Stormwater Best Management Practice

Vegetated Filter Strip

Minimum Measure: Post Construction Stormwater Management in New Development and Redevelopment
Subcategory: Filtration

Description

Vegetated filter strips (grassed filter strips, filter strips and grassed filters) are vegetated surfaces that treat sheet flow from adjacent surfaces. Filter strips function by slowing stormwater velocities, filtering out sediment and other pollutants, and providing some infiltration into underlying soils. Filter strips were originally an agricultural treatment practice and have more recently evolved into an urban practice. With proper design and maintenance, filter strips can provide relatively high pollutant removal. However, for the filter strip to be effective, stormwater should maintain sheet flow throughout the length of the filter strip. This creates a challenge, as heavier, concentrated flows that receive little or no treatment can overwhelm the practice.

A vegetated filter strip can infiltrate and treat stormwater flow from adjacent surfaces using a variety of plants.

Photo Credit: Steven Chase for USEPA, 2019

Common Terms

Stormwater hot spots are areas where land use or activities generate highly contaminated stormwater discharges, with pollutant concentrations exceeding those typically found in stormwater. Examples include gas stations, vehicle repair areas and waste storage areas.

A **stormwater retrofit** is a stormwater management practice (usually structural) put into place after development or construction of a stormwater control to improve water quality, protect downstream channels, reduce flooding or meet other specific objectives that did not exist at the time of original construction.

Pretreatment plays an important role in stormwater treatment. Pretreatment structures, installed immediately upgradient to a stormwater control, reduce flow rates and remove sediment and debris before stormwater enters a stormwater control. This helps to improve the stormwater control's pollutant removal efficiency and reduces maintenance requirements.

Applicability

Filter strips are applicable in most regions but are restricted in some situations because they consume a large amount of space relative to other practices. Filter strips are most suitable for treating stormwater discharge from roads and highways, roof downspouts, very small parking lots, and pervious surfaces. They are also ideal components of the "outer zone" of a stream buffer (see Riparian/Forested Buffer fact sheet) or as pretreatment to a structural practice. For example, the *Maryland Stormwater Design Manual* does not consider the filter strip a treatment practice, but does encourage the use of filter strips to supplement other practices (MDE, 2009).

Regional Applicability

Filter strips are applicable in most regions of the country. However, they may be impractical in arid areas where the cost of irrigating the grass on the filter strip will most likely outweigh its water quality benefits.

Urban Areas

Urban areas are areas with dense development in which little pervious surface exists. Filter strips are impractical in urban areas because they require a large amount of space.

Stormwater Hot Spots

Filter strips should not receive hot spot stormwater because the practice has minimal pollutant removal

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ability and encourages infiltration, both of which may encourage dispersal of hot spot pollutants. Similarly, filter strips should not slope toward or convey stormwater over septic drain fields or contaminated groundwater plumes.

Stormwater Retrofit

Filter strips are generally a poor retrofit option because they take up a relatively large amount of space and cannot treat large drainage areas.

Cold Water (Trout) Streams

Some cold water species, such as trout, are sensitive to changes in temperature. While some treatment practices, such as wet ponds (see Wet Ponds fact sheet), can warm stormwater substantially, filter strips do not pond water and are therefore not likely to increase stormwater temperatures. Thus, these practices are good for protecting cold water streams, as the *Massachusetts Stormwater Handbook* suggests (MDEP, 2008).

Siting and Design Considerations

Siting Considerations

In addition to assessing the applicability of filter strips for different regions and land uses, designers need to ensure that this management practice is feasible at the site in question. The following section provides basic guidelines for siting filter strips.

