Low Impact Development Discussion Paper

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Executive Summary

The Low Impact Development Discussion Paper is intended to raise awareness and stimulate a dialogue on the challenges associated with current stormwater management (SWM) practices in Ontario, identify the benefits of Low Impact Development (LID) and act as a roadmap for broad scale implementation of LID across Ontario.

LID techniques offer an effective and affordable option to mitigate the environmental impacts of urbanization, while offering beneficial outcomes to developers, municipalities and the public. LID manages rainfall at source - where it lands – through site planning and physical installations that, together, mimic the predevelopment hydrologic conditions. As a result, these practices support improved water quality, erosion control, and maintenance of groundwater recharge and baseflow. LID is well suited for greenfield development as well as existing (older) developed areas where stormwater treatment is limited. Depending upon the site and design criteria, LID can be used as the sole source for managing stormwater, or it can be incorporated with conventional practices as part of a 'treatment train' to meet a broad range of stormwater management goals.

Ontario's Ministry of the Environment (MOE) has long recognized that comprehensive stormwater management entails much more than an end-of-pipe pond. In 1991 the *Interim Stormwater Quality Control Guidelines for New Development* identified that 'Stormwater quality ponds should be considered as the last line of defence and applied only after all opportunities for infiltration of stormwater have been exhausted' (p. 8). Since then, a number of reports including the Ontario Ministry of Municipal Affairs and Housing (MMAH) 1995 *Making Choices: Alternative Development Standards Guidelines*, the *MOE's 2003 SWM Planning and Design Manual*, and more recently in the *Lake Simcoe Protection Act* (2008), and the MOE's 2010 *Policy Review of Municipal SWM in Light of Climate Change* have acknowledged a need to adopt a more aggressive approach to stormwater management through the use of lot level and conveyance controls.

To this end the Province has recently developed a suite of policies, incentives and legislation designed to promote LID and other best management practices,these include *Water Opportunities Act* (2010), Showcasing Water Innovation grant program, *Climate Ready: Ontario's Adaptation Strategy and Action Plan* and *Places to Grow Act* (2005) and the Growth Plan for the Greater Golden Horseshoe. Given the development pressures within the Golden Horseshoe Region, there is an imperative to implement LID more broadly than has been the case to date.

Moving forward, Credit Valley (CVC), Toronto and Region (TRCA) and Lake Simcoe Region Conservation Authorities (LSRCA) propose to work with the Province, area municipalities and the development community to help overcome the existing challenges related to wide-scale application of LID in Ontario. The Province, in the Draft Great Lakes Strategy (2012) and through funding provided in the Showcasing Water Innovations (SWI) grant program indicates a clear intent to work with CAs and others in improving the science and standards and approvals for SWM to support LID practices. It is recommended that these 'future actions' become immediate actions and current priorities for implementation, in part, through i) release of an Interpretation bulletin for the MOE's 2003 SWM Planning and Design Manual specific to implementation of LID practices; and, ii) approval of a Terms of Reference for a multi-stakeholder Review Team to maximize the benefits of investments made to SWI and ultimately, to update the MOE 2003 Manual with detailed guidance for LID practices.

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1 Introduction

This paper is intended to act as a roadmap for implementing creative solutions to manage stormwater sustainably over the long term to benefit the environment, the economy and society. Urbanization, with its increases in impervious surface cover, is changing the flow of water from urban lands during storms and snow melt events. The resulting changes in the volume of water running off lands, coupled with an increased frequency of flow and increased velocity cause erosion in streams and increase the risk of flooding. In addition, contaminants are picked up by the water from roads, sidewalks and yards and are transported to nearby creeks and streams. Both the National Water Research Institute (NWRI) and US Environmental Protection Agency (US EPA) have identified these contaminants as a threat to water quality in rivers and other sources of drinking water.[1,2]

Although stormwater practices have advanced since the days of conveying flows as quickly as possible from paved surfaces to nearby water bodies, research has shown that conventional end-of-pipe approaches alone do not achieve all of the water quality, erosion and flood protection benefits they were intended to provide; nor are they fully protecting baseflows for assimilative capacity, ecosystems and biodiversity.[3,4,5] In addition, municipalities are struggling to maintain a growing network of ponds and facilities while also managing the needs of other aging water and wastewater infrastructure. Many of these facilities have operational, monitoring and reporting requirements for compliance with Provincial operating permits and thus pose liabilities if they are not properly managed.

Low impact development (LID) techniques offer an effective and affordable alternative to mitigate the environmental impacts of urbanization, while offering beneficial outcomes to developers, municipalities and the public. LID techniques manage rainfall at source - where it lands – through site planning and physical installations that, together, mimic the predevelopment hydrologic conditions. LID is well suited for new subdivisions as well as existing (older) developed areas where stormwater treatment does not exist. Depending upon the site and design criteria, LID can be used as the sole source for managing stormwater, or it can be incorporated with conventional practices as part of a 'treatment train' to meet a broad range of stormwater management goals.

The imperative to adopt LID techniques is ever increasing due to multiple pressures including: municipal infrastructure affordability; stormwater impacts on water quality and quantity; impacts of erosion on property values and declining aquatic biodiversity. Further, the impacts of climate change are not yet fully realized but it is clear that LID techniques offer the potential to mitigate

[1] Environment Canada (2005). Threats to Sources of Drinking Water and Aquatic Ecosystem Health in Canada. Available at URL: www.nwri.ca/threats/indiex-e.html. updated 2003-01-013

[2] Lee, G.F. and A. Jones-Lee. Water Quality Aspects of Groundwater Recharge: Chemical Characteristics of Recharge Waters and Long-Term Liabilities of Recharge Projects, In: Proc. Of the Second International Symposium on Artificial Recharge, American Society of Civil Engineers, New York, NY, July (1994).

[3] Lake Simcoe Region Conservation Authority (2011). Stormwater Pond Maintenance and Anoxic Conditions Investigations – Final Report, 2011.Available at URL: http://www.lsrca.on.ca/pdf/reports/stormwater_maintenance.pdf

[4] Villard, P.V. and R. Ness (2006). Stormwater Management and Significant Channel Flows Below the Two-year Return. In Intelligent Modeling of Urban Water Systems. Monograph 15. Proceedings of the Stormwater and Urban Water Systems Modeling Conference February 23-24, 2006, Toronto, Ontario.

[5] CTC Source Water Protection Region and Ministry of Natural Resources (2011). Orangeville, Mono and Amaranth
Tier Three Water Budget and Local Area Risk Assessment.

some of the risks it poses by mimicking the natural water cycle more closely. The use of more resilient systems (such as LID) for this purpose is supported by the Ontario Ministry of the Environment (MOE) *Policy Review of Municipal Stormwater Management in Light of Climate Change*, which identified that "overall, municipalities need better tools to manage stormwater – and to build municipal stormwater systems that are resilient and adaptive to climate change to better protect the environment*."*

1.1 Stormwater Management in Ontario

Ontario's Ministry of the Environment (MOE) has long recognized that comprehensive stormwater management entails much more than an end-of-pipe pond. For instance, in its 1991 document, *Interim Stormwater Quality Control Guidelines for New Development*, the MOE states:

> Stormwater quality ponds should be considered as the last line of defense and applied only after all opportunities for infiltration of stormwater have been exhausted (p. 8).

Although the concepts have been recognized for several decades, LID practices are still not well-established in Ontario. To this end the Province has recently developed a suite of policies, incentives and legislation designed to promote LID and other best practices.

Examples include:

- *Water Opportunities Act*, 2010 – designed to foster innovative stormwater technologies, services and practices in the public and private sectors; also opens the door for the Province to require municipalities and other water service providers to prepare municipal water sustainability plans.
- Showcasing Water Innovation (SWI) - a $17 million grant program that runs to March 2014 to support Ontario's *Water Opportunities Act*, 2010.
- *Climate Ready: Ontario's Adaptation Strategy and Action Plan* - identifies a need for increased resilience of municipal stormwater systems in light of climate change induced alterations to rainfall intensities and storm patterns.
- Places to Grow plan for the Greater Golden Horseshoe region - municipalities are encouraged to implement and support innovative stormwater management actions as part of redevelopment and intensification.

Other initiatives by the MOE and other Provincial Ministries that have implications for LID include the:

- Lake Simcoe Protection Plan,
- Ontario's Draft Great Lakes Strategy and Canada Ontario Agreement Respecting the Great Lakes Basin Ecosystem,
- Provincial Policy Statement (2012: 5 year review)
- Ontario Building Code, and
- Modernization of approvals initiative

As indicated above, despite current and past initiatives by the Province, wide-scale adoption of LID has been minimal. This discussion paper bolsters the case for LID by discussing the limitations with existing SWM practices in Ontario, identifying the benefits of LID, and highlighting LID case studies. This paper also recommends how Conservation Authorities

(CAs), the Province, municipalities, and the development community can work together to bring LID into the mainstream while providing environmental and economic benefits to Ontarians.

1.2 Audience and Participation in the Discussion

The intended audience for this paper is informed stakeholders from municipalities, the development community, provincial agencies (Ontario Ministries of the Environment, Municipal Affairs and Housing, Natural Resources, Infrastructure), non-government organizations and Conservation Authorities.

1.3 Organization of this paper

In addition to this introduction section, this paper has five sections:

- Section 2 provides an overview of LID and why it is important.
- Section 3 outlines the stormwater management issues facing stakeholders as a result of current practices.
- Section 4 provides more details on how LID practices address the issues identified, who is doing LID and some examples of LID technique performance results.
- Section 5 outlines a proposed approach on how CAs can work with the Province and municipalities to help implement LID more quickly and broadly in Ontario.
- Section 6 presents next steps.

