MMSD
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FRESH COAST GUARDIANS

GREEN INFRASTRUCTURE OPERATIONS & MAINTENANCE STANDARDS GUIDE

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INTRODUCTION

Throughout Southeast Wisconsin, communities use a combination of traditional and green infrastructure (GI) strategies to manage stormwater runoff, mitigate flooding, and protect water quality. GI strategies such as engineered bioswales, stormwater trees in structural soils, and permeable pavement provide benefits over and above those of traditional ponds and underground storage systems. GI strategies can reduce the urban heat island effect, return water to the natural hydrologic cycle, create urban habitats, and beautify urban spaces.

Consistent and effective maintenance is critical to unlocking the full potential of GI to benefit our communities. GI involves a broad range of practices and materials whose maintenance needs differ from season to season and place to place. As more GI measures are being built in public and private spaces, there is a need to develop a stronger base of knowledge and practice around GI operation and maintenance in the region. This document is intended to support building that base of knowledge and practice in metropolitan Milwaukee by breaking down the operation and maintenance components — labor, materials, equipment and practices — to ensure the long-term success of GI strategies.

This document offers detailed guidance for the standard maintenance and inspection of the primary GI strategies used in the metropolitan Milwaukee region, as defined by MMSD. Since each GI strategy has very distinct requirements, this guide is organized by GI type to ensure that clear standards and practices are outlined for municipal and county staff, maintenance contractors, property managers, and the many volunteers who are involved in southeast Wisconsin's garden clubs, conservancies, and watershed groups. The guide supports pre-planning for maintenance activities by outlining recommended tasks, frequencies, equipment and material needs, safety steps, and weather considerations that need to be taken into account for effective GI maintenance.

This guide is intended to orient GI design around maintenance to achieve better long-term outcomes for installed GI strategies. Up-front consideration of the visibility of a GI strategy on a site, the type of owner and property manager who will be responsible for upkeep, aesthetic needs, and surrounding land uses can prompt different plan or material selections and other design approaches. By assessing the maintenance needs of different practices up-front, using this guide, designers will become important partners in ensuring maintenance success.

With the ever-changing environmental conditions and many stresses affecting the region's urban environments, developing strong, well-informed GI maintenance practices is one step that can help ensure that investments in GI are well spent and continue to benefit our region over time. Users of this guide are encouraged to add their own notes and experiences to help the Milwaukee metropolitan area GI network become a success story for community and water quality.

GOALS FOR USE OF THIS DOCUMENT

Successful GI maintenance begins with good design and carries through construction, inspection, and ongoing maintenance phases. This document was developed to advance seven goals:

1 Ensure the ongoing stormwater management (i.e. volume capture and pollutant removal) function of GI strategies installed.

2 Maintain the intended aesthetic appearance of plants, planting beds, surfacing, and other components of GI installations.

3 Ensure that GI is designed for ease of maintenance, and that the design reflects the level of maintenance that can be reasonably provided after construction. For example, for spaces where regular maintenance is less likely, designers can use this guide to identify low maintenance features to incorporate into designs.

4 Ensure that GI strategies include appropriate levels and types of pretreatment based on the surrounding land use, runoff patterns, and trash and debris loadings.

5 Ensure staff who are charged with O&M have the necessary information and tools to evaluate the condition and function of different GI installations, and accurately identify O&M issues.

6 Provide metrics and methods for tracking maintenance activities, both to ensure permit compliance and to assess long-term functionality.

7 Enable managers of multiple GI strategies or sites to plan and optimize maintenance efforts and resources.

INTENDED USERS

The document is intended to help many different user groups work effectively with GI:

- Regulators: Understanding the maintenance needs of different practices to inform the development of permit criteria, technical standards for GI strategies, and compliance assessments.
- Municipal Staff: Supporting capital project and system maintenance planning, contractor selection, and training field staff to maintain GI effectively.
- Maintenance Contractors: Giving maintenance and landscape contractors the specific information and planning tools needed to provide high-quality service for GI strategies.
- General Contractors: Identifying crucial elements for construction that can make maintenance easier and more effective, especially during the warranty period.
- Property Owners and Managers: Provide clear, concise outlines of maintenance needs that facilitate good planning and lead to a high-quality product.
- Engineers and Landscape Architects: Point to design approaches, considerations, and features that can be incorporated into project development to facilitate better maintenance outcomes.
- Volunteers: Promote effective planning and strong understanding of the methods, materials, and practices that go into healthy landscapes and working GI strategies.

GREEN INFRASTRUCTURE O&M STANDARDS

Operation and Maintenance Standards were created for the following 11 green infrastructure strategies.

1) BIORETENTION / BIOSWALES
2) CONSTRUCTED WETLANDS
3) GREEN ROOFS
4) NATIVE LANDSCAPING
5) PERMEABLE INTERLOCKING CONCRETE PAVERS (PICP)
6) PERVIOUS CONCRETE
7) POROUS ASPHALT
8) RAIN GARDENS
9) RAIN WATER HARVESTING (CISTERNS)
10) SOIL AMENDMENTS
11) STORMWATER TREES

Each green infrastructure strategy listed above has an individual maintenance standard that includes the following information.

TITLE OF STRATEGY

The title of the individual strategy.

DESCRIPTION

A description of the individual strategy.

COMMON PRACTICES AND APPLICATIONS

Common locations and applications of where individual strategies are installed.

TYPICAL SECTION

A visual representation of the specific GI strategy that lists the common components, including what is located under the surface.

INSPECTION AND MAINTENANCE

A summary of the expected inspection, operations and maintenance of the individual strategy.

MAINTENANCE TASKS

A table that lists each individual maintenance task that may be provided for when performing operations and maintenance on a specific strategy. The table also includes a brief description of the maintenance tasks, indications of when the task is necessary, and the recommended minimum frequency of the task.

EXPECTED ANNUAL MAINTENANCE SCHEDULE

A table that lists the specific maintenance tasks that are expected to be performed on an annual basis. It lists the task, season (spring, summer, fall, winter, post 2-inch rain event), and frequency each task is expected to be performed during each season or event.

MAINTENANCE TASKS

Each green infrastructure strategy has an individual maintenance standard for the specific activities that are involved in maintenance. Many of these activities, such as water or sediment removal, are common to multiple GI strategies. The tasks described are:

1) CONCRETE REPAIR
2) DEICING
3) EROSION REPAIR
4) GRAFFITI REMOVAL
5) GRAVEL JOINT FILLING
6) MANUAL WEED CONTROL
7) MOWING
8) INVASIVE SPECIES CONTROL
9) MULCH AMENDMENT & REPLACEMENT
10) ORGANIC DEBRIS REMOVAL
11) PIPE JETTING
12) PLOWING
13) PRUNING (STRUCTURAL)
14) SANITIZING
15) SEDIMENT REMOVAL
16) SEEDING
17) SETTLING REPAIR
18) SOIL AMENDMENT
19) STRUCTURAL CLEARING & MAINTENANCE
20) SURFACE MEDIA RENOVATION
21) TRASH REMOVAL
22) WATERING
23) WOODY VEGETATION REMOVAL
24) VACUUM CLEANING
25) VEGETATION MAINTENANCE

Each maintenance task listed above includes the following information.

TITLE OF MAINTENANCE TASK

The title of the individual maintenance task.

DESCRIPTION

A description of the individual maintenance task .

EQUIPMENT & MATERIALS

A list of equipment and materials needed to perform the individual maintenance task.

INSTRUCTIONS

Step-by-step instructions on how to the perform the individual maintenance task.

SPECIAL CONSIDERATIONS

Any special considerations for the individual maintenance task. This is where manufacturer recommendations are included, as well as priority or specialty items. It also includes any other general considerations, observations, and actions that may be needed while performing the individual task.

GENERAL MAINTENANCE NOTES

For all GI installation, inspection, and maintenance activities, there are a number of practices that can facilitate good planning, record-keeping, and facility performance. The list below, while not exhaustive, is a general reference list of recommended practices for anyone installing, inspecting, or maintaining GI installations.

PLANS, PERMITS & BASELINE PHOTOGRAPHS

It is strongly recommended that for each GI strategy or suite of strategies, the owner develops a binder, folder, or digital location with key baseline information about the strategy or strategies. This should include planting plans for any vegetated strategies, baseline photos, recommended plant heights, mow/no mow areas, and related stormwater permits, stormwater management plans, and other information supporting operation and maintenance.

O&M FORMS & INSPECTION LOGS

All facility operators should keep inspection and maintenance logs. Operators should record date, description and contractor (if applicable) for all repairs, landscape maintenance, and facility cleanout activities.

SITE INSPECTION

Sites should be inspected at the beginning of every maintenance season (i.e. after snow melt) to assess maintenance needs, especially for any facilities with unusual conditions or needs. Sites should also be inspected after every 2-inch (or greater) rainfall, with special attention to areas where debris may collect.

PHOTO DOCUMENTATION

Photo documentation is especially valuable for GI strategies. Photos should always be taken prior to starting maintenance activities and at their conclusion to document how the facility is performing, what maintenance activities have been completed, and how the strategy looks before and after maintenance.

FERTILIZERS/PESTICIDES/HERBICIDES

The use of fertilizers, pesticides, and herbicides are discouraged for GI strategies because of the potential for damage to downstream aquatic systems and wildlife. If pesticides and herbicides are required, use the services of licensed applicator, and only use products approved for aquatic use, where required. It is essential to ensure any application is confined to affected plants or areas. Note, the use of chemical herbicides in waters of the state, including stormwater treatment facilities, is regulated by the Wisconsin Department of Natural Resources (WDNR) — Aquatic Plant Management Program under NR 107, Wisconsin Administrative Code. Contact the WDNR prior to using herbicides and/or algaecides.

ACCESS

Maintain ingress/egress per design standards.

INFILTRATION/FLOW CONTROL

All bioretention/bioswale and rain gardens are to be fully drained (i.e. free from standing water) within 48 hours of a 1-inch rainfall. If ponding is observed in a GI strategy, photograph the ponding and record the time/date, current and antecedent (i.e. last two days) weather conditions, and any other relevant site conditions observed. Water should always be ponded in constructed wetland and no duration of surface ponding is acceptable for permeable pavements and green roofs.

POLLUTION PREVENTION

All sites must implement best management practices to prevent contamination of stormwater. *Never wash spills into a stormwater facility.* If contamination occurs, document the circumstances and the corrective action taken; include the time, date, weather and site conditions.

VECTORS (MOSQUITOS AND RATS)

Stormwater facilities must not harbor mosquito larvae or rodents that pose a threat to public health or that undermine the facility structure. Record the time/date, weather, and site conditions when any vector activity is observed, and record the dates when any vector abatement starts and ends.

MAINTENANCE STANDARDS

BIORETENTION / BIOSWALE

(ALSO REFERRED TO AS: BIOFILTERS, BIOFILTRATION, AND BIOINFILTRATION)

DESCRIPTION

A stormwater management practice that allows water to pool in a depressed vegetated area and then infiltrate through engineered soils and into a gravel layer where water collects and is stored. The infiltrating or engineered soil layer is a special mix that typically includes sand mixed with compost. This layer is typically 18 to 24 inches deep to prevent disturbance of the gravel layer during maintenance activities. Both bioretention and rain gardens include an engineered soil layer. Unlike a rain garden, the bioretention includes a gravel storage layer and sewer systems. These sewer systems often include a section of perforated underdrain located within the gravel layer that carries stormwater to a discharge point. They also typically include cleanouts and a series of overflow structures that control the ponding depth. Bioretention can capture the stormwater runoff where it infiltrates through the engineering soil to remove pollutants. Bioretention can also retain the stormwater, slowly discharging to downstream storm sewer systems and waterways.

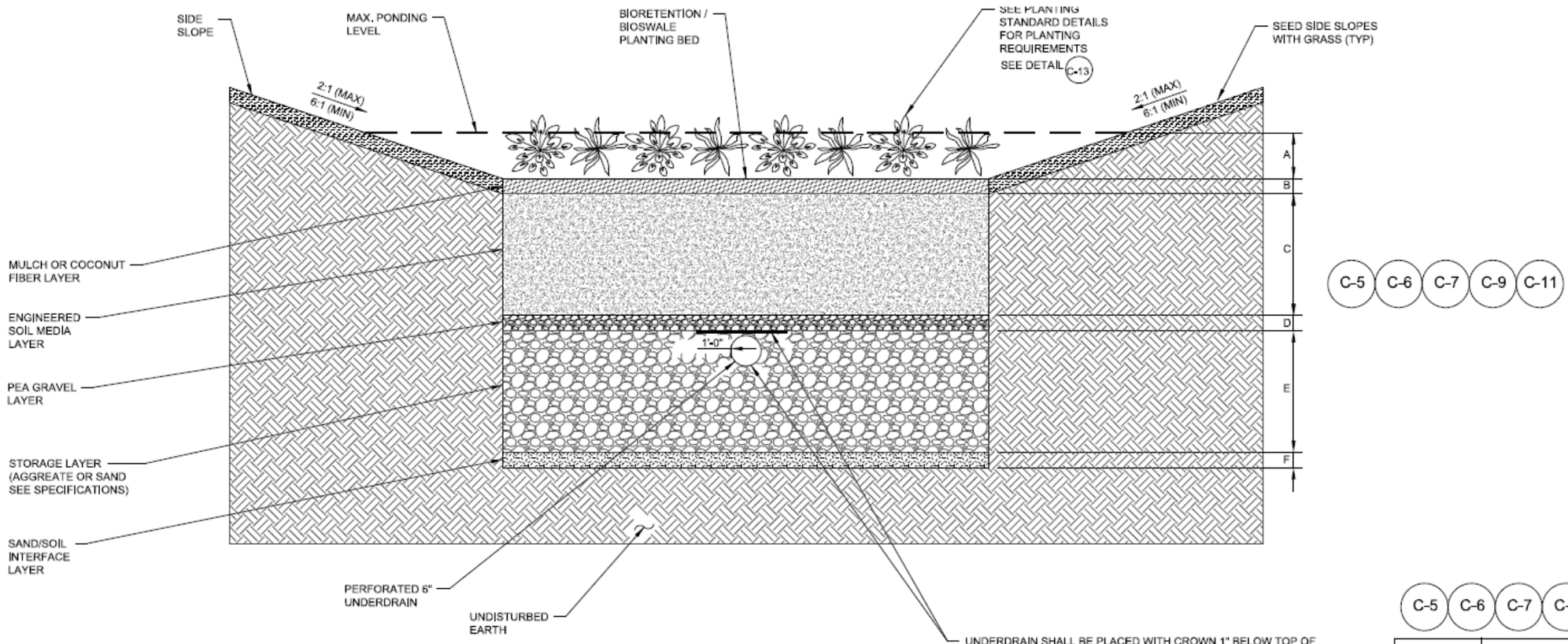
COMMON PRACTICES & APPLICATIONS

Bioretention can be constructed in a wide range of previously disturbed or developed areas, including areas with insufficient soils. Bioretention/Bioswales can be lined on the bottom, preventing stormwater from infiltrating, or can be purposely constructed in native soils with positive drainage to allow for infiltration of the treated stormwater. The engineered soils are used to provide infiltration and pollutant removal, and the gravel layer is used for collection and storage. Because of their filtration and storage layers, bioswales are well suited for applications with runoff from large impervious surfaces such as parking lots and roadway medians and can be incorporated or retrofitted into these designs.

BIORETENTION / BIOSWALE TYPICAL SECTIONS AND COMPONENTS

(Taken from MMSD's Bioretention-Bioswale GI Strategy Typical Details which can be found in MMSD's GI Calculator download.

Check the link for the most up-to-date sections: https://www.freshcoastguardians.com/static/GI_calc.zip)



C-5 C-6 C-7 C-9 C-11

C-5 C-6 C-7 C-9 C-11

DIMENSION	LAYER NAME	DEPTH
A	SURFACE PONDING	X
B	MULCH OR COCONUT FIBER	X
C	ENGINEERED SOIL MEDIA	X
D	PEA GRAVEL	X
E	STORAGE	X
F	SAND/SOIL INTERFACE	X

BIORETENTION / BIOSWALE TYPICAL CROSS-SECTION
(SLOPED SIDES)
SECTION A
NTS C-1

BIOSWALE

BIORETENTION / BIOSWALE INSPECTION & MAINTENANCE

This section provides guidance on maintenance activities that are typically required for these systems, along with suggested frequency for each activity. Individual systems may have more- or less- frequent maintenance needs depending on a variety of factors including the occurrence of large storm events, regional hydrologic conditions, and the upstream land use. Site-specific maintenance plans should always be consulted, as the successful functionality of the bioswale may have specific maintenance requirements that were considered during design.

Referring to Planting Plans & Photos: It is especially important to refer to planting plans and photos that show what types of vegetation should be present, and where maintenance crews should or should not mow.

Timing of Inspections: Bioretention should be inspected in the spring after snow melt, and after the end of the growing season to ensure the system will function as intended. In addition, because inflows from large storm events can damage vegetation, cause erosion, and clog inlets and outfall structures, bioswales should be inspected after any rain event of 2 inches in 24 hours or more. Inspection during the time of weed growth is also especially critical, as it is usually the top maintenance activity associated with these systems. For the Milwaukee area, this will begin in late-May through mid-July

Inspection Focus: Inspections should focus on the growth and condition of vegetation, including any weeds or invasives; soil conditions (especially sediment build-up or clogging); structural integrity; and stormwater flow paths and erosion. Maintenance of any items identified in the inspections should be completed within seven days of the inspection.

Initial Site Inspection: A site inspection should be performed after snow melt (mid-April) to identify any items that would not be covered in the expected annual maintenance visits. This would include:

- Identifying any bare areas in the bioswales
- Identifying any low or eroded areas in the engineered soil
- Identifying any structural component issues

Manual Weed Control: Depending on establishment and condition of planting bed, as many as 12 weeding visits could occur during the typical six-month growing season of mid-April through mid-October. The weeds are growing most aggressively from early May through mid-July (before native warm season grasses have filled out). During this period, visits may need to be weekly. Ornamental landscapes will typically require more visits than naturalized ones, but to begin with, naturalized landscapes will require more visits. As naturalized landscapes are established, the frequency of manual weed control will taper off.

BIORETENTION / BIOSWALE MAINTENANCE TASKS, INDICATORS, AND FREQUENCY

Task	Description	Maintenance Indicator	Minimum Frequency
General			
Sign Care	Wipe down sign.	If dust or grime is present.	Annually
Graffiti Removal	Remove graffiti from site structures, sign, or bioswale surfaces.	If graffiti is present on bioswale sign, or adjacent to bioswale area.	As needed
Structural Components			
Concrete Repair	Repair cracks on concrete structures.	If cracks or fractures are present on concrete structures located in bioswale.	As needed
Structural Clearing & Maintenance	Clear trash, debris, sediment, etc. from inlet and outlet structures, including catch basins and curb inlets, to clear and restore to function.	Clogged inlets, outlets, or outfall structures.	Biannually
Pipe Jetting	Jet pipes clogged with trash debris, sediment, etc. to clear and restore to function; maintain at least 50% function.	Clogged inlets, outlets, or outfall structures.	As needed
Vacuum Cleaning	Vacuum out trash, debris, sediment, etc. from clogged structures.	Clogged inlets, outlets, or outfall structures.	As needed
Vegetation Components			
Invasive Species Control	Control invasive species impacting desired plant species in bioswale. Refer to Appendix of Top 10 Invasive Species for list of the most common invasive species found in GI strategies in Southeastern WI.	Invasive plants are present in bioswale.	Biannually, or as needed

Task	Description	Maintenance Indicator	Minimum Frequency
Manual Weed Control	Remove weeds by hand weeding.	If weeds are present in bioswale area.	Monthly (spring through fall – more frequently May through July)
Mowing	Mow plants if height of vegetation exceeds recommended heights. Mow perimeter edge of bioswales within vegetated grassy areas.	If height of vegetation exceeds recommended heights.	Annually
Pest Management*	Inspect plants for signs of disease or predation.	Presence of pests or diseased plants.	Biannually
Plant Replacement	Remove and replace dead plants.	If at least 10% of the plants have died.	As needed
Pruning	Remove damaged, diseased or dead branches or woody plants, small trees, or shrubs	If damaged, diseased, or dead branches are present, or if safe line of sight is obstructed.	Annually
Vegetation Maintenance	Trimming and/or transplanting annual herbaceous vegetation.	Presence of decayed material.	Annually
Watering	Water plants as necessary to ensure survival during extended dry periods.	Yellow or brown tips of leaves, dying plants, or wilted/dehydrated leaves or stalks. Note, yellow leaves can also be an indicator that plants are receiving too much water.	As needed, depending on weather
Woody Vegetation Removal	Remove of woody vegetation or saplings.	If unplanned woody vegetation or saplings are present in bioswale.	Annually

Task	Description	Maintenance Indicator	Minimum Frequency
Growing Medium/Planting Bed Components			
Erosion Repair	Stabilize any disturbed areas with seed or live plantings and biodegradable erosion matting.	If minor (<20 sf), nonrecurring erosion is present within the bioswale, or if erosion is deeper than 2 inches.	As needed
Mulch Amendment/Replacement	Amend (i.e. rake, aerate, and add material) or replace mulch in bioswale.	If visible mulch is observed to have bare spots, depth is less than 2 inches or appears compacted or disarrayed in or around bioswale.	Annually, or as needed
Organic Debris Removal	Remove excess organic debris (e.g., leaves, plant decay, etc.) from bioswale.	If present in bioswale.	Biannually
Sediment Removal	Remove sediment from bioswale basin and surrounding areas, including gutters and sidewalks.	If sediment is present or visible in or around the bioswale, and if sediment is more than 1-inch deep.	Biannually or as needed
Settling Repair	Repair areas of bioswale that have settled.	Area is observed to be lower than surrounding areas of designed elevation of bioswale.	As needed
Surface Media Renovation	Remove top inches of filter media and cultivating the surface.	Bioswale is clogged or not draining properly or within 48 hours of a rainfall.	As needed
Trash Removal	Remove trash from bioswale planting beds and surrounding areas. Report any evidence of dumping.	If present in or around the bioswale.	Monthly (spring through fall)
*Integrated Pest Management (IPM) routines are encouraged. This involves inspecting the plants for signs of disease or predation. The IPM approach encourages non-chemical methods for treated diseases or pests as a first resort.			

BIORETENTION / BIOSWALE EXPECTED ANNUAL MAINTENANCE VISITS

It is recommended to complete twelve (12) site visits annually for bioswale maintenance. The timing and the tasks related to each of these site visits is detailed in the table below.

Task	Spring	Summer	Fall	Winter	After 2-inch Rainfall [1]
Site Inspection	1[2]				2
Mowing			1[3]		
Manual Weed Control	3	3	3		
Pest Management		1	1		
Invasive Species Control		1	1		
Vegetation Maintenance	1				
Trash Removal	2	2	2		2
Organic Debris Removal	1		1		2
Pruning			1		
Structural Clearing & Maintenance	1				2
Woody Vegetation Removal			1		
Sediment Removal	1		1		2
Mulch Amendment/Replacement	1				2
Total Minimum Annual Expected Maintenance	**4**	**3**	**3**		**2**

[1] A summary of rainfall data at General Mitchell Airport revealed that there has been at least one 2-inch rainfall from 2014-2019. This table assumes two 2-inch, 24-hour rainfalls per year for planning purposes.

[2] Initial site inspection shall be completed mid-April after snowmelt. The site inspection should be the focus and other maintenance tasks **should not be considered** at this time. Site inspections conducted after 2-inch rainfalls can be combined with other maintenance tasks as needed.

[3] Mowing frequency is based on an established, native landscape. Mowing may take place in late-fall or early-spring depending on plant species.

If the native landscaping is recently established, the mowing is usually conducted in decreasing frequencies from the date of planting. Often five mowings the first full growing season, four the second, three the third, and so on. This allows the native seed to germinated and prevent annual weeds from flowering and setting seed.

If ornamental grasses are used, they are not mown, but usually trimmed back in early spring of each year.

CONSTRUCTED WETLANDS

DESCRIPTION

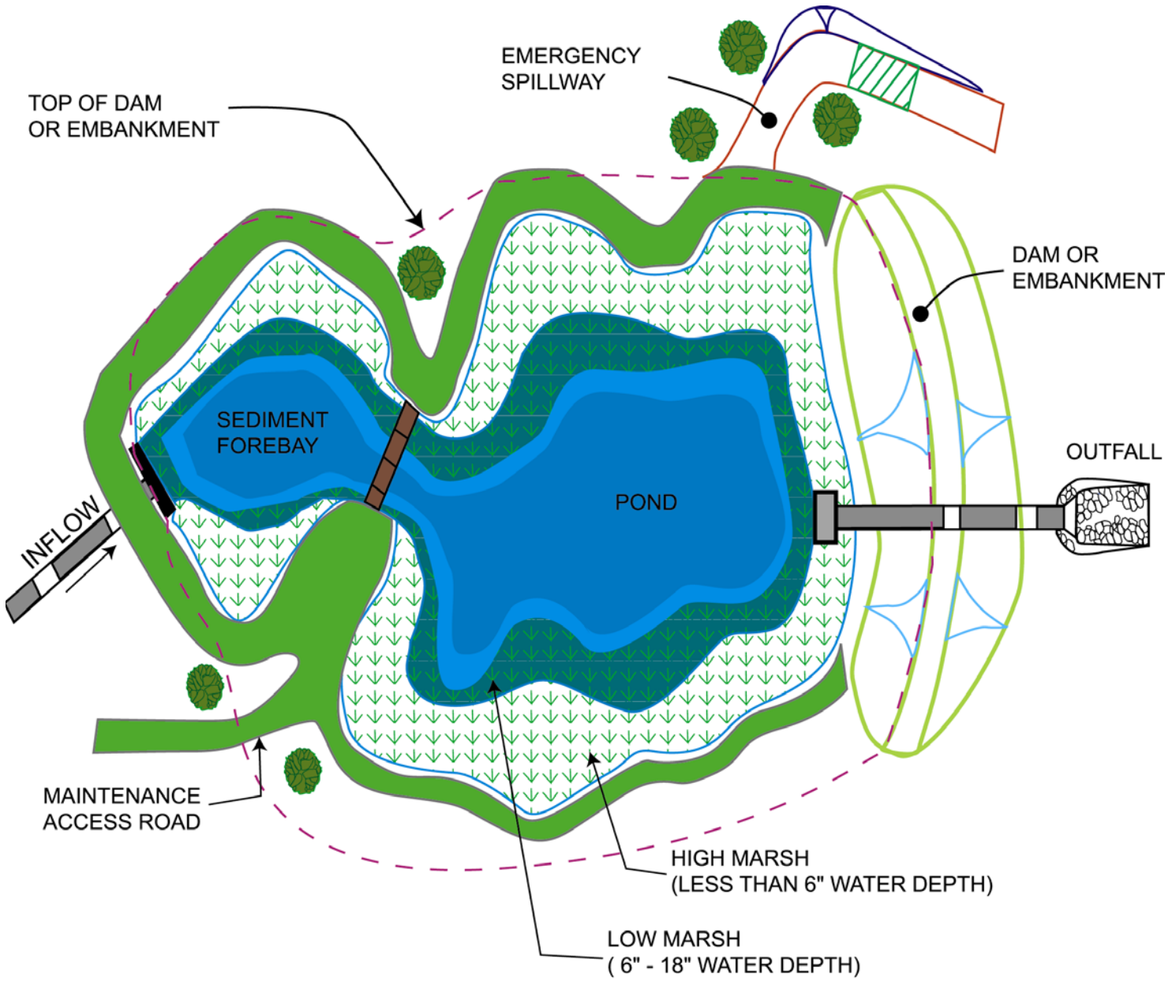
A stormwater management practice designed and constructed to simulate the pollutant removal, stormwater storage and other environmental benefits of natural wetlands. Constructed wetlands are often comprised of multiple inter-connected shallow pools, vegetation and microorganisms that remove pollutants through settling, biological uptake and biodegradation. Constructed wetland islands can be added to enhance pollutant control and improve habitat in constructed wetland systems or existing storm water ponds. Planted vegetation in constructed and natural wetlands are often adaptable to both dry and wet periods during the year. Constructed wetlands are managed and maintained to provide water quality benefits to downstream waterways while providing aquatic and wetland habitat for various species.

