Vegetated Filter Strips

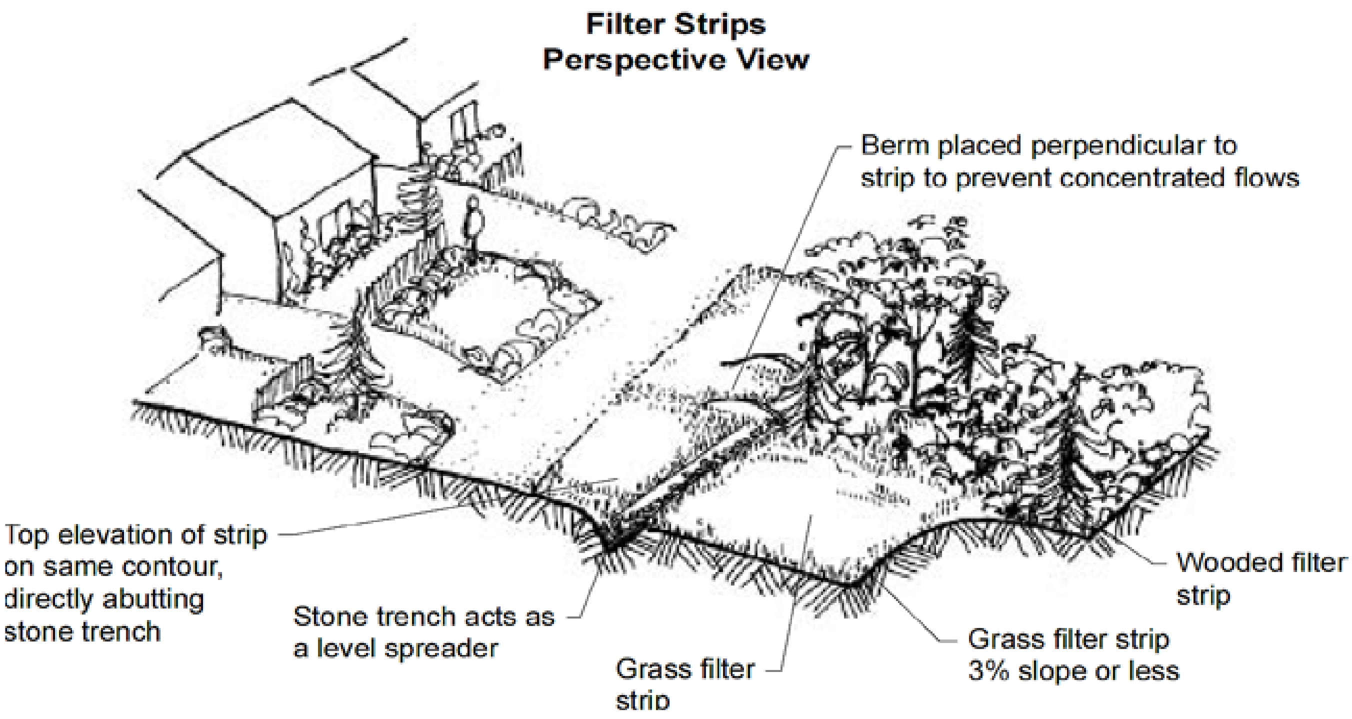
Maria Cahill, Green Girl Land Development Solutions; Derek C. Godwin and Marissa Sowles, Oregon Sea Grant Extension

A vegetated filter strip (VFS) is a gently sloping area covered in vegetation (grass or plants) receiving sheet-flow runoff from pervious and impervious surfaces. Generally, vegetated filter strips minimize flow velocities, filter pollutants, and collect sediment before passing the remaining runoff volume to a secondary facility, such as a swale or bioretention practice, but they can also be designed like rain gardens with amended soils to store and infiltrate runoff volumes. VFSs manage smaller volumes of runoff, generally less than 5 acres (Arnold 1991, Field 2007). Because VFSs require sheet-flow runoff, a level spreader is required where runoff has become concentrated, such as from downspouts. Traditionally they have been used in agricultural settings to protect streams from fertilizers and livestock waste, but urbanized versions are becoming more prevalent.

