2.2.15 Sand Filters

Description: Multi-chamber structure designed to treat stormwater runoff through filtration, using a sediment forebay, a sand bed as its primary filter media and, typically, an underdrain collection system.

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Typically requires 2 to 6 feet of head
- Maximum contributing drainage area of 10 acres for surface sand filter; 2 acres for perimeter sand filter
- Sand filter media with underdrain system

ADVANTAGES / BENEFITS:

- Applicable to small drainage areas
- Good for highly impervious areas
- Good retrofit capability

DISADVANTAGES / LIMITATIONS:

- High maintenance burden
- Not recommended for areas with high sediment content in stormwater or clay/silt runoff areas
- Relatively costly
- Possible odor problems

MAINTENANCE REQUIREMENTS:

- Inspect for clogging – rake first inch of sand
- Remove sediment from forebay / chamber
- Replace sand filter media as needed

POLLUTANT REMOVAL

80%	**Total Suspended Solids**
50/25%	**Nutrients** – Total Phosphorous / Total Nitrogen Removal
50%	**Metals** – Cadmium, Copper, Lead, and Zinc Removal
40%	**Pathogens** – Coliform, Streptococci, E. Coli Removal

STORMWATER MANAGEMENT SUITABILITY

P	Water Quality Protection
S	Streambank Protection
	On-Site Flood Control
	Downstream Flood Control

IMPLEMENTATION CONSIDERATIONS

L	Land Requirement
H	Capital Cost
H	Maintenance Burden

Residential Subdivision Use: No
Hi Density/Ultra-Urban: Yes
Drainage Area: 2-10 Ac. max.
Soils: Clay or silty soils may require pretreatment
Other considerations:

- Typically needs to be combined with other controls to proved water quantity control

L = Low M = Moderate H = High

2.2.15.1 General Description

Sand filters (also referred to as *filtration basins*) are structural stormwater controls that capture and temporarily store stormwater runoff and pass it through a filter bed of sand. Most sand filter systems consist of two-chamber structures. The first chamber is a sediment forebay or sedimentation chamber, which removes floatables and heavy sediments. The second is the filtration chamber, which removes additional pollutants by filtering the runoff through a sand bed. The filtered runoff is typically collected and returned to the conveyance system, though it can also be partially or fully infiltrated into the surrounding soil in areas with porous soils.

Because they have few site constraints beside head requirements, sand filters can be used on development sites where the use of other structural controls may be precluded. However, sand filter systems can be relatively expensive to construct, install, and maintain.

There are two primary sand filter system designs, the *surface sand filter* and the *perimeter sand filter*. Below are descriptions of these filter systems:

- **Surface Sand Filter** – The surface sand filter is a ground-level open air structure that consists of a pretreatment sediment forebay and a filter bed chamber. This system can treat drainage areas up to 10 acres in size and is typically located off-line. Surface sand filters can be designed as an excavation with earthen embankments or as a concrete or block structure.
- **Perimeter Sand Filter** – The perimeter sand filter is an enclosed filter system typically constructed just below grade in a vault along the edge of an impervious area such as a parking lot. The system consists of a sedimentation chamber and a sand bed filter. Runoff flows into the structure through a series of inlet grates located along the top of the control.

A third design variant, the *underground sand filter*, is intended primarily for extremely space limited and high density areas and is thus considered a limited application structural control. See subsection 2.2.16 for more details.

Surface Sand Filter **Perimeter Sand Filter**

Figure 2.2.15-1 Sand Filter Examples

2.2.15.2 Stormwater Management Suitability

Sand filter systems are designed primarily as off-line systems for stormwater quality (i.e., the removal of stormwater pollutants) and will typically need to be used in conjunction with another structural control to provide downstream streambank protection, on-site flood control, and downstream flood control, if required. However, under certain circumstances, filters can provide limited runoff quantity control, particularly for smaller storm events.

Water Quality

In sand filter systems, stormwater pollutants are removed through a combination of gravitational settling, filtration, and adsorption. The filtration process effectively removes suspended solids and particulates, biochemical oxygen demand (BOD), fecal coliform bacteria, and other pollutants. Surface sand filters with a grass cover have additional opportunities for bacterial decomposition as well as vegetation uptake of pollutants, particularly nutrients. Section 2.2.15.3 provides pollutant removal efficiencies that can be used for planning and design purposes.

Streambank Protection

For smaller sites, a sand filter may be designed to capture the entire streambank protection volume SP_v in either an off- or on-line configuration. Given that a sand filter system is typically designed to completely drain over 40 hours, the requirement of extended detention of the 1-year, 24-hour storm runoff volume will be met. For larger sites or where only the WQ_v is diverted to the sand filter facility, another structural control must be used to provide SP_v extended detention.

On-Site Flood Control

Another structural control must be used in conjunction with a sand filter system to reduce the post-development peak flow to pre-development levels (detention) if needed.

Downstream Flood Control

Sand filter facilities must provide flow diversion and/or be designed to safely pass extreme storm flows and protect the filter bed and facility.

The volume of runoff removed and treated by the sand filter may be taken in the on-site flood control and downstream flood control calculations (see Section 2.1).

2.2.15.3 Pollutant Removal Capabilities

Both the surface and perimeter sand filters are presumed to be able to remove 80% of the total suspended solids load in typical urban post-development runoff when sized, designed, constructed and maintained in accordance with the recommended specifications. Undersized or poorly designed sand filters can reduce TSS removal performance.

The following design pollutant removal rates are conservative average pollutant reduction percentages for design purposes derived from sampling data, modeling, and professional judgment. In a situation where a removal rate is not deemed sufficient, additional controls may be put in place at the given site in a series or "treatment train" approach.

