Low Impact Development Business & Multi-Residential Retrofits:

Optimizing Your Bottom Line through Low Impact Development

Business and Multi-Residential

CVC | CREDIT VALLEY CONSERVATION

Welcome to the Credit Valley Conservation Be A Leader Grey to Green Series

As the Chair of Credit Valley Conservation, and City Councillor for Mississauga, I have first hand experience with pressures our communities face with aging infrastructure, changing climate, a growing population, and fiscal crisis. It's growing more difficult to find the resources to meet growing needs.

Municipal infrastructure is regularly overwhelmed and ineffective. Time and time again—especially this past summer—we're reminded that existing systems cannot manage intense storms and are failing to protect the environment.

But there is a solution, and it's not as expensive as you might think. In fact, the low impact development (LID) approach easily ties into existing systems, our public lands, road right-of-ways, commercial and institutional properties and residential homes all present opportunities. Properly maintained LID features promise a quick return on investment and many other benefits. With LID, you can:

- **Protect assets and defer larger investments.** LID barriers can slow the flow to storm sewers during intense rain events, giving them more time to process stormwater. In this way, LID helps meet asset management requirements, reduces damage to existing systems, and extends the useful life of infrastructure.
- **Save money. Smaller, more frequent events cause costly damage.** LID practices encourage infiltration and can help reduce the amount of erosion, and pollutants to creeks, rivers, and streams that leads to regular and often expensive maintenance and lost revenues from beach closures.
- **Increase tax revenue.** Free space in growing cities is at a premium. The cost of land can be as much as four times the cost of new infrastructure. LID practices require minimal land expropriation, and often fit into existing urban infrastructure, leaving more land available for development and tax revenue.
- **Build resiliency and protect the environment.** One technology alone isn't enough to ensure resiliency. Adding LID measures to a treatment train can reduce the frequency of flood-related residential damage due to overwhelmed existing systems. LID can also reduce the flow of contaminated stormwater to surface waters, which can harm aquatic environments, and increase the cost of treatment at the drinking water level.

If you see opportunities for LID in your municipality, we encourage you to review the business case (Chapter 1) and pass along this user-friendly guide to your clients, municipality's staff, property managers, land developers and infrastructure teams.

On behalf of all of us at Credit Valley Conservation, we hope this Guide can help create vibrant, healthy, sustainable communities!

Pat Mullin

Councillor, City of Mississauga and Region of Peel
Chair, Credit Valley Conservation

P.S. This guide is a living document. We invite you to share your experiences with LID for future editions, and reach out to the CVC team for further guidance and collaboration. Please visit our website for access to all the Grey to Green guides: http://www.creditvalleyca.ca/low-impact-development/low-impact-development-support/stormwatermanagement-lid-guidance-documents/

Acknowledgements

Project Team

Chris Despins
Robb Lukes
Kyle Vander Linden
Phil James
Christine Zimmer
Tyler Babony
Alex Waterfield

Technical Advisory Committee

John Nemeth, Region of Peel
Derek Gray, Greater Toronto Airport Authority
Tim Gallagher, Stantec
Mike Burkhart, Bernardi Building Supply
David Armstrong, Armstrong Manufacturing
Ted Fujarczuk, Unifay Fedar Investments
Dan Miller, R.J. Burnside and Associates Ltd.
Cheryl Evans, REEP Green Solutions
Lorna Howieson, IMAX
Nick Gollan, City of Kitchener
Vicky Liu, Reinders and Rieder Ltd.
Lora Field, Ministry of Economic Development, Trade and Employment
Angela Maclean, City of Waterloo

Comments or questions on this document should be directed to:

Christine Zimmer
Senior Manager, Protection and Restoration
Credit Valley Conservation
1255 Old Derry Road
Mississauga, Ontario L5N 6R4
905-670-1615 x. 229
czimmer@creditvalleyca.ca

Phil James
Manager, Protection and Restoration
Credit Valley Conservation
1255 Old Derry Road
Mississauga, Ontario L5N 6R4
905-670-1615 x. 234
pjames@creditvalleyca.ca

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Welcome to the Grey to Green Business & Multi-Residential Retrofits Guide

LID

low impact development is a green infrastructure approach to stormwater management that uses simple cost-effective landscaped features and other techniques to filter, store, infiltrate and use rainfall where it falls.

Who should read this guide?

The Grey to Green retrofit guide is aimed at you - the owners, property managers, operators and staff at businesses, multi-residential properties, colleges and universities. This guide will benefit staff from facilities, environmental, health and safety and sustainability departments. Planners, engineers and contractors will also find technical guidance and information on RFPs, construction supervision and life-cycle activities.

This guide is also for anyone interested in promoting more sustainable practices in the business and multi-residential community, including board members, employees, customers, students or residents.

Why should I read this guide?

Across Ontario, the costs of managing property are rising. Businesses and multi-residential properties face pressure to develop sustainable practices and to "green" their brand. At the same time, extreme weather events are becoming more common and putting greater strain on aging municipal infrastructure. The risk of flooding and water-related damages has increased, and it is no longer enough to simply maintain the current water infrastructure.

LID can help you to better manage stormwater on your property. It can reduce your risks, and add to the value of your property or brand. You need to take the initiative to go beyond the standard methods and implement green infrastructure practices such as LID. This guide will show you how.