Design

Vegetated filter strips are like flattened swales and are typically designed to convey, treat, and capture the stormwater runoff from surfaces draining to the filter strip during 80 to 90% of annual storm events. In Oregon, this is usually a 1-inch, 24-hour design storm. In some cases, cities may require VFSs to infiltrate larger storm events, especially where local soils drain well.

Where pollutant loading is low, a simpler facility that removes total suspended solids may be all that is needed. As with other conveyance treatment facilities, such as swales, the minimum retention time in the facility should be 9 minutes. In the case of a facility that has replaced slow-draining native soils with amended planting soils (infiltration rates between 2 and 12 inches per



Vegetated Filter Strip Design (NRCS 2008). Slope design may vary from site to site.

LOW IMPACT DEVELOPMENT

FACT SHEET

Oregon Sea Grant
Corvallis, Oregon

ORESU-G-11-003

hour), this minimum retention time likely will be very easy to achieve, and water quality treatment will be more effective than simply passing it over the surface. Depending on the VFS design, replacing native soil with amended soil may trigger state underground injection control (UIC) requirements (see the UIC Regulations section below). Check with your local planning department for specific design requirements for your area.

SIZING

Generally, high-infiltrating soils and lower slopes will result in a shorter VFS. Many guidelines include a 10- to 15-foot minimum length, with length specified as the dimension normal to flow. Stream buffers are often designed as vegetated filter strips and are 50 to 200 feet in length. Generally, 100-foot stream buffers seem to be a reasonable balance between restricting land use and providing water quality benefits.[1] Ultimately, however, the length of the filter strip that should be used in these circumstances depends on pollutant levels, as well as stream sensitivity.

Ideally, when inflow to the facility is overland, the width of the facility should span the entire impervious area width from which the facility is receiving runoff (Barr 2001, Field 2007). However, there are many examples of filter strips receiving inflow from concentrated flows that may be narrower.

SLOPE

Ideal slopes are 5% or less, with up to 15% acceptable but not encouraged (Arnold 1993, Field 2007). Steeper slopes do not allow time for infiltration and pollutant removal, but different vegetation types can aid in infiltration affecting the percent slope suitable for a specific site. As mentioned above, greater slopes generally require larger facilities; lateral slope should not exceed 1% (LIDMM 2008).

FLOW VELOCITIES

VFSs are not designed to handle high velocities of runoff (Field 2007). Overland flow and spreader facilities help to keep the velocities below erosive levels, but this should be confirmed in the design. Dense plantings will also play a significant role in slowing flows.

SOILS AND MEDIA

Vegetated filter strips should incorporate amended planting soil or amended native soils with infiltration rates that are not so low that small storms cannot pass through the soil column for treatment, but not so high that stormwater doesn't have enough "retention time" in the soil. The ideal infiltration rate is between ½ inch/hour and 12 inches/hour.[2] The top 18 inches of soil is typically amended with organic compost and soil mixtures to create a sandy loam soil. In some cases, the existing topsoil is replaced with a soil mix, as specified by the local jurisdiction. Replacing native soil with amended soil may trigger state underground injection control (UIC) requirements, depending on the VFS design (see the UIC Regulations section below). In addition to infiltration rates, other key considerations for robust plant establishment and stormwater treatment by plants and soil include soil pH (between 5.5 and 7.5[3]), cation exchange capacity (>5 millequivalents/100grams), and the resulting soil mix should be 60% sandy loam and 40% compost. Be sure that imported soil and compost are free of weed seeds.

Native soils should always be tested in the proposed filter strip location to determine the infiltration rate of the native undisturbed soils below the amended topsoil. The infiltration rate should be at least ½ inch/hour when

Suggested slope percents based on soil and vegetation types

		Maximum Filter Strip Slope (Percent)	
Filter Strip Soil Type	Hydrologic Soil Group	Turf Grass, Native Grasses, and Meadows	Planted and Indigenous Woods
Sand	A	7	5
Sandy Loam	B	8	7
Loam, Silt Loam	B	8	8
Sandy Clay Loam	C	8	8
Clay Loam, Silty Clay, Clay	D	8	8

Adapted from the LIDMM 2008.

1 http://www.co.chatham.nc.us/dept/planning/planning_dept/watershed_review_board/supporting_documents/cases/cecc_request_05-05/Scientific_Lit_Excerpt.pdf using an infiltration facility that receives runoff from elsewhere; some jurisdictions require higher rates. Since stormwater has already passed through the middle, amended soil layer and received treatment, there is no recommended maximum infiltration rate for the native soils.

