Advancing Low Impact Development as a Smart Solution for Stormwater Management

Version 3.0 - Monitoring Data 2011 to 2015

CVC | a Leader for Clean Water

Partnerships Produce Results

Strong partnerships are key to the success of CVC's programs. Our LID efforts are not possible without collaboration from many dedicated supporters.

Ontario

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Credit Valley Conservation

Message from the Board Chair

As the Chair of the Credit Valley Conservation (CVC) and Councillor for the City of Mississauga, I have seen first hand the importance of urban stormwater management in the Credit River watershed. Situated in one of the most densely populated regions of Canada, our watershed is experiencing new challenges related to climate change and aging infrastructure.

Two major storm events in the last four years have affected my municipality directly. The most recent event on July 8, 2013 resulted in a record-breaking 126 mm (or approximately five inches) of rain in less than two hours, causing extensive flooding in many neighbourhoods.

Alongside the devastating personal cost, more frequent extreme storms result in costly infrastructure repair and replacement. The total replacement value for stormwater infrastructure assets in the City of Mississauga was estimated at $1.7 billion in 2011.[i] Ecological impacts such as degraded water quality and erosion have financial implications to communities.

Faced with these challenges and increasing financial constraints, we need innovative, cost-effective solutions to manage our stormwater.

Through this report I am pleased to share information on how CVC is leading the application of innovative stormwater management tools called low impact development (LID).

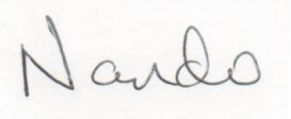
LID is part of the stormwater management solution. It is proving to be a low cost, immediate option for addressing some of our existing urban stormwater concerns. Our LID program combines investment in LID demonstration sites with monitoring and knowledge transfer. It is guided by stakeholder needs and designed to address questions regarding implementation, operations, performance and maintenance.

Our 11 in-the-ground LID demonstration sites, implemented with support from over 40 private and public partners including the province of Ontario's Showcasing Water Innovation Fund, are showing the potential of LID in various land types including industrial-commercial lands, road right-of-ways and public and residential lands. Our monitoring information is filling critical information gaps about long-term LID performance and life cycle budgeting. Results are informing decisions about how to optimize LID performance alongside conventional stormwater management systems and expand the use of LID applications throughout the watershed.

Through our partnerships with provincial, national and international LID experts, we hope to show how LID provides tools that meet community and watershed needs.

I hope this report provides you with the information you need to advance your work on LID. Thank you for sharing in our progress. We welcome your feedback.

Sincerely,



Nando Iannicca, Chair of Credit Valley Conservation, City of Mississauga Councillor

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Navigating This Report

This report describes how CVC's Water Resources Management and Restoration Group is addressing important stormwater challenges in the Credit River watershed.

It highlights the impacts of recent extreme storm and flooding events and explains how CVC is working with partners to deliver innovative stormwater management solutions.

The report is designed to allow partners and stakeholders to evaluate the success of our programs. It provides information on how partners can help advance stormwater management science.

The report is divided into several sections, providing information on stormwater challenges, stakeholder priorities, how our program and activity areas are addressing challenges and concerns, and proposed future action.

For more information about the content in this document, please visit www.BeALeader.ca or contact CVC's Water Restoration Group at sustainability@creditvalleyca.ca.

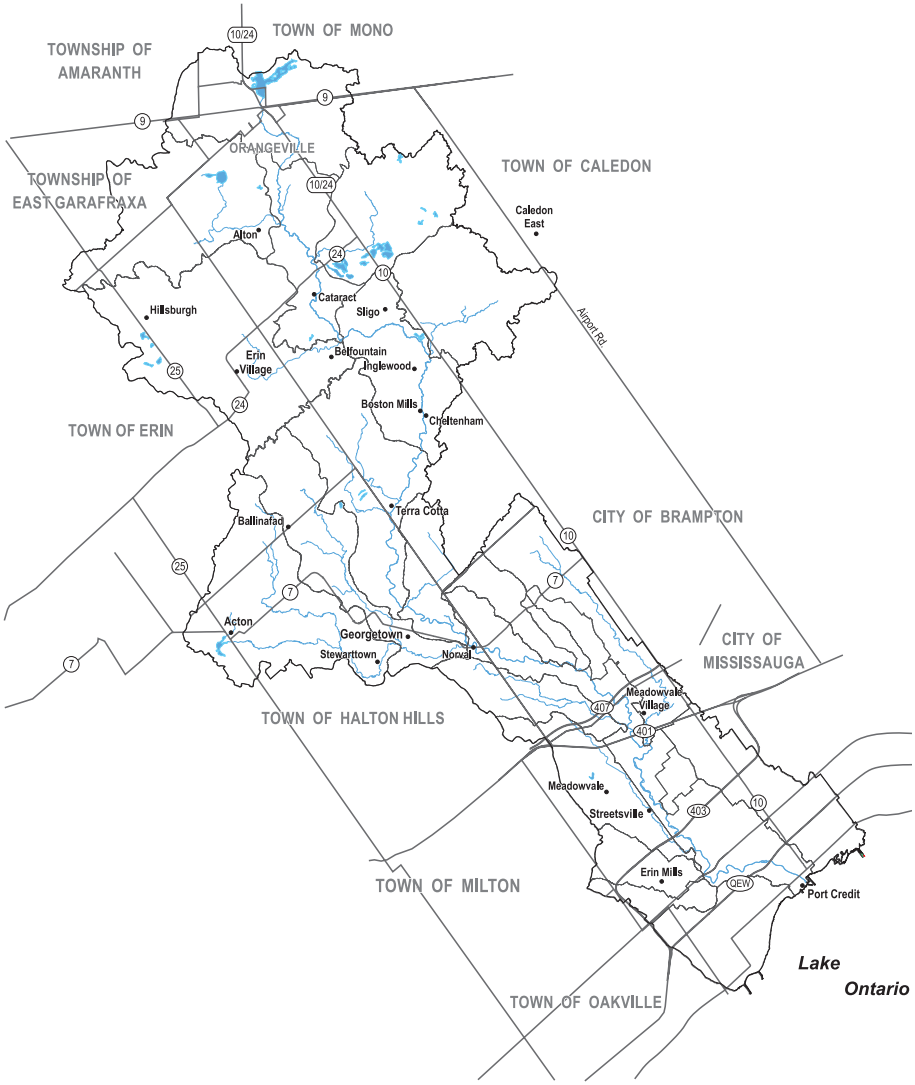
Credit Valley Conservation

Your Partner for Clean Water

Our watershed is located within one of the most densely populated and fastest growing jurisdictions in Canada. Over 700,000 people live and work within the Credit Valley Conservation jurisdiction.

The area contains unique landscapes and is home to over 1,600 species of plants and animals as well as 1,500 km of freshwater streams and rivers. The past century has brought unprecedented change to the Credit Valley watershed. Our jurisdiction is under tremendous pressure from intensified urban land use and the increasing impacts of climate change. The economic, social and environmental outcomes of these pressures will greatly influence the way we live and interact with our surroundings in the future.

The work CVC does to lead, collaborate and innovate is helping municipalities and businesses adapt in the face of change. It is our hope that this report motivates discussion around shared challenges and inspires potential partners to get involved.



Our Watershed

A watershed is an area of land that drains to a common low elevation point such as a river, lake or ocean. The boundary of a watershed is based on the elevation and natural contours of a landscape, and often encompasses multiple municipalities. For example, a drop of water that lands anywhere inside the boundary of the Credit River watershed will eventually end up in the Credit River, which flows south into Lake Ontario.

Credit Valley Conservation

Our Mandate:

CVC is a community-based environmental organization that has been working for over 60 years to ensure a clean supply of water for human and environmental needs. Through partnerships with public and private organizations both within and outside of the Credit River watershed we provide a range of activities and services that help conserve, restore, develop and manage natural resources in the jurisdiction.

The CVC mandate is to understand the natural character of the Credit River watershed and embark on a program of conservation that includes:

- Development of regulations and permitting.
- Oversight of water resources and natural heritage.
- Ownership of sensitive land for protection, appreciation and recreation where compatible.
- Stewardship initiatives with residents and landowners.

Water Resources Management & Restoration

Our Approach:

Through a wide range of activities and programs, CVC's Watershed Knowledge department is working with partners "to ensure abundant, safe, clean water for environmentally, socially and economically healthy communities within the Credit River watershed".

We provide effective, cost-efficient services that support local governments and businesses in their efforts to reduce environmental impacts and safeguard themselves against water-related risks.

Our watershed management work focuses both on present and future issues and needs. CVC's Watershed Knowledge department works to:

- Identify resilient, cost-effective solutions for drinking water, sewage and stormwater system challenges to ensure sustainability.
- Listen and engage with partners and stakeholders to address information gaps and uncertainties about innovative stormwater management.
- Discover opportunities to design and build innovative stormwater management demonstration sites.
- Consult with our Expert Advisory Committee to develop and implement strong monitoring programs to better understand stormwater management performance and address information gaps.
- Change the way people interact with the rivers, streams and lakes around them and raise awareness about potentially harmful activities.

A Leader in Smart Solutions to Stormwater Management

Through our innovative demonstration sites and monitoring program, CVC is advancing the science of stormwater in the Credit River watershed and addressing our stakeholder priorities and concerns about:

- Maintenance requirements
- Life cycle costs
- Water quality and quantity performance
- Building resiliency
- Erosion and sediment control

Our performance data helps municipalities respond to requirements in the Province of Ontario's *Water Opportunities Act, Great Lakes Protection Act, Planning Act.* It can also help address local municipal risks and liabilities associated with stormwater infrastructure by informing asset management plans, design guidelines and criteria.

