

Portico Community Church Parking Lot Retrofit

Location: Mississauga

Constructed: 2010-2012



Public Lands

Project Objectives, Design & Performance

- Develop one of the first LID parking lots in Ontario in accordance with CVC/TRCA LID Stormwater Guidelines.
- The 2 hectare parking lot at Portico Community Church features permeable pavers and two bioswales. These LID features help to treat and reduce runoff flowing into the Credit River.
- 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

- Rigerous testing of bioretention soils before delivery to the site will prevent time consuming and costly soil replacements.
- When building a demonstration site, some mature plants should be included in the landscaping to ensure site looks full, colourful and healthy.
- Volunteers from the local community have assisted with planting and maintenance at Portico Community Church. Community engagement is a great way to reduce costs and promote LID projects.

Practices Implemented

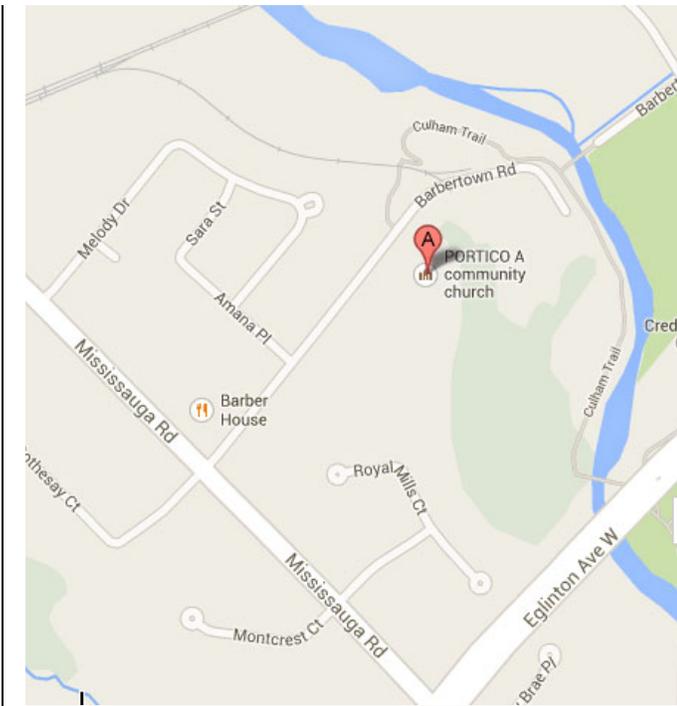


Barriers & Issues Encountered



Overview

PORTICO a Community Church is located in the Streetsville neighborhood of Mississauga, Ontario, immediately beside the Credit River. PORTICO is a growing multi-cultural and multi-generational church. PORTICO works toward maximizing their positive impact on the community while making a conscious effort to minimize their impact on the environment.



Location of PORTICO Community Church

The church expanded their Mississauga campus in 2009 and added more than 200 paved parking spaces to serve their growing congregation. As part of the redevelopment project, the church used a combination of LID practices to slow, filter and absorb rainwater running off their parking lot before it flows into the adjacent Credit River. As an early adopter of LID, several adaptive changes had to be made to get a landscape that worked for the site.

Goals and Drivers

In 2010, PORTICO Community Church and CVC entered into a partnership to improve the health and appearance of the LID practices on site. The goals and drivers for this project were:

- Reduce erosion and pollutants flowing into the Credit River by implementing bioretention practices that filter and detain runoff from the two hectare parking lot.

- Develop a showcase site used to promote LID in the Credit River watershed using the design guidance in the *CVC/TRCA LID Stormwater Management Planning and Design Guide*.
- Involve PORTICO congregation in construction and planting of the project and educate them on the Credit River watershed and LID.

Successes

The successes achieved through this project include:

Performance – The bioswales and bioretention cell installed in the parking lot have reduced runoff volume and pollution flowing into the Credit River.

Demonstration showcase – This site has been used to highlight LID practices through presentations, events, and site tours.

Partnerships – The project has engaged the community surrounding PORTICO Community Church. Volunteers from PORTICO worked together with CVC staff to rebuild and maintain the bioretention cells.

Overcoming Barriers & Lessons Learned

Some of the barriers faced in this project included:

- There was difficulty getting seed to establish in swales taking large runoff flows.
- Soils used on site did not match the design specification resulting in poor stormwater capture and plant establishment.
- Limited budget and soil issues set back landscape establishment.

The following approach was used to address these challenges:

- Soil performance was monitored and soil composition was tested. When results showed deficient soil media it was replaced. The replacement soil media was tested against the specification before being brought onsite.
- Some plants were saved and replanted after soil replacement. In May 2012, the plants were reassessed and another replanting took place in September 2012

Lessons learned through this project include:

- Bioretention soil specifications must be clearly defined in the design specifications, and be enforced.
- Soils should be tested before being brought onto the construction site. To ensure consistency samples should be taken, one each from the bottom, middle, and top of the supply pile.
- Seed should not be used when a landscaped LID practice will be taking runoff immediately. If the practice can be kept offline and the property owner can wait two to three years for an established landscape, then seeding is acceptable.
- Landscaping of LID practices should fit the surrounding aesthetic standard. In urban Mississauga most property owners want a neat, organized, and colourful landscape.

