CASE STUDY

Sustainable Technologies
EVALUATION PROGRAM

Low Impact Development Series

The Queensway Sustainable Sidewalk Pilot Project

Featured practice:

- Bioretention

Groups involved:

- City of Toronto: Transportation Services, Urban Forestry and City Planning
- Toronto Water
- Deep Root Canada
- Ryerson University

Construction date:

October 2008

The Sustainable Sidewalk project was initiated as a solution to address the disturbance of street tree roots associated with the removal of sidewalks for utility cuts. A working group with participants from various City of Toronto Divisions, was formed in order to investigate sidewalk designs and underground structures that promoted tree growth while reducing the impact and restoration work associated with utility cuts. After much review the working group decided to use soil cells and in the fall of 2008 constructed The Queensway Sustainable Sidewalk Pilot Project. The design included two underground bioretention areas supporting four trees, constructed in the parking lay-by on the north side of the street. The site became the first installation of the Silva Cell system in the world where stormwater was routed into soil cells for the purpose of filtering the water and quality control. Stormwater management performance was evaluated along with street tree survival.

Two common reasons that street trees struggle are (i) they do not receive enough water and (ii) their roots struggle in tight soils which have been compacted to meet the loading requirements of sidewalks or parking areas. Soil cells like the Silva Cell system include frames that protect soils from compaction while still providing the structural support to accommodate the weight of vehicles. With the frames meeting the loading requirements, tree roots are able to grow freely in the uncompacted soil. To ensure the trees receive enough water, stormwater from the surrounding area can be directed into the system. The potential stormwater management benefits of the system will also increase over time as the trees grow, since larger trees will provide more opportunities for rainwater interception and evapotranspiration. The benefits include retention, and contaminant reduction through filtering particulate, biotic activity, and tree uptake.

STUDY SITE

Located in a primarily commercial area, the two biorentention systems are located in the parking lay-by between Moynes and Berl Avenues on north side of The Queensway. All of the surface runoff from the roadway and adjacent sidewalk - approximately 385 m^2 per system - can be directed to the bioretention systems though typical stormwater catchbasins. Unlike daylighted bioretention or rain gardens which take up approximately 6 to 10% of the drainage area, underground systems such as these require very little surface land area, leaving more space for public use. Despite this, their stormwater control performance is similar to surface installations, since key process - filtration, infiltration and evaporation - are still occuring below surface in the extensive soil system.

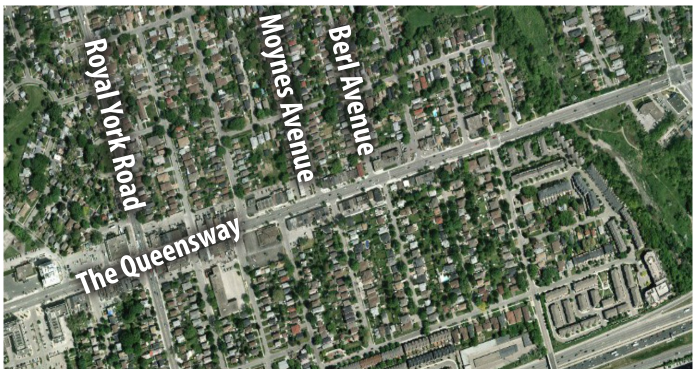

Figure 1. Study site location

Project Objectives

- Evaluate a solution that minimizes the impact of sidewalk removal during utility cuts on the health of street trees
- Research sustainable boulevard design to reduce time, impact and restoration needs associated with utility installations, improve tree health, and increase tree canopy
- Mitigate the negative effects of high stormwater runoff volumes and contaminant loads by using soil cells
- Determine the feasibility of adding stormwater management to a suspended pavement system
- Evaluate the effect of on- and off-line systems on tree health

PLANNING AND REGULATIONS

Urban trees are an important climate change adaptation tool as they help to moderate temperatures and reduce the impact of storm events on city infrastructure and the community. Current street tree health is often quite poor and many trees die before they can grow large enough to realize their full potential with respect to stormwater and urban heat island benefits. Barriers to street tree health have been identified as poor soil quality, insufficient soil and water quantities, salt contamination from roadways and sidewalks, damage during infrastructure replacement, and reduced water availability due to evaporation from hot pavement surfaces. While not a formal policy when this project began, the City's street tree survival initiatives are referenced in many policies and reports. In 2004, Urban Forestry Services started promoting the concept of a working tree, highlighting the environmental and social benefits of street trees which, from an economic perspective, pay for themselves many times over.

While Urban Forestry Services manages the City's street trees, this project required multiple Divisions to work collaboratively to fund and implement the project. The working group consisted of members from City Planning, Transportation Services, Urban Forestry, Urban Planning and Toronto Water. Transportation Services funded the engineering works, City Planning funded the soil cells, and Toronto Water funded the stormwater works and monitoring. The group enlisted Deep Root Canada Corporation, the Canadian supplier of Silva Cells, to provide technical support and design the system based on the catchment area and the rainfall event they wanted to manage. The design provides for adequate soil volumes for the trees, incorporates the use of captured rainwater for their irrigation, and satisfies the City's structural loading requirements.

