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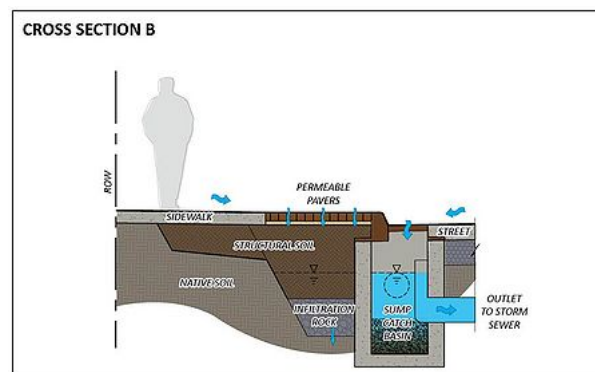
## Operation and maintenance (O&M) of tree trenches and tree boxes



**Green Infrastructure:** Trees can be an important tool for retention and detention of stormwater runoff. Trees provide additional benefits, including cleaner air, reduction of heat island effects, carbon sequestration, reduced noise pollution, reduced pavement maintenance needs, and cooler cars in shaded parking lots.

This page provides guidance for operation and maintenance (O&M) of tree trenches and tree boxes. A tree trench is a **bioretention practice** that contains one or more trees. Tree trenches and boxes may be designed as **infiltration** ([https://stormwater.pca.state.mn.us/index.php?title=Stormwater\\_infiltration\\_Best\\_Management\\_Practices](https://stormwater.pca.state.mn.us/index.php?title=Stormwater_infiltration_Best_Management_Practices)) or **filtration** (<https://stormwater.pca.state.mn.us/index.php?title=Filtration>) (**underdrained**) systems.

Supplemental information can be found on the page called Operation and maintenance of tree trenches and tree boxes - supplemental information. Supplemental information includes the following.



Cross section of the tree system installed for the Central Corridor Light Rail Transit project in St. Paul, MN. Image courtesy of the Capitol Region Watershed District (<http://www.capitolregionwd.org/>).

- Supplemental watering
- Pruning
- Staking and straightening
- Protecting the trunk
- Mulching
- Fertilizers
- Check tree safety
- Tree health troubleshooting guidelines
- References

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Completed tree system, Marquette and 2nd Avenue Busways project, Minneapolis, MN. Image Courtesy of The Kestrel Design Group.

## Overview of typical O&M Issues

In addition to runoff reduction and stormwater treatment, street trees and tree boxes provide a range of community benefits. Trees contribute to air pollution reduction, **carbon sequestration**, reduction in **heat island** effect, habitat creation for wildlife, and can be used as tools for **climate adaptation**. **Green stormwater infrastructure (GSI)** trees are often planted in highly visible areas and are subject to public interaction, vandalism, and winter **deicing**, but trees typically remain resilient with proper maintenance.

O&M of tree trenches and boxes generally requires a low level of effort and expertise, and street trees can have life spans of up to 60 years (Cappiella et al. ([https://www.chesapeakebay.net/documents/Urban\\_Tree\\_Canopy\\_EP\\_Report\\_WQGIT\\_approved\\_final.pdf](https://www.chesapeakebay.net/documents/Urban_Tree_Canopy_EP_Report_WQGIT_approved_final.pdf)), 2016). **Green infrastructure** managers do share common issues and concerns related to trees. The most common O&M concerns for tree trenches and tree boxes include

- general poor health,
- insufficient water for growth,
- accumulation of litter and debris in the inlet, and
- spent and lost mulch.

The sections below describe best practices to prevent or minimize these common problems.