How should I read this guide?

In this Grey to Green Business & Multi-Residential Retrofits guide we will present the business case for LID, as well as provide in-depth guidance, tools and case studies to make LID a mainstream practice for businesses, colleges, universities and multi-residential properties of all sizes. To help draw attention to the information that is important to you, this guide uses the following colour-coded icons:

Businesses

Multi-residential

Colleges & Universities

Where should I go for more information?

For more information on the design, construction and life-cycle activities of LID features as well as case studies of business and multi-residential properties that have implemented LID on their property, please visit Credit Valley Conservation's Be a Leader website:

bealeader.ca

Check out the entire suite of Grey to Green Retrofit Guides:

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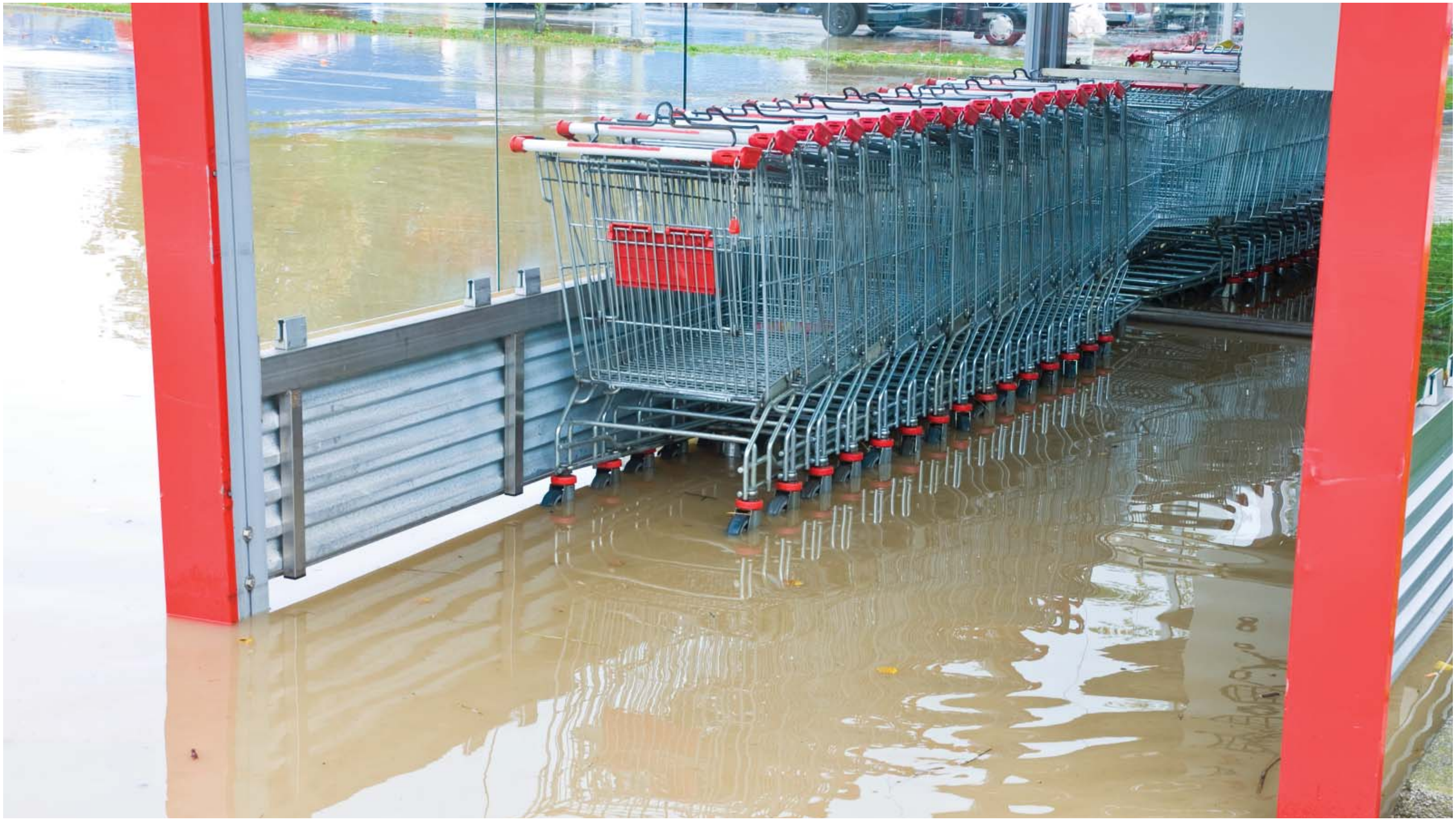
1.0 Making the Case for Grey to Green Business and Multi-Residential Retrofits



1.1 Minimizing your risk

By taking steps to better manage stormwater on your business, college, university or multi-residential property you can reduce your environmental impact and lessen the risk you face during your day-to-day operations. Some of the risks that you may face include:

- Rising costs of managing your property, including water, wastewater, stormwater, electricity, natural gas, maintenance and repair of facility buildings and grounds
- Rising insurance costs
- The need to comply with environmental regulations at the provincial and municipal levels
- Maintaining your brand/reputation among your peers and customers in an increasingly competitive field

Are you aware of all the risks to your business, post-secondary institution or multi-residential property? Many people are not. In fact, many Ontarians are unaware that since 1995 a state of emergency has been declared almost every year in Ontario due to extreme weather events[1]. Water-related insurance claims are now the leading property claim at $1.7 billion per year, surpassing fire claims for this first time[2].