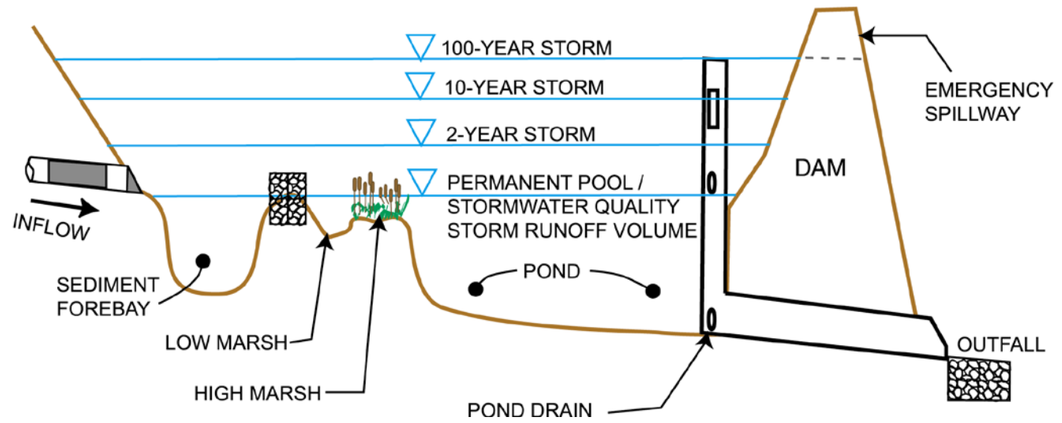
COMMON PRACTICES & APPLICATIONS

The various features of constructed wetlands can be designed to offer habitat for a variety of species. Common site conditions that are favorable to the development of a constructed wetland include surface area equaling approximately 3-5% of the contributing drainage area to mitigate pollutants, minimal invasive species on neighboring properties, and dedicated resources to conduct maintenance over the lifetime of the facility. Public trails and educational displays and signs can be incorporated into constructed wetlands which are often suitable for public spaces.

CONSTRUCTED WETLAND TYPICAL SECTION AND COMPONENTS

(this example was taken from New Jersey Stormwater Best Management Practices Manual – Chapter 9.2: Standard for Constructed Stormwater Wetlands – February 2004)





CONSTRUCTED WETLAND INSPECTION AND MAINTENANCE

This section provides guidance on maintenance activities that are typically required for these systems, along with suggested frequency for each activity. Individual systems may have more- or less-frequent maintenance needs depending on a variety of factors including the occurrence of large storm events, regional hydrologic conditions, and the upstream land use. Site-specific maintenance plans should always be consulted to as the successful functionality of the constructed wetland may have specific maintenance requirements that were considered during design.

Maintenance Plans: Maintenance of constructed wetlands is a critical component to the success of this type of designed facility. A detailed maintenance plan should be implemented to ensure plant matter is harvested at the appropriate times of year (typically fall), and to ensure the designated water areas do not become clogged with excess vegetative growth.

Burning: Intentionally burning plant growth is a measure sometimes used to control invasives and promote regrowth of desired plant species. Many prairie species flourish in the months following a control burn. This document does not outline burning as a specific maintenance task but recognizes that there are instances where burning may be the most effective method to control invasive species, especially in or around wetlands.

- A burn plan should be developed for the specific best management practice if controlled burns are necessary. The burn plan should include information such as emergency contacts, specific area to be burned, desired/required weather conditions, time-of-year considerations, required equipment, and more.
- Controlled burns are typically conducted in mid-spring. Too much rain in preceding days will make it difficult to maintain the fire, while dry conditions will make it difficult to control the fire and keep the burn in the designated area.
- Burning vegetation in GI strategies in urban areas should be conducted carefully, as public safety, private property and infrastructure are the primary concerns and considerations when choosing to use this type of control. Burn permits or approvals from the local fire department may be required.
- Controlled burns should not be conducted on windy days to minimize the potential for unintentional impacts or spreading.
- All controlled burned areas should be carefully monitored during and after the burn, to prevent unintentional impacts from spreading and to ensure the fire will not restart.

Referring to Planting Plans & Photos: It is important to refer to planting plans and past photos that show what types of vegetation should be present, and where maintenance crews should or should not remove vegetation. Designed and constructed pools of water or flowing water areas

should particularly be evaluated per the planting plan, to prevent these areas from becoming clogged over time with excess plant growth.

Timing of Inspections: Regular inspections and maintenance are critical to the effective operation of constructed wetlands as the vegetation needs to be monitored and harvested instead of naturally dying off. The many shallow pools, channels and upland areas need to be inspected and maintained to ensure they remain clear of leaves and debris that could back up water or divert flows. Inspection during the time of weed growth is also critical. For the Milwaukee area, this is late-May through mid-July.

Inspection Focus: Inspections should focus on the growth and condition of vegetation, including any weeds or invasives; wet pool or flowing water areas and specifically plant growth in these areas that was not called for in the planting plans; structural integrity of the inlets/outlets and other artificial structures throughout the constructed wetland; and storm water paths and erosion. Maintenance of any items identified in the inspections should be completed within 30 days of inspection.

Initial Site Inspection: A site inspection should be performed after snow melt (mid-April) to identify any items that would not be covered in the expected annual maintenance visits. This would include:

- Identifying any bare areas in or around the constructed wetland.
- Identifying any low or eroded areas in the embankment or berm.
- Identifying any structural component issues.

Manual Weed Control: Depending on establishment and condition of planting bed, as many as 12 weeding visits could occur during the typical 6 month growing season of mid-April through mid-October. The weeds are growing most aggressively from early May through mid-July (before native warm season grasses have filled out). During this period, visits may need to be weekly. Ornamental landscapes will typically require more visits than naturalized ones, but to begin with, naturalized landscapes will require more visits. As naturalized landscapes are established, the frequency of manual weed control will taper off.

CONSTRUCTED WETLAND MAINTENANCE TASKS, INDICATORS, AND FREQUENCY

Task	Description	Maintenance Indicator	Minimum Frequency
General			
Sign Care	Wipe down sign.	If dust or grime is present.	Annually
Graffiti Removal	Remove graffiti from site structures, signage, or GI surfaces.	If graffiti is present on GI signage, or adjacent to GI area.	As needed
Structural Components			
Concrete Repair	Repair cracks on concrete structures.	If cracks or fractures are present on concrete structures located in wetland area.	As needed
Pipe Jetting	Jet pipes clogged with trash debris, sediment, etc. to clear and restore to functioning.	Clogged inlets, outlets, or outfall structures.	As needed
Structural Clearing & Maintenance	Clearing trash, debris, sediments from inlet or outlet structures that may be hindering function.	Clogged inlets, outlets, or outfall structures.	Annually or as needed
Vegetation Components			
Invasive Species Control	Controlling invasive species impacting desired plant species in constructed wetland. Refer to Appendix of Top 10 Invasive Species for list of the most common invasive species found in GI strategies in Southeastern WI.	Invasive plants or animals are present in constructed wetland.	Biannually, or as needed
Manual Weed Control	Remove weeds by hand weeding.	If weeds are present in wetland area.	Monthly (spring through fall – more frequently May through July)

Task	Description	Maintenance Indicator	Minimum Frequency
Mowing	Mowing plants if height of vegetation exceeds recommended heights. Mow perimeter edge of constructed wetland within vegetated grassy areas.	If height of vegetation exceeds recommended heights.	Annually
Pest Management*	Inspect plants for signs of disease or predation.	Presence of pests or diseased plants.	Biannually
Plant Replacement	Remove and replace dead plants.	If at least 10% of the plants have died.	As needed
Pruning	Remove damaged, diseased or dead branches or woody plants, small trees, or shrubs	If damaged, diseased, or dead branches are present, or if safe line of sight is obstructed.	Annually
Vegetation Maintenance	Trimming and/or transplanting annual herbaceous vegetation.	Presence of decayed material.	Annually
Woody Vegetation Removal	Removal of woody vegetation or saplings.	If unplanned woody vegetation or saplings are present in constructed wetland.	Annually
Growing Medium/Constructed Wetland Components			
Erosion Repair	Stabilize any disturbed areas with seed and biodegradable erosion matting.	If minor (<20 sf), nonrecurring erosion is present within the wetland, or if erosion is deeper than 2 inches.	As needed
Organic Debris Removal	Remove excess organic debris (e.g., leaves, plant decay, etc.) from constructed wetland.	If present in constructed wetland.	Biannually
Sediment Removal	Remove sediment from constructed wetland and surrounding areas, including forebay.	If sediment is present or visible in or around the constructed wetland.	Biannually

Task	Description	Maintenance Indicator	Minimum Frequency
Settling Repair	Repairing areas of constructed wetland that have settled.	Area is observed to be lower than surrounding areas of designed elevation of constructed wetland.	As needed
Trash Removal	Remove trash from constructed wetland and surrounding areas. Report large dumping.	If present in or around the constructed wetland.	Monthly (spring through fall)
* Integrated Pest Management (IPM) routines are encouraged. This involves inspecting the plants for signs of disease or predation. The IPM approach encourages non-chemical methods for treated diseases or pests as a first resort.			

CONSTRUCTED WETLAND EXPECTED ANNUAL MAINTENANCE

It is recommended to complete twelve (12) site visits annually for constructed wetland maintenance. The timing and the tasks related to each of these site visits is detailed in the below table.

Task	Spring	Summer	Fall	Winter	After 2-inch Rainfall [1]
Site Inspection	1[2]				2
Mowing			1[3]		
Manual Weed Control	3	3	3		
Pest Management		1	1		
Invasive Species Control		1	1		
Vegetation Maintenance	**1**				
Trash Removal	2	2	2		2
Organic Debris Removal	1		1		2
Inlet Clearing & Maintenance	1				2
Pruning			1		
Woody Vegetation Removal			1		
Sediment Removal	1		1		2
Total Minimum Annual Expected Maintenance	**4**	**3**	**3**		**2**

[1] A summary of rainfall data at General Mitchell Airport revealed that there has been at least one 2-inch rainfall from 2014-2019. This table assumes two 2-inch, 24-hour rainfalls per year for planning purposes.

[2] Initial site inspection shall be completed mid-April after snowmelt. The site inspection should be the focus and other maintenance tasks **should not be considered** at this time. Site inspections conducted after 2-inch rainfalls can be combined with other maintenance tasks as needed.

[3] Mowing frequency is based on an established, native landscape. Mowing may take place in late-fall or early-spring depending on plant species.

If the native landscaping is recently established, the mowing is usually conducted in decreasing frequencies from the date of planting. Often five mowings the first full growing season, four the second, three the third, and so on. This allows the native seed to germinated and prevent annual weeds from flowering and setting seed.

If ornamental grasses are used, they are not mown, but usually trimmed back in early spring of each year.

GREEN ROOF

DESCRIPTION

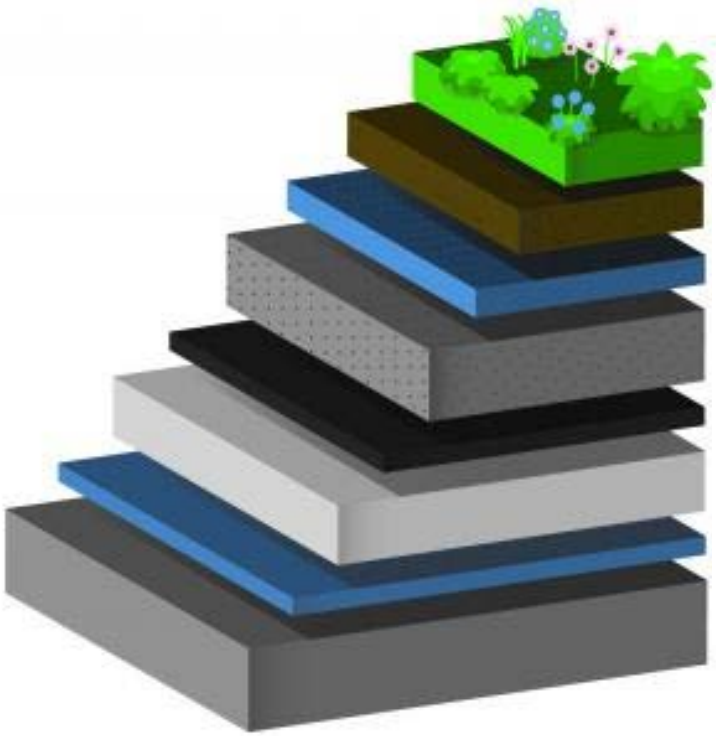
A green roof refers to a roof structure, often a building, that is either partially or completely planted with vegetation growing in soil or soil medium to absorb rainwater. Green roofs can be planted in waterproof trays or on top of a waterproof barrier. There are two types of green roofs: intensive, and extensive. Intensive are thicker, with a minimum depth of 12.8 cm (5.0 in), and extensive roofs, which are shallower, ranging in depth from 2 cm (0.79 in) to 12.7 cm (5.0 in).

COMMON PRACTICES & APPLICATIONS

Green roofs (also known as eco-roofs) act as stormwater management systems by collecting and managing the stormwater that falls on them. They can be retrofitted on existing buildings or redevelopments, or installed on new buildings, and are especially valuable in urban areas, where green space or pervious area is limited. The type of green roof is dependent on the roof structure and what it can support based on weight. This dictates the design, and ultimately the specific type of maintenance needed for each individual roof.

GREEN ROOF TYPICAL SECTION AND COMPONENTS

(Taken from EPA's Common Green Roof Layers: https://www.epa.gov/heat-islands/using-green-roofs-reduce-heat-islands#types)



Note the figure above represents the most common design of green roof and not all layers shown will be found on every green roof. Extensive green roofs may be simpler than intensive green roofs, and all types of roof will vary by manufacturer.

GREEN ROOF INSPECTION AND MAINTENANCE

This section provides guidance on maintenance activities that are typically required for these systems, along with suggested frequency for each activity. Individual systems may have more- or less- frequent maintenance needs depending on a variety of factors including the number and timing of large storm events, overly wet or dry (i.e. drought), irrigation and access. Site-specific maintenance plans should always be consulted, as the successful functionality of the green roof may have specific maintenance requirements that were considered during design.

Referring to Planting Plan, Design Plans, & Manufacturer Recommendations: It is especially important to refer to planting plans and photos that show what types of vegetation, soil mixture, roof membrane, and drainage structures that should be present. It is also important to refer to design plans and manufacturer recommendations, as green roof components and maintenance are specific to the design and type. Intensive roofs are heavier and tend to require more maintenance, where extensive tend to be lighter and require less (or even) minimal maintenance.

Timing of Inspections: Green roof maintenance is especially important during the first 3-5 years of installation, to ensure proper vegetation establishment. Green roofs should be inspected in the spring after snow melt, and after the end of the growing season to ensure the system will function as intended. In addition, because inflows from large storm events can damage vegetation, cause erosion, and clog inlets and outfall structures, green roofs should be inspected after any rain event of 2 inches in 24 hours or more. It is also important to check to make sure the roof is draining, and that there are no leaks in the membrane of the roof. Inspection during the time of weed growth is also critical. For the Milwaukee area, this is late-May through mid-July.

Inspection Focus: Because of the nature of green roofs and the location of maintenance activities, be sure to consult with the facilities manager and review design plans and manufacturer maintenance recommendations prior to performing any maintenance activities on a green roof. The following are general green roof maintenance considerations.

- **Personal Safety**: Maintenance crews must be trained to work on rooftop environments and must always utilize safety measures, including lines, harnesses, etc. Also, beware of potential nesting birds when approaching the roof.
- **Materials:** Never leave materials out that could blow off the roof and pose a hazard to people on the ground.
- **Roof Membrane:** The roof membrane must always be protected. It prevents water from entering the buildings and/or structures and can be easily damaged by foot traffic and maintenance tools (such a shovels). Anyone working on the roof needs to know what the membrane is, what it looks like, where it occurs in the profile of the roof, and ultimately how it should be protected. Roofs with organic membranes should be protected with a root barrier, which is usually a sheet of polyethylene, because plants will eat organic membranes (like bitumen). This sheet also needs to be maintained, and if it is damaged, it should be repaired.

- **Weight**: Green roofs are designed to a specific saturated weight, which is the weight of all the material when it is completely wet, this includes soil, drainage components, and plants. It is critical that maintenance workers do not add soil, change plantings, or store materials that would increase the weight of the roof system. This could cause damage to the roof structure, and potentially result in collapse. Rooftop soils are usually specially blended lightweight soils, and therefore planting soil should never be added to a roof without first consulting a design professional (engineer, landscape architect, architect).
- **Wind Scour:** One of the greatest threats to rooftop plantings is wind scour. Wind can desiccate plantings when it rolls over a parapet wall, or around rooftop mechanical equipment. The higher the roof, the more wind scour tends to increase, ultimately creating a bigger problem. Unvegetated soil will quickly blow away, and if the soil was necessary to weigh down a non-adhered roof membrane, then the membrane can become damaged as well.
- **Firebreaks:** A firebreak is a gap in vegetation or other combustible material that acts as a barrier to slow or stop the progress of a fire. Note that many insurers require that firebreaks are established and maintained on large roofs. Consult the facilities manager or design plans to ensure that if necessary, this is properly maintained.
- **Drainage Structures:** In general, pitched roofs have external gutters and downspouts, while flat roofs have internal roof drains. It is important for maintenance to know where the roof is actually draining, since the green roof components can disguise this. Internal drains are often protected in an enclosed metal box that can be accessed by opening a lid. It is important that these features be inspected frequently to make sure they are not clogged.

Site Inspections: A site inspection should be performed once after snow melt (mid-April), once in summer, and once in fall a to identify any items that might occur during expected annual maintenance, but also need special attention to, specific to green roofs:

- Identifying any bare or eroded areas caused by wind scour and/or wind desiccation, especially at roof edges and next to rooftop objects. Note, that some areas may end up being completely inhospitable to vegetation. In those cases, the plantings and planting soil should be replaced with an inorganic ballast (typically rock), that has the same saturated weight as the planned soil and vegetation.
- Identifying any structural component issues, including but not limited to leaks, tears, perforations, or deficiencies in membranes, root barriers, and drains.
- Monitoring weed control, especially if weed growth occurs in gravel beds that might be used to separate vegetation from mechanical features or adjacent building walls. Vegetation can climb behind and/or under flashing and impair the roof seal. This may also include inspecting and maintain firebreaks by removing weedy vegetation in a gravel break or restoring gravel paths that serve as firebreaks.

GREEN ROOF MAINTENANCE TASKS, INDICATORS, AND FREQUENCY

Task	Description	Maintenance Indicator	Minimum Frequency
General			
Sign Care	Wipe down sign.	If dust or grime is present.	Annually
Structural Components			
Membrane and Root Barrier Inspection [1]	Repair any leaks, tears, perforations, or structural deficiencies.	Noticeable leaks, and/or tears or perforations of the membrane, root barrier, or structural components.	Annually, or as needed
Structural Clearing & Maintenance	Clear trash, debris, sediment from conveyance structures, including gutters and/or roof drains draining to and from the green roof.	Clogged gutters, drains, pipes, or structures.	Monthly (spring through fall) or as needed
Vegetation Components			
Invasive Species Control	Control invasive species impacting desired plant species on green roof. Refer to Appendix of Top 10 Invasive Species for list of the most common invasive species found in GI strategies in Southeastern WI.	Invasive plants are present on the green roof.	Biannually
Manual Weed Control	Remove weeds by hand weeding.	If weeds are present on or around green roof, adjacent structures or gravel breaks.	Monthly (spring through fall – more frequently May through July)
Pest Management*	Inspect plants for signs of disease or predation.	Presence of pests or diseased plants.	Biannually
Plant Replacement	Remove and replace dead plants or sedums.	If at least 10% of the plants have died.	As needed
Vegetation Maintenance	Trimming and/or transplanting annual herbaceous vegetation.	Presence of decayed material.	Annually

Task	Description	Maintenance Indicator	Minimum Frequency
Watering	Water plants as necessary to ensure survival during extended dry periods.	Yellow or brown tips of leaves, dying plants, or wilted/dehydrated leaves or stalks. Note, yellow leaves can also be an indicator that plants are receiving too much water.	As needed, depending on weather
Woody Vegetation Removal	Remove of woody vegetation or saplings.	If unplanned woody vegetation or saplings are present on green roof.	Annually
Growing Medium/Planting Bed Components			
Erosion Repair	Stabilize any disturbed areas with seed or an inorganic ballast (typically rock) that has the same saturated weight as the planned soil and vegetation.	If minor (<20 sf), nonrecurring erosion is present within the green roof.	As needed
Organic Debris Removal	Remove excess organic debris (e.g., leaves, plant decay, etc.) from roof system.	If present on green roof.	Biannually
Sediment Removal	Remove sediment from green roof and surrounding areas, including gutters and roof.	If sediment is present/visible in or around the green roof.	Biannually or as needed.
Surface Media Renovation	Remove top inches of filter media and cultivating the surface. Check product type, structure, vegetation depth, and manufacturer recommendations prior to performing renovation.	Green roof is clogged or not draining properly within 48 hours of a rainfall (provided outlets are cleared).	As needed
Trash Removal	Remove trash from green roof planting beds and surrounding areas. Report any observed evidence of dumping.	If present on or around the green roof.	Biannually

[1] Membrane and Root Barrier Maintenance is not included as a maintenance task because membranes, barriers, and structural components of green roofs tend to be specific to manufacturer. Contact manufacturer for repair or replacement of parts.

* Integrated Pest Management (IPM) routines are encouraged. This involves inspecting the plants for signs of disease or predation. The IPM approach encourages non-chemical methods for treated diseases or pests as a first resort.

GREEN ROOF EXPECTED ANNUAL MAINTENANCE

It is recommended to complete eight (8) site visits annually for green roof maintenance. The timing and the tasks related to each of these site visits is detailed in the below table.

Task	**Spring**	**Summer**	**Fall**	**Winter**	**After 2-inch Rainfall [1]**
Site Inspection	1	1	1		2
Manual Weed Control	2	2	2		
Pest Management		1	1		
Invasive Species Control		1	1		
Vegetation Maintenance	1				
Trash Removal	1		1		2
Organic Debris Removal	1		1		2
Structural Clearing & Maintenance	1	1	1		2
Woody Vegetation Removal			1		
Sediment Removal	1	1	1		2
Total Minimum Annual Expected Maintenance	2	2	2		2

[1] A summary of rainfall data at General Mitchell Airport revealed that there has been at least one 2-inch rainfall from 2014-2019. This table assumes two 2-inch, 24-hour rainfalls per year for planning purposes.

NATIVE LANDSCAPING

DESCRIPTION

Native landscapes in Southeastern (SE) Wisconsin include a wide variety of plant communities, including forests, prairies, and savannahs. Native landscaping with grass or sedge dominated plant communities refers to plants with deep growing root systems that increase the infiltration capacity of soils by breaking up hardening soil structures and introducing macropores and organic matter. Native landscaping uses colorful native plants, non-invasive ornamentals, or a combination of the two to create a prairie-type setting. In addition, many native plants and grasses provide important habitat functions for birds, butterflies, and bees. As such, native landscaping can be used as a habitat enhancement feature of stormwater projects to achieve biodiversity goals.

COMMON PRACTICES & APPLICATIONS

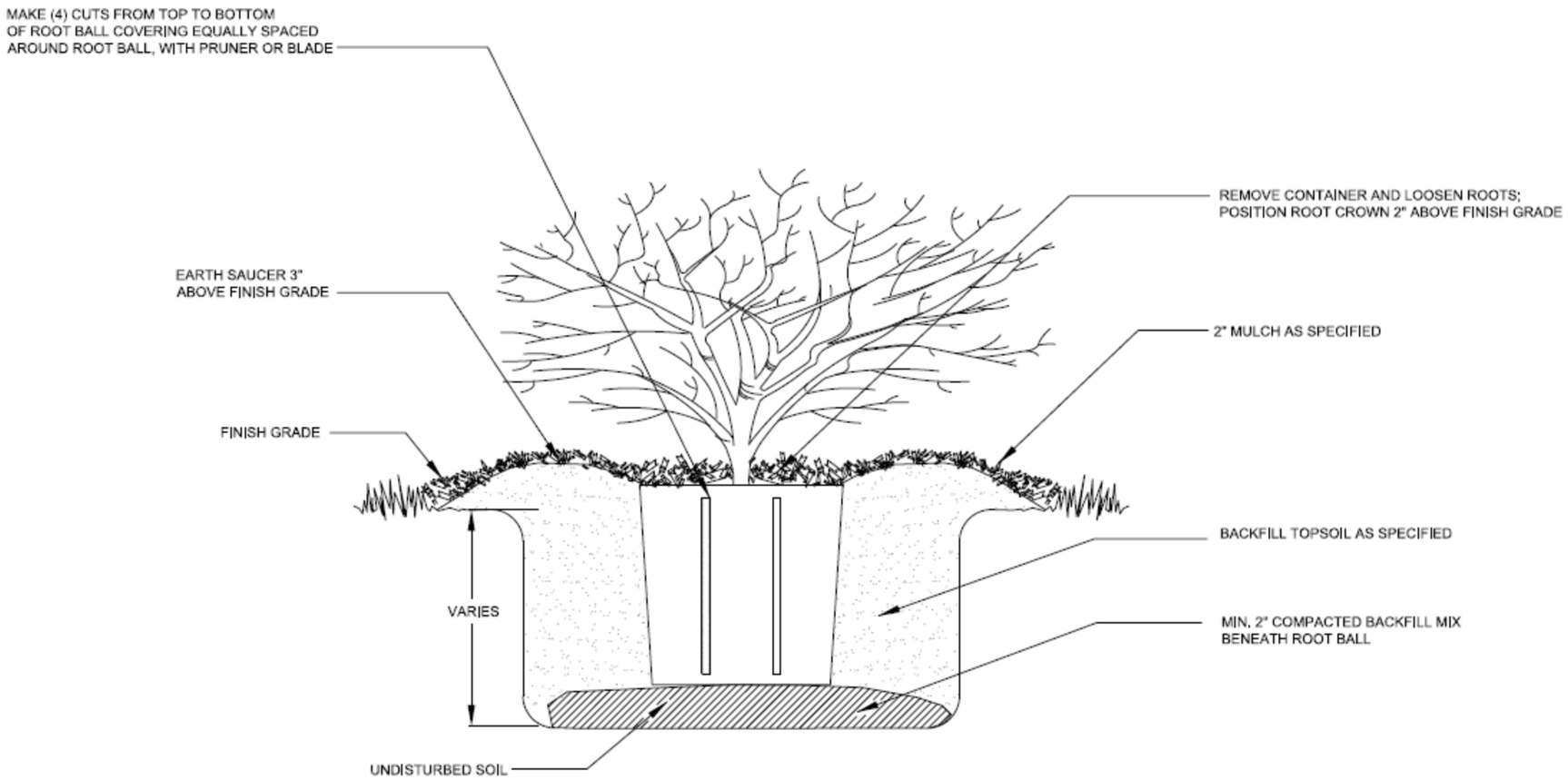
Native plant species can tolerate the drought and flooding cycles of an area, have evolved in a particular area, and are adapted to local climate conditions. Native prairie plants are typically used in many GI strategies in SE Wisconsin, including bioswales, rain gardens, and wetlands.

