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Best Management Practice Fact Sheet 5:

Vegetated Roofs

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This fact sheet is one of a 15-part series on urban *stormwater management* practices.

Please refer to definitions in the glossary at the end of this fact sheet.
Glossary terms are *italicized* on first mention in the text. For a comprehensive list, see Virginia Cooperative Extension (VCE) publication 426-119, "Urban Stormwater: Terms and Definitions."

What Is a Vegetated Roof?

A *vegetated roof* (VR) is a *best management practice* (BMP) that reduces *stormwater* runoff and pollution. Vegetation and *media* create a permeable system on a previously *impervious surface*. The VR intercepts rainfall and filters runoff while reducing the volume and velocity. Vegetated roofs consist of a waterproofing barrier, drainage system, and engineered growing media. There are two types of VRs: intensive and extensive. *Intensive vegetated roofs* are deeper and heavier, while *extensive vegetated roofs* are shallower, lighter, and more common (see Figure 1). The type of VR determines the amount of maintenance necessary to maintain the vegetation.

Figure 1. Photograph of vegetated roof. Note that roof contains both intensive and extensive sections.
Source: Fairfax County Government Center, 2010. Photo courtesy of D. Sample.

Where Can VRs Be Used?

Vegetated roofs can be used in new building designs where the roof is engineered to support their weight. They can also be used to retrofit an existing roof if it can support the additional weight of at least 15 to 30 pounds per square foot. While VRs are generally used on flat roofs, they can work on shallow, sloped roofs that can withstand the additional weight.

Vegetated roofs are recommended in urban areas where other BMPs may not be possible due to a lack of space. Like permeable pavement, VRs maintain the original function of the space they occupy, while simultaneously removing impervious surfaces. They also moderate the *heat island* effect in urban areas. They can extend the lifespan of a roof, reduce heating and cooling costs for the building, and create new interactive and functional green space where there was none.

Vegetated roofs can be used in nonurban locations as well. In many cases, VRs are combined with additional BMPs to treat stormwater through multiple practices.

How Do VRs Work?

Vegetated roofs consist of multiple layers, including: (1) a top layer of vegetation, (2) a media layer, (3) a drainage layer, (4) a root barrier, and (5) an *impermeable liner* which blocks moisture also serves as a *root barrier* to prevent roof damage (see Figure 2). Rainfall is intercepted and is allowed to infiltrate into the media

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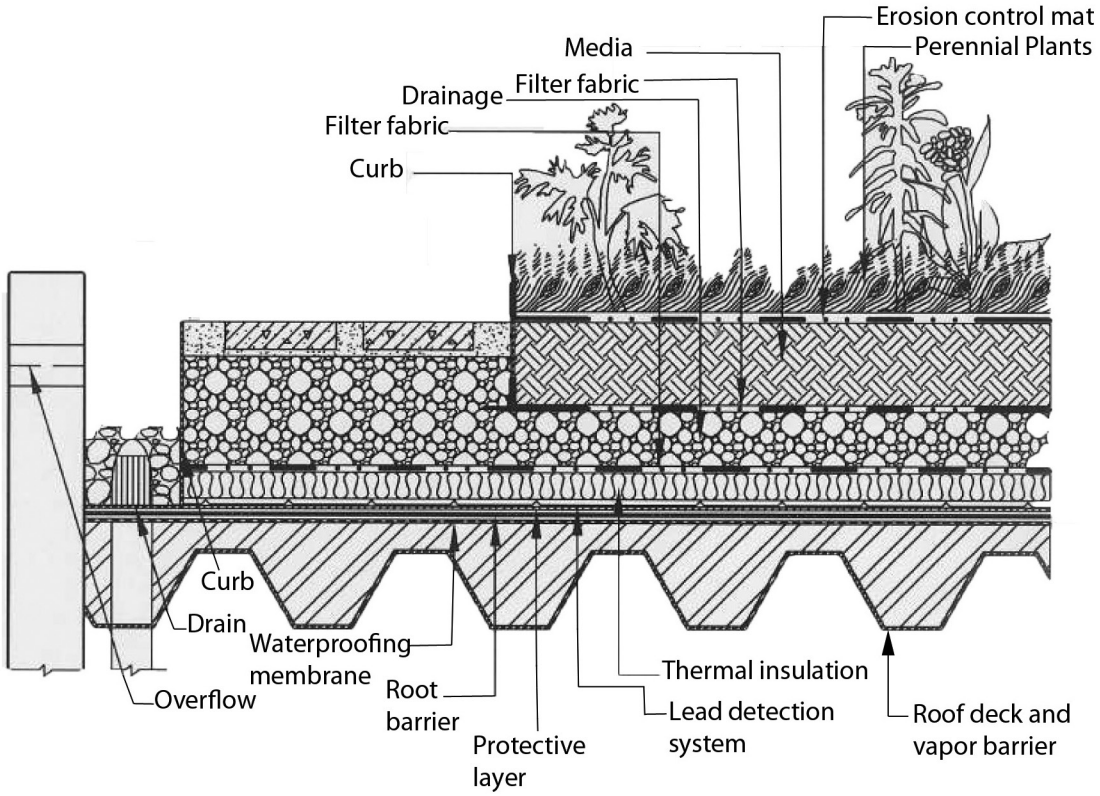