The 2012 CDP Water Disclosure Global Report surveyed publicly traded companies in the FTSE Global Equity Index Series (Global 500) on behalf of investment firms with more than US$50 trillion in assets. More than half of respondents (53%) have experienced detrimental water-related business impacts such as business interruption and property damage from flooding. Associated financial costs for some companies have been as high as $200 million. The most commonly reported risks include flooding, water scarcity/ water supply, reputation damages and higher regulatory compliance costs.[3]

Flood risk

Extreme storm events are on the rise across the country, increasing the risk of local flooding. For instance, the City of Windsor has faced particularly wet weather in recent years. The city's wettest year on record was 2011, with rainfall of 1,568 mm (almost double the annual average of 844mm)[4]. This increase in rainfall volume puts stress on local stormwater infrastructure and increases the risk of flooding.

In July 2013 the Greater Toronto and Hamilton Area (GTHA) experienced two extreme weather events in one month. On July 8, a record-breaking 125 millimeters (five inches) fell in a two-hour period, an intensity that rivals records from 1954's Hurricane Hazel - one of the area's worst storms. The resulting floods stranded commuters and caused extensive infrastructure damage and business disruptions. More than 300,000 people and businesses experienced mass power outages. The storm is expected to cost insurers more than CAN$850 million[5].

Environment Canada reports that most natural disasters in Canada are flooding events and the number of floods has been steadily increasing since the 1960s[6]. It is not just the extreme events that are costly. Leading U.S. agencies predict that damages from an event that has a 1-in-10 chance of occurring (10-year) can result in building, content and inventory losses of US$48 million to $60 million in urbanized areas[7].

Figure 1.1.1: On June 28, 2013 a storm in the Waterloo region experienced a sudden high-volume rainfall. The resulting flooding stranded cars and caused property damage at Fairview Mall. (Source: CTV)

Do you want to bet?

A 50-year event has a 1-in-50 chance of occurring in any given year and a 100-year event has a 1-in-100 chance. If you were to wager, you might like those odds. However, you may want to consider that in the last eight years leading up to 2013, the GTHA has experienced eight extreme events, five 50-year events and three 100-year events. Are you prepared for when the next perfect storm hits?

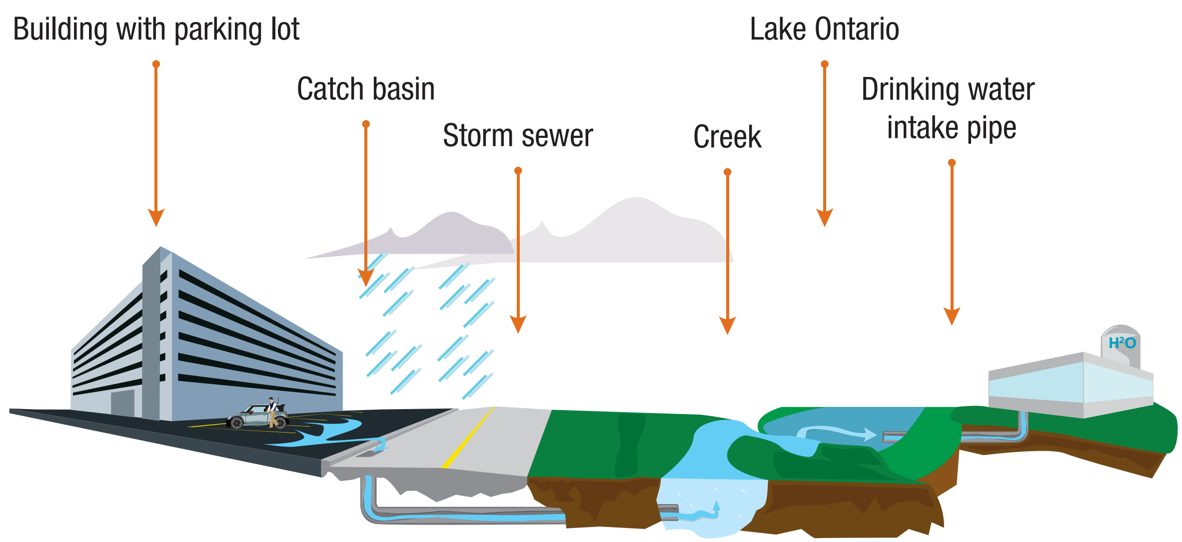


Figure 1.1.2: Conventional approach to stormwater management. (Source: CVC)

Given the changing climate, it is likely that what was once a 1-in-100 year event may change dramatically. These historical trends can no longer be relied upon exclusively to predict future storm events—business owners, condominium corporations, colleges and universities must take the initiative to make sure their properties are prepared for the amount and intensity of rainfall that will land on their properties.