Drainage Area

Typically, filter strips treat very small drainage areas such as roads, sidewalks and small parking lots. Although some guidelines include area-based limits—for example, the Pennsylvania Department of Environmental Protection recommends the ratio of drainage area to filter strip area be less than 6:1 (PDEP, 2006)—most limiting design factors refer to the length of flow leading to the practice. As stormwater flows over the ground's surface, it changes from sheet flow to concentrated flow. Rather than moving uniformly over the surface, the concentrated flow forms rivulets that are slightly deeper and cover less area than the sheet flow. When flow concentrates, it moves too rapidly for a grassed filter strip to effectively treat it. Furthermore, this concentrated flow can lead to scouring. To prevent this, the length of the filter strip (with length measured normal, or parallel, to flow) should span at least the length of the drainage area. The recommended maximum flow length (the length of the drainage area, measured normal to flow) depends on the drainage area's permeable and impermeable surface areas. Generally, flow lengths should not exceed 75 feet for impervious surfaces and 150 feet for pervious surfaces (Battiata et al., 2014).

Slope

To encourage sheet flow, filter strips should have slopes of at least 2 percent, with a maximum slope of 5 to 6 percent (Battiata et al., 2014; MDEP, 2008). However, certain combinations of filter strip length, soil type and vegetation can allow for slightly steeper slopes (PDEP, 2006). Slopes that are too steep can encourage the formation of concentrated flow.

Soils

Topsoil depth and composition are important for the establishment and maintenance of healthy vegetation, as well as the proper functioning of the filter strip. Topsoil should be at least 8 to 18 inches deep (PDEP, 2006; Battiata et al., 2014). The soil should be native or amended with organic compost to allow for water retention and infiltration. Soils with high clay content are not suitable for filter strips, as they prevent infiltration. An ideal soil infiltration rate is between 0.5 and 12 inches per hour (Cahill et al., 2018). The *Pennsylvania Stormwater Best Management Practices Manual* recommends a time of 48 to 72 hours maximum for the filter strip to filter standing water; if standing water doesn't drain in that time, reexamine the soil composition and consider a lower-density soil (PDEP, 2006).

Groundwater

Filter strips should be separate from the groundwater or any confining layer (e.g., bedrock) by between 2 and 4 feet to prevent contamination and to ensure that the filter strip can adequately drain between storms (MDEP, 2008; PDEP, 2006).

Design Considerations

Filter strips appear to be a minimal design practice because they are basically a grassed slope. However, certain design features can improve the filter strip's ability to provide a small amount of water quality treatment. The following are design variations or features that can improve the function of a filter strip:

- The top layer of a vegetated filter strip can consist of turf grasses, meadow grasses, shrubs, native vegetation or trees. The planting of the vegetation should be dense to increase infiltration, withstand relatively high-velocity flows and prevent soil erosion.

- For larger versions of the practice, a pea gravel diaphragm, level spreader or concrete curb stop at the top of the slope can maintain sheet flow into the practice. A pea gravel diaphragm (a small, gravel-filled trench running along the top of the filter strip) also acts as a pretreatment device, settling out sediment particles before they reach the practice. A typical pea gravel diaphragm is 12 inches long and 24 to 36 inches deep (PDEP, 2006).
- To help reduce ponding, the filter strip design can incorporate a pervious berm of vegetated sand and gravel at the toe of the slope. This berm should be 6 to 12 inches tall and resistant to erosion. The berm should allow for the infiltration of ponded water within 24 hours (PDEP, 2006).
- The filter strip length (normal, or parallel, to flow) should be a function of slope, vegetation cover, soil type, stream sensitivity and contamination level (PDEP, 2006). Lengths are often 50 to 200 feet (Cahill et al., 2018), though the *Minnesota Stormwater Best Management Practices Manual* recommends a minimum length of 25 feet and a maximum length of 300 feet (MPCA, 2000). As the slope increases and the soil composition becomes less permeable (i.e., higher clay or silt fractions), the length should increase to maintain sheet flow and infiltration. For examples of specific recommendations, see the *NJ Stormwater Best Management Practices Manual* (NJDEP, 2014) and Pennsylvania's stormwater manual (PDEP, 2006).
- Both the top and toe of the slope should be as flat as possible to encourage sheet flow and prevent erosion. The top of the slope should be directly next to the pea gravel diaphragm.

Regional Variations

In cold climates, filter strips provide a convenient area for snow storage and treatment. If serving this purpose, vegetation in the filter strip should be salt-tolerant, and a maintenance schedule should include the removal of sand built up at the bottom of the slope (PDEP, 2006). In arid or semiarid climates, designers should specify drought-tolerant grasses to minimize irrigation requirements.