2 Low Impact Development (LID)

2.1 What is LID?

LID is a stormwater management design philosophy as expressed through various techniques and measures that approach stormwater as a resource as opposed to something that must be 'dealt with'. LID optimizes urban form within a mandate to co-exist with natural features. One goal of LID is to reproduce, as closely as possible, the pre-development hydrologic regime of a developed area. In other words, developments that employ the LID philosophy are designed to have minimal changes in the amount of run-off from precipitation events by using measures such as permeable pavement, infiltration trenches, rain storage, etc. to retain and/or store water so that the timing of flows from lots and neighbourhoods closely parallel pre-development patterns. In this way, LID is more than just a set of best management practices: it is an approach that protects the natural water balance and water quality of watersheds. LID is most effective when implemented with a watershed scale understanding of how best to protect or restore the natural water balance and includes innovative site design, distributed engineering techniques, and operational practices that infiltrate, filter, evaporate, harvest and detain runoff, and prevent pollution.

Exhibit 1 Institutional and Residential Examples of LID

[left] Green roof on Instructional Centre Building, University of Toronto Mississauga (Mississauga, ON)
[right] Naturalized landscaping on residential street (Orangeville, ON);

In literature sources, LID may also be called *better site design, sustainable urban drainage systems, water sensitive urban design*, *stormwater source controls, innovative stormwater management, or green infrastructure.*

There are five key principles for LID, the first of which is that existing natural systems are used as the integrating framework for planning. In other words, LID is a watershed-based approach for protecting environmentally sensitive resources while leveraging opportunities for stormwater management at watershed, neighbourhood and lot level scales. Secondly, LID focuses on runoff prevention through engineered techniques and preserving and extending tree canopies. A third LID principle is to treat stormwater as close to the source area as possible. Techniques to keep stormwater close to where it lands include natural open drainage, flattened slopes and decentralized lot and conveyance practices. Fourthly, LID entails creation of multifunctional landscapes including aesthetic features, reduced heat island effects and water conservation

benefits. Clean stormwater can be allowed to meet the water needs of natural ecosystems (i.e. watercourses, wetlands, woodlands). The fifth principle is to educate municipal representatives, property owners, property management staff and other stakeholders on how to maintain LID. For some LID techniques, legal agreements are needed to ensure long term operations and maintenance of LID features on private property.

LID is part of a broader movement to smart growth and sustainable urban development. As such, progressive developers and municipalities will be identifying and refining LID techniques over time and incorporating them more completely into urban designs. These approaches are compatible with LID and they work towards meeting the public's desire for vibrant cities, healthy lifestyles, clean air and water, walkable streets and reduced heat island effects of urban centers.

2.2 Where can LID be Used?

LID can be used in any urban setting, whether residential, institutional, commercial or industrial. This flexible form of stormwater management is independent of land size or use, and can be implemented successfully in subdivisions with typical single detached households, dense urban settings, along road right-of-ways (ROW) and many other types of greenfield or brownfield development, infill retrofits or redevelopment.

Exhibit 2 Retrofit and New Development Examples of LID

[left] Permeable pavement & bioretention road ROW retrofit on Elm Drive (Mississauga, ON); [right] Linear wetland at University of Ontario Institute of Technology (Oshawa, ON)

Often there is a misconception that LID is not suited to certain land uses or certain soil types, however this is often not the case. In sites with well draining soils, LID practices can significantly improve infiltration and groundwater recharge. In areas with soils with low permeability, other benefits of LID, including filtration, evaporation, detention and/or re-use can be realized. In high density settings like office buildings, green roofs and rainwater harvesting systems can be directly integrated within the building footprint, and other practices, such as permeable pavement can be used to transform existing land uses to those that reduce impermeable area. Furthermore, in areas developed before the introduction of current stormwater controls, LID retrofits are sometimes the only option to permit infill and redevelopment; particularly in cases where little land is available to dedicate to wet ponds.

2.3 Why is LID important?

Box 1 Cost Savings with LID

Credit Valley Conservation's new parking lot was constructed with permeable pavers, providing a cost savings of $90,000 compared to a conventional asphalt lot with catch basins. For more information on this site, visit: www.creditvalleyca.ca/low-impact-development/.

LID is important because current stormwater management practices are creating challenges for municipalities and the environment. In addition to the challenges of urban expansion and population growth, aging infrastructure and climate change, municipalities are faced with maintenance liabilities from a growing number of stormwater ponds. LID can be used in a treatment train approach with end-of-pipe controls to meet a full range of stormwater goals (flood control, water quality, erosion and water balance) affordably. For example, LID can be used to meet water quality and water balance objectives while a downstream dry detention basin can be used to meet flood control objectives. Or in some cases, LID can be used as an affordable alternative to end of pipe controls as described in Box 1. Case studies cited later in this paper provide additional examples.

Recent scientific research evaluating a range of stormwater management treatment options has found that conventional pipe and pond treatment configurations alone generally do not meet water quality, water balance or thermal objectives.[6] So, conventional SWM approaches are not only costing Ontario municipalities large amounts of money, they are also affecting the health of Ontario ecosystems. For instance, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has identified habitat degradation and loss associated with intensive urbanization as the number one threat to the Redside Dace (*Clinostomus elongatus*), an endangered fish in Ontario.[7] LID is an important step in attempting to re-establish the balance on which our ecosystems depend by offering improved water quality results and habitat protection for aquatic and terrestrial species.

More broadly, LID can also help developers, municipalities and the Province to achieve their green development goals, including the Provincial objectives set out in Places to Grow and the Provincial Policy Statement (2005).

LID also provides the opportunity to improve stormwater management through its use of distributed infrastructure and lot level measures. Distributed systems offer more resilient infrastructure than conventional, larger end-of-pipe facilities. Resilient infrastructure can be defined as infrastructure with the ability to "reduce the magnitude and/or duration of disruptive events. [Resilience] depends upon [infrastructure's] ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event."[8] The importance of having resilient infrastructure will continue to increase as the changing climate increasingly affects water and weather patterns and tests municipalities' ability to adapt to changing conditions.

[6] NOAA/UNH (2011). Forging the Link: Linking the Economic Benefits of Low Impact Development and Community Decisions.
[7] COSEWIC (2007). COSEWIC Assessment and Update Status Report on Redside Dace Clinostomus elongatus in Canada. Available at URL: http://publications.gc.ca/collections/collection_2007/ec/CW69-14-519-2007E.pdf
[8] U.S. National Infrastructure Advisory Council (2009). Critical Infrastructure Resilience: Final Report and Recommendations, Available at URL: http://www.dhs.gov/xlibrary/assets/niac/niac_critical_infrastructure_resilience.pdf

These important advantages are expanded upon later in this paper.

2.4 Why hasn't LID been widely adopted?

LID has not been widely adopted in part because it is still perceived as a new approach and is mistakenly assumed to be experimental. Without widespread municipal adoption, professionals in the development business, including engineers, landscape architects, architects, contractors and others, have not invested sufficient time to become familiar with the LID approach. Also there is suspicion that some LID techniques are not suitable to cold climates. Indeed, there will need to be experimentation with techniques over time in the spirit of continuous improvement, but numerous LID techniques have been in place in Canadian and American (Minnesota, New Hampshire, Michigan) locations for decades and have proven to be superior to and/or enhance conventional approaches, as discussed later in this paper. A map highlighting the various cities in Southern Ontario where one or more residential or Industrial/Commercial/Institutional (ICI) LID practices have been implemented is shown below.

Exhibit 3 Locations in Ontario of LID Practices

Finally, LID is not widely adopted in part because the development approvals process is more conducive to large end-of-pipe designs as they have clear design criteria and performance requirements as specified in the MOE 2003 Stormwater Management Planning and Design Manual. The current manual does not include the same degree of clarity with respect to LID, nor does it provide guidance on the credit applicable when incorporating LID within the treatment train (i.e., permit a reduction in downstream pond size when implementing LID). These issues can lead to a longer or more involved approvals process for all parties (developer, municipality, provincial representatives and conservation authorities).

2.5 Moving Forward on LID

For all the reasons outlined above, and discussed in more detail in the following sections, the time for widespread adoption of LID is here. LID is urgently needed to enhance (or in cases replace) conventional stormwater approaches to better suit the needs of municipalities, to better protect water quality and biodiversity and to better prepare for climate change impacts on the water cycle. This paper includes steps the conservation authorities propose to take to assist in bringing LID into common practice, starting with the highest priorities areas: lands under immediate development pressure in the Golden Horseshoe Region.

3 Stormwater Management Issues Facing Stakeholders

Since the early 1980's there has been growing recognition of the challenges presented by stormwater. This section briefly outlines challenges faced by various stakeholders, including municipalities, developers, development approval agencies, private land owners and the public. The issues outlined below clearly make the case that new approaches to stormwater management, and urban sprawl more broadly, are urgently needed.

3.1 Municipalities

The specific challenges municipalities face that are associated with stormwater management include: infrastructure affordability; compliance with operating permits and water quality objectives; liability from infrastructure and property damage, pond sediment removal requirements; increased in-stream erosion and flood risk; and meeting water supply needs in growing municipalities. The challenges of climate change are still emerging but clearly municipalities will have a key role in addressing the challenges of water cycle changes induced by the changing climate. Significant costs resulting from unusual storms are already taking a toll.