Our work on low impact development (LID) has contributed to the Province of Ontario's goal of becoming North America's water innovation leader by 2015 through sustainable water, wastewater and infrastructure planning.

Investing In Success

With support from funding agencies and partners, CVC is expanding LID knowledge and increasing awareness of the benefits of LID. As of 2013, CVC received $3.55 million in financial and in-kind support from funders, industry and public partners to support LID efforts in improving stormwater management, reducing costs, and protecting our watershed. By investing in LID, our partners take a proactive approach to managing stormwater risk and protecting the health of our environment.

Ribbon cutting ceremony for a LID demonstration site

Growing Local Green Business

CVC has engaged over 3000 storm water professionals across Canada and the USA on innovative stormwater management approaches using workshops, site tours and guidance documents. Local business are hiring and training new staff on these practices and one business reported that 40 per cent of new work has been driven by LID and net revenue is projected to increase by $900,000 over the next five years.[ii]

The Cost of Flooding

Our climate is changing. Extreme weather events are producing stormwater volumes, in some cases, beyond the capacity of current infrastructure. With the frequency and magnitude of extreme weather expected to increase, alternative and complementary stormwater management solutions are urgently needed.

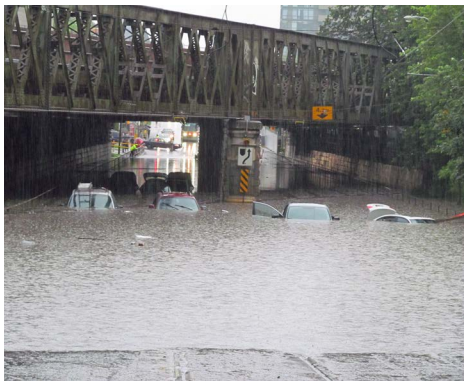
More Frequent Extreme Weather

Almost every year since 1995, Ontario has had a state of emergency linked to severe weather.[iii] The City of Windsor saw extreme events that caused severe flooding in 2007 and 2010. Additionally, 2011 was the wettest year on record in Windsor.[iv] The Ottawa region experienced one extreme event every year for over five years and in the GTA there have been four extreme rainfall events in the past ten years[v]. These high intensity storms produced heavy rainfall in very short periods. Large volumes of stormwater runoff overstress conventional stormwater systems leading to flooding, erosion, habitat destruction, degraded water quality, damage to infrastructure systems and post-flooding health-related concerns including mould growth and contaminated water.

In July 2013, the GTA experienced its most severe storm event in 60 years. Nearly five inches (126 mm) of rain fell in a two-hour period. In comparison, during Hurricane Hazel (a devastating event in 1954 where 81 lives were lost) the two-hour maximum precipitation was 91 mm and over two days was 285 mm.[vi] Conventional municipal drainage systems could not carry stormwater away fast enough. Roads and highways were overcome with floodwater closing major transportation corridors including Highway 427. GO Train passengers were stranded, and power outages and basement flooding were widespread with property damage of approximately $1 billion.[vii]

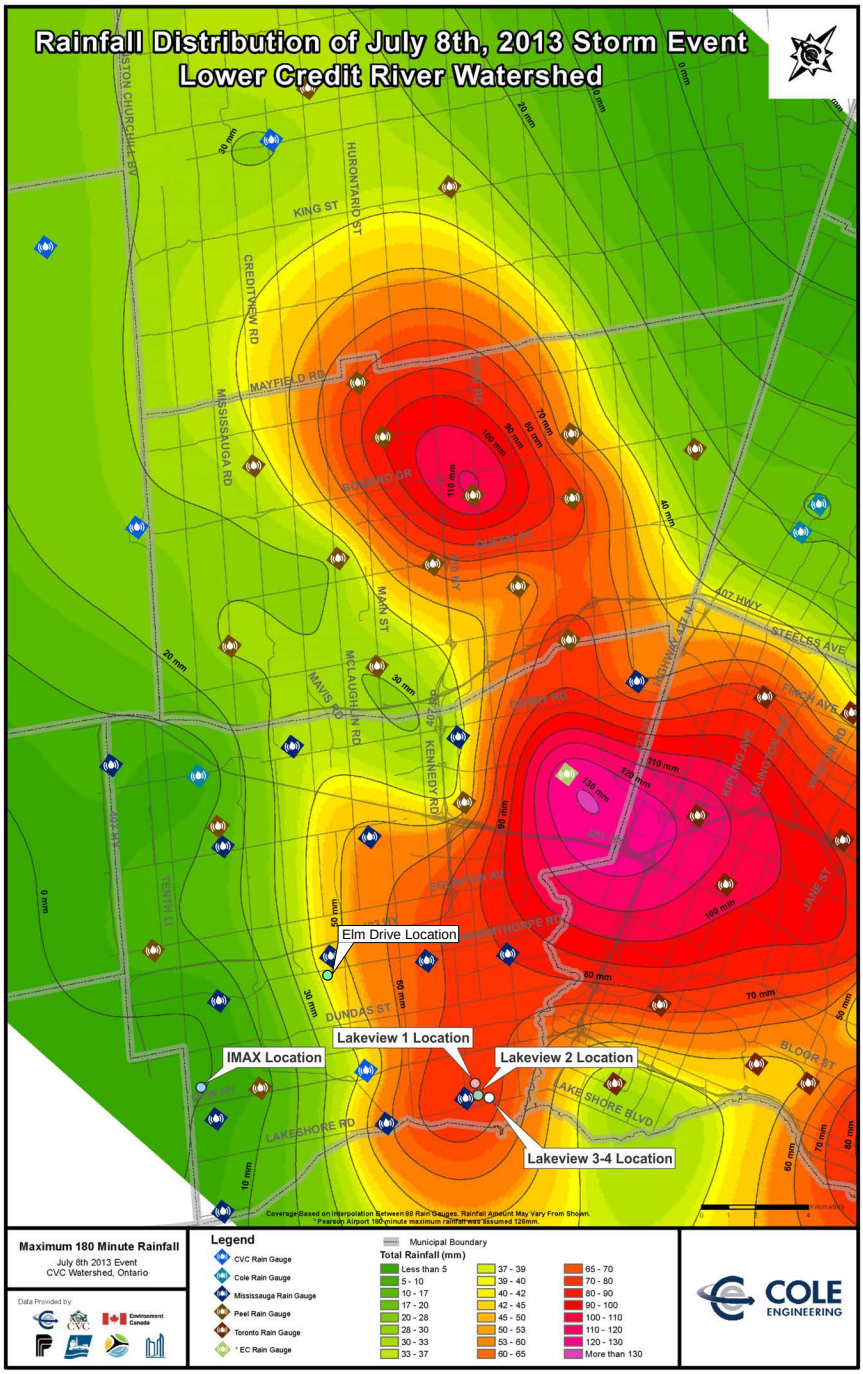
"I've never seen anything like this before ever in my community. A lot of (people) don't have insurance, there are young people living in basement apartments who not only don't have any more possessions but they don't have a place to live."

- Jim Tovey, Councillor Ward 1 Mississauga in Response to July 8, 2013 Flooding[viii]



During the July 8th storm, areas of Toronto experienced sudden flooding that caused extensive property damage

Photographs courtesy of www.teenaintoronto.com



The storm of July 8th was severe because of the intensity of rainfall. The intensity far exceeded the capacity of the storm sewer system. Runoff was conveyed along city streets to creeks and rivers. As a result, most of the flooding occurred along transportation corridors, in basements and exposed infrastructure such as electrical substations.[ix]

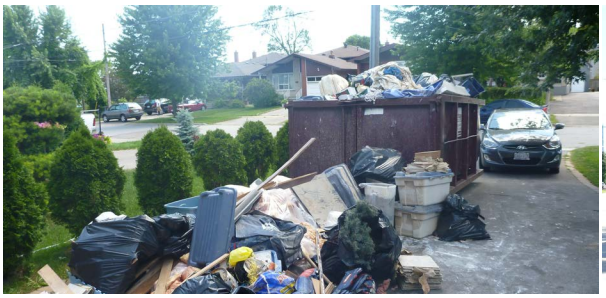
Tim Mereu,
Water Resources Engineer, Toronto

Costs are Adding Up

When extreme weather causes flooding, the impacts are damaging and costly to public infrastructure, private property and the natural environment.

Increasing Insurance Claims

Insurance claims submitted after major storm events in southern Ontario show the rising financial impacts of extreme weather. As a result, insurance coverage is expected to be more expensive and may be limited in the future. Claims only account for a small portion of the actual cost of damage because not all losses can be recovered through insurance, as flooding due to overland flow is often not covered. Overall costs due to loss and damage are estimated to be much higher.



