Sustainable Technologies EVALUATION PROGRAM

Stormwater Tree Trench

Stormwater Tree Trenches are linear bioretention practices that manage stormwater while also promoting healthy tree growth. They are most often located behind the curb in the road right-of-way and consist of a series of tree planting pits connected to subsurface trenches filled with special engineered soils and/or structural soil support systems that support the surrounding pavement and foster root growth. Tree trenches offer solutions to multiple urban environmental challenges: they improve urban tree health by providing irrigation and allowing them to survive longer in harsh conditions, while also reducing roadway flooding, contributing to stormwater pollutant removal, and decreasing the volume of runoff entering local waterways. Tree trenches consist of planting soil, stormwater piping, structural soil media or filter media contained within a modular soil support system, and trees. The engineered soil (or soil support system) may extend under paved surfaces next to the tree planting pit to provide more soil volume for water storage and tree growth.

DESIGN

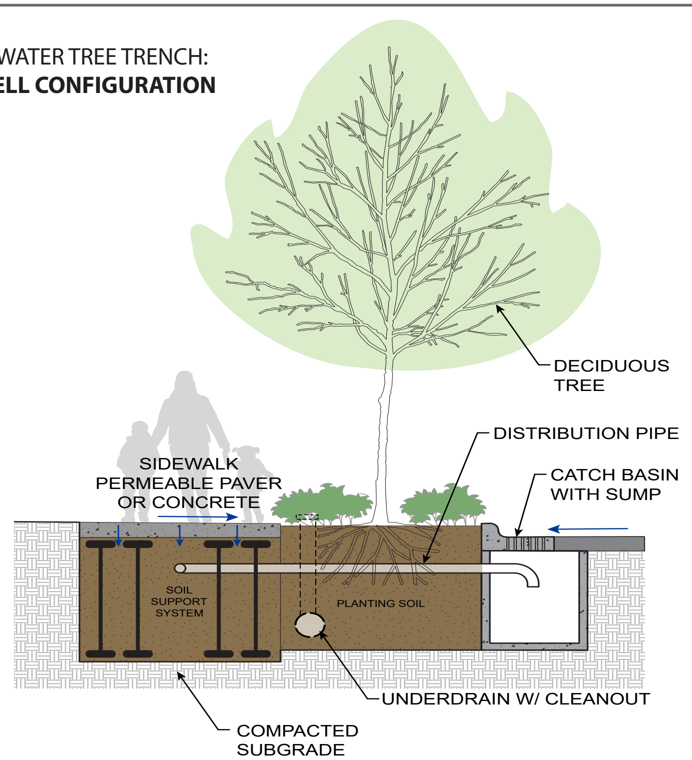
GEOMETRY AND SITE LAYOUT

Tree trenches are most often modular systems that are connected hydrologically through a sub-surface drainage pipe network, however road runoff may also be directed to the surface via curb cuts or surface drains. In both cases, inlets are offset from the root ball to avoid accumulation of road salt during early tree establishment.

INLETS

Water can enter the tree trench in a variety of ways from surface drainage into the tree well from adjacent sidewalks and from the road through curb cuts or depressed drains, to direct vertical drainage through permeable pavers, and from catch basin inlets in the roadway that direct runoff into the trench through distribution pipes. It is recommended that each tree trench have multiple inlets to keep any one drainage area relatively small, which provides redundancy to the system.