NATIVE LANDSCAPING (SHRUB) TYPICAL SECTION AND COMPONENTS

There are other native landscaping details considering the wide variety of plant communities, but the detail shown below is specific to a container grown shrub.

(taken from MMSD's Native Landscaping GI Strategy Typical Details which can be found in MMSD's GI Calculator download

Check the link for the most up-to-date sections: https://www.freshcoastguardians.com/static/GI_calc.zip)



NATIVE LANDSCAPING DETAIL

NTS

NATIVE LANDSCAPING INSPECTION & MAINTENANCE

This section provides guidance on maintenance activities that are typically required for these systems, along with suggested frequency for each activity. Individual systems may have more- or less- frequent maintenance needs depending on a variety of factors including the occurrence of large storm events, regional hydrologic conditions, and the upstream land use. Site-specific maintenance plans should always be consulted, as the successful functionality of the plants may have specific maintenance requirements that were considered during design.

Referring to Planting Plans, Photos and Plant Identification: One of the greatest challenges for native landscaping maintenance is plant identification. Maintenance professionals must distinguish healthy desirable plants from weeds and invasive plants. It is especially important to refer to planting plans and photos that show what types of vegetation should be present. There are numerous electronic applications for plant identification that can identify plants at various stages of growth.

Timing of Inspections: Maintenance tasks for native landscaping vary by season. Conducting the right tasks at the right point in the growing season will improve plant survival, aesthetics, and infiltration capacity.

Inspection Focus: It is also important to identify when areas are in the installment and establishment phase, when plant loss is expected, and plant identification may be the most challenging. Maintenance teams should expect approximately 10% of plant material to fail during the first year after planting, and plan accordingly for replacements. Warranties may cover part or all the replacement and are important tools to reduce replacement costs for the expected failure of some plants.

Initial Site Inspection: A site inspection should be performed after snow melt (mid-April) to identify any items that would not be covered in the expected annual maintenance visits. This would include:

- Identifying any bare areas in the landscaping.
- Identifying any low or eroded areas in the landscaped areas.

Manual Weed Control: Depending on establishment and condition of planting bed, as many as 12 weeding visits could occur during the typical six-month growing season of mid-April through mid-October. The weeds are growing most aggressively from early May through mid-July (before native warm season grasses have filled out). During this period, visits may need to be weekly. Ornamental landscapes will typically require more visits than naturalized ones, but to begin with, naturalized landscapes will require more visits. As naturalized landscapes are established, the frequency of manual weed control will taper off.

NATIVE LANDSCAPING MAINTENANCE TASKS, INDICATORS, AND FREQUENCY

Task	Description	Maintenance Indicator	Minimum Frequency
General			
Sign Care	Wipe down sign.	If dust or grime is present.	Annually
Graffiti Removal	Remove graffiti from site structures, sign, or GI surfaces.	If graffiti is present on signage, or adjacent to area.	As needed
Vegetation Components			
Invasive Species Control	Remove any invasive species affecting desired plant species in landscaped area. Refer to Appendix of Top 10 Invasive Species for list of the most common invasive species found in GI strategies in Southeastern WI.	Invasive plants are present in landscaped area.	Biannually, or as needed
Manual Weed Control	Remove weeds by hand weeding.	If weeds are present in landscaped areas.	Monthly (spring through fall – more frequently May through July)
Mowing	If directed by landscape plan, mow plants if height of vegetation exceed recommended heights. Mow perimeter edge of naturalized landscape within vegetated grassy areas.	If height of vegetation exceeds recommended heights.	Annually
Pest Management*	Inspect plants for signs of disease or predation.	Presence of pests or diseased plants.	Biannually
Plant Replacement	Remove and replace dead plants.	If at least 10% of the plants have died.	As needed

Task	Description	Maintenance Indicator	Minimum Frequency
Pruning	Remove damaged, diseased or dead branches or woody plants, small trees, or shrubs	If damaged, diseased, or dead branches are present, or if safe line of sight is obstructed.	Annually
Vegetation Maintenance	Trimming and/or transplanting annual herbaceous vegetation.	Presence of decayed material.	Annually
Watering	Water plants as necessary to ensure survival during extended dry periods	Yellow or brown tips of leaves, dying plants, or wilted/dehydrated leaves or stalks. Note, yellow leaves can also be an indicator that plants are receiving too much water.	As needed, depending on weather
Woody Vegetation Removal	Remove woody vegetation or saplings.	If unplanned woody vegetation or saplings are present in landscaped area.	Annually
Growing Medium/Planting Bed Components			
Erosion Repair	Stabilize any disturbed areas with seed or live plants and biodegradable erosion matting.	If minor (<20 sf), nonrecurring erosion is present within the landscaped area, or if erosion is deeper than 2 inches.	As needed
Mulch Amendment/Replacement	Amend (i.e. rake, aerate, and add material) or replace mulch in landscaped areas.	If visible mulch is observed to have bare spots, depth is less than 2 inches or appears compacted or disarrayed in or around landscaped area.	Annually or as needed
Organic Debris Removal	Remove excess organic debris (e.g., leaves, plant decay, etc.) from landscaped surfaces.	If present in landscaped area.	Biannually

Task	Description	Maintenance Indicator	Minimum Frequency
Sediment Removal	Remove sediment from landscaping and surrounding areas, including gutters and sidewalks.	If sediment is present or visible in or around the landscaped area, and if sediment is more than 1 inch deep.	Biannually or as needed
Settling Repair	Repair areas of landscaping that have settled.	Area is observed to be lower than surrounding areas of designed elevation of landscaping.	As needed
Trash Removal	Remove trash from landscaped planting beds and surrounding areas. Report any evidence of dumping.	If present in or around the landscaped area.	Monthly (through spring and fall)
* Integrated Pest Management (IPM) routines are encouraged. This involves inspecting the plants for signs of disease or predation. The IPM approach encourages non-chemical methods for treated diseases or pests as a first resort.			

NATIVE LANDSCAPING EXPECTED ANNUAL MAINTENANCE

It is recommended to complete twelve (12) site visits annually for native landscaping maintenance. The timing and the tasks related to each of these site visits is detailed in the below table.

Task	Spring	Summer	Fall	Winter	After 2-inch Rainfall [1]
Site Inspection	1[2]				2
Mowing			1[3]		
Manual Weed Control	3	3	3		
Pest Management		1	1		
Invasive Species Control		1	1		
Vegetation Maintenance	1				
Trash Removal	2	2	2		2
Organic Debris Removal	1		1		2
Pruning			1		
Woody Vegetation Removal			1		
Sediment Removal	1		1		2
Mulch Amendment/Replacement	1				2
Total Minimum Annual Expected Maintenance	**4**	**3**	**3**		**2**

[1] A summary of rainfall data at General Mitchell Airport revealed that there has been at least one 2-inch rainfall from 2014-2019. This table assumes two 2-inch, 24-hour rainfalls per year for planning purposes.

[2] Initial site inspection shall be completed mid-April after snowmelt. The site inspection should be the focus and other maintenance tasks **should not be considered** at this time. Site inspections conducted after 2-inch rainfalls can be combined with other maintenance tasks as needed.

[3] Mowing frequency is based on an established, native landscape. Mowing may take place in late-fall or early-spring depending on plant species.

If the native landscaping is recently established, the mowing is usually conducted in decreasing frequencies from the date of planting. Often five mowings the first full growing season, four the second, three the third, and so on. This allows the native seed to germinate and prevent annual weeds from flowering and setting seed.

If ornamental grasses are used, they are not mown, but usually trimmed back in early spring of each year.

PERMEABLE INTERLOCKING CONCRETE PAVEMENT

DESCRIPTION

Permeable Interlocking Concrete Pavement (PICP) consists of concrete pavement units or bricks that when assembled into a pattern, creates open joints. These joint openings are typically filled with an open-graded chip stone that allow water to run through. The overall ratio of void space to the paver surface is approximately 13%. The paving units are placed on a bedding layer of permeable aggregates, which is laid over a base and subbase layer of open-graded aggregates. Perforated underdrains are typically placed in bottom storage layer to collect and convey water out of the system if it does not infiltrate within the design period, which is typically 48 to 72 hours. These systems provide infiltration and groundwater recharge and are capable of tremendous amounts of storage. Of equal importance is the structural functionality of the pavement. PICP is designed as a flexible pavement for structural load, desired storage, and frost depth requirements. The concrete blocks that form the pavers have the added benefit of being a cooler surface than dark pavements and reduce heat island effects.

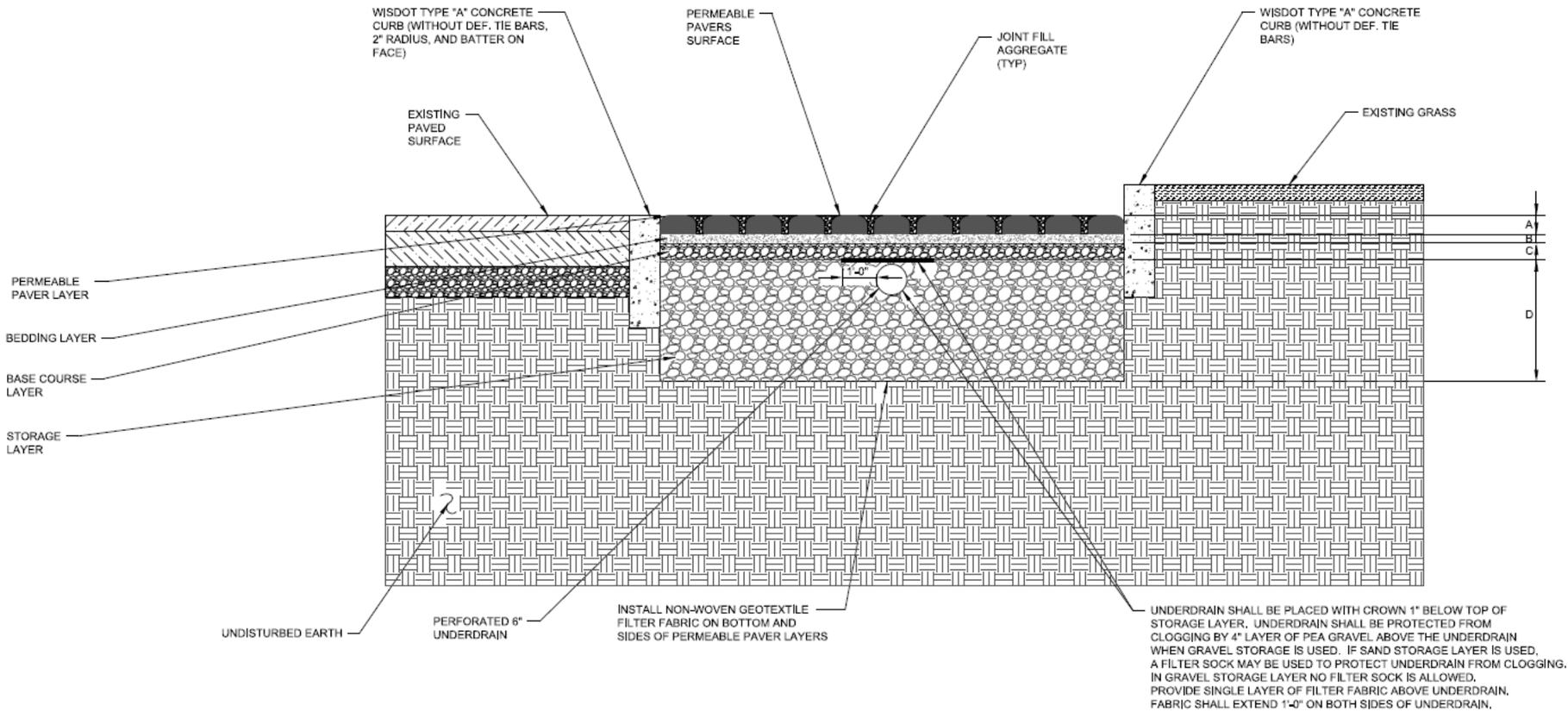
COMMON PRACTICES & APPLICATIONS

PICP is well-suited for parking areas, sidewalks, recreational areas, driveways, and roadway parking lanes with proper design considerations. PICP has been used in heavy duty applications such as shipping container storage because of its tremendous durability. Heavy duty volume applications require a commitment to proper design, construction quality assurance, and long-term operations and maintenance.

PERMEABLE INTERLOCKING CONCRETE PAVEMENT TYPICAL SECTION AND COMPONENTS

(taken from MMSD's Porous Pavement GI Strategy Typical Details which can be found in MMSD's GI Calculator download

Check the link for the most up-to-date sections: https://www.freshcoastguardians.com/static/GI_calc.zip)



DIMENSION	LAYER NAME	DEPTH
A	PERMEABLE PAVERS	X
B	BEDDING	X
C	BASE COURSE	X
D	STORAGE	X

PERMEABLE PAVERS TYPICAL CROSS-SECTION

SECTION A
NTS C-14

PERMEABLE INTERLOCKING CONCRETE PAVEMENT INSPECTION & MAINTENANCE

This section provides guidance on maintenance activities that are typically required for these systems, along with suggested frequency for each activity. Individual systems may have more- or less- frequent maintenance needs depending on a variety of factors including the occurrence of large storm events, regional hydrologic conditions, and the upstream land use. Site-specific maintenance plans should always be consulted, as the successful functionality of the pavement may have specific maintenance requirements that were considered during design.

There are a number of important principles for PICP inspection and maintenance that will extend the life and function of these systems.

Reducing run-on of sediment and debris: Controlling run-on and preventing tracking or transport of debris onto PICP surfaces is key to extending the life of PICP systems. Approaches to this include:

- Practice strict erosion and sediment control on upstream or contributing areas.
- Vacuuming or sweeping of upstream areas that contribute sediment or debris can be effective in minimizing run-on.
- Mow surrounding grass away from the PICP surface. Consider collecting grass clippings to prevent debris from collecting in joints.
- Do not store materials such as sand, salt, mulch, soil, yard waste, and other stockpiles on permeable surfaces.
- Stockpiling snow on PICPs is not recommended and will lead to premature clogging. Stockpiled snow areas on PICPs will require additional maintenance and vacuuming to prevent clogging and deterioration.

Repairing cuts for utilities: Repairs may be needed for cuts made for utilities. Repairs can typically be made by removal and reuse of the existing paver blocks. Subbase repair may be required to match the initial construction standards.

Informational Signs: Posting signs that alert people to the use of PICPs for surfacing are helpful and recommended. Signage should indicate any limitations on design load (i.e. passenger vehicles only, light truck traffic, etc.) as well as, applicable warnings regarding plowing, use of salt, snow stockpiling, and avoiding debris run-on.

Routine PICP Maintenance:

Routine preventative cleaning of PICP is more effective than corrective cleaning, but both practices are feasible and will be needed at some point in the life of the PICP system. At a minimum, if the recommendations above regarding stockpiling and run-on prevention are followed, 3x yearly vacuum cleaning of the interlocking concrete pavers will remove sediments and contaminants to prevent clogging. All sweepings from routine vacuuming must be disposed of according to appropriate standards.

Preventative sweeping is recommended during high-use periods, or if sediment and debris has washed onto PICP areas.

Gravel Joint Filling: The gravel joint fill in PICP tends to settle substantially during the first 3 to 6 months after its initial installation. Construction specifications should require that the contractor revisit the site 6 months after construction to refill the joints with gravel.

Power-washing of PICP should be used for cleaning acutely clogged areas.

- Power-washing activity should only be done in conjunction with use of a high velocity vacuum head so that debris is removed, and not just displaced. A power vacuum, such as Elgin Whirlwind or Tymco 500X is recommended.
- Power-washing may be required prior to vacuum sweeping to dislodge trapped particles in acutely clogged areas.
- Power-washing should occur at mid-pressure, typically less than 500 pounds per square inch, and at a low angle less than 45 degrees, to drive sediment and material out of the void spaces, instead of deeper clogging.
- Replacement of the PICP gap stone may be necessary if vacuum pressure has removed stones.

Additional Standards: This list provides a quick reference for PICP maintenance.

- Never replace permeable pavers with impermeable materials.
- Never use any type of seal coating on PICPs.
- Inspect PICPs annually for pavement deterioration or spalling and replace pavers as needed where these occur.
- Monitor periodically to ensure that the pavement surfaces are draining effectively after storm. Ponding on PICP surfaces should not routinely occur.
- Major clogging may necessitate restoration of PICP by removal of pavers, cleaning of subbase, and reuse of existing pavers.

Winter PICP Maintenance Guidance

Regular winter maintenance is critical to effective and safe operation of PICP.

- Plow after every storm. Special plow blades may be used to prevent scarring but are not necessary. Raised blade plowing is not recommended.
- Salt of any type can damage concrete surfaces and should be used sparingly.
- Apply deicing treatment before plowing to facilitate plowing and break the bond between compacted snow and pavement. Magnesium chloride should not be used, nor should deicers that contain ammonium nitrate or ammonium sulfate. Similar to all types of concrete pavement, pervious concrete has the concern in northern climates for damage from chloride deicing.

Site Inspections: A site inspection should be performed once after snow melt (mid-April) to identify any items that might occur during expected annual maintenance, but also need special attention to, specific to PICP including:

- Identifying any damaged pavement.
- Identifying any structural component issues, including cleanouts and outfalls.
- Identifying need for gravel joint replacement.
- After rainfall, ensure that system is draining and there is no standing water on the pavement system.

PERMEABLE INTERLOCKING CONCRETE PAVEMENT MAINTENANCE TASKS, INDICATORS, AND FREQUENCY

Task	Description	Maintenance Indicator	Minimum Frequency
General			
Sign Care	Wipe down sign.	If dust or grime is present.	Annually
Graffiti Removal	Remove graffiti from site structures, sign, or GI strategy surfaces.	If graffiti is present on GI sign, or adjacent to GI area.	As needed
Trash Removal	Remove trash from surface and surrounding areas. Report large dumping.	If present in or around the pavement.	Monthly (spring through fall)
Structural Components			
Pavement Repair	Repair damaged pavement.	Damaged pavement.	As needed
Power-wash	Power-wash pavement to drive debris and sediment out of joints.	Clogged pavement.	Biannually or as needed
Vacuum Sweep	Vacuum or dry sweep pavement depending on manufacturer recommendations or available equipment.	Standing water on the surface of the pavement after a precipitation event.	3x per Year or as needed
Vegetation			
Manual Weed Control	Remove weeds by hand weeding.	If weeds are present in joints.	Biannually
Leaf Blow or Vacuum Sweep	Remove surface debris by sweeping, vacuuming, or leaf-blowing debris.	If debris and/or sediment accumulate on pavement.	Monthly (spring through fall)
Filter Medium Components			
Gravel Joint Filling	Use mechanical sweeping or brush to replace joint aggregate.	Aggregate loss (either by time or after vacuum).	As needed (approximately every 5 years)

Task	Description	Maintenance Indicator	Minimum Frequency
Winter Maintenance			
Deicing	Remove ice from pavement surface either by a deicing agent free from magnesium chloride, ammonium nitrate or ammonium sulfate.	Before storm events	As needed
Plowing	Use snowplow to remove snow from surface of pavement.	Storm event.	As needed (during or after storm)

PERMEABLE INTERLOCKING CONCRETE PAVEMENT EXPECTED ANNUAL MAINTENANCE

It is recommended to complete eight (8) site visits annually (not including visits for deicing and plowing) for permeable interlocking concrete pavement maintenance. The timing and the tasks related to each of these site visits is detailed in the below table.

Task	**Spring**	**Summer**	**Fall**	**Winter**	**After 2-inch Rainfall [1]**
Site Inspection	1				2
Vacuum Sweep / Leaf Blowing	2	2	2		2
Power-wash	1		2		
Manual Weed Control	1		1		2
Plowing				*	
Deicing				*	
Trash Removal	2	2	2		2
Total Minimum Annual Expected Maintenance	**2**	**2**	**2**	*****	**2**

[1] A summary of rainfall data at General Mitchell Airport revealed that there has been at least one 2-inch rainfall from 2014-2019. This table assumes two 2-inch, 24-hour rainfalls per year for planning purposes.

*Plowing and deicing are dependent on number of snowfalls. Plowing should take place during/after every storm event, and deicing should be done prior to storm event.

PERVIOUS CONCRETE

DESCRIPTION

Pervious concrete is an open-graded rigid pavement typically consisting of approximately 20% voids. It lacks the fine aggregates of standard concrete and is primarily comprised of rounded and angular aggregates such as gravel and crushed stone. The appearance of pervious concrete is like that of a Rice-Krispy treat. Pervious concrete provides infiltration and recharge and are capable of a tremendous amount of storage. Of equal importance is the structural pavement functionality. The pavement system depth is designed as a rigid pavement for structural load, desired storage and frost depth requirements. Meltwater readily drains through porous surfaces thereby preventing black ice. Use of added thickness and admixtures are commonly used for heavy duty applications. Pervious concrete systems may include an underdrain in the storage layer to collect and convey water out of the system if it does not infiltrate within the design period, which is typically 48 to 72 hours. Pervious concrete is more resistant to long-term clogging than porous asphalt because, once cured, the pavement does not remain tacky. As such clogged pervious concrete can be more successfully restored. Pervious concrete has the added benefit of being a cooler surface than dark pavements and reduces heat island effects.

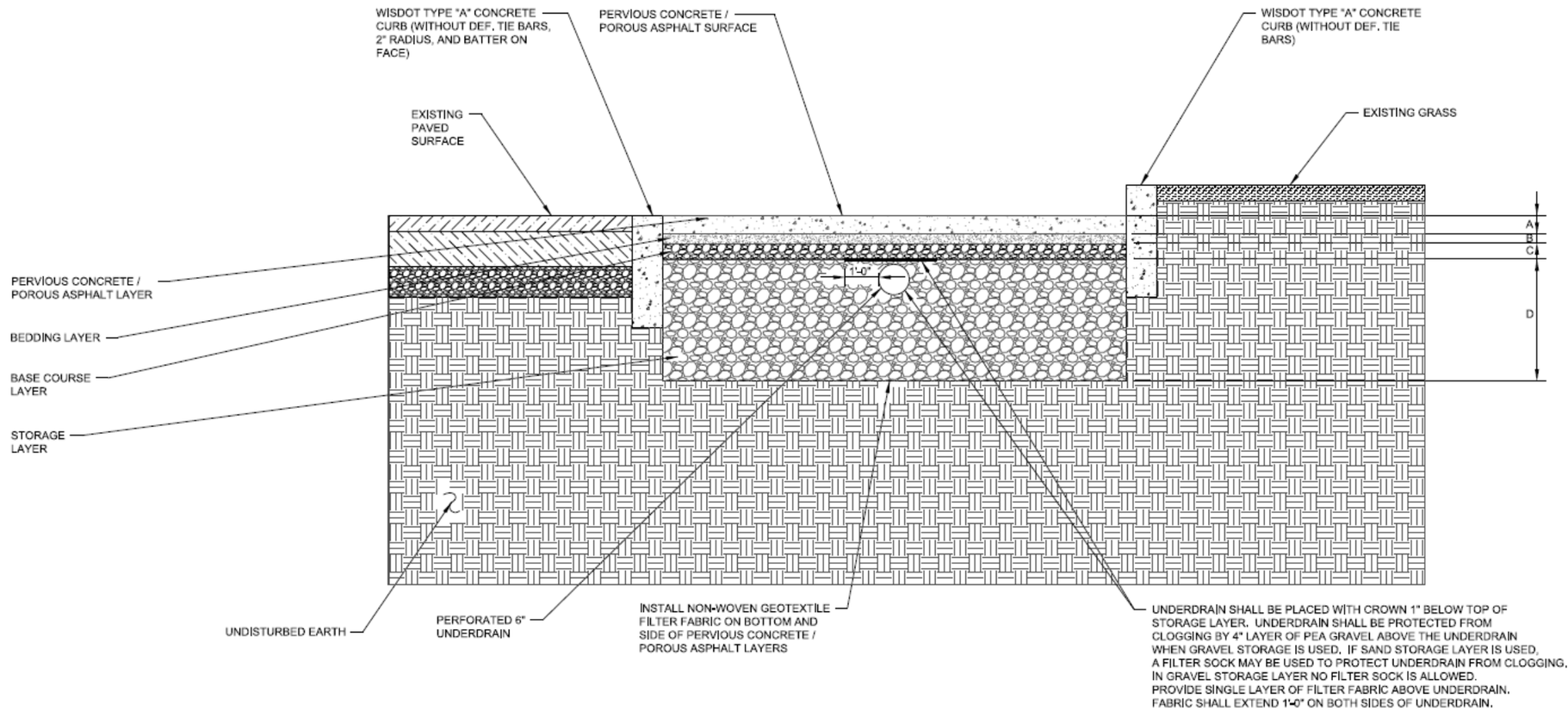
COMMON PRACTICES & APPLICATIONS

Pervious concrete is well-suited for parking areas, sidewalks, recreational areas, driveways, and roadways with proper design considerations. Higher volume applications require a commitment to proper design, construction quality assurance, and long-term operations and maintenance. Construction requirements include allowing 7 to 14 days (depending upon mix design and weather conditions) for concrete cure prior to usage. Pervious concrete is best used in locations with low to no usage of chloride deicers. Heavy usage of chloride deicers has resulted in rapid deterioration of pervious concrete.

