Overview

The Credit Valley Conservation head office is located on Old Derry Road in the Meadowvale Conservation Area in Mississauga, Ontario.

The CVC head office addition is located at 1255 Old Derry Road, Mississauga, Ontario

Established in 1954, Credit Valley Conservation (CVC) is one of 36 conservation authorities in Ontario with a mandate to ensure Ontario's water, land and natural habitats are conserved, restored and responsibly managed through watershed-based programs.

The new addition to the CVC head office is registered with the Canada Green Building Council, and is certified LEED Gold. The building includes many green features, including daylighting, high-efficiency HVAC system and other features like operable windows. The building also features numerous low impact development (LID) practices, such as permeable parking lots and a rainwater harvesting (RWH) system supplying non-potable water to toilets, urinals and outdoor hose taps.

In 2016, the City of Mississauga is introducing a Stormwater Charge, as the current funding for the stormwater infrastructure is not sufficient to maintain current levels of service. Property owners are charged based on the amount of impervious surfaces on their properties, as these put the most strain on stormwater infrastructure. A credit program will also be established to recognize property owners that implement stormwater best management practices that benefit the city's infrastructure. A percentage of the stormwater charge, up to a maximum of 50%, will be refunded back to the property owners based four categories: Peak Flow Reduction, Water Quality Treatment, Runoff Volume Reduction and Pollution Prevention. CVC is currently developing an application for the Mississauga Stormwater Charge Credit, with a focus on the LID installed at the site. Options for future LID features are also being considered.

Goals and Drivers

Given CVC's mandate, the conservation authority and its member municipalities approached the construction of an addition to the CVC head office as an opportunity to showcase a green building that effectively manages water resources on the site in keeping with the Credit River Water Management Strategy.

The goals and drivers for the project included:

- Creating a demonstration site that showcased LID practices within a typical commercial office setting
- Providing an opportunity to 'learn by doing' and closely monitor the performance and maintenance of LID practices
- Identifying and communicating ways to improve the design, installation and management of LID features

Successes

The successes achieved with this project include:

Demonstration showcase – The LID practices at CVC Head Office has been showcased through numerous events and site tours, and represent LID practices that can be installed at a typical medium-sized commercial office building. In addition, it demonstrates features that may be eligible for Mississauga's Stormwater Charge Credit Program.

Performance - Results from the monitoring period show that the LID at CVC Head Office reduces the runoff volume of rain events by 63%. This is an improvement from typical parking lots where the majority of runoff travels directly into the storm sewers and into our streams and Lake Ontario. The site also removes 81% of total suspended solids.

Water conservation – The rainwater harvesting system has allowed CVC to use over 400 000 L of reclaimed water, reducing the strain on the municipal drinking water system.

Overcoming Barriers and Lessons Learned

The barriers and issues encountered with this project included:

- The need to tighten the project budget meant that a retaining strip was used for the permeable pavement rather than a concrete curb. There is evidence this is not providing the necessary support, as some spreading of the pavers has been identified at the edge of the lot.

- During commissioning, issues were encountered with the rainwater harvesting system that prevented it from properly switching from rainwater supply to municipal supply in times when the tank was dry
- The permeable parking lot was constructed prior to completion of building construction, exposing it to the risk of mud tracking from heavy equipment on site
- The LEED requirement of using locally sourced materials led to the use of recycled concrete for the base layer of the permeable pavement. “Clear” recycled concrete free of fines was ordered, but fines were observed during installation. This may be causing lower infiltrations rates in the permeable pavement

The following approaches were used to address these barriers and issues:

- The RWH system was modified post-construction to incorporate a new low-level control system that automatically ‘topped-up’ the tank with municipal water when the tank level was low
- CVC staff communicated with contractors (in person and through signage) to emphasize the need for construction equipment and vehicles to keep off the permeable pavers, minimizing mud tracking incidents. Further details are provided at http://www.creditvalleyca.ca/low-impact-development/
- An additional lot, installed in 2012, utilizes a concrete curb and was installed without the use of recycled concrete

Lessons learned:

- To ensure the long-term integrity of a permeable paver installation, using concrete curbs is preferable to edging restraints
- Engineering specifications must provide more detailed information on low-level control systems for contractors to ensure that the top-up process terminates at a height that still permits rainwater to be collected within the tank. Further details are provided at http://www.creditvalleyca.ca/low-impact-development/.

