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Best Management Practice Fact Sheet 13:

Constructed Wetlands

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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 "Urban Stormwater: Terms and Definitions," Virginia Cooperative Extension (VCE) publication 426-119.

What Is a Constructed Wetland?

A *constructed wetland* (CW) is a low-cost and *sustainable* engineered *best management practice* (BMP) designed to reduce *stormwater* pollution. Constructed wetlands are considered to be one of the most reliable *stormwater treatment practices*. They are designed to function similarly to a self-*sustaining* natural *wetland*, and should require only moderate maintenance to function (figure 1).

Figure 1. Typical Constructed Wetland.
Photo courtesy of Cully Hession, biological systems engineering, Virginia Tech.

Where Can Constructed Wetlands Be Used?

An adequate, consistent water supply and the *soil texture* are two primary considerations when determining where CWs can be located. A constant *baseflow* from an upstream source is necessary to maintain an appropriate environment for wetland plant growth.

Sandy soils should be avoided if possible; otherwise, the wetland may not hold water. Soils in a wetland must be saturated for certain periods during a year. If the soil where the CW is needed is too coarse (i.e., too much sand), an *impermeable liner* can be used to help it hold water and minimize *seepage* losses.

How Do Constructed Wetlands Work?

Management of stormwater focuses on two objectives: water quantity control and water quality improvement.

"Water quantity control" is provided by constructed wetlands in the form of storage. This storage is the space that begins at the normal water surface elevation and ends at the top of the dam or control elevation. CWs effectively reduce and retard *peak stream flows* by acting like a buffer or shock absorber for flows into the receiving body of water.

"Water quality improvement" in CWs is provided by natural processes, including *biological uptake*, *microbial decomposition*, and *settling*. CWs are most effective at removing excess *nutrients* and *sediment*.

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Limitations

- Constructed wetlands are large — about 3 to 5 percent of the *watershed* that drains to the CW. If land is expensive, this can mean a high treatment cost.
- A minimum of 4 inches of *hydric soils* are needed to support plant growth.
- May export nutrients when vegetation is not actively growing or is dying back.
- Must maintain water levels to limit dry periods to a maximum of 30 days to maintain vegetation.
- May raise water temperatures due to long standing time.
- Must consider mosquito control.
- Increased *infiltration* may result in *groundwater contamination*.

Maintenance

Routine maintenance (annual)

- Monitor sediment levels. Excess sediment can fill in the CW, harming vegetation and reducing wetland performance.
- Monitor and replace wetland plants as needed.
- Inspect the CW regularly (e.g., are the inlet and outlet structures functioning and clear of debris?) and repair as needed.
- Remove trash and debris.

Nonroutine maintenance (as needed)

- Remove excess accumulated sediment (see above).
- Control *invasive species* and thin woody plant growth to keep vegetation manageable.

Performance

Constructed wetlands are effective at removing multiple pollutants from incoming water flow. A typical CW is expected to reduce total phosphorus by 50 percent and total nitrogen by 25 percent.

In a more advanced design, the constructed wetland is much larger (figure 2). The larger size helps provide a longer residence time. Advanced designs also provide for variable bottom topography, which promotes dense and diverse vegetation and enhances treatment. Advanced CW designs can improve the expected reduction of total phosphorus to 75 percent and of total nitrogen to 55 percent.

Expected Cost

The use of constructed wetlands is a relatively inexpensive stormwater treatment practice when compared to other alternatives. verage construction costs are estimated to be \$9 per ft^2 of surface area of the wetland (Washington State Department of Ecology, & Herrera Environmental Consultants, 2012). Annual maintenance cost is estimated to be 3 to 5 percent of the construction cost. The value of land is not included in this analysis.

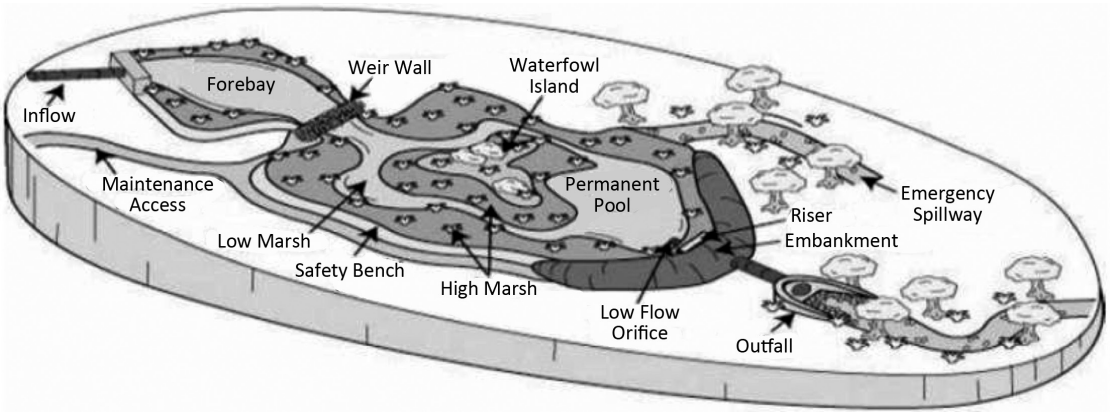

Figure 2. Sample constructed wetlands plan by the Virginia Department of Conservation and Recreation (VA-DCR; 2011).

