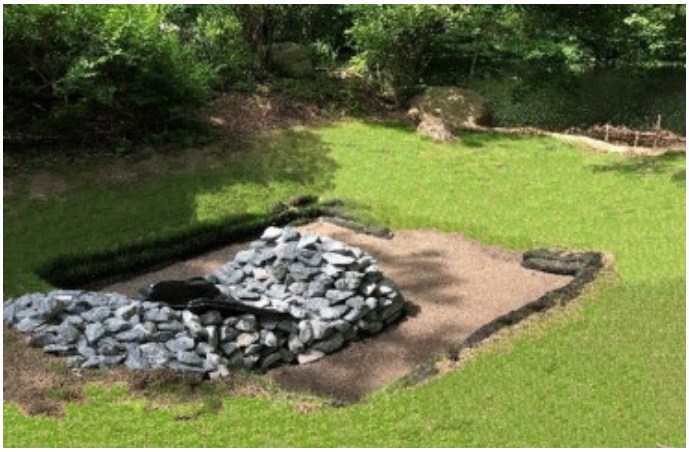
Sand Filter



Stormwater BMP Type

Pretreatment BMP	□
Infiltration BMP	□
Filtering BMP	■
Stormwater Pond BMP	□
Stormwater Wetland BMP	□
Water Quality Conveyance BMP	□
Stormwater Reuse BMP	□
Proprietary BMP	□
Other BMPs and Accessories	□

Stormwater Management Suitability

Retention	■
Treatment	■
Pretreatment	□
Peak Runoff Attenuation	■

Pollutant Removal

Sediment*	**High**
Phosphorus	**Moderate**
Nitrogen	**Moderate**
Bacteria	**High**

*Includes sediment-bound pollutants and floatables (with pretreatment)

/mplementation

Capital Cost	**Medium**
Maintenance Burden	**High**
Land Requirement	**Medium**

Description

Sand filters are sand-filled basins or trenches that capture, temporarily store, and filter stormwater runoff. Sand filters can be designed as surface filters or underground filters. The design guidelines in this section focus on surface sand filters. Sand filters require less space than other filtering practices but must be in locations with adequate elevation to provide the necessary hydraulic head. Sand filters have higher longevity than other filtering practices and generally have a lower land requirement than bioretention basins.

Sand filters are frequently designed to infiltrate but are always equipped with an underdrain to capture filtered water and assist with drainage from the system. Following pretreatment, stormwater is temporarily stored above the surface of the sand filter and flows downward through a layer of sand that filters the runoff before discharging from the system through an underdrain or into the underlying soil via infiltration. Pollutants in runoff are treated in sand filters through the processes of settling, filtration, and adsorption. Surface sand filters may also be used to provide stormwater quantity control when designed as on-line facilities.

Sand filters are better suited for impervious drainage areas. They are not recommended for use in pervious drainage areas where high sediment loads, and organic material can clog the sand bed.

Advantages

- Applicable to small drainage areas.
- May require less space than other BMPs.

- Ideal for stormwater retrofits and highly developed sites.
- High solids, metals, and bacteria removal efficiency.
- High longevity.

Limitations

- Limited to smaller drainage areas.
- Frequent maintenance required.
- Typically require a minimum head difference of approximately 5 feet between the allowable pool elevation above the filter and outlet of the filter.
- Not feasible in areas of high-water tables.
- Should not be used in areas of heavy sediment loads (i.e., unstabilized construction sites).
- Can be unattractive without grass or vegetative cover. Bioretention may be a more aesthetically pleasing alternative due to incorporation of more diverse selection of plants.

Siting Considerations

- **Drainage Area and Head:** The maximum contributing drainage area for surface sand filters is 5 acres. Sand filters are best located where there is adequate surface area to temporarily store stormwater and enough elevation difference (2 to 6 feet) between the design pool elevation and the outlet of the sand filter (underdrain or underlying soil).