Planning and Regulations

Rainwater harvesting systems must be designed and installed in accordance with applicable codes and regulations, the principal one being the Ontario Building Code. The Code specifies the permitted uses of non-potable water and the measures to be taken to protect the potable water supply (both within the building and the municipality as a whole).

CVC staff and the design team worked with the City of Mississauga to ensure that all necessary permits, including those for the RWH system, were obtained. The permeable paver parking lot built during construction of the addition, as well as an expansion lot added shortly after construction, both received permits in accordance with the City of Mississauga’s parking lot bylaw.

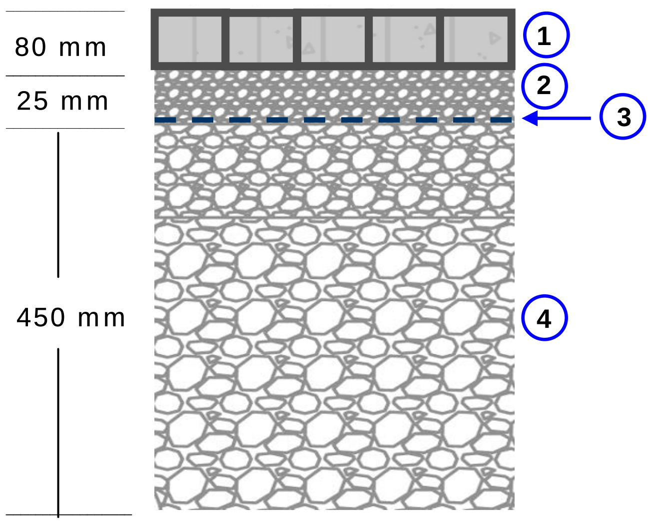
Design

One of the main goals during design of the CVC head office expansion was to use resources (water, gas, electricity) more efficiently and to manage stormwater more sustainably. This led to the expansion attaining LEED Gold certification.

Permeable Pavement

Replacing an older existing impervious asphalt parking lot with a permeable paver lot was one of the ways design goals were met. The permeable parking lot is roughly 1,462 m^2, and provides a total of 52 spaces for visitors and staff. The permeable pavers primarily handle rainfall landing directly on the lot, with only a small portion of the surrounding asphalt roadway runoff being directed towards the practice. The runoff from asphalt sections is primarily drained to grass swales.

To provide a firm base and adequate storage volume for the parking lot, the permeable pavement installation utilizes several layers (as shown in the section view below).



Section view of the permeable pavement, illustrating the various

1	**Permeable interlocking concrete pavers** – the pavers (Uni-Ecostone by Unilock) have nubs around them which leave a consistent 1 cm space between each paver that allows water to drain through.
2	**Bedding layer (1.18 to 4.75 mm diameter washed chip stone)** – the bedding provides a level surface for the pavers. The same chip stone also fills the spaces between the pavers.
3	**Drainage fabric** – the drainage fabric separates the bedding and base layers.
4	**Base layer (22 mm diameter recycled concrete) –** the base layer provides structural support to the pavement and a storage reservoir for stormwater.

Around the perimeter of the lot, the pavers are retained using edging restraints, as shown below.

Close-up photograph of permeable paver edging restraint

The purpose of the edging restraint is to ensure that optimal spacing between pavers is maintained throughout the lifespan of the parking lot (i.e., prevent the pavers from spreading). In practice, however, a majority of permeable paver installations have a concrete curb rather than an edging restraint to retain pavers.

Installing an edging restraint is typically done because they are cheaper than curbs. These capital savings may be outweighed by operation and maintenance expenses incurred if the restraints fail and the paver spacing must be corrected in future installations.

Edge restraints can be displaced by cars and winter maintenance. The stability of an edging restraint compared to a standard concrete curb will be tested at the CVC head office because an additional permeable pavement expansion lot was constructed on the property.