Infrastructure Affordability

Municipalities are already facing infrastructure affordability challenges with many water supply, wastewater and stormwater infrastructure systems approaching the end of their planned service life. Municipal infrastructure requires major economic investment for rehabilitation or replacement. The current national municipal deficit for water supply, wastewater and stormwater systems stands at $31 billion for the existing capital stock, while new needs are estimated at $56.6 billion.[9]

Compliance and Maintenance Requirements and Liabilities

Stormwater management (SWM) ponds are widely used in Ontario for erosion, flood and stormwater quality control. Proper maintenance of SWM ponds plays a crucial role in meeting MOE 2003 Stormwater Management Planning and Design Manual's water quality requirements. A recently released study by the Lake Simcoe Region Conservation Authority (LSRCA) found that the effluent water quality of wet ponds deteriorates over time due to sediment accumulation and other chemical processes within the pond so that, instead of being phosphorous sinks, wet ponds can become sources of phosphorus to receiving water bodies, if not properly maintained.[10] In general, reduction of the wet storage area in wet ponds due to sediment accumulation tends to reduce the water quality and quantity control capacity of the facility and increases flood risk.[11]

Municipalities are responsible for monitoring and reporting on stormwater facility performance to meet Certificate of Approval requirements. Research in the United States, and by the LSRCA, Toronto and Region Conservation Authority (TRCA) and by CVC have found that stormwater systems relying solely on wet detention ponds are deficient in meeting water quality and erosion

[9] Federation of Canadian Municipalities (2007). Danger Ahead: The Coming Collapse of Canada's Municipal Infrastructure.
[10] Lake Simcoe Region Conservation Authority (2010). 2010 Stormwater Pond Maintenance and Anoxic Conditions Investigation. FINAL REPORT.
[11] Drake, J. and Guo, Y. (2008). Maintenance of Wet Stormwater Ponds in Ontario, CWRA 33(4) 1-18.

criteria.[12,13] Thus stormwater facilities in some municipalities are creating a compliance liability in addition to providing inadequate water resource protection.

To maintain design depths, SWM ponds require sediment removal, which is typically the responsibility of the local municipality. The majority of municipalities in Ontario have not yet planned or executed these required pond clean outs and therefore lifecycle costs of maintaining SWM ponds are largely unknown. There is a growing concern that the removal and disposal of this sediment will be very costly to the municipality, particularly if the sediment is contaminated and requires specialized disposal.[14] A recent study by the Lake Simcoe Region Conservation Authority of wet pond maintenance requirements found the median cost estimate for sediment removal to be an estimated $267,000 with the most expensive being $1.6 million.[15] These costs are consistent with the maintenance requirements for a 1.8 hectare stormwater retention pond located in Mississauga. Sediment from runoff had accumulated to the point that it was adversely affecting the detention capacity of the pond. A total of 5,600 m^3 of sediment was removed from the pond. The project took one year to complete and had a final cost of $1.3 million.[16]

In addition to issues with sediment accumulation and treatment of nutrients, ponds can also be a source of thermal pollution. This issue is of particular concern for ponds located within cold water systems, as increased temperatures can have negative impacts on fish populations, particularly among sensitive species like Brook Trout and Redside Dace. Although there are means by which these impacts can be mitigated during conveyance or at the end-of-pipe, such as cooling trenches and pond 'floating islands,' the use of LID is preferable as it can be used as a preventative measure, significantly reducing thermal loading at the source.[17]

Erosion and Flood Risk

Under conventional subdivision design approaches, urbanization increases stream discharge. For example, TRCA records for the average annual discharge in the Rouge River, Highland Creek and the Little Rouge River since the early 1960's clearly indicate increasing trends over time. Increased flow rates associated with increased impervious surfaces exacerbates erosion within receiving watercourses and can also result in enlargement of the receiving stream channel. These changes can lead to channel instability, degraded aquatic habitat, downstream hazards (such as increasing bank erosion and channel migration) and increased costs to the

[12] Lake Simcoe Region Conservation Authority (2011). Stormwater Pond Maintenance and Anoxic Conditions Investigations – Final Report, 2011.Available at URL: http://www.lsrca.on.ca/pdf/reports/stormwater_maintenance.pdf

[13] Villard, P.V. and R. Ness (2006). Stormwater Management and Significant Channel Flows Below the Two-year Return. In Intelligent Modeling of Urban Water Systems. Monograph 15. Proceedings of the Stormwater and Urban Water Systems Modeling Conference February 23-24, 2006, Toronto, Ontario.

[14] Drake, J. and Guo, Y. (2008). Maintenance of Wet Stormwater Ponds in Ontario, CWRA 33(4) 1-18 .

[15] Lake Simcoe Region Conservation Authority (2011). Stormwater Pond Maintenance and Anoxic Conditions Investigations – Final Report, 2011.Available at URL: http://www.lsrca.on.ca/pdf/reports/stormwater_maintenance.pdf

[16] City of Mississauga (2008). Lake Wabukayne: Innovation in Storm Water Management Pond Maintenance. Available at URL: http://www.tac-atc.ca/english/resourcecentre/readingroom/conference/conf2008/docs/aw3/mississauga.pdf

[17] Credit Valley Conservation (2011). Study Report: Thermal Impacts of Urbanization Including Preventative and Mitigation Techniques. Available at URL: http://www.creditvalleyca.ca/sustainability/lid/stormwaterguidance/downloads/Thermal%20Study%200411.pdf

municipality and Conservation Authority for items such as erosion protection maintenance and responding to property owner complaints.

Examples are numerous of municipalities incurring on-going costs from erosion in areas with existing fully built-out subdivisions relying upon older stormwater infrastructure systems. For example, the Cooksville Creek watershed in Mississauga is 97% developed, has 47.5% impervious surface cover and has minimal SWM infrastructure. Since 1983, erosion control, conveyance improvement and flood protection works completed along the Cooksville Creek have cost the City of Mississauga approximately $10.6 million. Over the next ten years, the City is forecasting to spend another $19.3 million on erosion control, conveyance improvement and flood protection works along Cooksville Creek, not including maintenance costs for minor or emergency erosion concerns. For built-out areas with little available land for stormwater pond retrofits like Cooksville Creek, retrofitting with small-scale distributed practices may be one of the few ways to help mitigate these erosion costs. Box 2 provides more detailed results of an analysis of an urbanized subwatershed.

Box 2 Conventional Stormwater Approaches Not Controlling Baseflows

In a recently urbanized subwatershed in the Credit Valley watershed, impervious cover has increased by 62.5% since the 1950's. As a result of this increased impervious cover, there have been large increases in runoff volumes discharging to the subwatershed's creek.

Although this subwatershed utilizes conventional stormwater management practices to control peak flows (employing a total of 36 ponds to date), monitoring has shown that these controls may not be sufficient. Analysis of peak flows for the ten year period from 1998 through 2009 confirms the discharge (m^3/s) has increased significantly; in fact, the flows in the creek have increased by roughly two orders of magnitude. This increase has occurred despite conventional post to pre control measures in the form of conventional stormwater management facilities. These results are consistent with results in the Rouge River, Highland Creek and Little Rouge River.

The reason for these increasing trends is a matter of some speculation but they are likely due to a combination of factors that include: increased runoff volume; an altered shape of the subwatershed; and, changes in the timing of peak flows from developments within the watershed. Despite peak flow attenuation with end-of-pipe measures, the longer duration of higher flows (due to increased volume) may combine with downstream tributaries to increase the downstream peak flows. In addition to an increase in impervious cover, water flows are also altered by a reduction in infiltration and evapotranspiration.

These examples highlight the fact that stormwater can have significant impacts on both terrestrial and aquatic systems. These impacts, in turn, can place financial burdens on municipalities to address these issues through erosion control and other stormwater management programs.

Growth and Water Supplies

Municipalities in the Greater Golden Horseshoe region face intense development pressure, as identified in Ontario's Places to Grow plan. This development pressure is taxing available potable water supplies in some regions, especially those relying on groundwater sources. Improved water conservation, aquifer recharge and source water quality protection are three key aspects of the water management challenges arising from intensification plans.

These challenges are also being identified in less dense, but equally important areas – headwaters. A recently released Tier 3 source protection risk assessment and Phase 2 Subwatershed Study in the headwaters of the Credit Valley Watershed have found that future growth and future pumping scenarios could have a significant impact on baseflows of headwater streams if conventional (end of pipe) stormwater management practices alone are adopted.

Modeling predictions show a combination of LID applied in both new and existing areas can help mitigate baseflow reductions.[18,19]

Box 3 Climate Change and Stormwater

Climate change is already creating changes in the water cycle through increased rainfall intensities and altered frequencies and other important aspects of water quantity and quality (such as the temperature regime of watercourses). These changes are evident by the occurrence of three 100-year and five 50-year storm events over the past 12 year period, resulting in claims from extreme weather increasing by 20 fold in the past 30 years.[1]

The insurance industry has become concerned with the increasing amount of sewer backup, urban flooding and water damage in Canada. In fact, "within the last 10 years, water-related losses have become the predominant type of loss, accounting for 40% of personal property insurance claims." [2]

In August 2005, a single heavy storm event in the City of Toronto resulted in the washout of a major arterial road, damage to three other roads, slope failures threatening existing homes as well as damage to a wastewater plant downstream. This single rain event cost the City of Toronto an estimated $34 million, including $6 million for the immediate repair of Finch Avenue, $9 million for surrounding parks, and over 1,600 over-time staff hours. The Insurance Bureau of Canada estimated that over $400 million was paid out to private citizens to cover flood damages to basements from this storm.