Basement flooding from the July 8 storm caused significant property damage in Mississauga's Lakeview neighbourhood

Insurance Claims associated with extreme weather in the GTA[x,xi]

Date	Location	Insurance claims submitted
July 2004	Peterborough	$100 million
August 2005	Toronto	$500 million
July 2009	Hamilton	$200 million
July 2013	Mississauga/Toronto/Brampton	$1 billion

Lost Revenue

The International Joint Commission states that urban stormwater is one of the leading threats to our Great Lakes. Beach closures and reduced recreational fishing due to poor water quality contribute significantly less income to local economies. The economic loss from beach closures and reduced recreational fishing is estimated to be up to $87 million annually.[xii]

Erosion Prevention Costs

Erosion protection is necessary and is not exclusive to extreme events. Erosion prevention is currently underfunded in the Credit River watershed and more investment is required to meet today's erosion control standards. In the City of Mississauga, over $40 million is needed for erosion protection of one creek over a 10 year period.[xiii]

Water-related damages associated with urban flooding are the leading source of Canadian personal property insurance claims. Approximately 40 per cent of all personal property claims are associated with water-related damages. [xiv]

Greater Risk and Liability

More frequent and intense urban flooding is an increasing liability, particularly in older developed areas. During the post-war development boom many municipalities across Canada were established without long-term flood and water quality control measures. Between 60 and 75 per cent of the GTA was built prior to flood control.[xv] With more frequent storms, the risk of damage due to flooding grows. Flood-related class-action lawsuits against municipalities, conservation authorities and the province for damages due to flooding are becoming more common. Lawsuits can be a significant threat to municipal finances. The City of Stratford recently issued a $7.7 million settlement from a class action lawsuit, eight years after the flooding event occurred.[xvi]

Drought conditions at Island Lake in the summer of 2007

Impervious surfaces prevent infiltration resulting in runoff during rain events

Adapting to New Stormwater Management Realities

Our approach needs to change in order to stay ahead of stormwater challenges. We need to think of stormwater management not just in terms of dealing with storms, but as managing our water cycle during dry periods to optimize water and waste water. We need to be able to manage extreme rainfall events such as the July 8, 2013 storm, combination events like the excessive rain and snow runoff causing the Bow River flood in Calgary in 2013, and extended periods of drought as occurred in southern Ontario in 2007. These types of events are increasing in frequency.

As municipalities grapple with these new climate realities and their associated costs, they are rethinking how to manage stormwater using a variety of innovative solutions. Faced with increased weather-related damages, delays in upgrading and constructing new infrastructure facilities, and reduced insurance coverage, they want real solutions now.

Managing the Urban Water Cycle

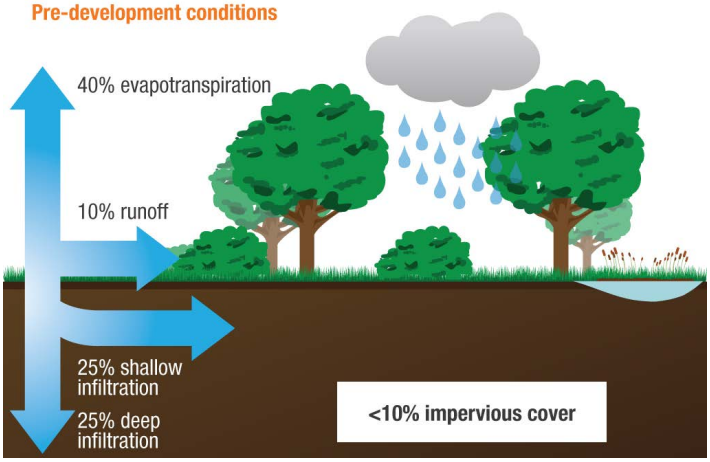
Recent studies show conventional stormwater management pipe and pond configurations alone generally do not meeting thermal, water quality and water balance objectives. Innovative stormwater management aims to manage the runoff component of the water balance at the source. Permeable surfaces in urban environments facilitate infiltration and reduce runoff, mimicking a more natural hydrological regime. The figures on the following page illustrate the natural and urban water cycle and show the influence of innovative stormwater management on the urban water cycle.

Natural vs Urban Water Balance

In a natural setting - few rain events each year produce stormwater runoff. Performance monitoring has found that runoff from LID facilities is similar to natural ground cover. This reduction in runoff relieves pressure on stormwater infrastructure and receiving watercourses.

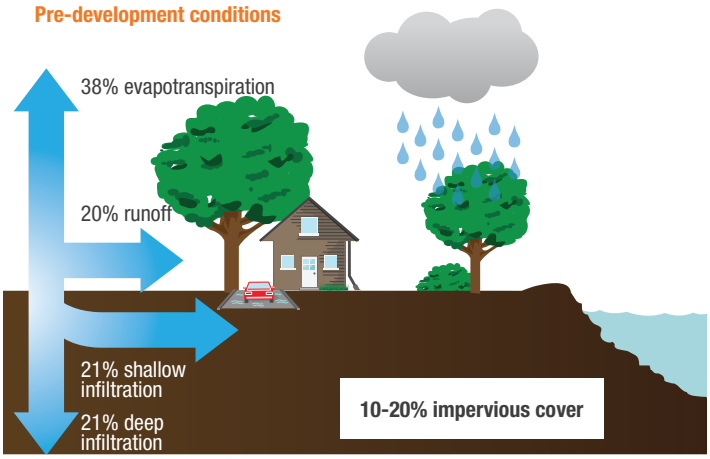
Natural Ground Cover

Pre-development conditions



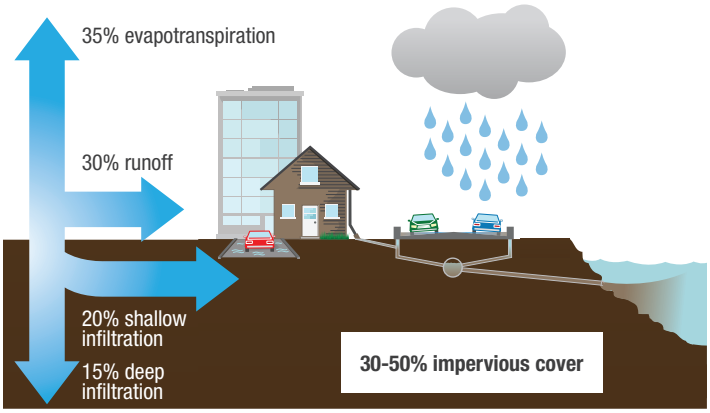
Rural Hydrology

Pre-development conditions



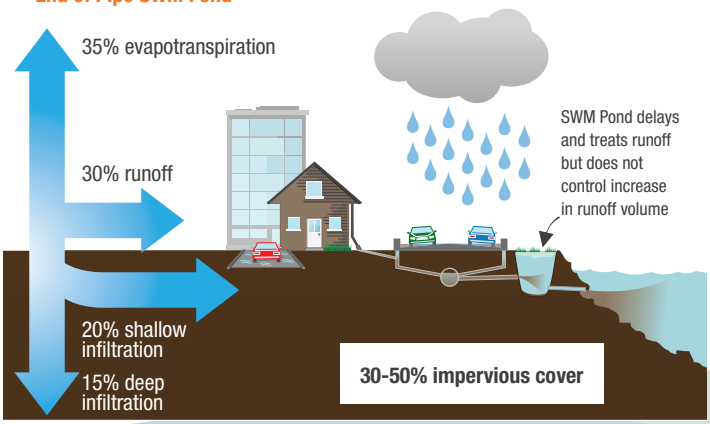
Urban Hydrology

Typical pre 1990's development : No water quality stormwater control



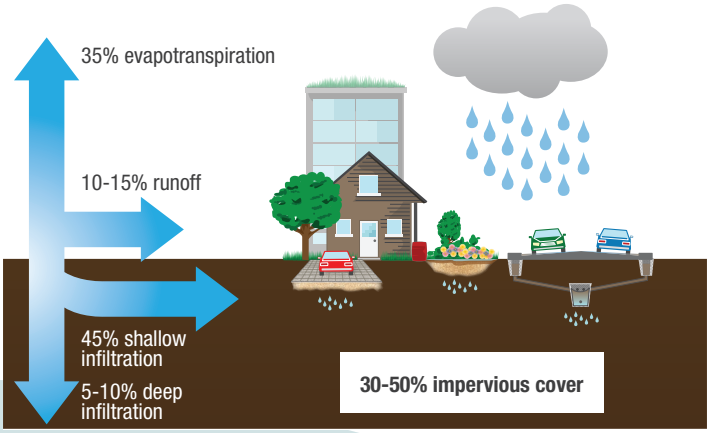
Urban Hydrology

Typical development: Stormwater management using End of Pipe SWM Pond



Urban Hydrology

Development with Low Impact Development



Adapted from FISRWG, 1998[xvi]

The Low Impact Development Advantage

CVC and municipalities have been managing the risk of damage from floods, through methods that include limiting development in floodplains and upgrading and adding additional stormwater infrastructure. The later can be time consuming and costly as it may require land expropriation.

LID is gaining wide acceptance across Canada and the US as a way to supplement existing stormwater management infrastructure and help relieve damage from flooding and drought while conventional practices are upgraded.

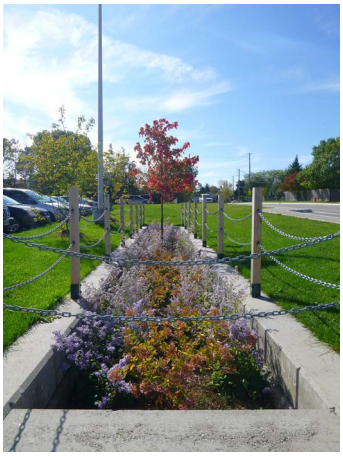
What is LID?

LID is a stormwater management strategy that helps reduce the impacts of stormwater by collecting and treating runoff as close to its source as possible.

Mimicking Nature to Manage Impact

LID technologies are designed to mimic the natural movement of water in the environment. They are engineered landscape features that infiltrate, filter and store stormwater runoff. They also provide surfaces for evaporation to occur. By emulating natural or pre-development conditions at a site, LID technologies help reduce the volume of runoff, removing nutrients, pathogens and metals. LID technolgies can also restore groundwater and stream flows, support waste water dilution, protect our fisheries and enhance human well-being.