Permeable pavement expansion parking lot during construction

The design of the expansion parking lot differs from the original permeable lot in two ways. First, the expansion lot uses a conventional concrete curb for edge restraint. Second, it uses a darker-coloured stone. The differences between the two permeable lots will allow CVC to monitor any differences in the operation and maintenance between the two lots.

Grass Swales

Small grass swales were installed between the permeable paver parking lot and the asphalt roadway serving the building. These swales primarily collect and convey runoff from the asphalt roadway as there is typically little to no runoff from the permeable paver lot that drains to the grass swales.

Rainwater Harvesting System

The RWH system uses a 5,000 litre rainwater storage tank located the basement of the building. Rainwater from the roof is directed through interior rain leaders to a central mechanical room. The roof runoff is directed through 75 mm diameter ABS piping to the tank. The same size pipe is used to convey excess rainwater from the tank when there is too much volume in the storage tank. All excess rainwater is discharged through the building's 150 mm diameter storm drain, connected to an on-site wetland. The tank is also periodically filled with water that was collected in the building's sump pump, as a high water table surrounds the building.

The rainwater and groundwater collected via the sump pump is used to supply non-potable water to toilets and urinals in the building addition and also supplies water to outdoor hose taps. To supply this water to the connected fixtures, the system uses a standard constant-speed style pump and pressure tank. The multi-stage pump provides a flow rate of 40 litres per minute (LPM), while the pressure tank stores 100 litres.

Key Facts

Issues

- One of the permeable parking lots uses an edging restraint for the permeable pavers (rather than a concrete curb), which may cause the pavers to spread.
- The rainwater harvesting (RWH) system's filter was placed upstream of the pump (on the suction line), which tends to increase the amount of wear on the pump.

Solutions and Lessons Learned

- To permit runoff from the paver lot to be conveyed to additional features (such as grass swales), a low profile or 'ribbon'-style curb should be used instead of a traditional curb.
- When designing RWH systems, it is recommended that all treatment components (filters, Ultraviolet lamps, etc.) be installed downstream of the pump, on the discharge line of piping. If intake of debris into the pump is a concern, a line strainer filter can be used to protect the pump from large debris while minimizing wear.

Indoor rainwater storage tank, located in the basement

Rainwater is treated by a 100-micron particle filter (model JUDO JFXL-T). Maintenance of the filtration system is minimized by using this type of filter because it includes an automatic timer-based self-cleaning backwash system. One potential long-term performance issue associated with the design of the treatment system is the filter location. The filter is located upstream of the pump (on the section line), which tends to increase the amount of wear on the pump. When designing RWH systems, it is recommended that all treatment components (filters, Ultraviolet lamps, etc.) be installed downstream of the pump, on the discharge line of piping. If intake of debris into the pump is a concern, a line strainer filter can be used to protect the pump from large debris while minimizing wear.

In times when the tank is nearly empty (from insufficient rainfall or excess demands from indoor or outdoor use), a 'top-up' system is used to supply the tank with potable municipal water. The RWH system uses a rod-style mechanical float to determine a low level, at which time a normally-closed solenoid valve opens to permit potable water to enter the tank. The building's potable water system is protected from contamination by the non-potable rainwater by using a backflow prevention device.

Construction and Commissioning

Construction of the grass swales and LID practices at the CVC head office involved a variety of trades, including site service contractors, landscaping professionals, plumbers and other specialists. Specialized equipment was also used during construction which helped to speed up installation (and reduce the costs) of the permeable pavement parking lot.

Grass Swales.

One issue that arose during construction was that the grass swales were seeded but weren't kept offline to permit the grass seed to grow and become established along the swale. Without a proper establishment period, the seed did not have the right conditions to grow. As a result, weed species grew in the swales, and there was poor overall grass cover. This led to the formation of rills (erosion channels) along the length of the swale.

Grass swales, with erosion channels (rills)

To prevent issues with grass swales during or following construction, they should either be: seeded and left offline to permit establishment (preferred), or sodded, if it is not possible to leave the swale offline for a period of time.

