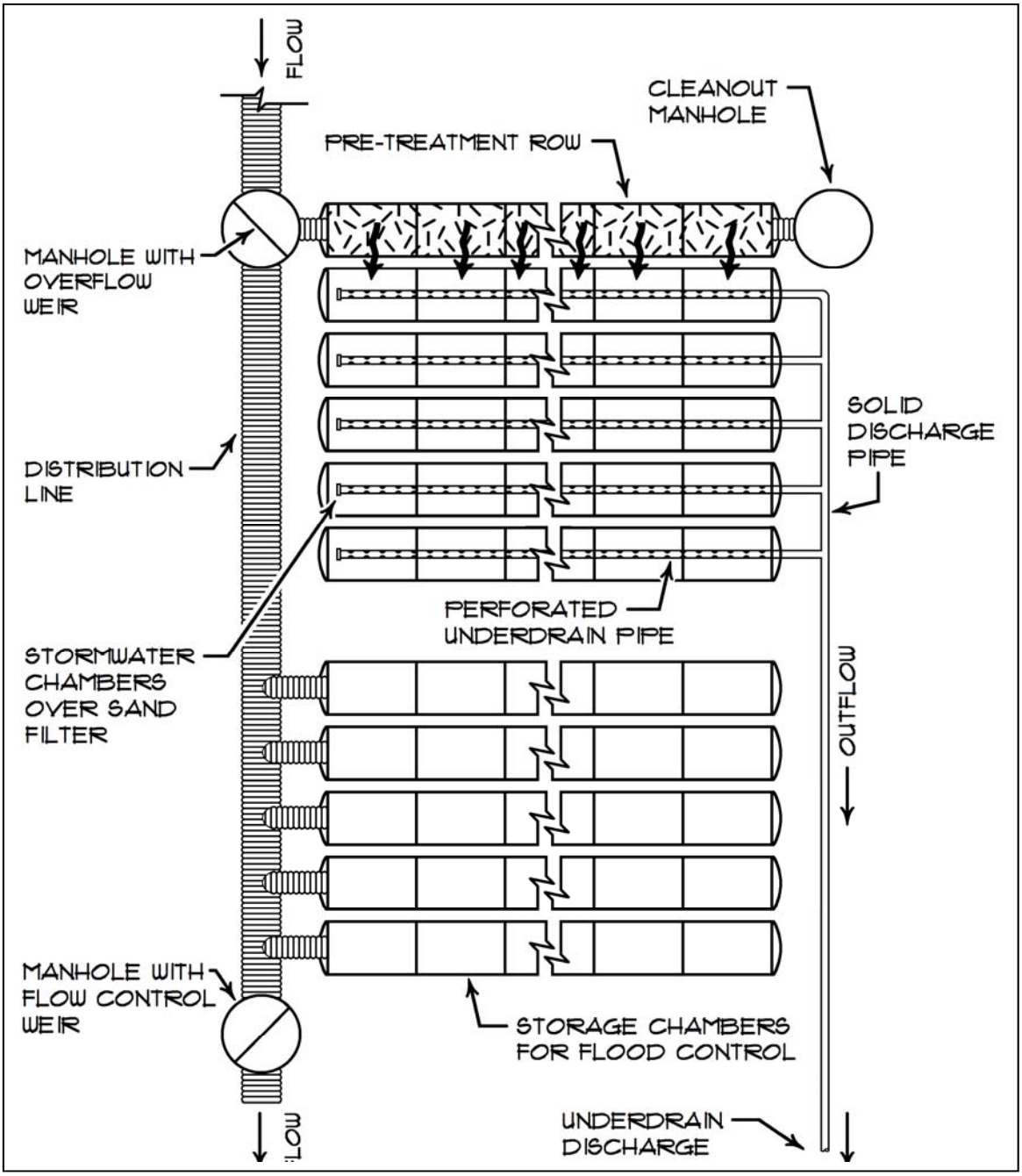

Figure 7.3.1 – Subsurface Sand Filter with Detention Plan View

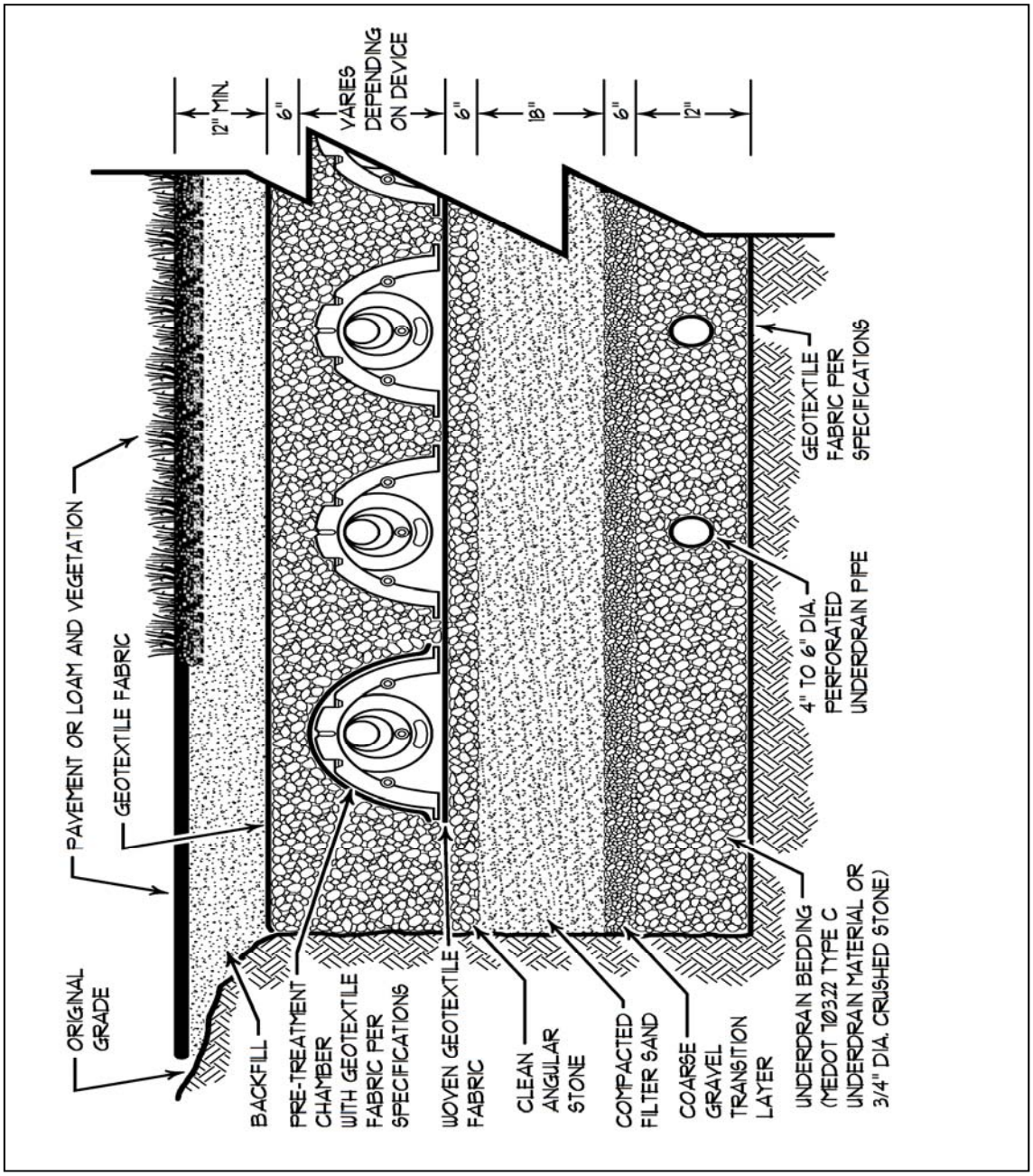

Figure 7.3.2 – Cross-Section of a Subsurface Sand Filter with Chambers

Pre-Treatment: Because accessing a subsurface filter for maintenance is difficult, protecting the long-term effectiveness of the sand layer is essential, a pre-treatment system that is maintainable must be provided. At this time, only proprietary systems that have been tested and show to have an effective sediment removal rate, long-term effectiveness and access for maintenance are acceptable and pre-approved by the Department. A 5-year maintenance contract for regular seasonal inspection of the system and for the cleaning the device will be required. All proprietary pre-treatment systems must be approved by the Department. The design and sizing of currently approved systems are specified in letters that are found in Appendix B of this manual.