When incorporated into multiple locations and different land use types across a watershed, LID is an effective tool for managing the impacts of stormwater such as erosion, degrading water quality and associated costs. LID also helps to protect natural features and biodiversity.



Benefits of LID

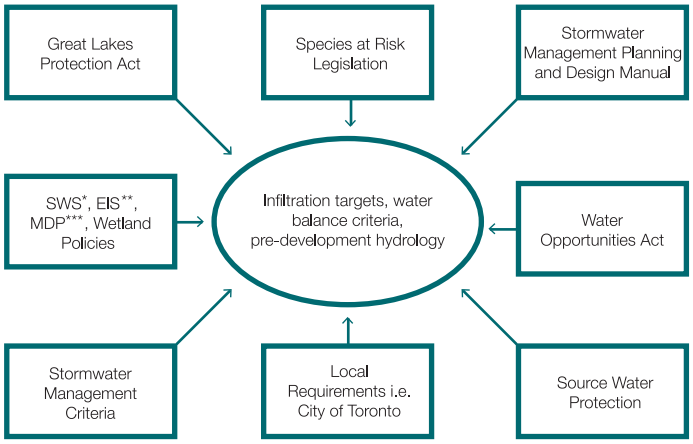
LID provides direct and indirect benefits to the environment, human health and the local economy.

Direct Benefits	Indirect Benefits
Decreases runoff volume and peak discharges	Increases green space, creating healthier living and work environments
Improves water quality through on-site natural filtration	Creates local green jobs
Reduces erosion	Contributes to wildlife habitats
Replenishes groundwater resources	Reduces urban heat through permeable surfaces
Improves climate change resilience	Decreases beach closures and increases fishing activities leading to greater revenues from tourism, supporting Ontario's economy
Reduces water-related infrastructure damages	Lowers road maintenance costs
Reduces spending on: • municipal infrastructure fixes and upgrades • land acquisition for stormwater management • traditional stormwater infrastructure	Enhances property values
	Increases road safety with traffic calming measures
Maintains or enhances source water quality, improving wastewater treatment plant assimilation and reducing drinking water treatment needs	Reduces road noise levels through vegetation buffers
Creates less strain on wastewater treatment plants and combined sewer outflow systems during wet conditions	Vegetation absorbs carbon dioxide

Policy Drivers for LID

Ontario's *Water Opportunities Act, Great Lakes Protection Act*, *Planning Act*, and the Ministry of the Environment and Climate Change identify the need to adopt LID for new development and LID retrofits for existing urban areas, in order to address impacts of climate change and urbanization on stormwater management infrastructure.

Ontario Policies - Drivers for LID



* SWS – Subwatershed Study
** EIS – Environmental Impact Study
*** MDP – Master Drainage Plan

An Effective, Low Cost and Rapid Response Solution

Implementing LID practices saves money for developers, property owners, and communities while preserving water quality, reducing erosion risk, protecting fisheries and recreational uses.

LID road retrofits save 25 per cent on average compared to traditional stormwater management practices.[xix]

LID projects are easy to incorporate into new developments, urban retrofits or redevelopments. They require less land area and are adaptable to different land types and conditions, providing planners and designers with tools to optimize land and protect natural features. LID retrofits cost less than conventional curb and gutter systems.

The United States Environmental Protection Agency showed construction cost savings ranging from 15 to 80 per cent, with an average of 25 per cent using LID compared to conventional stormwater management.[xx]

Various funding sources are available to municipalities to support investment in stormwater infrastructure including the federal Gas Tax Fund. The Gas Tax Fund is a long-term, flexible and predictable source of funding for municipalities to invest in infrastructure and long-term planning projects that improve asset management. These investments can be made in 17 categories of infrastructure, including stormwater.[xviii] In Ontario, the Gas Tax Fund is administered by the Association of Municipalities of Ontario and distributed to municipalities on a per-capita basis. Several municipalities in Ontario are using the Gas Tax Fund to invest in stormwater management. In 2012 alone, 18 stormwater-related projects were completed, benefiting from Gas Tax Funds.

The Gas Tax Fund can be used as the sole source, or one of multiple funding sources to fund up to 100 per cent of an infrastructure project.[xxi]

The Economic Side of LID: Local Green Jobs

LID projects built through CVC's Showcasing Water Innovation grant help raise the profile of LID. One local landscaping and eco-consulting business is seeing an increase in their services related to LID. One local business reported that 40 per cent of new work has been driven by LID and that net revenue is expected to grow by $900,000 over the next five years.[xxii] With higher profit, companies are also able to train and hire more employees.

A Real World Test of LID: Elm Drive Demonstration Project

CVC's LID demonstration site at Elm Drive in Mississauga is proving that in addition to managing normal rainwater and stormwater conditions, LID can also help reduce extreme weather impacts. Although not designed to control stormwater generated from an extreme weather event, monitoring results show that the Elm Drive LID provided effective stormwater infrastructure relief during the July 2013 storm event.

Severe storm performance of LID at Elm Drive included:

- Delayed the peak discharge of stormwater by 20 minutes, slowing the rate at which stormwater entered already overburdened storm sewers.
- Volume reduction of 30 per cent, reducing stress on infrastructure, helping to control erosion and reducing pollutants entering storm sewers and streams.
- Rapidly infiltrated stormwater into soils, avoiding water pooling.
- Withstood the storm, suffering no damage and requiring no maintenance after the event.
- The performance of Elm Drive showed that simple, low cost LID practices provide resilience and interim solutions during extreme events. This has led to the City of Mississauga passing a "First-of-its-Kind" Council Resolution 0046-2014 in March 2014. This has led to the City of Mississauga passing a Council Resolution 0046-2014 in March 2014 that all future capital roads projects must consider the use of LID.

Bioretention cells and permeable pavers at Elm Drive

LID Performance Monitoring

As a relatively new stormwater management technology, monitoring LID is a critical part of successful implementation. Municipalities, developers and landowners spend a lot of money to design, build and operate stormwater management facilities and systems. Monitoring provides valuable information to operators, decision makers and stakeholders about the performance of systems, how to reduce risks and costs, and ensure they have control over stormwater investments.

CVC is working actively with partners, suppliers, the development community, municipalities and the province to address stakeholder priorities through LID monitoring. This will help lower costs, reduce risk and build resilience into stormwater management.

About CVC's Storm Water Monitoring

CVC conducts storm water monitoring in three main areas. Through CVC's Infrastructure Performance and Risk Assessment (IPRA), CVC monitors individual facilities at the site level including conventional end-of-pipe systems and LID practices.

Monitoring activities include:

- **Compliance Monitoring** to evaluate whether a system is working as designed to meet minimum acceptable requirements.
- **Performance Monitoring** to measure how well an LID practice performs against design objectives and targets. This allows for comparison with other facilities, technologies, and/or development contexts.
- **Adaptive Monitoring** to assess how a practice can be improved, for example to improve water quality, meet hydrologic goals, last longer, require less maintenance or meet the challenges of climate change.

Reducing Risk and Supporting Investment through LID Monitoring

CVC's IPRA program is a multi-year stormwater monitoring program focusing on gathering detailed information to evaluate stormwater performance in various land use types and climate conditions. IPRA looks at the effectiveness of flood control, erosion protection, nutrient removal, cold climate performance and maintaining pre-development water balance.

The IPRA program is designed to identify opportunities to reduce stormwater risks and provide data required for future infrastructure investment and planning. To ensure the program meets stakeholder needs and produces leading edge information, CVC is working with an Expert Advisory Committee consisting of municipalities, regional government, Ontario's Ministry of the Environment, consultants, universities and industry.

To advance the use of stormwater designs and practices, CVC is working with partners and stakeholders to address their questions about performance, operations, implementation and maintenance.

Consulting Our Stakeholders to Identify Needs

In December 2012, CVC held an engagement session with stakeholders and experts in the industry to identify the top priority monitoring objectives related to LID. Participants completed a survey ranking CVC's 19 stormwater monitoring objectives based on their own information needs and importance to their organizations.