PERVIOUS CONCRETE TYPICAL SECTION OR COMPONENTS

(taken from MMSD's Porous Pavement GI Strategy Typical Details which can be found in MMSD's GI Calculator download

Check the link for the most up-to-date sections: https://www.freshcoastguardians.com/static/GI_calc.zip)



DIMENSION	LAYER NAME	DEPTH
A	PERVIOUS CONCRETE / POROUS ASPHALT	X
B	BEDDING	X
C	BASE COURSE	X
D	STORAGE	X

PERVIOUS CONCRETE / POROUS ASPHALT TYPICAL CROSS-SECTION

SECTION A
NTS C-16

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PERVIOUS CONCRETE INSPECTION AND MAINTENANCE

This section provides guidance on maintenance activities that are typically required for these systems, along with suggested frequency for each activity. Individual systems may have more- or less- frequent maintenance needs depending on a variety of factors including the occurrence of large storm events, regional hydrologic conditions, and the upstream land use. Site-specific maintenance plans should always be consulted, as the successful functionality of the pavement may have specific maintenance requirements that were considered during design.

There are a number of important principles for pervious concrete inspection and maintenance that will extend the life and function of these systems.

Reducing run-on of sediment and debris: Controlling run-on and preventing tracking or transport of debris onto pervious surfaces is key to extending the life of pervious systems. Approaches to this include:

- Practice strict erosion and sediment control on adjacent or contributing areas.
- Vacuuming or sweeping of adjacent non-pervious concrete that contribute sediment or debris can be effective in minimizing run-on.
- Do not store materials such as sand, salt, mulch, soil, yard waste, and other stockpiles on pervious surfaces.
- Stockpiling snow on pervious concrete is not recommended and will lead to premature clogging. Stockpiled snow areas on pervious concrete will require additional maintenance and vacuuming to prevent clogging and deterioration.

Repairing cuts for utilities: Repairs may be needed for cuts made for utilities. Repairs can typically be made using standard (non-porous) concrete for most damages. Repairs using standard concrete should not exceed 15% of the total area.

Informational Signs: Posting signs that alert people to the use of pervious surfaces are helpful and recommended. Signage should indicate any limitations on design load (i.e. passenger vehicles only, light truck traffic, etc.) as well as, applicable warnings regarding plowing, use of salt, snow stockpiling, and avoiding debris run-on.

Surface Raveling: Occurs when surface aggregates loosen and is common only in the first few weeks after concrete is laid. This can be reduced with proper compaction and curing techniques.

Routine Pervious Concrete Maintenance:

Routine preventative cleaning of pervious concrete is more effective than corrective cleaning, but both practices are feasible and will be needed at some point in the life of the pervious system. At a minimum, if the recommendations above regarding stockpiling and run-on prevention are followed, 3x yearly vacuum cleaning of the interlocking concrete pavers will remove sediments and contaminants to prevent clogging. All sweepings from routine vacuuming must be disposed of according to appropriate standards.

Power-washing is recommended during high-use periods, or if sediment and debris has washed onto pervious surfaces.

Power-washing of pervious concrete should be used for cleaning acutely clogged areas.

- Power-washing activity should only be done in conjunction with use of a high velocity vacuum head so that debris is removed, and not just displaced. A power vacuum, such as Elgin Whirlwind or Tymco 500X is recommended.
- Power-washing may be required prior to vacuum sweeping to dislodge trapped particles in acutely clogged areas.
- Power-washing should occur at mid-pressure, typically less than 500 pounds per square inch, and at a low angle less than 45 degrees, to drive sediment and material out of the void spaces, instead of deeper clogging.

Additional Standards: This list provides a quick reference for pervious concrete maintenance:

- No winter sanding of pervious concretes is permitted.
- Minimize application of salt for ice control.
- Never reseal or repave with impermeable materials.
- Inspect annually for pavement deterioration or spalling.
- Monitor periodically to ensure that the pavement surface drains effectively after storms.
- Clean routinely and preventatively during high-use periods using a vacuum sweeper.
- Power-washing may be required prior to vacuum sweeping to dislodge trapped particles in acutely clogged areas.
- Major clogging may necessitate replacement of the paving surface.

Restoration and Cleaning of Acutely Clogged Areas:

Cleaning and rehabilitation of pervious concrete is recommended for pavement areas that are acutely clogged and where standard vacuum cleaning is insufficient. Pavement restoration cleaning can be conducted by using a high-suction vacuum head used in combination with a vacuum/jet truck. The Bunyan Infiltration Restoration Device (BIRD) uses an array of high-pressure water nozzles to loosen material while simultaneously removing the material from the surface by vacuum.

- Restorative cleaning can be very effective and provide a substantial maintenance benefit not achieved through routine cleaning by regenerative air vacuum.
- The cleaning method, while costly due to the intensive labor and equipment needs, can be done effectively after as many as five years after pavement installation.

Winter Pervious Concrete Maintenance Guidance

Regular winter maintenance is critical to effective and safe operation of pervious concrete.

- Plow after every storm. Special plow blades may be used to prevent scarring but are not necessary. Raised blade plowing is not recommended.
- Salt of any type can damage concrete surfaces and should be used sparingly. Salt usage will vary and is heavily dependent upon shading. For shaded areas, pervious concrete may not achieve salt reduction.
- Apply anti or deicing treatment before plowing to control compact snow and ice not removed by plowing. Magnesium chloride should not be used, nor should deicers that contain ammonium nitrate or ammonium sulfate. Similar to all types of concrete pavement, pervious concrete has the concern in northern climates for damage from chloride deicing.

Site Inspections: A site inspection should be performed once after snow melt (mid-April) to identify any items that might occur during expected annual maintenance, but also need special attention to, specific to pervious concrete including:

- Identifying any damaged pavement.
- Identifying any structural component issues, including cleanouts and outfalls.
- After rainfall, ensure that system is draining and there is no standing water on the pavement system.

PERVIOUS CONCRETE MAINTENANCE TASKS, INDICATORS, AND FREQUENCY

Task	Description	Maintenance Indicator	Minimum Frequency
General			
Sign Care	Wipe down sign.	If dust or grime is present.	Annually
Graffiti Removal	Remove graffiti from site structures, sign, or GI strategy surfaces.	If graffiti is present on GI sign, or adjacent to GI area.	As needed
Trash Removal	Remove trash from surface and surrounding areas. Report large dumping.	If present in or around the pavement.	Monthly (spring through fall)
Structural Components			
Pavement Repair	Repair damaged pavement.	Damaged pavement.	As needed
Power-wash	Power-wash pavement to drive debris and sediment out of joints.	Clogged pavement.	Monthly (spring through fall)
Vacuum Sweep	Vacuum or dry sweep pavement depending on manufacturer recommendations or available equipment.	Standing water on the surface of the pavement after a precipitation event.	3x per Year or as needed
Vegetation			
Manual Weed Control	Remove weeds by hand weeding.	If weeds are present in joints.	Biannually
Leaf Blow or Vacuum Sweep	Remove surface debris by sweeping, vacuuming, or leaf-blowing debris.	If debris and/or sediment accumulate on pavement.	Monthly (spring through fall)
Winter Maintenance			
Deicing	Remove ice from pavement surface either by a deicing agent free from magnesium chloride, ammonium nitrate or ammonium sulfate.	Before storm events	As needed

Task	Description	Maintenance Indicator	Minimum Frequency
Plowing	Use snowplow to remove snow from surface of pavement.	Storm event.	As needed (during or after storm)

PERVIOUS CONCRETE EXPECTED ANNUAL MAINTENANCE

It is recommended to complete eight (8) site visits annually (not including visits for deicing and plowing) for pervious concrete. The timing and the tasks related to each of these site visits is detailed in the below table.

Task	**Spring**	**Summer**	**Fall**	**Winter**	**After 2-inch Rainfall [1]**
Site Inspection	1				2
Vacuum Sweep	1	1	1		2
Power-wash	2	2	2		2
Manual Weed Control	1		1		2
Plowing				*	
Deicing				*	
Trash Removal	2	2	2		2
Total Minimum Annual Expected Maintenance	**2**	**2**	**2**	*****	**2**

[1] A summary of rainfall data at General Mitchell Airport revealed that there has been at least one 2-inch rainfall from 2014-2019. This table assumes two 2-inch, 24-hour rainfalls per year for planning purposes.

*Plowing and deicing are dependent on number of snowfalls. Plowing should take place during/after every storm event, and deicing should be done prior to storm event.

POROUS ASPHALT

DESCRIPTION

Porous asphalt pavements are an open graded flexible pavement combined of coarse aggregate and asphalt binder and commonly a strength modifier. Typically, porous asphalt has about 18% or greater voids and an aggregate storage reservoir road base. Porous pavements provide infiltration and recharge and are capable of a tremendous amount of storage. Of equal importance is the structural pavement functionality. The pavement system depth is designed for structural load, desired storage and frost depth requirements. Porous pavement systems may include an underdrain and liner if necessary.

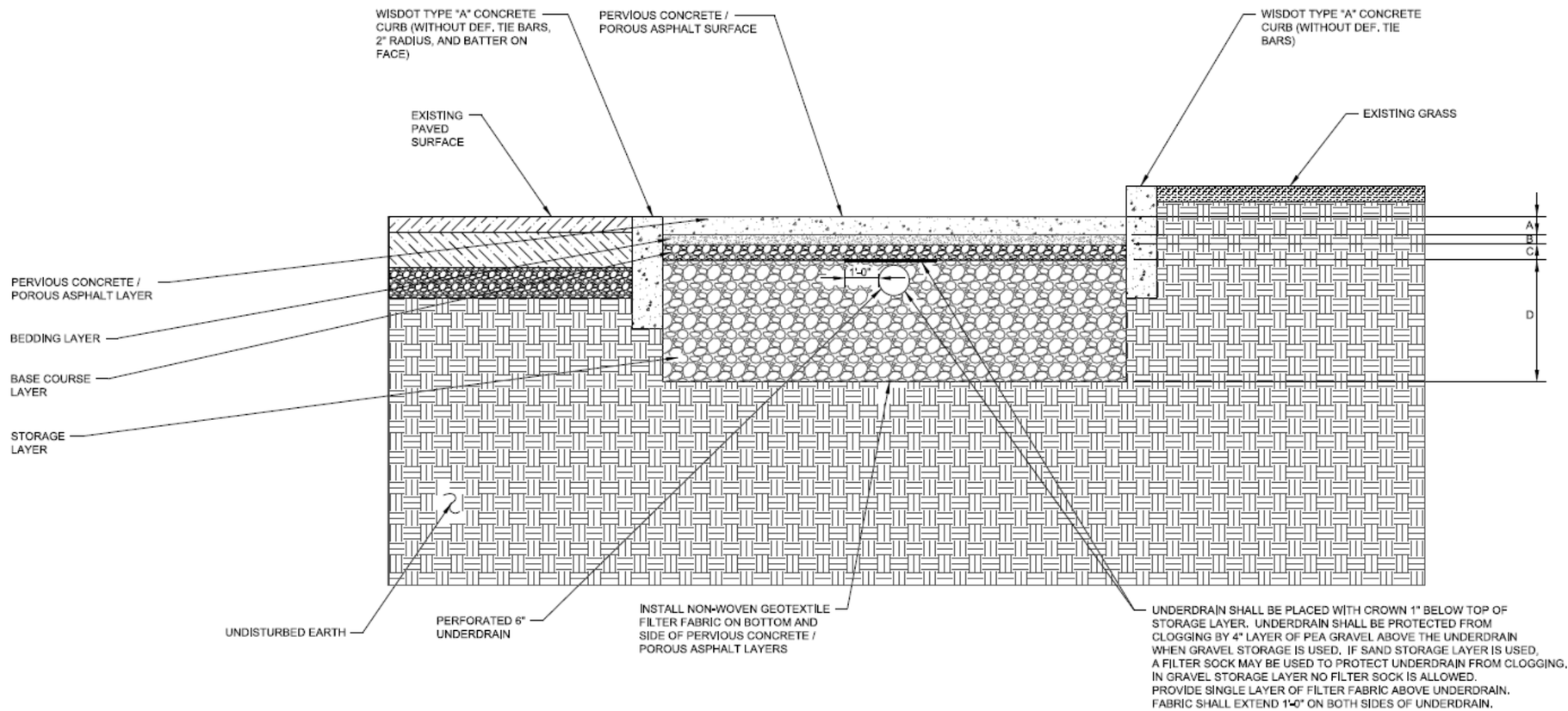
COMMON PRACTICES & APPLICATIONS

Porous asphalt is well-suited for parking areas, recreational areas (e.g., basketball and tennis courts), driveways, and roadways with proper design considerations. Porous asphalt can also be used for sidewalks and pathways. Higher volume roads and highways have also been constructed of porous asphalt with some success but require a commitment to proper design, construction quality assurance, and long-term operations and maintenance.

POROUS ASPHALT TYPICAL SECTION OR COMPONENTS

(taken from MMSD's Porous Pavement GI Strategy Typical Details which can be found in MMSD's GI Calculator download

Check the link for the most up-to-date sections: https://www.freshcoastguardians.com/static/GI_calc.zip)



PERVIOUS CONCRETE / POROUS ASPHALT TYPICAL CROSS-SECTION

SECTION A
NTS C-16

DIMENSION	LAYER NAME	DEPTH
A	PERVIOUS CONCRETE / POROUS ASPHALT	X
B	BEDDING	X
C	BASE COURSE	X
D	STORAGE	X

POROUS ASPHALT INSPECTION AND MAINTENANCE

This section provides guidance on maintenance activities that are typically required for these systems, along with suggested frequency for each activity. Individual systems may have more- or less- frequent maintenance needs depending on a variety of factors including the occurrence of large storm events, regional hydrologic conditions, and the upstream land use. Site-specific maintenance plans should always be consulted, as the successful functionality of the porous asphalt may have specific maintenance requirements that were considered during design.

There are a number of important principles for porous asphalt inspection and maintenance that will extend the life and function of these systems.

Reducing run-on of sediment and debris: Controlling run-on and preventing tracking or transport of debris onto porous surfaces is key to extending the life of porous systems. Approaches to this include:

- Practice strict erosion and sediment control on adjacent or contributing areas.
- Vacuuming or sweeping of adjacent non-porous asphalt that contribute sediment or debris can be effective in minimizing run-on.
- Do not store materials such as sand, salt, mulch, soil, yard waste, and other stockpiles on porous surfaces.
- Stockpiling snow on porous asphalt is not recommended and will lead to premature clogging. Stockpiled snow areas on porous asphalt will require additional maintenance and vacuuming to prevent clogging and deterioration.

Repairing cuts for utilities: Repairs may be needed for cuts made for utilities. Repairs can typically be made using standard (non-porous) asphalt for most damages. Repairs using standard asphalt should not exceed 15% of the total area.

Informational Signs: Posting signs that alert people to the use of porous surfaces are helpful and recommended. Signage should indicate any limitations on design load (i.e. passenger vehicles only, light truck traffic, etc.) as well as, applicable warnings regarding plowing, use of salt, snow stockpiling, and avoiding debris run-on.

Routine Porous Asphalt Maintenance:

Routine preventative cleaning of porous asphalt is more effective than corrective cleaning, but both practices are feasible and will be needed at some point in the life of the pervious system. At a minimum, if the recommendations above regarding stockpiling and run-on prevent are followed, 3x yearly vacuum cleaning of the porous asphalt will remove sediments and contaminants to prevent clogging. All sweepings from routine vacuuming must be disposed of according to appropriate standards. Power-washing is recommended during high-use periods, or if sediment and debris has washed onto porous surfaces.

Power-washing of porous asphalt should be used for cleaning acutely clogged areas.

- Power-washing activity should only be done in conjunction with use of a high velocity vacuum head so that debris is removed, and not just displaced. A power vacuum, such as Elgin Whirlwind or Tymco 500X is recommended.
- Power-washing may be required prior to vacuum sweeping to dislodge trapped particles in acutely clogged areas.
- Power-washing should occur at mid-pressure, typically less than 500 pounds per square inch, and at a low angle less than 45 degrees, to drive sediment and material out of the void spaces, instead of deeper clogging.

Additional Standards: This list provides a quick reference for porous asphalt maintenance:

- No winter sanding of porous asphalt is permitted.
- Minimize application of salt for ice control.
- Never reseal or repave with impermeable materials.
- Inspect annually for pavement deterioration or spalling.
- Monitor periodically to ensure that the pavement surface drains effectively after storms.
- Clean routinely and preventatively during high-use periods using a vacuum sweeper.
- Power-washing may be required prior to vacuum sweeping to dislodge trapped particles in acutely clogged areas.
- Major clogging may necessitate replacement of the paving surface.

Restoration and Cleaning of Acutely Clogged Areas:

Cleaning and rehabilitation of porous asphalt is recommended for pavement areas that are acutely clogged and where standard vacuum cleaning is insufficient. Pavement restoration cleaning can be conducted by using a high-suction vacuum head used in combination with a vacuum/jet truck. The Bunyan Infiltration Restoration Device (BIRD) uses an array of high-pressure water nozzles to loosen material while simultaneously removing the material from the surface by vacuum.

- Restorative cleaning can be very effective and provide a substantial maintenance benefit not achieved through routine cleaning by regenerative air vacuum.
- The cleaning method, while costly due to the intensive labor and equipment needs, can be done effectively after as many as five years after pavement installation.

Winter Porous Asphalt Maintenance Guidance

Regular winter maintenance is critical to effective and safe operation of porous asphalt.

- Plow after every storm. Special plow blades may be used to prevent scarring but are not necessary. Raised blade plowing is not recommended.

- Up to ~75% net salt reduction for porous asphalt have been documented. Excess salt applications may be needed during challenging storm events, but salt reductions typically occur between storm events with no black ice formation.
- Apply anti or deicing treatment before plowing to control compact snow and ice not removed by plowing. Magnesium chloride should not be used, nor should deicers that contain ammonium nitrate or ammonium sulfate.

Site Inspections: A site inspection should be performed once after snow melt (mid-April) to identify any items that might occur during expected annual maintenance, but also need special attention to, specific to porous asphalt including:

- Identifying any damaged pavement.
- Identifying any structural component issues, including cleanouts and outfalls.
- After rainfall, ensure that system is draining and there is no standing water on the pavement system.

POROUS ASPHALT MAINTENANCE TASKS, INDICATORS, AND FREQUENCY

Task	Description	Maintenance Indicator	Minimum Frequency
General			
Sign Care	Wipe down sign.	If dust or grime is present.	Annually
Graffiti Removal	Remove graffiti from site structures, sign, or GI strategy surfaces.	If graffiti is present on GI sign, or adjacent to GI area.	As needed
Trash Removal	Remove trash from surface and surrounding areas. Report large dumping.	If present in or around the pavement.	Monthly (spring through fall)
Structural Components			
Pavement Repair	Repair damaged pavement.	Damaged pavement.	As needed
Power-wash	Power-wash pavement to drive debris and sediment out of joints.	Clogged pavement.	Monthly (spring through fall)
Vacuum Sweep	Vacuum or dry sweep pavement depending on manufacturer recommendations or available equipment.	Standing water on the surface of the pavement after a precipitation event.	3x per Year or as needed
Vegetation			
Manual Weed Control	Remove weeds by hand weeding.	If weeds are present.	Biannually
Leaf Blow or Vacuum Sweep	Remove surface debris by sweeping, vacuuming, or leaf-blowing debris.	If debris and/or sediment accumulate on pavement.	Monthly (spring through fall)
Winter Maintenance			
Deicing	Remove ice from pavement surface either by a deicing agent free from magnesium chloride, ammonium nitrate or ammonium sulfate.	Before storm events.	As needed

Task	Description	Maintenance Indicator	Minimum Frequency
Plowing	Use snowplow to remove snow from surface of pavement.	Storm event.	As needed (during or after storm)

POROUS ASPHALT EXPECTED ANNUAL MAINTENANCE

It is recommended to complete eight (8) site visits annually (not including visits for deicing and plowing) for porous asphalt maintenance. The timing and the tasks related to each of these site visits is detailed in the below table.

Task	**Spring**	**Summer**	**Fall**	**Winter**	**After 2-inch Rainfall [1]**
Site Inspection	1				2
Vacuum Sweep	1	1	1		2
Power-wash	2	2	2		2
Manual Weed Control	1		1		2
Plowing				*	
Deicing				*	
Trash Removal	2	2	2		2
Total Minimum Annual Expected Maintenance	**2**	**2**	**2**	*****	**2**

[1] A summary of rainfall data at General Mitchell Airport revealed that there has been at least one 2-inch rainfall from 2014-2019. This table assumes two 2-inch, 24-hour rainfalls per year for planning purposes.

*Plowing and deicing are dependent on number of snowfalls. Plowing should take place during/after every storm event, and deicing should be done prior to storm event.

RAIN GARDEN

DESCRIPTION

A stormwater management practice consisting of a depression in the soil that is planted with dense, herbaceous vegetation, including both flowers and grasses, designed to capture stormwater runoff and melting snow, naturally absorbing them into the ground. Though rain gardens and bioswales appear similar from above, rain gardens often use the surrounding native topsoil and they are not constructed with the gravel storage layer or underdrain and sewer system functions. Rain gardens are completely reliant on the native subgrade to infiltrate the collected runoff, in addition to minor amounts of evapotranspiration. It is important that the subgrade soils are well draining, otherwise rain gardens will begin to pool and fail to drain properly.

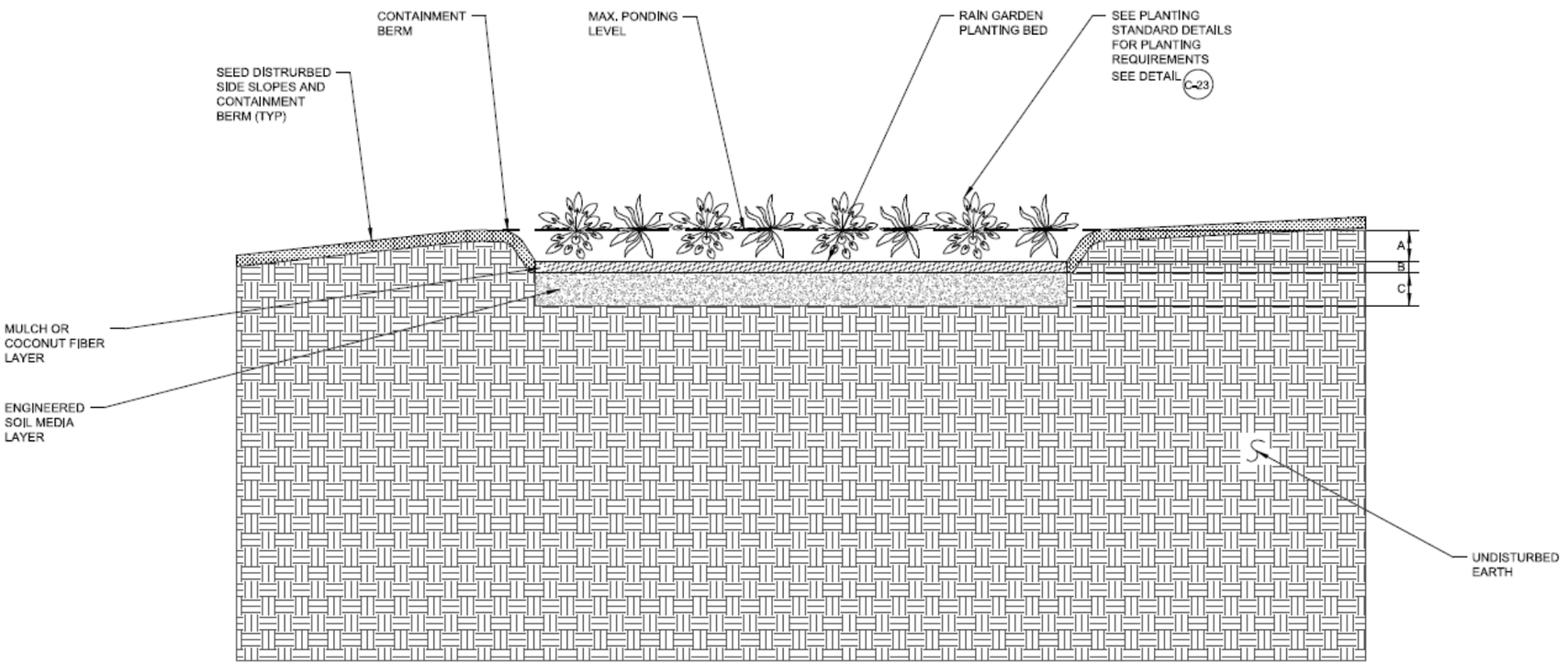
COMMON PRACTICES & APPLICATIONS

Rain gardens are most applicable to small drainage areas, making them most applicable for use on residential properties. Commonly, downspouts from rooftops are directed to drain into rain gardens. However, they can also be designed to collect and absorb water from hillsides, driveways, and other impervious surfaces.

RAIN GARDEN TYPICAL SECTION OR COMPONENTS

(taken from MMSD's Rain Garden GI Strategy Typical Details which can be found in MMSD's GI Calculator download

Check the tool for the most up-to-date sections: https://www.freshcoastguardians.com/static/GI_calc.zip)



DIMENSION	LAYER NAME	DEPTH
A	SURFACE PONDING	X
B	MULCH OR COCONUT FIBER	X
C	ENGINEERED SOIL MEDIA	X

RAIN GARDEN TYPICAL CROSS-SECTION

SECTION A C-20
NTS

DETAIL 21 C-22

RAIN GARDEN INSPECTION AND MAINTENANCE

This section provides guidance on maintenance activities that are typically required for these systems, along with suggested frequency for each activity. Individual systems may have more- or less- frequent maintenance needs depending on a variety of factors including the occurrence of large storm events, regional hydrologic conditions, and the upstream land use. Site-specific maintenance plans should always be consulted, as the successful functionality of the rain garden may have specific maintenance requirements that were considered during design.

Referring to Planting Plans & Photos: It is especially important to refer to planting plans and photos that show what types of vegetation should be present, and where maintenance crews should or should not mow.

Timing of Inspections: Rain gardens maintenance can typically be performed as part of standard landscaping. Regular inspection and maintenance, beginning after snow melt, is critical to the effective operation of rain gardens to insure they remain clear of leaves and debris, support healthy vegetation, and are free draining. In addition, because erosion and inflows from large storm events can damage vegetation, cause erosion and ponding, and clog downspouts, rain gardens should be inspected after any rain event of 2 inches in 24 hours or more. Inspection during the time of weed growth is also especially critical, as it is usually the top maintenance activity associated with these systems. For the Milwaukee area, this will begin in late May / early June.

Inspection Focus: Inspections should focus on the growth and condition of vegetation, including any weeds or invasives; soil conditions (especially sediment build-up or clogging); and stormwater flow paths and erosion. Maintenance of any items identified in the inspections should be completed within 7 days of the inspection.

Initial Site Inspection: A site inspection should be performed after snow melt (mid-April) to identify any items that would not be covered in the expected annual maintenance visits. This would include:

- Identifying any bare areas in the rain gardens
- Identifying any low or eroded areas in the engineered soil
- Identifying any structural component issues

Manual Weed Control: Depending on establishment and condition of planting bed, as many as 12 weeding visits could occur during the typical six month growing season of mid-April through mid-October. The weeds are growing most aggressively from early May through mid-July (before native warm season grasses have filled out). During this period, visits may need to be weekly. Ornamental landscapes will typically require more visits than naturalized ones, but to begin with, naturalized landscapes will require more visits. As naturalized landscapes are established, the frequency of manual weed control will taper off.