As climate change intensifies, municipalities can expect to face increasing challenges for design, maintenance, operation and repair of stormwater systems and in-stream protection of water quality, erosion prevention and floodplain management. Given these types of impacts, the MOE's recently completed *Policy Review of Municipal Stormwater Management in the Light of Climate Change* has stated that "adaptation to climate change based on best available science is a priority for Ontario" and that:

> *the MOE approvals process for municipal stormwater management requires review to include identifying measures to encourage source control best practices for municipal stormwater management.*[3]

[1] Insurance Bureau of Canada (2008). Tale of Two Cities. Available at URL: http://insurancegk.blogspot.com/2011/04/natural-disasters.html.
[2]. Insurance Bureau of Canada (2011). The Wingham Rain Barrel Pilot Project. Available at URL: http://www.ibc.ca/en/Natural_Disasters/documents/Barrel/RainBarrelPilot-Report.pdf
[3] Ontario Ministry of the Environment (MOE) (2010). Policy Review of Municipal Stormwater Management in the Light of Climate Change – Summary Report.

3.2 Development approval agencies

The current edition of the MOE Stormwater Management Manual (2003) promotes a treatment train approach to stormwater management, which encompasses the use of LID. The Manual falls short in terms of technical details and thus,the current approvals process, does not fully recognize this fact. Stormwater management is becoming distributed into the urban form, and refining the permit and approvals process to recognize the entire treatment train is paramount. Concurrently, there are many goals and objectives guiding development approvals for which stormwater considerations must be incorporated, such as ensuring development proposals meet the requirements of the Great Lakes Water Quality Agreement and near shore protection, Places to Grow, the Lake Simcoe Act, source water quality protection provisions, species at risk plans and others.

[18] CTC Source Water Protection Region and Ministry of Natural Resources (2011). Orangeville, Mono and Amaranth
Tier Three Water Budget and Local Area Risk Assessment.
[19] Credit Valley Conservation (2010). Headwaters Subwatershed Study: Subwatershed 19. Phase 2: Impact Assessment and Evaluation of Alternative Management Strategies.

Chapter 5 of this paper proposes a way for Conservation Authorities to assist the Province in the development approvals process to accelerate approvals for more comprehensive LID approaches including site level plans with LID techniques. This will assist the Province to meet its Open for Business objectives for streamlined processes.

3.3 Developers

Developers are interested in maximizing the profit available from their lands, which relates to the number of dwellings, lifestyles and quality of life supported by neighbourhoods they build. Developers also have an interest in expedient approvals processes, as delays can add significant expense to a given project. It is important to ensure that progressive developers who implement innovative stormwater management practices like LID, are supported by approvals agencies by providing a streamlined approvals process.

> *By implementing low impact development (LID) features within the Wychwood community, we have been able to achieve a number of benefits. First, we have avoided the need for a stormwater pond on the site, thereby increasing the number of developable lots within the community. Sequoia Grove is also able to provide homeowners with unique landscaped features, including 'bioretention' planters within the road right-of ways in the western portion of the site and a large planted bioretention swale on the eastern portion. These features shall not only treat the runoff, but will provide visually appealing green amenities for our purchasers.*
>
> -Giulio Bianchi, Principal, Sequoia Grove Homes

3.4 Private landowners & the public

Private landowners are affected by stormwater management in terms of its effects on property values. For instance, repeated basement flooding has a negative impact on the re-sale value of properties, not to mention inconvenience, cost and potential health and safety issues for residents. Property values can also be greatly influenced by the water quality of nearby waterbodies and the availability and quality of water-related amenities in neighbourhoods, such as beaches, water-side parklands and boating opportunities.

Plants and animals living in or close to water are also valued by members of the general public for their uses and, often, for their intrinsic value. The aesthetic beauty of healthy aquatic environments contributes to positive lifestyles and health. LID can play a role in helping to maintain or improve upon the treatment provided by conventional stormwater treatment facilities.

4 LID as a Solution

4.1 Benefits of LID and Costs of Not Implementing LID

Infrastructure Affordability, Maintenance Costs and Compliance

There are good economic and ecological reasons to implement LID stormwater management and, conversely, as discussed in Section 3, the costs and risks associated with current practices can be quite substantial. LID is often erroneously perceived to only add expense to a project. This perception reflects a focus on individual budget line items, such as the added expense of porous concrete over traditional pavement. From a development-wide, life cycle perspective, LID can reduce development costs[20] because it may reduce the need for conventional infrastructure (such as curbing, piping, ponds, catch-basins) and can increase the number of developable lots. Furthermore, LID is expected to reduce the costs incurred by municipalities for the maintenance of SWM facilities by permitting them to perform maintenance activities in-house rather than hire contractors to perform complex end-of-pipe maintenance and rehabilitation activities (such as pond sediment removal). In cases where LID is used as part of a treatment train to enhance conventional approaches, it is anticipated the added capital and O&M costs for LID features will be offset with decreased end-of-pipe infrastructure costs.

A study carried out for the Ontario Ministry of Natural Resources (MNR) highlights inefficiencies in the delivery of water infrastructure with urban sprawl. In areas facing development pressure, more compact urban form is more affordable over the long term. For instance, the MNR report suggests that "more compact and efficient urbanization in the Greater Toronto Area would save (in 1995 dollars) about $10 billion to $16 billion in infrastructure costs and about $2.5 billion to $4 billion in operating and maintenance costs over 25 years". The report also states that "if external costs (for emissions, health care, traffic policing, etc.) are considered as well as capital and maintenance, then approximately $700 million to $1 billion per year could be saved by a more efficient pattern of development."[21] The LID approach is conducive to more compact development with increased natural cover.

Over and above infrastructure cost considerations, LID has other benefits, as outlined in Box 4. In comparison with traditional stormwater management practices, LID is cost effective on a life cycle basis and has additional benefits including better erosion control, improved water quality and greater aesthetic appeal.

[20] NOAA/UNH (2011). Forging the Link: Linking the Economic Benefits of Low Impact Development and Community Decisions.

[21] Krantzberg, Dr. G. (2006). A Valuation of Ecological Services In The Great Lakes Basin Ecosystem to Sustain Healthy Communities and a Dynamic Economy. Prepared for the Ontario Ministry of Natural Resources.

Box 4 Benefit - Cost Ratio of Protecting the Great Lakes with a LID Approach

A recent study by the MOE regarding an economic valuation of restoring the Great Lakes considered two development scenarios: low impact versus conventional development[1]. The study found that sustainable greenfield development and retrofits of existing development, combined with the effects of expanded natural cover, comprise an economically beneficial management approach. Overall, the study findings estimated the benefit-cost ratio in favour of low impact versus conventional development.

LID measures included in the analysis were: green roofs; infiltration trenches/beds; permeable concrete; stormwater harvesting; lot re-grading; and, naturalized landscaping. The present value associated with decreased beach closures and increased recreational fishing ranged from $776 million to $1,551 million. It is important to note that the benefits of LID identified in the MOE study were highest when the LID measures were implemented at the time of development; retrofitted LID measures also resulted in benefits but to a lesser degree than those implemented from the outset as an integral component of the subdivisions.

[1]Ontario Ministry of the Environment (2010). Assessing the Economic Value of Protecting the Great Lakes: Rouge River Case Study for Nutrient Reduction and Nearshore Health Protection. Available at URL: http://www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@subject/@greatlakes/documents/nativedocs/stdprod_086943.pdf

Erosion and Flood Risk Reduction

LID is an important component of water quality treatment and erosion reduction. By taking a watershed approach and understanding the water balance within a region, the bigger picture can be incorporated into lot and neighbourhood development, redevelopment and infill goals. The requirements to maintain flows below unstable erosive levels can be approximated through the application of distributed LID techniques. Box 5 outlines work underway to reduce erosion and flood risk in Cooksville Creek, Mississauga.

Box 5 Case Study: Elm Drive

The City of Mississauga has recently completed streets projects in Ontario. Elm Drive, an existing urban street in Mississauga, has been retrofitted with permeable pavement and bioretention planters. These LID practices are used to treat the runoff from the roadway, providing site-based infiltration and temporary storage for slow release to the storm sewer. A total of six bioretention planters were constructed adjacent to the street, and are designed to reduce the runoff volume from the site by 71% during the 2-year storm event and by 23% during a 100-year storm event.

Preliminary monitoring by Credit Valley Conservation has found that the LID retrofit at Elm Drive is successful at treating and retaining stormwater runoff up to the 13 mm storm event which accounts for 80 % of rainfall during a given year. Thus, it indicates that runoff from rain events ≤ 13 mm is either infiltrated or lost through evapotranspiration. Larger events (>13 mm) also showed a delay in the time to peak in outflows from the cells. Further refinements are being made to the design which may equate to better performance in the future.

One innovative aspect of this project is an easement agreement established between the City and the Peel District School Board (PDSB). This agreement allows the City to manage stormwater on district property and permits the City to enter school property to maintain the practice. The total cost of construction for this road retrofit was approximately $595,000, of which $325,000 went towards constructing the LID techniques.

Water Quantity and Conservation

As indicated in Section 3, improved water conservation, aquifer recharge and source water quality protection are among the water management challenges facing municipalities with population growth pressures. The LID approach promotes understanding water balance in watersheds and therefore is a first step in comprehensive water quantity management. LID contributes to groundwater recharge, which is important for source water protection in water-stressed regions. Groundwater recharge also helps maintain the baseflow of streams and rivers, especially during periods of drought, which is important for assimilative capacity and fisheries. A LID approach recognizes that stormwater is a resource that communities can use in place of potable water where the highest quality water is not required. LID techniques such as rainwater harvesting cisterns can help promote water and energy conservation by substituting the use of potable water (both chemical and energy intensive) with rainwater for the purposes of toilet and urinal flushing, industrial process water use and outdoor landscape irrigation. The benefits of rainwater re-use are becoming increasingly recognized by municipalities throughout Ontario, the City of Guelph, for instance, offers a residential rainwater harvesting rebate program, valued at up to $2000 for residents.[22] Investments in non-potable water use and water efficiency have direct impacts on municipal budgets, as these investments (through subsidies, education programs, etc.) are often lower in cost than the capital costs associated with building additional water treatment and distribution infrastructure. Box 6 outlines the results of an analysis on LID techniques to reduce runoff volumes from a shopping center parking lot.