While flood control isn't the primary purpose of LID, it does provide added resilience when combined with existing stormwater infrastructure. LID has the ability to reduce runoff volumes, divert or delay water from entering overstressed and aging stormwater infrastructure and better protect your assets from extreme events. At CVC's Elm Drive retrofit location, the LID measures have been shown to offer a mean annual runoff reduction of 93%. During the July 8, 2013 storm event, the bioretention planters provided up to 40% volume reduction and held water back for 40 minutes before it entered the municipal systems[9].

Retrofitting your property with LID stormwater management practices can be an important step in managing the risks associated with extreme events.

Regulatory compliance risk

When evaluating how well your assets are protected, you need to consider how to meet and stay ahead of regulations that impact your business, institution or condominium. Consider both current and future water regulations that may affect your property or operations. These can include higher compliance costs, reduced ability to service your clients, increased taxes or the evolution of stormwater utilities. Being proactive and taking steps to be ahead of changing or new regulations is just good business management.

Stormwater utilities

Stormwater utilities are relatively new to Ontario but have been implemented in many municipalities throughout the United States. Some of the first municipalities to introduce stormwater ratres include the City of Waterloo and the City of Kitchener, which established stormwater utilities in 2010.

The City of Mississauga will implement a stormwater utility starting in 2016. The Town of Aurora, the City of St. Thomas, and the City of London have also implemented tiered flat fees for the use of stormwater infrastructure.

The details of these funding systems vary by municipality, but the general idea is that properties that put the most strain on municipal stormwater infrastructure pay a higher monthly fee. The user fee that the property owner pays to the municipality is based on total impervious area, or land use and property size.

Did you know that six Ontario municipalities have implemented or are in the process of implementing stormwater utilities or flat rates?

It is very likely that your site is part of a group of land uses considered to generate the most stormwater. Commercial, industrial, and institutional sites tend to have large roof and parking surface areas and less green space, which will cause the most rainfall from the site to enter municipal systems.

To encourage property owners and managers to reduce runoff quantity and improve quality from private properties, stormwater utilities programs often have credit programs. Credit programs offer reductions in the monthly stormwater utility fee if the property owner implements on site practices that divert water from the municipal storm sewer system or improve the quality of water conveyed there. Some credit programs also provide fee reductions for industrial and commercial businesses that provide programs to educate employees on stormwater management and its relationship with the environment. Each municipality that runs an incentive program will have different criteria for receiving stormwater credits. If stormwater utilities incentives are available in your jurisdiction, it is important to consult with the municipality to determine the LID retrofit options that qualify.

Figure 1.1.3: Commercial areas have a lot of impervious cover. This figure shows roof cover in red and asphalt cover in blue. Water can not sink into the ground so it ends up entering municipal stormwater systems or pooling on the property. (Source: CVC)

Spills

Many municipalities and agencies have the ability to impose fines for illegal discharges, dumping, spills and excessive sediment releases to surface water, groundwater sources or even to a municipal sewer. In some cases these fines can be more than $100,000 and do not include the cost of the cleanup. Protect yourself from this risk by ensuring that you have pollution prevention strategies in place and consider how LID could help. For more details on pollution prevention, see Chapter 2.

Figure 1.1.4: Fines can significantly impact the profitability of industrial operations. Implementing pollution prevention can pay off by reducing potential fines and cleanup bills associated with spills. (Source: CVC)

Risk of reputation damages

It takes a company or institution a lot of time and effort to forge a good reputation within the community. Unfortunately, it takes much less time and effort to tarnish a reputation. Whether you run a small or large business, your reputation is a large contributor to your success.

If you are operating a site without pollution prevention controls, consider the impact on your corporate reputation if a spill were to occur. Alternatively, consider what your customers or residents would think if their vehicles were flooded in your parking lot as a result of insufficient onsite stormwater controls.

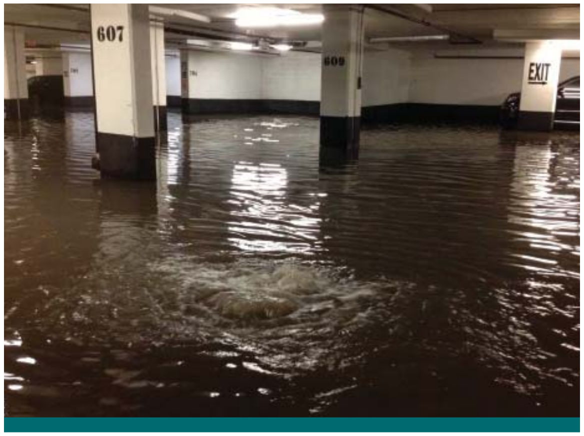


Figure 1.1.5: This photograph shows an underground parking structure during an extreme event. Could this be your property? (Source: CVC)

These public relations nightmares can be avoided. An LID retrofit demonstrates that you are doing your part and taking a leadership role in managing stormwater on your property. It can also help you avoid costly damage.

Industry Canada promotes the principles and practices of corporate social responsibility (CSR). The foundation of CSR is that a business or corporation is responsible for its actions as well as the social, environmental, and ethical outcomes of those actions. By taking responsibility for the impacts of your business decisions, you can enhance your reputation and profile within the community.