RAIN GARDEN MAINTENANCE TASKS, INDICATORS AND FREQUENCY

Task	Description	Maintenance Indicator	Minimum Frequency
General			
Sign Care	Wipe down sign.	If dust or grime is present.	Annually
Graffiti Removal	Remove graffiti from site structures, sign, or GI strategy surfaces.	If graffiti is present on GI sign, or adjacent to GI area.	As needed
Structural Components			
Structural Clearing & Maintenance	Clear trash, debris, sediments, etc. from conveyance structures or gutters draining to the rain garden.	Clogged downspouts, gutters, pipes, or structures.	Biannually
Vegetation Components			
Invasive Species Control	Control invasive species impacting desired plant species in rain garden. Refer to Appendix of Top 10 Invasive Species for list of the most common invasive species found in GI strategies in Southeastern WI.	Invasive plants are present in rain garden.	Biannually
Manual Weed Control	Remove weeds by hand weeding.	If weeds are present in rain garden.	Monthly (spring through fall – more frequently May through July)
Mowing	Mow plants if height of vegetation exceeds recommended heights. Mow perimeter edge of naturalized GI within vegetated grassy areas.	If height of vegetation exceeds recommended heights.	Annually
Pest Management*	Inspect plants for signs of disease or predation.	Presence of pests or diseased plants.	Biannually
Plant Replacement	Remove and replace dead plants.	If at least 10% of the plants have died.	As needed

Task	Description	Maintenance Indicator	Minimum Frequency
Pruning	Remove damaged, diseased or dead branches or woody plants, small trees, or shrubs	If damaged, diseased, or dead branches are present, or if safe line of sight is obstructed.	Annually
Vegetation Maintenance	Trimming and/or transplanting annual herbaceous vegetation.	Presence of decayed material.	Annually
Watering	Water plants as necessary to ensure survival during extended dry periods.	Yellow or brown tips or leaves, dying plants, or wilted/dehydrated leaves or stalks. Note, yellow leaves can also be an indicator that plants are receiving too much water.	As needed, depending on weather
Woody Vegetation Removal	Remove woody vegetation or saplings.	If unplanned woody vegetation or saplings are present in rain garden.	Annually
Growing Medium/Planting Bed Components			
Erosion Repair	Stabilize any disturbed areas with live plantings or seed and biodegradable erosion matting.	If minor (<20 sf), nonrecurring erosion is present within the rain garden, or if erosion is deeper than 2 inches.	As needed
Mulch Amendment/Replacement	Amend (i.e. rake, aerate, and add material), or replace mulch in rain garden.	If visible mulch is observed to have bare spots, depth is less than 2 inches or appears compacted or disarrayed in or around the rain garden.	Annually or as needed
Organic Debris Removal	Remove excess organic debris (e.g., leaves, plant decay, etc.) from rain garden surfaces.	If present in rain garden.	Biannually
Sediment Removal	Remove sediment from rain garden basin and surrounding areas, including gutters and sidewalks.	If sediment is present or visible in or around the rain garden, and if sediment is more than 1 inch.	Biannually or as needed
Settling Repair	Repair rain garden areas that have settled.	Area is observed to be lower than surrounding areas of designed elevation of the rain garden.	As needed

Task	Description	Maintenance Indicator	Minimum Frequency
Surface Media Renovation	Remove top inches of filter media and cultivating the surface.	Rain garden area is clogged or not draining properly within 48 hours of a rainfall.	As needed
Trash Removal	Remove trash from rain garden planting beds and surrounding areas. Report any evidence of dumping.	If present in or around the rain garden.	Monthly (spring through fall)
* Integrated Pest Management (IPM) routines are encouraged. This involves inspecting the plants for signs of disease or predation. The IPM approach encourages non-chemical methods for treated diseases or pests as a first resort.			

RAIN GARDEN EXPECTED ANNUAL MAINTENANCE

It is recommended to complete twelve (12) site visits annually for rain garden maintenance. The timing and the tasks related to each of these site visits is detailed in the below table.

Task	Spring	Summer	Fall	Winter	After 2-inch Rainfall [1]
Site Inspection	1[2]				2
Mowing			1[3]		
Manual Weed Control	3	3	3		
Pest Management		1	1		
Invasive Species Control		1	1		
Vegetation Maintenance	**1**				
Trash Removal	2	2	2		2
Organic Debris Removal	1		1		2
Pruning			2		
Structural Clearing & Maintenance	1				2
Woody Vegetation Removal			1		
Sediment Removal	1		1		2
Mulch Amendment/Replacement	1				2
Total Minimum Annual Expected Maintenance	**4**	**3**	**3**		**2**

[1] A summary of rainfall data at General Mitchell Airport revealed that there has been at least one 2-inch rainfall from 2014-2019. This table assumes two 2-inch, 24-hour rainfalls per year for planning purposes.

[2] Initial site inspection shall be completed mid-April after snowmelt. The site inspection should be the focus and other maintenance tasks **should not be considered** at this time. Site inspections conducted after 2-inch rainfalls can be combined with other maintenance tasks as needed.

[3] Mowing frequency is based on an established, native landscape. Mowing may take place in late-fall or early-spring depending on plant species.

If the native landscaping is recently established, the mowing is usually conducted in decreasing frequencies from the date of planting. Often five mowings the first full growing season, four the second, three the third, and so on. This allows the native seed to germinated and prevent annual weeds from flowering and setting seed.

If ornamental grasses are used, they are not mown, but usually trimmed back in early spring of each year.

RAINWATER HARVESTING (CISTERNS)

DESCRIPTION

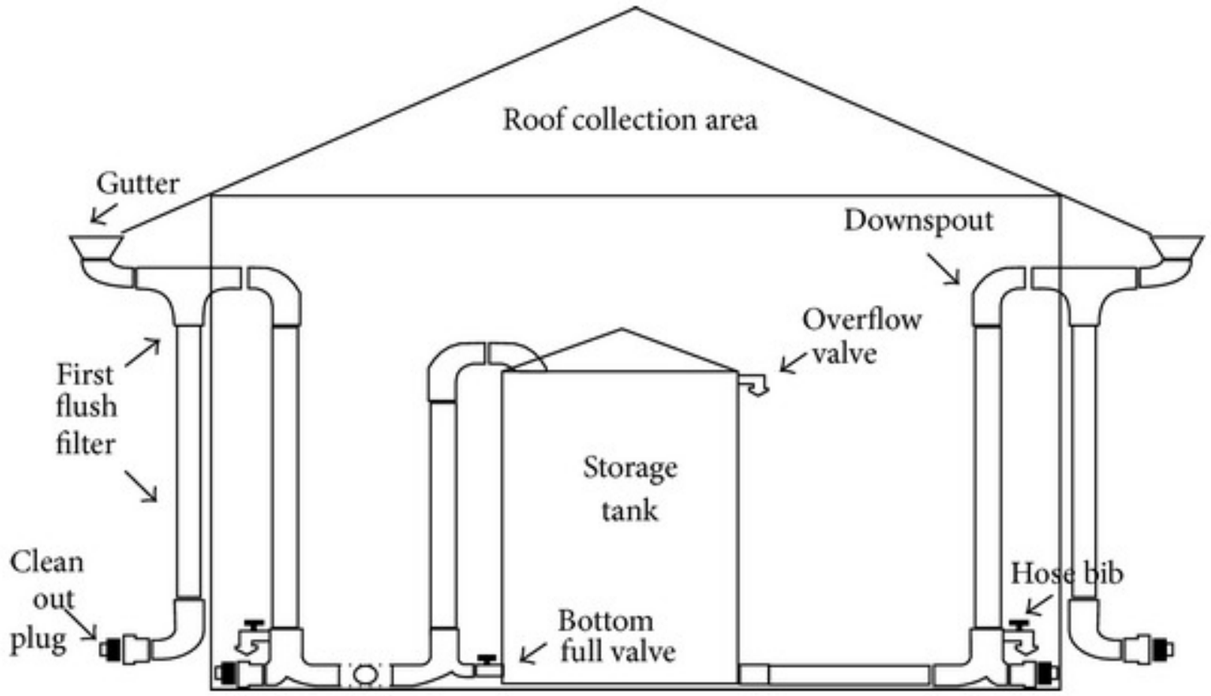
Rainwater harvesting systems typically divert and store runoff from residential and commercial roofs. They tend to be lower maintenance than most GI strategies and might only require periodic cleaning of leaf debris and rooftop particulates. Rainwater harvesting can collect water from fields and parking lots as well. Rooftop runoff is typically considered 'clean' runoff; however, it may contain airborne pollutants (nutrients), pollutants from roofing materials (metals or hydrocarbons), and bacteria from birds. Rooftop runoff contamination is usually at low levels of concern in comparison with other impervious surfaces. Rainwater harvesting systems typically capture rooftop runoff by diverting downspouts through a prefilter and into a rain barrel or cistern. Cisterns and barrels are commonly dark opaque materials to prevent algae growth, with large systems often underground. Non-potable uses are most common which require a separate plumbing system for irrigation. The basic components of a rainwater harvesting system include a catchment surface, gutters and downspouts, leaf screens, first-flush diverters, and roof washer, one (or more) storage tanks, delivery system, and treatment/purification. Rain barrels tend to be more simplified versions of rainwater harvesting systems but include many of the same components.

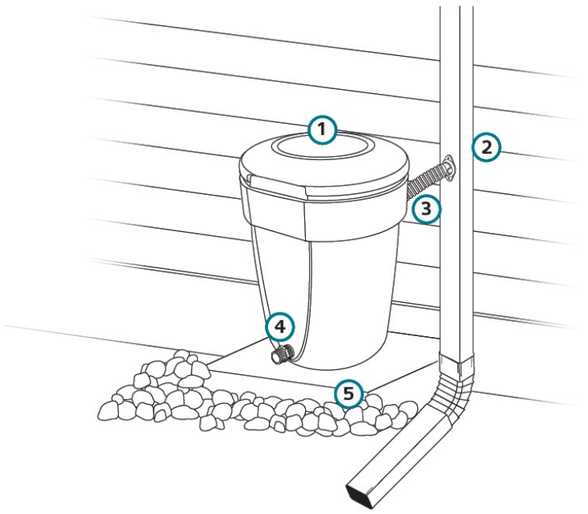
COMMON PRACTICES & APPLICATIONS

Rainwater harvesting can be used to capture and store water for reuse for small residential applications to large scale commercial and industrial. Rainwater reuse is typically non-potable and used for irrigation, graywater systems (toilets and laundry), and fire suppression with proper considerations for usage and demand. Rainwater harvesting can be easily converted to drinking water quality standards with the proper disinfection and testing needs. Rainwater harvesting often is not used for large volume control for stormwater management simply because of the large volumes required. For example, rain barrels commonly capture 50 gallons of rooftop runoff and a 1200 square-foot rooftop generates approximately 695 gallons for a 1-inch rain. Though that is not always the case, another reason they are not always used for volume control is because the systems need to be emptied after rain events, and to be used as water source, the systems need to be full. For rainwater harvesting to be a feasible type of stormwater management requires substantial storage volume, planning, and design.

RAINWATER HARVESTING TYPICAL SECTIONS OR COMPONENTS

(Schematic of rainwater harvesting system (Shitirah Akib). from https://www.researchgate.net/figure/Schematic-of-a-rainwater-harvesting-system_fig8_259923841)





RAINWATER HARVESTING INSPECTION AND MAINTENANCE

This section provides guidance on maintenance activities that are typically required for these systems, along with suggested frequency for each activity. Individual systems may have more- or less- frequent maintenance needs depending on a variety of factors including the occurrence of large storm events and type of system. Site-specific maintenance plans should always be consulted, as the successful functionality of the rainwater harvesting system may have specific maintenance requirements that were considered during design.

Inspection Focus: Rainwater collection and storage facilities require a variety of forms of routine maintenance. Some of the routine maintenance activities that are needed periodically are:

- Removing debris from the roof, leaf guard, gutter, gutter screen, and first-flush diverter.
- Inspecting and repairing vent screens.
- Removing sediment from the tank.
- Testing the coliform bacteria levels in your untreated-water storage tank. *Note for rain barrels, if purpose of rainwater collection is non-potable uses, testing is not necessary.*
- Disinfecting the water storage tank if total coliform levels reach 500 colony-forming units per 100 milliliters (500 CFU/100 ml) or if fecal coliform levels reach 100 CFU/100 ml.

Untreated water with total coliform levels above 500 CFU/100 ml or where fecal coliform levels rise above 100 CFU/100 ml should not be used, even for non-potable purposes until it has been disinfected. Disinfection can also help prevent heavy biological growths that can foul your treatment system and contaminate your plumbing system. The most convenient way to control biological growth in the storage tank is for them to be constructed below ground surface or in a dark opaque container. If biological growth occurs, the addition of a small amount of chlorine bleach periodically.

Rainwater harvesting systems almost always require a pump to pressurize the water and deliver it to its intended use. When the use is located in the building, there is usually a day tank involved so that any sanitation required is only sanitizing a small amount of water, not the entire system. Other system setups use an on-demand pump. In this case, there would be a fine filter involved, similar to a cartridge filter, especially if the water is used for drip irrigation or in a building.

Depending on the type of rainwater harvesting system, the maintenance tasks may be refined, but the tasks, indicators, and expected frequency are general recommendations. Refer to manufacturer recommendations for specific maintenance activities and recommendations.

Initial Site Inspection: A site inspection should be performed after snow melt (mid-April) to identify any items that would not be covered in the expected annual maintenance visits. This would include:

- Installing the system components after winter, if necessary. This includes disinfecting system if it was not used during winter months.
- Identifying any structural component issues.

RAINWATER HARVESTING MAINTENANCE TASKS, INDICATORS, AND EXPECTED FREQUENCY

Task	Description	Maintenance Indicator	Minimum Frequency
General			
Sign Care	Wipe down signage.	If dust or grime is present.	Annually
Graffiti Removal	Remove graffiti from structure or signs.	If graffiti is present on structures or adjacent signs and structures.	As needed
Structural Components			
Sanitizing	Sanitizing if positive tests for contamination.	Positive test for contamination.	Monthly (spring through fall)
Sediment Removal	Removal sediment from prefilter and tank.	Visible sediment in prefilter or tank.	Monthly (spring through fall)
Structural Clearing & Maintenance	Clearing trash, debris, sediment from screens, conveyance structures, including roof and gutters draining to the cistern.	Clogged gutters, cisterns, or conveyance structures.	Biannually or as needed
Testing	Testing the coliform bacteria levels in tank.	Presence of biological growth.	Monthly (spring through fall)
Winterizing	Winterize system per manufacturer recommendations prior to freeze thaw conditions.	Prior to freeze thaw conditions.	Annually
Many components of rainwater harvesting systems tend to be specific to manufacturer. Refer to manufacturer recommendations for specific maintenance activities and contact the manufacturer for repair or replacement of parts.			

RAINWATER HARVESTING EXPECTED ANNUAL FREQUENCY

It is recommended to complete ten (10) site visits annually for rainwater harvesting maintenance. The timing and the tasks related to each of these site visits is detailed in the below table.

Task	Spring	Summer	Fall	Winter	After 2-inch Rainfall [1]
Site Inspection	1[2]		1		2
Sanitizing	2	2	2		
Sediment Removal	2	2	2		
Structural Clearing & Maintenance	1		1		
Testing[3]	2	2	2		2
Winterizing			1[4]		
Total Minimum Annual Expected Maintenance	**3**	**2**	**3**		**2**

[1] A summary of rainfall data at General Mitchell Airport revealed that there has been at least one 2-inch rainfall from 2014-2019. This table assumes two 2-inch, 24-hour rainfalls per year for planning purposes.

[2] Initial site inspection shall be completed mid-April after snowmelt. The site inspection should be the focus and other maintenance tasks **should not be considered** at this time. Site inspections conducted after 2-inch rainfalls can be combined with other maintenance tasks as needed.

[3] For rain barrels, if purpose of rainwater collection is non-potable uses, testing is *not* necessary.

[4] Winterizing instructions shall be followed according the specific product and manufacturer recommendations. The focus of this inspection is to winterize or disconnect the system and should be performed separate from other maintenance tasks.

SOIL AMENDMENTS

DESCRIPTION

Soil amendments transform lawns to act like stormwater sponges. Healthy lawns develop thick root systems that help absorb more rain, reduce water pollution, and the amount of water that gets into sewers. Grasses with thick root systems become more drought-tolerant and out-compete weeds.

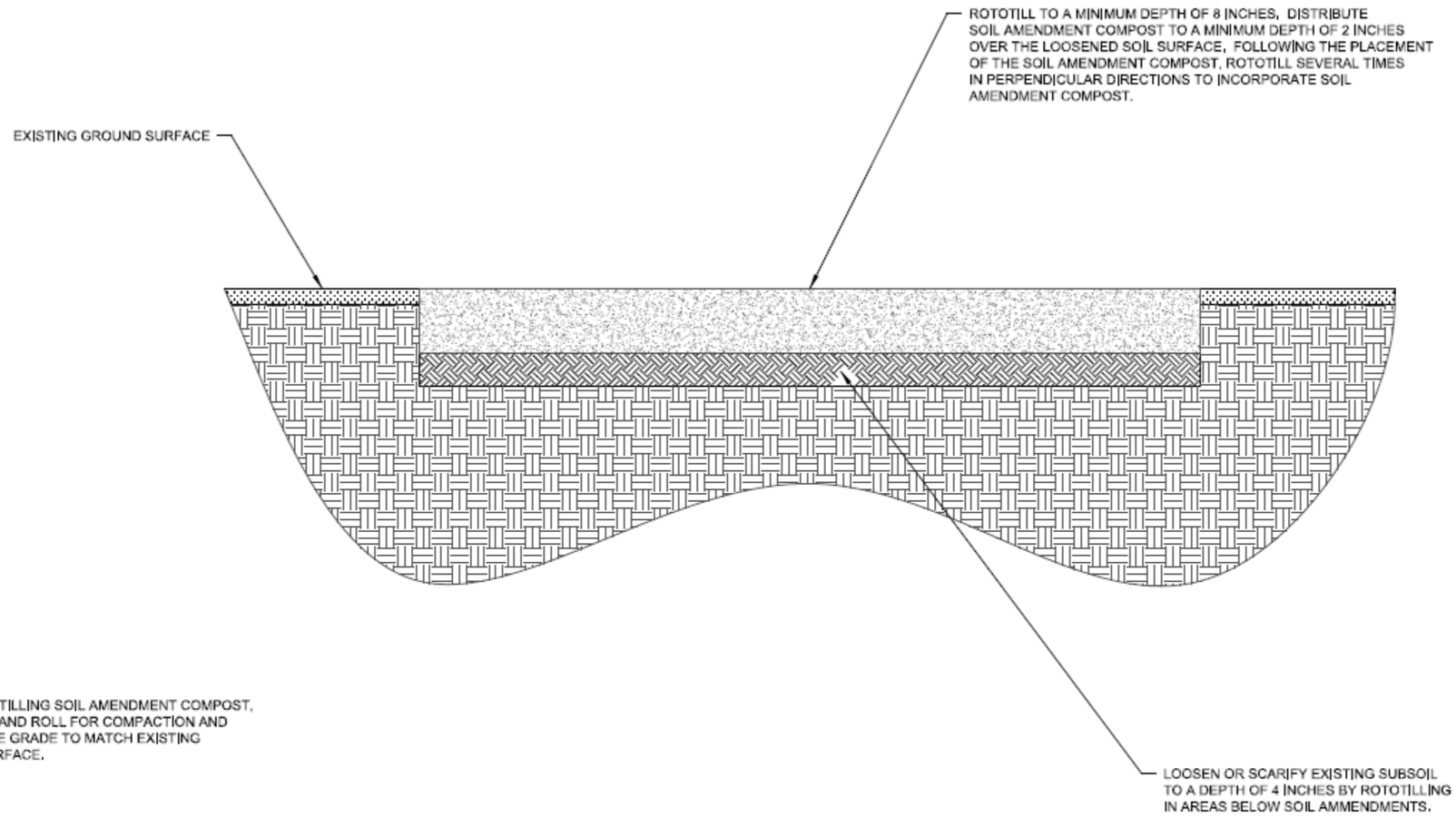
COMMON PRACTICES & APPLICATIONS

Soil amendments may include top-dressing areas of vegetation, or removing, amending, and replacing soil by excavation. For turfgrass applications, the use of sod is discouraged, and seed is recommended. Soil amendments can be implemented in almost all sites with lawns but are commonly found on residential lawns.

SOIL AMENDMENT TYPICAL SECTION AND COMPONENTS

(taken from MMSD's Soil Amendment GI Strategy Typical Details which can be found in MMSD's GI Calculator download)

Check the link for the most up-to-date sections: https://www.freshcoastguardians.com/static/GI_calc.zip)



NOTE

1. AFTER ROTOTILLING SOIL AMENDMENT COMPOST, WATER OR HAND ROLL FOR COMPACTION AND RAKE TO FINE GRADE TO MATCH EXISTING GROUND SURFACE.

SOIL AMMENDMENT
TYPICAL CROSS-SECTION
NTS

SOIL AMENDMENT INSPECTION AND MAINTENANCE

This section provides guidance on maintenance activities that are typically required for these systems, along with suggested frequency for each activity. Individual systems may have more- or less- frequent maintenance needs depending on a variety of factors including the occurrence of large storm events, regional hydrologic conditions, and the upstream land use. Site-specific maintenance plans should always be consulted, as the successful functionality of the soil amendments may have specific maintenance requirements that were considered during design.

Referring to Planting Plans & Photos: It is especially important to refer to planting plans to note the type of soil amendment that was installed.

Inspection Focus: The maintenance steps are site dependent and must be adapted to site and soil conditions. In some cases, soil may simply be aerated to alleviate compaction. In other cases, soils may need to be excavated and a portion replaced with one of several types of soil amendment materials. In all cases, care must be taken to ensure the proper revegetation and erosion control are practices for disturbed areas.

SOIL AMENDMENT MAINTENANCE TASKS, INDICATORS, AND FREQUENCY

Task	Description	Maintenance Indicator	Minimum Frequency
General			
Sign Care	Wipe down sign.	If dust or grime is present.	Annually
Graffiti Removal	Remove graffiti from site structures, signage, or surrounding surfaces.	If graffiti is present on GI signage, or adjacent to GI area.	As needed
Vegetation Components			
Invasive Species Control	Control invasive species impacting desired plant species in amended area. Refer to Appendix of Top 10 Invasive Species for list of the most common invasive species found in GI strategies in Southeastern WI.	Invasive plants are present in amended area.	Biannually or as needed
Manual Weed Control	Remove weeds by hand weeding.	If weeds are present in amended soil areas.	Monthly (spring through fall)
Pest Management*	Inspect plants for signs of disease or predation.	Presence of pests or diseased plants.	Biannually
Watering	Water plants as necessary to ensure survival during extended dry periods.	Brown tips of grass, or grass or seed is not growing.	As needed, depending on weather
Growing Medium/Planting Bed Components			
Erosion Repair	Stabilize any disturbed areas with seed and biodegradable erosion matting.	If minor (<20 sf), nonrecurring erosion is present within the area, or if erosion is deeper than 2 inches.	As needed
Organic Debris Removal	Remove excess organic debris (e.g., leaves, plant decay, etc.) from soil surfaces.	If present in or around the amended areas.	Biannually
Settling Repair	Repairing areas of practice that have settled.	Area is observed to be lower than surrounding areas of designed elevation.	As needed

Task	Description	Maintenance Indicator	Minimum Frequency
Trash Removal	Remove trash from amended and surrounding areas. Report any evidence of dumping.	If present in or around the amended areas.	Monthly (spring through fall)
* Integrated Pest Management (IPM) routines are encouraged. This involves inspecting the plants for signs of disease or predation. The IPM approach encourages non-chemical methods for treated diseases or pests as a first resort.			

SOIL AMENDMENT EXPECTED ANNUAL FREQUENCY

It is recommended to complete eight (8) site visits annually for soil amendment maintenance. The timing and the tasks related to each of these site visits is detailed in the below table.

Task	Spring	Summer	Fall	Winter	After 2-inch Rainfall [1]
Site Inspection	1				2
Manual Weed Control	2	2	2		
Pest Management		1	1		
Invasive Species Control		1	1		
Trash Removal	2	2	2		2
Organic Debris Removal	1		1		2
Mulch Amendment/Replacement	1				2
Total Minimum Annual Expected Maintenance*	**2**	**2**	**2**		**2**

[1] A summary of rainfall data at General Mitchell Airport revealed that there has been at least one 2-inch rainfall from 2014-2019. This table assumes two 2-inch, 24-hour rainfalls per year for planning purposes.

*These visits are separate from those made to mow the turfgrass, of which there are approximately 26.

STORMWATER TREES

DESCRIPTION

Stormwater trees are trees can hold rainwater in their leaves and branches, infiltrate it into the ground, absorb it through their root systems, and evapotranspire it into the atmosphere. They can be used in conjunction with engineering soils and other types of GI and work best when they are mature.

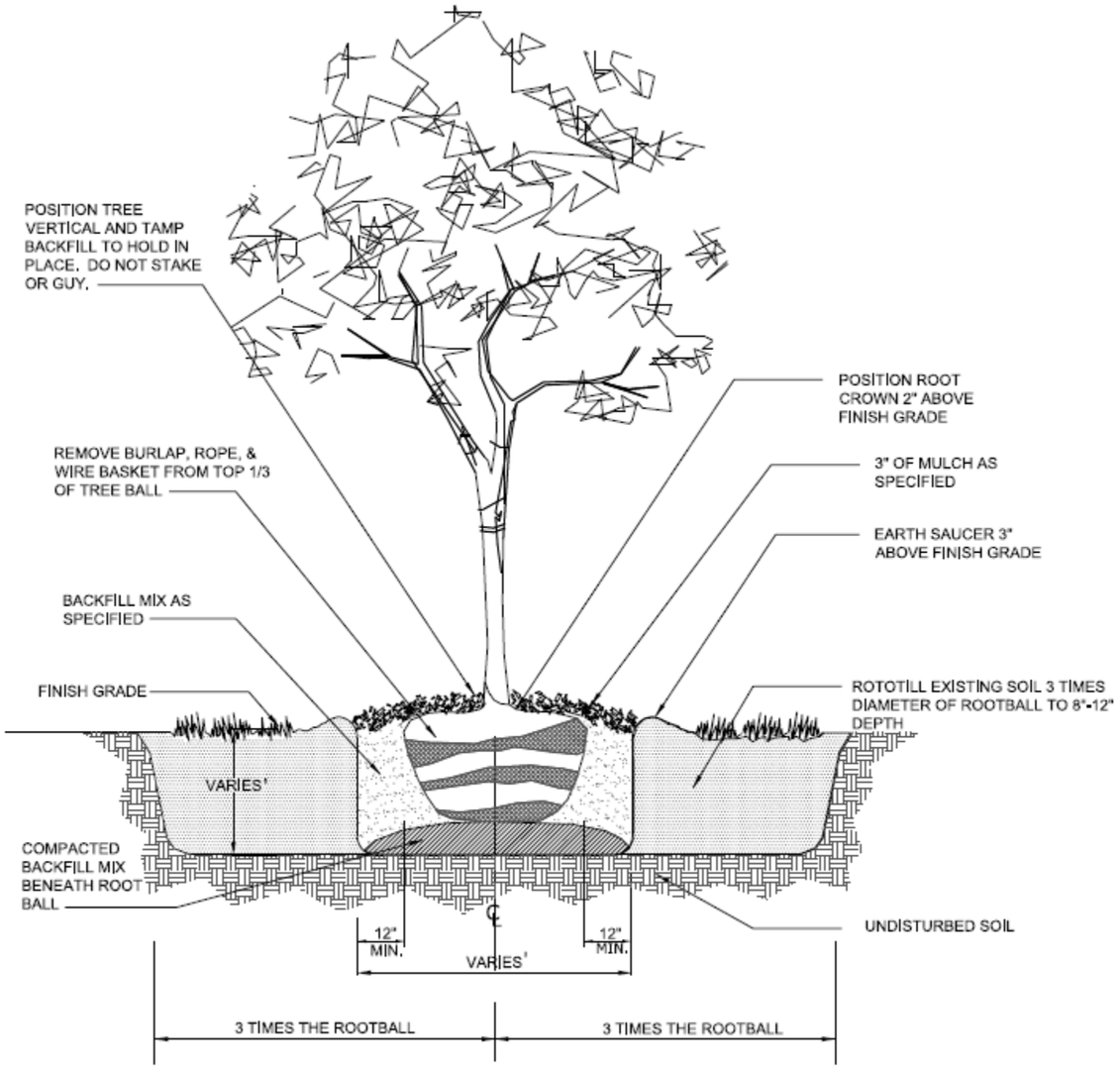
COMMON PRACTICES & APPLICATIONS

Stormwater trees are commonly planted adjacent to roadways or sidewalks in urban areas. They can also be found in conjunction with other stormwater-managing landscapes and practices, including bioswales, native landscaping, and soil amendments.