Planning & Regulations

PORTICO Church added onto its existing building and expanded their parking lot in 2008 and 2009. The site design was led by Dickinson & Hicks Architects with MTE Consultants as the subcontracted design engineers. The site drains directly to the Credit River. The outlet, which is within the floodplain, also showed signs of erosion damage and needed to be reconstructed. Due to the discharge directly to the river and the work within and the floodplain, the church required shoreline alteration and site plan permits from CVC. The City and CVC required stormwater treatment and control of flows for erosion protection.

Design

To meet requirements, the consultants designed a system of swales within the parking lot islands. Also, 50 of the 608 parking spaces were constructed using permeable interlocking concrete pavers. To reduce erosive flows to the Credit River, flow restriction plates

were installed in parking lot catchbasins. In major storm events (greater than 25 mm), stormwater will back up into the parking lot temporarily.

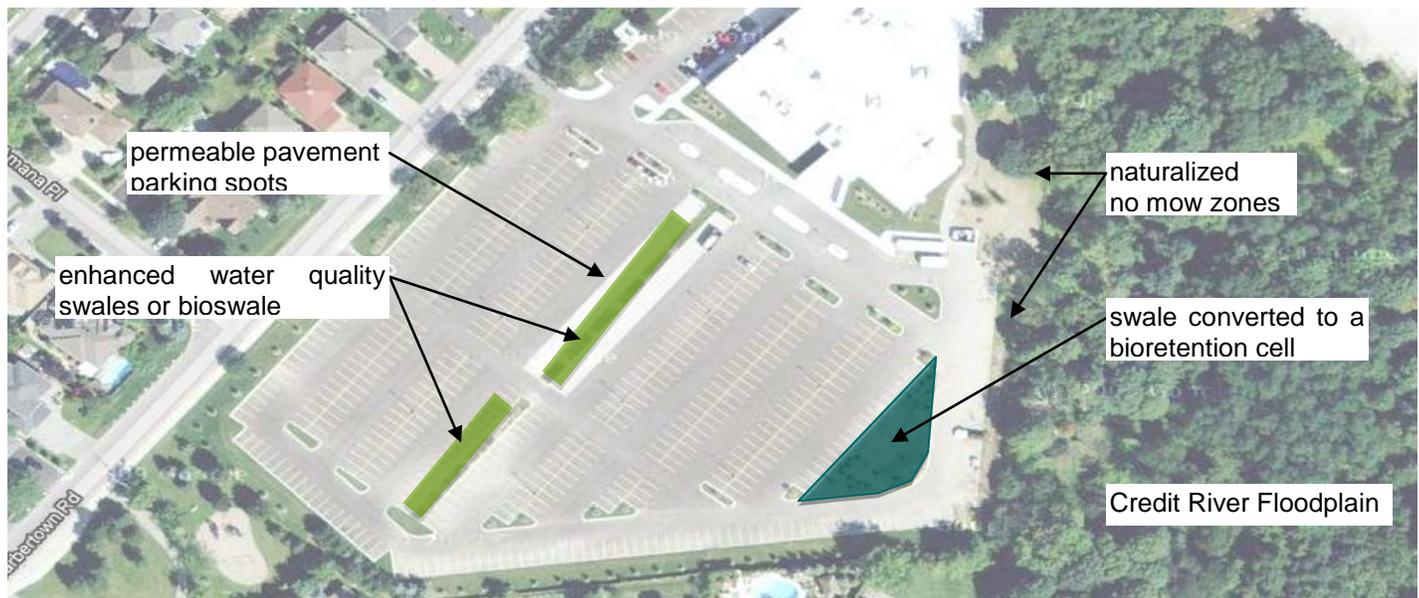
The challenge for the consultant was that guidance for permeable pavement and water quality swales (commonly referred to as bioswales) had not been formalized in Ontario. The design approach followed industry standards for the permeable pavement and guidance for enhanced grass swales in the 2003 MOE Stormwater Management Design Guide.



One year after seeding, the native grasses had not germinated and weeds were filling in the swales. (Source: CVC)

In June 2010 PORTICO contacted CVC to evaluate the swales and help to improve their appearance. The seed had not taken and the swales looked weedy and barren. The soil was also eroding and draining poorly.

The swales had been seeded with a native seed mix, consisting of equal parts Canada flatstemmed bluegrass, Indian grass, switch grass, and little bluestem. These native grass seeds often take a full year to germinate. An annual rye and oat mix was used the first year to stabilize the soil and green the site.



The following year the native grasses did not come up as expected and weeds were taking over. CVC determined that likely causes were poor soils and runoff flows. The soils used were low in organic content and high in clay. The swale also had large runoff flows draining to it that could wash out seed before it had a chance to establish.