## Design phase O&M considerations

Tree trenches and tree boxes have a small footprint and should be designed to treat a relatively small drainage area (0.25 acres or less per tree). Surface area of the tree trench or box and surface area to drainage area ratio are key design characteristics. Design specifications vary based on the selected filter **media** ([https://stormwater.pca.state.mn.us/index.php?title=Design\\_criteria\\_for\\_bioretention#Materials\\_specifications\\_-\\_filter\\_media](https://stormwater.pca.state.mn.us/index.php?title=Design_criteria_for_bioretention#Materials_specifications_-_filter_media)) and filter box manufacturer (most tree trench and box systems are proprietary practices). Properly **sizing** and designing the tree box will help prevent O&M issues. Designers should consider

- minimizing the surface area to drainage area ratio, based on the manufacturer guidelines;
- properly sizing the tree box or tree trench to manage an appropriate surface area based on local precipitation patterns;
- selecting regionally appropriate species that are tolerant to the soil and growth media (see Design Guidelines for Tree Quality and Planting ([https://stormwater.pca.state.mn.us/index.php?title=Design\\_guidelines\\_for\\_tree\\_quality\\_and\\_planting\\_-\\_tree\\_trenches\\_and\\_tree\\_boxes](https://stormwater.pca.state.mn.us/index.php?title=Design_guidelines_for_tree_quality_and_planting_-_tree_trenches_and_tree_boxes))); and
- selecting species that will grow in the limited space provided by the filter box (see Design Guidelines for Tree Quality and Planting ([https://stormwater.pca.state.mn.us/index.php?title=Design\\_guidelines\\_for\\_tree\\_quality\\_and\\_planting\\_-\\_tree\\_trenches\\_and\\_tree\\_boxes](https://stormwater.pca.state.mn.us/index.php?title=Design_guidelines_for_tree_quality_and_planting_-_tree_trenches_and_tree_boxes))).

Designers should also consider the maintenance schedules and tasks when locating tree trenches or tree boxes on their site. The small surface area of tree boxes makes them versatile. However, they should be placed within areas that are easily accessible to ensure proper maintenance. Maintenance of tree trenches and tree boxes does not require large or heavy equipment, but routine maintenance should be expected once or twice a year. Designers can incorporate solutions to facilitate the following maintenance activities.

- Incorporating multiple and easy access points
- Placement near supportive companion plants to prevent diseases
- Installing **observation wells**
- Specifying the optimized soil **media** ([https://stormwater.pca.state.mn.us/index.php?title=Design\\_criteria\\_for\\_bioretention#Materials\\_specifications\\_-\\_filter\\_media](https://stormwater.pca.state.mn.us/index.php?title=Design_criteria_for_bioretention#Materials_specifications_-_filter_media)) composition and depth to effectively trap or **sequester** nutrients (phosphorus in particular), and that can also support the desired species
- Site-specific species selections that take into account sun exposure, shade, proximity to traffic corners (visibility issues), salt-tolerance, etc.
- Providing educational signage to increase public awareness
- Installing measures like low fencing to prevent damage from pedestrian foot traffic

Designers should consult and include any local requirements regarding **green infrastructure**. O&M considerations often depend on whether the practice is located on public land, private land, or in the public right of way. For example, plantings in the public right of way that conflict with any traffic safety considerations could require increased O&M, such as pruning or complete removal.

The designer should also provide a site-specific O&M plan that includes the following.

- Construction inspection schedule and checklists
- Post-construction routine maintenance schedule and checklists
- Operating instructions for the practice (if applicable)

Additional information that should be included in O&M plans is described in the Post-Construction Phase O&M Considerations ([https://stormwater.pca.state.mn.us/index.php?title=Operation\\_and\\_maintenance\\_\(O%26M\)\\_of\\_tree\\_trenches\\_and\\_tree\\_boxes#Construction\\_Phase\\_O.26M\\_Considerations](https://stormwater.pca.state.mn.us/index.php?title=Operation_and_maintenance_(O%26M)_of_tree_trenches_and_tree_boxes#Construction_Phase_O.26M_Considerations)) section. Example O&M plans are also provided below ([https://stormwater.pca.state.mn.us/index.php?title=Operation\\_and\\_maintenance\\_\(O%26M\)\\_of\\_tree\\_trenches\\_and\\_tree\\_boxes#Maintenance\\_Training\\_Documents\\_and\\_Videos](https://stormwater.pca.state.mn.us/index.php?title=Operation_and_maintenance_(O%26M)_of_tree_trenches_and_tree_boxes#Maintenance_Training_Documents_and_Videos)).