- **Slopes:** Sand filters can be used on sites with slopes of approximately 6 percent or less. Locate sand filters where the topography allows the design of the sand filter bottom to be level.

- **Soils:** Sand filters that return filtered runoff to the conveyance system and do not infiltrate into the ground can be used in almost any soil type. Sand filters that rely on infiltration should be used only when the soil infiltration characteristics are appropriate (see Chapter 10 - General Design Guidance for Stormwater Infiltration Systems for design guidance for stormwater infiltration systems).

- **Land Use:** Sand filters are suitable in urban and rural settings. Sand filter systems are generally applicable to highly impervious sites. Potential locations include along shared-use paths, along borders of parking lots, and within available open space/pervious areas. Sand filters should be sited in locations that will not be used as dedicated snow storage areas and which have low likelihood for pedestrian traffic.

- **Water Table and Bedrock:** For sand filters designed for infiltration (unlined systems), at least 3 feet of separation is recommended between the bottom of the sand and the seasonal high groundwater table (SHGT) and bedrock to maintain adequate drainage, prevent structural damage to the filter, and minimize the potential for interaction with groundwater. The vertical separation distance to the SHGT or bedrock may be reduced to 2 feet as described in Chapter 10 - General Design Guidance for Stormwater Infiltration Systems.

Soil Evaluation

- Conduct an evaluation of the soil characteristics and subsurface conditions at the location of the proposed system including soil type, depth to the seasonal high groundwater table, depth to bedrock, and soil infiltration rate. Refer to Chapter 10 - General Design Guidance for Stormwater Infiltration Systems for soil evaluation guidance.

Design Recommendations

General Considerations

This section addresses two types of surface sand filter designs. Figure 13-21 is a schematic of a surface sand filter design. (See Table 13-9):

- **Surface Sand Filter with Underdrain - Unlined (Partial Infiltration System):** All surface sand filters should be designed with an underdrain to account for potential infiltration failure due to clogging, groundwater mounding, or periods of excessive rainfall. Underdrained systems can be used with any soil type or soil infiltration rate. The underdrain should be raised above the bottom of the system to maximize infiltration. Underdrained sand filter systems (without a liner) are suitable for providing stormwater retention, although only the infiltrated volume (not the volume discharged via the underdrain) can be credited toward the Standard 1 retention requirement.

- **Surface Sand Filter with Underdrain and Liner (Flow-Through System):** An underdrain and liner are required for use with Land Uses with Higher Potential Pollutant Loads (LUHPPLs) (see Chapter 10 - General Design Guidance for Stormwater Infiltration Systems), in locations where contaminated soils exist, where the required vertical separation to SHGT cannot be met, or in locations with unacceptable horizontal setbacks for infiltration. Such systems are suitable for providing treatment but do not provide retention credit.

Figure 13-21 is a schematic of a surface sand filter design.

Table 13-6. Surface Sand Filter Design Types

Type of System	Underdrain Type	Infiltration or Filtration Design?	Suitable for Retention?	Suitable for Treatment?	General Conditions for Use
Surface Sand Filter with Underdrain – Unlined Partial Infiltration System	Raised Underdrain	Infiltration and Filtration	Yes (infiltration volume only)	Yes	All HSG Soil types
Surface Sand Filter with Underdrain and Liner Flow-Through System	Underdrain and Impermeable Liner	Filtration Only	No	Yes	Land Uses with Higher Potential Pollutant Loads Contaminated sites Where required vertical separation to SHGT cannot be met Sites with unacceptable setback distances for infiltration

Pretreatment

- Incorporate pretreatment measures at locations where runoff enters the sand filter in accordance with the Pretreatment BMPs section of this Manual.
- Acceptable pretreatment measures include vegetative filter strips, sediment forebays, pretreatment swales, deep sump hooded catch basins, and proprietary pretreatment devices.
- Sediment forebays should have a minimum storage volume of 25% of the Water Quality Volume (WQV) and release it to the filter media over a 24-hour period, while flow-through Pretreatment BMPs should treat at least the equivalent Water Quality Flow (WQF).