CVC worked with the site designer to find a solution that would re-landscape the swales and improve stormwater performance on site. The hard infrastructure, such as curb openings, catchbasins, and subdains, was functional and still useable. Only the plants and soils would need to be modified to make the practices work. The following actions were recommended by CVC and Dickinson & Hicks:

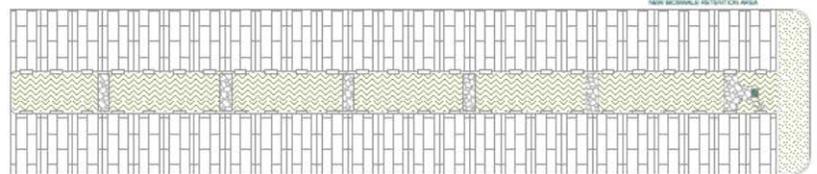
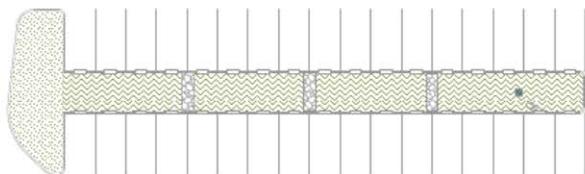
1. Replace soils and sod instead of seed in the long swales at the center of parking lot to make them **enhanced water quality swales or bioswales.**
2. Convert the swale in the triangular parking island to a **bioretention cell** through soil replacement, regrading and new landscaping.

More information on the redesign of each of these features is provided below.

Bioswale

There are two sections of bioswales located in the center of the parking lot. The lower swale is flanked by permeable paver parking spaces while the upper swale stands alone, taking flow from a smaller area. Combined the swales take flow from approximately one hectare of asphalt parking lot. The swales are three meters wide with the upper swale being 40 m long and the lower swale being 60 m long. Before the upgrade the swale soils were clay and low in organics. Also, there were nine check dams that consisted of large angular (150 mm diameter typ.) stone rising about 300 mm above the surface of the swale. The check dams helped to slow runoff and encouraged infiltration.

For the redesign, a perforated pipe under the swale and the check dams was to remain but the clay-type soils between the check dams would be replaced with a sandy bioretention soil.



The two sections of bioswales with check dams running down the center of the PORTICO parking lot

Bioretention Soil

Bioretention soil is a soil mix that consists of mainly sand but also some finer soil particles and organics. The mix presented in the table below and used for the PORTICO project is based on many years of testing and monitoring. This optimal mix provides high pollutant capture and high long term infiltration capacity.

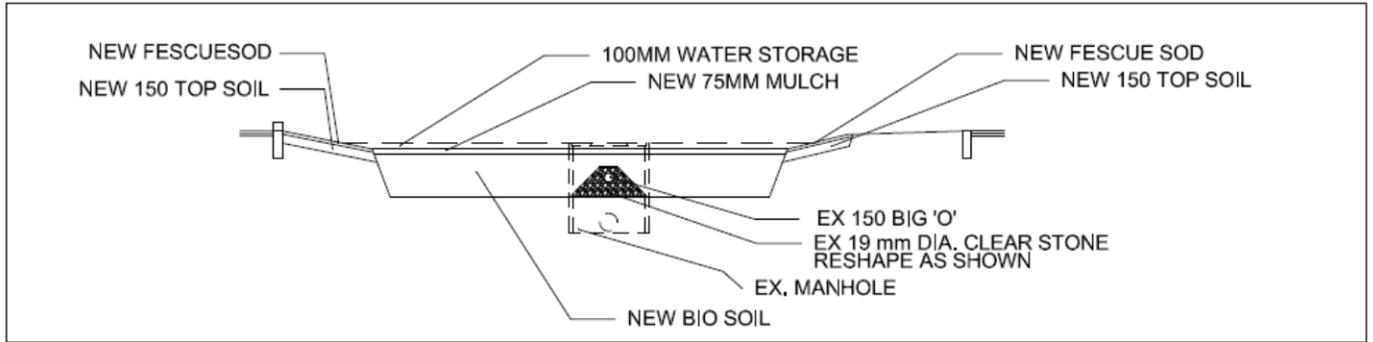
Component	Percentage by weight
Sand (2.0 to 0.05mmØ)	85 – 88%
Fines (<0.05mmØ)	8 – 12%
Organic Matter	3 – 5%
Additional requirements	
<ul style="list-style-type: none"> • CEC greater than 10mg/100g • pH = 5.5 – 7.5 • Hydraulic conductivity greater than 25mm/hr • No objects greater than 50mm 	

Instead of reseeding the practice would be covered by sod. The sod product used came from Greenhorizons Ltd. and is called Pure Fine Fescue. This sod is typically used in the rough areas of golf courses, but it also works well for this application. This sod is grown in a sandy soil that will allow stormwater to drain through. Also, the fescue grows deep roots which help sustain it through dry periods while helping to maintain the porosity and infiltration capacity of the soil underneath.

These improvements to the bioswale will filter and absorb more runoff from the parking lot. For the construction methodology see the Construction & Commissioning section.