- **Total Suspended Solids – 80%**
- **Total Phosphorus – 50%**
- **Total Nitrogen – 25%**
- **Fecal Coliform – 40%**
- **Heavy Metals – 50%**

For additional information and data on pollutant removal capabilities for sand filters, see the National Pollutant Removal Performance Database (2nd Edition) available at www.cwp.org and the National Stormwater Best Management Practices (BMP) Database at www.bmpdatabase.org

2.2.15.4 Application and Site Feasibility Criteria

Sand filter systems are well suited for highly impervious areas where land available for structural controls is limited. Sand filters should primarily be considered for new construction or retrofit opportunities for commercial, industrial, and institutional areas where the sediment load is relatively low, such as: parking lots, driveways, loading docks, gas stations, garages, airport runways/taxiways, and storage yards. Sand filters may also be feasible and appropriate in some multi-family or higher density residential developments.

To avoid rapid clogging and failure of the filter media, the use of sand filters should be avoided in areas with less than 50% impervious cover, or high sediment yield sites with clay/silt soils.

The following basic criteria should be evaluated to ensure the suitability of a sand filter facility for meeting stormwater management objectives on a site or development.

General Feasibility

- Suitable for Residential Subdivision Usage – NO
- Suitable for High Density/Ultra Urban Areas – YES
- Regional Stormwater Control – NO

Physical Feasibility - Physical Constraints at Project Site

- Drainage Area – 10 acres maximum for surface sand filter; 2 acres maximum for perimeter sand filter
- Space Required – Function of available head at site
- Site Slope – No more than 6% slope across filter location
- Minimum Head – Elevation difference needed at a site from the inflow to the outflow: 5 feet for surface sand filters; 2 to 3 feet for perimeter sand filters
- Minimum Depth to Water Table – For a surface sand filter with infiltration (earthen structure), 2 feet are required between the bottom of the sand filter and the elevation of the seasonally high water table
- Soils – No restrictions; Group “A” soils generally required to allow infiltration (for surface sand filter earthen structure)
- Downstream Water Surface - Downstream flood conditions need to be verified to avoid surcharging and back washing of the filter material.

Other Constraints / Considerations

- Aquifer Protection – Do not allow infiltration of filtered hotspot runoff into groundwater

2.2.15.5 Planning and Design Criteria

The following criteria are to be considered ***minimum*** *standards for the design of a sand filter facility. Consult with the local review authority to determine if there are any variations to these criteria or additional standards that must be followed.*

A. LOCATION AND SITING

- Surface sand filters should have a contributing drainage area of 10 acres or less. The maximum drainage area for a perimeter sand filter is 2 acres.

Sand filter systems are generally applied to land uses with a high percentage of impervious surfaces. Sites with less than 50% imperviousness or high clay/silt sediment loads must not use a sand filter without adequate pretreatment due to potential clogging and failure of the filter bed. Any disturbed areas within the sand filter facility drainage area should be identified and stabilized. Filtration controls should only be constructed after the construction site is stabilized.

- Surface sand filters are generally used in an off-line configuration where the water quality volume (WQ_v) is diverted to the filter facility through the use of a flow diversion structure and flow splitter. Stormwater flows greater than the WQ_v are diverted to other controls or downstream using a diversion structure or flow splitter.
- Perimeter sand filters are typically sited along the edge, or perimeter, of an impervious area such as a parking lot.
- Sand filter systems are designed for intermittent flow and must be allowed to drain and reaerate between rainfall events. They should not be used on sites with a continuous flow from groundwater, sump pumps, or other sources.

B. GENERAL DESIGN

Surface Sand Filter

- A surface sand filter facility consists of a two-chamber open-air structure, which is located at ground-level. The first chamber is the sediment forebay (a.k.a sedimentation chamber) while the second chamber houses the sand filter bed. Flow enters the sedimentation chamber where settling of larger sediment particles occurs. Runoff is then discharged from the sedimentation chamber through a perforated standpipe into the filtration chamber. After passing though the filter bed, runoff is collected by a perforated pipe and gravel underdrain system. Figure 2.2.15-6 provides plan view and profile schematics of a surface sand filter.

Perimeter Sand Filter

- A perimeter sand filter facility is a vault structure located just below grade level. Runoff enters the device through inlet grates along the top of the structure into the sedimentation chamber. Runoff is discharged from the sedimentation chamber through a weir into the filtration chamber. After passing through the filter bed, runoff is collected by a perforated pipe and gravel underdrain system. Figure 2.2.15-7 provides plan view and profile schematics of a perimeter sand filter.

C. PHYSICAL SPECIFICATIONS / GEOMETRY

Surface Sand Filter

- The entire treatment system (including the sedimentation chamber) must temporarily hold at least 75% of the WQ_v prior to filtration. Figure 2.2.15-2 illustrates the distribution of the treatment volume (0.75 WQv) among the various components of the surface sand filter, including:
    - Vs – volume within the sedimentation basin
    - Vf – volume within the voids in the filter bed
    - Vf-temp – temporary volume stored above the filter bed
    - As – the surface area of the sedimentation basin
    - Af – surface area of the filter media
    - hs – height of water in the sedimentation basin
    - htemp - depth of temporary volume
    - hf – average height of water above the filter media (1/2 htemp)
    - df – depth of filter media

- The sedimentation chamber must be sized to at least 25% of the computed WQ_v and have a length-to-width ratio of at least 2:1. Inlet and outlet structures should be located at opposite ends of the chamber.

The filter area is sized based on the principles of Darcy's Law. A coefficient of permeability (k) of 3.5 ft/day for sand should be used. The filter bed is typically designed to completely drain in 40 hours or less.