Figure 1.1.6: Spills entering water bodies can result in heavy fines for the polluter. This image shows a diesel spill in a creek. A filter sock was used to contain the spill.(Source: CVC)

Transparency is vital to your reputation. Research conducted by the Global Reporting Initiative indicates that 82% of U.S. companies cited transparency as the main factor influencing corporate reputations[10].

Being transparent about the impact your business has on the environment is an important facet of CSR. By identifying the impact your business has on the environment and actively making changes to mitigate this impact, you are building your reputation with key stakeholder groups (clients, suppliers, residents, tenants, community members, etc.) LID retrofits, especially those that are highly visible, promote a “green” reputation with these groups.

Reporting to your customers, residents, and shareholders on your organization’s sustainability is essential to promote your environmental reputation. Customer pressure has forced many companies to become more transparent and report on sustainability within their business framework. For example, Wal-Mart implemented a supplier sustainability initiative in 2009[11]. This initiative demonstrates that large successful corporations are evolving their business practices to maintain and elevate their reputation.

An LID retrofit implemented on your site can significantly improve the social, environmental, and ethical reputation of your business within your community.

Stay ahead of the curve – go green!

Green businesses can gain market share by tapping into the rapidly growing green procurement and green supply chain initiatives.

Climate change risk

Recent climate change science predicts that throughout Canada the intensity of rainfall during storms will increase significantly, especially during short storms. Events which are now considered extreme will occur more frequently.[12] Are you prepared?

The Canadian Standards Association has summarized and predicted climate changes in Ontario[13]. These predicted changes to precipitation patterns indicate water management practices and infrastructure will be more vulnerable to failure. Flooding is not the only risk that we face from climate change. Hotter and drier summer conditions will put a strain on both freshwater ecosystems and municipal water supplies. Robust and holistic stormwater management systems that manage water both at the source (on your property), along the conveyance network, and at the end-of-pipe, are necessary to adapt to this unprecedented change in precipitation. However, as municipalities face ongoing infrastructure deficit, assets may need to last longer than originally intended, perhaps leading to unanticipated flooding and increased operational and maintenance costs.

It is important that all property owners and managers prepare for what is no longer the unexpected. As the current infrastructure deficit highlights, there are significant consequences to not doing enough or ignoring the risks. Mitigation and adaptation are necessary to reduce vulnerability and the potential impact.

Reduce your risk

Since 1995, extreme weather has caused a state of emergency to be declared almost every year in Ontario resulting from extreme weather events[14]. Water-related insurance claims are now the leading property claim nationally at $1.7 billion per year, surpassing fire claims for this first time[15]. In fact, extreme weather costs Ontario tax payers approximately $6 billion per year. Retrofitting your property with LID features can help you mitigate risks to your property.

"Given that SMEs (small to medium enterprises) account for 99.8% of enterprises, 60% of employment, and 57% of gross domestic product in Canada, they are an essential partner in the country's action on climate change, resource conservation and other areas of environmental management."

– Strandberg Consulting for Industry Canada[16]

Figure 1.2.7: Storms can create liability issues for business owners. Flooding and the resulting infrastructure damage can harm customers and their property. (Source: CVC)

Water supply risk

There is a significant risk to municipal or private water supplies resulting from poor environmental practices, spills and a lack of adequate stormwater management. In Ontario, there are two sources of water that can supply your property:

- **Surface water** – rivers and lakes
- **Groundwater** – municipal or private wells

Maintaining the quality and quantity of our water supply is closely linked to stormwater management and the practices on your property. During rain events, water collects contaminants from the urban environment including land surfaces and delivers them to watercourses. Pavement and other non-natural surfaces reduce the area for rainwater to infiltrate into the ground and recharge groundwater supplies.

A reduction in the amount of water or the quality of the water which is supplied to your property can significantly impact your operations. Water shortages and municipal water bans are becoming more common and poor water quality often results in higher processing and treatment costs. These costs are passed on to the end user. This can affect the overall affordability of your property, impact lease or rental rates, limit manufacturing operations or otherwise disrupt the way in which your customers use your site.

LID emphasizes the use of distributed, small-scale stormwater controls to more closely mimic the natural movement of water, but rainwater can also be harvested from rooftops and used for indoor and outdoor use, such as toilet flushing and outdoor irrigation. These actions can help to save money on water bills. The principles of LID are part of an evolution in stormwater management in Ontario, based on the principle that rainwater is managed close to where it falls and can be a resource for your property. By implementing LID measures on your site, you will do your part to ensure that you and all Ontarians have access to abundant clean water.

Figure 1.1.8: Following rainfall events a plume of polluted water (from stormwater runoff) can often be seen discharging from the Humber River into Lake Ontario – the drinking water source for 8.5 million Ontarians. (Source: City of Toronto)

Case Study: IMAX Head Office

LID Feature:

- **Permeable pavement**
- **Bioswales**
- **Enhanced filtration units**

In 2013, IMAX partnered with CVC to retrofit its aging parking lot at its Mississauga, Ontario head office. The parking lot now includes several green LID features that help manage stormwater on the property.

Why did IMAX go green?

Poor drainage in the IMAX parking lot was causing several safety and maintenance issues, including

- Flooding of electrical boxes in the parking lot that caused business disruptions from power outages
- Asphalt degrading quicker than normal, increasing operating expenses
- Ice forming in the winter, creating slips, trips and fall hazards

Incorporating LID features in the parking lot retrofit allowed IMAX to address these concerns.