Bioretention Cell

While the bioswale in the center of the parking lot was simply improved, the swale in the large triangular parking island was replaced with a bioretention cell. Bioretention cells are capable of treating and infiltrating much more runoff than a typical swale. A bioretention cell is different from a swale in that it is a shallow landscaped depression rather than a channel. Stormwater runoff gathers in the large flat depression and ponds temporarily to a shallow depth (typically 100-



C
A1.5 SCALE NTS
PARKING LOT BIORETENTION CELL (TRIANGLE) CROSS SECTION

200 mm) before filtering through the soil. Water from larger rain events will overflow into a catchbasin. This design forces most of the stormwater runoff to be filtered through the bioretention soil. Only large storm events, greater than 20 mm, will pond enough to overflow. The design details for the bioretention cell are summarized in the table below:

Component	Design Detail
Drainage Area	0.75 ha
Bioretention Area	235 sq m
Depth of Ponding	150 mm
Depth of Bioretention Soil	625 mm
Depth of Mulch	75 mm
Total Stormwater Storage	215 cu m
Maximum Storm Size Capture before Overflow	20 mm

There are many different landscaping options for bioretention cells. The landscape plan for this large cell consisted of a mix of native trees, shrubs, and herbaceous plants. The trees were grouped toward the centre to provide a backdrop. Showy shrubs were planted around the trees and then followed by grasses and herbaceous plants. Plant species for dry, moist and wet areas were specified, including:

Dry Zone: showy stonecrop, little bluestem

Moist Zone: summer storm perennial hibiscus, switch grass, big bluestem

Wet Zone: swamp milkweed, Joe pye-weed

The Pure Fine Fescue sod was used on the slopes and around the border. Like in the swale, the sod provides instant stabilization of the slopes. The sod also acts as a pretreatment grass filter strip for the bioretention cell.

Construction & Commissioning

The improvements to the PORTICO parking lot occurred in phases from 2008 to 2012. The following

sections present an illustrated timeline of the major events in the implementation of the stormwater management features.

Spring 2009 - Parking Lot Expansion



The image above was taken after the parking lot was constructed but before the landscaping was installed. Many curbscuts were required to get the large volume of stormwater runoff from the parking lot into the swale.

The original parking lot was reconstructed and expanded for a total paved area of two hectares. The swales in the parking islands were graded with low organic and clayey topsoil or subsoil. They were then seeded with a native seed mix and temporary cover crop of annual rye.

Summer/Fall 2010 - Identification of deficiencies and improvements



The swale in 2010 had sparse vegetation that was mainly weeds. The native seed had either washed out or could not germinate in the poor soils.

In the summer of 2010, Dickinson & Hicks and CVC identified deficiencies with the landscaping approach and ways to improve the treatment capacity of the stormwater practices. The project team developed redesign plans and raised funds over the Fall 2010 and Winter 2011.

June 2011 - Replacement of soils and landscaping



The image shows the bioswale as the replacement bioretention soil is being installed. In the background is a section of replaced geotextile drainage fabric that goes over the subdrain.

Hawkey Church Management, Inc. replaced the soils and landscaping over the course of a week in June 2011. The following steps were taken in the bioswale in the centre of the parking lot:

- The low organic clay soils in the swales were replaced with an engineered bioretention soil to the depth of the underdrain, approximately 300 mm to 500 mm deep.

- The check dams including the clay soils beneath them remained in place and continued serving the purpose of slowing flows down and encouraging infiltration.
- The existing perforated 150 mm “Big-O” underdrain pipe surrounded with 20 mm dia. clearstone remained. The filter fabric wrapped over the stone was replaced with fresh fabric because it was clogged with the clay soil.
- The bioretention soil was to be graded 150 mm below the curb cut inlets to account for the thickness of the sod and still allow runoff from the parking lot to enter the swale.
- The swales were then covered with a fescue sod that immediately stabilized the surface of the soil and readied the swale to take runoff from the parking lot.



The image shows the bioretention cell excavation with the new soil being added. The stand pipe in the foreground is the cleanout at the upstream end of the subdrain. The downstream end of the subdrain outlets into the catchbasin which then drains to the Credit River.

The following steps were taken to transform the swale in the large triangle parking island to a bioretention cell:

- The cell was excavated to a depth of 800 mm with the excavated clay soils being hauled offsite.
- The existing perforated 150 mm “Big-O” underdrain pipe surrounded with 20 mm dia. clearstone was left in place. The filter fabric wrapped around the clear stone was replaced because it may have been clogged with clay soil.
- The native clay subsoil at the bottom of the excavation was scarified using the toothed bucket on the excavator to encourage infiltration.
- The excavation was then filled with about 700 mm depth of bioretention soil. This depth accounted for some settling to occur and for the necessary 75mm depth of mulch and 100 mm of surface ponding below the catchbasin overflow.

- The bioretention bed where ponding would occur was mulched with 75 mm of well shredded hardwood mulch. This type of mulch locks together better than chipped mulch or mulch with large pieces and will be less likely to float around.
- Slopes surrounding the bioretention were covered with the same sod used for the bioswales. This sod will help prevent erosion of the slopes and act as a pretreatment filter strip for the bioretention.

June & July 2011- Planting and Monitoring of the Bioretention Cell



The first attempt at planting was complicated by waterlogged soils.

The soils were given about a week to settle before volunteers from CVC and PORTICO Church planted. Planting was suspended after the soils were found to be waterlogged and not draining even after several dry weather days. Only trees and shrubs were planted.

Over the course of June and July the bioretention cell soils were observed. Extended ponding and waterlogged soils continued to be a problem. The roots of shrubs and trees began to decay from the continually wet conditions. Soil samples were sent to a lab for grain size analysis and found that the clay content was 10% to 20% higher than what was specified. Based on this evidence, a decision was made to replace bioretention soil with a mix that met specification.