Participants included:

- Municipal decision makers
- Provincial and federal environmental agencies
- Engineering and planning professionals
- Conservation authorities
- Academics
- Watershed groups

Stakeholder engagement session for LID objectives

Our LID Monitoring Priorities

Our stakeholders identified top priorities to help maximize the benefits of investment in LID, and provide the data needed to develop long-term solutions for stormwater management plans. Our monitoring priorities in order of importance include:

Maintenance requirements: Understanding long-term maintenance needs and programs, and the impact of maintenance on performance

Life cycle costs: Determining the life cycle costs for LID practices

Water quality and quantity performance: Assessing the water quality and quantity performance of LID designs

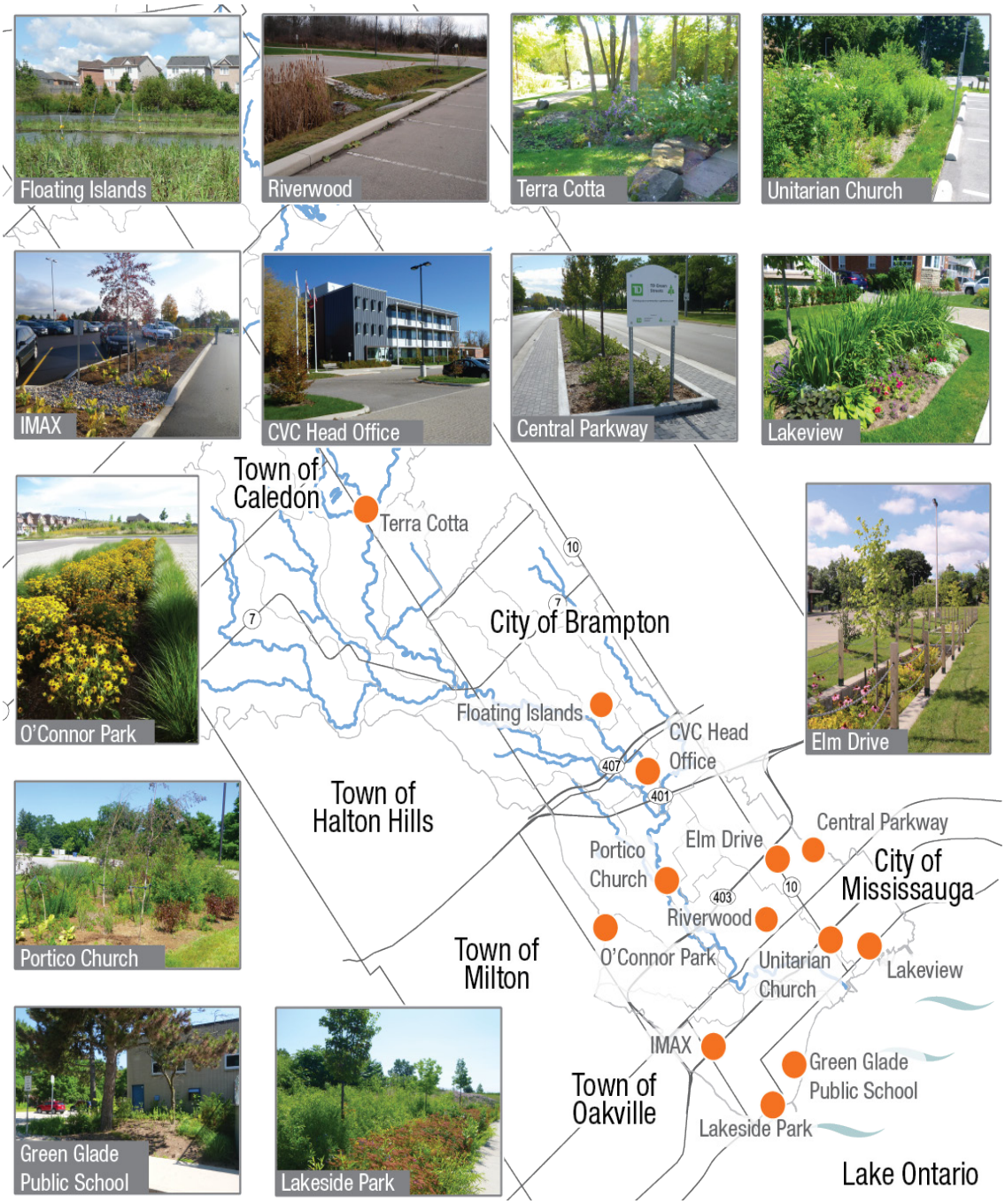
Building resiliency: Understanding how a site with multiple LID practices treats stormwater runoff and manages stormwater quantity as a whole

Flood and erosion control: Understanding how effectively LID systems provide flood and erosion controls and support water quality, help to recharge the water table and protect natural features

Our LID Monitoring Demonstration Sites

CVC has supported the implementation many LID sites in Mississauga and across the watershed. CVC is currently reporting on the performance of 13 LID demonstration sites. CVC monitors LID sites including retrofits to public land, rights-of-way, residential, and commercial/industrial sectors.

Our monitoring data shows that our sites perform well compared with other North American examples. To share lessons learned, CVC has developed a series of design, construction, retrofit and monitoring guides. The guides are intended to make it easier for engineering, landscape and construction professionals to build effective LID practices in different municipalities. They can be found at www.BeALeader.ca.



Addressing our Stakeholder LID priorities

This section highlights how our LID demonstration sites that are a part of the IPRA program are meeting stakeholder priorities.

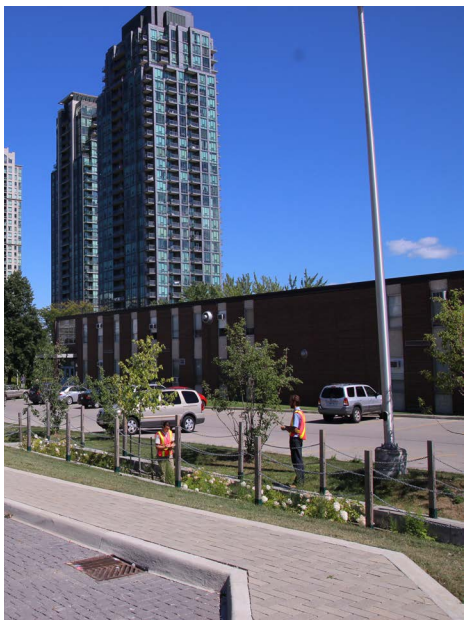
Elm Drive

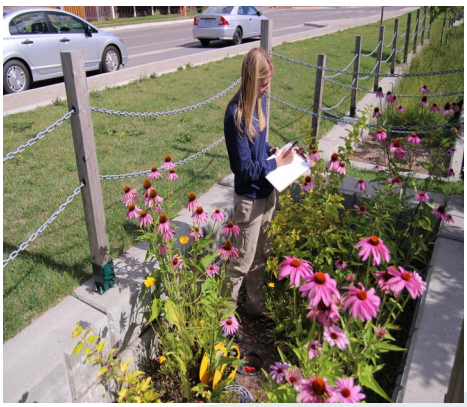
Location: Mississauga

Constructed: May 2011

Type of LID: Green street retrofit

Goal: Improve stormwater quality and reduce runoff at the site





Located in the heart of downtown Mississauga, two blocks away from Square One Shopping Centre, Elm Drive is a mixed-use street with residential homes and an Adult Education Centre owned by the Peel District School Board. LID at Elm Drive involves a treatment train of permeable pavement and bioretention planters (or rain gardens). Runoff is directed into the LID technologies, where pollutants are filtered out and cleaner water enters Cooksville Creek and eventually Lake Ontario, our drinking water source.

Water quantity control

- For the majority of rainfall events, little to no stormwater runoff leaves the site. From 2011-2015, 285 events were monitored with an average total runoff volume reduction of 80%. Only approximately 12 events produce runoff in a given year replicating a more natural water cycle in an urbanized setting to support the local ecosystem and reduce stress on existing stormwater management infrastructure.
- Approximately 90% of the storm events were less than 25 mm and had a total runoff volume reduction of 93 per cent, reducing stress on local infrastructure and streams.
- Peak flow reductions surpassed design estimates. For the two-year to five-year storm events (events with 33 to 45 mm rainfall in 4 hours), peak flow was reduced by 66 to 95 per cent.

Water quality control

- For the 12 events per year that produce runoff to the municipal sewer, negligible pollutants entered Cooksville Creek and Lake Ontario.
- Total suspended solid removal was 88 per cent compared to 80 per cent removal criteria in conventional stormwater ponds. This is comparable to an international database and in some cases outperforms similar LID features listed in the database. For total phosphorous the load reduction was 91 per cent.
- Load reduction performance results show that for all parameters an estimated load reduction of at least 86 per cent with the exception of nitrate, which was 60 per cent.

Long-term maintenance needs

- The maintenance requirements at Elm Drive have been document since 2011 using inspection checklists and photo logs to establish the long-term maintenance needs for different LID treatments such as permeable pavement and bioretention units. With continued funding, long-term maintenance monitoring at Elm Drive will help determine life cycle costs for LID features.

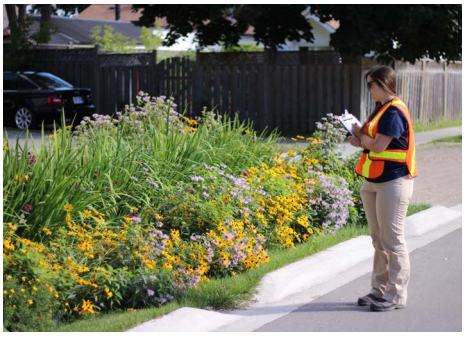
Lakeview

Location: Mississauga

Constructed: August 2012

Type of LID: Roadside and road right-of-way retrofit

Goal: Reduce stormwater runoff and improve water quality flowing into storm sewers



The Lakeview Green Street project uses enhanced roadside bioretention planters (or rain gardens) and permeable pavement driveways to reduce stormwater runoff and improve water quality flowing into storm sewers and eventually into Lake Ontario. This project is the first-of-its-kind" in Canada. It replaces traditional curb, gutter and buried sewer systems. Monitoring stations compare the performance of traditional curb and gutter, and open ditch systems against LID rain garden and permeable pavement.

Water quantity control

- Preliminary results show that the Lakeview bioretention boulevard units are able to completely infiltrate rain events up to 25 mm. These event account for 90 per cent of annual rain events.
- The overall volume reduction of 92 per cent reduces stress on infrastructure, helping to control erosion and reducing pollutants entering storm sewers and Lake Ontario.
- The LID bioswale had an overall load reduction of 93 per cent removal for total suspended solids and 83 per cent removal of total phosphorous.

