Unitarian Congregation

Location: Mississauga
Constructed: 2011

Case Study

Public Lands

Project Objectives, Design and Performance

- After the expansion of the church, CVC worked with the congregation and their designer to upgrade a drainage depresion to a bioretention cell that filters and infiltraters runoff from the parking area.
- Due to the already sandy soils and budget constraints, engineered soils were not trucked in for this site. Instead the native sandy soil was loosened to a depth of one metre and compost was mixed into the upper layers.
- The environmentally engaged congregation wanted a naturalized landscape with attractive native plants, that would create an island of habitat for birds, insects and small animals in the middle of urban Mississauga.
- Credit Valley Conservation staff are currently monitoring water levels, landscape health and maintenance needs of the bioswale in order to understand the life cycle performance of LID practices

Overcoming Barriers and Lessons Learned

- Planting of the bioretention swale was completed in steps due to incremental funding from various grants. The south end was planted in 2011 and the north end in 2012 with CVC's assistance.
- There was a delay in installing educational signage due to resource constraints, which led to initial misunderstandings about the function of the bioretention cell from some members of the congregation and neighbours.
- The sod edge has served well as a filter and erosion control, but the maintenance crews have found it difficult to trim. Also, the sod has been slowly spreading from the edge into the cell.
- Coordination of all skills required to install and maintain the project is a large time commitment for a non-profit organization. Strong project leadership, resourcefullness and committments from dedicated volunteers are necessairy for a successful project.

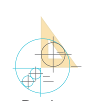
Practices Implemented

Bioretention

Barriers and Issues Encountered

Construction & Comissioning

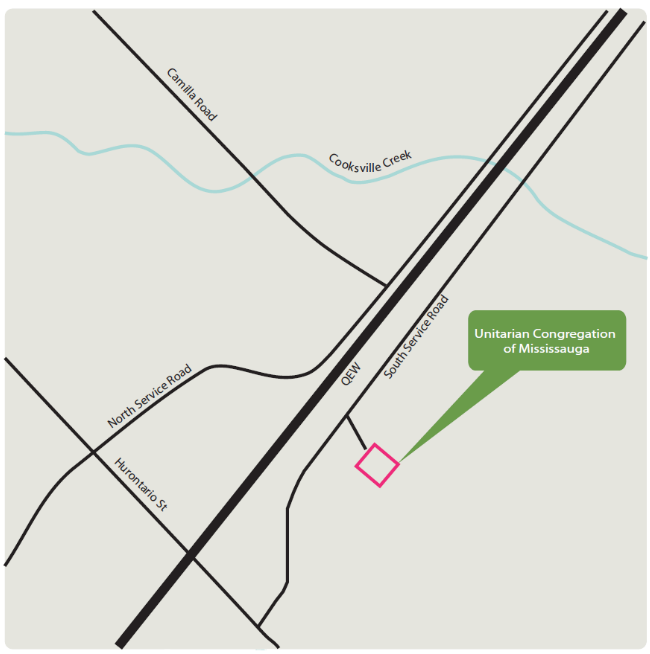
Operation & Maintenance



Design

Overview

The Unitarian Congregation in Mississauga (UCM) is located on South Service Road within the Cooksville Creek Watershed. The site drains to Cooksville Creek which then flows into Lake Ontario. The site sits on sandy soils, which are ideal conditions for low impact development practices that infiltrate stormwater. As part of the UCM Greening Initiative led by Carole Berry, a large bioretention cell was constructed in the center of the parking lot. The bioretention cell filters and absorbs rainwater running off the parking lot. The bioretention cell is also landscaped with many native plants that create habitat for the numerous bird and insect species on the site.



UCM community volunteers maintain the LID features on this site. The volunteers work hard to create a very special landscape showcasing the beauty and variety of species native to the Lake Ontario shoreline region.

Goals & Drivers

The UCM greening initiatives influenced the goals and drivers for this project, which included:

- Removing invasive plants
- Naturalizing the site with native plants
- Reducing use of water
- Providing habitat for birds, insects, and small mammals
- Creating natural barriers to reduce noise and improve views
- Catching and filtering stormwater run-off from the parking lot
- Adding to the urban forest in Mississauga

Successes

Joint partnership – UCM and Credit Valley Conservation (CVC) formed a partnership through CVC's Greening Corporate Grounds program. The goal of the program is to assist corporations, businesses and institutions to take environmentally positive steps to enhance their landscape.