- *Pre-Treatment Flow-Through Structure:* Flow-through pre-treatment systems that process or filter 90% of the annual runoff volume from its drainage area without overflowing may be approved. See Figure 7.3.3 representing a subsurface sand filter with a flow-through pre-treatment structure, Figure 7.3.4 for its cross-section.
- *Pre-Treatment Chamber Structure:* A row of chambers wrapped in filter fabric may be provided as pre-treatment. A list of approved pre-treatment chambers is provided in Appendix B. See the graphic representation of a subsurface sand filter with a flow-through pre-treatment structure. In the instance that a pre-treatment chamber row is considered, the following must be provided:
    - *Access/Diversion Structure:* An adequately sized structure placed directly in front of the chamber treatment row is required for inspection and maintenance. This structure should be a minimum of 48 inch wide to allow access to the chambers, and have a weir or elevation overflow manifold. The actual size of the structure may vary based on the weir design, pipe sizes, pipe angles and flow rate over the weir. A second structure and manhole must be provided at the opposite end of the row for maintenance. Additional access structures should be provided when the length of the treatment row exceeds 50 feet.
    - *Capacity:* The pre-treatment row must have the flow capacity of the peak flow from a one-year 24-hour storm event without overflowing.
    - *Overflow:* An overflow before the treatment row should be directed towards additional storage chambers, to a suitable discharge location; but not to the system with the sand filter and underdrain. The elevation of the weir/manifold is typically set between the elevations of the midpoint of the chamber and the top of the chamber.
    - *Geotextile Filter Fabric Composition:* Two layers of a woven geotextile fabric meeting AASHTO M288 specifications or equivalent should be placed between the stone and the pre-treatment chambers for stormwater filtration, a durable surface for maintenance operations (to prevent scour of the underlying stone during high pressure jetting). A layer of either woven or non-woven geotextile is required over the side of perforated chambers to filter flows through the sidewalls.
    - *Multiple Pre-treatment Rows:* A treatment row is required for each inlet point if more than one enters the detention system. If the number of chambers required exceeds the available length of treatment, a second row of chambers can be placed adjacent to the first row. However, separate access structures are required for each row.