## Construction phase O&M considerations

Proper construction methods and sequencing play a significant role in reducing O&M problems. Some key items during the construction phase include the following.

### 1. Before construction begins

1. Ensure that the **contributing drainage area** ([https://stormwater.pca.state.mn.us/index.php?title=Contributing\\_drainage\\_area\\_to\\_stormwater\\_BMPs](https://stormwater.pca.state.mn.us/index.php?title=Contributing_drainage_area_to_stormwater_BMPs)) is fully stabilized with vegetation prior to the beginning of construction. Also make sure that impervious areas in the contributing drainage area are clean. If this is not possible, use barriers or diversions ([https://stormwater.pca.state.mn.us/index.php?title=Sediment\\_control\\_practices\\_-\\_Diversion\\_barrier\\_controls\\_\(cofferdams/temporary\\_dikes\)](https://stormwater.pca.state.mn.us/index.php?title=Sediment_control_practices_-_Diversion_barrier_controls_(cofferdams/temporary_dikes))) to direct stormwater flows from the contributing drainage area away from the practice.
2. Install any needed **erosion protection** ([https://stormwater.pca.state.mn.us/index.php?title=Erosion\\_prevention\\_practices](https://stormwater.pca.state.mn.us/index.php?title=Erosion_prevention_practices)) and **sediment control** ([https://stormwater.pca.state.mn.us/index.php?title=Sediment\\_control\\_practices](https://stormwater.pca.state.mn.us/index.php?title=Sediment_control_practices)) in your construction site and prepare a storm water pollution prevention plan ([https://stormwater.pca.state.mn.us/index.php?title=MN\\_CSW\\_Permit\\_Section\\_5\\_Stormwater\\_Pollution\\_Prevention\\_Plan\\_\(SWPPP\)\\_Content](https://stormwater.pca.state.mn.us/index.php?title=MN_CSW_Permit_Section_5_Stormwater_Pollution_Prevention_Plan_(SWPPP)_Content)) (SWPPP).
3. Designate a stormwater supervisor to make sure someone is responsible for erosion and sediment control.
4. Hold a pre-construction meeting to review the construction plans and the sequencing of construction. Other agenda items could include discussing the status of the pre-construction drainage, erosion, and sediment controls; and reviewing or assign points of contacts for the stormwater and/or green infrastructure key personnel.

### 2. During construction

1. Construct any **pretreatment** (<https://stormwater.pca.state.mn.us/index.php?title=Pretreatment>) devices before installing any tree boxes or trenches. Depending on the site design and drainage pattern, this may not be necessary, but stormwater should be directed away from the boxes during the construction phase.
2. Ensure heavy equipment does not enter the footprint of the practice to avoid compaction ([https://stormwater.pca.state.mn.us/index.php/Alleviating\\_compaction\\_from\\_construction\\_activities](https://stormwater.pca.state.mn.us/index.php/Alleviating_compaction_from_construction_activities)) of the infiltration medium.
3. Store any soil, mulch, or gravel media away from the practice footprint to avoid clogging the infiltration medium.
4. Inspect the practice during construction to ensure that the tree trenches or tree boxes are built in accordance with the approved design and standards and specifications. Use detailed inspection checklists that include sign-offs by qualified individuals at critical stages of construction to ensure that the contractor's interpretation of the plan is acceptable to the professional designer. An example construction phase inspection checklist is provided below ([https://stormwater.pca.state.mn.us/index.php?title=Operation\\_and\\_maintenance\\_\(O%26M\)\\_of\\_tree\\_trenches\\_and\\_tree\\_boxes#Maintenance\\_Training\\_Documents\\_and\\_Videos](https://stormwater.pca.state.mn.us/index.php?title=Operation_and_maintenance_(O%26M)_of_tree_trenches_and_tree_boxes#Maintenance_Training_Documents_and_Videos)).

