

BMP 6.4.7: Constructed Filter



Filters are structures or excavated areas containing a layer of sand, compost, organic material, peat, or other filter media that reduce pollutant levels in stormwater runoff by filtering sediments, metals, hydrocarbons, and other pollutants.

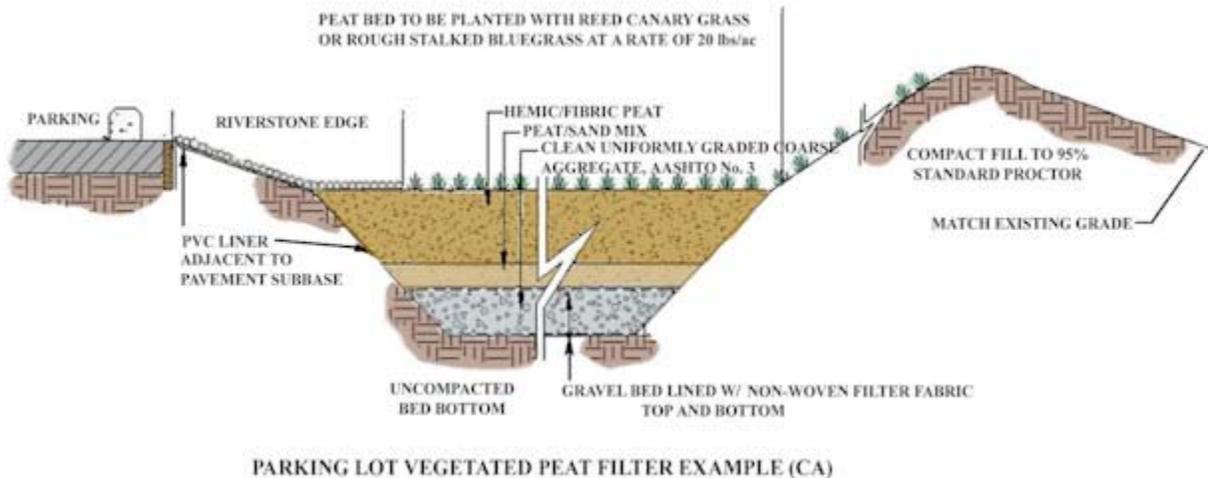
<p style="text-align: center;"><u>Key Design Elements</u></p> <ul style="list-style-type: none"> ▪ Follow Infiltration Systems Guidelines in Appendix C ▪ Drain down – should empty within the guidelines in Chapter 3 ▪ Minimum permeability of filtration medium required ▪ Minimum depth of filtering medium = 12" ▪ Perforated pipes in stone, as required ▪ May be designed to collect and convey filtered runoff down-gradient ▪ May be designed to infiltrate ▪ Pretreatment for debris and sediment may be needed ▪ Should be sized for drainage area ▪ Regular inspection and maintenance required for continued functioning ▪ Positive overflow is needed 	<p style="text-align: center;"><u>Potential Applications</u></p> <p>Residential: Limited Commercial: Yes Ultra Urban: Yes Industrial: Yes Retrofit: Yes Highway/Road: Yes</p> <hr/> <p style="text-align: center;"><u>Stormwater Functions</u></p> <p>Volume Reduction: Low-High* Recharge: Low-High* Peak Rate Control: Low-High* Water Quality: High</p> <p>* Depends on if infiltration is used</p> <hr/> <p style="text-align: center;"><u>Water Quality Functions</u></p> <p>TSS: 85% TP: 85% NO3: 30%</p>
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Other Considerations

- **Protocol 1. Site Evaluation and Soil Infiltration Testing** and **Protocol 2. Infiltration Systems Guidelines** should be followed, see Appendix C
- Certain applications may warrant spill containment.

Description

A stormwater filter is a structure or excavation filled with material and designed to filter stormwater runoff to improve water quality. The filter media may be comprised of materials such as sand, peat, compost, granular activated carbon (GAC), perlite, or other material. Additional filtration media will be acceptable for use as long as data is available to verify the media is capable of meeting performance goals. In some applications the stormwater runoff flows through an open air, “pretreatment” chamber to allow the large particles and debris to settle out (sedimentation). Surface vegetation is another good option for pretreatment. The runoff then passes through the filter media where additional pollutants are filtered out, and is collected in an under-drain and returned to the conveyance system, receiving waters or infiltrated into the soil mantle.