Box 5 "Big Box" Retail & ICI LID Opportunities

In urbanized areas with "big box" retail and industrial/commercial centres, parking areas and rooftops often comprise a large majority of the land use on these sites. These impervious surfaces in turn generate significant quantities of stormwater runoff.

To assess the change in runoff from a parking lot on these types of properties following a LID retrofit, an analysis was conducted by CVC for a large 7.5 ha parking lot. Assuming that permeable pavers remove the first 15 mm of each rainfall event, the two year runoff volume can be reduced by 35% to 45%, and a 10% to 20% reduction of the 100 year runoff can be achieved. This analysis found that the permeable pavers provided the greatest benefit for more frequent events; while still providing some reduction in release rate and runoff volume for major storm events.

If a rainwater harvesting system were utilized on a large roof surface of 0.25 ha, approximately 850,000 Litres of rainwater could be collected annually and re-used for toilet flushing and outdoor landscape irrigation. This use would also provide the additional benefits of reducing the site release rate and runoff volume.

Water Quality

LID offers improved water quality in terms of pollutant removal and reduced nutrient loading through a planned approach to grading, the use of plants, natural features, filtration and distributed infiltration techniques to accept stormwater flows. Long-term data from the University of New Hampshire Stormwater Center (UNHSC) and Villanova University in Pennsylvania found mature bioretention facilities providing 97% total suspended solids (TSS) removal[23,24]. Additional studies on the pollutant removal performance of bioretention systems

[22] City of Guelph (2011). Rainwater Harvesting System Rebate Program. Available at URL: http://www.guelph.ca/living.cfm?itemid=78750&smocid=2338

[23] University of New Hampshire Stormwater Center (UNHSC) (2006). 2005 Data Rep., CICEET, Durham, N.H.

have found a 70-85% phosphorus removal in a laboratory setting[25], while field results in Maryland reported a 77-79% reduction[26]. Further studies, however, have noted lower phosphorus treatment efficiencies or net increases in loading, emphasizing the importance of effective guidelines, sound design and appropriate soils selection to ensuring LID treatment performance.

A number of studies on the treatment effectiveness of LID practices in a Canadian context are currently underway by several CAs, including CVC, TRCA and LSRCA. One of the first comprehensive studies in Canada, conducted by the TRCA, compared the runoff from an asphalt parking lot to the stormwater infiltrated in a permeable pavement lot and a bioswale. Their study found that concentrations of zinc, phosphorus, total suspended solids and oil and grease were significantly lower in the permeable paver infiltrate than the asphalt lot runoff[27].

Biodiversity Protection

LID promotes a watershed approach to protect sensitive areas. It also promotes natural land cover and leads to more diverse plants and habitat refuges within developed areas. LID can play a pivotal role in habitat protection and aquatic species biodiversity recovery. For instance, according to the Ministry of Natural Resources, land development within the vicinity of Redside Dace habitat must "attempt to mimic pre-development hydrologic regimes by incorporating a 'treatment-train' approach and low-impact development designs."[28] More broadly, LID is an important aspect of the Lake Ontario Biodiversity Conservation Strategy in recognition of its ability to reduce sediment and nutrient loads and improve habitat diversity. LID is vital to protecting and restoring ecosystem health in a comprehensive, affordable and aesthetically pleasing manner.

Resilient Infrastructure and Climate Change Adaptation

Using the full capacity for water infiltration and storage along the treatment train, from individual lots to the receiving water body, is very important to reduce the risk of flooding. LID is an important component of creating resilient infrastructure to mitigate risks of changes to storm intensities as a result of climate change.

Climate Ready: Ontario's Adaptation Strategy and Action Plan identifies a need for increased resilience of municipal stormwater systems in light of climate change's alterations to rainfall intensities and storm patterns. The strategy identifies the need to "ensure Ontario's stormwater management systems are sufficiently resilient to handle a range of precipitation patterns to limit the impact on near shore water quality and on ecosystems." The MOE's vision for resilient municipal stormwater systems includes lot and conveyance system source controls and

[24] US EPA (2006). 2006 Summary Rep.—Section 319 National Monitoring Program Projects, NCSU Water Quality Group, Raleigh, N.C.
[25] Davis, A. P., Shokouhian, M., Sharma, H., and Minami, C. (2006). Water quality improvement through bioretention media: Nitrogen and phosphorus removal. Water Environ. Res., 78(3), 284–293.
[26] Davis, A. P. (2007). Field performance of bioretention: Water quality. Environ. Eng. Sci., 24(8), 1048–1063.
[27] Toronto and Region Conservation Authority (2008). Performance Evaluation of Permeable Pavement and a
Bioretention Swale Seneca College, King City, Ontario.
[28] Ministry of Natural Resources (MNR) (2011). DRAFT Guidance for Development Activities in Redside Dace Protected Habitat.

community designs that limit the disruption of the water cycle. The need for long term planning and guidance pertaining to water reuse and LID are recognized in the strategy.

In their report *Policy Review of Municipal Stormwater Management in Light of Climate Change*, the MOE recognizes LID as an important practice. The MOE concludes that "municipal stormwater management adaptation to climate change based on best available science is a priority for Ontario" and that resilient systems are necessary to strengthen municipalities' ability to adapt to climate change.

LID and Land Developers

The reduction in the volume of stormwater requiring treatment can reduce the size of (or in some cases even eliminate the need for) a stormwater management pond or other end-of-pipe facility. As a result, the available developable land area is larger with direct benefits for developers. LID can also permit municipalities and developers to retrofit or increase density in urban areas without the need to expand or replace existing stormwater infrastructure.

LID can also increase residents' access to recreation amenities and enhanced green spaces along public right-of-ways thereby having a positive effect on the image of development areas and, ultimately, a positive effect on the lifestyle of residents.

> *Adding LID practices to our stormwater management 'toolbox' gives us greater flexibility to make the most effective use of the lands we develop while also adding value for our customers. We are currently working with Conservation Authorities in Ontario to implement LID projects and we're committed to collaborating with them to ensure that these, and future, projects are a success.*
>
> - Leith Moore, Vice President – Land Development, Sorbara Development Group

Green Job Creation

LID can also act as a catalyst for the creation of green jobs in Ontario. As LID practices increase, the demand for related products, materials and skills will also increase. This demand will create green jobs among materials suppliers, product manufacturers and will drive growth in workers skilled in LID implementation. These workers include designers (engineers and architects), installers (site service contractors and landscaping firms), long-term operation and maintenance staff (grounds maintenance personnel and dedicated LID management crews) and others employed in related professions.

> *The landscape industry in Ontario is valued at over 7 billion dollars, and employs 70,000 people in a variety of trades, from landscape designers and contractors to irrigation and grounds management professionals. We believe that the future growth of the landscaping industry is based on expanding the perception of horticulture from an occupation that is in the business of creating beauty, to an occupation that provides economic, environmental, social and health benefits through green infrastructure and LID.*
>
> - Tony DiGiovanni, Executive Director, Landscape Ontario

4.2 Who is Doing LID?

This profile focuses on Ontario activities and also briefly outlines LID activities in the United States. Many other jurisdictions implement LID, including British Columbia and Alberta and, internationally, Germany, Australia and the United Kingdom. Readers are encouraged to also reference the LID activities in other parts of the world.

4.2.1 Province of Ontario

As indicated in Section 2, LID offers a means to assist the Province and municipalities in meeting the objectives of the Provincial Policy Statement (2005), *Water Opportunities Act* (2010), Places to Grow plans and other goals and priorities. Under Ontario's *Water Opportunities Act*, municipalities will be required to develop sustainable water, stormwater and wastewater plans. Among other elements, water sustainability plans may include: a water conservation plan; an assessment of risks to the future delivery of municipal services from climate change; and, consideration of technologies, services and practices that promote the efficient use of water and reduce negative impacts on Ontario's water resources. The sustainability plans may also require asset and financial planning to address the growing infrastructure deficit in many of Ontario's communities. LID practices will assist municipalities in meeting such sustainability planning provisions under the Act. Use of stormwater as a resource in water sustainability plans can therefore contribute to potable water conservation goals, reduced infrastructure investment needs for drinking water and wastewater collection systems, and reduced energy consumption.

Ontario's Draft Great Lakes Strategy was released in June 2012 for public consultation, and in November 2012, the Province is in the process of finalizing the Strategy to guide their efforts to protect the Great Lakes and their negotiation of the Canada-Ontario Agreement. Green Infrastructure, low impact development, and stormwater management are strongly supported throughout the Draft Strategy and specifically in Future Actions identified under Goal 2: Protecting Water, Goal 5: Enhancing Understanding and Adaptation, and Goal 6: Ensuring Environmentally Sustainable Economic Opportunities and Innovation (see Appendix A for full details).