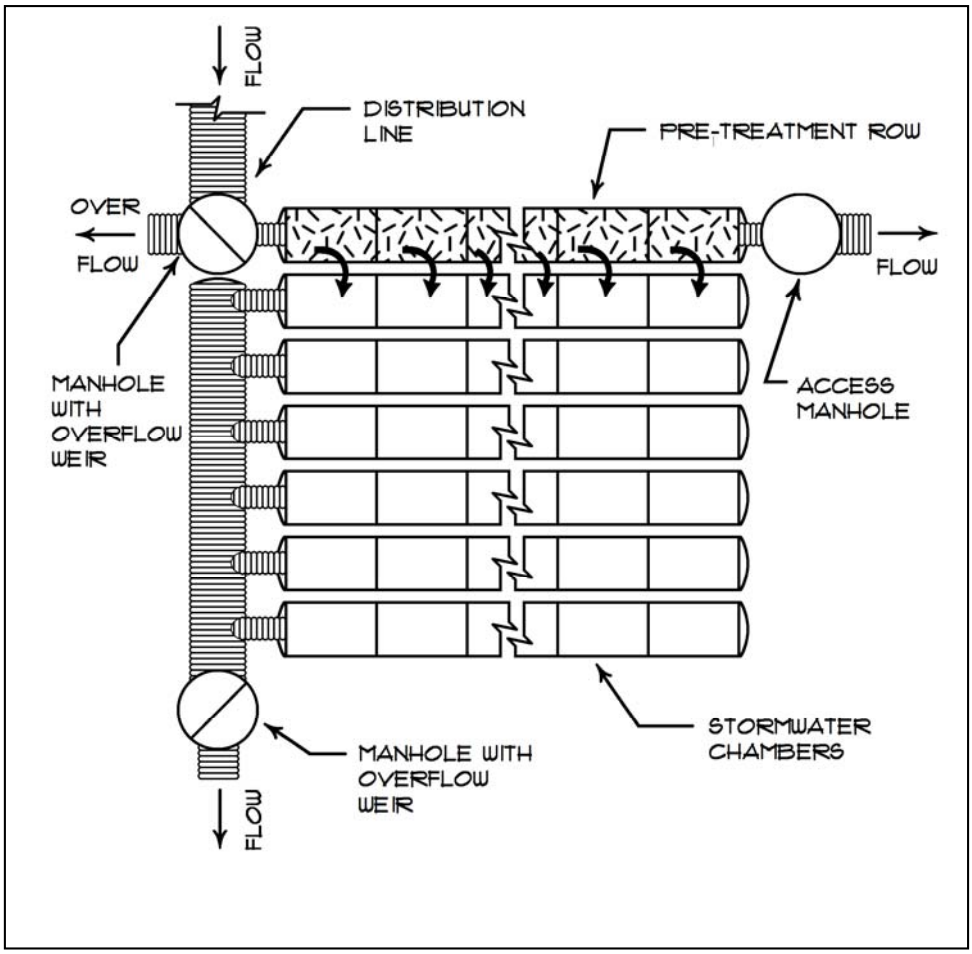

Figure 7.3.3 - Layout of a Subsurface System with a Pretreatment Row

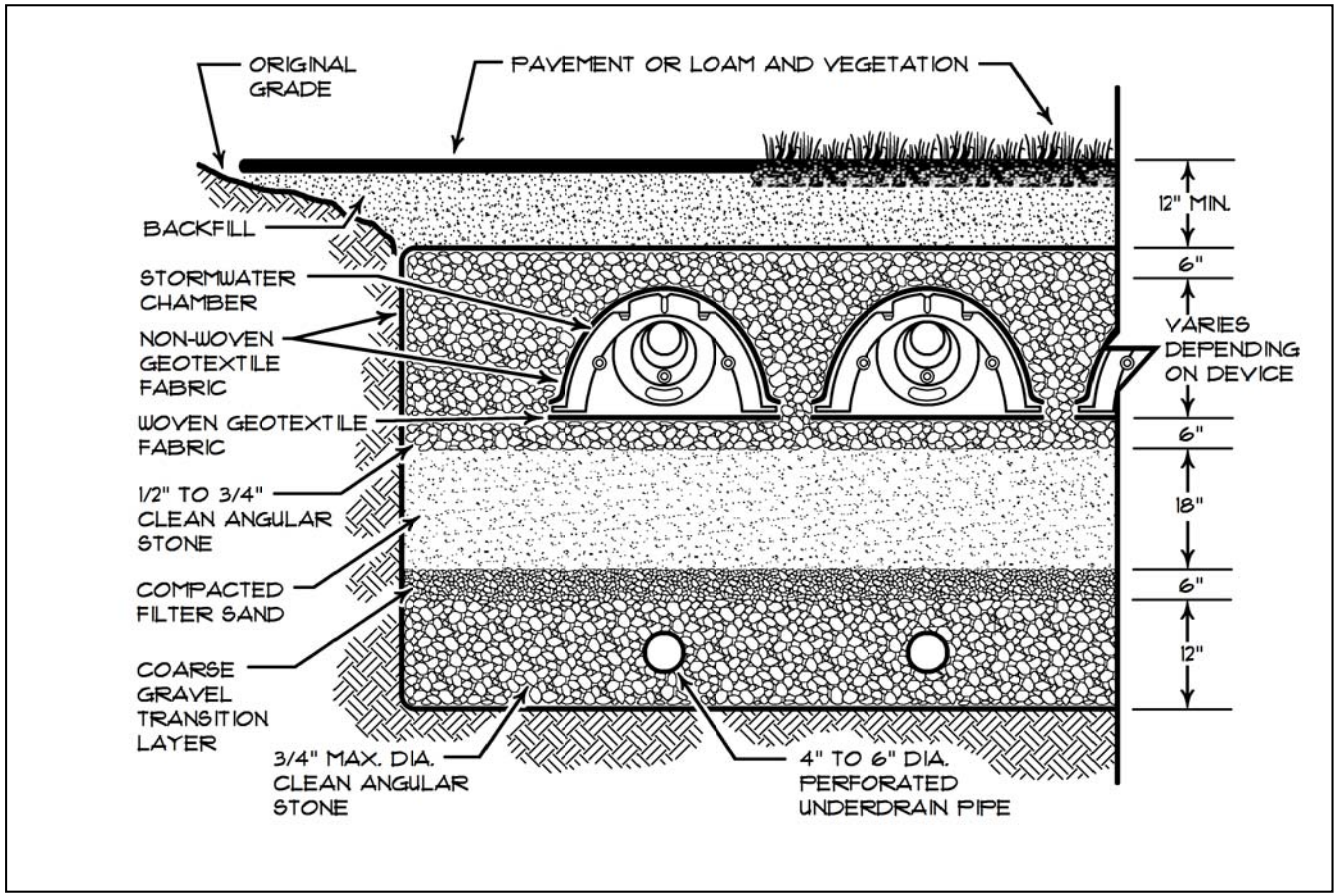

Figure 7.3.4 – Cross-section of a Chamber Pretreatment Row

Outlet: The channel protection volume must be discharged through a network of underdrain pipe placed below the sand filter or through a proprietary filter system approved by the Department. The outlet of the underdrain pipe system should have a single outlet with a diameter that is no greater than eight inches

- *Outlet:* The channel protection volume is typically discharged through an outlet control structure with a weir plate controlling the release rate from the chamber system via a series of orifices or weir crests. The outlet plate is designed to obtain the required 24 to 48 hour release time.
- *Regulated 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 subsurface chamber system, the contractor should flood the vegetated basin to the design elevation with clean water and adjust the outflow to obtain a 24 hour to 48 hour release time.
- *Connection Pipes:* All connection pipes should be 12" in diameter or greater. A chambered pre-treatment row system and the chambers over the sand filter and underdrain should not be connected with a pipe.
- *Flooding Control Outlet*: Flood volumes are typically discharged through an outlet control structure with a weir plate controlling the release rate from the chamber system via a series of orifices or weir crests to manage the peak flow rates.
- *Downgradient Discharge Area:* Each underdrain system must discharge to an area capable of withstanding concentrated flows and saturated conditions without eroding.

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

- *Manufacturers Specifications:* The chamber system must be installed in accordance with the manufacturer's written instructions for installation. Inspection during and after construction and until the site is stabilized must be performed by the manufacturer's representative.
- *Site Preparation:* Requirement for subgrade soil bearing capacity should meet or exceed the chamber manufacturer's allowable subgrade soil bearing capacity.