Community Driven – Community members have championed the site, a visible demonstration of their commitment to environmental and social responsibility.

Overcoming Barriers & Lessons Learned

As with any project, there will be challenges faced during the design, construction, and establishment phases. The barriers and issues encountered with this project include:

Funding - As a non-profit UCM had very little budget to work with and creative solutions were necessary. The project was funded by TD Canada Trust, Friend's of the Environment, the David Suzuki Foundation and church member donations. Design and construction choices were also made to reduce costs: changes to the existing layout were minimized, material donations were accepted, and volunteers assisted with planting. Parts of the project were constructed and planted as funds became available overtime.

Maintenance - Invasive species have been persistent so it takes continual attention to keep them in check. Once native species are firmly established, the invasive species threat should lessen. Periodic volunteering parties have helped, but it has been difficult finding consistent volunteer support for maintenance. UCM applied for and was granted a Canada Summer Jobs wage subsidy for a part-time student stewardship assistant for six weeks to take care of maintenance on site in 2012 and 2013.

Outreach - The congregation and neighbours did not understand the purpose of the bioretention swale. Newsletters and updates to the UCM website helped to educate the congregation. Signage is now in place to explain the practice but it took time to design and it required fund raising for installation.

Lessons Learned

- The maintenance crew found it difficult to trim the sod around the edge of the bioretention cell. Furthermore, the sod is slowly spreading into the planting bed of the cell. One alternative would be to use landscape fabric and riverstone, which would still require some maintenance like weeding and replenishing and is more costly.
- The overflow catchbasin grate occasionally clogs with mulch. The mulch, which was donated, is poorly shredded and contains large pieces that easily float. Well shredded mulch will lock together and float less. A domed grate would be less likely to clog than the flat grate currently used.

Planning & Regulations

UCM has been an institution in Mississauga since 1954. In 1999 the church property underwent redevelopment. The redesign was shaped by the seven Unitarian Principles which includes respect for the interdependent web of all life. The new worship space and surrounding grounds were developed using green building guidelines. Once the new church building was constructed in 2010, attention turned to the parking lot and landscape. Carole Berry, the Greening Initiative Coordinator, led the effort to develop the grounds sustainably. She partnered with CVC's Greening Corporate Grounds program to remove invasive species on the property and plant native plant gardens.

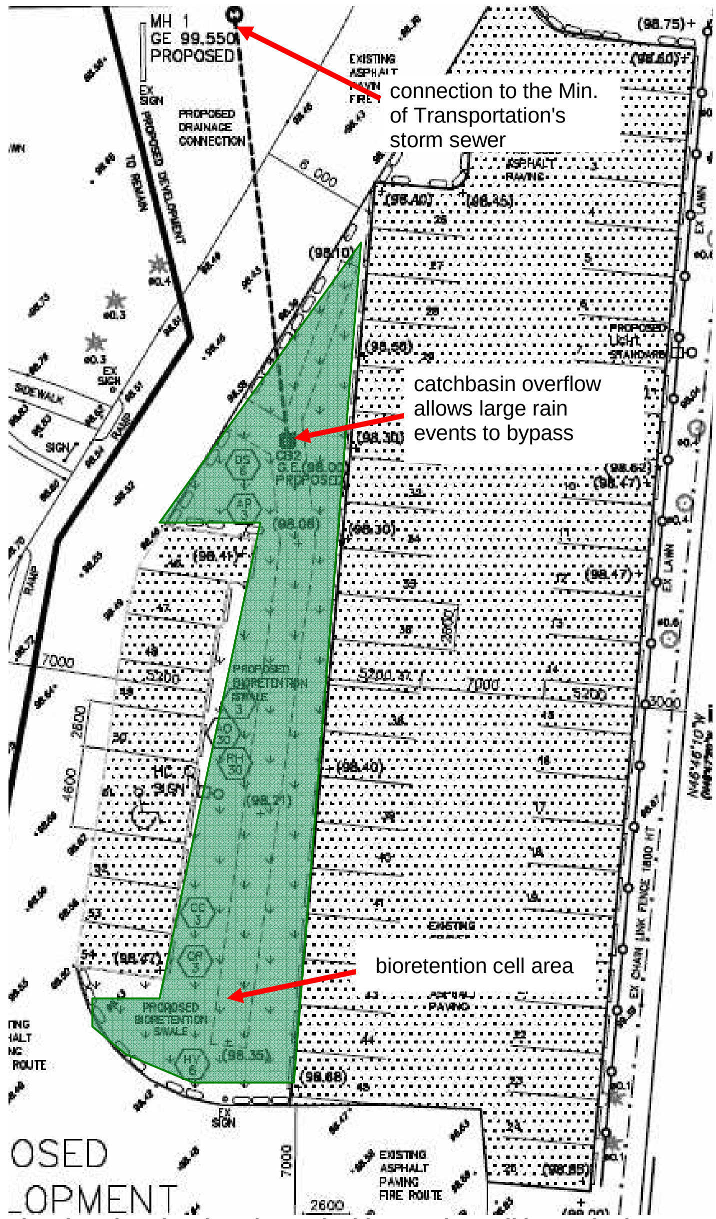
The parking lot design and construction was led by Doug Rylett of Tafler Rylett Architects. In addition to permits from the City of Mississauga, the project required a permit from the Ministry of Transportation as the project would connect to one of their storm sewers along the South Service Road of the Queen Elizabeth Way. The agencies favoured an LID solution to help address the erosion and water quality issues of Cooksville Creek.