Figure 2. Cross section of extensive vegetated roof (VA-DCR 2011).

layer, where it is then stored and utilized by selective drought- and heat-resistant vegetation. Typically, roofs can store up to half an inch of rainfall. Rainfall that is over this amount is collected in the drainage layer and discharged away from the roof.

By storing rainfall, the VR increases the *residence time* of the runoff, which reduces *peak runoff* entering a *stormwater conveyance system*. The stored water then returns either directly to the atmosphere through *evaporation* or indirectly by *evapotranspiration* through the vegetation growing within the VR.

Limitations

- Vegetated roofs are limited to specifically engineered roofs or to existing roofs that have the additional structural support necessary to withstand their additional weight.
- Because of weight load constraints, only a small amount of runoff storage is available (4 to 6 inches) for the more common extensive roof.
- They require adequate roof access for maintenance.
- To reduce maintenance, drought-resistant plants are recommended. Irrigation may be necessary to protect vegetation during drought periods longer than two weeks. Irrigation is also essential in the initial planting period.
- Roofs with steeper slopes may require stabilization frames to prevent sliding.

Maintenance

Routine Maintenance (annual)

- Moderate maintenance is required — usually periodic weeding and watering (depending on vegetation).
- Confirm that plants are growing well; reseed or replant bare areas to prevent *erosion* and improve *filtration*.

Nonroutine Maintenance
(as needed)

- An application of a minimum amount of controlled- or slow-release fertilizer may be necessary for vegetation establishment or maintenance. Extreme care should be taken not to overfertilize in order to prevent excess *nutrients* from leaving the roof in the discharge.

Performance

Vegetated roofs are effective at reducing pollutants — mostly through runoff reduction and some biological uptake. An extensive VR is expected to reduce total phosphorus (TP) by 45 percent and total nitrogen (TN) by 45 percent, which includes mass load reductions from runoff reduction. An intensive system is deeper, which provides a longer residence time. Intensive VR systems can improve the expected reduction of TP to 60 percent and TN to 60 percent (VA-DCR 2011).

Expected Cost

Vegetated roofs have relatively high initial installation costs when compared to other alternative stormwater BMPs; however, they provide many benefits. Initial costs depend on site conditions and accessibly of the roof, the roof surface area, and the type of VR system being installed. The VR industry provides an average cost range of $9 to $24 per square foot (Renetzky, 2005). Maintenance costs are typically low and can be incorporated into the landscaping budget.

Additional Information

The Virginia departments of Conservation and Recreation (VA-DCR) and Environmental Quality (VA-DEQ) are the two state agencies that address nonpoint source pollution. The VA-DCR oversees agricultural conservation; VA-DEQ regulates stormwater through the Virginia Stormwater Management Program.

Additional information on best management practices can be found at the Virginia Stormwater BMP Clearinghouse website at http://vwrrc.vt.edu/swc. The BMP Clearinghouse is jointly administered by the VA-DEQ and the Virginia Water Resources Research Center, which has an oversight committee called the Virginia Stormwater BMP Clearinghouse Committee. Committee members represent various stakeholder groups involved with stormwater management.

