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Operation and maintenance of swales - supplemental information

Green Infrastructure: Swales can be an important tool for retention and detention of stormwater runoff. Because they utilize vegetation, swales provide additional benefits, including cleaner air, carbon sequestration, improved biological habitat, and aesthetic value.

This page provides guidance for operation and maintenance (O&M) of **swales** (https://stormwater.pca.state.mn.us/index.php?title=Dry_swale_(Grass_swale)). This includes **dry swales** (https://stormwater.pca.state.mn.us/index.php?title=Dry_swale_(Grass_swale)), **wet swales** (https://stormwater.pca.state.mn.us/index.php?title=Wet_swale_(wetland_channel)), **bioswales**, and high gradient **step pools**.

Image of a swale at Lino Lakes city hall

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Sustainable service life

The service life of swales depends upon the pollutant of concern.

Infiltration rate service life before clogging

It is known that plant roots are essential in **macropore** formation, which helps maintain infiltration into soil. If proper **pretreatment** (https://stormwater.pca.state.mn.us/index.php?title=Pretreatment) is present, service life for **infiltration** (https://stormwater.pca.state.mn.us/index.php?title=Stormwater_infiltration_Best_Management_Practices) should be unlimited. However, if construction site runoff (or another source of fines) is not prevented from entering the swale, clogging will occur, limiting or eliminating the infiltration function of the system, thus requiring restorative maintenance or repair (Brown and Hunt (https://apps.dasnr.okstate.edu/SSL/lid.okstate.edu/MVuploaded_files/Brown2010.pdf), 2010).

Nitrogen reduction

Nitrogen removal is not a primary function of dry swales.

Phosphorus reduction

Phosphorus (P) removal in swales is achieved primarily through infiltration and sorption of phosphorus to trapped sediments. Sediment bound phosphorus is removed through **sedimentation** (https://stormwater.pca.state.mn.us/index.php?title=Stormwater_sedimentation_Best_Management_Practices), while removal of soluble phosphorus depends on the type of soil/ **media** (https://stormwater.pca.state.mn.us/index.php?title=Design_criteria_for_bioretention#Materials_specifications_-_filter_media) used. If the soil/media is already saturated with P (i.e., its P binding sites are full), it will not be able to retain additional dissolved P and the P in stormwater will tend to leach from the soil/media as it passes through the biofilter (Hunt et al., 2006 (https://owl.cwp.org/mdocs-posts/evaluating-bioretention-hydrology-and-nutrient-removal-at-three-field-sites-in-north-carolina/)). It is highly recommended that the P-index of the media at installation be below 36 milligrams-P per kilogram of soil, to ensure P removal capacity. Laboratory research has suggested an oxalate extractable P concentration of 20 to 40 milligrams per liter will provide consistent removal of P (O'Neill and Davis, 2012). Leaching of phosphorus from soil or media is a concern for filtration swales (those having an **underdrain**). For information on phosphorus leaching from bioretention media, see the Design criteria for bioretention (https://stormwater.pca.state.mn.us/index.php?title=Design_criteria_for_bioretention#Addressing_phosphorus_leaching_concerns_with_media_mixes) page.

Heavy metals retention

Metals are typically retained in infiltration systems (including dry swales) through sedimentation and adsorption processes. Since there are a finite amount of sorption sites for metals in a particular soil/media, there will be a finite service life for the removal of dissolved metals. Morgan et al. (https://www.pca.state.mn.us/sites/default/files/

p-gen3-13s.pdf) (2011) investigated cadmium, copper, and zinc removal and retention with batch and column experiments. Using synthetic stormwater at typical stormwater concentrations, they found that 6 inches of filter media composed of 30 percent **compost** (https://stormwater.pca.state.mn.us/index.php?title=Compost_and_stormwater_management) and 70 percent sand will last 95 years until breakthrough (i.e., when the effluent concentration is 10 percent of the influent concentration). They also found that increasing compost from 0 percent to 10 percent more than doubles the expected lifespan for 10 percent breakthrough in 6 inches of filter media for retainage of cadmium and zinc. Using accelerated dosing laboratory experiments, Hatt et al. (2011) found that breakthrough of Zn was observed after 2000 pore volumes, but did not observe breakthrough for Cd, Cu, and Pb after 15 years of synthetic stormwater passed through the media. However, concentrations of Cd, Cu, and Pb on soil/media particles exceeded human and/or ecological health levels, which could have an impact on disposal if the soil/media needed replacement. Since the majority of metals retainage occurs in the upper 2 to 4 inches of the soil/media (Li and Davis, 2008), long-term metals capture may only require rejuvenation of the upper portion of the media.