To obtain the permits the Ministry of Transportation and City of Mississauga required plans and a stormwater management report stamped by a licensed professional engineer. In the summer of 2011, UCM retained the volunteered services of a licensed engineer, Bill Notenboom, to work with Doug Rylett on the design and stamp the plans. CVC LID experts were also brought into the project team to provide technical support on a bioretention cell design.

Design

Bioretention Cell

The initial design followed the standard bioretention cell design specification in the *CVC/TRCA LID Planning and Design Guide*. This standard approach specifies a sand and compost soil mix to be used with a gravel bed and underdrain. The native soil would be excavated, hauled offsite, and then be replaced with the engineered bioretention soil media. This approach had a high cost estimate and led to the consideration of other alternatives.



The plan view drawing shows the bioretention cell layout in the UCM parking lot. All of the parking lot areas drain to the bioretention cell.

The UCM sits on very sandy soils, which is unique for Mississauga. Rather than excavate soil that is already sandy and replacing it with another sandy soil, the design team considered options to use the soils in place. The consultants dug a test pit on site to a depth of about two meters to verify that the sand layer was deep and consistent. The lower cost alternative approach chosen for the site was to mix compost into the native sand at a proportion of 1 part compost to 2 parts native sand.

Another concern at the site was the fluctuating water table and whether to install an underdrain. The monitoring well on site showed that the water table fluctuates from as deep as three meters to as shallow as 30 cm from the surface. The area where the bioretention cell was proposed already takes stormwater runoff from the parking lot and is dry the majority of the time. However, during wet periods in the spring, ponding would sometimes occur for a few days. Bioretention cells are designed not to pond more than one day after a rainfall. UCM and the design team agreed that this occasional extended ponding time was acceptable. If the ponding becomes a nuisance, an underdrain can be added at a later date.

Due to these deviations from the standard design, a conservative approach to sizing the bioretention cell was taken. The area of the bioretention cell (250 sq m) is just over 10% of the drainage area (2300 sq m).

The design also called for the installation of an overflow catchbasin which would connect to the newly installed QEW storm sewer. The overflow is a standard catchbasin inlet with a flat grate on top. The catchbasin is set about 15 cm above the bioretention cell's soil surface. This ensures that smaller events will soak into the soil and only larger event will overflow into the storm sewer and bypass the bioretention cell.

Landscaping

UCM wanted a naturalized landscape with attractive native plants and a habitat for birds, insects and small animals. The landscaping consists of a variety of native plants placed throughout the garden. The design specified plants for dry, moist and wet areas of the bioretention cell. The species included:

Dry

- Staghorn Sumac
- Red Oak
- Butterfly Milkweed
- Lance Leaved Coreopsis
- Gray Goldenrod
- Wild Bergamot

Moist

- Red Maple
- Trembling Aspen
- New England Aster
- Wild Strawberry
- Culver's-root

Wet

- Late Goldenrod
- Tall Meadow-rue
- Common Elderberry

New England Aster does well in bioretention areas and can handle the salts and pollutants that may run off of roads and parking lots.