Further, Ontario's Showcasing Water Innovation (SWI) is a $17 million grant program that runs to March 2014 to support Ontario's *Water Opportunities Act*, 2010 and Ontario's Draft Great Lakes Strategy (2012). One goal of the *Water Opportunities Act* is to foster innovative stormwater technologies, services and practices in the public and private sectors. SWI resources are currently being utilized by a number of organizations in support of this goal. Given conservation authorities (CA's) role in local watershed management, many CA's were fortunate to receive grant funding, among them were CVC and TRCA who each received funding to support implementation of LID technologies. These projects help encourage adoption of LID approaches and technologies by addressing critical barriers to implementation of LID practices in retrofit and new development contexts through full scale technology demonstrations, scientific evaluations of the financial and technical feasibility of the practices, and knowledge transfer programming. Results of the effectiveness evaluations will be used to improve and enhance existing LID best practice guidelines and demonstrate innovative partnership models and delivery strategies for implementation. In recognition of the critical role that proper construction, operation and maintenance practices plays in the successful performance of LID, these projects also assess best practices for construction, assumption (when the landowner assumes responsibility of the LID feature from the contractor), and

maintaining LID practices and provide a variety of practical guidance documents for stakeholders to encourage adoption of LID. Ideally, these materials should be referenced in provincial guidelines such as MOE's SWM Planning and Design Manual (2003).

The draft revised Provincial Policy Statement (PPS) released in September 2012, includes new policies for planning for stormwater management under Section 1.6 "Infrastructure and Public Service Facilities". As well, a new policy (1.6.2) has been added that encourages green infrastructure approaches. These new policies will encourage consideration of low impact development earlier in land use planning decisions.

LID approaches are necessary to implement the Places to Grow plan for the Greater Golden Horseshoe region. Under the plan, municipalities are encouraged to implement and support innovative stormwater management actions as part of redevelopment and intensification.

Other Ontario government departments also have an interest in promoting LID, including the Ministry of Municipal Affairs and Housing (MMAH). MMAH released the *Municipal Planning and Financial Tools for Economic Development* in 2011, which is a handbook that provides descriptions of planning and financial tools for municipal economic development goals. The handbook promotes sustainable land-use planning and includes the aspects of green infrastructure and lower-impact development. It identifies groundwater recharge, reduced stormwater runoff and water recovery in its Sustainability Connection check list for land use planning (in *Municipal Planning and Financial Tools for Economic Development*). MMAH also highlights LID as an element of site plan control in *Key Planning Act Tools to Support Climate Change Action*.

The Ministry of Infrastructure's plan *Building Together: Jobs and Prosperity for all Ontarians* recognizes the impact climate change will have on stormwater infrastructure and cites the need to reduce water demand through promotion of conservation and use of green infrastructure.

The MOE has provided funding support for the development of the Credit Valley Conservation Authority and Toronto and Region Conservation Authority *Low Impact Development Stormwater Management Planning and Design Guide*. This document provides guidance to developers, consultants, municipalities and landowners on understanding and implementing LID. MOE has also funded CVC and TRCA stormwater monitoring programs (www.iswm.ca, bealeader.ca and www.sustainabletechnologies.ca) which provide on-line performance data of innovative and LID stormwater management practices in Ontario. Data from these programs will also be incorporated in future updates to the CVC/TRCA LID Design Guide and CVC's LID Construction Guides. Ideally, the lessons learned should be considered for province-wide application in updates to provincial guidelines such as MOE's SWM Planning and Design Manual (2003).

Long Term/Cold Weather Performance of LID in Ontario

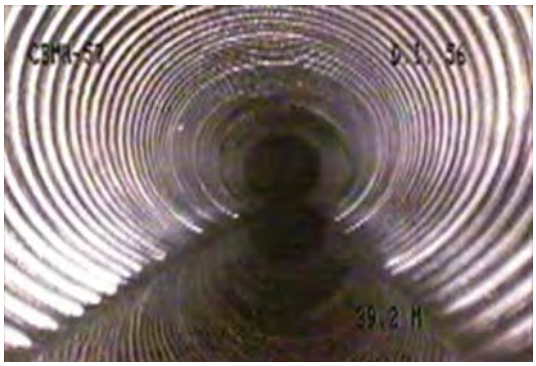
There are a variety of LID installations throughout Ontario, some of which have been operational for more than 15 years. Some of these sites are highlighted in Exhibit 4.

Exhibit 4 Ontario Examples of LID Practices in Operation for More than 10 Years

From top left to bottom right: Permeable Pavement at Belfountain Conservation Area (21 years), Green Roof over Below-ground Parking Garage at Gananoque Road Condominiums (30 years), Grass Swale and Perforated Pipe Drainage System in Ottawa (20 years), Exfiltration System in Etobicoke (17 years), Permeable Pavement at Jerrett's Funeral Home (14 years), Bioretention at York University (10 years).

Long term performance monitoring has been conducted at a number of LID sites in Ontario, including some of those included in Exhibit 4. For instance, studies conducted on the grass swale and perforated pipe drainage systems in Ottawa found that they continued to function effectively even after 20 years of service (with little maintenance).[29] As shown in Exhibit 5 video inspections of the perforated pipe found little deterioration, sediment accumulation or any other issue that would impair system performance.

Exhibit 5 Image from CCTV inspection of perforated pipe



Testing at the site found that runoff volumes were 14-27% of those in the conventional system and, due to these lower runoff volumes, the amount of TSS released was reduced by 81-95%.

[29]City of Ottawa (2008). 20 Year Performance Evaluation of Grass Swale and Perforated Pipe Drainage Systems. Available at URL: http://www.sustainabletechnologies.ca/Portals/_Rainbow/Documents/20%20Year%20Performance%20Evaluation%20of%20GSPP_Final%20Report_%20July%202008%20Edition_%20Main%20Text.pdf

In the review of performance, no evidence was discovered that would indicate nutrient or metal concentrations had increased in the grass swales since construction.

The experience in the GTA with the Etobicoke Exfiltration System is similar. Three sites were designed and constructed between 1992 and 1994 as a demonstration project in the City of Etobicoke. The sites were conveyance pipe-based exfiltration systems as illustrated in Exhibit 4. Monitoring at the Etobicoke sites found that they could exfiltrate all runoff from storms greater than the nominal 15 mm of rainfall, providing that antecedent conditions are dry and that storm intensity is not excessive[30].

The above examples demonstrate that LID practices can operate successfully given Canada's cold climate. To further examine the cold weather performance of LID practices the TRCA and CVC through funding from the province's SWI program and its partners, have conducted extensive monitoring of LID practices specifically aimed at evaluating cold weather performance. TRCA's study of a permeable pavement parking lot in King City, Ontario found that the lot functioned well during cold weather with temperatures as low as -25°C[31]. The STEP study also reported that a bioswale adjacent to the parking lot also performed well during the winter. Temperatures within the swale remained above freezing and there was no evidence of melt water backing up onto the parking lot. Most recently CVC conducted monitoring on bioswales retrofitted within the existing residential road allowance. Preliminary data found the bioswales were able to absorb a 24 mm storm event (95% of total annual average rainfall depth). This is promising performance given the tight soils in the area and the constraints posed by a retrofit scenario.

These, and other, LID monitoring projects conducted by Conservation Authorities and municipalities across Ontario have demonstrated that the majority of these practices are able to meet their intended stormwater management objectives. Ongoing performance monitoring by LSRCA, CVC and TRCA and other CA's are providing new insights into these techniques, including best practices for their design, construction and maintenance. To ensure that LID practices are successful over the long-term, CAs, with the assistance of partner funding, have published materials such as the CVC/TRCA *Low Impact Development Stormwater Management Planning and Design Guide*, CVC *Landscape Design Guide for Low Impact Development* and the CVC *Low Impact Development Construction Guide*. For further information and to access these documents refer to www.creditvalleyca.ca/low-impact-development/ and www.sustainabletechnologies.ca.

4.2.2 United States

The United States Environmental Protection Agency (U.S. EPA) actively promotes LID in publications such as *Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices, December 2007.*[32] Under the U.S. *Clean Water Act*, management controls are required for many stormwater related activities, including erosion and sediment control during construction activities and non-point pollution controls in watersheds with impaired water quality.

[30] Stormwater Assessment Monitoring and Performance Program (2004). Performance Assessment of a Perforated Pipe Stormwater Exfiltration System – Toronto, Ontario. URL: http://www.sustainabletechnologies.ca/Portals/_Rainbow/Documents/Exfil_ES.pdf

[31] Toronto and Region Conservation Authority (2008). Performance Evaluation of Permeable Pavement and a Bioretention Swale Seneca College, King City, Ontario.

[32] Available at URL: http://www.epa.gov/owow/NPS/lid/costs07/documents/reducingstormwatercosts.pdf

A number of jurisdictions in the U.S. have implemented LID programs for stormwater management and these programs are at various stages of maturity. A recent CVC survey investigated the regulatory, construction, inspection, maintenance, and financing issues related to various LID stormwater management programs of U.S. cities and regions.[33] The jurisdictions surveyed were selected based upon development pressures and climate regimes similar to Ontario, and included:

- Capital Area Regional Planning Commission, Wisconsin;
- Capital Region Watershed District, Minnesota;
- Chicago, Illinois;
- Grayling, Michigan;
- Philadelphia, Pennsylvania;
- Portland, Oregon; and
- Seattle, Washington.

The survey found that these jurisdictions have had to adapt and modify their standard practices to incorporate LID within their stormwater management programs. These municipalities and regions have, however, found a variety of pathways and tools to overcome barriers and implement LID on a broader scale. For further information, the report is available at www.creditvalleyca.ca/low-impact-development/.

Various studies and case studies conducted in the US have also confirmed that LID practices can perform in cold climates. Refer, for example, to case studies documented in the above-noted USEPA study of 2007.

4.3 Considerations in Implementing LID

4.3.1 Maintenance on Private Property

LID often entails a combination of public and private responsibilities. Private landowners may be required to maintain LID measures on their properties. Unlike SWM ponds, vegetation plays a key role in LID performance. Studies in the US and Canada have found that landscape design plays a critical role in private landowners maintaining LID features.[34,35] To assist designers select vegetation that is best suited to thrive and minimize maintenance requirements within LID features, CVC has developed the *Landscape Guide for Low Impact Development*.