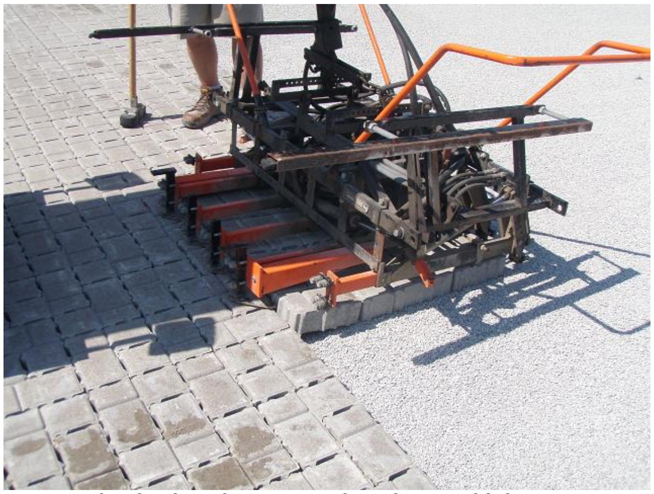
Permeable Pavement

The soils in the area surrounding the office are predominantly sandy silt glacial till of low permeability (with some permeable sand lenses). The boreholes taken prior to construction in the location of the parking lot found both sand and gravel fill and sandy silt glacial till. The observed depth to groundwater was 2.8 meters.

Granular 'A' crushed recycled concrete was usedas the base layer for the pavers. One of the drivers for the use of this recycled material was to receive points under the LEED rating system. Although 'clear' recycled content was specified, the fill that was delivered and installed contained a fair amount of fines. Following construction, these fines were later observed 'washing out' in the stormwater discharged from the underdrain. These additional fines may pose longer-term issues with the performance of the permeable parking lot, as infiltration testing in 2015 showed a reduced infiltration capacity. When designing a permeable pavement parking lot, it is important to confirm with the aggregate supplier that a green product meets the same criteria as the traditional one. In this case, the supplier should have verified whether the recycled concrete could be provided free of fines, or if not, indicate that a non-recycled product (like 'clear crushed stone') is recommended for the project.

To maximize infiltration at the site, a 100 mm diameter corrugated PVC pipe was installed within a trench 300 mm below the sub-grade (a sump-style drain). To prevent clogging, the pipe was covered with geotextile fabric and granular filter materials. A bedding layer, comprised of Aggregate Size No.8, was placed on top of the granular base. Geotextile drainage fabric was used to separate the two layers.

Unilock Eco-Optilock pavers were placed overtop of the bedding layer. This sped up installation of the pavers because this particular paver has an 'L-shape' and includes nubs that surround the outer perimeter of each stone. This design permits multiple pavers to be placed simultaneously using mechanized equipment, shown in the following picture:



Mechanized equipment used to place multiple pavers

Once the pavers were installed and compacted, the 1cm spacing between the pavers was filled with washed chip stone.

Close-up view of the chip stone used in-between pavers

The expansion lot constructed following the first paver lot also used Unilock Eco-Optilock, but a dark grey (rather than light grey) colour was selected. Unlike the first lot, the expansion lot was installed without using the mechanized stone placement equipment. As such, it required more man-hours to complete the second lot.

Photograph of the expansion parking lot, following construction

Rainwater Harvesting System

As discussed in the design section, the RWH system uses a top-up system to supply municipal water in times when the tank is dry. The system was originally designed to use a different method, known as a 'bypass system.' The bypass system would bypass all of the RWH components (tank, pump and filtration system) and supply municipal water directly to the connected fixtures.

During commissioning of the building, there were challenges associated with getting the bypass system to operate as intended. The RWH system control panel would not re-set the bypass system once sufficient rainwater was in the tank (i.e., potable water would be used to meet demands in the event of a low tank level, but the system would not automatically reset to rainwater once there was sufficient supply back inside the tank).

Given the complexities of modifying the control panel, the partners involved with the RWH system design and commissioning worked together to implement the top-up system now being used.