Polycyclic aromatic hydrocarbons (PAHs) reduction

Accumulation of **polycyclic aromatic hydrocarbons** (PAHs) in sediments has been found to be so high in some stormwater retention ponds that disposal costs for the dredging spoils were prohibitively high. Research has shown that **bioretention practices**, on the other hand, are "a viable solution for sustainable petroleum hydrocarbon removal from stormwater, and that vegetation can enhance overall performance and stimulate biodegradation." (Lefevre et al., 2012). **Dry swales** (https://stormwater.pca.state.mn.us/index.php?title=Dry_swale_(Grass_swale)) provide some of the same functions as rain gardens, and therefore would be expected to provide some PAH management. However, swale performance in PAH management has not been the focus of any identified studies.

Erosion protection and sediment monitoring, removal, and disposal

Regular inspection of not only the BMP but also the immediate surrounding catchment area is necessary to ensure a long lifespan of the water quality improvement feature. Erosion should be identified as soon as possible to avoid the contribution of significant sediment to the BMP.

Pretreatment (https://stormwater.pca.state.mn.us/index.php?title=Pretreatment) devices need to be maintained for long-term functionality of the entire BMP. Accumulated sediment in filter strips, rock diaphragms, water quality sump catch basins, or any pretreatment features will need to be inspected yearly.

Timing of cleaning of these features is dependent on their design and sediment storage capabilities. In watersheds with erosion or high sediment loadings, the frequency of clean out will likely be increased. A vacuum truck is typically used for sediment removal. It is possible that any sediment removed from pretreatment devices or from the bottom of a dry swale may contain high levels of pollutants. All sediments, similar to those retrieved from a stormwater pond during dredging, may be subjected to the **MPCA's guidance for reuse and disposal** (https://www.pca.state.mn.us/sites/default/files/wq-strm4-16.pdf).

Sediment loading can potentially lead to a drop in infiltration or filtration rates. It is recommended that infiltration performance evaluations follow the four level assessment systems in **Stormwater Treatment: Assessment and Maintenance** (http://stormwaterbook.safl.umn.edu/)</span< (Gulliver et al., 2010). See **Assessing the performance of dry swale (grass swale)** (https://stormwater.pca.state.mn.us/index.php?title=Assessing_the_performance_of_dry_swale_(grass_swale)) for a summary of assessment methods.

Seeding, planting, and landscaping maintenance

Plant selection during the design process is essential to limit the amount of maintenance required. It is also critical to identify who will be maintaining the BMP in perpetuity and to design the plantings or seedings accordingly. The decision to install containerized plants or to seed will dictate the appearance of the BMP for years to come. If the BMP is designed to be seeded with an appropriate native plant based seed mix, it is essential the owner have trained staff or the ability to hire specialized management professionals. Seedings can provide plant diversity and dense coverage that helps maintain drawdown rates, but landscape management professionals that have not been trained to identify and appropriately manage weeds within the seeding may inadvertently allow the BMP to become infested and the designed plant diversity be lost. The following are minimum requirements for seed establishment and plant coverage.

- At least 50 percent of specified vegetation cover at end of the first growing season, not including REQUIRED cover crop
- At least 90 percent of specified vegetation cover at end of the third growing season, not including REQUIRED cover crop
- Supplement seeding/plantings to meet project specifications if cover requirements are not met
- Tailor percent coverage requirements to project goals and vegetation. For example, percent cover required for turf after one growing season would likely be 100 percent, whereas it would be lower for other vegetation types.

For information on **Minnesota plant lists** (https://stormwater.pca.state.mn.us/index.php/Minnesota_plant_lists) or **Plants for swales** (https://stormwater.pca.state.mn.us/index.php?title=Plants_for_swales)

For proper nutrient control, swales must not be fertilized unless a soil test from a certified lab indicates nutrient deficiency. If this is the case, apply the minimum rate of appropriate nutrients to provide a suitable environment for vegetation establishment while also minimizing the mobilization (and loss) of nutrients to downstream receiving waters. Irrigation may be needed during establishment, depending on soils, precipitation, and if stormwater flows are kept off-line during establishment.