Construction

The overflow catchbasin and storm sewer connection were constructed first using standard construction practices. The construction of the bioretention cell followed this sequence:

1. Removed the top 20 cm of topsoil and reused it along the perimeter of the parking lot.

2. Excavated the sandy soil to an additional depth of 60 cm and stockpiled it on the side of the excavation.

3. Used the tooth bucket to loosen and roughen the sandy soil at the bottom of the excavation to improve infiltration.

4. Returned stockpiled sand into the excavation in two 30 cm layers. The returned sand was broken up and loosened to improve its ability to store and infiltrate rainwater.

5. Thoroughly mixed in 10-15 cm of compost between each layer with a roto-tiller.

6. Finely graded the surface of the sand and compost mixture to about 20 cm below the top of the overflow.

This will leave room for about 50-75 mm of mulch and 125-150 mm of surface ponding depth.

The top image shows the bioretention area staked out and the topsoil removed. The lower image shows the compost being spread and readied for mixing into the sand soil. (Source: Tafler Rylett Architects)

These steps were completed with a professional contractor and backhoe operator. The contractor took care not to compact the bioretention area soils by keeping the heavy excavation equipment off to the side.

With the soils in place, the remaining steps of planting and spreading the mulch could be done by volunteers from UCM and CVC. Due to available resources, the bioretention cell was planted in two phases: the south end was planted in 2011 and the north end in 2012.

A year after major construction, different pre-treatment options for the edge There is no curb surrounding the parking lot so curb stops are used for the parking spaces. Rainwater running off the parking lot enters from all directions, often called sheet flow. There were a few locations where the flow concentrated, creating erosion problems. Grass or gravel filter strips are the two most common options for pretreating and slowing down sheet flow entering bioretention. A fescue grass sod from Green Horizons was donated to the church to use as a filter strip. The sod successfully stabilized the edge and eliminated most of the erosion issues, but the grass has created other maintenance issues that are noted in the maintenance section.

Volunteers planting for the first phase of planting in 2011.

Installation of sod strips around perimeter of bioretention swale to reduce erosion and pretreat runoff entering the swale

Economics (Capital Costs)

The approximate costs for the bioretention cell construction are provided in the table below.

Capital Costs	
Item	**Cost**
Design of the Bioretention Cell	$8,000
Heavy Construction: installation of catchbasin overflow, stormsewer connection, excavation and amendment of soils	$50,000
Leaf compost for amendment	Donated
Sod	Dontated
Mulch	Donated
Labour for planting/ landscaping	Volunteered
Plants (trees, shrubs, herbaceous plants)	$4,100
Total:	**$62,100**

From 2011 - 2013 approximately $13,000 was raised through grant funds for landscaping and maintenance of the bioretention cell and other sustainable site features at the church. Sources of funds included TD Canada Trust, Government of Canada Student Employment subsidy, and the David Suzuki Foundation.

Operations & Maintenance

Maintenance enhances the performance, aesthetics, and longevity of LID practices, particularly during the initial establishment phase. Ongoing maintenance prevents small problems from becoming large ones and improves the public reception of the practice. It may be necessary to follow-up with the contractor throughout the warranty period to ensure that activities specified within the maintenance agreement are taking place.

As is often the issue with non-profit organizations, UCM had to work hard to arrange for regular maintenance of landscaped features including the bioretention cell. Carole Berry, was the driving force behind the effort. She explained, “volunteers are the backbone of this project. Over 60 people of all ages, diversity, and abilities worked collectively to build (and maintain) the gardens." In reaching out to the wider community, Carole also brought in residents of a local half-way house. UCM also obtained paid part-time assistance from college students through a Canada Summer Jobs subsidy for six weeks in 2013.

In the case of the UCM bioretention cell, maintenance includes removing accumulated trash and sediment, weeding, mulching and watering. The college students helped with the more difficult tasks such as the addition of mulch, large invasive species removal (phragmites), and grass removal from the interior of the bioretention swale. The college students also created a reference binder for volunteers.

Vegetation grew rapidly in the 2013 growing season, leading to a vey well established practice

Maintenance performed to date has been establishment maintenance and is not typical of long term maintenance. An establishment maintenance schedule can be found in the next section. The pictures on the next page show the transformation of the garden from planting to establishment.