Interior view of rainwater storage tank during top-up filling process

Sediment and Erosion Control

To facilitate staff parking prior to completion of the addition, it was necessary to park vehicles on the permeable pavement lot during construction. To minimize sediment in the facility, construction fencing was erected around the lot and construction vehicles were instructed not to enter the permeable lot. However, despite these measures, there were some instances where construction vehicles tracked mud onto the lot.

Picture showing mud tracking from construction vehicles

Another challenging issue was that the contractor did not budget for maintenance of the sediment and erosion control measures. For instance, the tracking pad at the entrance to the construction site was not properly maintained (i.e., aggregate was not replenished) which led to the tracking of mud on the asphalt roadway used by the construction vehicles. This same roadway was also used by CVC staff en route to the permeable pavement lot, and mud was transferred to these vehicles, ultimately tracking onto the permeable lot.

To ensure the long-term performance of LID practices, it is important that construction contracts provide for maintenance of erosion and sediment control structures. Furthermore, it is critical that a construction site supervisor provide instructions to all contractors and sub-contractors on site about how to act appropriately to protect the LID practices.

Key Facts

Issues

- Grass swales were seeded but weren't kept offline to permit the grass seed to grow and become established.
- Although 'clear' recycled content was specified, the fill delivered and installed contained a fair amount of fines.
- The contractor did not budget for maintenance of erosion and sediment control structures, which led to tracking mud on the building's asphalt roadway and permeable paver parking lot.

Solutions & Lessons Learned

- Grass swales should be seeded and left offline to permit establishment (preferred), or sodded if it is not possible to leave the swale offline for a period of time.
- It is important to confirm with the suppliers that green products meet the same criteria as traditional ones.
- Construction contracts must provide clear budget provisions for maintenance of erosion and sediment control structures.

Economics

The approximate costs for the office expansion are provided below.

Capital Costs	
Item	**Cost**
Permeable pavement parking lot (1,462 m^2 / 52 spaces)	$186,000
Permeable pavement expansion parking lot (2,400 m^2 / 72 spaces)	$340,000
Rainwater harvesting system	$20,000*

*Note: cost does not include some of the RWH system components for which cost figures were unavailable.

Informal cost estimates of the unit cost of permeable pavement ranges from three to four times that of conventional asphalt. However, there are multiple site specific factors that can offset the permeable paver premium or even make permeable pavers a more cost effective alternative. Economies of scale, savings from the competitive bidding process, elimination of underground storm sewer and life cycle costs are some factors that make permeable pavers more affordable. When these factors are considered, the initial capital costs for the permeable paver parking lot were estimated to be $91,500 less than a conventional asphalt lot.

Additional expense was incurred following construction of the RWH system to compensate for some of the issues encountered during commissioning. A top-up system was added, and some of the non-potable water piping was reworked to move the post-storage particle filter from the discharge section to the suction section of piping to better protect the pump from fines. The tank was cleaned six months after installation, a process requiring two personnel and roughly one day to complete. Additional raintank cleaning will add maintenance costs, at about $200 per cleaning. Another RWH expense is inspection and testing of the various backflow prevention devices installed as part of the system. This must typically be conducted on an annual basis by a qualified plumber.

Operations and Maintenance

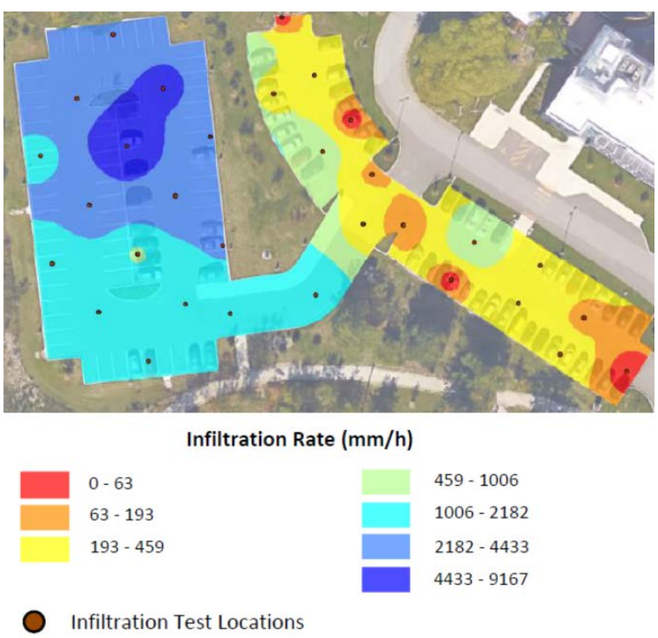
In the case of the permeable parking lot, there is initial evidence that the edging restraints are not providing the necessary support for the pavers in certain sections of the lot. Some spreading of the pavers at the edge of the lot was observed. As part of the one-year construction warranty between the contractor and CVC, the pavers that had moved out of alignment were adjusted by the contractor. CVC has now taken over management of the parking lot and is monitoring the status of the pavers for any further issues. These initial issues with the edging restraint were one of the factors influencing CVC to specify a concrete curb for the expansion lot constructed approximately one year after the first lot.