How is IMAX benefitting from its green parking lot?

Extended infrastructure lifespan – Better drainage increases the lifespan of the asphalt surface, and reduces cracking, upheaval and potholes. By extending the parking lot lifespan IMAX will reduce capital costs.

Reduced liability – Permeable pavers and better onsite drainage reduce winter ice formation. This lessens the chances of slips, trips and falls.

Reduced operating expenses – These features will also reduce the risk of incurring ongoing expenses associated with municipal stormwater fees. Under Mississauga's proposed stormwater fees, IMAX could face an annual fee of over $2,700 per year for its parking lot alone.

"Employees at IMAX have thought this has been a great project for us. Protecting the environment but also expanding our parking lot are vast benefits for us. It's been a win-win scenario."

– Mark Welton, President, IMAX Corporation

For more information on how IMAX is making its parking lot green through LID, check out: youtu.be/i5MHNkfpSyU

(Source: WaterTAP)

For more information, check out the IMAX Head Office Case Study in Appendix A.

1.2 Protecting your assets

Ontario has a large stormwater infrastructure deficit and the province's population is expected to increase by four million in the next 25 years[17]. Ontario municipalities must make a significant investment in older developed areas while still meeting the needs of growth areas. This work will take money and time. The City of Toronto estimates that it will take until 2022 to erase its more than $2.7 billion deficit in wastewater and stormwater[18].

Figure 1.2.1: This photo shows a shopping centre that was forced to temporarily shut down as a result of significant urban flooding. How would your property fair in a similar situation? (Source: CVC)

We know from the past eight years that the current level of protection is not sufficient, so how will you protect yourself, your property, your business, or where you live? It is important to ask yourself these questions.

- [ ] **Are your assets and investments protected?**

By retrofitting with LID and managing stormwater on your property, you are adding to the resiliency of the overall stormwater management system and are better protecting your assets and investments. LID practices are a resilient form of stormwater infrastructure that can better cope with changing and erratic weather patterns than conventional practices.

- [ ] **Have you diversified your level of protection?**

In combination with existing municipal stormwater infrastructure LID provides a holistic approach that better protects your property and investments from all rainfall events.

- [ ] **Are you staying ahead of regulations?**

Stormwater utilities and other related regulations could be in effect (or on the way) for your area. By retrofitting your property with LID you can stay ahead of these changes and you may even qualify for a rebate.

- [ ] **Can your operation continue to operate in extreme events?**

LID has the ability to help you stay dry during rainfall events. Combined with backup power systems and a good plan, LID gives you a better chance of operating during extreme events.

Perception: 58% of Canadians feel municipalities are doing an excellent or very good job at upgrading systems to handle excess stormwater.[19]

Reality: Ontario has a substantial stormwater infrastructure deficit. For example, it is estimated that only 35% of developed urban areas in the greater Toronto area has stormwater management controls.[20]

1.3 Create a competitive advantage

How can LID help you create a competitive advantage? The following sections describe how LID can result in:

- Higher returns on lease or rental rates
- Higher property and resale values
- Higher occupancy rates
- Increased sales and foot traffic
- A healthier and safer work environment
- Improved "triple-bottom-line" reporting
- Increased marketing opportunities
- Increased access to funding or financing
- Reduced insurance costs

Returns on lease and rental rates

LID practices like bioretention, bioswales, tree planters, and landscape alternatives incorporate more green space than conventional stormwater infrastructure. Green spaces also enhance a landscape's aesthetic value

Though the financial impact is harder to measure accurately, incorporating LID techniques into a site can provide distinct competitive advantages within the marketplace. Green areas adjacent to retail, office, institutional, and residential buildings present a friendlier image to the public than hard concrete surfaces. In the fiercely competitive land management sector, these property greenings can positively impact customer experience and promote lease retention.

A study of the office building rental industry completed by the University of San Diego concluded the average rent fee for green office buildings is more than $3.50 per square foot higher than conventional properties[21].

Higher property and resale value

Through increased green space and the corresponding aesthetic value, it has been demonstrated that property value and the potential for future site redevelopment both increased with the use of LID[22]. In general, people are willing to pay more for real estate with green features. Developments that use the natural landscape as the basis for their overall design carry a sale-price premium, are less expensive to build, and are sold more quickly than conventional developments[23]. When real estate appraisers were surveyed, 86% agreed that the property values are elevated by landscape features and 92% agreed that landscaping increased the sales appeal of commercial real estate[24].

Higher occupancy rates

Commercial districts enhanced with LID features have higher occupancy rates and enhanced property values. Landscape amenities have the highest correlation with occupancy rates from a list of 30 variables including building architecture, urban design, and direct access to arterial routes.[25]

Green office buildings also showed lower vacancy rates than their conventional counterparts. The strong correlation between green site features and positive perception of the property is expected to carry over to other land-use types in a similar manner.

Figure 1.3.1: Aesthetically pleasing landscapes translate into higher occupancy and improved bottom lines. (Source: Aquafor Beech)

Increased sales and foot traffic

Greening a commercial property such as a big box store or shopping plaza may also attract customers. In a survey conducted in the United States, 74% of the respondents indicated that they preferred shopping at commercial establishments that incorporated trees and landscaping into their parking lots and hard structures[26].