### 3. After construction

1. Verify that the tree trenches or tree boxes were built in accordance with the approved design and standards and specifications.
2. Verify that tree is staked and supported with guy wires to promote stable growth, if necessary.
3. Verify that the contributing drainage area is fully stabilized with vegetation prior to removing any barriers, diversions, or erosion and sediment control measures.
4. Verify that the practice actually captures and infiltrates runoff. Conduct a full inundation test to inspect the underdrain and outflow function. For more information, see Assessing the performance of tree trenches and tree boxes.
5. Use detailed inspection checklists that include sign-offs by qualified individuals at the completion of construction, to ensure that the contractor's interpretation of the plan is acceptable to the professional designer. An example construction phase inspection checklist is provided below ([https://stormwater.pca.state.mn.us/index.php?title=Operation\\_and\\_maintenance\\_\(O%26M\)\\_of\\_tree\\_trenches\\_and\\_tree\\_boxes#Maintenance\\_Training\\_Documents\\_and\\_Videos](https://stormwater.pca.state.mn.us/index.php?title=Operation_and_maintenance_(O%26M)_of_tree_trenches_and_tree_boxes#Maintenance_Training_Documents_and_Videos)).

## Post-construction phase O&M

Post-construction maintenance is performed on tree trenches and tree boxes to maintain proper infiltration, filtration, and to promote healthy vegetation. Immediately after construction, short-term maintenance goals include efforts to establish and keep the tree healthy. Not all trees are guaranteed to survive the establishment phase, so care should be taken to inspect the health following construction. Important post-construction considerations are provided below.

- A site-specific **Operations and Maintenance Plan** should be prepared by the designer prior to putting the stormwater practice into operation. This plan should provide any operating procedures related to the practices. The plan should also provide clear maintenance expectations, activities, and schedules. Include photos if possible. Be clear who is responsible for maintenance and the type of expertise needed for distinct O&M activities. The O&M plan should include an anticipated budget for O&M activities. The O&M plan should also include an example O&M inspection checklist and an example maintenance report. Example O&M plans are provided here ([https://stormwater.pca.state.mn.us/index.php?title=Operation\\_and\\_maintenance\\_\(O%26M\)\\_of\\_tree\\_trenches\\_and\\_tree\\_boxes#Maintenance\\_Training\\_Documents\\_and\\_Videos](https://stormwater.pca.state.mn.us/index.php?title=Operation_and_maintenance_(O%26M)_of_tree_trenches_and_tree_boxes#Maintenance_Training_Documents_and_Videos)) and a schedule of general maintenance activities is provided in the adjacent table.
- A legally binding and enforceable maintenance agreement should be executed between the practice owner and the local review authority. Example maintenance agreements are provided here ([https://stormwater.pca.state.mn.us/index.php?title=Operation\\_and\\_maintenance\\_\(O%26M\)\\_of\\_tree\\_trenches\\_and\\_tree\\_boxes#Maintenance\\_Training\\_Documents\\_and\\_Videos](https://stormwater.pca.state.mn.us/index.php?title=Operation_and_maintenance_(O%26M)_of_tree_trenches_and_tree_boxes#Maintenance_Training_Documents_and_Videos)).
- Inspection and maintenance activities are distinct and can be done as separate activities or together. Inspection will typically assess the practice for any O&M issues, whereas maintenance will address the O&M issues identified by the inspection. A dedicated inspection effort on a large number of BMPs can help prioritize maintenance activities.
- Maintenance activities should be careful not to cause compaction. No vehicles or stockpiling should be allowed within the footprint of the practice. Foot traffic should be kept to a minimum.
- BMP areas generally should not be used as dedicated snow storage areas.