Water quality control

- Water quality control is provided by volume reductions and filtration through the LID practice
- The LID bioswale had an overall load reduction of 93 per cent removal for total suspended solids and 83 per cent removal of total phosphorous.
- The performance results observed at Lakeview are consistent with the results entered in International Stormwater Best Management Practices Database for similar LID facilities.

Early detection of construction deficiencies

- Monitoring highlighted deficiencies in construction which were able to be fixed quickly to ensure optimal performance and reduce maintenance.

IMAX

Location: Mississauga

Constructed: Fall 2012

Type of LID: Parking lot retrofit

Goal: Collect, absorb and filter pollutants from stormwater runoff before it flows to nearby waterways

The IMAX corporate head office, located in Mississauga, is a demonstration site for LID on industrial-commercial properties. The renovated parking lot incorporates a variety of technologies that collect, absorb, and filter pollutants from stormwater runoff before it flows into Sheridan Creek and into Lake Ontario. CVC installed seven monitoring stations to assess the performance of LID practices, both individually and collectively.

Water quantity control - Permeable pavement

- Permeable pavement is effective at reducing runoff even with poorly infiltrating soils. The average infiltration rate of the permeable pavement treatment is 4500 mm/hr. In the winter it is 1500 mm/hr.
- All bioretention units surpass the surface ponding drawdown criteria of 24 hours.
- Volume reductions at IMAX show that LID is successful at controlling stormwater runoff in areas that have native soils with low permeability. The overall volume reduction for rain events less than 25 mm ranged from 64 to 90 per cent for the bioretention treatments. For the permeable pavement treatments it was 62 to 99 per cent.

Water quality control - Permeable pavement

- The IMAX site showed good load reductions for total suspended solid and total phosphorous reducing the pollutants entering Sheridan Creek and Lake Ontario. Load removals for total suspended solids are outperforming the criteria of 80 percent removal for conventional stormwater ponds.
- Pollutant load reductions for the bioretention units for rain events less than 25 mm were 97 to 99 per cent for total suspended solids and 57 to 90 per cent removal for total phosphorous.
- For the permeable pavement treatments load reductions were 93 to 100 per cent for total suspended solids and 92 to 100 per cent for total phosphorous.

Improved function and cost savings

- The parking lot retrofit provides a better functioning parking lot with improved aesthetics and drainage.
- Issues such as year round ponding posed by the old parking lot have been eliminated as a result of the parking lot retrofit. Routine site visits and maintenance inspections have shown good drainage with no undesired ponding.

CVC Head Office

Location: Mississauga

Constructed: 2012

Type of LID: Parking lot retrofit

The CVC head office building features low impact development practices including a rainwater harvesting system to supplying grey water for toilet flushing and irrigation. It also has a permeable pavement parking lot with grass swales. Performance findings are based on 2013 to 2015 monitoring results.

Monitoring data and analysis has shown:

- 67% volume reduction for rainfall events less than 25 mm
- 81% total suspended solids removal
- 69% total phosphorus removal
- Median of 81% reduction in peak flows over all events
- Since monitoring was initiated 400 000 L of water has been reused, representing a cost savings of $845. This supports CVC in applying for the City of Mississauga's stormwater credit program.

Riverwood Conservancy

Location: Mississauga

Constructed: Early 2000s

Type of LID: Parking lot retrofit

The Riverwood Conservancy is located in central Mississauga and near the east bank of the Credit River. The main parking lot for the Riverwood Conservancy includes a bioretention swale. Parking lot runoff enters the bioswales through the curb cuts for bioswale treatment. Performance findings are based on 2010 to 2012 monitoring results.

Monitoring data and analysis has shown:

- The Riverwood bioswale reduces the volume of rain events by a median of 70%
- Benefits for water quantity and quality include:
- 65% volume reduction for rainfall events less than 25 mm in size
  - 89% total suspended solids removal
  - Median of 80% reduction in peak flows over all events

Central Parkway

Location: Mississauga

Constructed: 2014

Type of LID: Road retrofit

A wide median on Central Parkway East in Mississauga was retrofit in the existing streetscape and will serve as a demonstration for stormwater management. This tree-lined planter will serve dual functions as bioretention/filtration of stormwater and beautification/aesthetic improvement. The bioretention system created within the median will utilize the DeepRoot Silva Cell system, a modular suspended-pavement soil cell system. Performance findings are based on 2015 monitoring results.

Monitoring data and analysis has shown:

- Average peak flow reduction of 96%
- Average volume reduction of 97%
- 98% volume reduction for events less than 25 mm (5 of the 8 monitored events are less than 25 mm)
- These findings are consistent with CVC's other monitored roadside LID sites

Floating Islands

Location: Brampton

Constructed: 2011

Type of LID: Stormwater pond retrofit

The floating islands are located in Brampton, ON. The islands are located within a stormwater management pond on property owned by the City of Brampton that drains into Fletcher's Creek. The intent of the islands was to reduce the temperature and improve the quality of stormwater. Each island is comprised of a ThermaGreen MD50, base material fabricated for this type of application. Performance findings are based on 2011 to 2012 monitoring results.

Monitoring data and analysis has shown:

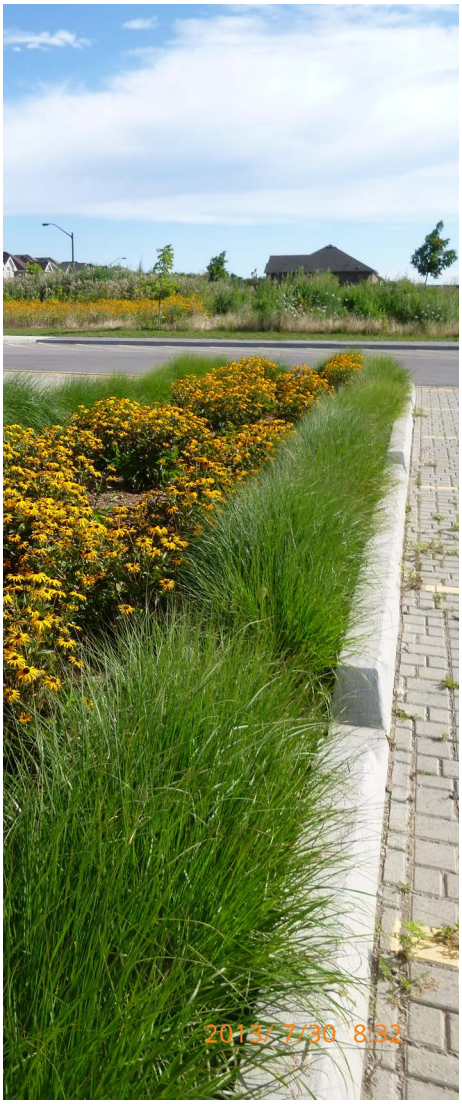
- Temperature difference between top and bottom layers ranged from 0.4°C to 13.5°C in 2011 and from 0.1°C to 8.4°C in 2012. This suggests that the thermal benefits were more prominent when the island vegetation was fully developed in the second year of study. The mature island vegetation resulted in less stratification, therefore reduced chances of anoxic discharge being released.
- Outlet temperatures occasionally exceeded the redside dace target temperature of 24°C but were always less than inlet temperatures for the storms analyzed in this study. This indicates that the islands mitigated thermal impacts by providing cooling and mixing.
- Floating island thermal benefits largely depended on rainfall duration, time, and intensity and air temperature.

Public Lands

Location: Mississauga

Constructed: 2012

Type of LID: Parking lot retrofit



The public lands sites have been built or retrofitted with green infrastructure (typically bioretention and/or permeable pavement) to reduce environmental impacts of stormwater runoff while increasing the aesthetic appeal of public spaces. Each public lands demonstration site is unique in its design. Performance findings are based on 2013 to 2014 monitoring results.

Monitoring data and analysis has shown:

- All Public Land sites surpass the surface ponding drawdown criteria of 24 hours.
- Water level monitoring has shown that these LID sites are performing well under winter conditions.
- Property managers have indicated that maintaining bioretention features requires no more time than traditional landscaped gardens.

Building Confidence in LID

Credit Valley Conservation has reached out to multiple stakeholders to gain perspective on the perceived barriers to adoption of LID technologies. One of the best ways to build consensus, confidence and overcome perceived barriers is to install LID demonstration sites, monitor them and share results.

By working with partners and stakeholders CVC has been able to install and monitor LID demonstration sites to address common perceived maintenance and lifecycle costing barriers. These sites have also provided the performance data needed to build confidence in LID. The following section shares some of the lessons learned and how they can be used to overcome obstacles to wide scale implementation.

"Everything is either an opportunity to grow or an obstacle to keep you from growing. You get to choose."

Wayne Dyer

Common Misconception: LID Maintenance will be costly and onerous

What we have found through Monitoring:

To answer stakeholder concerns about maintenance and lifecycle costs, CVC is assessing the construction and maintenance of LID practices. Our experience shows that maintenance requirements and costs depend on the proper selection of LID feature, landscape design and construction practices. By selecting the appropriate LID practice and landscape design for the location and land use, LID doesn't need to increase property maintenance requirements or cost.

It's important to select the right design for the right location. This can be done through communication with frequent site users. For example, municipal parks are maintained by municipal parks staff. Engaging parks staff when designing LID features within the park can provide critical information, such as selecting the plants staff are familiar with. CVC's monitoring program has found that when park staff are familiar the plants, there is no increase in operational costs compared with conventional garden features in parks. In cases where municipalities have implemented stormwater management rate systems, putting LID features into parks can be an incentive for parks and recreation staff. Operational costs for maintaining LID landscape features and permeable parking lots are generally paid through the stormwater rate instead of from the park's budget.