DESIGN

The design uses Silva Cells for large bioretention systems underneath the sidewalks. The soil in the bioretention systems promote healthy root growth and adequate room for the roots to spread as the tree grows. Though designed and built in the same way the two underground bioretention systems at the Queensway Sustainable Sidewalk became a side-by-side comparison of two different design options after the trees had established themselves. The east bioretention treats and infiltrates stormwater from the adjacent road, while the west bioretenion only receives water from the opening at the surface around the tree trunk. This comparison allows for evaluation of the effect of both strategies on tree health, and quantification of the added stormwater management benefit of the first option. Through rainfall interception, evapotranspiration, and infiltration, street trees reduce total runoff volumes and delay peak flows to the sewer system. Plus the resulting exfiltration from the cells into the surrounding soils - the Queensway study cells are isolated from the surrounding soils (bathtubs essentially) for the study but that is not the current standard design.

Figure 2. Silva Cell "top" deck prior to organic layer and screenings for pavers. (Image courtesy of City of Toronto)

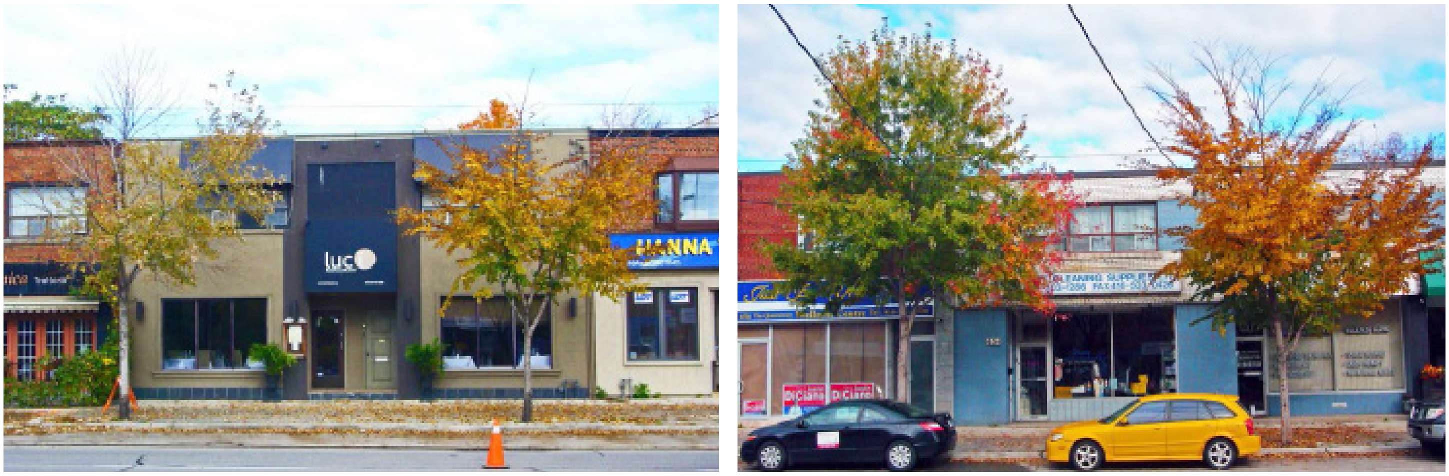

Figure 3. Trees in fall 2014, left is the west bioretention which were isolated from road run-off and on the right is the east bioretention which remained on-line. (Image courtesy of Deep Root Canada)

Bioretention

Two sets of underground bioretention systems were installed using an 800 mm deep Silva Cell system around existing utilities. For each biroetention, one double catch basin was constructed to divert road runoff into the cells. Stormwater runoff enters the first catchbasin and is directed to the top of the underground bioretention cells and is distributed through the system by a perforated pipe which sits on top of the soil. This allows the water to infiltrate through the soil until it reaches the bottom of the system. If the system reaches its storage capacity the catchbasin would fill up and overflow. The excess flow travels downstream to the first set of standard catchbasins connected directly to the storm sewer. The stormwater collected in the Silva Cell eventually flows to the storm sewer - but only after some volume reduction (root uptake) and soil wetting. The outlet is a 3/4 inch opening versus an 8 inch inlet pipe. This restriction allows for extended contact time for biotic activity and tree uptake and retention with slow release of stormwater to the storm sewer which results in a reduced impact to the receiving waters (both volume and velocity).

Figure 4. Distribution pipe on top of soil (image courtesy of City of Toronto)

The trees are two American Liberty elms (*Ulmus americana 'libertas'*) and two Freeman hybrid maples (*Acer x fremanii*). Silva Cell designs aim for 30 m^3 of soil per tree, but in a shared cell this may sometimes be reduced to 15 m^3 per tree. At this site each tree has approximately 16 m^3 of bioretention soil - a 64 m^3 combined total for the site. The soil mix is 80% sand, 20% unscreened topsoil, and has a void space of 10-20%.