VEGETATION

The interaction of soil, plants, and the beneficial microbes that concentrate on plant roots is what ultimately provides the filtration benefit of vegetated filter strips—the more plants, the more treatment. A vegetated filter strip that won't infiltrate the water-quality storm will still provide some reduction of total suspended solids. Plant density is even more important in this case, since the above-ground structure of the plants is what slows runoff and allows sediments to settle out.

Several varieties of trees, shrubs, grasses, and ground covers are acceptable for filter strips in both sun and shade conditions. The VFS should be densely vegetated for maximum runoff treatment and to control weeds. Local jurisdictions often provide specifications for density, size, and types of vegetation to use. Vegetation should be selected based on its tolerance to flooding and its ability to survive in the local climate conditions with no fertilizers, no herbicides or insecticides, and minimal to no watering after establishment. Vegetation such as perennial flowers, ornamental grasses, and shrubs can add significant appeal to the facility. Filter strips can also be designed to attract beneficial insects and wildlife. Contact your local OSU Extension Service office or planning department for a list of plants appropriate for your area. Because downstream seed dispersal during flooding and spreading by birds is well documented in natural wetlands, it's important to take special care to avoid noxious weeds (also known as invasive plant species). A list of noxious weeds is available on the Oregon Department of Agriculture's Web site at http://www.oregon.gov/ODA/PLANT/WEEDS/.

Army Corps of Engineers

Vegetated filter strips are being used more often in urban areas for small parking lots. Source: Army Corps of Engineers (http://www.lrc.usace.army.mil/co-r/best_management_practices.htm).

In most cases, native plants are preferred, not just because nonnative seeds and rhizomes can greatly impact the habitat potential of our natural land and drainageways, but also because native plants will provide more food for native insects and birds. Even when native insects and birds find nonnative plants appealing, nonnative plants don't provide as much nutrition. Finally, native plants support native microbes and other native soil life, while nonnatives have been found to negatively impact the composition of the soil life.

ROUTING

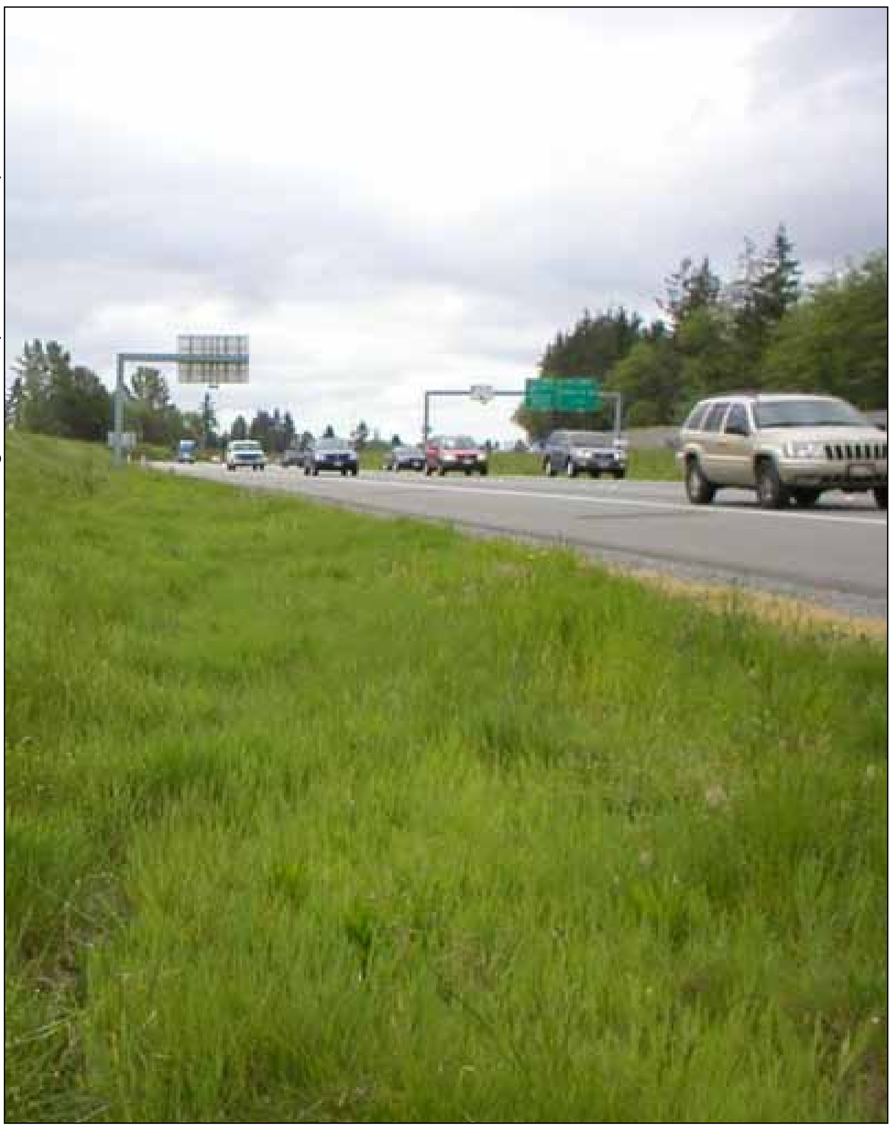
Runoff must enter a VFS as sheet—not concentrated—flow. This can be achieved with level spreaders. A level spreader is a stone-filled gravel trench, with or without a perforated pipe, concrete weir, runnel, or curb (Arnold 1993). In designing a level spreader and other VFS components, care should be exercised to avoid triggering UIC requirements (see UIC Regulations section below). The most appropriate level spreader for a downspout delivering roof runoff is a gravel trench (LIDMM 2008). Regardless of type, the spreader should be continuous and level; Field has additional information regarding these devices (Barr 2001, Field 2007).