See the adjacent tables for a schedule of general maintenance activities and common problems and troubleshooting.

### Overview and schedule of general maintenance activities for tree trenches and tree boxes

Link to this table

#### First Year of Operation

Activity	Frequency	Time period	Level of effort	O&M benefit <sup>a</sup>
Check that there is no ponding within the box or trench.	At least twice after storm events > 0.5 inches	Within the first 6 months	1-2 hours	1,5
Check for evidence of clogging in the media.	At least twice after storm events > 0.5 inches	Within the first 6 months	1-2 hours	1
Supplemental watering, during drier periods, particularly if keeping stormwater offline trees are established.	1/week initially	During first two months of the growing season	1-2 hours	2,3,4,5,6
	As needed	First growing season	1-2 hours	2,3,4,5,6

**First Year of Operation**

<b>Activity</b>	<b>Frequency</b>	<b>Time period</b>	<b>Level of effort</b>	<b>O&amp;M benefit<sup>a</sup></b>
Remove any weeds present	As needed	First growing season	1-2 hours	2,3,4,5,6
Remove any trash or debris	As needed	First growing season	1-2 hours	1,2,3,4,5,6
Add mulch if layer is less than 3 inches <sup>b</sup>	As needed	First growing season	1-2 hours	4,5
Clean root collar	Annually	During growing season	1-2 hours	1
Remove stakes	As needed	End of growing season	1-2 hours	5
Inspect tree health	Biannually and after large storms	First growing season	1-2 hours	1,2,5,6

**After First Year of Operation**

<b>Activity</b>	<b>Frequency</b>	<b>Time period</b>	<b>Level of effort</b>	<b>O&amp;M benefit<sup>a</sup></b>
Check that there is no ponding within the box or trench.	Biannually	Any time when ground is not frozen	1-2 hours	1,5
Check for evidence of clogging	Biannually	In spring and fall	1-2	1
Supplemental watering during drier periods	As needed or when soil is dry 3 inches below the surface	Dry periods until roots are established	1-2 hours	2,3,4,5,6
Remove any weeds present	As needed	During growing season	1-2 hours	2,3,4,5,6
Remove any trash or debris	As needed	Any time	1-2 hours	1,2,3,4,5,6
Add mulch if layer is less than 3 inches	Annually	During growing season	1-2 hours	4,5
Remove stakes (if still present)	Once	End of second growing season	1-2 hours	5
Prune excess growth	<ul style="list-style-type: none"> <li>▪ Once in year 2 or 3,</li> <li>▪ Every three years between years 4-10,</li> <li>▪ Every five years as needed after 10 years</li> </ul>	End of winter or early spring	1-2 hours	2,5,6
Inspect tree health and safety	Biannually and after large storms	During growing season	1-2 hours	1,2,5,6

**After 5+ Years of Operation (non-routine maintenance)**

### First Year of Operation

Activity	Frequency	Time period	Level of effort	O&M benefit <sup>a</sup>
After long term operation of the practice, some occasional and infrequent maintenance activities might be required, such as tree or media replacement.	As needed	As needed	Could be significant depending on the activity	1,2,3,4,5,6

<sup>a</sup>Key to Maintenance Benefits:

1. Proper stormwater flow and infiltration
2. Creation and maintenance of wildlife habitat
3. Creation and maintenance of pollinator habitat
4. Nutrient cycling and storage
5. Aesthetics and public enjoyment
6. Carbon sequestration

<sup>b</sup>Note that many practitioners are minimizing the use of mulch or using alternatives to mulch to control weeds. Using mulch can cause clogging of inlet, outlet, and bypass pipes, and can introduce invasive species such as jump worms. Alternatives to mulch include ground vegetation such as clover or sedges, or arranging plantings in more dense configurations so as to minimize use of mulch.