The bioretention soil mix had high clay content and failed to drain within 24 hours after a rain event.

September 2011 - Second Replacement of Bioretention Soil and Planting

To ensure that the bioretention soil brought to the site met the specification, three samples from the mechanically mixed pile were sent to an independent lab for grain size analysis. When it was confirmed that the soil provided met the specification, the new soil was brought to the site.



A slinger truck was used to place the soil saving time and labour. The slinger truck is able to evenly spread the soil without having to enter the facility with heavy soil movement equipment.

A slinger truck was used to place the bioretention soil saving time and labour. Dump trucks deposit a load in one place that then has to be moved around by heavy soil moving equipment or human labour. The conveyor belt spreader of the slinger truck can evenly spread the soil around the bioretention cell without using heavy equipment that could also cause detrimental compaction.

As with the first planting, the soil was given a week to settle before planting took place. Trees and shrubs were salvaged from the first planting, but they were in poor health due to the repotting and replanting. In addition, about 150 small herbaceous plugs were

planted. This planting was limited due to budget and only partially covered the large bioretention cell area. A lesson applied from the previous planting was to wait until all plants were planted to add the mulch. This reduces the time and care needed to spread mulch around the plants.



For the second planting, the mulch was added after all plants were in the ground, which was more efficient than trying to plant in the already mulched cell.

September 2012 - Third Planting



The landscaping was assessed after one year to see what plants had been successful and what could be added to fill in the sparse landscape.

After one year, CVC conducted an assessment of the plants that had been successful in the cell. Some plants bounced back after the stress of replanting the previous year while others died. The successful plants from the previous planting included New England aster, red maple and shrubby cinquefoil. Fern Ridge Landscaping was then enlisted to implement a planting plan of native and cultivar trees, shrubs, and herbaceous plants. The final design created large groupings or drifts of species that provide year round interest, texture and colour. Larger stock was used to help stabilize the soils faster and provide an instant landscape.

Another issue addressed in this landscape makeover was erosion channels. A year of operation revealed where preferential flow paths were in the system. An erosion channel formed near the overflow catchbasin that was several centimeters deep. When the cell was replanted a decorative river stone channel was used to cover and stabilize the eroded channel.



The improved landscaping added more trees and shrubs plus a decorative river stone channel that also addressed an area of concentrated erosive flow.

Economic (Capital and O&M Costs)

Replacing soils and landscaping was estimated to cost \$64,000, including design, materials, equipment and labour. Costs were kept low for the church through the following cost sharing:

- **Dickson & Dickinson Architects** provided design services for the project and incorporated CVC recommendations
- **CVC** raised funds for materials through grants, **Walmart-Evergreen Community Grant** and the **Sobey's Community Environment Fund**.
- **CVC** also donated project management, tools, and volunteer support.
- **Hawkey Church Management, Inc.** donated construction labour and equipment.
- **PORTICO** provided volunteers for planting and covered the costs associated with repairing the irrigation lines and electrical lines disrupted by construction.
- **Greenhorizons Ltd.** provided installation of the sod as a donation.

The approximate costs of retrofitting the PORTICO Community Church Parking lot are provided in the following table:

Materials	Cost
Bioretention soil	\$21,000
Geotextiles/erosion control	\$200
Sod	\$9,000.
Mulch	\$800
Plants	\$3,500
Subtotal	\$34,500
Contractor Expenses	Cost
labour and equipment	\$23,000
Soil disposal	\$7,000
Subtotal	\$30,000
TOTAL	\$64,500

Operations and Maintenance

Maintenance is important, particularly during the initial establishment phase, because it enhances the performance, aesthetics, and longevity of the LID practice. In the long run, maintenance will prevent small problems from becoming large ones and improve overall public acceptance of the practice.

The bioretention cell and bioswale maintenance activities at PORTICO have been provided by a combination of the church's maintenance staff, as well as by volunteers through PORTICO Church and Conservation Youth Corps (CYC). The maintenance activities include removing accumulated trash and sediments, weeding, mulching and watering. The majority of maintenance completed to date has been establishment maintenance and is not typical of long term maintenance. The tasks performed include:

Watering - The bioretention cell has an irrigation system around the edge that has consistently watered the cell during the establishment period. In 2013, the irrigation for the bioretention cell was turned off and will remain off except if the plants show drought stress. Temporary irrigation provided by perforated hoses was used to water the sod in the bioswale on a daily basis for the first two weeks and then periodically through the following hot, dry summer. Beyond that time, the deep-rooted sod has not needed watering.



The above image shows the sod shortly after placement and the temporary soaker hoses used to water the sod during establishment.

Litter pickup and sediment removal - Litter pickup is completed on a weekly basis or more frequently in some cases by maintenance staff. The large parking lot generates significant amounts of sediment that accumulate at the inlets. The sediment is removed several times a year.

Weeding - The bioretention cell is large and it will take time for the desirable plants to fill in the space. In the meantime weeds, particularly lady's thumb and yellow nut sedge, continue to be a problem. Weeding is carried out about three to four times a season by CYC and PORTICO church volunteers.