Variations

There are a wide variety of Filter Applications, including surface and subsurface, vegetated, perimeter, infiltration, and others. There are also a variety of filter products that may be purchased. Examples of these variations include:

Surface Non-vegetated Filter

A Surface Non-vegetated Filter is constructed by excavation or by use of a structural container. The surface may be covered in sand, peat, gravel, river stone, or similar material.



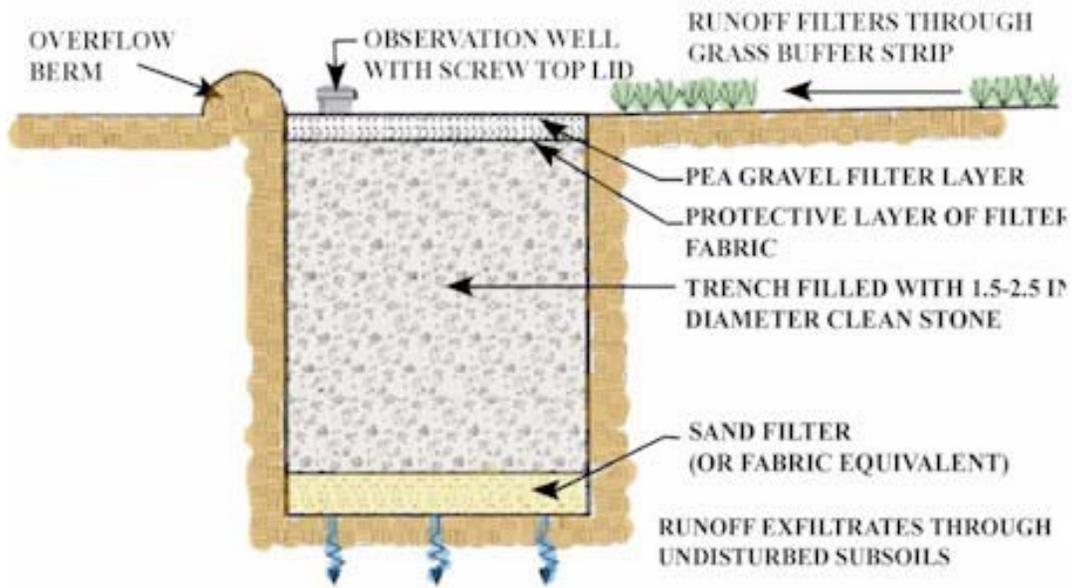
Vegetated Filter

A layer of vegetation is planted on top of the filtering medium. Composted amended soil may serve as a filter media. For filters composed of filtering media such as sand (where topsoil is required for vegetation) a layer of nonwoven, permeable geotextile should separate the topsoil and vegetation from the filter media.



Infiltration Filter

Filters may be designed to allow some portion of the treated water to infiltrate. Infiltration Design Criteria apply for all Filters designed with infiltration. In all cases, a positive overflow system is recommended.



Contained Filter

In contained Filters, infiltration is not incorporated into the design. Contained Filters may consist of a physical structure, such as a precast concrete box. For excavated filters, an impermeable liner is added to the bottom of the excavation to convey the filtered runoff downstream.