In addition to guidance materials, other tools are available to ensure the proper care of LID practices by landowners. One such tool is the recording of LID practices against the property deed to ensure that they are not removed and to give the municipality the right of entry onto the property to conduct inspections. This practice can also be enforced through legal agreements such as easements or covenants. This approach has been taken in a number of U.S.

[33] Credit Valley Conservation (2010). Survey of Municipal Policies and Administrative Approaches for Overcoming Institutional Barriers to Low Impact Development. Available at URL: http://www.creditvalleyca.ca/low-impact-development/.

[34] City of Seattle (2010). Seattle's Natural Drainage Systems. Available at URL: http://www.seattle.gov/util/groups/public/@spu/@usm/documents/webcontent/spu02_019984.pdf

[35] Freeman & Associates (2008). Market Research and Marketing Strategy: Lot-level Stormwater Control in the Residential Sector. City of Mississauga. Available at URL: http://www.creditvalleyca.ca/low-impact-development/.

jurisdictions, including Seattle, Philadelphia and Portland, among others. If inspections reveal that LID facilities are not being maintained, written notices are provided, and if not followed up by the property owner, fines can be levied against the property owner.[36]

Another mechanism to promote both the implementation and adequate maintenance of LID practices is by providing private landowners with rebates or other incentives through a municipal stormwater funding mechanism, such as a stormwater utility fee or stormwater rate. Stormwater rates would provide municipalities with a dedicated funding source for stormwater management works (including LID maintenance in cases of non-compliance). This would also be one of the most equitable arrangements, as fees would be based upon stormwater runoff contribution rather than current taxation mechanisms based on property value. This type of fee structure would incentivize existing property owners to retrofit lots with LID BMPs for the purpose of lowering their stormwater rate fees. Stormwater rates would also encourage maintenance of LIDs on private property, as property owners would have to maintain the performance of the LID features in order to reduce runoff (and maintain a lowered stormwater rate).[37] Examples of Ontario municipalities that have already implemented this type of funding structure include Kitchener and Waterloo.[38]

Making use of conservative designs and factors of safety are other methods for reducing the impacts associated with improperly maintained LIDs on private property. By assuming worst case infiltration rates, over sizing practices and/or installing additional redundant lot level BMPs, additional capacity is provided for managing stormwater on-site, which can be relied upon to provide the needed treatment capacity even if insufficient maintenance is performed by the property owner. This approach has been taken in several US jurisdictions, including Seattle and the State of Wisconsin.[39]

Ensuring the adequate maintenance of LID facilities, particularly those located on private property, presents municipalities with some new challenges with regards to stormwater management in Ontario. However, as described above, there are a variety of tools that are available to assist municipalities address these challenges. For further information, please refer to the CVC's *Survey of Municipal Policies and Administrative Approaches for Overcoming Institutional Barriers to Low Impact Development* and the *Municipal Stormwater Financing Study* available at www.creditvalleyca.ca/low-impact-development/.

4.3.2 Public Awareness & Perception

The lack of public awareness of stormwater issues and requirements contributes to an on-going demand for conventional housing subdivision designs. LID will require public education for on-

[36] Credit Valley Conservation (2010). Survey of Municipal Policies and Administrative Approaches for Overcoming Institutional Barriers to Low Impact Development. Available at URL: http://www.creditvalleyca.ca/low-impact-development/.

[37] Credit Valley Conservation (2010). Credit River Water Management Strategy Update – Municipal Stormwater Financing Study. Available at URL: http://www.creditvalleyca.ca/low-impact-development/.

[38] City of Kitchener/City of Waterloo (2010). Kitchener/Waterloo Stormwater Utility based on Impervious Area: A Tale of Two Cities. Available at URL: http://www.creditvalleyca.ca/sustainability/events/lidconference2010/downloads/lid-sessiond/3DDMcGoldrickNGollan-Kitchener-WaterlooStor.pdf

[39] Credit Valley Conservation (2010). Survey of Municipal Policies and Administrative Approaches for Overcoming Institutional Barriers to Low Impact Development. Available at URL: http://www.creditvalleyca.ca/low-impact-development/.

going use and maintenance of lot level measures. There is evidence of interest from some homeowners for different subdivision types. For example, research on a sustainable community design demonstration project in Okotoks, Alberta found that incorporating environmental stormwater management methods was favoured by consumers over conventional underground pipes.[40]

The aesthetics of LID practices also play a role in the public acceptance of LID practices – which in turn will impact both the implementation and the maintenance of these features. Market research conducted by Freeman Associates on homeowners of single-detached households within the City of Mississauga found that they have a strong emotional connection to their home and the landscape that surrounds it. Participants used terms such as "beautiful," "tranquil place," and "peaceful sanctuary" to describe their landscape, and thus homeowners have an aesthetic motivation towards creating and maintaining their home landscape in order to attain these goals[41].

Freeman Associates found that residents preferred LID landscape designs to the traditional grassed lawn when colourful plants and aesthetic design were considered. Freeman Associate has integrated this motivation into a marketing strategy for the City of Mississauga. The strategy recommends that the City promote lot level BMPs/water efficient landscapes by utilizing visuals of beautiful gardens, rather than technical information such as water savings. By using these types of techniques municipalities can connect with residents on a more 'emotional' level to encourage both the adoption and maintenance of LID practices. Information from this study has formed the basis of CVC *Landscape Design Guide for Low Impact Development.*

[40] Canada Mortgage and Housing Corporation (2002). Sustainable Community Design Demonstration in Okotoks, Alberta: Testing Consumer Receptivity.

[41] Freeman Associates (2008). Market research and Marketing Strategy: Lot-level Stormwater Control in the Residential Sector. City of Mississauga. Available at URL: http://www.creditvalleyca.ca/low-impact-development/.

5 How CA's can Help

With intense development pressures within the Greater Golden Horseshoe area, the potential for missed opportunities is too great to ignore. By identifying barriers and collaborating on solutions to implement LID, the potential impacts on water quality from conventional stormwater approaches can be mitigated up front as opposed to after the fact at the municipality's and taxpayers' expense. Further, the need to reduce increased erosion and flood risk in the face of climate change is urgent considering the long term nature of built subdivisions and implemented infrastructure.

Given these growth and environmental pressures and with the assistance of partner funding, CVC, LSRCA and TRCA have made great strides in producing resource materials and tools to facilitate the adoption of LID – providing guidance on LID design, construction, operation & maintenance and monitoring. To assist in broader and timely application of LID across Ontario, CVC, LSRCA and TRCA are recommending the establishment of a Multi-Agency LID Review Team. The following sub-sections outline a proposed approach, subject to further elaboration in consultation with the Province and other stakeholders.

5.1 Create a Review Team for LID Projects and Promotion of LID

Through the Showcasing Water Innovations grant program, it is proposed that a multi-stakeholder LID Review Team and framework be formalized to initiate dialogue between the stormwater regulation authorities and to identify the barriers and opportunities associated with implementing LID across Ontario. For example, based on experience to date, it is recognized that there are procedural hurdles that are discouraging LID projects from being approved and implemented. In keeping with the Province's One Window Approvals initiatives, the Multi-Agency LID Review Team will therefore work closely to coordinate reviews of LID projects to streamline the process to the extent possible.

The review team proposed will consist of dedicated LID plan reviewers from the MOE, each of the author CAs (TRCA, CVC and LSRCA), and the participating municipalities. The project focus area encompasses Credit Valley, Lake Simcoe Region and Toronto Region watersheds as these regions are experiencing intense development pressures and have adopted newly approved SWM Criteria documents which have been vetted through municipalities, provincial agencies and the building industry. These Conservation Authorities have also been very active in trying to implement LID; through the various demonstration sites, monitoring programs and technical reports and guidelines. This experience will assist the team in identifying and resolving issues that impede LID implementation. These CAs will work with the MOE to identify criteria for approvals, and to consistently message the requirement for LID techniques as part of development plans submitted.

The Building Industry and Land Development Association (BILD) is in receipt of the Credit Valley Conservation's Stormwater Management Criteria document dated September 2012 and we offer the following comments on behalf of BILD Halton and Peel Chapter members:

We greatly value the open dialogue that you and your staff have provided us with by producing a comprehensive consultation sessions for this review. …At our working group meetings, we were able to establish a clear understanding of the objectives and rationale for the criteria update. Our meeting also resulted in modifications to the original proposal, which we believe will be beneficial to all parties. As such, the proposed criteria document, as modified, is acceptable to BILD…"

The proposed Multi-Agency LID Review Team will work to improve the permitting process by using past and future projects as points for discussion and for mapping out a revised process. For instance, there are many projects within the three CA jurisdictions where LID was proposed but the approvals process limited the use of LID or was slowed compared to conventional projects. There are also projects in which LID approvals were granted in a timely manner. The team will identify the barriers, perceptions and/or processes that contributed to limited approvals or slowed processes (as well as instances where LID received timely approvals) and will work with municipal and provincial representatives to propose solutions for new applications.