If a level spreader is not used, Arnold suggests the use of dams or berms at the top of the facility, and every 50 to 100 feet (Arnold 1993).

Like many low impact development facilities, a bypass system may be needed for high flows during storms that exceed the design capacity (Barr 2001).

To enhance storage capacity, a berm at the bottom of the facility will allow ponding, but the effectiveness of this measure is dependent on the slope of the facility and the height of the berm, and alternatives include an underdrain and overflow weir (Field 2007). If infiltration rates are so low that the plants will have wet feet for too long, you may consider building a smaller VFS with an under-drain pipe (underdrain) that will allow the water to leave the bottom of the facility. Depending on the design of the underdrain (perforations all around vs. perforation on the top and sides), the vertical setback from high seasonal aquifer, and the discharge point, an underdrain may trigger state UIC requirements (see the UIC Regulations section below).

Washington State Department of Transportation (WSDOT)



Vegetated Filter Strip along highway (WSDOT 2009).

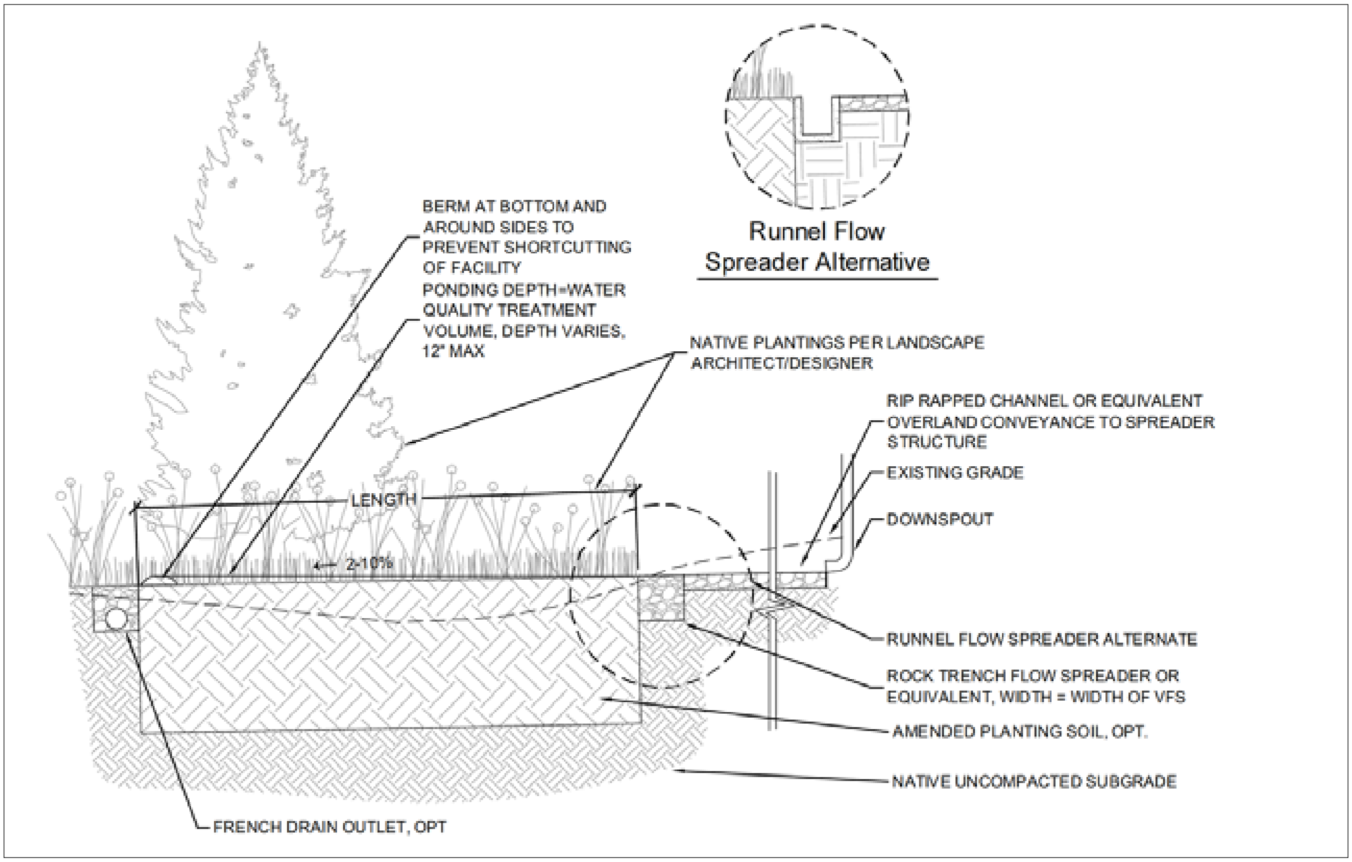
Setbacks

Lined vegetated strips aren't typical but could be designed for water quality only, with no setback requirements. Setbacks for infiltration facilities vary by jurisdiction. The City of Portland requires setbacks of at least 10 feet from building foundations and 5 feet from property lines (PSMM 2008). Along with this, a minimum landscape requirement in Portland's zoning codes bans building walls within 5 feet of