As discussed in the *Economics* section, tank cleaning is expected to be one of the major O&M tasks associated with the RWH system. This maintenance task is listed as one of the potential O&M requirements in the CVC Low Impact Development Stormwater Management Planning and Design Guide. The Guide emphasizes that tank cleaning and other maintenance tasks will vary based upon site conditions, such as the amount of debris deposited on the catchment surface and the pretreatment method used. The anticipated frequency of tank cleaning for the CVC system (approx. once per year) could be lessened by installing a screen mesh or "sock"-style filter on the piping conveying rainwater to the tank from the roof. The use of a pre-storage filter is highly recommended with RWH systems as it prevents large amounts of debris from entering the tank. It also provides other benefits such as reducing potential wear on the pump and pressure system.

In the summer of 2015, the raintank was cleaned for the first time in several years. Sediment and some larger debris had accumulated in the tank. It is suspected that the sediment is largely from the sump pump and the large debris from the roof. This cleaning was done in-house, using a wet/dry shop-vac and a pressure washer. It took about 2 hours, and required two staff members. Due to a sump pump failure in the fall of 2015, the raintank required additional cleaning. An outside contractor was used at a cost of about $200 for half a day of work. Moving forward, the use of an outside contractor is considered preferable to using CVC staff as the tank is cleaned much more thoroughly for a competitive price. Starting in 2016, the raintank is expected to be cleaned in this manner once per year.

Accumulated sediment and debris in the rain tank.

At of the end of 2015, the older permeable lot had been vacuumed once, in 2012. There has been no maintenance on the new permeable lot. Infiltration tests were completed for both permeable parking lots in November 2015. On average, the newer lot had higher infiltration rates, and there is evidence of clogging in some areas of the older lot. Vacuuming is being planning for the older lot in spring/summer 2016, followed by another round of infiltration tests. Further maintenance may be completed based on the requirements of CVC's application for Mississauga's Stormwater Charge Credit Program.



Contour map of infiltration test results

Snow plowing and de-icer will be applied to the permeable lots as needed, but use of sand will be prohibited due to its tendency to clog the pavers. There is typically less ponding on permeable lots, so it is estimated there will be less need for snow plowing and de-icer application.

Key Facts

Issues

- Sediment and debris had collected in the raintank. In 2015 it had been cleaned once by CVC staff and once by an outside contractor.
- Infiltration tests on the permeable parking lots have shown evidence of clogging in portions of the older lot.

Solutions & Lessons Learned

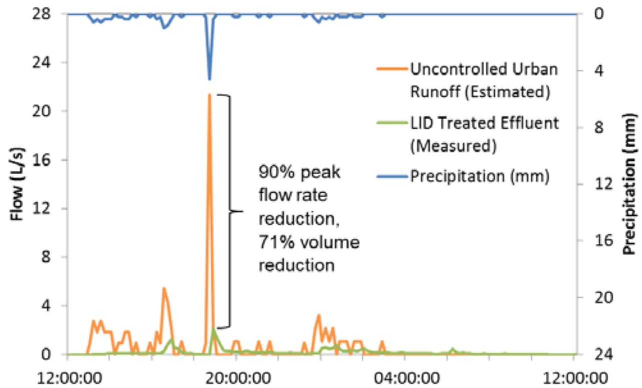
- Moving forward, the raintank will be cleaned about once per year by an outside contractor, at a cost of around $200 each time.
- Restorative maintenance such as vacuuming is planned for the permeable lots in 2016. Additional infiltration tests will be completed after this maintenance.