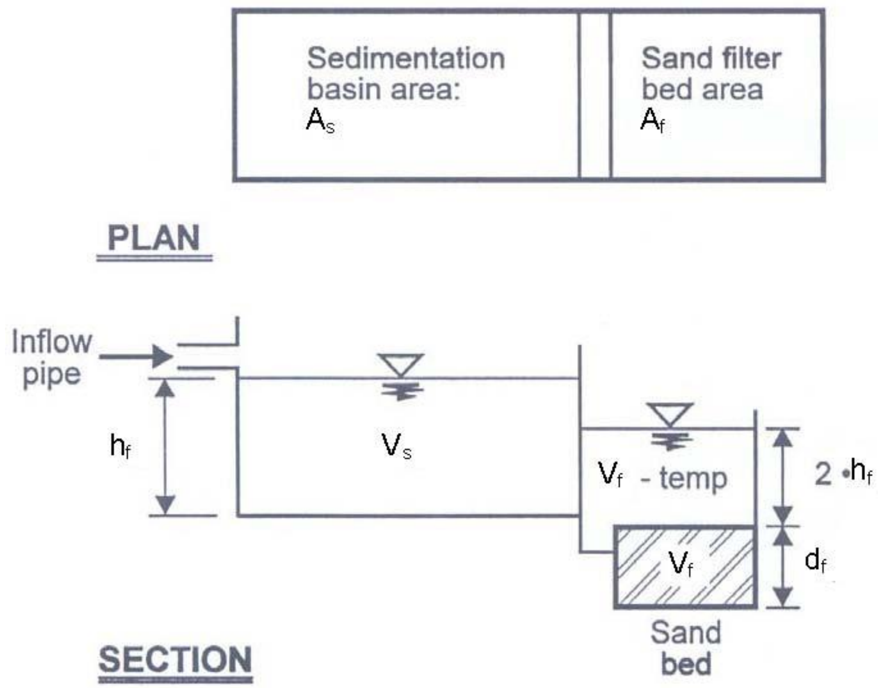

Figure 2.2.15-2 Surface Sand Filter Volumes
Source: Claytor and Schueler, 1996

- The filter media consists of an 18-inch layer of clean washed medium sand (meeting ASTM C-33 concrete sand or TnDOT Fine Aggregate for Concrete, Section 903.01) on top of the underdrain system. Three inches of topsoil are placed over the sand bed. Permeable filter fabric is placed both above and below the sand bed to prevent clogging of the sand filter and the underdrain system. A proper fabric selection with equal fore-openings is critical. Figure 2.2.15-4 illustrates a typical media cross section.
- The filter bed is equipped with a 6-inch perforated PVC pipe (AASHTO M 252) underdrain in a gravel layer. The underdrain must have a minimum grade of 1/8-inch per foot (1% slope). Holes should be 3/8-inch diameter and spaced approximately 6 inches on center. Gravel should be clean washed aggregate with a maximum diameter of 3.5 inches and a minimum diameter of 1.5 inches with a void space of about 40% meeting the gradation listed below. Aggregate contaminated with soil shall not be used.

Gradation

Sieve Size	**% Passing**
2 ½"	100
2"	90 – 100
1 ½"	35 – 70
1"	0 – 15
½"	0 - 5

- The structure of the surface sand filter may be constructed of impermeable media such as concrete, or through the use of excavations and earthen embankments. When constructed with earthen walls/embankments, filter fabric should be used to line the bottom and side slopes of the structures before installation of the underdrain system and filter media.

Perimeter Sand Filter

- The entire treatment system (including the sedimentation chamber) must temporarily hold at least 75% of the WQv prior to filtration. Figure 2.2.15-3 illustrates the distribution of the treatment volume (0.75 WQv) among the various components of the perimeter sand filter, including**:**

- V_w – wet pool volume within the sedimentation basin
- V_f – volume within the voids in the filter bed
- V_{temp} – temporary volume stored above the filter bed
- A_s – the surface area of the sedimentation basin
- A_f – surface area of the filter media
- h_f – average height of water above the filter media (1/2 h_{temp})
- h_{temp} - depth of temporary volume
- d_f – depth of filter media

- The sedimentation chamber must be sized to at least 50% of the computed WQ_v.
- The filter area is sized based on the principles of Darcy's Law. A coefficient of permeability (k) of 3.5 ft/day for sand should be used. The filter bed is typically designed to completely drain in 40 hours or less.
- The filter media should consist of a 12- to 18-inch layer of clean washed medium sand (meeting ASTM C-33 concrete sand or TnDOT Fine Aggregate for Concrete, Section 903.01) on top of the underdrain system. Figure 2.2.15-4 illustrates a typical media cross section.
- The perimeter sand filter is equipped with a 4 inch perforated PVC pipe (AASHTO M 252) underdrain in a gravel layer. The underdrain must have a minimum grade of 1/8 inch per foot (1% slope). Holes should be 3/8-inch diameter and spaced approximately 6 inches on center. A permeable filter fabric should be placed between the gravel layer and the filter media. Gravel should be clean washed aggregate with a maximum diameter of 3.5 inches and a minimum diameter of 1.5 inches with a void space of about 40% meeting the following gradation. Aggregate contaminated with soil shall not be used.