When considering the social draw of a retrofit, it is important to know the demographics of the site user. Businesses or institutions that are targeted towards young and/or socially progressive segments of the population may see market gains from advertising their site as environmentally sustainable. This advertising strategy may be successful for post-secondary educational institutions and some commercial retailers.

These decisions can offer a competitive advantage. Starting in 2009, Universitas Indonesia began compiling a yearly ranking of green universities around the world. Universities are ranked on various metrics from programs offered and campus design. These rankings are widely reported in the media and are a competitive advantage for the schools that rank highly.

Case Study: Conestoga College

LID Features:

- Enhanced grass swale
- Soakaways and infiltration gallery
- Pollution prevention

In 2010, Conestoga College constructed a satellite campus in Cambridge. Several LID features were included in the site design to help the college reach its goal of being a zero-runoff campus.

Why did Conestoga College go green?

Green features were included on the Conestoga College Cambridge Campus to:

- Meet sustainable, ecological and economic objectives defined in the Conestoga Campus Master Plan
- Reduce environmental impacts to Blair Creek, one of the last remaining cold water fisheries in Kitchener

How is Conestoga College benefitting from a green campus?

Protecting assets – The large-capacity bioswale installed in the parking lot retains water from large rainfalls. This will help to prevent risk and potential damage from flooding.

Corporate social responsibility – The green design of the campus, as well as the stormwater management pond, helps reduces the release of thermally enriched water into Blair Creek. Green features also protect and enhance groundwater quantity and quality.

For more information, check out the Conestoga Case Study in Appendix A.

Reduced operating expenses and liabilities

Municipalities are turning towards stormwater management rates as a way to address stormwater deficit. These rates are calculated on the amount of impervious cover on a site. These costs can be a monthly expense and, depending on the size of the property, can be quite high. Both tenants and landowners can benefit from LID as a way to reduce these monthly bills.

Healthier environment

LID practices that include a landscaped component such as bioretention, bioswale, green roof or other vegetated practice are commonly perceived as enhancing the aesthetics of a site and can have significant physiological and psychological benefits to the site user. By promoting better health, companies can potentially reduce employee medical costs. Proximity to green space tends to draw people outside to use recreational features. In some cases, researchers have observed an increase in outdoor physical activities after LID practices have been installed[27].

In addition, vegetated landscapes generally promote a healthier work environment. Encounters with everyday nature, like a view from an office window or a walk through a garden, can help to restore the ability to concentrate, calm feelings of anxiety and reduce aggression. Research demonstrates that response to trees and vegetation can be linked to health, and in turn related to economic benefits[28]. In fact, a view of natural setting reduces the number of sick days taken by office workers[29].

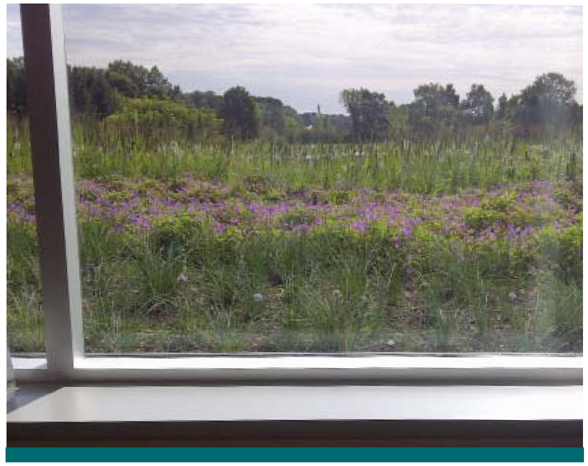


Figure 1.3.2: Enjoy the view? So do employees, tenants and customers. Green roofs and other landscaped features have been shown to improve wellbeing, boost employee morale and reduce sick days. (Source: Aquafor Beech)

Safety enhancements

Safety is a major concern for all property owners and managers. Pedestrians must have safe access to building entrances from parking lots and transit hubs.

Preventable slips, trips and falls along these routes are a concern for site owners, operators, and their commercial liability insurers because they result in some of the most common and costly liability claims against property owners[30].

Did you know that the average WSIB high-impact claim can cost up to $30,000?[31]

You can reduce the risk of slips, trips and falls and avoid costly claims by considering alternatives pavement surfaces such as permeable interlocking pavers, pervious concrete or porous asphalt. Due to their quick-draining nature, standing water and ice formation on the surface of permeable pavement can be reduced.

Figure 1.3.3: Poor drainage can lead to ice formation on parking lots and pedestrian access paths.

Figure 1.3.4: Over-applied de-icing salt to prevent slips and falls is common in many parking lots. Permeable pavements can reduce the need for salt. (Source: Aquafor Beech)

Triple-bottom-line reporting

In response to mounting pressure for transparency, many organizations are choosing to report on sustainability and CSR. A recent study of more than 3,000 international corporate leaders, industry experts and academic scholars found that 70% include sustainability within their management agendas and that heavy adopters are finding that their companies' sustainability activities are adding to their profits. Two–thirds indicated that this transition was necessary in order to be competitive in today's marketplace[32].