Weeding is especially important during the plant establishment period, when vegetation cover is not 100 percent yet. Some weeding will always be needed. It is also important to budget for some plant replacement (at least 5 to 10 percent of the original plantings or seedings) during the first few years in case some of the plants or seed that were originally installed don’t become vigorous. It is HIGHLY RECOMMENDED that the install contractor be responsible for a plant warranty period. Typically, plant warranty periods can be 60 days or up to one year from preliminary acceptance through final inspections. If budget allows, installing larger plants (#1 container vs. 4” pot) during construction can decrease replacement rates if properly cared for during the establishment period.

Weeding in years after initial establishment should be targeted and thorough. Total eradication of aggressive weeds at each maintenance visit will ultimately reduce the overall effort required to keep the BMP weed free. Mulch is generally not recommended for use in swales since flowing water typically washes it downstream; however, mulch may be appropriate in planting beds or around individual trees on upper sideslopes and adjacent areas.

Rubbish and trash removal will likely be needed more frequently than in the adjacent landscape. Trash removal is important for prevention of mosquitoes and for the overall appearance of the BMP.

Snow and salt considerations

Dry swales generally should not be used as dedicated snow storage areas, but can be with the following considerations.

- Snow storage should not occur in areas designated as potential stormwater hotspots for road salt.
- Areas designed for infiltration should be protected from excessive snow storage where sand and salt is applied.

- Specific snow storage areas should be assigned that will provide some filtration before the stormwater reaches the BMP areas. NOTE: *Chloride will not be attenuated in filtration or infiltration BMPs such as dry swales.
- When used for snow storage, or if used to treat parking lot runoff, the BMP area should be planted with salt tolerant and non-woody plant species.
- BMPs should always be inspected for sand build-up on the surface following the spring melt event.

General maintenance activities and schedule are provided below.

Maintenance Agreements

A Maintenance Agreement is a legally binding agreement between two parties, and is defined as ”a nonpossessory right to use and/or enter onto the real property of another without possessing it.“ Maintenance Agreements are often required for the issuance of a permit for construction of a stormwater management feature and are written and approved by legal counsel. Maintenance Agreements are often similar to Construction Easements. A Maintenance Agreement is required for one party to define and enforce maintenance by another party. The Agreement also defines site access and maintenance of any features or infrastructure if the property owner fails to perform the required maintenance.

Maintenance Agreements are commonly established for a defined period such as five years for a residential site or 10 to 20 years for a commercial/governmental site after construction of the infiltration or filtration practice. Maintenance agreements often define the types of inspection and maintenance that would be required for that infiltration or filtration practice and what the timing and duration of the inspections and maintenance may be. Essential inspection and maintenance activities include but are not limited to drawdown time, sediment removal, erosion monitoring and correction, and vegetative maintenance and weeding. If maintenance is required to be performed due to failure of the site owner to properly maintain the infiltration or filtration practices, payment or reimbursement terms of the maintenance work are defined in the Agreement. Below is an example list of maintenance standards from an actual Maintenance Agreement.

- Live plantings and seeding areas shall be watered as necessary to achieve performance standards.
- Weeding and vegetation management (e.g., mowing, spot spraying) shall be conducted as necessary to achieve performance standards.
- Dead plant material, garbage, and other debris shall be removed from the swale at least annually.
- Silt/sediment should be removed from the swale bottom when the accumulation exceeds one inch.
- Side slopes must be inspected for erosion and the formation of rills or gullies at least annually, and erosion problems must be corrected immediately.
- If properly planned, designed, constructed, and maintained (including protected from sediment and compaction and incorporating sufficient pretreatment), a dry swale is likely to retain its effectiveness for well over 20 years. After that time, inspection will reveal whether sedimentation warrants scraping out the swale bottom and replanting it.

In some project areas, a drainage easement may be required. Having an easement provides a mechanism for enforcement of maintenance agreements to help ensure swales are maintained and functioning. Drainage easements also require that the land use not be altered in the future. Drainage easements exist in perpetuity and are required property deed amendment to be passed down to all future property owners.

As defined by the Maintenance Agreement, the landowner should agree to provide notification immediately upon any change of the legal status or ownership of the property. Copies of all duly executed property transfer documents should be submitted as soon as a property transfer is made final.

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