a property line, thereby ensuring the 10 feet of building setback. Walls should also be set back a minimum of 100 feet from down-gradient slopes of 10 percent. Add 5 feet of setback for each additional slope percentage up to 30%, and avoid installing an infiltration vegetated filter strip where the down-gradient slope exceeds 30%. The Oregon DEQ requires a minimum soil depth of 3 feet, from the bottom of the vegetated filter strip to the seasonal high groundwater table.

Physical Setting

Due to a VFS's need for space, they may not be ideal for retrofitting, unless space is adequate (Barr 2001). They can, however, help meet open-space requirements in new developments (UDFCD 2008). Ideal locations for VFSs are roads, highways,[4] and roof downspouts, as well as small parking lots and pervious surfaces (Barr 2001, Field 2007).

4 The Retardation of Heavy Metals in Stormwater Runoff by Highway Grass Strips: http://www.wsdot.wa.gov/research/reports/fullreports/404.1.pdf



Maria Cahill

VFS with a flow spreader for concentrated flows and a berm to retain the volume of the water-quality storm.

An alternative location could be the center of a driveway, usually 3 feet wide with two 3-foot aisles of paved driveway. The paved portions should be slightly sloped toward the center filter strip (PSMM 2008). VFSs can also be located along a stream as the outer zone of a stream buffer (Field 2007).

When placing a facility, potential for groundwater contamination should be considered, especially if the facility is located in urban areas or other areas with high pollutant levels in runoff (Barr 2001, Field 2007).