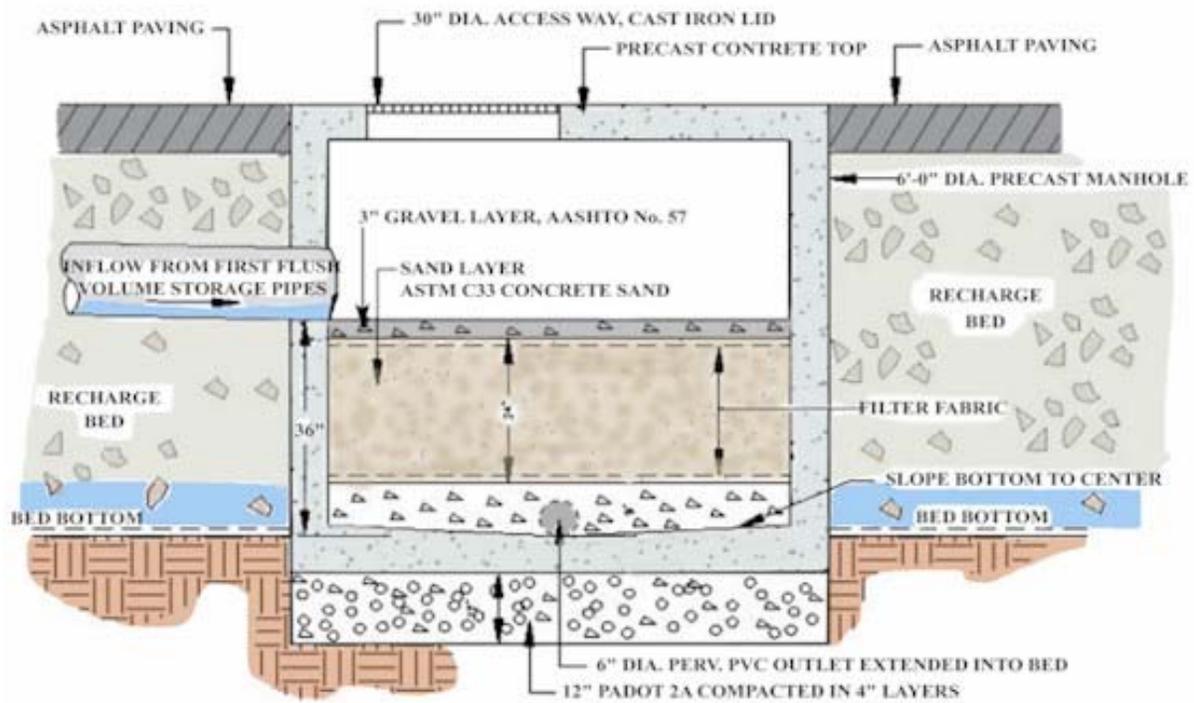
Linear “Perimeter” Filters

Perimeter Filters may consist of enclosed chambers (such as trench drains) that run along the perimeter of an impervious surface. Perimeter Filters may also be constructed by excavation and vegetated. All perimeter filters should be designed with the necessary filter medium and sized in accordance with the drainage area.



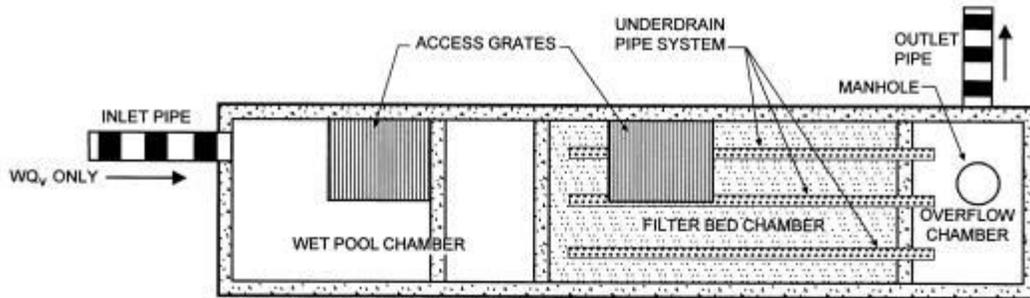
Small Subsurface Filter

A Small Subsurface filter is an inlet designed to treat runoff at the collection source by filtration. Small Subsurface filters are useful for Hotspot Pretreatment and similar in function to Water Quality Inserts. Small Subsurface filters should be carefully designed and maintained so that runoff is directed through the filter media.