During this period, a few maintenance issues have been noted at the site. For example, in 2013, an excellent growing season reduced the need for establishment watering but created the need for more frequent weeding and pruning maintenance. Invasive species have also been aggressively taking over the planted native species but UCM has been weeding them on a weekly basis.

The narrow grass strip has also resulted in some maintenance issues. It has been difficult to mow and trim. In addition, the grass has been creeping into the planting bed. A river stone gravel strip could have been a suitable alternative. Stone strips can have their own maintenance issues though like weed growth or the stone not staying in one place.

A hot dry summer in 2012 hindered the establishment of the landscape and many areas remained bare.

A wet growing season in 2013 was good for establishing desirable plants but it was also good for aggressive invasive plants.

As of September 2013, 2 years after planting the site is fully vegetated and well established.

CVC staff have also noted that water picks up and deposits the mulch on top of the catch basin during large storm events. The large pieces of mulch float easily and collect on and around the catchbasin overflow. This can impact the performance of the LID features, causing stormwater to backup into the parking lot. To address this issue, the use of a better quality shredded mulch is recommended. Stacking stone up around the catchbasin or using a domed catchbasin will help to reduce mulch buildup on the grate.

Ponding that extended beyond 24 hours was also noted during a few extremely wet periods. Ponding water occurred for 10 consecutive days due to Hurricane Sandy's constant rainfall. This could impact maintenance in the future by compacting soils and damaging plants. If ponding becomes a frequent nuisance, then the site can be retrofitted with an underdrain.

Mulch collects on the catchbasin overflow during large storm events.

Monitoring Performance

The UCM bioretention cell is part of two studies led by CVC. The first is a long-term collection of lifecycle maintenance and costs and the second involves the testing of methods or protocols for certifying and commissioning stormwater practices. Both projects began in 2012. The lifecycle monitoring project is ongoing and the certification protocols finished in 2013. These two studies and their results to date are described below.

Certification Protocols Summary

Municipalities and businesses (property owners and managers) should have protocols in place to thoroughly inspect work done on their property to ensure that the work was carried out in accordance with the design and was properly constructed. A thorough certification protocol reduces the risk to the owner. It ensures they are assuming a facility that is functioning properly and will not require costly near or long term repairs.

LID is a new stormwater management practice for Ontario municipalities, businesses, and places of worship, like UCM. To assist these organizations, CVC has developed certification protocols for infiltration and filtration practices. UCM is one of seven bioretention sites where the protocols were piloted. At Unitarian Church, the following protocols were performed:

- Visual inspection
- Vegetation survey
- As-constructed survey
- Soil testing
- Infiltration testing
- Water level monitoring

The protocol results are presented in the sections below which outline whether the facility passed or failed the various protocols and recommendations to address identified deficiencies.

Visual Inspection Findings

A standard visual inspection of the drainage area, inlets, outlets, and bioretention bed was performed on October 29th, 2013. Overall, the facility passed the visual inspection protocol. However, the catchbasin which acts as an overflow was covered with geotextile cloth to prevent sediment and mulch from leaving the site. The cloth will need to be cleaned or replaced frequently to prevent extended or deep ponding problems. An alternative option like stacked stone or fencing is recommended for keeping mulch and debris out of the overflow. Shredded mulch and additional vegetation will also reduce the mulch that makes its way to the overflow.

Vegetation Survey Findings

The vegetation protocol is a tool that evaluates the overall condition of the vegetation in a practice. When carrying out the vegetation protocol, the property owner records the percentage of covered ground and invasive, dead, struggling or unattractive plants, the symptoms of the dead and struggling plants and the reason for their decline. The site must pass each of those assessment items in order for the property owner to shift to a post establishment maintenance program. Once plant health and species makeup are recorded, the property owner then determine if the aesthetic goals are being met. At UCM, the goals were to provide habitat for birds and butterflies, colour and year round interest. The property owner can then determine what site management changes can be made and which plant species need to be replaced.

The landscaping assessments were conducted in September 2013 and overall, the site passes the vegetation survey. The plants are thriving and are meeting the aesthetic goals.