Gradation

Sieve Size	**% Passing**
2 ½"	100
2"	90 – 100
1 ½"	35 – 70
1"	0 – 15
½"	0 - 5

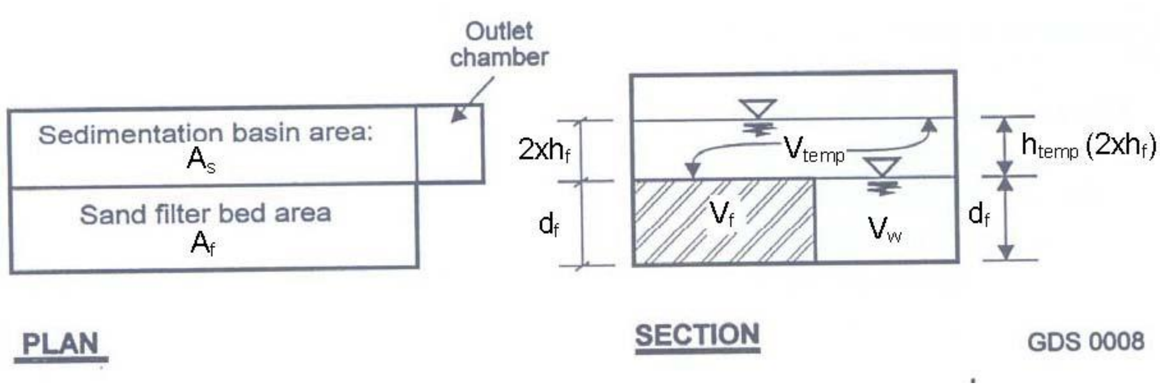

Figure 2.2.15-3 Perimeter Sand Filter Volumes
(Source: Claytor and Schueler, 1996)

D. PRETREATMENT / INLETS

- Pretreatment of runoff in a sand filter system is provided by the sedimentation chamber.
- Inlets to surface sand filters are to be provided with energy dissipaters. Exit velocities from the sedimentation chamber must be nonerosive.
- Figure 2.2.15-5 shows a typical inlet pipe from the sedimentation basin to the filter media basin for the surface sand filter.

E. OUTLET STRUCTURES

- Outlet pipe is to be provided from the underdrain system to the facility discharge. Due to the slow rate of filtration, outlet protection is generally unnecessary (except for emergency overflows and spillways).

F. EMERGENCY SPILLWAY

- An emergency or bypass spillway must be included in the surface sand filter to safely pass flows that exceed the design storm flows. The spillway prevents filter water levels from overtopping the embankment and causing structural damage. The emergency spillway should be located so that downstream buildings and structures will not be impacted by spillway discharges.

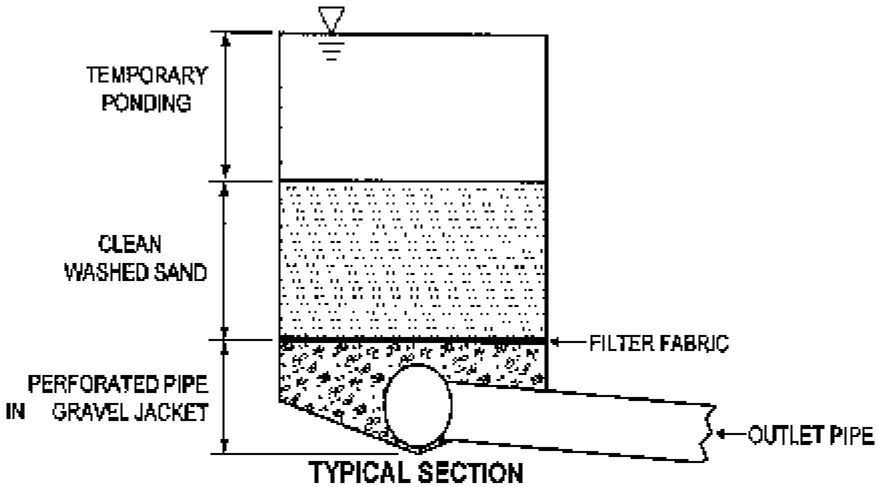

Figure 2.2.15-4 Typical Sand Filter Media Cross Sections
(Source: StormwaterCenter.net)

G. MAINTENANCE ACCESS

- Adequate access must be provided for all sand filter systems for inspection and maintenance, including the appropriate equipment and vehicles. Access grates to the filter bed need to be included in a perimeter sand filter design. Facility designs must enable maintenance personnel to easily replace upper layers of the filter media.

H. SAFETY FEATURES

- Surface sand filter facilities can be fenced to prevent access. Inlet and access grates to perimeter sand filters may be locked.

I. LANDSCAPING

- Surface filters can be designed with a grass cover to aid in pollutant removal and prevent clogging. The grass should be capable of withstanding frequent periods of inundation and drought.