STORMWATER TREE TYPICAL SECTION AND COMPONENTS

(taken from MMSD's Stormwater Trees GI Strategy Typical Details which can be found in MMSD's GI Calculator download

Check the tool for the most up-to-date sections: https://www.freshcoastguardians.com/static/GI_calc.zip)



STORMWATER TREE DETAIL

NTS

STORMWATER TREE INSPECTION AND MAINTENANCE

This section provides guidance on maintenance activities that are typically required for these systems, along with suggested frequency for each activity. Individual systems may have more- or less- frequent maintenance needs depending on a variety of factors including the occurrence of large storm events, regional hydrologic conditions, and the upstream land use. Site-specific maintenance plans should always be consulted, as the successful functionality of the trees may have specific maintenance requirements that were considered during design.

Inspection Focus: Stormwater trees require specific maintenance measures during establishment, (i.e. 1 – 3 years after planting) that generally are not required once the tree is well-established. Stormwater tree maintenance should be performed in the fall after leaf-off and any time that the following conditions are observed:

- Tree roots are exposed.
- Trash, debris, litter and leaves are present.
- Evidence of standing water on or around the tree 48 hours after rainfall.
- Evidence of animal burrows, other holes, or erosion.
- Drought conditions.
- Dead, dying or damaged branches or leaves are present.

Manual Weed Control: Depending on establishment and condition of planting bed, as many as 12 weeding visits could occur during the typical six-month growing season of mid-April through mid-October. The weeds are growing most aggressively from early May through mid-July (before native warm season grasses have filled out). During this period, visits may need to be weekly. Ornamental landscapes will typically require more visits than naturalized ones, but to begin with, naturalized landscapes will require more visits. As naturalized landscapes are established, the frequency of manual weed control will taper off

STORMWATER TREE MAINTENANCE TASKS, INDICATORS, AND FREQUENCY

Task	Description	Maintenance Indicator	Minimum Frequency
General			
Signage Care	Wipe down signage.	If dust or grime is present.	Annually
Graffiti Removal	Remove graffiti from site structures, signage, or surrounding surfaces.	If graffiti is present on GI signage, or adjacent to GI area.	As needed
Structural Components			
Tree Grate	Monitor trunk growth and repair or replace damaged tree grates.	Trunk growing too close to the grate opening or damage to tree grate.	As needed
Vegetation Components			
Manual Weed Control	Remove weeds by hand weeding.	If weeds are present around tree area.	Monthly (spring through fall)
Pest Management*	Inspect plants for signs of disease or predation.	Presence of pests or diseased plants.	Biannually
Pruning (Structural)	Pruning trees or tree branches.	If tree is becoming too large for designated space, or if low branches are growing outside the space over streets or sidewalks.	Annually
Watering	Water plants as necessary to ensure survival during extended dry periods.	Yellow or brown tips of leaves, dying plants, or wilted/dehydrated leaves or stalks. Note, yellow leaves can also be an indicator that plants are receiving too much water.	As needed, depending on weather
Growing Medium/Planting Bed Components			
Organic Debris Removal	Remove excess organic debris (e.g., leaves, plant decay, etc.) from tree areas.	If present in or around tree area.	Biannually

Task	Description	Maintenance Indicator	Minimum Frequency
Mulch Amendment/Replacement	Amending or replacing mulch in tree area.	If mulch is observed to have bare spots, depth is less than 2 inches or appears compacted or disarrayed in or around tree area.	Annually or as needed
Trash Removal	Remove trash from tree planting beds and surrounding areas. Report large dumping.	If present in or around the tree area.	Monthly (spring through fall)
* Integrated Pest Management (IPM) routines are encouraged. This involves inspecting the plants for signs of disease or predation. The IPM approach encourages non-chemical methods for treated diseases or pests as a first resort.			

STORMWATER TREE EXPECTED ANNUAL FREQUENCY

It is recommended to complete eight (8) site visits annually for stormwater tree maintenance. The timing and the tasks related to each of these site visits is detailed in the below table.

Task	**Spring**	**Summer**	**Fall**	**Winter**	**After 2-inch Rainfall [1]**
Site Inspection	1				2
Pest Management		1	1		
Manual Weed Control	2	2	2		
Pruning			1		
Trash Removal	2	2	2		2
Organic Debris Removal	1		1		2
Mulch Amendment/Replacement	1				2
Total Minimum Annual Expected Maintenance	**2**	**2**	**2**		**2**

[1] A summary of rainfall data at General Mitchell Airport revealed that there has been at least one 2-inch rainfall from 2014-2019. This table assumes two 2-inch, 24-hour rainfalls per year for planning purposes.

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MAINTENANCE TASKS

CONCRETE REPAIR

DESCRIPTION

This section describes the procedure for repairing hairline or larger cracks in the concrete within a GI area. This task should be performed for any cracks found during inspections of the GI area.

EQUIPMENT & MATERIALS

- Chisel
- Hammer
- Masonry Trowel
- Scrub Brush
- Concrete Crack Patching Compound
- Concrete Mixing Tray
- Water
- Tarp
- Personal Protective Equipment (PPE): gloves

INSTRUCTIONS

1) Protect surrounding plants and GI components by covering them with a tarp.
2) Undercut the crack using a chisel and small hammer to widen the base of the crack.
3) Remove all debris and small particles.
4) Mix the concrete crack patching compound per the manufacturer's recommendations.
5) Tamp the mixture to remove air pockets.
6) Smooth the mixture with a trowel and wait for the patch to set.

SPECIAL CONSIDERATIONS

- Schedule concrete work early in the day for final setting to occur during the workday. Protect the patch from pedestrian and vehicular traffic using safety cones or other barricades and ensure that personnel are present during the final setting period to prevent vandalism and damage.
- Maintain protective measures during the five to seven day curing period.
- Concrete repairs should be limited to days with temperature ranges between 40- and 80-degrees Fahrenheit.
- Concrete repair shall be avoided within a 48-hour period of forecasted rain.

D E I C I NG

DESCRIPTION

This section describes the procedures for the deicing of permeable, pervious, and porous pavement. This task should be performed before and after snow events, sleet events, freezing rain events, and as needed during the winter season. Accumulated snow should be removed by shoveling, sweeping or plowing before it bonds with the pavement. If ice or snowpack accumulates, road salt or other deicers can be used in moderation to clear the pavement. Magnesium chloride should not be used, nor should deicers that contain ammonium nitrate or ammonium sulfate.

EQUIPMENT & MATERIALS

- Deicer
- Bucket
- Shovel
- Broom
- Snowplow
- Personal Protective Equipment (PPE): boots and gloves

INSTRUCTIONS

1) Shovel/sweep/plow snow in pavement area. (See Plowing Section.)
2) Apply deicer to pavement area if shoveling/sweeping/plowing is not sufficient.
3) Repeat as necessary

SPECIAL CONSIDERATIONS

- Deicers should be used in moderation.
- Sand or cinders should not be applied onto or adjacent to any porous pavement.

EROSION REPAIR

DESCRIPTION

This section describes the procedure for the repair of eroded areas. This task should be performed when water has eroded soils, causing bare spots or depositions of eroded soils in the bottom of the strategy. If erosion caused plants to wash away or die off, additional plantings may be necessary.

EQUIPMENT & MATERIALS

- Soils
- Shovel
- Wheelbarrow
- Seed
- Mulch or Matting
- Plants
- Personal Protective Equipment (PPE): gloves

INSTRUCTIONS

1) Remove debris and loose soils.
2) Apply replacement soils to fill in cracks, low spots.
3) Cover with seed and mulch/matting.
4) Replace plants that were affected in the repaired area.

SPECIAL CONSIDERATIONS

- Consult with facilities manager prior to repairing eroded area. GI strategy may have specialty soils or plants.
- Note that constant erosion is an indicator that there is an issue with run-on, either too much run-on, or it is entering the strategy too quickly. If erosion of same location in practice persists after first erosion repair, steps may need to be taken to address the run-on problem.

GRAFFITI REMOVAL

DESCRIPTION

This section describes the procedure for the removal of graffiti from GI elements. This task should be performed as necessary when graffiti is present on any GI, signage, or areas adjacent to the GI strategy area.

EQUIPMENT & MATERIALS

- Tarp
- Pressure Washer
- Chemical Graffiti Removal Solvent
- Metal/Plastic Brush
- Utility Knife
- Paint
- Rags
- Trash Bags
- Personal Protective Equipment (PPE): gloves

INSTRUCTIONS

1) Cover surrounding areas with a tarp to protect plants and GI strategy components.
2) If graffiti is sticker based, remove sticker from surface by holding the utility knife at a low angle relative to surface to prevent scratching.
3) Use a pressure washer to wash surface.
4) Apply chemical graffiti removal solvent per the manufacturer's instructions.
5) Scrub surface with metal or plastic brush.
6) Wipe away graffiti solvent with rags.
7) Pressure wash or rinse surface clean.
8) If necessary, re-paint the affected area.

SPECIAL CONSIDERATIONS

- Remove to the greatest extent possible and report any graffiti that could not be removed.

GRAVEL JOINT FILLING

DESCRIPTION

This section describes the procedure for filling the joints in permeable interlocking concrete pavements with gravel. This task should be performed when approximately 20% of the gravel is missing between the joints, typically after 5 years, or after a sweeping event occurs where joint material is incidentally removed.

EQUIPMENT & MATERIALS

- Disposal Bin
- Skid Steer with Mechanical Brush Attachment or Broom
- (Clear-washed) Gravel Material

INSTRUCTIONS

1) Obtain clear-washed joint material and check the manufacturer specifications for type of gravel joint material needed for specific product.
2) Dump gravel joint material onto pavement.
3) If using skid steer, use mechanical brush attachment with the brush turned to 30-degree angle to push piles of gravel in passes over the permeable interlocking concrete pavement to fill joints.
4) If using broom, brush gravel over permeable interlocking concrete pavement to fill joints.
5) Brush using either of the two methods until joints are full or to “lip” of pavers. Joints are full when excess material is left at the end of a pass with broom or brush.
6) Store or dispose of excess material and trash at an approved facility or location.

SPECIAL CONSIDERATIONS

- Obtain clear-washed joint material from a reputable vendor.
- Review facility plans, manufacturer specifications, and manufacturer recommendations for joint material sizes, and product recommendations.

INVASIVE SPECIES CONTROL

DESCRIPTION

This section describes the procedure for controlling invasive species in GI strategies. This task should be performed when invasive species are observed in the GI strategy, before they can flower and set seed, and begin impacting the desired plant species and performance of the practice.

EQUIPMENT & MATERIALS

- Rake
- Shovel
- Wheelbarrow/Bucket/Bags
- Native seed/soil mix or mulch
- Personal Protection Equipment (PPE) & Proper Clothing: closed-toed shoes, long pants, long sleeve shirts, and gloves

INSTRUCTIONS

1) Identify invasive species.
2) Pull invasive plants to remove entire plant and as much of the root system as possible. Note: Placing a foot next to the base of the plants hat is going to be pulled will help keep the soil in place as the roots slide out of the ground.
3) Do not impact remaining plant growth.
4) Cover exposed earth with native seed/soil mix or mulch.
5) Clean equipment when done working on a site with invasive species to prevent the spread of invasives to other sites.

SPECIAL CONSIDERATIONS

- Invasive plants that should be pulled before they go to seed. Refer to Appendix of Top 10 Invasive Species for list of the most common invasive species found in GI strategies in Southeastern Wisconsin and more specific management options for these species. Garlic mustard (*Alliaria petiolata*) should be placed in a bag and disposed of in the trash, *not* included in a compost pile to avoid spreading the invasive plant further.
- Hand pulling of plants is easiest when the soil is moist, immediately after a rain.
- The use of chemical herbicides or algaecides in waters of the state, including GI strategies, is regulated by the Wisconsin Department of Natural Resources- Aquatic Plant Management Program under NR 107, Wisconsin Administrative Code. Contact the WDNR to apply for applicable permits prior to using herbicides and/or algaecides in pre-treatment forebays or in constructed wetlands. In addition to contacting the WDNR, consider “hand-wicking” the wedding rather than spray application to reduce the amount of herbicide need and to be more deliberate in the application.

- Certain plants may cause skin irritation, such as poison ivy (*Toxicodendron radicans*), poison sumac (*Toxicodendron vernix*), poison oak (*Toxicodendron deversilobum*), stinging nettle (*Urtica dioica*), wild parsnip (*Pastinaca* sativa) and more. In addition, some plants have thorns or can prick skin when in contact with the plant, such as raspberries (*Rubus,* sp.), thistle (*Cirsium arvense*), and more. Be sure to wear gloves, long pants, closed-toed shoes and long sleeve shirts when working with invasive plants or weeds.

MANUAL WEED CONTROL

DESCRIPTION

This section describes the procedure for controlling weeds by hand. This task should be performed routinely, when undesirable plant growth is observed in between the desired plants.

EQUIPMENT & MATERIALS

- Rake
- Shovel
- Wheelbarrow/Bucket
- Personal Protective Equipment (PPE): gloves

INSTRUCTIONS

1) Identify unwanted weeds.
2) Pull weeds to remove entire plant and as much of the root system as possible.
   Note: Placing a foot next to the base of the weed that is going to be pulled will help keep the soil in place as the roots slide out of the ground.
3) Do not impact remaining plant growth.

SPECIAL CONSIDERATIONS

- If available, use planting plan to identify the plants that were initially intended, and be sure not to remove plants that are not weeds.
- Hand pulling of weeds is easiest when the soil is moist, immediately after a rain.
- The use of chemical herbicides or algaecides in waters of the state, including storm water treatment facilities, is regulated by the Wisconsin Department of Natural Resources- Aquatic Plant Management Program under NR 107, Wisconsin Administrative Code. Contact the WDNR to apply for applicable permits prior to using herbicides and/or algaecides in pre-treatment forebays or in constructed wetlands. In addition to contacting the WDNR, consider “hand-wicking” then weeding rather than spray application to reduce the amount of herbicide need and to be more deliberate in the application.
- Certain plants may cause skin irritation, such as poison ivy (*Toxicodendron radicans*), poison sumac (*Toxicodendron vernix*), poison oak (*Toxicodendron deversilobum*), stinging nettle (*Urtica dioica*), wild parsnip (*Pastinaca* sativa) and more. In addition, some plants have thorns or can prick skin when in contact with the plant, such as raspberries (*Rubus*, sp.), thistle (*Cirsium arvense*), and more. Be sure to where gloves and long sleeves to cover arms when working with invasive plants or weeds.
- Invasive plants that should be pulled in early spring before it goes to seed. Refer to Appendix of Top 10 Invasive Species for list of the most common invasive species in Southeastern Wisconsin. Removed plants should be placed in a bag and disposed of in the trash, *not* included in a compost pile to avoid spreading the invasive plant further.

MOWING

DESCRIPTION

This section describes the procedure for mowing vegetation in GI strategies. This task should be performed once during the year, in spring or fall, in areas planted with native species, to reduce weed growth and to prevent the release of excess nutrients from decaying plants in fall. Bioswales planted with low-growing, manicured grasses should be mowed more frequently, depending on rain fall and plant growth.

EQUIPMENT & MATERIALS

- Flail Mower
- Lawn Mower
- Weed Wacker
- Oil/Gas
- Rake
- Wheelbarrow
- Tarp
- Personal Protective Equipment (PPE): safety glasses

INSTRUCTIONS

1) Walk site to observe and remove any debris or unsafe materials that may be in the work zone.
2) Mow grasses to approximately 3-4 inches in height.
3) Mow native flowering plants to 6-8 inches in height.
4) Rake/remove cuttings and dispose of properly. Grass clipping should not be allowed to accumulate on the street, near the storm inlet, or in the GI strategies (as not to clog the area for infiltration).

SPECIAL CONSIDERATIONS

- Once established, native plantings should be burned. If burning is not possible, mowing may occur once per season in late spring or early fall and the cuttings removed and disposed of. Note burn permits or approvals from the local fire department may be required
- Take precautions to stay away from ground-nesting birds, wildlife, and nesting areas. You can find more information on nesting birds and their nesting times on the Wisconsin Department of Natural Resources Website: https://dnr.wi.gov/files/PDF/pubs/ER/ER0633.pdf

MULCH AMENDMENT & REPLACEMENT

DESCRIPTION

This section describes the procedure for a mulch amendment or replacement. This task should be performed when visible mulch is observed to have bare spots, if the depth of mulch is less than 2 inches, or if mulch appears to be compacted or disarrayed. When plants are established and lush, no additional mulch amendment is necessary, and can be counter-productive in disturbing soil beds, filling in storage capacity and adding more "floatable" matter to cause outlet blockages.

EQUIPMENT & MATERIALS

- Mulch: decomposed leaf mulch or shredded hardwood bark mulch
- Rake
- Shovel
- Wheelbarrow
- Tarp
- Personal Protective Equipment (PPE): gloves

INSTRUCTIONS

1) Rake decomposed leaf mulch in areas with herbaceous plants and rake shredded hardwood bark mulch in areas with woody plantings to maintain a loose top layer. Rake away from vegetation, trees, or shrubs. If replacing, use rake and shovel to remove, making sure not to disturb vegetation.
2) Apply mulch as needed to maintain a three (3) inch layer. Do not apply mulch against the trunks of trees and shrubs in a volcano-like mound as this will damage the plants.

SPECIAL CONSIDERATIONS

- Consult with facilities manager prior to amendments or replacements. GI strategy may have specialty mulch such as a fungi-enhanced mulch.

ORGANIC DEBRIS REMOVAL

DESCRIPTION

This section describes the procedure for removing accumulations of excess organic debris from GI strategy. This task should be performed routinely in the late fall and in spring after snowmelt, or when accumulations of decaying material has been observed.

EQUIPMENT & MATERIALS

- Rake
- Shovel
- Broom
- Wheelbarrow
- Tarp/Bags
- Personal Protective Equipment (PPE): gloves

INSTRUCTIONS

1) Identify decaying organic material to be removed and note any damaged or dead plants nearby that should be replaced.
2) Rake or shovel decaying material and place in wheelbarrow or on tarps, in bags. Decaying material that does not consist of invasive plants can be disposed of in compost piles.
3) Inspect areas where decaying material accumulated for evidence that the regular plant growth needs to be replaced/re-seeded.
4) Replace/re-seed plants as necessary.

SPECIAL CONSIDERATIONS

- Consult with facilities manager to review planting plan to confirm recommended replacement plantings.
- Weeds or invasive plants should not be added to compost piles to avoid spreading the plant further.
- Note the type of excess debris may dictate when it should be removed. For example, drifted piles of leaves from large shade trees are best removed in November.
- In naturalized landscapes where biomass is particularly dense, burning should be considered. Note burn permits or approvals from the local fire department may be required.

PIPE JETTING

DESCRIPTION

This section describes the procedure for pipe jetting. Pipe jetting should be performed when 30% or more of the cross-sectional area of a pipe is blocked or when specified by the owner or operator.

EQUIPMENT & MATERIALS

- Crowbar
- Measuring Wheel
- Hand Tools
- Manhole Hooks
- Closed-Circuit Television (CCTV) Equipment
- Push Broom
- Jetter Hoses, Fittings, Clamps, Nozzles
- High Pressure Pumping System
- Shovel or Spade
- Ladder
- Flashlight
- Personal Protective Equipment (PPE)

INSTRUCTIONS

1) Sweep the area surrounding the structure.
2) Remove any trash, sediment, or debris that is restricting access or flow control.
3) Remove pre-treatment device if not permanently attached to the structure and clean if necessary.
4) Position jet system so that reel is adjacent to the selected access structure and utilize an inlet, manhole, or control structure as the primary maintenance access point.
5) Insert jetter hose into pipe through the flexible hose guard.
6) Insert hose guard into the pipe to guide the jetter hose and prevent wear from friction.
7) Ensure a vacuum tube is present within the structure to vacuum jetted waste material (see vacuum section).
8) Start high-pressure pump after ensuring the nozzle is fully secured. Jet-rod the conveyance pipe structure and perform as many passes as needed to clean the structure.
9) Pipe jetting is complete once the jetted water is clear.
10) Complete a post-maintenance inspection of pipes with CCTV camera.

SPECIAL CONSIDERATIONS

- Vacuuming should not be performed within 48 hours of a significant rainstorm (>1-inch) rainstorm.

- Confirm that the jetter equipment waste storage tank is free from debris from another project.
- When using hydraulically propelled cleaning tools, all access structures that are not used as entry points must be closed and secured.
- When using hydraulically propelled cleaning tools, take precaution to ensure that the water pressure does not damage or cause flooding to nearby property.

PLOWING

DESCRIPTION

This section describes the procedure for snow plowing. Plowing should be performed to remove snow after and/or during every snowstorm. Special plow blades may be used to prevent scarring but are not necessary. Raised blade is not recommended.

EQUIPMENT & MATERIALS

- Shovel
- Gloves
- Snowplow
- Deicer (See Deicing Section)
- Personal Protective Equipment (PPE)

INSTRUCTIONS

1) Use snowplow or shovel to remove snow from permeable/pervious/porous pavement surface.
2) Apply deicing treatments during and after storms as necessary to control compact snow and ice not removed by the plow.

SPECIAL CONSIDERATIONS

- See manufacturer recommendations for special plow blades.

PRUNING (STRUCTURAL)

DESCRIPTION

This section describes the procedure for maintenance pruning, including woody plants, small trees, and shrubs. Maintenance pruning should be competed as necessary to remove damaged, diseased, or dead branches. Vegetation adjacent to walkways or street intersections should be maintained to keep safe lines of sight for pedestrians and vehicles.

EQUIPMENT & MATERIALS

- Chain Saw
- Hand Saw, Pruning Pole Saws, Pole Clips
- Pruning Shears and Loppers
- Push Broom
- Chipper trailer
- Lift with a dump box or Wheelbarrow
- Rake
- Personal Protective Equipment (PPE)

INSTRUCTIONS

1) Using clean and sterilized pruning tools, make clean and even cuts using proper tools for the size of each branch.
2) Remove low limbs as needed to maintain safe overhead and line of sight clearances for pedestrians and vehicles.
3) Remove all dead, damaged, diseased, or dying branches back to the nearest branching point taking care to avoid damage to the branch collar.
4) Carefully cut as close to the branch collar without cutting the branch collar itself. Preserve the branch collar for proper healing.
5) Cut branches into pieces that can easily be carried and remove any material to be disposed at an approved off-site location.

SPECIAL CONSIDERATIONS

- Pruning efforts should be made to protect clear sight lines. Ensure that branches and limbs are not impeding with street traffic, pedestrian traffic, or structures. Ideal clearances may not be practical in all cases, particularly for young trees.
- Owner or operator shall make arrangements with the utility company for the removal of any limbs or branches in conflict with electrical distribution lines. Tree pruning near electrical wires shall only be conducted by a qualified line clearance arborist. Electrical Utilities warn to keep 10 feet from all primary/distribution power lines.
- Avoid pruning the following during the growing season to reduce the likelihood of injury due to fungus and parasites: oaks (prune in winter or early spring), elms (prune in early spring), and fruit trees (prune in winter).

SANITIZING

DESCRIPTION

This section describes the procedure for sanitizing. Sanitizing should be completed for cisterns, tanks or rain barrels if trash, sediment, or organic debris is present within the rainwater harvesting system, the system has just been installed, or a bacterial test result is positive.

EQUIPMENT & MATERIALS

- Screwdrivers
- Wrenches
- Pliers
- Mallet
- Crowbar
- Unscented liquid household bleach
- Pressure washer
- Manhole hooks
- Metal/Plastic Brush
- Detergent
- Personal Protective Equipment (PPE): safety glasses and gloves

INSTRUCTIONS

1) Drain: Empty any water using approved vacuum cleaning and waste disposal protocols.
2) Clean:
    - Clean and scrub all internal surfaces using a brush or high-pressure washer and a mixture of detergent and water.
    - Wash all internal surfaces using a pressure washer or fill the tank with water and let stand for a few hours. Drain all water using approved waste disposal protocols.
3) Sanitize:
    - Fill 25% of the tank with clean water.
    - Add 3 cups of 5%-8.25% unscented liquid household bleach for every 100 gallons of water (a chlorine concentration of about 100 ppm or mg/L).
    - Mix the solution in the tank and fill to full capacity with clean water.
    - Let the solution stand for 24 hours with all covers and valves closed.
    - Empty the tank using approved waste disposal protocols.
4) Check the tank for residual chlorine concentration.
    - Refill the tank with clean water and let stand for 30 minutes.
    - Test the chlorine levels. The tank is safe for use if the chlorine concentration is 0.5 mg/L or less.
    - If the concentration is higher, empty the tank using approved waste disposal protocols and repeat the above steps until the concentration is 0.5 mg/L or less.
5) Sanitize any associated piping or hoses using the same procedures as described above.

SPECIAL CONSIDERATIONS

- If the tank is required for use urgently, the bleach concentration can be doubled, and the standing time can be reduced from 24 hours to 8 hours.
- Contaminated water must be disposed of using approved waste disposal protocols.