Online Resources

American Society of Civil Engineers – http://email.asce.org/ewri/VegetatedRoof.html

Charles River Watershed Association – www.crwa.org/projects/stormwater/stormwaterBMPs.html

Greenroof Industry Resource Portal – www.greenroofs.com/Greenroofs101/faqs.htm

Low Impact Development Center – www.lid-stormwater.net/greenroofs_home.htm

Michigan State University – www.hrt.msu.edu/greenroof/

Pennsylvania Department of Environmental Protection – www.elibrary.dep.state.pa.us/dsweb/Get/Document-68000/6.5.1%20BMP%20Vegetated%20Roof.pdf

U.S. Environmental Protection Agency –

www.epa.gov/owow/NPS/roofcover.pdf

www.epa.gov/heatisld/mitigation/greenroofs.htm

http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=114

Virginia Stormwater BMP Clearinghouse – http://vwrrc.vt.edu/swc/

Companion Virginia Cooperative Extension Publications

Daniels, W., G. Evanylo, L. Fox, K. Haering, S. Hodges, R. Maguire, D. Sample, et al. 2011. *Urban Nutrient Management Handbook*. Edited by M. Goatley. VCE Publication 430-350.

Gilland, T., L. Fox, M. Andruczyk, and L. Swanson. 2009 Urban Water-Quality Management - What Is a Watershed? VCE Publication 426-041.

Sample, D., et al. 2011-2012. Best Management Practices Fact Sheet Series 1-15, VCE Publications 426-120 through 426-134.

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Renetzky, David. 2005. Vegetative Roof Systems. *Currents* 7 (Fall 2005). Newsletter of the American Society of Civil Engineers, Environmental and Water Resources Institute. http://email.asce.org/ewri/VegetatedRoof.html.

Virginia Department of Conservation and Recreation (VA-DCR). 2011. *Virginia DCR Stormwater Design Specification No. 5: Vegetated Roof*, Version 2.3. http://vwrrc.vt.edu/swc/NonPBMPSpecsMarch11/VASWMBMPSpec5VEGETATEDROOF.html.

Glossary of Terms

Best management practice (BMP) – Any treatment practice for urban lands that reduces pollution from stormwater. A BMP can be either a physical structure or a management practice. Agricultural lands use a similar, but different, set of BMPs to mitigate agricultural runoff.

Detention time – See residence time.

Erosion – A process by either physical processes, such as water or wind, or chemical means that moves soil or rock deposits. Excessive erosion is considered an environmental problem that is very difficult to reverse.

Evaporation – process by which water changes from liquid to gas and is "lost" to the atmosphere.

Evapotranspiration – When water is released by a plant and evaporates from leaves and soil.

Extensive vegetated roof – A vegetated roof with a media depth of 4 to 6 inches; vegetation is composed of drought-resistant plants whose only water source is usually rainwater.

Filtration – a treatment method that removes pollutants using straining, sedimentation, and similar processes.

Green roof – See vegetated roof.

Heat Island – this is an effect, observed in urban areas, of elevated ambient temperatures, which occurs due to storage of heat in the mass of concrete. This mass takes longer to cool than surrounding areas, producing the observed effect.

Impermeable liner – A material designed to retard seepage from ponds and wetlands.

Impervious surfaces – Hard surfaces that do not allow *infiltration* of rainfall into them; not *pervious*.

Infiltration – The process by which water (surface water, rainfall, or runoff) enters the soil.

Intensive vegetated roof – A vegetated roof with soil depth ranging from 10 inches to 4 feet. Vegetation can be composed of shrubs and trees in addition to other plants. Irrigation is generally necessary.

Media, media filter bed, filter bed – The topsoil that supports plant growth with a best management practice. Bioretention media is used in dry swale and typically has a high-sand content and low-clay and -phosphorus content.

Nutrients – Substances required for growth of all biological organisms. When considering water qualities, nutrients of greatest concern are nitrogen and phosphorus in stormwater, because they are often limiting in downstream waters. Excessive amounts of these substances are pollution and can cause algal blooms and dead zones to occur in downstream waters.

Peak runoff – The highest water flows off a surface during a storm event.

Pervious – A ground surface that is porous and allows infiltration into it.

Residence time – Is the average time it takes water to travel through a treatment system such as a VR. Residence time can also be called *detention time*.

Root barrier – Protects the impermeable liner from root puncture. It must be either a dense inorganic material that inhibits root penetration or contain a root repellant ingredient, such as copper.

Stormwater – Water that originates from impervious surfaces during rain events; often associated with urban areas. Also called runoff.

Stormwater conveyance system – Means by which stormwater is transported in urban areas.

Stormwater management – The management of runoff from pre- to postdevelopment, often using *stormwater treatment practices* and BMPs to manage quality and control release into receiving bodies of water.

Stormwater treatment practice – A type of BMP that is structural and reduces pollution of water that runs through it.

Vegetated roof – A roof designed and constructed to support living vegetation; also known as *green roofs*.

Vegetated roof media – A composite of inorganic and organic materials that support plant growth and filter runoff.