### Common problems and how to troubleshoot them for tree trenches and tree boxes

Link to this table

Symptom	Possible causes	Solution
Standing water within the infiltration area for more than 48 hours	This might be because a pretreatment is no longer working, or there are excessive sediment loads due to erosion or high sediment loads from the contributing area.	<ul style="list-style-type: none"> <li>▪ If applicable, clean the pretreatment area with more frequency.</li> <li>▪ Scrape, clean or vacuum the infiltration area.</li> <li>▪ Aerate the infiltration area</li> <li>▪ Stabilize erosion in the drainage area.</li> <li>▪ Contact manufacturer.</li> </ul>
Rainwater does not appear to flow to the infiltration/filtration area	Leaves, sediment, trash, or plant debris may be blocking the flow path to the inlet	Remove these materials on a regular basis
Tree is not growing or shows signs of poor health during inspections	<ul style="list-style-type: none"> <li>▪ Species selection is inappropriate for the site</li> <li>▪ Over or underwatering</li> <li>▪ Disease or other problems</li> </ul>	Consult with an arborist. Check that plants are suited to the local conditions.
Erosion or scouring around the inlet	Flow is obstructed by debris or improper grading	Correct for drainage and flow path issues to make sure flows are evenly distributed. Make sure the flow paths are unobstructed

## Maintenance Costs

Maintenance costs vary depending on a number of factors, including but not limited to the following.

- Size of the practice and its **contributing drainage area** ([https://stormwater.pca.state.mn.us/index.php?title=Contributing\\_drainage\\_area\\_to\\_stormwater\\_BMPs](https://stormwater.pca.state.mn.us/index.php?title=Contributing_drainage_area_to_stormwater_BMPs))
- Type of plantings used
- Site visit frequency
- Level of maintenance needed
- Local weather conditions
- Staffing needs (number of staff, external vs. internal staff, etc)
- Travel time between sites
- Efficiencies of scale (single GI (**green infrastructure**) vs. a cluster of GI)
- Equipment needed

Maintenance costs for trees and tree boxes should be relatively low compared to other green infrastructure practices, partially due to their size. Routine maintenance can take as little as 30 minutes per unit and does not require any special training, tools, or machinery. Because routine maintenance does not require any specialized training, the range of annual maintenance cost is around \$100-\$500 (CRWA ([https://www.crwa.org/uploads/1/2/6/7/126781580/crwa\\_tree\\_pit.pdf](https://www.crwa.org/uploads/1/2/6/7/126781580/crwa_tree_pit.pdf))). A study published in 2017 (<https://owl.cwp.org/mdocs-posts/cost-of-maintaining-green-infrastructure/>) by ASCE describes the annual maintenance cost for a tree planter to be \$260 per year, based on 2015 data from Fort Collins, CO (Clary (<https://owl.cwp.org/mdocs-posts/cost-of-maintaining-green-infrastructure/>), 2017).

## Useful Resources

### Additional Detailed O&M Information

- More detailed information regarding specific maintenance activities are provided at Operation and maintenance of tree trenches and tree boxes - supplemental information. Topics discussed include the following.
  - Supplemental watering
  - Pruning
  - Staking and straightening
  - Protecting the trunk
  - Mulching
  - Fertilizers
  - Checking tree safety
  - Tree health and troubleshooting guidelines
  - References

## Case Studies

- Application of Stormwater Tree Trenches in the City of Vancouver ([https://sustain.ubc.ca/sites/default/files/2018-52%20Application%20of%20Stormwater%20Tree%20Trenches%20in%20the%20City%20of%20Vancouver\\_Vega.pdf](https://sustain.ubc.ca/sites/default/files/2018-52%20Application%20of%20Stormwater%20Tree%20Trenches%20in%20the%20City%20of%20Vancouver_Vega.pdf)), 2018
- Case studies for tree trenches and tree boxes ([https://stormwater.pca.state.mn.us/index.php?title=Case\\_studies\\_for\\_tree\\_trenches\\_and\\_tree\\_boxes](https://stormwater.pca.state.mn.us/index.php?title=Case_studies_for_tree_trenches_and_tree_boxes))