Long-term Performance

In addition to keeping records of the operations and maintenance work that is performed on the LID features, CVC is also conducting more extensive performance assessments on the LID infrastructure. Monitoring at the CVC Head Office site began in summer 2014. This monitoring program encompasses the older permeable parking lot, the adjacent swales and the rainwater harvesting tank.

Installation of exterior housing for performance assessment equipment

Based on monitoring data from summer 2014 to fall 2015, the site is performing well from both a water quality and water quantity perspective. For the 62 storm events monitored, the median stormwater volume reduction was 70%, and the median peak flow reduction was 81%. The total load reduction in TSS was 81%, which exceeds the Ontario Ministry of the Environment and Climate Change's criteria for enhanced water quality treatment of 80% TSS removal. For storm events of 25 mm or less, which represents 90% of all storm events in Mississauga annually, the total volume reduction was 67%, and the total load reduction in TSS was 86%.



A typical high-intensity rain event on October 3 and 4, 2014. The LID at CVC Head Office achieved a 90% peak flow reduction and a 71% volume reduction for this event.

Key Facts

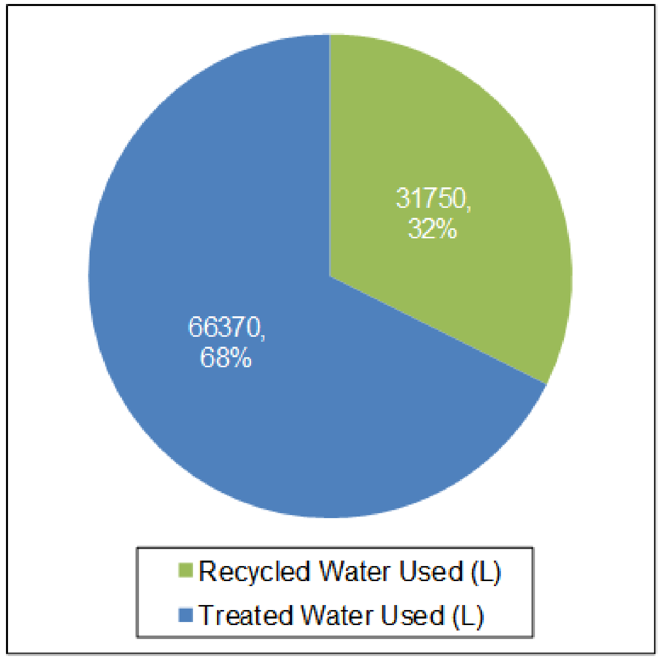
Stormwater Management Performance

- The site has reduced the runoff volume from rain events by 63%.
- The site achieves a median peak flow reduction of 81%
- Water quality benefits include an 81% total suspended solids removal and 69% total phosphorus removal.
- For events under 25 mm, representing 90% of events in southern Ontario, the total volume reduction was 67% and a total TSS removal of 86%.

Water Re-Use

- On average, 26% of CVC total water usage was reclaimed water.
- Total reclaimed water usage from August 2013 to December 2015 was over 400 000 L.
- Cost savings of $845 through not using municipal water.

CVC is also monitoring water savings associated with the RWH system through water meters installed on both the rainwater supply and the municipal top-up supply. The total reclaimed water used during the period from August 2013 to December 2015, and thus municipal water saved, was over 400 000 L, leading to a cost savings of $845. The median reclaimed water usage during workdays was 1300 L. On average, about 26% of CVC's total water usage was reclaimedwater, not including the months the RWH system was offline. In May 2015, 32% of CVC's total water usage was reclaimed water.



CVC Head Office Water Usage for May 2015

For further details on the infrastructure performance assessment work being conducted at the CVC head office, visit the CVC website at creditvalleyca.ca/low-impact-development.

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