Assessment Item	Metric / Passing Threshold	Result	Pass / Fail
1. What percentage of the ground is covered?	80%	85%	Pass
2. What percentage of plants is invasive/ undesirable?	5%	3%	Pass
3. What percentage of planted species has died?	5%	0%	Pass
4. What percentage of the species is thriving? Ex. ranked 3 or higher	80%	100%	Pass
5. Does the site meet aesthetic goals?	Yes	Yes	Pass

As-constructed Survey Findings

The as-constructed survey was compared with the design plans for consistency. Specifically, the drainage area and the practice area were confirmed. The drainage patterns were evaluated to ensure no bypass is occurring. Results are summarized in the table below:

Assessment Item	Design	As-built	Pass / Fail
1. Contributing drainage area:	2800 m^2	2767 m^2	Pass
2. Bioretention area	225 m^2	227.5 m^2	Pass
3. Surface storage volume	25 m^3	25 m^3	Pass

The bioretention facility and drainage area sizes match the design and there is no bypass.

Soil Test Findings

Bioretention soil is a critical component that needs to be tested by the contractor before it is even delivered to the site. This testing protocol verifies that the soil placed by the contractor meets the specification. The soil composition target and the soil test results are in the table below:

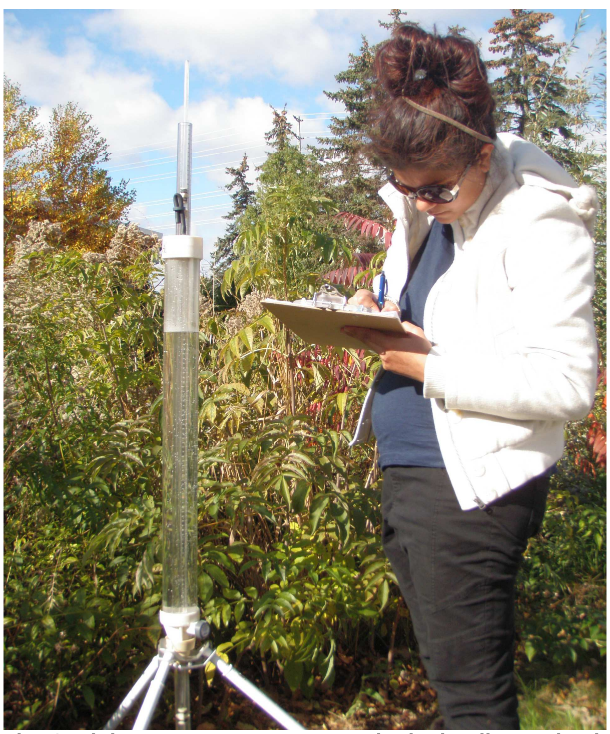
Texture	Metric/Passing Threshold	Test Result	Pass/Fail
Coarse to fine sands >0.075 mm dia.	88 - 92 % by weight	60%	Fail
Silt and Clay (< 0.075mm dia. or sieve 270)	8- 12 % by weight	40%	Fail
Organic Content:	3- 5% by dry weight	0.72%	Fail
Cationic exchange capacity (CEC):	>10 meq/100 g	11 meq/100 g	Pass
Soil Acidity:	5.5 - 7.5 pH	7.1 pH	Pass

The soils used in the bioretention failed to meet the bioretention soil specification. However, the UCM bioretention cell is unique in that the sandy soils at the site were amended rather than replaced with a bioretention soil mix. The practice may still function despite the higher content of fines. Additional testing and observations were made in this case to confirm functionality and certification.

Infiltration Test Findings

The Guelph Permeameter method was used at the site on October 29, 2013. The Guelph Permeameter is one of several methods to measure the saturated hydraulic conductivity of soils which can then be translated into an infiltration rate. The bioretention facility passes the infiltration capacity protocol threshold of 25 mm/hr.

The tests were performed within a 24 hours dry period to ensure accurate infiltration results. A total of three tests for field saturated hydraulic conductivity were conducted and converted to an infiltration rate. The average infiltration rate of the three wells was 26 mm/hr which is higher than the 25mm/hr passing threshold.



The Guelph Permeameter measure the hydraulic conductivity of the soil which can be converted to an infiltration rate.

Continuous Water Level Monitoring

The collection of water level data over time within the practice can provide drawdown times for ponding and infiltration rates over a variety of antecedent conditions and storm types. This type of monitoring is cost effective and interpreting the results is straightforward. To collect water level data, observation wells and inexpensive water level loggers need to be installed.