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 https://www.swbmp.vwrrc.vt.edu/ (Permanent link: https://perma.cc/WC5L-KCZ8). The BMP Clearinghouse is jointly administered by the VA-DEQ and the Virginia Water Resources Research Center.

Online Resources

Charles River Watershed Association – https://www.crwa.org/hs-fs/hub/311892/file-634282714-pdf/Our_Work_/Blue_Cities_Initiative/Resources/Stormwater_BMPs/CRWA_Stormwater_Wetlands.pdf

Sewanee Wetland Rsearch Station - http://sewaneewetlands.org/constructed-wetlands Permanent link: https://perma.cc/PVM4-8H52

National Environmental Services Center – http://www.nesc.wvu.edu/ecommerce/products/WW_Design/WWBKDM83DL.pdf

New Jersey Department of Environmental Protection – http://state.nj.us/dep/stormwater/bmp_manual2.htm

North Carolina State University – https://stormwater.bae.ncsu.edu/research-projects/constructed-stormwater-wetlands/ (Permanent link: https://perma.cc/S5YL-BBBW)

U.S. Environmental Protection Agency – https://www.epa.gov/wetlands/constructed-wetlands (Permanent link: https://perma.cc/M5VM-34LM)

Virginia Stormwater BMP Clearinghouse – https://www.swbmp.vwrrc.vt.edu/ (Permanent link: https://perma.cc/WC5L-KCZ8)

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 J. M. Goatley. VCE Publication 430-350.

L. Fox, and M. Andruczyk. 2018. *Urban Water Quality Management: What Is a Watershed?* VCE Publication 426-041.

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Washington State Department of Ecology, & Herrera Environmental Consultants. *PugetSound Stormwater BMP Cost Database. 2012*

Virginia Department of Environmental Quality (VA DEQ). 2011. *Virginia DEQ Stormwater Design Specification No.13: Constructed Wetlands*, Version 1.9. https://www.swbmp.vwrrc.vt.edu/wp-content/uploads/2017/11/BMP-Spec-No-13_CONSTRUCTED-WETLAND_v1-9_03012011.pdf.

Glossary of Terms

Anaerobic – Chemical reactions that proceed without the presence of oxygen.

Baseflow – The portion of flow in a stream that continues even during extended dry periods.

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

Biological uptake – The process by which plants absorb nutrients for nourishment and growth.

Constructed wetland – A wetland that is designed to provide water quality treatment of stormwater. CWs have been used to treat domestic wastewater.

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

Groundwater contamination – The presence of unwanted chemical compounds in groundwater. In this case, we would normally be referring to dissolved compounds, such as nitrates. It could possibly include unwanted bacteria.

Habitat – The environment where organisms, like plants, normally live.

Hydric soils – Soils that form under saturated conditions. When saturated conditions exist, *anaerobic* chemical processes dominate and unique chemical properties develop. A common characteristic of hydric soils is the presence of a rotten-egg odor, indicating the presence of hydrogen sulfide (H_2S) gas.

Impervious surface – A hard surface that does not allow infiltration of rainfall into it; not *pervious*.

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

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

Invasive species – Nonnative species that can cause adverse economic or ecological impacts to the environment, usually due to the tendency of these introduced species to dominate local *habitats* and replace native ecological communities.

Microbial decomposition – The breakdown of compounds or organic matters into smaller one with the aid of microorganisms.

Nutrients – Substances that are required for growth of all biological organisms. When considering water quality, the nutrients of most concern in stormwater are nitrogen and phosphorus. Excessive amounts of these substances are pollution and can cause algal blooms and dead zones to occur in streams and estuaries.

Peak stream flows – The highest water flows within a stream during a storm event.

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

Residence time – The average time it takes water to travel through a treatment system such as a CW. Residence time can also be called "detention time."

Sediment – Soil, rock, or biological material particles formed by weathering, decomposition, and erosion. In water environments, sediment is transported across a watershed via streams.

Seepage – Water that is lost through the bottom of a lake or wetland.

Settling – The process by which particles that are heavier than water fall to the bottom under the influence of gravity.

Soil texture – Describes the composition of soil based on its particle sizes. According to the U.S. Department of Agriculture's classification, soils are classified as sands (larger than 0.05 millimeter, or mm), silts (0.002 to 0.05 mm), and clays (smaller than 0.002 mm).

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

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

Sustainable – The ability of the system to endure and remain productive over a long period of time.

Sustaining – The act of enduring (see "sustainable").

Watershed – A unit of land that drains to a single "pour point." Boundaries are determined by water flowing from higher elevations to the pour point. A pour point is the point of exit from the watershed, or where the water would flow out of the watershed if it were turned on end.

Wetland – Land that has hydric soil and wetland vegetation and is periodically saturated with water.