Limitations

Filter strips have several limitations related to their performance and space consumption:

- Sheet flow is difficult to maintain, and concentrated flow will limit the practice's effectiveness.
- Filter strips are not suitable for the treatment of high-velocity flows.
- Filter strips require a large amount of space, typically equal to the impervious area they treat, often making them infeasible in urban environments where land prices are high.
- If standing water remains for 3 days or more, filter strips can allow mosquitos to breed.
- Proper design requires careful planning and execution. Slight problems in the design, such as improper grading, can render the practice ineffective in terms of pollutant removal or sediment buildup.

For treating large volumes of stormwater, a more suitable treatment control, such as a bioretention, should follow filter strips.

Maintenance Considerations

Filter strips require similar maintenance to other vegetative practices (e.g., see Grassed Swales fact sheet). Maintenance is very important for filter strips, particularly to ensure that concentrated flow does not short-circuit the practice. Maintenance practices include:

- Monitoring of recently planted vegetation to ensure the filter strip is establishing it properly.
- Regular mowing, trimming, watering, fertilizing and reseeding of the vegetation, as applicable to the local conditions.
- Regular inspection of the vegetation for damage from foot or vehicle traffic. To prevent pollution, sediment buildup and damage to the vegetation, municipalities should discourage public use of the strips.
- Removal of accumulated sediment and debris at the toe, the berm and the strip itself. This monitoring is important to make sure preferential flow paths haven't developed and sheet flow is consistent. This should happen at least biannually, or when sediment accumulates to a height of 2 inches or greater.
- Soil aeration if the drainage time of the filter strip becomes significantly slower than the original drainage time due to soil compaction.

Effectiveness

Filter strips can provide a small amount of groundwater recharge as stormwater flows over the vegetated surface and ponds at the toe of the slope. Through this infiltration, or stormwater reduction, filter strips can provide some pollutant removal. Based on a review of multiple studies, a report by the Center for Watershed Protection calculated an average stormwater reduction of 51 percent and average load reductions for total nitrogen, total phosphorus and total solids of 56, 66 and 86 percent, respectively (Battiata et al., 2014).

Filter strips also have the potential to reduce stormwater by 20 to 85 percent via infiltration by soil and plants. Filter strips are most effective during 80 to 95 percent of annual storm events. However, effectiveness is less for very large storm events or when flow velocities exceed 1.3 feet per second (Battiata et al, 2014).

A North Carolina study observed four different urban vegetative filter strip systems (two 25-foot, two 50-foot) for the removal of pollutants by infiltration. Although both sizes were effective at removing total suspended solids, only the 50-foot systems were able to consistently remove nitrogen and phosphorus (Winston et al., 2011).

Cost Considerations[1]

Filter strip costs depend on a number of factors, the first and most important of which is the land available for the practice. In some situations, this land is available as wasted space beyond backyards or adjacent to roadsides, but this practice is cost-prohibitive when land prices are high and land could serve other purposes.

In addition to land costs, construction costs can vary depending on the size, type and complexity of the practice. Costs can be low when the practice only includes seeding or planting for small, simple variations. For more complex variations that require grading, level spreaders, pea gravel diaphragms or toe berms, additional excavation, grading and material costs will be necessary. Due to these variations, cost estimates range from $0 to $65,000 per acre of practice (PDEP, 2006), with other estimates falling closer to the middle of the range at $25,000 to $35,000 per acre (King & Hagan, 2011).

Annual maintenance costs include mowing, weeding, inspection and litter removal, which can be $130 to $1,800 per acre of the filter strip. The cost may be toward the lower end of the range if maintenance needs are already part of the site's existing landscape maintenance routine or if local vegetation growth rates or landscaping labor rates are low (PDEP, 2006).

[1] Prices updated to 2020 dollars. Inflation rates obtained from the Bureau of Labor Statistics CPI Inflation Calculator Web site https://data.bls.gov/cgi-bin/cpicalc.pl.

Additional Information

Additional information on related practices and the Phase II MS4 program can be found at EPA's National Menu of Best Management Practices (BMPs) for Stormwater website

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