## Maintenance Training Documents and Videos



- International Society of Arboriculture – Tree Risk Assessment Qualification (<https://www.isa-arbor.com/Credentials/ISA-Tree-Risk-Assessment-Qualification>)
- Tree Care Industry Association (TCIA) – ANSI A300 Tree Care Standards ([https://www.tcia.org/TCIA/Build\\_Your\\_Business/A300\\_Standards/A300\\_Standards.aspx](https://www.tcia.org/TCIA/Build_Your_Business/A300_Standards/A300_Standards.aspx))
- Shade Tree Maintenance (<https://youtu.be/8emNNf3QyWA>) (Youtube video)
- Tree planting aftercare (<https://extension.psu.edu/planting-aftercare-webinar-essential-to-tree-establishment-and-survival>)

## Example O&M Plans, Checklists, Reports, and Maintenance Agreements for tree trenches and tree boxes

Link to this table

Symptom	Possible causes
Operation & Maintenance Plan	City of Redding, CA: Instructions to Inspect and Maintain Tree Box ( <a href="https://www.cityofredding.org/home/showpublisheddocument/21791/637209189268570000">https://www.cityofredding.org/home/showpublisheddocument/21791/637209189268570000</a> )
Construction phase inspection checklist	District of Columbia Department of Energy and Environment, Construction Inspection Checklists ( <a href="https://doee.dc.gov/sites/default/files/dc/sites/ddoe/publication/attachments/Appendix%20K%20%20Construction%20Inspection%20Checklists.pdf">https://doee.dc.gov/sites/default/files/dc/sites/ddoe/publication/attachments/Appendix%20K%20%20Construction%20Inspection%20Checklists.pdf</a> )
O&M inspection checklist	<ul style="list-style-type: none"> <li>▪ Regular Inspection and Maintenance Guidance for Bioretention Systems / Tree Filters (New Hampshire) (<a href="https://www.unh.edu/unhsc/sites/unh.edu.unhsc/files/UNHSC%20Biofilter%20Maintenance%20Guidance%20and%20Checklist%201-11_0.pdf">https://www.unh.edu/unhsc/sites/unh.edu.unhsc/files/UNHSC%20Biofilter%20Maintenance%20Guidance%20and%20Checklist%201-11_0.pdf</a>)</li> <li>▪ Maintenance and inspection report for tree trench (<a href="https://stormwater.pca.state.mn.us/index.php?title=Maintenance_inspection_report_for_tree_trench/tree_box">https://stormwater.pca.state.mn.us/index.php?title=Maintenance_inspection_report_for_tree_trench/tree_box</a>)</li> </ul>
Maintenance Agreements	<ul style="list-style-type: none"> <li>▪ Example maintenance agreement (<a href="https://stormwater.pca.state.mn.us/index.php?title=Example_Maintenance_Agreement_2">https://stormwater.pca.state.mn.us/index.php?title=Example_Maintenance_Agreement_2</a>)</li> <li>▪ Example maintenance agreement (<a href="https://stormwater.pca.state.mn.us/index.php?title=Example_Maintenance_Agreement_3">https://stormwater.pca.state.mn.us/index.php?title=Example_Maintenance_Agreement_3</a>)</li> <li>▪ Elements of a Green Infrastructure Maintenance Business Plan (EPA) (<a href="https://www.epa.gov/sites/production/files/2015-10/documents/mmsd_tech_assistance.pdf">https://www.epa.gov/sites/production/files/2015-10/documents/mmsd_tech_assistance.pdf</a>)</li> </ul>