Conservation Youth Corps volunteer removes weeds from PORTICO site in September 2012

Mowing - One of the benefits of the Pure Fine Fescue sod is that it does not need to be mowed. The sod around the bioretention cell and in the bioswale is mowed once in the fall but then left to grow the rest of the year. Some weeds have grown into the un-mowed

sod and resulted in an overall untidy look. In 2014, the sod will be mowed for a more tidy look but will be cut to height no smaller than six inches.



Stone stacked around the catchbasin helps to screen floating mulch from overflowing into the catchbasin.

Winter Maintenance - Snow storage areas are limited the large church parking lot and several times a week all the parking spaces in the lot are needed. The main concern of snow storage in bioretention is compaction of the soils. Whenever possible the snow from the parking lot at PORTICO is stored on the grass filter strip around the bioretention cell, but not on the soil bed itself. The bioswale in the centre of the parking lot is a primary snow storage area; this swale will be monitored over time for signs of reduced performance. As for deicing salts, no stormwater practice including bioretention captures chloride salt. The shrubs and grasses chosen for the bioswale and bioretention cell are tolerant of chloride, and no salt damage or decreased performance due to chloride salts has been observed.

Monitoring Performance

The PORTICO bioretention cell is part of two studies led by CVC. The first involves testing methods or protocols for certifying and commissioning bioretention practices and the second is a long-term collection of lifecycle maintenance and costs. Both projects began in 2012. The lifecycle monitoring project is ongoing and the certification protocols finished in 2013. These two studies and 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 work is carried out in accordance with the design and was

properly constructed. A thorough certification protocol reduces an owners risk. 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 PORTICO Church. To assist these organizations, CVC has developed certification protocols for bioretention practices. PORTICO is one of seven bioretention sites where the protocols were piloted. At PORTICO 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 had deficiencies to be addressed.

Visual Inspection Findings

The most recent visual inspection was performed on October 29, 2013. Overall the bioretention cell passed most of the visual inspection criteria; however a few deficiencies were identified:

- The inlets have sediment build up and some are obstructed with tall vegetation. This is causing ponding and sedimentation in the parking lot.
- There is no drop behind the inlet into the sod. Even a small buildup of vegetation and sediment can cause stormwater to backup into the parking lot. Lowering the sod and creating a channel for the flows into the bioretention cell will reduce this problem, but some ponding in the parking lot will continue to be a problem due to the grading of the asphalt.
- The mulch depth is less than the desired range of 50-100 mm with many spots of the bare bioretention mix exposed. A layer of mulch should be reapplied to increase mulch depth. This will sustain vegetation and protect bioretention mix from erosion.

While the facilities are functional, addressing these issues will help to improve performance of the practice. Once these recommendations are implemented, the facility is expected to pass the visual inspection.



Visual Inspection - Inlet obstructions with sediment build-up and tall grass

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 undesirable 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 determines if the aesthetic goals of the original site design are being met, which can include but are not limited to colour, year-round interest, clean formal appearance and planter visibility. The property owner can then determine which site management changes can be made and which plant species need to be replaced. An assessment of the bioretention cell vegetation was carried out in September 2013 and is summarized in the table below. Only the bioretention cell was evaluated during the vegetation survey.

Assessment Item	Metric / Passing Threshold	Result	Pass / Fail
1. What percentage of the ground is covered?	80%	80%	Pass
2. What percentage of plants is invasive/undesirable?	5%	5%	Pass
3. What percentage of planted species has died?	5%	10%	Fail
4. What percentage of the species is thriving? Eg. ranked 3 or higher	80%	50%	Fail
5. Does the site meet aesthetic goals? Eg. colour, year-round interest, clean formal appearance and planter visibility	Yes	No	Fail

In order to improve the bioretention cell, dead and struggling plants should be substituted with a different species that is currently thriving in the bioretention cell.

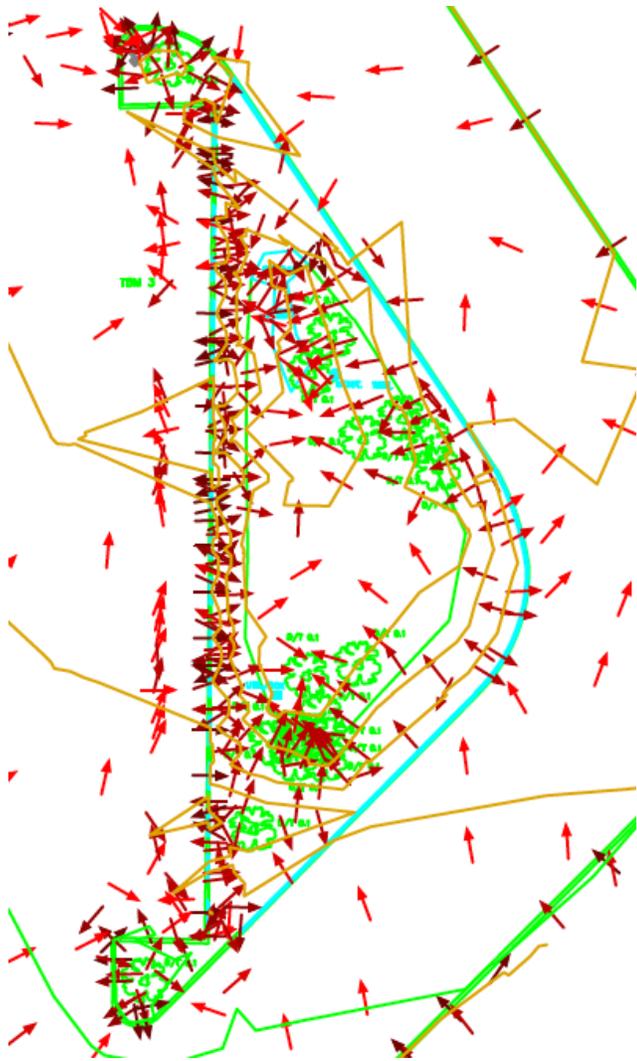
For example, the black lace elder and the oakleaf hydrangea have died. These plants could be replaced with more summer storm hibiscus, which is thriving. Other plants that are struggling such as the pigsqueek, shrubby cinquefoil and american smoke bush could be replaced with swamp milkweed, big bluestem, vibrant dome New England aster and switch grass. Adding more of these plants will also add colour and year-round interest. Weeding the site early in the growing season will help control the weeds that are growing in the bioswale and provide a clean formal appearance.