Sizing and Dimensions

- Surface Sand Filter Bed (Bottom) Area
  - Sand filter should be designed by either the Static or Dynamic Methods as described in Chapter 10 - General Design Guidance for Stormwater Infiltration Systems.
  - Sand filter should completely drain in 48 hours or less after the end of the design storm as described in Chapter 10.
  - For the drain time analysis, use the coefficient of permeability of the filter media (3.5 feet per day or 1.75 inches per hour for sand). If the sand filter is designed

with a loam surface, use a coefficient of permeability value of 1.0 feet per day or 0.52 inches per hour.

- Sand Filter Bed Thickness
  - 18 inches (minimum)
  - Filter bed thickness may be limited by the requirement to maintain adequate separation to groundwater and bedrock as specified in Chapter 10.

- Ponding Depth
  - Maximum for water quality storm: 24 inches
  - Maximum for overflow events: 36 inches

- Bottom Width
  - Minimum: 4 feet

- Bottom Slope
  - Design the top and bottom of sand filter bed to be level.

- Side Slopes
  - Maximum: 3(H):1(V) slopes. If site topography does not allow for 3(H):1(V) slopes, vertical concrete walls with a maximum height of 30 inches can be used.

Inlet

- Design the inlet in accordance with the Inlet and Outlet Controls section of this Manual.

- Runoff can be introduced to the sand filter through overland flow, curb cuts, inlet structures, swales/channels, and/or pipes.

- Design the sand filter in an off-line configuration to the extent feasible if runoff is delivered by a storm drain pipe or is along the main storm conveyance system.

Outlet & Overflow

- Design the outlet in accordance with the Inlet and Outlet Controls section of this Manual.

- Outlets are typically a stabilized spillway, gabion berm, concrete weir, precast concrete structure, or polyethylene/polyvinyl chloride riser structure.

- On-line systems should be designed to avoid erosion of the sand filter bed and have a primary outlet sized to convey the 10-year, 24-hour storm event, at a minimum, to the storm drainage system or stabilized channel. An emergency spillway is required to convey the 100-year storm event (assuming the primary outlet is not designed to pass the 100-year storm event).

- Off-line systems should be designed with a bypass or overflow for flows in excess of the water quality storm

Underdrain System

- Minimum underdrain pipe diameter: 4 inches
- Minimum underdrain pipe slope: 0.5%
- Use two layers of gravel with the underdrain system. Both layers of gravel should be located below and extend across the entire bottom of the sand filter. The upper gravel layer should consist of 3 inches of pea gravel, and the lower layer should consist of a 12-inch thick gravel sump.
- For unlined systems, install the perforated underdrain pipe 2 inches below the top of the gravel sump to promote infiltration. For systems that are lined with an impermeable liner to prevent infiltration, install the underdrain pipe 2 inches above the bottom of the gravel sump so the system can drain between storm events.
- Lay underdrain such that perforations are on the bottom of the pipe.
- Use solid (non-perforated) pipe sections and watertight joints wherever the underdrain system passes below berms, extends down steep slopes, connects to a drainage structure and/or daylights.
- Place filter fabric along sidewalls of excavation and above the pea gravel (below the sand layer) for a distance of 1 to 2 feet on both sides of the underdrain. Filter fabric shall not be placed across the entire width of the sand filter.
- Other considerations when designing/installing underdrains:
    - Provide a marking stake and an animal guard for underdrains that daylight at grade.
    - If designed with laterals, space collection laterals every 25 feet or less.
- Include a minimum of two observation wells/cleanouts for each underdrain; one at the upstream end and one at the downstream end.
- Cleanouts shall be at least 4 inches in diameter, be non-perforated and extend to the surface. Cap cleanouts with a watertight removable cap. The cleanout should be easily visible.
- Provide one cleanout for every 1,000 square feet of surface area (at a minimum) or for every 250 linear feet of total pipe length in larger systems.