STORMWATER TREE TRENCH:
SOIL CELL CONFIGURATION



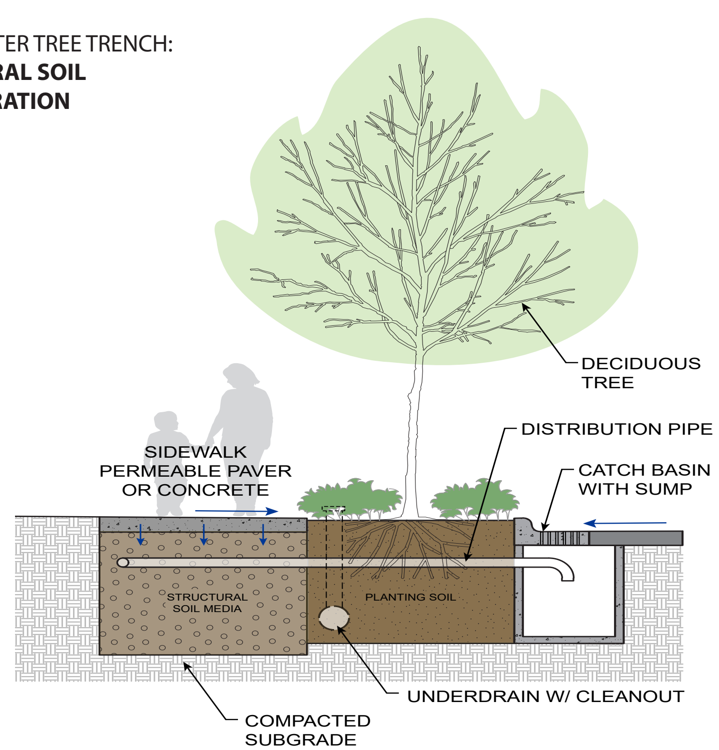
PRE-TREATMENT

If water enters the trench via a catchbasin, a structural pre-treatment device, like a catch basin shield or filter, should be included to collect silt and sediment from the runoff before it enters the trench. Surface inlet systems should have a sump or stone diaphragm to dissipate energy and spread flows. Pre-treatment devices should be easy to access and clean out, as maintenance of these devices is key to the long-term success of tree trenches.

SOIL VOLUME

Each tree planted should have minimum 30 m^3 soil volume. This can be 30 m^3 of soil within the planting pit or 16 m^3 within the planting pit, with root access to an additional 14 m^3 of engineered structural soil media or planting soil under adjacent supported pavements. If more than one tree shares the same trench a minimum 20 m^3 per tree is acceptable as the roots will still have ample room to spread.

STORMWATER TREE TRENCH:
STRUCTURAL SOIL CONFIGURATION



BMP	Ability to meet stormwater criteria		
	Water balance	Water quality	Stream erosion control
Tree Trench	Partial, based on native soil infiltration rate and if flow restrictor is used	Yes - size for water quality storage requirement	Partial - based on native soil infiltration rate, available storage and if flow restrictor is used

STRUCTURAL SOIL MEDIA

Structural soil is an engineered soil medium that can be compacted to support sidewalk or roadway pavement installation requirements while also permitting tree root growth. Structural soil media is used adjacent to tree pits to provide more room for tree roots to spread out under paved surfaces that surround the tree trench.

MODULAR SOIL SUPPORT SYSTEMS

Modular soil support systems consist of modular frames (or cells), in a variety of sizes, that provide structural support for paved surfaces without the need for a compacted soil base within the root zone. Modular soil support systems are an alternative to structural soil media and are used adjacent to tree pits to provide room for tree roots to spread out under paved surfaces surrounding the tree trench. Growing media in soil support systems typically has higher organic content than structural soils. The looser structure and higher nutrient content of the soil in modular support systems provides the most favourable environment for healthy tree growth in the urban setting.

STRUCTURAL CONCRETE PANEL

A structural concrete panel configuration is an alternative to modular soil support systems that uses a "bridge deck" over bioretention or growing media that extends into the pedestrian clearway, and is supported on each side by concrete supports and compacted granular material. The benefit of this approach is that the soil under the drainage media does not need to be compacted, allowing for greater infiltration.

CONVEYANCE AND OVERFLOW

Runoff is directed from surrounding impervious surfaces through curb cuts and surface drains to the tree trench where it percolates through the soil media to the underlying ground or underdrain. If the runoff exceeds the design capacity, the underdrain directs the excess filtered stormwater to a storm sewer or downstream LID practices. During intense storm events, excess runoff will overflow directly to the storm sewer either through an outlet in the catchbasin or via a surface overflow within the tree trench.

CONFIGURATION

Liners and gravel storage areas below the trench should be avoided to maximize infiltration and to encourage tree roots to penetrate the sub-soil.