Lesson 1

Right design for the right location and use can minimize maintenance. Know how the land is being used.

"No additional maintenance is required at parks with LID."

- Tad Makula and Rich Hurren, City of Mississauga

The photo of O'Connor Park shows a highly visible demonstration site. The same municipal staff maintained and landscaped the grounds both prior to and after retrofitting. This site is perfect for a high impact visual interest, but it requires no more maintenance than before.

In areas where there are fewer resources or community support to maintain LID features, such as high rental occupancy residential roads, installing grassed LID features may be an appropriate option. Grass swales appear no different to residents than conventional grassed landscape. There is no extra maintenance required beyond that of a conventional lawn. They are not as deep as traditional swales so they are easier for the resident to maintain.

In retrofit conditions, designers are encouraged to see how the retrofitted landscape will be used in order to select the appropriate feature. In retrofit conditions, designers are encouraged to see how the retrofitted landscape will be used in order to select appropriate LID features The photo of cigarette butts in permeable pavers illustrates the importance of knowing about everyday site use before selecting a LID practice. This location is an unofficial smoking area. Unfortunately cigarette butts are thrown on the ground and accumulate in the spaces between the permeable pavers. The cigarette butts compromise the performance the LID feature and increase maintenance needs. This stresses the importance of knowing how the site is used and designating alternative spaces for incompatible uses.

Cigarette butts in permeable pavers

Bioretention cell at O'Connor Park

Grass swale in the Lakeview neighbourhood

Common Misconception: Residents will not maintain the LID features

What we have found through Monitoring:

One barrier preventing LID adoption in residential road rights-of-way is the belief that residents will not maintain the LID practice. In high rental areas, or areas where there is less community support, incorporating LID grassed swales may be the preferred option. Rain gardens can be installed in areas with high owner occupancy, where residents have been impacted by basement flooding or water restrictions, have a sense of community, are "eco-friendly" or where municipal staff have already initiated environmental campaigns. In the Lakeview residential neighborhood, the local councillor and community embraced rain gardens and are enhancing these gardens with their own flowers. They see these rain gardens as improving the aesthetic value. Residents from neighboring streets have approached the councillor and city to adopt these techniques on their roadways.

What we have found through Monitoring:

By installing onsite stormwater technologies, IMAX has reduced their risk of flooding through a parking lot retrofit which has added extra security in light of climate extremes. In addition to treating rainfall, the parking lot provides IMAX with substantial cost savings, as permeable pavers increase the lifespan of the parking lot. This amounts to $345 per month savings over conventional practices.

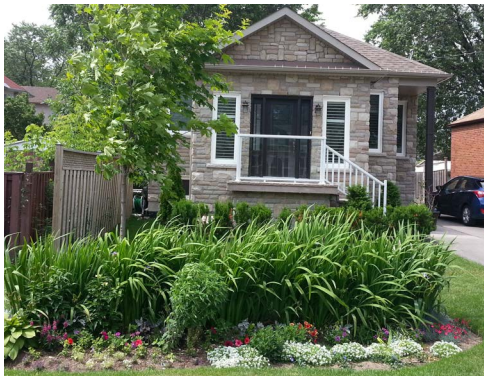
Winter maintenance inspections have shown that more salt remains on the surface of permeable pavement than asphalt where the same amount of salt was originally applied. This suggests that permable pavement surfaces require less winter road salt. With less ponding on the surface, there is a lower risk of slips and falls. Monitoring shows that the weight of the snow in the winter did not damage the plants in bioretention units.

"We are excited to take part in a construction project that is designed to manage stormwater runoff and improve water quality in Sheridan Creek. This new technology will also remedy a number of challenging maintenance issues and reduce our operating costs over the long term."

- Nancy Cole – IMAX Facility and Administration Manager

Lesson 2

Know your community when selecting LID. Designing the right LID for the right location is key.



Bioretention swale

Lesson 3

Applying the right LID can save on operating costs and reduce risks.

Road salt on permeable pavement vs. asphalt

Common Misconception: LID does not work in the winter

What we have found through Monitoring:

Our monitoring stations are set up to monitor changes in groundwater levels. Results from 11 sites show us that LID features work in the winter. Water is still able to infiltrate, reducing ponding and refreezing, and keeping catchbasins clear. CVC's monitoring results are consistent with and in some cases out perform data reported in the CVC's monitoring results are consistent with and in some cases out performing data reported in the International BMP database (BMPDB) and National Stormwater Quality Database (NSQD), and Sustainable Technologies Evaluation Program (STEP). These provide performance results and guidance that support the implementation of LID. The information provided by these sources is important to enhancing LID design and performance.. For more detailed information on specific sites, please visit www.BeALeader.ca

Permeable pavement infiltration is able to drain water in the winter at a rate of approximately 1500 mm/hr. This rate is quick enough to drain water into the space between pavers which decreases the potential for water to freeze and form ice on the surface. This improves safety, reducing slips and falls when compared to asphalt surfaces that do not drain and allow ice to form. Slips and falls can be costly. The average lifetime cost of a high-impact WSIB claim can range from $33,000 to $52,000.[xxiii]

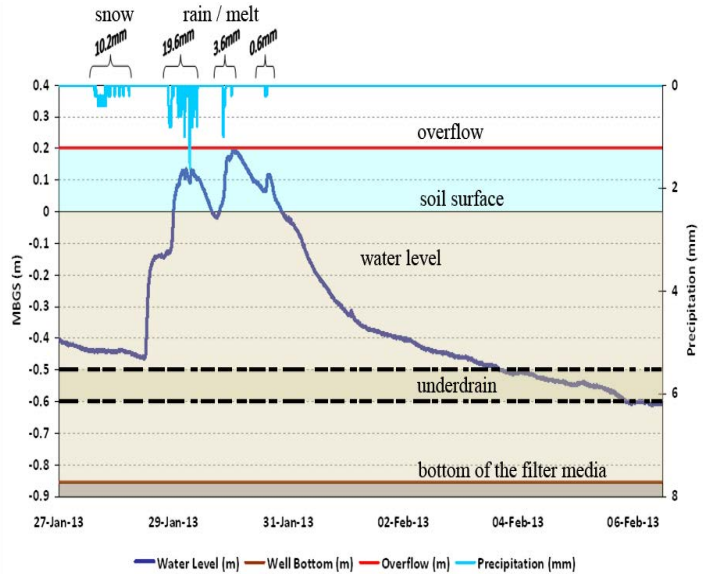
Infiltration vs. business-as-usual site ponding

Lesson 4

Water level monitoring within LID features shows they do function during winter thaws

Inlets at Portico Community Church

Landscaped LID features also performed during winter months. This graph shows water level fluctuations during winter thaws at Portico Community Church.



Common Misconception: LID does not work in clay soils

What we have found through monitoring:

Clay soils drain water more slowly than sandy soils. LID uses the natural drainage characteristics of a site, so clay soils are often considered a barrier to a successful practice. CVC's demonstration sites have been designed with this in mind. Underdrains were built into the Elm, Lakeview, and IMAX sites to help drain away excess water. Monitoring has shown that these sites are still able to control water quality and quantity during extreme storm events. Listed below is a brief summary of findings for each site:

Lesson 5

LID features can perform in clay soils.

Elm Drive (Monitoring Data Summary for 2011-2015)*

Elm Drive was designed to remove 80 per cent total suspended solids, monitoring data shows that Elm drive is actually outperforming the design by removing 88 per cent of total suspended solids including July 8, 2013 from the analysis. This exceeds Level One MOECC requirements and conventional pond performance. Unlike a conventional pond that contributes runoff and pollutants to a stream for most rainfall events, Elm Drive is able to mimic nature by capturing nearly 90 per cent of rainfall events, with only approximately 12 events producing runoff in a given year.

Elm Drive was designed to reduce the peak flow of a 33 mm and 45 mm rainfall event by 37 and 27 per cent, respectfully compared to preretrofit conditions. What we found was that Elm Drive is outperforming expectations by reducing 33 to 45 mm storm events by 66 to 95 per cent indicating that Elm Drive does a great job of controlling water quantity.

- Elm Drive is achieving erosion control and is meeting CVC stormwater management criteria by detaining a minimum of 5 mm of rainfall on-site. The LID practices mimic the natural water cycle by absorbing nearly 90 per cent of rainfall events (or storms up to 25 mm). Only about 12 rain events produce runoff to the municipal storm sewer per year.

- Elm Drive is designed to recharge groundwater by 3 mm per rainfall event. Elm drive is performing above expectations by recharging groundwater up to 25 mm for all sizes of events.