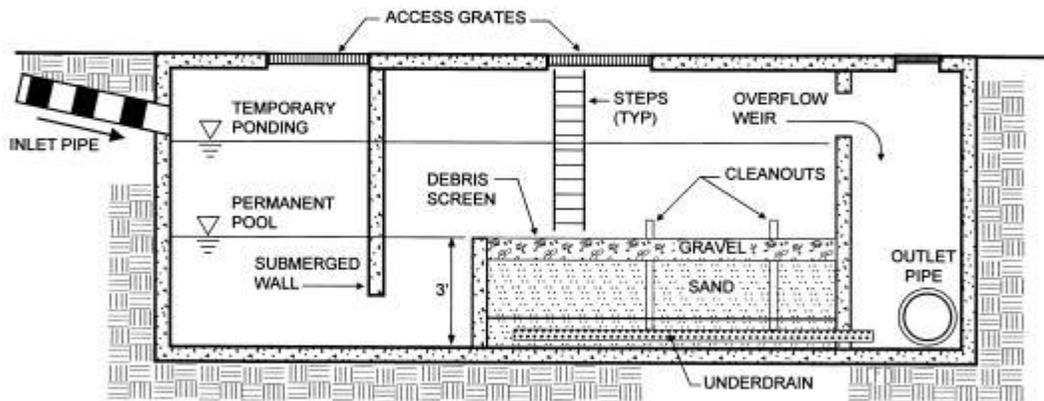


Large Subsurface Filter

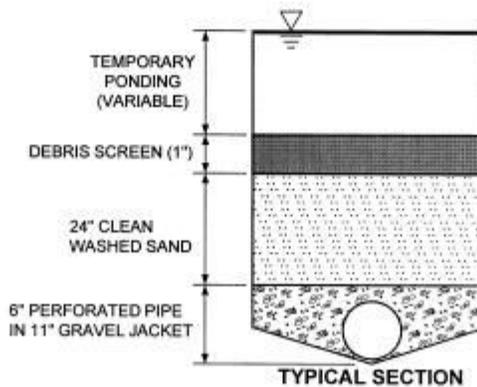
Large Subsurface Filters receive relatively large amounts of flow directed into an underground box that has separate chambers, one to settle large particles, and one to filter small particles. The water discharges through an outlet pipe and into the stormwater system.



PLAN VIEW



PROFILE



TYPICAL SECTION

Manufactured Filtration Systems

There are a considerable number of manufactured filtration systems available, some of which also incorporate oil/water separators, vortex systems, etc. The Designer should obtain product specific information directly from the manufacturer.

Applications

Filters are applicable in urbanized areas having high pollutant loads and are especially applicable where there is limited area for construction of other BMPs. Filters may be used as a pretreatment BMP before other BMPs such as Wet Ponds or Infiltration systems. Filters may be used in Hot Spot areas for water quality treatment, and spill containment capabilities may be incorporated into a filter. Examples of typical areas that benefit from the use of a Filter BMP include:

- Parking lots
- Roadways and Highways
- Light Industrial sites
- Marina areas
- Transportation facilities
- Fast food and shopping areas
- Waste Transfer Stations
- Urban Streetscapes

Design Considerations

1. Filters should be sized as per the Control Guideline that applies. All filters should be designed so that **larger storms may safely overflow or bypass the filter**. Flow splitters, multistage chambers, and other devices may be used. A flow splitter may be necessary to allow only a portion of the runoff to enter the filter. This would create an “off-line” filter, where the volume and velocity of runoff entering the filter is controlled. If the filter is “on-line”, excess flow should be designed to bypass the filter and continue to another quality BMP.
2. **Entering velocity should be controlled**. A level spreader may be used to spread flow evenly across the filter surface during all storms without eroding the filter material. Parking lots may be designed to sheet flow to filters. Small riprap or riverstone edges may be used to reduce velocity and distribute flow.
3. **Pretreatment** may be necessary in areas with especially high levels of debris, large sediment, etc. Pretreatment may include oil/grit separators, vegetated filter strips, or grass swales. These measures will settle out the large particles and reduce velocity of the runoff before it enters the filter.
4. The **Filter Media** may be a variety of materials and in most cases should have a minimum depth of 12 inches and a maximum depth of 30 inches, although variations on these guidelines are acceptable if justified by the designer. Coarser materials allow for more hydraulic conductivity, but finer media filter particles of a smaller size. Sand has been found to be a good balance between these two criteria, but different types of media remove different pollutants. While sand is a reliable material to remove TSS, (Debusk and Langston, 1997) peat removes slightly more

TP, Cu, Cd, and Ni than sand. The Filter Media should have a minimum hydraulic conductivity (k) as follows:

- Sand 3.5 ft/day
- Peat 2.5 ft/day
- Leaf compost 8.7 ft/day

5. A **Gravel Layer** at least 6” deep is recommended beneath the Filter Media.
6. **Under drain piping** should be 4” minimum (diameter) perforated pipes, with a lateral spacing of no more than 10’. A collector pipe can be used, (running perpendicular to laterals) with a slope of 1%. All underground pipes should have clean-outs accessible from the surface.
7. A **Drawdown Time** of not more than 72 hours is recommended for Filters.
8. The **Size** of a Filter is determined by the Volume to be treated:

$$A = V \times d / (k \times t(h+d))$$

- A = Surface area of Filter (square feet)**
- V = Water volume (cubic feet)**
- d = Depth of Filter Media (min 1.5 ft; max 2.5 ft)**
- t = Drawdown time (days), not to exceed 72 hours**
- h = Head (average in feet)**
- k = Hydraulic conductivity (ft/day)**

9. When a Filter has accumulated sediment in its pore space, its hydraulic conductivity is reduced, and so is its ability to removal pollutants. **Maintenance and Inspection** are essential for continued performance of a Filter. Based upon inspection, some or all portions of the filter media may require replacement.
10. Filters should be designed with **sufficient maintenance access** (clean-outs, room for surface cleaning, etc.). Filters that are visible and simple in design are more likely to be maintained correctly.

Detailed Stormwater Functions

Volume Reduction Calculations

If a Filter is designed to include infiltration, the Volume Reduction is a function of the Area of the Filter and infiltration rate. There is minimal volume reduction for Filters that are not designed to infiltrate.

Volume = Infiltration Volume* + Filter Volume

Infiltration Volume = Bottom Area (sf) x Infil. Rate (in/hr) x Drawdown time** (hr)

Filter Volume = Area of filter (sf) x Depth (ft) x 20%***

*For filters with infiltration only

** Not to exceed 72 hours

***For sand, amended soil, compost, peat; Use 20% unless more specific data is available

Peak Rate Mitigation Calculations

See Chapter 8 for Peak Rate Mitigation methodology which addresses link between volume reduction and peak rate control.

Water Quality Improvement

See Chapter 8 for Water Quality Improvement methodology, which addresses pollutant removal effectiveness of this BMP.

Construction Sequence

1. Permanent Filters should not be installed until the site is stabilized. Excessive sediment generated during construction can clog the Filter and prevent or reduce the anticipated post-construction water quality benefits. Stabilize all contributing areas before runoff enters filters.
2. Structures such as inlet boxes, reinforced concrete boxes, etc. should be installed in accordance with the manufacturers' or design engineers guidance.
3. Excavated filters that infiltrate or structural filters that infiltrate should be excavated in such a manner as to avoid compaction of the subbase. Structures may be set on a layer of clean, lightly compacted gravel (such as AASHTO #57).
4. Infiltration Filters should be underlain by a layer of permeable non-woven-geotextile.
5. Place underlying gravel/stone in minimum 6 inch lifts and lightly compact. Place underdrain pipes in gravel during placement.
6. Wrap and secure nonwoven geotextile to prevent gravel/stone from clogging with sediments.
7. Lay filtering material. Do not compact.
8. Saturate filter media and allow media to drain to properly settle and distribute.
9. For vegetated filters, a layer of nonwoven geotextile between non-organic filter media and planting media is recommended.
10. There should be sufficient space (head) between the top of the filtering bed and the overflow of the Filter to allow for the maximum head designed to be stored before filtration.



Maintenance and Inspection

Filters require a regular inspection and maintenance program in order to maintain the integrity of the filtering system and pollutant removal mechanisms. Studies have shown that filters are very effective upon installation, but quickly decrease in efficiency as sediment accumulates in the filter. (Urbonas, Urban Drainage and Flood Control District, CO) Odor is also a concern for filters that are not maintained. Inspection of the filter is recommended at least **four times a year**.

During inspection the following conditions should be considered:

- **Standing water** – any water left in a surface filter after the design drain down time indicates the filter is not optimally functioning.
- **Film or discoloration** of any surface filter material – this indicates organics or debris have clogged the filter surface.