Infiltration vegetated filter strips can be used where

- the seasonal high groundwater table is lower than 36 inches from the bottom of VFS
- the bedrock is lower than 24 inches from the bottom of the VFS

Filtration vegetation filter strips should be used instead of infiltration VFS

- where the seasonal high groundwater table is higher than 36 inches from the bottom of VFS
- where bedrock is higher than 24 inches from the bottom of the VFS
- in potential stormwater hotspots (vehicle fueling areas, industrial loading, unloading, and material storage areas)
- in contaminated soils or groundwater
- on slopes exceeding 10% or in landslide areas
- where adequate setbacks discussed previously cannot be met

Pollutant Removal

A properly designed and well-functioning filtration VFS can remove about 35 to 60% of total suspended solids and 40% of nutrients in an urban setting (Arnold 1993, Barr 2001), varying from site to site depending on soils, vegetation, and retention time (Field 2007). Based on published research, the Center for Watershed Protection estimates event mean concentration phosphorus removal rates to be 60 to 65%, and nitrogen removal rates to be 30to

45% (CWP 2008).[5] Runoff reduction was estimated at 25 to 50% as well (CWP and CSN 2008). Pollutant removal is performed mainly through straining rather than bioretention (UDFCD 2008), yet there is some evidence that in forested VFSs, bioretention is more prevalent than VFSs constructed with grasses (Arnold 1993, NRCS 2008).

For vegetated filter strips designed to substantially infiltrate runoff, pollutant removal rates could be expected to mirror those for rain gardens.

Construction

Like all stormwater management facilities, care must be taken to properly construct a filter strip. If a facility will be used for infiltration, the proposed VFS location should be fenced off to prevent vehicular and foot traffic that will compact soils and reduce the infiltration rate of the native soils. To protect the soils during excavation, employ construction techniques such as using track equipment or excavating from the sides of the infiltration area. If the soils are exposed to rain, fine soil particles will be picked up and moved around and may clog the native subgrade soils. Rake the surface to loosen soil before proceeding. Raking will also be needed if the vegetated filter strip is dug by hand, because foot traffic in the facility area is probably unavoidable.

If the facility is for filtration only, then protecting the native soils in the facility area from compaction isn't as important, but any infiltration that can be achieved would be beneficial as long as appropriate setbacks exist. In addition, vegetation is difficult to establish in compacted soils, so for this reason, we recommend that the same care be taken in construction of either variation of VFS.

5 The Center for Watershed Protection published event mean concentrations for "Filters," which is a roughly equivalent term for vegetated filter strips.

Maintenance

Because vegetated filter strips can look very similar to regular gardens, some sort of permanent demarcation to prevent long-term compaction might be helpful, particularly in residential applications where owner turnover rates tend to be high compared to other land uses. Common maintenance tasks include: mowing and trimming dry grasses to appropriate lengths; replacing vegetation as needed; repairing eroded areas where channels have formed; maintaining the level spreader, and inspecting for excess sediment that may affect vegetation growth or sediment in pretreatment facilities such as sumped catch basins (dispose in approved location, check with local jurisdiction) (Barr 2001). Consistent maintenance ensures longevity and effectiveness of the facility, and VFSs require less maintenance than other vegetated best management practices (LIDMM 2008).

Cost

Without extensive grading and vegetation establishment, these facilities can be relatively inexpensive to install (Arnold 1993). Maintenance tasks are similar to those of open-space practices (UDFCD 2008).

Permits

Consult your local planning and building department. Ask about applicable permits, plumbing codes, and piping requirements. Find out if there are any maps, as-built drawings, or site-specific constraints. In many cases, if building a planter on a nonresidential site, a commercial building permit is required and a clearing, grading, and erosion control permit may be required if ground disturbance is extensive.

UIC REGULATIONS

A Class V Underground Injection Control (UIC) is a system designed "for the subsurface placement of fluids" and is regulated through the Oregon Department of Environmental Quality's UIC program. This program protects groundwater resources from injection of pollutants directly underground and may be rule-authorized or require a more formal permitting process, depending on the potential of various pollutants to be on-site based on land use. According to the U.S. Environmental Protection Agency, a Class V UIC well is also, by definition, any bored, drilled, or driven shaft, or a dug hole that is deeper than its widest surface dimension. Given this, the guidelines in the paragraph below are for designers who are considering a VFS to treat runoff before discharging it to surface water. These guidelines will help the designer avoid triggering UIC requirements in the design of a VFS. If a VFS is being considered for pre-treating runoff before discharging it to a UIC, such as a drywell or soakage trench, the designer should contact DEQ's UIC Program during the early planning stages for information about the UIC approval process and how to expeditei it.