- *Basin Excavation:* The basin area can be used as a sediment trap during construction before the installation of the subsurface system but the outlet structure and piping system must be protected from sedimentation with a sediment barrier. If the basin is to be used as a sediment trap, the sides of the embankments must be stabilized and maintained to prevent erosion. During the installation of the chamber system and sand filter, the excavation should be free of standing water.
- *Site Stabilization:* The site must be completely stabilized before water is discharged to the subsurface sand filter. Sediments from an unstabilized site affect the design flow rates of the measure and require cleaning prior to system use.
- *Compaction of Soil Filter:* Filter sand media and underdrain bedding material should be compacted to between 90 and 92% standard proctor. The filter should be installed in at least 2 lifts of 9 inches to prevent pockets of loose media.
- *Construction Sequence:* Any runoff from an unstable contributing drainage area should be diverted around the work area until stabilization is completed.

Maintenance: A legal agreement between the owner and an approved maintenance operator should identity the responsible inspector, all inspection and maintenance tasks, and all financial obligations.

- *Maintenance Agreement:* A legal contract with a 5 year time period should establish maintenance responsibilities and the cost to cover long-term inspection and maintenance needs.
- *Pre-treatment Device:* Cleaning of the pretreatment device should be performed as identified by the entity holding the maintenance contractual agreement. A routine but specific inspection schedule needs to be identified for every site based on site variables such as anticipated pollutant load, percent imperviousness, land use (i.e. road, industrial, commercial, residential), etc.
- *Drainage:* The filter should be draining within 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:* **T**he pretreatment structure must be cleaned when necessary.