Assessment Item	Metric / Passing Threshold	Result	Pass / Fail
1 – Surface Drawdown Time (hrs)	24 hrs	<24 hours for most events, up to 10 days for extreme wet periods	partial pass
2. Subsurface Drawdown Time (hrs)	48 hrs	4 days to never fully drawing down in Spring	Fail

The as-constructed bioretention facility failed to meet the drawdown criteria for surface ponding and sub-surface ponding. As acknowledged in the design, the water table can fluctuate significantly at the site. During wet periods in the spring, the subsurface storage area never fully drains. Despite this loss of capacity for part of the year, the practice still satisfies the water balance requirement on an annual basis. If the surface ponding becomes more frequent and a nuisance, then the church can retrofit the design with an underdrain.

Summary

The Unitarian Church bioretention facility passed all tests with the exception of the soil composition and continuous water level monitoring. The practice functions within the design parameters the majority of the time. The vegetation is in good health and the periods of prolonged ponding has not been a problem for the church. If these do become problems, then an underdrain can be added to ensure the ponding drawdown times are achieved.

The Certification Protocols for Filtration and Infiltration Practices and a more detailed report on the UCM performance under the protocols can be found on CVC's website at www.bealeader.ca.

Maintenance and Life-Cycle Cost Monitoring

The second study being led by CVC is the long-term collection of lifecycle maintenance and costs. As part of this study, CVC staff developed an inspection checklist to document maintenance needs during routine site visits. Along with these inspections, CVC staff meet with facility managers at least once a year to gather information on the bioretention cell's maintenance tasks and related costs. The data collection began in 2012 and will continue through the life of the practice. As the practice moves from the establishment period to routine maintenance, the inspections may occur quarterly or semi-annually.

Early Results as of Fall 2013

Two years of maintenance data has been collected, enough to determine the required maintenance for establishment and identify design issues that could be improved upon. Additional years of monitoring will be needed before a meaningful interpretation about long term performance, routine maintenance, and future rehabilitation can be made.

Establishment Maintenance Schedule

The level of maintenance is mostly dictated by the time since the initial planting and subsequent plantings. Once plants are established, less maintenance is needed. See table below for planting dates and details as these dates have a direct impact on the amount of maintenance occurring on the site.

Planting Date	Planting Details
September 2011	Initial planting
May 2012	Second planting
September 2012	Supplemental planting and installed grass filter strip
June 2013	Supplemental planting

The maintenance schedule below summarizes the establishment maintenance. The table shows the number of times each task was completed since the initial planting date of September 2011 to December 2013.

Maintenance Task Performed	Initial Planting Year (2011)	1st Year (2012)	2nd Year (2013)
Planting	1	2	1
Watering	1	6(10)	1
Weeding	4	26	26
Mulching	1	5	5
Other Plant Tasks*	1	1(2)	1(2)
Mowing grass filter strip	-	1	8
Removing trash	13	52	52
Removing sediment**	-	-	-
Clearing inlets and outlets	8	26	26
Lowering grade***	-	-	0(1)
Inspecting	3	12	14

*Other plant tasks include trimming, deadheading, cutting back and pruning
**Sediment removal was not carried out as buildup was not observed to be a problem.
*** Lowering grade of sod to let water in at the top end of the cell
(#) Recommended number of times tasks should have occurred

The number of times each task was completed was estimated from an interview with Carole Berry. She was asked whether each task was done weekly, monthly, or annually. Maintenance done by CVC was also recorded. From this information, the number of times was estimated for each year. In addition to observed maintenance, the recommended schedule is shown in brackets. The recommended schedule is based on additional maintenance that could have been done to address recurring issues observed during inspections.

Recommended Design Improvements

Based on observations during the establishment period, design recommendations are provided in the table below.

Design	Observations	Recommendations
Using a sod strip that contains creeping fescue as pretreatment	grass was difficult to mow and is creeping into the planting bed	Using a river stone gravel strip but that can have its own maintenance issues
Using a flat topped catch basin and large pieces of mulch	catch basin was partially or completely covered in mulch at least 75% of the time.	Using better shredded mulch, stacking stones up around the catchbasin, using a domed catchbasin, adding more vegetation

Visit www.bealeader.ca for the most up to date information on maintenance and lifecycle costs for this site.

Acknowledgements

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- Region of Peel
- Ontario Ministry of the Environment

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