Materials

- Surface Cover
    - The side slopes and surface of the sand filter bed should consist of 3 to 6 inches of loam/topsoil and grass. If a loam/topsoil and grass surface layer is selected for

the surface of the sand filter bed, use a hydraulic conductivity value of 1.04 feet per day (0.52 inches per hour) for system sizing.
    - To minimize maintenance, no additional cover material is required over the surface of the sand filter bed. Pea gravel or river stone may also be placed on top of the sand layer as an alternative to the exposed sand layer.
    - Filter fabric should not be used between the surface cover layer (if any) and the sand layer.

- Vegetation
    - Specify vegetation (e.g., drought tolerant grass) for the sand filter side slopes and on top of the sand filter bed (vegetation on the filter bed is optional) with the guidance provided in Appendix F of this Manual.

- Sand
    - Should be washed concrete sand (ASTM C33 or AASHTO M-6) or coarse washed sand that meets the gradation schedule as shown in State of Connecticut Department of Transportation Standard Specifications, Section M.01 (Aggregates), Table M.01.04-1 for Fine Aggregate Gradations.

- Pea Gravel
    - Should consist of 3/8" AASHTO No. 8 stone. Pea gravel should be clean (washed and free from dirt and debris) and rounded in shape.

- Gravel Sump
    - Should consist of 3/4" AASHTO No. 5 stone. Gravel should be clean (washed and free from dirt and debris), crushed, and angular.

- Filter Fabric
    - Use non-woven filter fabric that complies with State of Connecticut Department of Transportation Standard Specifications, Section M.08.01.19 (Drainage – Geotextiles).

- Underdrain (perforated and non-perforated pipe sections)
    - Polyethylene or polyvinyl pipe.

- Liner
    - If used, should consist of a 30 mil (minimum) HDPE or PVC liner, or one of the alternative liner systems described in Chapter 10 - General Design Guidance for Stormwater Infiltration Systems with the approval of the review authority.

- Turf Reinforcement Matting (TRM)
    - Stabilize the side slopes of the sand filter with TRM to limit erosion in locations where flow velocities exceed 3 to 5 feet per second (depending on soil and vegetation types) for the 1-year, 24-hour storm event.

- If used, shall be a woven material included on the CTDOT Qualified Products List that exceeds the design velocity of the design storm and allows for the growth of the proposed vegetative species.

Other Considerations

- If designing a lined system in a location where SHGT is located at or above the bottom of the liner or closed bottom of the system, complete a buoyancy analysis to ensure buoyancy of the system will not be an issue.

- For lined sand filters within LUHPPLs, a shutoff valve can be installed on the underdrain outlet to capture and contain accidental spills or releases that reach the bioretention system.

- Non-woven filter fabric should be placed along the sidewalls of the excavation to help direct the water flow downward, reduce lateral flows, and to reduce lateral soil migration. Place filter fabric along sidewalls of excavation and above the pea gravel (below the sand layer) for a distance of 1 to 2 feet on both sides of the underdrain. Filter fabric shall not be placed across the entire width of the sand filter.

Winter Operations

- Surface sand filters should not be used as dedicated snow storage areas. To the extent feasible, locate and design the system to avoid snow storage areas and potential damage from snow plowing activities. Refer to Chapter 7 - Overview of Structural Stormwater Best Management Practices for general design considerations related to winter operations.

Construction Recommendations

- The designing qualified professional should develop a detailed, site-specific construction sequence.

- The designing qualified professional should inspect the installation during the following stages of construction, at a minimum:
  - After excavation of the sand filter and scarification of bottom and sidewalls of excavation
  - After placement of gravel layer
  - After placement of underdrain before covering by the pea gravel layer
  - Inspection of sand material prior to placement
  - After placement and leveling of sand layer
  - After installation of bypass, outlet/overflow, and inlet controls
  - After grass and/or pea gravel surface cover have been installed

- The designing qualified professional should provide an as-built plan of the completed sand filter along with a certification that the system was designed in accordance with the

guidance contained in this Manual and other local or state requirements and that the system was installed in accordance with the approved plans.