For new plan reviews, municipalities and conservation authorities are often the first to be consulted on new projects where LID has been proposed by the proponent or where LID can be recommended. Municipalities and the partner CAs can bring these projects to the review team for a streamlined review. CVC, LSRCA and TRCA will be phasing in new criteria for volume control through recharge, water quality, flood control, and protection of natural heritage feature requirements. The CAs will work with the watershed municipalities, MOE, and the development community to adopt these controls and create consistency across jurisdictions. The most immediate of these requirements will be volume control which can only be done through LID practices. By adopting CVC, LSRCA, TRCA's volume criteria as the basis for approval (consistent with the MOE SWM Planning and Design Manual Section 3.1) site and watershed monitoring studies can help further refine our understanding and adoption of new technologies in light of SWI, Ontario's Draft Great Lakes Strategy and MOE (2010) SWM Policy Review in Light of Climate Change.

Recognizing that LID projects need to be encouraged and incentivized in the short term, the team will work to speed the approvals for new, retrofit and redevelopment LID projects. This information will help inform the Province's One Window Approach initiative as well as future updates and/or addendums to the MOE SWM Planning and Design Manual.

As an outcome of SWI, the Multi-Agency LID Review Team will identify what coordinated approaches or arrangements the MOE, CAs, and municipalities can take to improve the certification and enforcement of maintenance requirements on stormwater management systems and, ultimately, redefine stormwater management review responsibilities in light of LID. Some initial questions the review team will aim to answer include: the acceptable form of maintenance arrangements for LID; particularly those located on private property.

5.2 Support Municipalities

As part of MMAH's efforts at evaluating the effectiveness of the Provincial Policy Statement, the MMAH requires stormwater management integrated into municipal official plans. CAs can work with the municipalities within each of their jurisdictions to implement SWM within official plans.

MOE's *Water Opportunities Act* provisions for water sustainability plans include the establishment of performance measures for water, stormwater and wastewater. CAs can assist municipalities in the development of these plans and work with them to facilitate solutions for meeting more stringent performance standards for stormwater management. For instance, CAs and municipalities could collaborate on sub-watershed studies by including members from both parties on steering committees, and by agreeing upon mechanisms for implementing study recommendations.

Implementing LID into official plans, secondary plans and creating water sustainability plans will also assist municipalities in attaining the goals of the Places to Grow and Ontario's Climate Change Action Plan and potentially begin to address Great Lakes near shore water quality issues.

To encourage the uptake of LID by developers, municipalities may wish to offer financial incentives to the developer, recognizing the long-term economic, environmental and social benefits that LID offers. The three CAs and other stakeholders can offer ideas for such initiatives where the private and public sectors can work together to achieve smart growth.

Also, if there are opportunities for seed money under the Canada-Ontario Agreement for the Great Lakes, the CAs can support municipalities in making the case for LID funding support.

5.3 Facilitate a One-Window Approach

Ontario has committed to a modernization of its approvals process and this commitment is supported by the *Open for Business Act*, 2010. Among other commitments, this act commits the government to streamline its approvals process and harmonize legislation with other governments.

Building on the knowledge gained from the Multi-Agency LID review team, CVC, TRCA, LSRCA (and potentially other CAs) can participate in further multi-stakeholder initiatives to facilitate a one-window approach to innovative SWM/LID approvals. This effort would also be consistent with Ontario's initiative on Modernization of Approvals.

5.4 Guidelines, Case Studies and Training Materials

CVC and TRCA have worked jointly to develop guidance and other materials for the engineering, landscaping design and construction of LID sites (including guidance developed with MOE funding support). Through SWI funding support CAs across Ontario can continue to develop and disseminate guidelines, case studies and training materials and work with municipalities and industry to develop an innovative SWM industry to foster green job growth. Ideally, these materials should be referenced in provincial guidelines such as MOE's SWM Planning and Design Manual (2003).

MMAH recommends to municipalities in the 2011 planning document *Municipal Planning and Financial Tools for Economic Development* that LID be used to increase population densities

within cities while providing more green spaces. CAs can assist by providing guidance materials, working with municipalities, developers and private industry to implement additional LID sites. Furthermore, these materials and support shall assist municipalities and other stakeholders in attaining the goals of the *Water Opportunities Act*, Open for Business Initiative and MOI's Building Together: Jobs & Prosperity for Ontarians.

5.5 LID Implementation Support

CAs can provide scientific and engineering expertise to support the implementation of LID pilot/demonstration projects and verification of the efficacy of LID through monitoring/watershed studies. CVC, LSRCA and TRCA each has demonstration projects in their watersheds and are conducting research on the measures. Also, each of these CAs have established water balance criteria in their jurisdictions, which is essential to making proper stormwater management decisions.

The three partner CA's can work with interested parties, such as MOE, member municipalities and the Building Industry and Land Development Association (BILD) to identify key monitoring questions and initiate a more co-ordinated strategic LID monitoring program. This information can be made public on the STEP website (www.sustainabletechnologies.ca) and will help inform updates to the MOE SWM Planning and Design Manual and CVC/TRCA LID Guide. Another task which can be undertaken by the Multi-Agency LID review team through SWI and Ontario's Draft Great Lakes Strategy is to determine the SWM infrastructure sizing criteria (i.e., pond downsizing, utilization of dry ponds, LID sizing safety factors, etc.) to employ in cases where LID is being implemented. This work would focus upon identifying potential cost-efficiencies that can be achieved by combining conventional and LID infrastructure, while balancing the need for comprehensive SWM management requirements, including erosion control and flood protection.

Through these and other efforts, these CAs have the required knowledge and on-the-ground expertise to conduct monitoring, propose changes to design standards and approval processes and to facilitate transferring this knowledge to the various stakeholders involved. These efforts will ultimately inform municipalities to develop SWM planning approaches that work toward the various goals and initiatives of the Provincial Policy Statement, Planning for Climate Change, Great Lakes Strategy, *Water Opportunities Act*, *Clean Water Act*, and Places to Grow and Great Lakes Water Quality Agreement (GLWQA) / Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem (COA).

6 Next Steps

The Province, in the 2012 Draft Great Lakes Strategy (see Appendix A, items 1 and 4) and through funding provided in the Showcasing Water Innovations (SWI) grant program, indicates a clear intent to work with CAs and others in improving the science and standards and approvals for SWM to support LID practices. It is recommended that these 'future actions' become immediate actions and current priorities for implementation, in part, through:

i) immediate release of an Interpretation bulletin for the *MOE's 2003 SWM Planning and Design Manual* specific to implementation of LID practices. Such a Bulletin would assist in communicating information to developers, municipalities and review/approval bodies involved in stormwater management planning thus increasing uptake/application of the techniques. Currently, the MOE Manual promotes adoption of traditional stormwater management ponds since it's the only technique with specific direction; and,

ii) approval of a Terms of Reference for a multi-stakeholder Review Team to maximize the benefits of investments made to SWI and ultimately, to update the MOE 2003 Manual with detailed, province-wide guidance for LID practices.

Appendix A: Future Actions in Ontario's Draft Great Lakes Strategy (2012) in Support of LID

	Great Lakes Protection Strategy – Future Actions	Green Infrastructure/LID/stormwater references
1	GOAL 2: PROTECTING WATER Other Future Actions, p.38 *Strengthening municipal water, wastewater and stormwater management*	c) Assisting municipalities and others in reducing impacts of stormwater, including: - further supporting stormwater innovation demonstration projects and communicating the results of water innovation pilots to a broad audience - developing guidance and standardized approvals to facilitate and remove barriers to the uptake of innovative source control measures that reduce stormwater volumes, such as green infrastructure and low impact development - enhancing the Province's approach to stormwater approvals with greater emphasis on effluent quality and quantity, in turn driving greater use of innovative source control measures - seeking environmental considerations such as use of low impact development early in municipal planning decisions, so that stormwater is considered as part of project design and approvals, not after the fact, and - consulting on the development of overarching stormwater policy that supports the Canadian Council of Ministers of the Environment wastewater strategy.
2	GOAL 2: PROTECTING WATER p.39	d) Continuing to work with municipalities to minimize discharges of untreated sewage (such as overflows of combined sewers, and sewage bypassing a treatment plant) through: - improving tracking of sewage overflows and bypasses, and continuing to monitor incidents and municipal work to minimize untreated sewage discharges - encouraging municipalities to complete Pollution Prevention Control Plans and to make progress on reducing overflow and bypass volumes, and - promoting stormwater and green infrastructure approaches described above.
3	GOAL 2: PROTECTING WATER Other Future Actions, p.39 *Managing rural non-point sources of nutrients*	h) Seeking opportunities to reduce nutrient inputs to the environment and improving monitoring of performance from the agricultural sector in priority geographic areas including: - review of the related acts and regulations for opportunities to promote environmental stewardship, water quality protection,

		innovation, green infrastructure, and water and nutrient recycling, and - development of community partnerships to encourage the uptake of effective agricultural best management practices.
4	GOAL 5: ENHANCING UNDERSTANDING AND ADAPTATION p.51 *Delivering needed science*	i) Sustaining partnerships, data sharing, and other opportunities to help enhance science knowledge and capacity at conservation authorities, Ontario's universities, and among other Great Lakes research and protection partners. For example, collaborating on science that addresses barriers to using green infrastructure for stormwater management, such as development of design standards that are appropriate for Ontario soil conditions.
5	GOAL 6: ENSURING ENVIRONMENTALLY SUSTAINABLE ECONOMIC OPPORTUNITIES AND INNOVATION p.56 *Supporting the development of innovative water technologies, services and practices*	g) Encouraging industrial practices that minimize water consumption, recycle water, use reclaimed wastewater or stormwater for business operations or processing, and apply low impact development to stormwater management. (e.g., permeable parking lots).
6	GOAL 6: ENSURING ENVIRONMENTALLY SUSTAINABLE ECONOMIC OPPORTUNITIES AND INNOVATION p.56	h) Encouraging development and use of green technologies and demonstrating leadership in green building, green infrastructure such as coastal wetlands, and water and energy conservation.