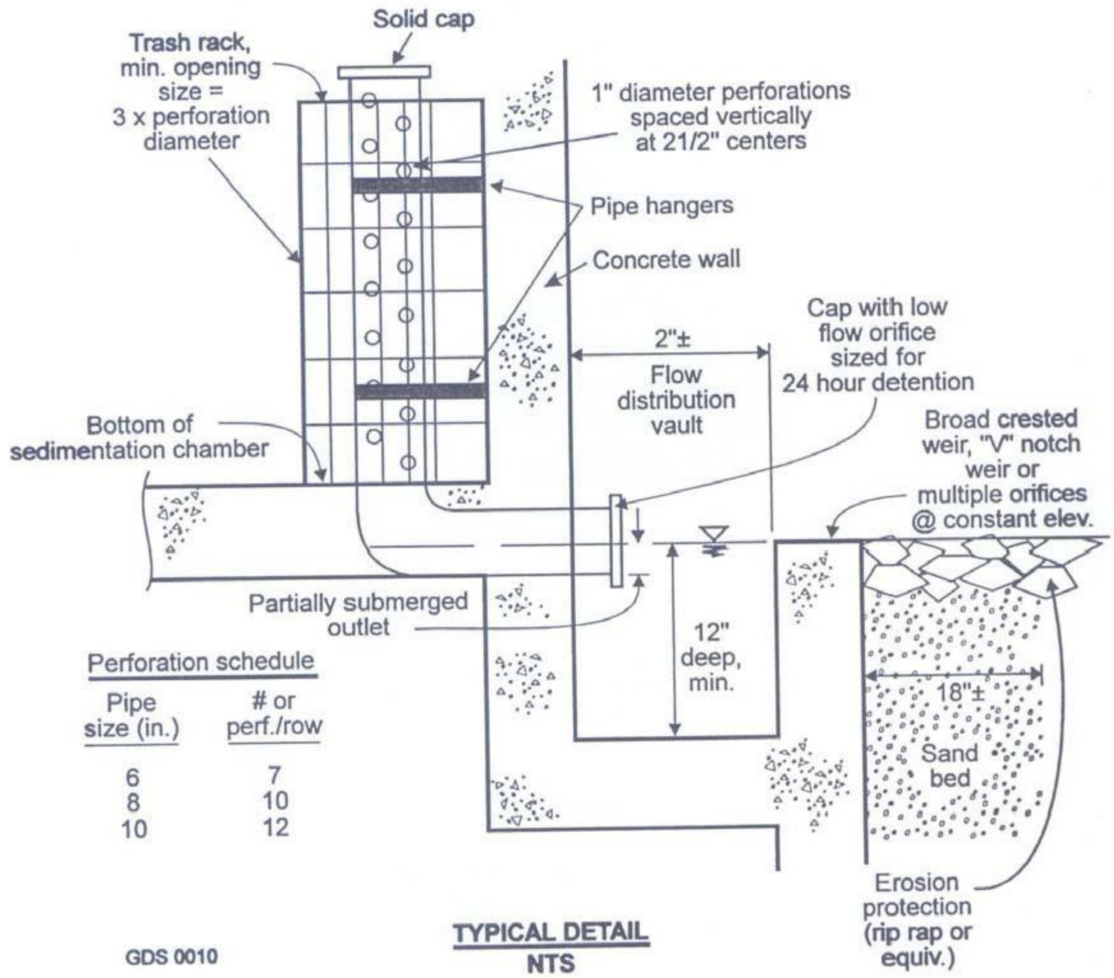

Figure 2.2.15-5 Surface Sand Filter Perforated Stand-Pipe
(Source: Claytor and Schueler, 1996)

J. ADDITIONAL SITE-SPECIFIC DESIGN CRITERIA AND ISSUES

Physiographic Factors - Local terrain design constraints

- Low Relief – Use of surface sand filter may be limited by low head
- High Relief – Filter bed surface must be level
- Karst – Use polyliner or impermeable membrane to seal bottom of earthen surface sand filter or use watertight structure

Soils

- No restrictions

Special Downstream Watershed Considerations

- Trout Stream – Evaluate for stream warming; use shorter drain time (24 hours)
- Aquifer Protection – Use polyliner or impermeable membrane to seal bottom of earthen surface sand filter or use watertight structure; no infiltration of filter runoff into groundwater

2.2.15.6 Design Procedures

Step 1. Compute runoff control volumes from the Stormwater Management Design Approach

Calculate the Water Quality Volume (WQ_v), Streambank Protection Volume (SP_v), On-Site Flood Control Volume (Q_p), and the Downstream Flood Control Volume (V_f). Details on the Stormwater Management Design Approach are found in the Murfreesboro Stormwater Planning, Low Impact Design and Credit Guide.

Step 2. Determine if the development site and conditions are appropriate for the use of a surface or perimeter sand filter.

Consider the Application and Site Feasibility Criteria in subsections 2.2.15.4 and 2.2.15.5-A (Location and Siting).

Step 3. Confirm local design criteria and applicability

Consider any special site-specific design conditions/criteria from subsection 2.2.15.5-J (Additional Site-Specific Design Criteria and Issues).

Check with local officials and other agencies to determine if there are any additional restrictions and/or surface water or watershed requirements that may apply.

Step 4. Compute WQ_v peak discharge (Q_{wq})

The peak rate of discharge for water quality design storm is needed for sizing of off-line diversion structures (see subsection 2.1.10).

(a) Using WQ_v, compute CN
(b) Compute time of concentration using TR-55 method
(c) Determine appropriate unit peak discharge from time of concentration
(d) Compute Q_{wq} from unit peak discharge, drainage area, and WQ_v.

Step 5. Size flow diversion structure, if needed

A flow regulator (or flow splitter diversion structure) should be supplied to divert the WQ_v to the sand filter facility.

Size low flow orifice, weir, or other device to pass Q_{wq}.

Step 6. Size filtration basin chamber

The filter area is sized using the following equation (based on Darcy's Law):

$$A_f = (WQ_v)\ (d_f) \,/\, [(k)\ (h_f + d_f)\ (t_f)]$$

where:

Af = surface area of filter bed (ft^2)
df = filter bed depth ((typically 18 inches, no more than 24 inches)
k = coefficient of permeability of filter media (ft/day) (use 3.5 ft/day for sand)
hf = average height of water above filter bed (ft)
(1/2 hmax, which varies based on site but hmax is typically ≤ 6 feet)
tf = design filter bed drain time (days) (1.67 days or 40 hours is recommended maximum)

Set preliminary dimensions of filtration basin chamber.

See subsection 2.2.15.5-C (Physical Specifications/Geometry) for filter media specifications.