## References

- Capiella, Karen, Sally Claggett, Keith Cline, Michael Galving, Peter MacDonagh, Jessica Sanders, Thomas Whitlow, and Qingfu Xiao. 2016. Recommendation of the Expert Panel to Define BMP Effectiveness for Urban Tree Canopy Expansion ([https://www.chesapeakebay.net/documents/Urban\\_Tree\\_Canopy\\_EP\\_Report\\_WQGIT\\_approved\\_final.pdf](https://www.chesapeakebay.net/documents/Urban_Tree_Canopy_EP_Report_WQGIT_approved_final.pdf)).
- Charles River Watershed Association (CRWA). 2008. Stormwater Tree Pit Low Impact Best Management Practice (BMP) Information Sheet ([https://www.crwa.org/uploads/1/2/6/7/126781580/crwa\\_tree\\_pit.pdf](https://www.crwa.org/uploads/1/2/6/7/126781580/crwa_tree_pit.pdf)).
- Clary, J., Piza, H. 2017. Cost of Maintaining Green Infrastructure (<https://owl.cwp.org/mdocs-posts/cost-of-maintaining-green-infrastructure/>). American Society of Civil Engineers (ASCE), Reston, VA.

## Related pages

## General information on trees

- Overview for trees
- Types of tree BMPs
- Plant lists for trees
- Street sweeping - this page provides a summary of an on-going project to develop a street sweeping credit
- Street sweeping for trees
- References for trees
- Supporting material for trees
- Neat websites and articles for trees
- Links to tree ordinances and forest management master plans
- Green Infrastructure benefits of tree trenches and tree boxes

## Tree trenches and tree boxes

- Design guidelines for tree quality and planting - tree trenches and tree boxes
- Design guidelines for soil characteristics - tree trenches and tree boxes
- Construction guidelines for tree trenches and tree boxes
- Protection of existing trees on construction sites
- Operation and maintenance of tree trenches and tree boxes
- Assessing the performance of tree trenches and tree boxes
- Calculating credits for tree trenches and tree boxes
- Case studies for tree trenches and tree boxes
- Soil amendments to enhance phosphorus sorption
- Green Infrastructure benefits of tree trenches and tree boxes
- Summary of permit requirements for infiltration
- Tree trench/box photo gallery
- Fact sheet for tree trenches and tree boxes
- Requirements, recommendations and information for using trees as a BMP in the MIDS calculator
- Requirements, recommendations and information for using trees with an underdrain as a BMP in the MIDS calculator

## Urban Forestry

For more information on urban forestry, we suggest visiting the following websites.

- Urban and Community Forestry (<http://www.fs.fed.us/ucf/>) - USDA Forest Service
- Urban Forestry & Ecosystem Management (<http://www.phila.gov/ParksandRecreation/aboutus/divisions/Pages/UrbanForestryEcosystemManagement.aspx>) - City of Philadelphia
- Watershed Forestry Resource Guide (<http://www.forestsforwatersheds.org/reduce-stormwater/>) - Center for Watershed Protection and US Forest Service - Northeastern Area State & Private Forestry
- American Forests (<http://www.americanforests.org/our-programs/urbanforests/>)
- Urban Forestry (<http://urbanforestry.frec.vt.edu/>) - Virginia Tech University
- Stormwater to Street Trees: Engineering Urban Forests for Stormwater Management (<http://water.epa.gov/pollution/green/upload/stormwater2streettrees.pdf>) - U.S. EPA
- Green Step Cities (<http://greenstep.pca.state.mn.us/bestPracticesDetail.cfm?bpid=16>). This page provides a summary of urban forestry practices that cities can implement to help become a Green Step City (<http://greenstep.pca.state.mn.us/bestPractices.cfm>) and a list of cities that are implementing the practices, including links.

Retrieved from "https://stormwater.pca.state.mn.us/index.php?title=Operation\_and\_maintenance\_(O%26M)\_of\_tree\_trenches\_and\_tree\_boxes&oldid=54124"

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