To avoid UIC triggers when sizing a VFS, avoid designing a facility that is deeper than the widest surface dimension. Also, depending on the design of the french drain outlet, the rock trench flow spreader, and the final discharge point for the VFS, it may be considered a UIC: be sure the design does not place runoff (that which exceeds the capacity of the facility) into the ground. In addition, the underdrain in the drain outlet should be pipe that has a solid bottom and perforations on just the top and sides, and routes runoff to a stormwater conveyance system that discharges to surface water. In general, an underdrain composed of pipe with perforations on the bottom (as well as the top and sides) that routes runoff from large storm events down into the ground will trigger state UIC requirements even if the underdrain was designed to route runoff to a stormwater conveyance system.

By definition, a lined filtration VFS is not a UIC because it does not infiltrate. However, the disposal point of runoff from the french drain may trigger UIC requirements.

For more information on low impact development (LID) and UICs, see the DEQ's fact sheet, "Underground Injection Control Storm Water Information" at http://www.deq.state.or.us/wq/pubs/factsheets/uic/uicstormwater.pdf.

References and Resources

Arnold, J. A. (ed.), D. E. Line, S. W. Coffey, and J. Spooner. 1993. *Stormwater Management Guidance Manual*. Raleigh, NC: North Carolina Cooperative Extension Service and North Carolina Division of Environmental Management.

Barr Engineering Company. 2001. *Minnesota Urban Small Sites BMP Manual: Stormwater Best Management Practices for Cold Climates*. St. Paul, MN: Metropolitan Council Environmental Services.

Center for Watershed Protection (CWP) and Chesapeake Stormwater Network (CSN). 2008. *Technical Memorandum: The Runoff Reduction Method*. Ellicott City, MD.

Field, R., T. N. Tafuri, S. Muthukrishnan, R. A. Acquisto, and A. Selvakumar. 2006. *The Use of Best Management Practices (BMPs) in Urban Watersheds*. Lancaster, PA: DEStech Publications, Inc.

Lower Columbia River Estuary Partnership (LCREP). Lower Columbia River Field Guide to Water Quality Friendly Development: Techniques and Examples. Accessed from: http://www.lcrep.org/sites/default/files/fieldguide/techniques.htm

Low Impact Development Manual for Michigan (LIDMM): A design guide for implementers and reviewers. 2008. Funded by the Michigan Department of Environmental Quality, through a grant from the U.S. Environmental Protection Agency. Detroit, MI: Southeast Michigan Council Of Governments (SEMCOG).

Natural Resources Conservation Service (NRCS). 2008. NRCS Planning and Design Manual. Accessed from: http://www.wsi.nrcs.usda.gov/products/UrbanBMPs/water.html (scroll down to section E, "Water Quality Treatment and Constituent Entrapment," and select "Filter Strips"). Washington, DC.

North Carolina Division of Water Quality (NCDWQ). July 2007. *Stormwater Best Management Practices Manual*. Raleigh, NC.

Portland Stormwater Management Manual (PSMM). July 2008. Portland, OR: City of Portland: Bureau of Environmental Services.

Stormwater Manager's Resource Center (SMRC) of the Center for Watershed Protection, Inc. 2000. Ellicott City, MD. Web site: www.stormwatercenter.net

Urban Drainage and Flood Control District (UDFCD). 1999 (rev. 2008). Drainage Criteria Manual (Vol 3). Denver, CO.

Washington State Department of Transportation (WSDOT). 2009. Environment–Research. By Herrera Environmental Consultants, Inc. and Northwest Hydraulic Consultants. Web site with links to related reports and documentation (April 2004 through May 2005): http://wsdot.wa.gov/Environment/WaterQuality/Research/Reports.htm

Editing and layout by Rick Cooper; template design by Patricia Andersson.

This report was prepared by Oregon Sea Grant under award number NA06OAR4170010 (project number A/ESG-07) from the National Oceanic and Atmospheric Administration's National Sea Grant College Program, U.S. Department of Commerce, and by appropriations made by the Oregon State legislature. The statements, findings, conclusions, and recommendations are those of the authors and do not necessarily reflect the views of these funders.