Step 7. Size sedimentation chamber

***Surface sand filter*:** The sedimentation chamber should be sized to at least 25% of the computed WQ_v and have a length-to-width ratio of 2:1. The Camp-Hazen equation is used to compute the required surface area:

$$A_s = -(Q_o/w) * Ln(1-E)$$

Where:

A_s = sedimentation basin surface area (ft^2)
Q_o = rate of outflow = the WQ_v over a 24-hour period
w = particle settling velocity (ft/sec)
E = trap efficiency

Assuming:

- 90% sediment trap efficiency (0.9)
- particle settling velocity (ft/sec) = 0.0033 ft/sec for imperviousness < 75%
- particle settling velocity (ft/sec) = 0.0004 ft/sec for imperviousness ≥ 75%
  average of 24 hour holding period

Then:

$A_s = (0.066)(WQ_v)\ ft^2$ for $I < 75\%$

$A_s = (0.0081)(WQ_v)\ ft^2$ for $I \geq 75\%$

Set preliminary dimensions of sedimentation chamber.

***Perimeter sand filter*:** The sedimentation chamber should be sized to at least 50% of the computed WQ_v. Use same approach as for surface sand filter.

Step 8. Compute V_{min}

$V_{min} = 0.75 * WQ_v$

Step 9. Compute storage volumes within entire facility and sedimentation chamber orifice size

***Surface sand filter*: $V_{min} = 0.75\ WQ_v = V_s + V_f + V_{f\text{-}temp}$**

(1) Compute V_f = water volume within filter bed/gravel/pipe = $A_f * d_f * n$
    Where: n = porosity = 0.4 for most applications
(2) Compute $V_{f\text{-}temp}$ = temporary storage volume above the filter bed = $2 * h_f * A_f$
(3) Compute V_s = volume within sediment chamber = $V_{min} - V_f - V_{f\text{-}temp}$
(4) Compute h_s = height in sedimentation chamber = V_s/A_s
(5) Ensure h_s and h_f fit available head and other dimensions still fit – change as necessary in design iterations until all site dimensions fit.
(6) Size orifice from sediment chamber to filter chamber to release V_s within 24-hours at average release rate with 0.5 h_s as average head.
(7) Design outlet structure with perforations allowing for a safety factor of 10 (see example)
(8) Size distribution chamber to spread flow over filtration media – level spreader weir or orifices.

***Perimeter sand filter*:**

(1) Compute V_f = water volume within filter bed/gravel/pipe = A_f * d_f * **n**
Where: n = porosity = 0.4 for most applications

(2) Compute V_w = wet pool storage volume A_s * 2 feet minimum
(3) Compute V_{temp} = temporary storage volume = V_{min} – (V_f + V_w)
(4) Compute h_{temp} = temporary storage height = V_{temp} / (A_f + A_s)
(5) Ensure $h_{temp} \geq 2 * h_f$, otherwise decrease h_f and re-compute. Ensure dimensions fit available head and area – change as necessary in design iterations until all site dimensions fit.
(6) Size distribution slots from sediment chamber to filter chamber.

Step 10. Design inlets, pretreatment facilities, underdrain system, and outlet structures

See subsection 2.2.15-5-D through H for more details. Step

11. Compute overflow weir sizes

***Surface sand filter*:**

1. Size overflow weir at elevation h_s in sedimentation chamber (above perforated stand pipe) to handle surcharge of flow through filter system from storms producing more than 1.5 inches (see example in Appendix D).
2. Plan inlet protection for overflow from sedimentation chamber and size overflow weir at elevation h_f in filtration chamber (above perforated stand pipe) to handle surcharge of flow through filter system from storms producing more than 1.5 inches (see example).

Perimeter sand filter: Size overflow weir at end of sedimentation chamber to handle excess inflow, set at WQ_v elevation.

See Appendix D-3 for a Sand Filter Design Example

2.2.15.7 Inspection and Maintenance Requirements

Table 2.2.15-1 Typical Maintenance Activities for Sand Filters(Source: WMI, 1997; Pitt, 1997)

Activity	Schedule
• Ensure that contributing area, facility, inlets, and outlets are clear of debris. • Ensure that the contributing area is stabilized and mowed, with clippings removed. • Remove trash and debris. • Check to ensure that the filter surface is not clogging (also check after moderate and major storms). • Ensure that activities in the drainage area minimize oil/grease and sediment entry to the system. • If permanent water level is present (perimeter sand filter), ensure that the chamber does not leak and normal pool level is retained.	Monthly

• Check to see that the filter bed is clean of sediment, and the sediment chamber is not more than 50% full or 6 inches, whichever is less, of sediment. Remove sediment as necessary. • Stabilize disturbed area contributing to the heavy sediment load. • Make sure that there is no evidence of deterioration, spalling, or cracking of concrete. • Inspect grates (perimeter sand filter). • Inspect inlets, outlets, and overflow spillway to ensure good condition and no evidence of erosion. • Repair or replace any damaged structural parts. • Stabilize any eroded areas. • Ensure that flow is not bypassing the facility. • Ensure that no noticeable odors are detected outside the facility.	Annually
• If filter bed is clogged or partially clogged, manual manipulation of the surface layer of sand may be required. Remove the top few inches of sand, roto-till or otherwise cultivate the surface, and replace media with sand meeting the design specifications. • Replace any filter fabric that has become clogged.	As needed

Additional Maintenance Considerations and Requirements

- A record should be kept of the dewatering time for a sand filter to determine if maintenance is necessary.
- When the filtering capacity of the sand filter facility diminishes substantially (i.e., when water ponds on the surface of the filter bed for more than 48 hours), then the top layers of the filter media (topsoil and 2 to 3 inches of sand) will need to be removed and replaced. This will typically need to be done every 3 to 5 years for low sediment applications, more often for areas of high sediment yield or high oil and grease.
- Removed sediment and media may usually be disposed of in a landfill.