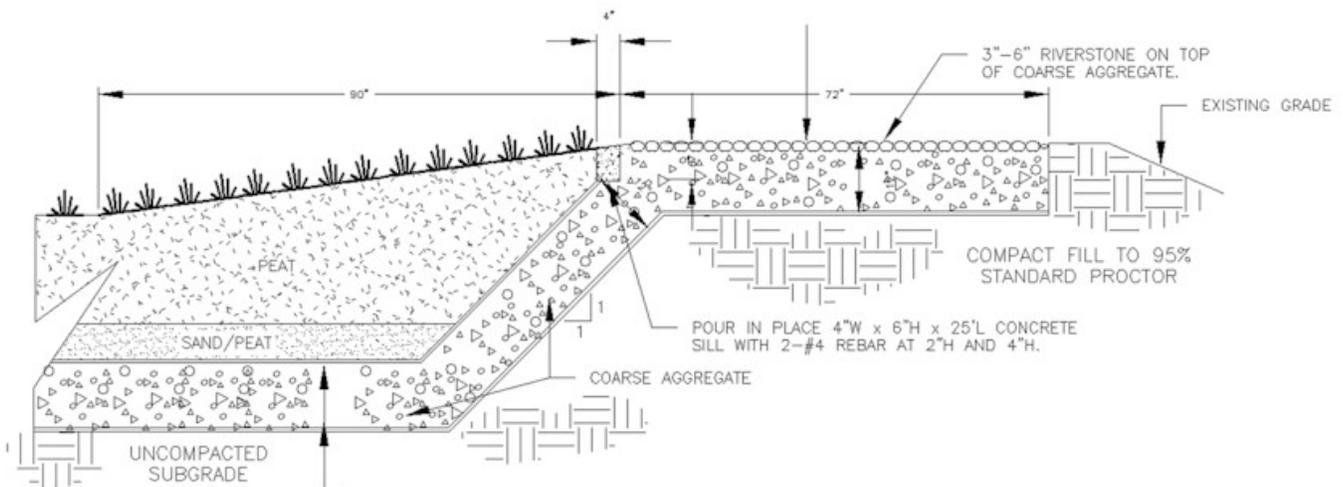
Filter Maintenance

- Remove trash and debris as necessary
- Scrape silt with rakes
- Till and aerate filter area
- Replace filtering medium if scraping/removal has reduced depth of filtering media

In areas where the potential exists for the discharge and accumulation of toxic pollutants (such as metals), filter media removed from filters must be handled and disposed of in accordance with all state and federal regulations.

Winter concerns

Pennsylvania’s winter temperatures go below freezing about four months out of every year, and surface filtration may not take place as well in the winter. Peat and compost may hold water, freeze, and become impervious on the surface. Design options that allow directly for subsurface discharge into the filter media during cold weather may overcome this condition.



Cost Issues

Filter costs vary according to the filtering medial (sand, peat, compost), land clearing, excavation, grading, inlet and outlet structures, perforated pipes, encasing structure (if used), and maintenance cost. Underground structures may contribute significantly to the cost of a Filter.

Specifications

1. **Stone/Gravel** shall be uniformly graded coarse aggregate, 1 inch to ¾ inch with a wash loss of no more than 0.5%, AASHTO size number 57 per AASHTO Specifications, Part I, 19th Ed., 1998, or later and shall have voids 40% as measured by ASTM-C29.
2. **Peat** shall have ash content <15%, pH range 3.3-5.2, loose bulk density range 0.12-0.14 g/cc.
3. **Sand** shall be ASTM-C-33 (or AASHTO M-6) size (0.02" – 0.04"), concrete sand, clean, medium to fine sand, no organic material.
4. **Non-Woven Geotextile** shall consist of needled nonwoven polypropylene fibers and meet the following properties:
 - a. Grab Tensile Strength (ASTM-D4632) ³ 120 lbs
 - b. Mullen Burst Strength (ASTM-D3786) ³ 225 psi
 - c. Flow Rate (ASTM-D4491) ³ 95 gal/min/ft²
 - d. UV Resistance after 500 hrs (ASTM-D4355)³ 70%
 - e. Heat-set or heat-calendared fabrics are not permitted

Acceptable types include Mirafi 140N, Amoco 4547, Geotex 451, or approved others.

5. **Pipe** shall be continuously perforated, smooth interior, with a minimum inside diameter of 8-inches. High-density polyethylene (HDPE) pipe shall meet AASHTO M252, Type S or AASHTO M294, Type S.

References

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“Stormwater Sand Filter Sizing and Design – A Unit Operations Approach” Urbonas

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