SEDIMENT REMOVAL

DESCRIPTION

Removing sediment from GI strategies and structures is crucial to their function. Sediment can damage vegetation by burying stems and coating leaves. Excess sediment also clogs soil beds and surfaces, leading to reduced infiltration and reduced storage capacity. This section describes procedures for removing sediment from the surfaces, inflow, and outflow points of GI strategies, and from pre-treatment devices.

EQUIPMENT & MATERIALS

- Broom
- Digging fork
- Scoop shovel
- Flathead shovel
- Leaf blower
- Brush
- 5-gallon bucket
- Tarp
- Trash bags
- Personal Protective Equipment (PPE): safety vest, safety glasses, and gloves

INSTRUCTIONS

For All Areas:

(1) Use a tarp to contain and collect sediment for bagging and removal.
(2) Take care to note areas of erosion, clogging, and soil compaction when performing these tasks.

For GI Strategy Surface Areas:

(1) Observe the surface area for areas of sediment accumulation and flows.
(2) Using a small rake, shovel or trowel, separate accumulated sediment from soil or soil media by gently scraping the top surface of the practice to a depth of 1 to 3 inches, depending upon the depth of the accumulated sediment. Sediment may be mixed in with mulch, which should be removed and replaced as necessary. Take care not to damage plants or remove filter media, unless the media is compacted or clogged (see Surface Media Renovation).
(3) Using a flat head shovel, carefully remove the excess sediment from the practice and place in a container for disposal.
(4) Note any underlying areas with soil compaction, erosion, or flow paths; see procedures for “Soil Amendment”.
(5) Any bare areas within a vegetated practice must be immediately repaired or stabilized; see procedures for “Soil Amendment,” “Mulch Amendment,” and “Surface Media Renovation.”

For Inflow and Outflow Areas:

(1) Sweep and dispose of accumulated sediment in the area extending 4 to 5 feet on either side of curb cut openings, gutter lines, and areas up-gradient (uphill) of inflow areas.
(2) For trench drains, use a leaf blower to blow out accumulated sediment. In some cases, grates or covers may need to be removed to fully access the inflow area.

For Pre-Treatment Devices such as forebays, filter strips, or inlet filters:

(1) Evaluate the extent of sedimentation. Where any clogging has occurred, use a scrub brush or pressure washer to remove fine sediment from filters or pores, taking care not to tear or damage the material.
(2) If tears of 3 inches or more are found in any filter fabric inlet devices, the device must be replaced; note to a field supervisor the location of any that need replacement.

SPECIAL CONSIDERATIONS

- While sediment tends to be heavier after winter snow melts, sediment removal should be done year-round.
- Some practices in areas with more sediment-generating land uses, or erodible soils, may require more frequent sediment removal. In these cases, field supervisors should note where pre-treatment or non-structural controls such as more frequent sweeping may be beneficial.
- Early spring is particularly important for sediment removal in order to remove any de-icing salts that may have accumulated over winter months.
- Removal of sediment from subsurface structures such as inlets, pipes and culverts are described in the “Pipe Jetting” and “Vacuum Cleaning” sections.
- If there is a significant volume of sediment, or it accumulates in permanently wet or hard-to-access locations, mechanized equipment such as a mini-excavator or portable vacuum excavator may be used at the discretion of the forewoman or field supervisor to provide more efficient and safe removal.

SEEDING

DESCRIPTION

This section describes the procedure to re-seed areas of GI strategies that have eroded, where vegetation has not survived, or where repairs have been completed. This task should be performed as needed in conjunction with other tasks to ensure vegetation cover and root systems will provide slope stability and promote infiltration allowing the practice to function as designed. Seeding to establish permanent plants should only be completed when ground temperatures are above 53 degrees Fahrenheit, during spring and early fall (typically mid-April through mid-September) to avoid hot temperatures and direct sunlight during summer when seed and sprouting vegetation tend to burn out. Temporary seeding can be done during fall, before the first frost, to establish a temporary growth of vegetation. This is typically done with quick growing plants to minimize erosion and soil loss over winter and in early spring.

EQUIPMENT & MATERIALS

- Seed
- Soil
- Mulch
- Rake
- Spreader / Seeder
- Trash bag (for removing invasives)
- Personal Protective Equipment (PPE)

INSTRUCTIONS

1) Remove weeds, other debris that will prevent seed from getting established.
    a. The use of herbicides to prepare the soil should follow safety protocols and manufacturers' directions.
2) Rake area to be seeded to establish a loose top layer. Fill and repair any gullies, low or eroded areas.
3) Spread seed uniformly in two directions If mechanical seed driller or silt seeder is used in place of spreader or seeder, then omit Step 4.
4) Cover seeded area with no more than ¼-inch of soil.
5) Water seeded area.
6) Mulch seeded area to prevent area from drying out and to protect seed and sprouts from burning out in direct sunlight.
7) Repeat watering daily (if it does not rain) to establish vegetation.

SPECIAL CONSIDERATIONS

- Heavy rains that occur before seed gets established may require additional seeding if rains wash the seed away.
- Dormant seed can be planted after November 1st.

SETTLING REPAIR

DESCRIPTION

This section describes the procedure for repairing areas of a GI strategy that have settled. This task should be performed when areas are observed to be lower than the surrounding areas or lower than the elevations as designed.

EQUIPMENT & MATERIALS

- Rake
- Shovel
- Wheelbarrow
- Tarp
- Soil or stone
- Personal Protective Equipment (PPE)

INSTRUCTIONS

1) Identify area that has settled which needs repair.
    a. If area is very large, or if the settling is greater than 2 feet, contact project manager/ review original designs, planting plans, etc.
2) Scrape/remove rock and stone from settled areas. If planted, remove plants carefully, taking care not to harm the plant or the root systems.
3) Fill area with stone or soil as directed by the project manager. Restore surface as directed.

SPECIAL CONSIDERATIONS

- If site is too deep (> 2 feet) or too large, contact project manager or site engineer to determine if the repair will maintain the performance of the GI strategy as designed.

SOIL AMENDMENT

DESCRIPTION

Soil Amendment is the process of improving disturbed soils and soils with a low organic content by restoring soil porosity and adding a soil amendment, such as compost, for the purpose of re-establishing the soil's long-term capacity for infiltration, pollutant removal, and supporting healthy plant growth. Soil amendment media usually consists of compost but can also include the use of mulch, manures, sand, and manufactured microbial solutions.

The maintenance steps in this section must be adapted to site and soil conditions. In some cases, soil may simply be aerated to alleviate compaction. In other cases, soils may need to be excavated and a portion replaced with one of several types of soil amendment materials. In all cases, care must be taken to ensure that proper re-vegetation and erosion control are practiced for all disturbed areas.

EQUIPMENT & MATERIALS

Soil Amendment may be done mechanically or by hand. The following tools are required for amending soil by hand:

- Engineered soil, where specified for bio-swales
- Other soil amendment material as specified
- Topsoil (for back-fill where aeration/de-compaction is required)
- Shovel
- Hand rake
- Tamper
- Water tank and hose
- Bucket
- Trash bags
- Spading fork
- Pitchfork
- Wheelbarrow
- Personal Protective Equipment (PPE): safety glasses, safety vest, and gloves

INSTRUCTIONS

1) Where necessary, carefully remove any accumulated sediment or soil and transfer to disposal containers.
2) Observe the underlying surface area and conditions to note areas of erosion, flow paths, and soil compaction/ hardening.
3) In areas of soil compaction/hardening, check for the depth of compaction with a spading fork. Excavate to compacted depth with a shovel. Till/aerate the surrounding edges of the excavated area. Following specifications for the GI strategy, backfill with engineered soil, or a combination of topsoil and amended soil at a ratio of 2:1.

4) In areas of evident flow paths, gently rake the surface soils to loosen to a depth of roughly 1-inch. Apply engineered soil or amended topsoil.
5) In areas of erosion, replace lost soil with engineered soil or amended topsoil.
6) Rake and shovel soil to conform to the slope specified by the design. Gently tamp into place – do not compact the soils.
7) Replant and water any vegetation disturbed by the soil amendment.
8) Clean up any excess soil that may have been blow or transported into surrounding non-vegetated areas.

SPECIAL CONSIDERATIONS

- Carefully observe sediment deposits, erosion areas, or compacted soil, and alert a field supervisor if necessary. Sedimentation and soil compaction can seriously affect a practice's function.
- Soil amendment is highly site-specific and will depend both on design and on the nature of the land uses in the area. Soil tests should be conducted during construction and periodically to predict both the type of soil amendment needed, and the frequency with which amendments may be required.
- Typically, where compost is used, compost should be added at a volume of 2 parts soil to 1-part compost (2:1). If a proprietary product is used, the manufacturer's instructions should be followed in terms of mixing and application rate.
- Soil compaction (i.e. hardening) can be treated by tilling and other physical loosening of the soil. Compaction must be addressed prior to adding a soil amendment.

STRUCTURAL CLEARING & MAINTENANCE

DESCRIPTION

This section describes the procedure for clearing and maintaining inlets and catch basin structures. This includes sediment, trash and debris removal.

EQUIPMENT & MATERIALS

- Shovel
- Rake
- Vacuum or Vacuum Truck
- Tarp
- Manhole Pick or Crowbar
- Sledgehammer
- Personal Protective Equipment (PPE): gloves

INSTRUCTIONS

1) Carefully use hands, or proper tools to remove the inlet, catch basin, or manhole cover. If a manhole cover is difficult to remove, use sledgehammer and crowbar to loosen cover from structure.
2) If structure is more than 2-inches full of sediment, and access allows, use shovel to remove sediment and debris.
3) If site allows for onsite disposal of organic debris, spread organic debris and sediment onsite. If not, or if sediment and debris contain non-organic materials, dispose at approved facility or location.
4) If sediment has caused pipes to clog, or access or depth of material does not allow, use vacuum truck to clear completely.

SPECIAL CONSIDERATIONS

- Removal of debris from inlets may require confined space entry.

SURFACE MEDIA RENOVATION

DESCRIPTION

This section describes the procedure for renovating surface media. This task is different from mulch amendment/replacement as it applies to GI strategies where conventional mulch is not used. This task should be performed when the surface layer of a practice is visibly compacted, or where mulch and soil have been removed due to sediment accumulation (see "Sediment Removal" and "Soil Amendment"). Surface media renovation must be done with the proper mix of engineered soil, topsoil, and/or soil amendment specified for the practice and requires coordination with the field supervisor or designer.

EQUIPMENT & MATERIALS

- Soil Amendment, engineered soil and/or topsoil as specified
- Mulch (if specified)
- Digging Fork
- Rake
- Shovel
- Tamper Bucket
- Trash Bags
- Personal Protective Equipment (PPE): safety vest, safety glasses, and gloves

INSTRUCTIONS

1) Observe the surface area to note any areas of compaction, erosion, or flow paths.
2) Where surface media is highly compacted or coated with sediment, gently rake the material and remove with a shovel into a container for disposal.
3) Gently rake the exposed surface to loosen the soil to a depth of approximately 1 to 3 inches, taking care to rake away from vegetation, trees, or shrubs.
4) Apply approximately 2 to 3 inches of engineered soil, amended soil or topsoil, as directed. Use the rake to mix gently into the loosened soil.
5) Contour the soil material to the specified grade of the practice's surface area. Tamp gently, but do not compact the soil.
6) Where mulch is to be used, apply mulch as needed to maintain a three (3) inch layer.

SPECIAL CONSIDERATIONS

- Ensure that mulch and all accumulated debris and sediment are removed before starting this task.
- Consult with the field supervisor or facilities manager before proceeding to ensure the correct surface amendment material is used.

TRASH REMOVAL

DESCRIPTION

This section describes the procedure for trash removal. This task should be performed when trash is present in or around the GI strategy. Trash should be removed all year round, and as necessary. Certain locations, especially those with heavy pedestrian traffic, may require more frequent trash removal.

EQUIPMENT & MATERIALS

- Trash Bags or Disposal Bin
- Trash picker
- Gloves
- Rake
- Personal Protective Equipment (PPE): gloves

INSTRUCTIONS

1) Use hands, rake, or trash picker to collect and remove trash from strategy or surrounding site.
2) Dispose of trash at an approved disposal facility or location.

WATERING

DESCRIPTION

Proper and timely watering are essential to the establishment, function and longevity of all vegetated practices. This section provides guidance on the timing and approaches for maintenance-related watering.

EQUIPMENT & MATERIALS

For municipal staff or contractors utilizing public hydrants:

- Hydrant key/wrench
- Backflow preventer

For truck/trailer mounted water tanks:

- Watering tank(s)
- Truck/trailer
- Water pump
- ¾" hose

All cases:

- Rain gauge
- Watering wand/nozzles
- Gator bags
- Personal Protective Equipment (PPE): gloves, safety glasses, and safety vest

INSTRUCTIONS

If watering off a public hydrant:

1) Install hydrant backflow preventer.
2) Open hydrants permitted to be opened with appropriate hydrant key/wrench.
3) Attach hose and adapter to backflow preventer.

For watering from tanks mounted on trucks or trailers:

1) Attach hoses to appropriate gravity or mechanical pumps for water tank(s).

All cases:

1) Soak the top 6 to 8 inches of soil evenly by constantly spraying water across the surface, rather than concentrating spray in one place.
2) Water trees by placing and filling gator bags.
3) Remove gator bags at the end of the growing season and no later than October.

SPECIAL CONSIDERATIONS

- A simple rain gauge can be mounted near GI strategies to monitor rainfall and more accurately predict when water will be necessary.
- Watering generally should be conducted from April through November.
- If possible, watering should occur at night or in the morning to minimize evaporation.

- Watering restrictions imposed due to drought must be observed; contact appropriate water agency to determine whether and when drought-related restrictions apply.
- Where not irrigated, watering of herbaceous plants should occur after 4 days without rainfall of 0.3-inch or greater, and herbaceous trees should be watered after 7 days without rain fall of 0.3-inch or greater.
- However, there are many times when judgment must be used to determine appropriate watering frequency. Maintenance staff must observe and consider, weather forecasts, site conditions and temperature to determine watering frequencies and needs. A log may be a useful tool to keep track of inches of water from watering and rain. Herbaceous plantings generally need 1-inch of water per week in cooler months and up to 2 inches of water per week during warmer months.
- Note that yellow leaves are also a common indicator of plants receiving too much water.

WOODY VEGETATION REMOVAL

DESCRIPTION

This section describes the procedure to remove woody vegetation or saplings. This task should be performed annually to prevent unplanned small trees from growing in GI strategies.

EQUIPMENT & MATERIALS

- Pruning shears
- Brush Cutter
- Rake
- Shovel
- Wheelbarrow
- Tarp/Bags/Bucket
- Soil
- Seed
- Personal Protective Equipment (PPE): safety glasses, safety vest, and gloves

INSTRUCTIONS

1) To hand pull woody vegetation:
    a. Pull woody plants from the base to completely remove the plant and roots disturbing as little soil as possible. It can be helpful to place a foot next to a sapling when removing it to prevent pulling up the adjacent soil.
    b. Use a hand shovel or spade to loosen the soil around larger plants to completely remove the root system.
2) To cut small woody vegetation:
    a. Use pruning shears or a brush cutter to cut small trees, woody vegetation to a height of 4-6 inches.
    b. Rake and collect removed plants for proper disposal.
3) Remaining holes from pulled plants should be filled with soil and re-seeded.

SPECIAL CONSIDERATIONS

- Consult with facilities manager prior to removing woody plants to ensure small trees were not previously placed to replace other vegetation.
- Pull plants when the soil is wet and loose (after a rainstorm) to reduce soil disturbance during removal. Disturbing the soil will bring weed seeds to the surface where they can germinate.
- Buckthorn (*Rhmanus* sp.) should be removed completely. If buckthorn will only be cut low, then it should be treated to prevent it from re-growing.

VACUUM CLEANING

DESCRIPTION

This section describes the procedure for vacuum cleaning permeable/pervious/porous pavement types. This task should be performed after the pavement is found to have standing water on the surface after a precipitation event.

EQUIPMENT & MATERIALS

- Vacuum Truck or Vacuum Attachment (wet and/or dry)
- Personal Protective Equipment (PPE)

INSTRUCTIONS

1) Safely block off area and surrounding area that needs to be cleaned.
2) Use vacuum truck or vacuum attachments to make slow passes over the pavement until the entire or target surface area has been cleaned.
3) Note, if vacuuming permeable interlocking concrete pavement systems with joint material, vacuuming will remove some joint aggregate material. Replenish removed joint aggregate material to “lip” over paver (see Gravel Joint Filling Section).
4) Clean machinery and dispose of collected trash, debris, etc. at approved disposal facility.

SPECIAL CONSIDERATIONS

- Refer to manufacturer specifications and recommendations for approved types of vacuum trucks or propriety vacuum attachments.

VEGETATION MAINTENANCE

DESCRIPTION

This section describes the procedures for annual herbaceous vegetation maintenance, trimming and transplanting. This task should be performed annually in spring and/or fall, depending on the plant species, to provide a healthy, appealing plant display and to thin aggressively growing plants.

EQUIPMENT & MATERIALS

- Rake
- Spade/Shovel
- Garden Knife
- String Trimmer
- Wheelbarrow
- Tarp/Bucket/Bags
- Personal Protective Equipment (PPE): gloves

INSTRUCTIONS

Vegetation Maintenance

1) Consult planting plan to determine varieties and location/extent of desired species in strategy.
2) Remove decayed material from previous season, including dried stalks, organic/leaf debris, and other loose/dislodged material.
3) Hand pull dried plant matter from previous season that is attached to existing plants without disturbing current plant growth.
4) Trim herbaceous plants to 4-6 inches in height with string trimmer in late spring and as needed to maintain safe sight lines in roadside facilities.
5) Rake removed/trimmed plant debris and place on tarp, in wheelbarrow/buckets/bags to dispose of properly off-site.

Transplanting

1) Consult planting plan to determine varieties and location/extent of desired species in strategy.
2) Use spade/shovel or garden knife to split or dig out plants to be thinned and/or transplanted through to the roots.
3) Dig a hole 1 ½ times the size of the root ball to be replanted. Cover root systems and base of plant with soil, so the top of the root ball/plant is even with the surrounding ground.
4) Fill remainder of hole with soil.
5) Water thoroughly to provide water to root systems.
6) Provide confirmation of transplanted species to facility manager for planting plan updates.

SPECIAL CONSIDERATIONS

- Note bare spots where last season's plant growth did not return and advise facility manager.
- Vegetation maintenance and transplanting should not be done in overly saturated soils.
- Remove all tags/labels/strings from new plants after planting.

INVASIVE SPECIES

10 Most Common Invasive Species in Green Infrastructure in Southeast Wisconsin

1. Cattails (*Typha*, sp.)

- Common name: Cattail; Narrow Leaf Cattail.
- Range and Habitat
    - Invades freshwater marshes, wet meadows, fens, roadsides, ditches, shallow ponds, stream, and lake shores, storm water ponds, biofilters.
    - It plays an important role as a source of food and shelter for some marsh-dwelling animals, but large mono-specific stands of invasive cattails spread vegetatively, displacing other plants providing food and cover, and excluding some less common species (WDNR, July 2015).
- Identification
    - Leaves: Erect, linear, and flat the leaf blades are 0.15-0.5" wide, and up to 3' long. About 15 leaves emerge per shoot. Dark green in color and rounded on the back of the blade. The top of the leaf sheath has thin, ear-shaped lobes at the junction with the blade that usually disintegrates in the summer.
    - Flowers: Numerous tiny flowers densely packed into a cylindrical spike at end of stem, divided into upper section of yellow, male flowers and lower brown, sausage-shaped section of female flowers. Gap between male and female sections is about 0.5-4" in narrow-leaved cattail. They flower in late spring.
    - Fruits & seeds: Seeds are tiny (about 1 mm), dispersed by wind with the aid of numerous hairs. Each narrow-leaved cattail spike produces thousands of seeds that remain viable for up to 100 years.
    - Roots: Plants reproduce vegetatively by means of starchy underground rhizomes to form large colonies (WDNR, July 2015).
- Similar species:
    - Common (broad-leaved) cattail (*Typha latifolia*; native) generally does not have a gap between male and female sections of the inflorescence and differs in several often tiny features of the leaves, flowers, and fruits. Hybrid cattail (*Typha* x *glauca*) is a hybrid of common and narrow-leaved cattails, and its structure is intermediate between that of its parental species. The best way to identify the hybrids is to first learn the characteristics of *T. angustifolia* and *T. latifolia*, then look for plants that are intermediate (WDNR, July 2015).

- Control

    - Flooding: Mow or cut cattails as short as possible in late fall to allow snowmelt and spring rains to rise above the remaining plants. Where possible maintain a water level of a minimum of 3" above the cut stems for the entire growing season.

    - Mechanical: Cut all stems, both green and dead in mid to late summer or early fall. Removal of the entire plant is difficult, but possible in very wet soils or through excavation, especially for small clusters of cattail growth. Remove cut or mowed plant material from the bottom of the BMP.

    - Chemical: some aquatic herbicides can be applied to cattails in the growing season. After plants die (days/weeks), the plant decaying plant material should be removed from the BMP (WDNR, July 2015)[1]

2. Crown Vetch (*Securicgera varia)*

- Common names: trailing crown vetch, purple crown vetch.

- Range and Habitat

    - Reproduces via rhizomes that can grow up to 10 feet per year.

    - Seeds can remain viable in the soil for more than 15 years.

    - Crown vetch can grow in full to partial sun, is drought tolerant but can also withstands heavy precipitation, and thrives in many different soil types.

    - Invades a variety of ecosystems, including those mimicked in green infrastructure storm water facilities.

- Identification

    - Leaves: Pinnately compound, alternate, 2-6" long, with 11-25 elliptical leaflets occurring in an odd number. Leaves are hairless.

    - Flowers: Pea-like, ranging in color from pink or lavender to white. Flowers are clustered in flat-topped umbels of 14-20 flowers that grow on long stalks extending from the leaf axils. Bloom from mid-spring through August.

    - Fruits & seeds: Long, slender, pointed seed pods contain 3-7 narrow seeds each. Seeds remain viable in the soil for up to 15 years.

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- Roots: Reproduces by fleshy rhizomes that grow up to 10' long. Roots are not fibrous, limiting the utility of crown vetch for erosion control.

- Similar Species: Crown vetch can be distinguished from other plants in the legume family by its compound leaves that have an odd number of leaflets. Also, its leaves and flower stalks arise from the main stem and the species has flat-topped umbels.

- Control

    - Mechanical: For smaller infestations, repeated hand-pulling can be effective as long as the whole plant, including the roots, is removed. Larger infestations can be covered with black landscape plastic or fabric for a minimum of one entire growing season.

    - Chemical: Foliar spray until leaves are wet but not dripping. Increase efficacy by hand-pulling and clearing previous year's growth to ensure herbicide contacts the actively growing plants. Application during spring or early summer while the plants are actively growing typically produces the best results for herbicide treatments[1].

3. Goldenrod (*Solidago,* sp.)

- Common names:

    - As currently understood, twenty-four species of goldenrods have been reported to occur in Wisconsin. One species, *Solidago canadensis*, is so common, widespread and variable as to be emblematic of the genus (UWGB 2015).

- Range and Habitat:

    - The native Canada Goldenrod occurs in almost all of the counties in Wisconsin. Natural habitats include disturbed areas of moist to dry prairies, openings in both floodplain and upland forests, thickets, savannas, limestone glades, and gravel seeps. In more developed areas, it occurs in both cultivated and abandoned fields, vacant lots, power-line clearance areas, and along fences, roadsides, and railroads. The preference is full to partial sun, and average moisture levels. This plant will tolerate some drought, in which case it will probably drop some of its lower leaves. This plant tolerates a variety of soils, perhaps even preferring a heavier soil with some clay content. During the fall, powdery mildew occasionally attacks the leaves (Illinois Wildflowers, 2002-2017).

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- Identification

    - Stems are often 3 to 4 feet tall with a roughly pyrimidal shaped inflorescence at the tip, comprised of numerous small, yellow flower heads. Each head is made up of several small yellow flowers surrounded by a series of overlapping bracts. The heads tend to be twisted such that they all or mostly appear to arise from the top side of the lateral branches of the inflorescence, the flower heads therefore said to be "secund" (UWBG, 2015).

    - Leaves are tapering to base and tip with three prominent veins running nearly parallel from near the base. Stems are pubescent below the inflorescence, though some varieties may be glabrous near the base of the stem (UWGB, 2015).

    - This species forms large clones by strongly spreading rhizomes beneath the soil surface. When making an identification it is important to remember that the inflorescence shape can be severely modified in any individual stem if the stem tip is damaged during growth, as may be the case if the stem is browsed by an animal or otherwise cut or broken off as the plant is developing. It is best to recognize the clonal nature of these plants and to consider the typical inflorescence shape of the population UWGB, 2015).

- Similar species:

    - Grass-leaved goldenrod, Great plains flat-topped goldenrod, coastal plain flat-topped goldenrod, white goldenrod, blue-stemmed goldenrod, zigzag goldenrod, giant goldenrod, hairy goldenrod, early goldenrod, Missouri goldenrod, velvety goldenrod, gray goldenrod, Ohio goldenrod, swamp goldenrod, prairie goldenrod, riddell's goldenrod, stiff goldenrod, wrinkle-leaved goldenrod, cliff goldenrod, dune goldenrod, showy goldenrod, northern bog goldenrod, elm-leaved goldenrod.

- Control

    - Mechanical: Cut all stems, both green and dead in mid to late summer or early fall. Where possible maintain a water level of a minimum of 3" above the cut stems for the entire growing season;

    - Chemical: some herbicides can be applied to goldenrod in the growing season. After plants die (days/weeks), the plant decaying plant material should be removed from the BMP (WDNR, July 2017)[1].

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4. Thistle (*Cirsium* sp.)

- Common name: creeping thistle, field thistle, perennial thistle, European marsh thistle, Canada Thistle.

- Range and Habitat

    - Invades undisturbed areas such as prairies, savannas, glades, dunes, streambanks, sedge meadows, and forest openings. Also invades croplands, pastures, lawns, gardens, roadsides, ditches, and waste sites.

    - Once it has established it spreads quickly, forming monocultures (WDNR, July 2015).

- Identification

    - Leaves: Simple, alternate, lance-shaped, tapering, irregularly lobed, with spiny, toothed margins, stalkless. Green on both sides; smooth early but becoming pubescent with maturity.

    - Flowers: Numerous, small (0.5-0.75" wide), purple to pink (rarely white) terminal flower heads. Bracts have spineless tips. Blooms June-September.

    - Fruits & seeds: Small, light brown with a tuft of tan hairs loosely attached to the tip to enable wind dispersal. Seeds are often spread by mowing after flowering has begun.

    - Roots: Reproduces clonally by creeping roots that grow laterally in soil, up to 10-12' per year. Also produces taproots that may grow more than 6' deep. Readily regenerates from root fragments.

    - Similar species: Canada thistle is distinguished from all other thistles by creeping lateral roots, dense clonal growth; and small dioecious flower heads (meaning male and female flowers are produced on separate plants; however, it is difficult to distinguish the two flower types based on appearance) (WDNR, July 2015).