Regular inspection and maintenance is critical to the effective operation of sand filter facilities as designed. Maintenance responsibility for a sand filter system should be vested with a responsible authority by means of a legally binding and enforceable maintenance agreement that is executed as a condition of plan approval.

2.2.4.8 Example Schematics

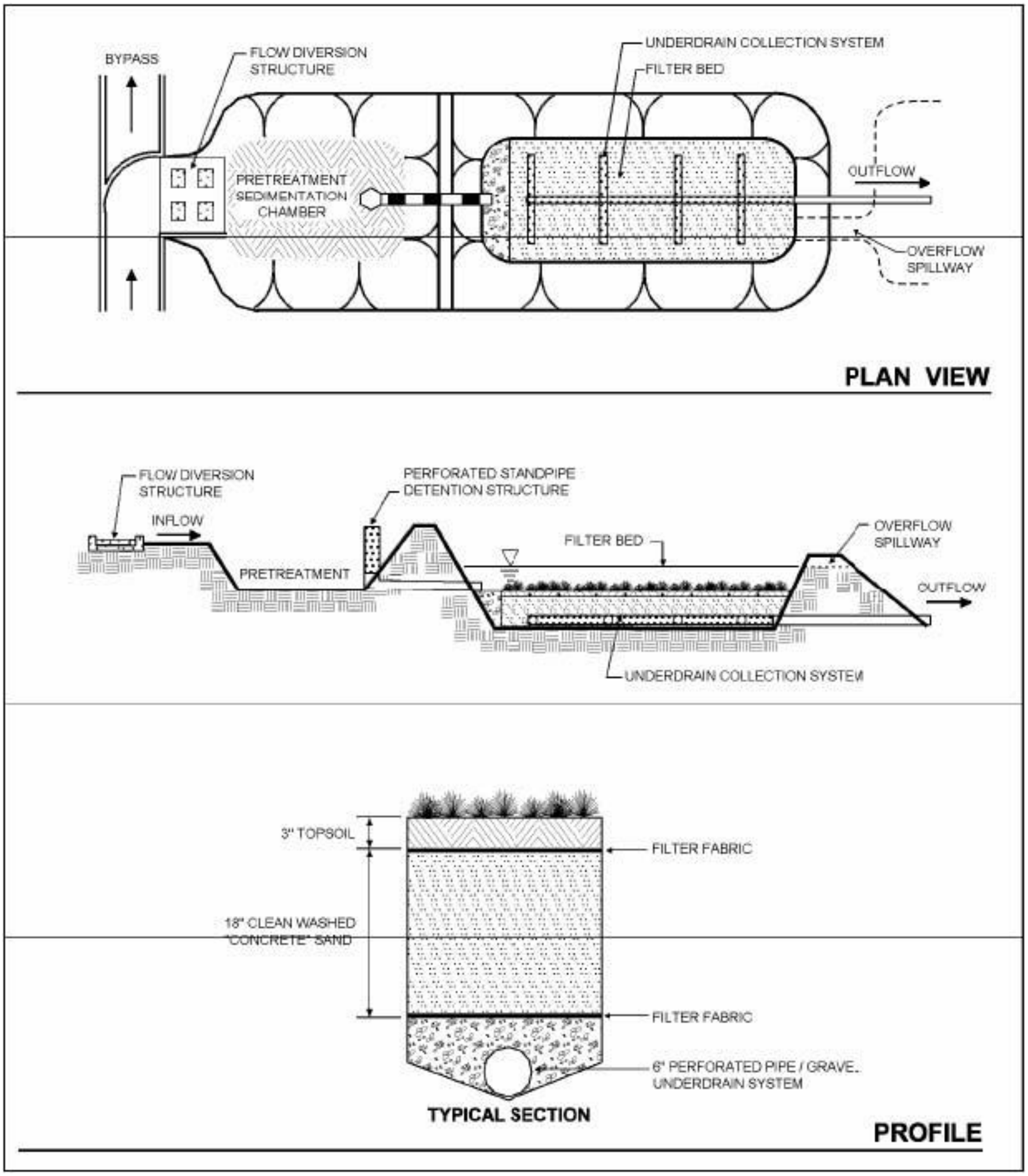

Figure 2.2.15-6 Schematic of Surface Sand Filter
(Source: Center for Watershed Protection)