As-constructed Survey Findings

The as-constructed survey is used to compare sizing, drainage areas, and flow paths to the design plans. An as-constructed survey was conducted for PORTICO in July 2013 and the results are summarized in the following table:

Assessment Item	Design	As-built	Pass / Fail
1. Contributing drainage area	7,500 m ²	7,650 m ²	Pass
2. Bioretention area	240 m ²	235 m ²	Pass
3. Total storage capacity (water quality storage volume)	220 m ³	216 m ³	Pass

The as-constructed bioretention area and drainage area are within 2% of the design, which falls well within the 20% design factor of safety.



An analysis of flow paths was conducted using the topographic survey of the site. The arrows in the plan view above show the direction of flow toward the bioretention cell.

Analysis of drainage flow paths show that many inlets are bypassed and the majority of flow enters through the curb openings at the east end of the cell. All the flow from the parking lot still enters the cell, but only through one location. Regrading the asphalt in the parking lot to address this problem would be costly. Alternatively, adaptations can be made to the area receiving the majority of flow such as additional erosion control and pretreatment.

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 objectives should be within the

range provided in the table below along with the soil test results for the site.

Texture	%	Test Result	Pass/Fail
Coarse to fine sands >0.075 mm dia.	88 - 92 % by weight	90.5%	Pass
Silt and clay (< 0.075mm dia. or sieve 270)	8- 12 % by weight	9.5%	Pass
Organic Content	3- 5% by dry weight (supplied by leaf and yard compost or composted pine mulch)	0.84%	Fail
Cationic exchange capacity (CEC)	>10 meq/100 g	11 meq/100 g	Pass
Soil Acidity	5.5 - 7.5 pH	7.0 pH	Pass

The site passes the soil testing protocol except for the organic content criteria, which did not meet the required objective range. The organic content's primary purpose is to sustain the health of the plants. Excessive organic content can result in leaching of nutrients into the stormwater. Over time, organics will buildup in the cell with the addition of mulch and plant matter. Replacement or amendments to this bioretention soil are not needed unless significant plant health issues arise.

Infiltration Test Findings

The Guelph Permeameter method was used to measure the in-situ infiltration capacity 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 as shown in figure below. A conservative design infiltration rate of 25 mm/hr is assumed for the bioretention soil; measured infiltration rates less than 25 mm/hr indicate a problem with the practice.

The tests were performed after a 24-hour dry period to ensure accurate results with no previous saturation. A total of three tests were performed on the bioretention soil bed. The infiltration rates were 118 mm/hr, 131 mm/hr and 158 mm/hr with an average of 122 mm/hr. The infiltration results coincide with the soil analysis results given larger sand particles and the higher

infiltration rate. The bioretention cell passes the infiltration test protocol.



The Guelph Permeameter apparatus is shown above. This test requires less water and takes less time than the double ring infiltrometer test.

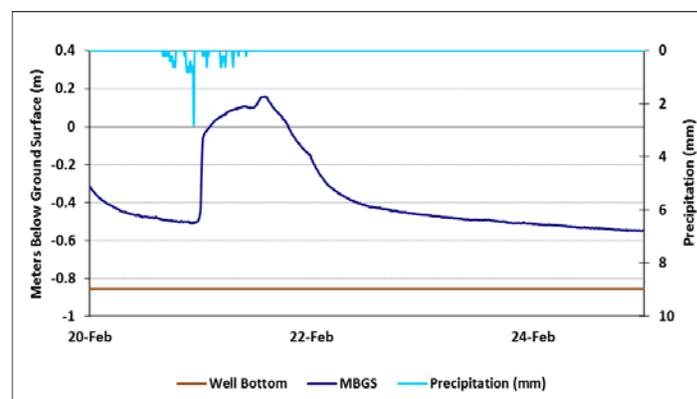
Level 3 – Continuous Water Level Monitoring

Infiltration testing will not provide the same level of accuracy as continuous monitoring. The collection of water level data over time within the practice can provide an accurate picture of infiltration rates and drain down times over a variety of antecedent conditions and storm types. This type of monitoring is cost effective and interpreting results is straightforward. To collect water level data, observation wells with inexpensive water level loggers need to be installed. In most conditions, the level loggers can be left in place through the winter and collect winter performance information. Water level data collection began at PORTICO in July 2012 and is still underway. An analysis of the data found that the bioretention cell functioned within the design parameters for subsurface drawdown time, but failed with the estimated loss rate at the surface and is summarized in the table below. Although we have visually inspected the site after large storms and have seen ponding, the facility is very large and the stormwater is usually able to infiltrate into the soil within the 24 hour threshold.