- The entire contributing drainage area should be completely stabilized prior to directing any flow to the system. Adequate vegetative cover must be established over any pervious area adjacent or contributing to the system before runoff can be accepted.
- Erosion and sediment controls should be in place during construction in accordance with the Connecticut Guidelines for Soil Erosion and Sediment Control and the Soil Erosion and Sediment Control (SESC) Plan developed for the project.
- Sand filters should not be used as temporary sediment traps for construction erosion and sediment control.
- During clearing and grading of the site, measures should be taken to avoid soil compaction at the location of the proposed system.
- The sand filter should be fenced off during the construction period to prevent disturbance of the soils.
- The sand filter should be excavated to the dimensions, side slopes, and elevations shown on the plans. The method of excavation should avoid compaction of the bottom of the system. A hydraulic excavator or backhoe loader, operating outside the limits of the sand filter, should be used to excavate the system. Excavation equipment should not be allowed within the limits of the sand filter.
- The gravel, pea gravel, and sand layers should be placed in the excavation by a hydraulic excavator or backhoe loader located outside the limits of the sand filter and then hand-raked to the desired elevation.
- Place the sand in 6 to 12-inch lifts. Lightly tamp or spray the surface of the sand with water. The sand can be expected to settle, especially after becoming saturated. For this reason, the elevation of the sand layer can be a couple of inches higher at installation than the design elevation in anticipation of settling. Sand should be carefully placed to avoid formation of voids and short-circuiting.
- Install vegetation (e.g., drought tolerant grass) on the side slopes and surface of the sand filter in accordance with the planting plan and plant schedule on the plans. Water vegetation thoroughly immediately after planting and as necessary until fully established.

Maintenance Needs

- Surface sand filters should be designed with easy access to all components of the system for maintenance purposes. Refer to Chapter 7 - Overview of Structural Stormwater Best Management Practices for general design considerations to reduce and facilitate system maintenance.

- Detailed inspection and maintenance requirements, inspection and maintenance schedules, and those parties responsible for maintenance should be identified on the plans and in the Stormwater Management Plan.
- Maintenance should be detailed in a legally binding maintenance agreement.
- Maintenance activities such as sediment removal, mowing, and repairs should be performed with rakes and light-weight equipment rather than heavy construction equipment to avoid compaction of the filter media and underlying soils. Heavy equipment may be used for sediment removal and other maintenance activities if the equipment is positioned outside the limits of the system. Heavy construction equipment should not be allowed within the limits of the system for maintenance purposes.

Recommended Maintenance Activities

- Inspect after major storms (1 inch or more of precipitation) in the first few months following construction.
- Inspect the sediment forebay or other pretreatment area twice a year.
- Inspect the remainder of the sand filter annually.
- Refer to Appendix B for maintenance inspection checklists, including items to focus on during inspections.
- Remove trash and organic debris (leaves) in the Spring and Fall.
- Remove sediment from the sediment forebay or other pretreatment area when it accumulates to a depth of more than 12 inches or 50% of the design depth. Clean outlet of sediment forebay or other pretreatment measures when drawdown time exceeds 36 hours after the end of a storm event.
- Remove sediment from the sand filter when the sediment accumulation exceeds 2 inches or when drawdown time exceeds 48 hours after the end of a storm event, indicating that the filter is clogged. Replace with fresh washed concrete sand that conforms to the specifications in this section.
- Weed as necessary. Mow grass within sand filter to a height of 6 inches or more. Maintain a healthy, vigorous stand of grass cover; re-seed as necessary.
- Periodically remove grass clippings to prevent clogging of the surface of the sand filter.
- Mowing should not be performed when the ground is soft to avoid the creation of ruts and compaction, which can reduce infiltration.

Figure 13-21. Surface Sand Filter Schematic