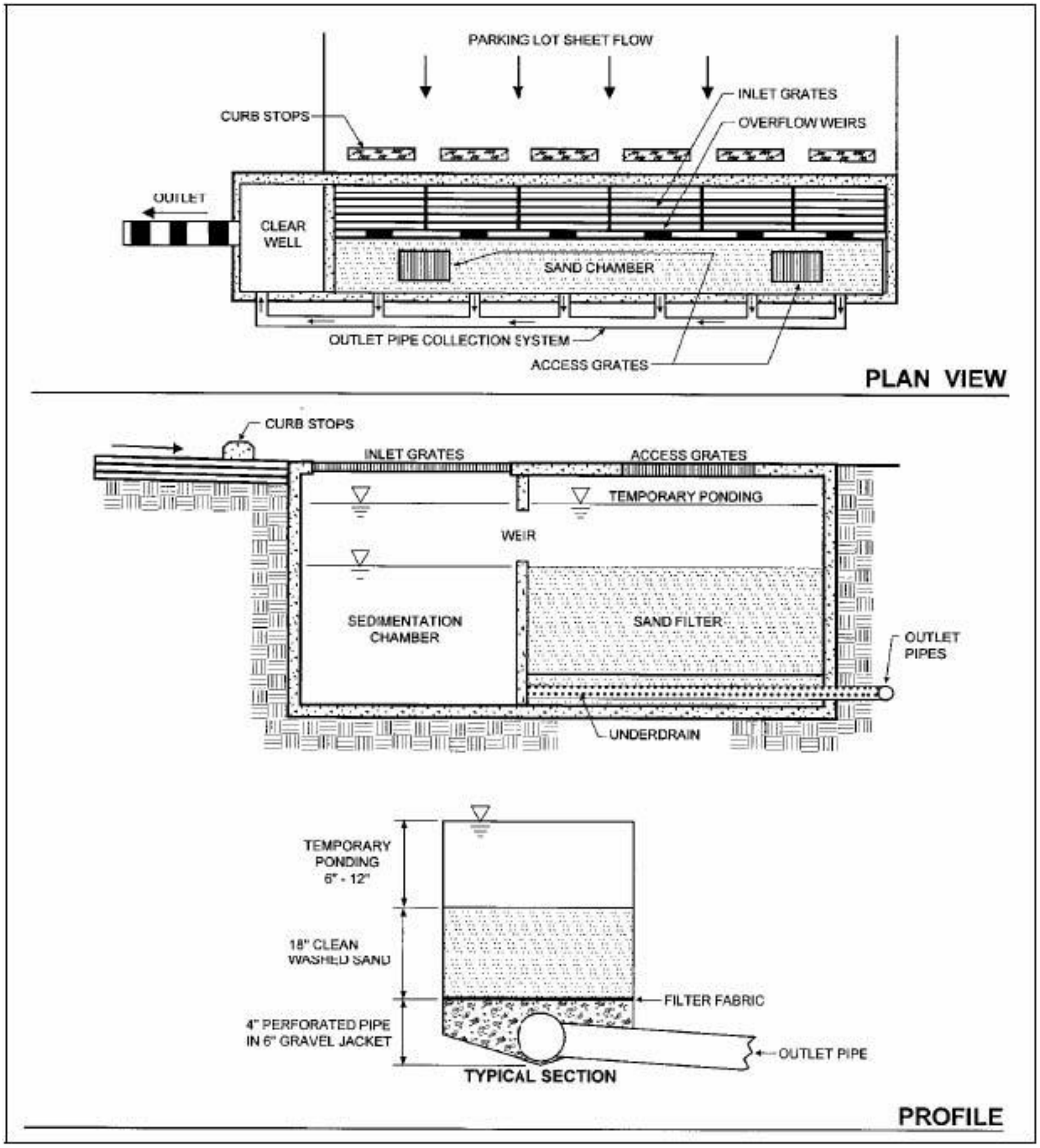

Figure 2.2.15-7 Schematic of Perimeter Sand Filter
(Source: Center for Watershed Protection)

2.2.15.9 Design Forms

Design Procedure Form: Sand Filters

PRELIMINARY HYDROLOGIC	
1a. Compute WQ_v volume requirements	
Copute Runoff Coefficient, R_v	R_v = ____________
Compute WQ_v	WQ_v = ____________ acre-ft
1b. Compute SP_v	SP_v = ____________ acre-ft
Copute average release rate	release rate = ____________ cfs
Compute Q_p (100-year detention volume required)	Q_p = ____________ acre-ft
Compute (as necessary) Q_f	Q_f = ____________ cfs
SAND FILTER DESIGN	
2. Is the use of a sand fiilter appropriate?	Low Point in development area = ____________
	Low Point at stream invert = ____________
	Total available head = ____________
	Average depth, h_f = ____________
	See subsections 5.2.15.4 and 5.2.15.5-A
3. Confirm localdesign criteria and applicability.	***See subsection 5.2.15.5-J***
4. Compute WQ_v peak discharge (Q_{vq})	
Compute Curve Number	CN = ____________
Compute Time of Concentration t_c	t_c = ____________ hour
Compute Q_{wq}	Q_{wq} = ____________ cfs
5. Size flow diversion structure	
Low flow orifice - Orifice equation	A = ____________ ft^2
	diameter = ____________ in
Overflow weir - Weir equation	Length = ____________ ft
6. Size filtration bed chamber	
Compute area from Darcy's Law	A_f = ____________ ft^2
Using length to width (2:1) ratio	L = ____________ ft
	W = ____________ ft
7. Size seidmentation chamber	
Compute area from Camp-Hazen equation	A_f = ____________ ft^2
Given W from step 5, compute Length	L = ____________ ft
8. Compute V_{min}	V_{min} = ____________ ft^3
9. Compute volume within practice	
<u>Surface sand filter</u>	
Volume within filter bed	V_f = ____________ ft^3
Temporary storage above filter bed	$V_{s\text{-}temp}$ = ____________ ft^3
Sedimentation chamber (remaining volume)	V_s = ____________ ft^3
Height in sedimentation chamber	h_s = ____________ ft
Perforated stand pipe - Orifice equation	A = ____________ ft^2
	diameter = ____________ in
<u>Perimeter sand filter</u>	
Compute volume in filter bed	V_f = ____________ ft^3
Compute wet pool storage	V_w = ____________ ft^3
Compute temporary storage	V_{temp} = ____________ ft^3
	h_{temp} = ____________ ft
10. Compute overflow weir sizes	
Compute overflow - Orifice equation	Q = ____________ cfs
Weir from sedimentation chamber - Weir equation	Length = ____________ ft
Weir from filtration chamber - Weir equation	Length = ____________ ft

Notes:

Sand filter – end