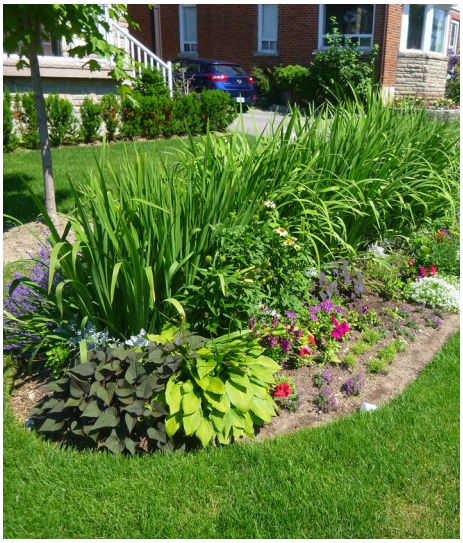
* **Peak Flow Reduction** – *The reduction in the rate of peak outflow from and LID system when compared to the peak inflow rate.*

Two-year storm – *A storm event that has a 50 per cent chance of occurring in a given year. For Elm drive a two-year design storm is 33 mm/4 hr.*

Five-year storm – *A storm event that has a 20 per cent chance of occurring in a given year. For Elm drive a five-year design storm is 45 mm/4 hr.*

100-year storm – *A storm event that has a one per cent change of occurring in a given year. For Elm drive a 100-year design storm is 79 mm/4 hr.*

Lakeview Bioswale (Summary of Monitoring data 2012-2015)



- Lakeview is showing similar results to Elm Drive by outperforming conventional ponds and removing 93 per cent of total suspended solids and 83 per cent for total phosphorous.
- Phosphorus is an essentially plant nutrient. Even small increases in phosphorus will cause significant algae growth in streams. Algae can cause many problems such as adding toxins to the water and causing damage to water treatment facilities and beach closures.
- The runoff volume reduction observed at this facility is 92 per cent. Note that ponds are designed to retain runoff and do not reduce the excess runoff volume created with urbanization.

IMAX (Summary of Monitoring data 2014-2015)

- Bioretention and permeable pavement increase the capacity of on-site stormwater storage before entering Sheridan Creek. The overall volume reduction for rain events less than 25 mm ranged from 64 to 90 per cent for the bioretention treatments. For the permeable pavement treatments it was 62 to 99 per cent.
- Pollutant load reductions for the bioretention units for rain events less than 25 mm were 97 to 99 per cent for total suspended solids and 57 to 90 per cent removal for total phosphorous.
- For the permeable pavement treatments load reductions were 93 to 100 per cent for total suspended solids and 92 to 100 per cent for total phosphorous.

Common Misconception: LID does not provide flood control

What we have found through monitoring:

LID offers a quick win solution to build capacity into existing stormwater management infrastructure while conventional practices are upgraded. In existing urban areas built prior to flood control requirements, there is little available land for conventional practices. Municipalities like Mississauga are finding that LID may be able to provide opportunities to build flood control capacity and reduce stress on existing infrastructure.

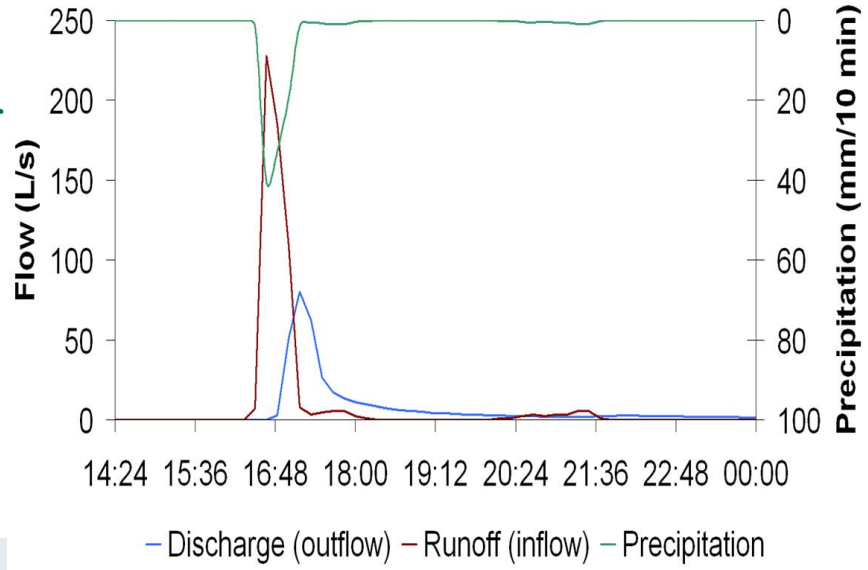
An example of this is the performance of Elm Drive on July 8, 2013 when there was 105 mm of precipitation in 5½ hours. Elm Drive was designed to reduce the peak flows from a 100-year storm by 13%; but monitoring results from Elm Drive on July 8, 2013 found that the LID features were able to reduce the peak flow by 60%, dramatically outperforming design criteria. These features also reduced runoff volume by 30% (which translates to almost a 1/3 of the rainfall being diverted from the municipal system). In addition a lag time of 20 minutes delayed flow to the storm sewers reducing stress on the municipal system.

Lesson 6

LID offers quick win solutions within existing urban areas where space is limited to build capacity into existing stormwater management.

Elm Drive's performance on July 8, 2013 showed that simple, low cost, LID practices offer quick win opportunities in flood-prone areas to build resiliency while larger scale stormwater measures are being designed, approved and constructed. This led to the City of Mississauga to pass a first-of-its-kind Council Resolution 0046-2014 in March 2014 that all future capital works transportation projects will evaluate the use of LID in all future capital roads projects.

Estimated runoff compared to measured discharge from the Elm Drive site during the July 8, 2013 storm event



Securing Infrastructure Funding Through Asset Management Planning

Asset management plans help municipalities make smart planning decisions about building, operating, maintaining, renewing and replacing infrastructure over the long-term. Having an asset management plan is a requirement for municipalities that request provincial infrastructure funding.

Developing an asset management plan requires a thorough understanding of infrastructure assets (e.g. water and wastewater infrastructures) including their condition, valuation and replacement costs, and expected life cycle performance levels. A plan involves setting strategic priorities about investments in assets and establishing a financial framework to plan accordingly.

Until recently, stormwater infrastructure was overlooked in asset management despite its strong relationship to water and wastewater infrastructure. CVC is working with stakeholders from across Ontario to develop a series of Grey to Green Guides that provide small, medium and large municipalities, and the private sector with guidance on integrating stormwater infrastructure, including LID, into the asset planning process.

More infrastructure asset management comparisons can be found in CVC's *Grey to Green Streets - Implementing Site Level LID Retrofits within the Road.*

Building Confidence That LID is Working

Most municipalities have protocols for commissioning or assuming stormwater infrastructure (e.g. constructed ponds, LID practices) from a developer or contractor after two years. The protocols help manage risk by ensuring that stormwater infrastructure is constructed properly and is functional before the municipality assumes ownership.

CVC provides LID construction training and has developed an LID Construction Guide with testing protocols based on results from the IPRA program. This ensures sites are constructed according to design specifications. For more information visit bealeader.ca

Building LID Capacity

Advancing the use of LID requires sharing knowledge and learning about LID successes and challenges. Information generated through CVC's LID monitoring programs build awareness about LID and inform further application of LID practices within the Credit Valley, across Ontario and by national and international partners including China, Denmark, and the USA.

Informing Provincial Regulatory Tools

Performance data from CVC's IPRA monitoring program shows how innovative stormwater management technologies are help achieve requirements laid out various provincial regulatory tools, including the Province of Ontario's *Water Opportunities Act, Building Together Guide for Municipal Asset Management Plans, and Great Lakes Protection Act*. IInformation collected on LID performance has contributed to the Province of Ontario's goal of becoming North America's water innovation leader by 2015 and will also be used to update the Ontario Ministry of Environment and Climate Change's 2003 Stormwater Management Planning and Design Guide.

Data and Knowledge Sharing on Stormwater Management

CVC contributes monitoring information to the International Stormwater Best Management Practices Database. The database collects information on LID demonstration projects, allows direct comparisons with other LID practices and technologies, and compares effectiveness in various geographic and climatic conditions in North America. These comparisons help expand the use and highlight the implementation of LID and CVC's leading edge data.

Educating Stakeholders

CVC communicates monitoring results through reports, presentations, site tours, and other public forums. CVC educates stakeholders about the effectiveness of LID at managing stormwater risks, reducing infrastructure costs and liability, and improving the resilience of our stormwater management systems.

Sharing LID Insights

Through local LID demonstration site tours, LID awareness and training sessions, and presentations at conferences, CVC is sharing knowledge of LID to help advance its use and to drive performance locally and internationally.

Long-term Partnerships

Project partners have entered into long-term management agreements to permit CVC to carry out performance monitoring on private lands. Ongoing participation in technical meetings, field tours and workshops ensure that project partners interact, connect and share their experiences with other stakeholders.

Future Directions

CVC's LID program is addressing many important stormwater challenges in the Credit River watershed and contributing to international best practices in LID. Our LID demonstration sites, monitoring program and knowledge and capacity building are addressing stakeholder questions about LID performance, operations, implementation and maintenance.

Our success is driven by:

- **Strong partnerships** with municipalities, provincial and federal agencies, engineering professionals and academia.
- **Listening to and engaging** with our stakeholders to identify uncertainties and address priority issues related to the implementation of integrated stormwater management solutions.
- **Working with our Expert Advisory Committee** to develop and implement a robust monitoring program to better understand LID performance and address knowledge gaps.
- **Sharing knowledge** locally, regionally and internationally to advance LID practices.

CVC's priorities and future direction include:

- Continuing to deliver on our **commitments to our partners.**
- Enhancing the **LID monitoring program** to include more sites and different types of land uses and soil types.
- Increasing the **integration and application of LID** through information and knowledge sharing including:
    - Developing and publishing **guidance documents and case studies.**
    - Developing **training modules** for professional development.
- Supporting **community engagement** in LID design and development.
- Building **new partnerships** with the Province of Ontario, municipalities, key stakeholders and potential funders to expand the application of LID.
- Seeking **funding and investment opportunities** to assist with wide-scale adoption of LID.

We look forward to working with you to maximize the benefits of LID!

For more information about the content in this document, please visit www.BeALeader.ca or contact CVC's Water Restoration Group at sustainability@creditvalleyca.ca.

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