DESIGN CONT'D

DISTRIBUTION AND UNDERDRAIN PIPES

The location of distribution pipes and the orientation of pipe perforations impacts how well storage volume is maximized and how well stormwater is distributed throughout the trench. To enhance volume control performance the underdrain pipes can be raised above the bottom of the trench and/or include slow release orifice features. Alternatively, the underdrain pipe may be at the trench bottom and connected to an upturned pipe assembly in the connecting manhole. Underdrain pipes drain directly to storm sewer pipes. It is critical to include multiple cleanout access points for maintenance.

GENERAL SPECIFICATIONS

Material	Specification
Structural Soil	• Structural soils are installed adjacent to tree planting pits under permeable or impermeable hardscapes. • Structural soils consist of 3 components, mixed in the following proportions by weight: crushed stone (100), clay loam (20), and hydrogel tackifier (0.03). • Total moisture at mixing should be 10% - AASHTO T-99 optimum moisture. • Crushed stone (granite or limestone) should be narrowly graded from 20-40 mm, highly angular with no fines. • The clay loam should conform to the USDA soil classification system (gravel <5%, sand 25-30%, silt 20-40%, clay 25-40%). Organic matter should range between 2-5%. • The hydrogel, a potassium propenoate-propenamide copolymer is added in a small amount to act as a tackifier, preventing separation of the stone and soil during mixing and installation. • Mixing can be done on a paved surface using front end loaders. Typically the stone is spread in a layer, the dry hydrogel is spread evenly on top and the screened moist loam is the top layer. • The entire pile is turned and mixed until a uniform blend is produced. The structural soil is then installed and compacted in 150 mm inch lifts.
Growing Medium	• Growing medium for use in tree planting beds and modular soil support systems shall be USDA loam, sandy clay loam or sandy loam with clay content between 15-35%; a combined clay/silt content of no more than 60%; and sand between 35-65%. • Growing medium shall have a pH value between 5.5 and 7.5. • Percent organic matter shall be 3-5%, by dry weight. Soluble salt level less than 2 mmhos/cm. • Growing media should be compacted to 80-90% below the tree root ball to prevent settling. • Bioretention media (see Bioretention Fact Sheet) may be used in lieu of growing media to achieve best stormwater storage and filtration results.
Soil Cells	• Soil cells are a structural system designed to be filled with growing media (or bioretention media) for tree rooting and support of vehicle loaded pavements. • The structures shall be designed to support loads up to and including AASHTO H-20 and Ontario Building Code standards for sidewalks. • Soil cells shall have been specifically designed and tested for the purpose of growing tree roots, and rainwater filtering, detention and retention. • Critical to the soil cell design is that each soil cell or stack of soil cells shall be structurally independent of all adjacent soil cell stacks such that a single stack or group of stacks can be removed after the completion of the installation to facilitate future utility installation and repair. • The structural design of each soil cell shall facilitate the movement of roots and water between each cell and into surrounding soils.
Bridge Deck	• Structural panel is 250 mm thick, and sits on equal-sized concrete supports on either side, which are underlain with 150 mm compacted granular 'A'. • Decompact under bioretention media for best iniltration results.
Aggregate Base	• Aggregates are used in soil cells below the cell frame (sub-base) and above the cell frame (base course). • Aggregate layers shall be comprised of 20 mm clear, crushed stone (ASTM C 33 No. 57).
Geotextile	• Geotextiles are typically used along the vertical sides of the stormwater tree trench to separate Growing Medium or Structural Soils from native soil or fill. • Geotextile material specifications should conform to Ontario Provincial Standard Specification (OPSS) 1860 for Class II geotextile fabrics. • Should be woven monofilament or non-woven needle punched fabrics. Woven slit film and non-woven heat bonded fabrics should not be used as they are prone to clogging. • Where root barrier is needed to prevent the migration of roots out of the tree trench, use impermeable ribbed barrier material with a thickness of 1-2 mm.
Underdrain	• HDPE or equivalent material, continuously perforated. • A standpipe from the distribution pipe to the cell surface can be used for inspection and maintenance of the underdrain. The top of the standpipe should be covered with a screw cap and a vandal-proof lock.