Assessment Item	Metric / Passing Threshold	Result	Pass / Fail
Estimated Loss Rate at Surface	25 mm/hr	11.5 mm/hr	Fail
Subsurface Drawdown Time (hrs)	48 hrs	18.4 hours	Pass

A lesson was learned from this pilot of water level monitoring. For the first four months, the water level logger was located in the observation well connected to the upstream end of the subdrain. The subdrain was always free flowing and never backed up. Consequently, the recorded water levels showed no increases or brief increases after rain events and was not an accurate representation of water levels in the soil. In October 2012, a new observation well was installed in a section of the bioretention cell not directly connected to the subdrain. The water level data from this well provided a more accurate picture of water levels in the bioretention soil.

The following figure shows that the bioretention facility can still function in the winter when the ground is frozen. This event had a total of 19.8 mm of precipitation fall and the bioretention facility was able to infiltrate all the runoff received from the adjacent parking lot with ponding for approximately 16.5 hours. Subsurface drawdown took place within the 48 hour threshold, demonstrating that bioretention facilities can still function in colder conditions.



Precipitation event and measured water level in February 2014

Summary

All certification protocol tests were completed by November 2013. The PORTICO Church bioretention facility is functioning well but there are several improvements that can be made to the inlets and vegetation to improve aesthetics and reduce maintenance. In the bioretention cell, some plant

species are dead or are struggling. To improve the bioretention cell function and appearance, these plants can be replaced with more plants that are thriving and that can add colour and year round interest.

The Final Certification Protocols are posted to CVC's website, 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 for PORTICO Church 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.

Results 2012 - 2014

Three years of maintenance data has been collected, enough to determine the required maintenance for establishment and identify design issues that could be improved upon.



This photo was taken as one of the LID Checklist Inspection photos for the photo log in order to track site progress and maintenance needs over time. Plants are still establishing and require extra maintenance at this time in order for them to survive.

A few trends were identified while reviewing the inspection checklist data from the past three years. The vegetation cover has improved from 2013 to 2014 as the plants have had another growing season and species that were struggling were replaced with a heartier species that can tolerate wet conditions better.

In 2012 some plants died off due to wet conditions as the soils were very saturated and some of the plants in the original plan did not survive, resulting in a failure rate of 14 per cent, and requiring action. In July 2014 additional plants were added to the facility to replace some of the original choices. By August 2014 the vegetation cover had reached 75 per cent and by September 2014 vegetation cover had reached 100 per cent. The additional plants that were added were well suited for the site conditions and are doing very well.

Mulch cover at this bioretention facility is important as the flow entering from the parking lot is substantial enough to cause erosion in areas. For inspections identifying more areas with bare soil, it corresponded with higher rate of erosion. In 2014 there was mulch applied to the facility which kept the surface covered 90% of the time, resulting in less erosion. 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 primarily 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
June 2011	Transplanting and planting the bioretention cell and sodding the bioswale
September 2011	Transplanting and planting the bioretention cell: planted 173 new herbaceous plants
September 2012	Full replanting of the bioretention cell: 12 trees, 71 shrubs and 122 perennials
July 2014	Planted a total of 48 new plants

The Conservation Youth Corp volunteers help out with maintenance, including weeding and planting. Over two days in 2014 they were able to remove a significant amount of weeds and add additional plants where needed. A landscaping contractor was hired to perform the remaining tasks throughout the growing season, which includes plant maintenance and mulching, as well as removing any sediment from the inlets. This large parking lot seems to accumulate a fair amount of sediment and the inlets need to be cleared monthly to

prevent excess sediment from entering the bioretention cell.



The Conservation Youth Corp volunteers helping with weeding in July 2014

Recommended Design Improvements

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

Design	Observations	Recommendations
Areas of concentrated flow entering the bioretention cell	Sediment accumulates in the parking lot where flow enters the swale	Remove flow blockages and install a concrete sediment trap behind the inlet where sediment will drop out and collect.
Curb cut inlets	Sod and soils behind the curb inlet are too high	A drop of 50 mm is recommended behind the curb inlet; do not assume sod and soils will settle.



The image shows how sediment builds up in the inlet rather than in the filter strip due to sod partially blocking the inlet.

Having sediment build-up and block the inlets was an issue as it was preventing flow from entering the

bioretention facility. During one-third of the inspections performed, the inlets failed as they were blocked. The issue with the curb cut inlets was addressed in August 2014 as the Conservation Youth Corp volunteers helped to lower them. The sod was lifted so that soil from underneath could be removed, resulting in a lower grade for the grassed area. This helps to increase flow of water into the bioretention facility. The contractor hired to perform site maintenance will be clearing them now as needed.



CYC volunteers removed soil from under the sod to lower the grade of the inlets

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

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