Monitoring

Ryerson University researchers were retained to evaluate the stormwater performance of the system, designing a monitoring program and equipment layout plan prior to construction. An impermeable membrane was installed in order to facilitate monitoring - an element that would not normally be included in a system of this kind. Prior to the monitoring program commencing in 2012 the west bioretention cells catchbasins were sealed, isolating them from road runoff to act as a control against the east set. This was done in order to evaluate its stormwater management performance as well as the effect of road runoff on tree health.

CONSTRUCTION AND COMMISSIONING

In the fall of 2008 construction took place over three days with a crew of five. Pave-Al excavated the area for the trenches and Silva Cell installed the boxes. The City completed the surface works as part of the road improvement projects, including granite sidewalks and seasonal flower beds. Since it was a retrofit, the design had to work around existing infrastructure, such as concrete ducts for telecommunications and gas laterals. Due to the modular and open structure of the Silva Cell there was no disruption to exisiting infrastructure during construction.

OPERATION AND MAINTENANCE

Proper maintenance of LID practices is crucial for optimizing performance, cost effectiveness, and aesthetics, especially during the initial establishment of vegetation. In some cases it is necessary to follow-up with the contractor to ensure that the activities specified within the maintenance agreement are taking place.

The estimated design life of the Silva Cell is over 100 years. When properly designed and installed, the units themselves are not expected to require maintenance within their design life.

Compared to a daylighted bioretention set-up the maintenance is consideraly less. In a daylighted system all the total suspended solids (TSS) build up on the surface creating a potential problem with sediment layer/barrier reducing infilration. To restore infiltration this film must be scraped off. While with the underground system the TSS is managed in the sump of the catchbasin. Therefore the only maintenance is catchbasin cleaning which can be done at the same time as other typical catchbasins in the area which is based on the TSS loads for the area. Initially the City believe they would need to maintain the distribution pipe on a regular basis but after blowing it out a few times they have decided it is not needed. Experience from other sites has indicated that emergency repairs for other infrastructure in the area will cost marginally more at soil cell sites compared to the typical street tree designs.

ACHIEVEMENTS

Increased Urban Tree Canopy. The pilot project demonstrated that the system can be used to increase the urban street canopy while using minimal surface area.

Stormwater management benefits. The city used the Silva Cell system to achieve the improved stormwater quality and reduced volumes provided by this type of street tree system.

Functional design. The location and design promoted LID use in an urban setting without the increased maintenance cost associated with daylighted bioretention swales

Joint partnership. All partners worked together to ensure the success of this project.

LESSONS LEARNED

- Trees that continued to receive stormwater runoff showed signs of improved health compared to isolated trees and displayed no negative impacts from choloride even though runoff is directed to the soil cells and root system
- Monitoring results have shown that the soils were able to reduce TSS and heavy metal concentrations in the road run off that entered the system. The TSS removal rate exceeded the 80% TSS reduction that most regulators require and was close to 90%. Also the outlet flow meter did not show any flow release after a rainfall of 3 mm that was preceded by a period of no rain.
- Post construction monitoring can evaluate when technologies are most effective and when they fail and can provide recommendations on how to improve technologies and implementation plans.
- Losses in soil porosity will not occur since tree root growth and die-off will continue to provide porosity.
- Ideally the inlet should be at the upstream end of the system to ensure water is evenly distributed. If the inlet must be in the middle of the system or when there is a grade issue, the use of a bed of clear crushed aggregate around the distribution pipe can be used to change the grade as needed.
- Water was not running in the upstream portion of the distribution pipe which could have been a result of the pipe settling due to the weight of the pipe. An elbow was installed in the catchbasin to compensate for this issue to ensure that water reaches all of the soil before it overflows into the catchbasin. To avoid this issue at new installations, larger distribution pipes (6"- 10") are placed on top of a Silva Cells deck to evenly support the weight of the pipe. Additionally, this design provides the additional capacity to change the grade of the pipe independent of the slope of the street to keep it flat.
- In-line cleanouts are easier to maintain, as cleanouts with corners catch more material and make it more difficult to create the force needed to flush the distribution pipes clean.
- Soil percolation rate can be a limiting factor in the amount of water into the system. By designing a system with a void space inside the Silva Cell above the soil, a larger storage area is created, allowing for more even distribution of water to the soil surface and more opportunity for infiltration.
- A trash hood/elbow on the inlet pipe in the catchbasin could further reduce the need for maintenance of the system's pipes by reducing the influent of floatables and other materials that could cause blockages in the distribution pipe

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Visit us at www.sustainabletechnologies.ca for more information about STEP and our studies related to urban runoff and low impact development.

About STEP

The water component of the Sustainable Technologies Evaluation Program (STEP) is a partnership between Toronto and Region Conservation Authority, Credit Valley Conservation, and Lake Simcoe Region Conservation Authority. Contact us at STEP@trca.on.ca.

Toronto and Region Conservation Authority