BENEFITS OF TREES

Stormwater Tree Trenches help support healthy street trees in urban settings where conventional plantings have limited space for root establishment. Trees play a critical role in stormwater management from reducing runoff through canopy interception, evapotranspiration, filtering out pollutants, and increasing infiltration capacity of soils, to storing rainwater. Trees also provide myriad other ecological benefits from shading impervious surfaces and thereby reducing urban heat island effects to providing wildlife habitat and improving the appearance of streets and neighbourhoods. Research has shown that healthy trees increase property values, increase retail spending, and contribute to a sense of community cohesion and safety.

At right is a list of trees that are known to tolerate conditions in northern (Zone 3), urban, stormwater tree trenches.

Latin Name	Common Name
Ulmus americana	American Elm
Acer x freemanii	Freeman's Maple
Alnus incana	White Alder
Celtis occidentalis	Hackberry
Gleditsia triacanthos var. inermis	Thornless Honeylocust
Gymnocladus dioicus	Kentucky Coffeetree
Quercus bicolor	Swamp White Oak
Quercus macrocarpa	Burr Oak
Quercus rubra	Red Oak

SITE CONSIDERATIONS

Wellhead Protection | Facilities receiving road or parking lot runoff should not be located within 2 year time-of-travel wellhead protection areas.

Site Topography | Contributing slopes should be between 1-5%. The bottom of the trench should be graded flat to allow water to spread out. A stepped, multi-cell design can also be used.

Water Table | Maintaining a separation of 1 m between the elevations of the bottom of the trench and the seasonally high water table, or top of bedrock, is recommended. Lesser or greater values may be considered based on groundwater mounding analysis. See STEP LID Planning and Design Guide for further guidance and spreadsheet tool.

Soil | Tree trenches can be construct over any soil type, but hydrologic soil group A and B are best for achieving water balance objectives. Facilities designed to infiltrate water should be located on portions of the site with the highest infiltration rates. Native soil infiltration rate at the proposed location and depth should be confirmed through in-situ measurements of hydraulic conductivity under field saturated conditions.

Drainage Area | Typical contributing drainage areas are between 150-300 m^2 per tree, with a maximum of 450 m^2 per tree.

Setback from Buildings | Tree trenches should be set back from the building far enough to allow for the tree canopy to grow to a healthy adult size, depending on the species selected. A minimum setback of 4 m from the building is recommended.

Overhead Wires | Tree trenches should be implemented with caution under overhead wires. If overhead wires conflict with proposed tree trench locations, check the height of existing wires, and choose small form trees that will not grow tall enough to interfere with wires.

Pollution Hot Spot Runoff | Tree trenches are not recommended in these areas.

Proximity to Underground Utilities | Designers should consult local utility design guidance for the horizontal and vertical clearances required.

Karst | Infiltration designs are unsuitable in areas of known or implied karst topography.

OPERATION AND MAINTENANCE

Tree trenches have fewer maintenance requirements than a bioswale or bioretention facility, but maintenance is still critical to the success of these BMPs. The most critical maintenance task for tree trenches is the vacuum removal of sediment and debris in pre-treatment devices. This should be done at least once per year, however the frequency of need will depend on the adjacent street uses, traffic volume and leaf drop. A monitoring program should be initiated when the tree trench is new to evaluate accumulation in pre-treatment areas and develop a maintenance plan for regular removal of build up.

In addition, sub-drains and distribution pipes within the tree trench must be designed for ease of maintenance. Pipe bends should be limited to 135 degrees to allow pipe cleaning equipment to access the full length of the pipe. Cleanout access points should be included along the length of the trench, and monitoring wells should be installed to monitor sub-surface water levels in the trench.

Tree care is also an important part of tree trench maintenance. Provide regular irrigation and weed control in the tree trench until trees are fully established. Prune trees once they are established to prevent safety hazards to pedestrians, overhead utility lines, and adjacent buildings. Monitor trees for damage by insects and other pests and replace trees that are in decline. A tree trench containing a diseased or dying tree is not a fully functional BMP.

The water component of the Sustainable Technologies Evaluation Program (STEP) is a collaboration between:

Toronto and Region Conservation Authority, Credit Valley Conservation, and Lake Simcoe Region Conservation Authority

For more information:

Visit the online LID Stormwater Management Planning and Design Guide for more information including links to all sources cited: wiki.sustainabletechnologies.ca.

LID Stormwater Inspection and Maintenance Guide (TRCA, 2016): sustainabletechnologies.ca.