- Control

    - Mechanical: Repeated pulling and mowing (minimum 3 times per growing season) weakens roots; mow when flower buds are formed but have not yet opened. Late spring (May/June) burns for 3 consecutive years stimulates seed germination and kills seedlings. Later season burns are needed because early season burning can stimulate plant growth and flowering.

- Chemical: Foliar spray glyphosate during the early bolting phase when plants are 6-10" tall, during the bud to flower phase, or rosettes in the fall (WDNR, July 2015)[1].

5. Cottonwood/Poplar trees (*Populus*, sp.)

- Common name: eastern cottonwood, plains cottonwood, Rio Grande cottonwood, plains poplar.

- Range and Habitat

  - Eastern cottonwood occurs from Alberta east to Quebec and south to Florida, Texas, Arizona, and northern Mexico. The distribution in Wisconsin is mostly southern and it is rare in the northern third. It does best on sunny, wet sites and can establish dense populations of seedlings on exposed, muddy soils.

  - Eastern cottonwood often occurs as a dominant or codominant component of floodplain and bottomland hardwood forests. It is a principal species in riverfront forests in the eastern United States. The maintenance of eastern cottonwood-dominated stands depends on periodic flooding. Most of these riparian areas tend to be in early successional stages and are composed chiefly of scrub willows (*Salix* spp.) interspersed with occasional eastern cottonwood stands (WDNR, July 2015).

- Identification

  - Leaves: The leaves of *Populus deltoides* are simple, alternate, toothed and broadly triangular. Buds are often resinous (sticky).

  - Bark: The bark of young trunks is similar to the pale greenish white color of other members of this genus. When the trees reach a large size the older bark splits repeatedly and becomes deeply furrowed and dark gray or even blackish.

  - Flowers: The flowers of the female aments (catkins) develop into capsules that split open at maturity to release numerous seeds with many hair-like structures which disperse the seeds great distances. The hairs, produced in great numbers, are the source of the name Cottonwood and can be a source of annoyance if they accumulate on window screens or enter open windows. Cottonwood trees produce male and female parts on separate trees. Male cottonwood trees don't produce seeds. Flowering is in April and dispersal of seeds in late May or early June in the Green Bay area (WDNR, July 2015).

- Similar species:

  - Black cottonwood (*Populus balsamifera*) and Fremont cottonwood (*Populus fremontii*).

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- Control
    - Mechanical: Pulling and mowing (minimum 3 times per growing season) weakens roots.

6. Buckthorn (*Rhamnus cathartica, Frangula alnus*)

- Common name: Common buckthorn, European buckthorn; Glossy buckthorn.
- Range and Habitat
    - Invades oak forests, riparian woods, savannas, prairies, old fields, and roadsides. It thrives particularly on well-drained soils, and can be problematic in green infrastructure storm water facilities designed to capture water and drain within a short amount of time.
    - Common buckthorn leafs out very early and retains its leaves late into the growing season, giving them a longer growing season than native plants.
    - Creates dense shade, eliminating regeneration of tree seedlings and understory species.
    - Allelopathic; produces chemical compounds that inhibit the growth of other vegetation (WDNR, July 2015).
- Identification
    - Common buckthorn (Rhamnus cathartica) has ovate or elliptic leaves, with prominent veins curving toward tip. Mostly opposite leaves, 1-2.5” long, with tiny teeth. Leaves remain on plants and stay green into fall. Bark is gray to brown with prominent light-colored lenticels. Cut bark exposes an orange inner cambium layer.
    - Glossy buckthorn (*Rhamnus frangula*; invasive) is similar to common buckthorn. Leaves are mostly opposite, with greater number of veins. Upper surface of leaves are shiny with undersides dull.
    - Flowers: Inconspicuous, small and clustered in leaf axils. Fragrant, greenish-yellow, 4-petaled flowers that bloom in spring.
    - Fruits & seeds: Abundant clusters of round, black, pea-sized fruit. Ripen on female plants in late summer. Dispersed by birds and mammals. Fruits remain on plants into winter after all the leaves have fallen.
    - Roots: Extensive, black fibrous root system (WDNR, July 2015).
- Similar species:
    - Alder buckthorn (*Rhamnus alnifolia*; native) is under 3’ tall with thornless twigs;

- Lance-leafed buckthorn (*R. lanceolata*; native) is less than 6' tall, found in wet areas and on dry limestone slopes, and has alternate leaves, 2-6" long, gradually tapering to a point at the tip.

- Carolina buckthorn (*R. caroliniana*; native), found in the southern Midwest, is 10-30' tall with toothed, mostly alternate leaves, 2-3" long (WDNR, July 2015).

- Control

  - Mechanical: Small plants may be hand pulled. Prescribed fire for seedlings. Larger plants can be dug or pulled using a leverage tool such as a weed wrench. Girdling trees requires stripping the bark to expose the inner hardwood at a minimum of six inches. Effective any time of year.

  - Chemical: Cut-stump treatment with glyphosate in late fall is very effective. Cut-stump, basal bark spray, or hand-wicking treatment around the stem with triclopyr in late fall through the winter to reduce environmental impact of chemical application[1].

7. Common Reed Canary Grass (*Phalaris arundinacea*)

- Common name: reed canary grass, canary grass.

- Range and Habitat

  - Forms dense, persistent monospecific stands in wetlands, moist meadows, riparian areas, storm water ponds, biofilters, and infiltration areas that outcompete desirable plants.

- Identification

  - Leaves: Blades are flat and have a rough texture on both surfaces. Leaf blades gradually taper from the base to the tip and are 4-8 inches long and about ½ inch wide. The ligule is unusually large—up to ½ inch long. Top leaves are horizontal.

  - Flowers: Densely clustered single florets that are green to purple when in bloom (May to mid-June) and turn golden tan as seeds form. The flower branches spread during bloom but draw close to the stem at maturity.

  - Fruits & seeds: Ripen in late June. Seeds can germinate immediately at maturation. Dispersed via waterways, animals, humans, and machines.

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- Roots: Rhizomes with large numbers of dormant buds create a thick fibrous mat at or just below the soil surface (WDNR, July 2015).

- Similar species:

    - Reed canary grass closely resembles orchard grass (*Dactylis glomerata*; non-native) as well as native bluejoint grass (*Calamagrostis canadensis*). Reed canary grass leaves are wider than orchard grass leaves. Reed canary grass has a transparent ligule and bluejoint does not (WDNR, July 2015).

- Control

    - Mechanical:
        - Small patches may be hand pulled, dug or covered with black plastic for a minimum of one growing season.
        - Close mowing 3 times per year can be effective to retard growth and prevent seed set.
        - Late spring or late fall burns for 5 to 6 years may be effective.
        - A combination of these methods over a couple of years may be necessary to fully eliminate a stand.

    - Chemical:
        - Small scattered clones can be controlled by tying stems together just before flowering, cutting off and bagging stems, and hand applying glyphosate to the cut stems to reduce damage to nearby plants.
        - Some herbicides can be applied to reed canary grass during the growing season. After plants die (days/weeks), the plant decaying plant material should be removed from the BMP (WDNR, July 2015)[1].

8. Garlic Mustard (*Aliiaria petiolata*)

- Common name: Mustard root, garlic root, and garlicwort.

- Range and Habitat

    - Invades high quality upland and floodplain forests and savannas, as well as disturbed areas, such as yards and roadsides. Can be found on the upper or dryer edges of storm water ponds, infiltration areas and biofilters. It is sometimes found in full sun, though most often grows in areas with some shade, and does not do well in acidic soils.

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- Native herbaceous cover has been shown to decline at sites invaded by garlic mustard.

- Garlic mustard exudes antifungal chemicals into the soil that disrupt associations between mycorrhizal fungi and native plants, suppressing native plant growth (WDNR, July 2015).

- Identification

  - Leaves: First year plants have basal leaves that are dark green, heart or kidney-shaped, with scalloped-edges and wrinkled appearance. On second year plants, stem leaves on flowering plants are alternate, triangular, with large teeth, and up to 2-3" across. Leaves and stems smell like garlic when crushed.

  - Flowers: Small, white, 4-petaled, and abundant. Bloom throughout the spring.

  - Fruits & seeds: Seed pods are long (1-2 ½)", slender capsules (siliques) green in color, drying to pale brown. Inside, seeds are small, shiny black, and arranged in a single row. Plants can be recognized in late summer and fall by their dry, papery brown, erect seedpods atop dead stalks. Seeds remain viable in the soil for at least 7 years.

  - Roots: White, slender taproot, "S"-shaped at the top. Will resprout from the root crown if only the top of the plant is removed (WDNR, July 2015).

- Similar species:

  - Several native white flowered plants, the toothworts (*Dentaria* spp.) and sweet cicely (*Osmorhiza claytonii*), bloom at about the same time as garlic mustard and may be mistaken for it. The leaves of native violets (*Viola* spp.) and the non-native creeping Charlie (*Glechoma hederaea*) may be mistaken for first year garlic mustard plants, but they will not have a garlic odor when crushed (WDNR, July 2015).

- Control

  - Mechanical: Hand pull in early spring before seed set. If plants are flowering, place in plastic bags for trash disposal or burn. Cut plants at their base just after the flower stalks have elongated but before any flowers have opened; may have to cut more than once during a growing season. Place pulled/cut plants in plastic bags for trash disposal. Use controlled burns in fall or early spring.

- Chemical: Some herbicides can be applied to garlic mustard during the early growing season, however this is not recommended as overspray may impact desired plant species. After plants die, the decaying plant material should be collected and disposed of (WDNR, July 2015)[1].

9. Norway Maple (*Acer platanoides*)

- Common name: Norway Maple.
- Range and Habitat
  - Large deciduous tree, dense canopy, 60' high when mature. Similar to native sugar maple except: broken leaf emits milky sap, upright green flower clusters, widely spreading winged fruit, regularly grooved bark, fall color always yellow.
  - Out-competes native sugar maple and is very shade tolerant. Wildflower diversity is reduced beneath because it forms a dense canopy (WDNR, July 2015).
- Identification
  - Leaves: Opposite, five lobed, coarsely toothed, pointed.
  - Flowers: Flat-topped upright cluster, yellowish green, appearing with the leaves, blooming in May.
  - Fruit: Widely spreading winged fruit, ripens in autumn (WDNR, July 2015).
- Similar species:
  - Red maple (*Acer rubrum*), sugar maple (*Acer saccharum*).
- Control
  - Mechanical: Repeated pulling and mowing (minimum 3 times per growing season) weakens roots.
  - Chemical: Cut-stump treatment with glyphosate; Cut-stump, basal bark spray, or hand-wicking treatment around the stem with triclopyr in late fall through the winter to reduce environmental impact of chemical application (WDNR, July 2015)[1].

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10. Teasel (*Dipsacus,* sp.)

- Common name: Fuller's teasel, wild teasel.
- Range and Habitat
    - Invades open areas, prairies, savannas, and sedge meadows, as well as roadsides and disturbed areas.
    - Rapid range expansion of cut-leaved teasel has been observed in several Midwestern states (WDNR, July 2015).
- Identification
    - Leaves: Opposite, large (up to 1.5' long), oblong, and prickly. Leaves of flowering plants join into cup around stem. Common teasel's leaves are not lobed.
    - Flowers: Hundreds of small flowers, clustered in dense, egg-shaped heads. Stiff, spiny, leaf-like bracts curve up from base of flower head. Common teasel has purple flowers and bracts longer than the flower heads. Common blooms from June-October.
    - Fruits & seeds: Each plant can produce as many as 2,000 seeds. Seeds remain viable in the soil for at least 2 years.
    - Roots: Deep taproot, up to 2' long and 1" in diameter (WDNR, July 2015).
- Similar species:
    - Cut-leaved teasel (*Dipsacus laciniatus*) leaves are broader and have deep, feathering lobes. Its bracts are shorter than the flower heads. The flowers are white and bloom from July-September (WDNR, July 2015).
- Control
    - Mechanical: Rosettes can be dug up making sure to remove as much of the root as possible. Mature plants can be cut in full bud stage; plant will re-sprout but will not flower. Bag and dispose of stems. Late spring burns.
    - Chemical: Some herbicides can be applied to teasel during the growing season. After plants die, the decaying plant material should be removed from the BMP (WDNR, July 2015)[1].

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Additional Considerations

- Algae (& other aquatics) can become established in standing water. These algal blooms can reduce the integrity of green infrastructure and pose potential public health concerns. Rain gardens, biofilters, and infiltration areas with clogged soils retain water longer than designed, allowing algae to bloom. Filamentous algae can dry and leave a thick film on the ground or attached to plants, which is unsightly and cause further clog the soils.

- Many different grasses can become established in small areas. Some grasses have root systems with runners that grow horizontally. It is best to pull the grasses out with the roots, if possible, instead of cutting to minimize the potential of regrowth in areas where grass is not desired.

- Norway maple and cottonwood trees are not the only tree species that can threaten the integrity of the urban green infrastructure. Many trees and sapling will establish themselves in green infrastructure (especially on green roofs) if not controlled. Tree roots can reduce the effectiveness of green infrastructure as well as cause damage to pavement through the infiltration of roots.

- Other species of herbaceous plants will become established if not mechanically or chemically controlled. Some of these species include: purple loosestrife (*Lythrum salicaria*), white sweet clover (*Melilotus albus*), Japenese barberry (*Berberis thunbergii*), horsetail, blindweed (*Convolvulus arvensis*), wild parsnip (*Pastinaca sativa*), Queen Anne's Lace (*Daucus carota*), and multiple honeysuckle species, among many others.

- Animals can utilize urban infrastructure for breeding or foraging. Some of the animals include muskrats and geese among others. Animals utilizing green infrastructure can reduce the effectiveness and become a nuisance if not controlled through avoidance measures.

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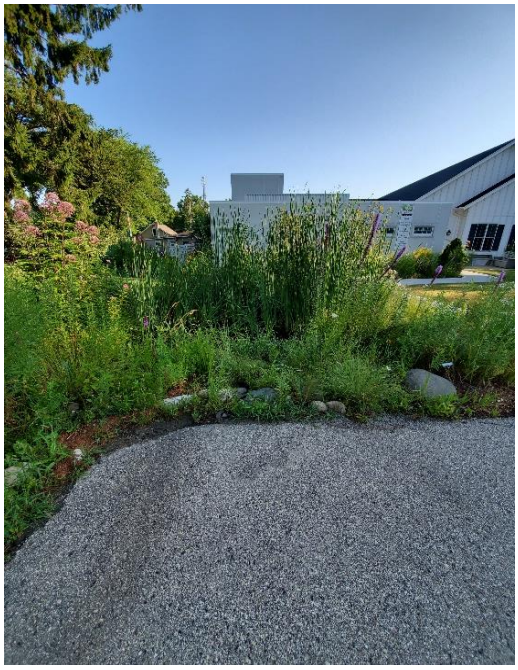
Reference Photographs

1. Cattails (*Typha*, sp.)

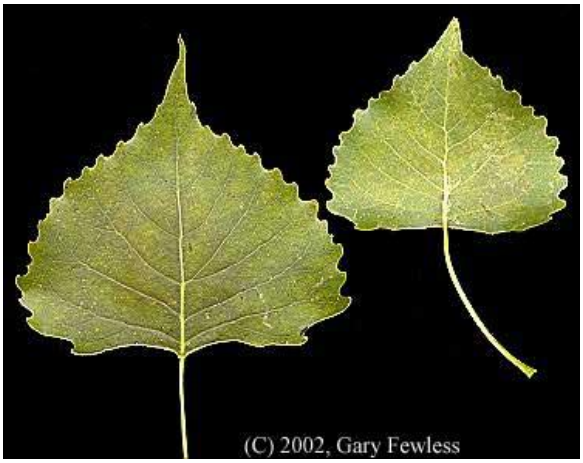


2. Crown Vetch (*Securicgera varia)*

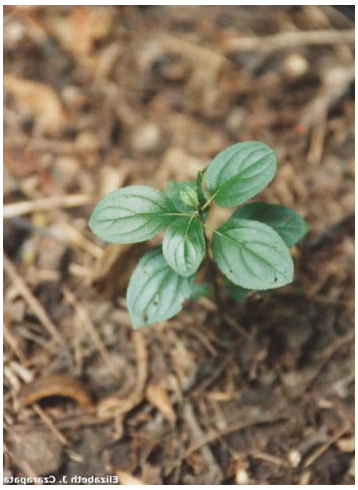
3. Goldenrod (*Solidago,* sp.)

4. Thistle (*Cirsium* sp.)

5. Cottonwood/Poplar trees (*Populus*, sp.)



6. Buckthorn (*Rhamnus cathartica, Frangula alnus*)

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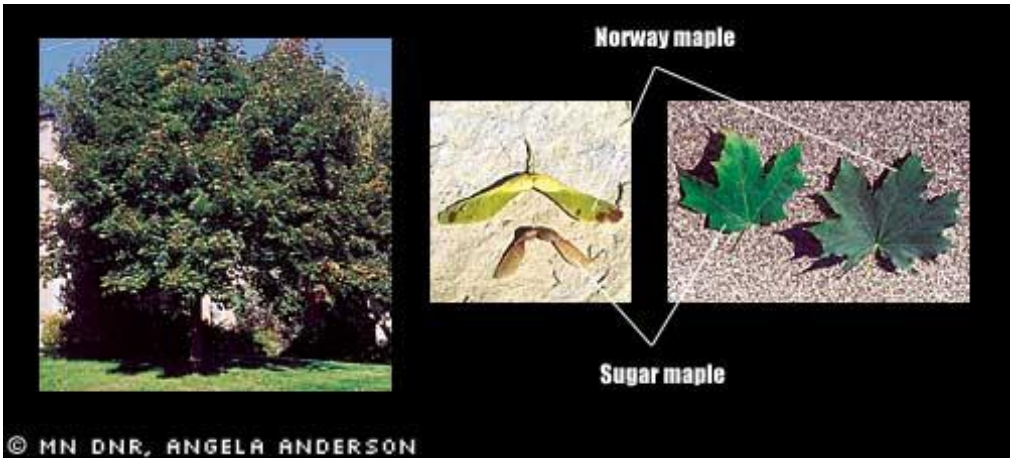
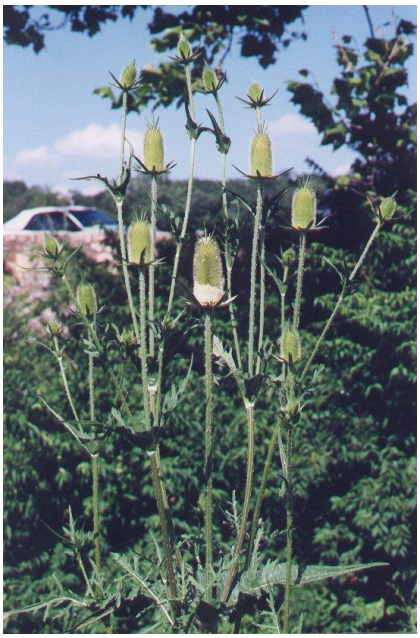
7. Common Reed Canary Grass (*Phalaris arundinacea*)

8. Garlic Mustard (*Aliiaria petiolata*)

9. Norway Maple (*Acer platanoides*)



10. Teasel (*Dipsacus,* sp.)



Additional Considerations

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MMSD RESOURCES

RESOURCE	AVAILABLE FROM	WEB ADDRESS
PLANS		
Regional Green Infrastructure Plan	MMSD	https://www.mmsd.com/static/MMSDGIP_Final.pdf
GI Operations & Maintenance Implementation Framework, 2016	MMSD	https://www.freshcoastguardians.com/application/files/6115/0427/9939/GI_OM_2016_Final_Report.pdf
Milwaukee Green Streets Plan, 2013	City of Milwaukee	https://www.mmsd.com/application/files/7814/8779/8665/Green_Streets_Stormwater_Manag.pdf
Various Plans	Fresh Coast Resource Center	https://www.freshcoastguardians.com/resources/our-plans
SIZING AND DESIGN OF GREEN INFRASTRUCTURE		
Green Infrastructure Desktop Sizing Tool	MMSD	http://www.freshcoastguardians.com/resources/sizing-your-project
Green Infrastructure Standard Specifications and Plan Templates, 2016	MMSD	https://www.mmsd.com/application/files/7514/8658/7515/MMSD_GI_Specs_and_Plan_Template_Report.FINAL.012717.pdf
Green Infrastructure Plant Selection Tool	MMSD	https://www.freshcoastguardians.com/resources/services/plant-selection
MAINTENANCE AND CARE OF GREEN INFRASTRUCTURE		
Fresh Coast Resource Center	MMSD	https://www.freshcoastguardians.com/contact
Operation & Maintenance Manual		
Green Infrastructure Care:	MMSD	
Rain Barrels	Fresh Coast Resource Center	https://www.freshcoastguardians.com/application/files/1915/5119/6195/13-056c2_DiverterRainBarrel02142019_Web.pdf
Rain Gardens	Fresh Coast Resource Center	https://www.freshcoastguardians.com/resources/green-strategies/rain-gardens
Soil Amendments	Fresh Coast Resource Center	https://www.freshcoastguardians.com/resources/green-strategies/soil-amendments
Native Landscape	Fresh Coast Resource Center	https://www.freshcoastguardians.com/resources/green-strategies/native-landscaping
Stormwater Tree	Fresh Coast Resource Center	https://www.freshcoastguardians.com/resources/green-strategies/stormwater-trees
Green Roofs	Fresh Coast Resource Center	https://www.freshcoastguardians.com/resources/green-strategies/green-roofs
Porous Pavements	Fresh Coast Resource Center	https://www.freshcoastguardians.com/resources/green-strategies/porous-pavement
Bioswales	Fresh Coast Resource Center	https://www.freshcoastguardians.com/resources/green-strategies/bioswales
Wetlands	Fresh Coast Resource Center	https://www.freshcoastguardians.com/resources/green-strategies/wetlands
VENDORS AND GREEN INFRASTRUCTURE TRAINING		
Green Vendor List	MMSD	https://www.freshcoastguardians.com/resources/vendors
Fresh Coast Resource Center Training Support	Fresh Coast Resource Center	https://www.freshcoastguardians.com/resources/services/workforce-development-training
FUNDING PROGRAMS		
Green Infrastructure Partnership Program	MMSD	https://www.mmsd.com/what-we-do/green-infrastructure/funding-programs
Green Solutions	MMSD	
Fund for Lake Michigan	FFLM	https://fundforlakemichigan.org/apply-for-funding/
Sweet Water Mini-Grant Program	Sweet Water	https://www.swwtwater.org/mini-grants
Wisconsin Coastal Management Program	Wisconsin Office for Coastal Management	https://doa.wi.gov/Pages/LocalGovtsGrants/CoastalGrants.aspx

2019 UNIT COSTS FOR MAINTENANCE BID ITEMS

	DETAILED DESCRIPTION	UNIT	TYPICAL UNIT PRICE	NOTES	SOURCES FOR ESTIMATED COST	2018 PRICES[1]
PLANTING MEDIA, COVER, AND SOD						
Compost	Blue Ribbon - Certified Organic	CY	$40.00		Minor's - Retail (2019)	$73.00
Shredded Hardwood Bark Mulch	Hemlock blend	CY	$45.00		Minor's - Retail (2019)	$63.53
Engineered Soil	Owl Run Nursery (pick-up/delivered)	CY	$60.00		Owl Run Nursery (2019)	$58.59
Sod	Blue Grass Blend	SF	$3.50		Minor's - Retail (2019)	$4.75
UNDERDRAINS						
6" PVC Underdrain (perforated)		LF	$25.00		Minnesota BMP Calculator (2019)	$24.95
PLANTS AND PLANT MATERIALS						
Native Plant Plugs	32 - 38 Cell Plug	EACH	$3.00	*enter any restrictions on when is the best time to order plugs/shrubs*	Taylor Creek Nursery Wholesale (2019)	$5.63
Root Stock Plants (18" spacing)	Variety of species	EACH	$3.00		Raintree Nursery (2019)	$3.77
Perennials, #1 Gallon	Variety of species incl. premium, #1 containers	EACH	$15.00	Consult a restoration nursery for the correct mix for your location and soil type	Minor's - Retail (2019)	$13.87
Shrubs, #5 Gallon	Variety of species, #5 containers	EACH	$60.00		Minor's - Retail (2019)	$59.00
Example Varieties:						
Ozark Witch Hazel		EACH	$50.00		Minor's - Retail (2019)	$50.00
Gray Dogwood		EACH	$25.00		Minor's - Retail (2019)	$50.00
Arrowwood Viburnum		EACH	$30.00		Minor's - Retail (2019)	$30.00
Pardon Me Daylily	#1 container, premium	EACH	$20.00		Minor's - Retail (2019)	$20.00
Northwind Switch Grass	#1 container, premium	EACH	$18.00		Minor's - Retail (2019)	$20.00
SEEDING MIXES						
Diverse Prairie Mix	"High Diversity P rairie Mix"	SY	$0.30		Taylor Creek Nursery Wholesale (2019)	$0.42
Detention Basin Wet Prairie Mix	"Wet Seed Mixes - Swale and Basin Mix"	SY	$0.20		Taylor Creek Nursery Wholesale (2019)	$1.70
Erosion Control Mix	$0.47/SY = $2280/AC	SY	$0.50		Reinders - Retail (2019)	$1.88
WISDOT Seed Mix No. 75 (Erosion Control)		LBS				
"Infiltration Seeding"	"Clay Soils - Mesic Prairie Mix" / SY	LS	$0.25		Taylor Creek Nursery Wholesale (2019)	$3,680.00
DECIDUOUS TREES						
Sienna Glen Maple	3" Caliper	EACH	$300.00	*enter any restrictions on when is the best time to order trees*	Minor's - Retail (2019)	$400.00
Swamp White Oak	3" Caliper	EACH	$300.00		Minor's - Retail (2019)	$400.00
Prairie Titan Kentucky Coffee Tree	2.5" Caliper (3" not available)	EACH	$250.00		Minor's - Retail (2019)	$400.00
Winter King Hawthorn	1.75"	EACH	$175.00		Minor's - Retail (2019)	$250.00
American Hornbeam	2"	EACH	$250.00		Minor's - Retail (2019)	$250.00
Autumn Brilliance Serviceberry	8'	EACH	$225.00		Minor's - Retail (2019)	$200.00
PAVER BLOCKS						
Paver Blocks (any variety)		SF				$7.33
Permedge Permeable Paver Edge Restraint		LF				$6.27
Pavers with Settling Stone & Joint Aggregate		SF				$13.13
Permeable 'patio paver' with underlayment		SF				$18.35
Kiarastone Pavers		SF				$8.81
STORM SEWER						
Storm Sewer	12" HDPE	LF				$56.46
Detention Basin Outlet Structure		EACH				$3,500.00
DEMOLITION						
Common Excavation		CY				$20.11
Saw Cut Pavement, Asphalt		LF				$3.01
Remove Existing Asphalt Pavement		SF				$7.60
Remove Existing Concrete Roadway		SF				$5.38
Pulverize Asphaltic Pavement, Full Depth		SF				$1.50

Notes:

1. From 2018-2019 Cost Study (source)

ACKNOWLEDGEMENTS

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