Sustainability reporting helps organizations communicate how well they are adhering to and performing on the "triple-bottom-line" scale of environmental, social and economic indicators.

Although sustainability reporting can create an element of reputation risk in the short term, the risk is outweighed by the significant benefits, which include:

- Better management
- Easier hiring and higher retention of top talent
- Increased operational efficiency
- Increase employee satisfaction and productivity
- Better performance measurement
- Greater stakeholder trust
- Increased revenues and market share
- Improved risk management resulting in easier access to financing

Over 3,000 companies worldwide report on sustainability. You should too.

If you do not report on sustainability you may appear less transparent in the eyes of your customers. Sustainability initiatives can help you stand out and provide a competitive advantage.

When properly implemented, sustainability reporting can help to establish a reputation for transparency and build trust. In fact, 82% of U.S. and 66% of European companies cite transparency as the main factor influencing their corporate reputation – that's higher than trust, product/service quality, leadership or even financial returns[33].

Marketing opportunities

Businesses, multi-residential properties, and post-secondary institutions that market their "green" properties can generate significant returns on their investment by attracting new employees, tenants, customers or students.

A green business or institution strives to promote a positive impact on the environment and community by developing and practicing business strategies that go beyond the business-as-usual and demonstrate a commitment to a healthy and sustainable future.

Eighty-nine percent of the Financial Times' TOP 500 companies have water policies and strategies. Coca-Cola has a water stewardship program which outlines four goals: managing risk, water use reduction, water recycling and water replenishment.[34,35]

Case Study: Port Credit Village Redevelopment

Green Features:

- Lakefront park space
- Accessibility to transit
- Decreased impervious surfaces
- Live-work units

Port Credit Village is an innovative housing development that includes 410 mixed-use residential units along Lake Ontario's waterfront in the City of Mississauga. A former starch factory, this site presented numerous opportunities for innovative urban planning and design.

Why did Port Credit Village go green?

Fram Building Group worked with the City of Mississauga to develop Port Credit Village as a high quality, well designed showcase project. Integrating green features into the site plan allowed Fram Building Group to:

- Meet the request from City of Mississauga to create more waterfront green space.
- Market to buyers interested in living in an innovative and green urban community.
- Sell units at a premium due to its proximity to transit.

How is Port Credit Village benefiting from green development?

Higher occupancy rates – Pre-sales were very strong with virtually all units sold by completion. Proximity to transit and amenities were a major factor to purchase in this neighbourhood. These factors will continue to drive up property values in the neighbourhood.

Corporate social responsibility – By providing pedestrian connectivity to parks, retail and transit, the neighbourhood promotes less car use and creates a healthier and more active community.

For more information, check out the Fram Building Group website at framhomes.com.

In an age of rapidly developing connectivity, corporate image and marketing opportunities through greening initiatives are becoming ever more important. In recent years companies such as General Electric, Wal-Mart, Vale-Inco, Coca-Cola, the Royal Bank of Canada, TD Bank and others have undertaken initiatives on everything from sustainable buildings, landscape alternatives, water conservation, alternative energy and technologies to combat climate change.

If you are a small operator compared to these companies, don't worry. It doesn't take a large amount of money or fancy marketing campaigns to broadcast your green sustainability initiatives. Social media and other free (or low-cost) options are available to get the word out to your customers. Engage your customers and let them know what you are doing to improve your sustainability.

The good news for resource-strapped small businesses is that it doesn't take fancy marketing campaigns to broadcast your reputation. When surveyed, customers say that their decision to buy is mainly influenced by a product/company's reputation (21%), word of mouth (19%), and brand loyalty (15%). Dollars spent on advertising impacts their decision only 9%.

– The Business Case for Corporate Social Responsibility - Industry Canada[36]

"By embedding sustainability into our business strategy, we realized that we could not only deliver environmental benefits but also increase efficiency of the value chain, reduce costs and improve business performance."

– Marco Marrone, CFO & Executive Vice President of Finance, Canadian Tire[37]

Figure 1.3.5: Canadian Tire can build its brand as a green corporation through the use of permeable pavement in its parking lot. (Source: Unilock)

Access to funding or financing

Being sustainable can also help you access additional sources of financial and funding. Businesses, universities, colleges and multi-residential properties that have more sustainable operations typically have more access to credit as they are increasingly perceived as better investments by financial institutions. Banks view sustainability as having an integrated approach to managing financial, social, and environmental risks and performance[38].

The federal government lists over 30 green funding and incentive programs. Businesses that qualify can receive funding or financing to support initiatives on their property, which can include renewable energy, building retrofits, alternative fuels and others. Ontario's Conservation Fund can also help you receive funding for new conservation programs and technologies for your property.

Reduced insurance costs

By minimizing the risks to your property, assets, and investments from extreme events and providing a safer environment for site users, you can better manage rising insurance costs. Owners that demonstrate proactive risk management are more likely to reduce their insurance premiums as their sites are perceived by insurers as having a lower risk profile[39]. If you better manage stormwater on your property through LID retrofits, you are more likely to have fewer insurance claims and pay lower premiums.

1.4 Construction costs

LID retrofits are alternatives to conventional site rehabilitation projects. For example, a green roof structure can be installed on your site instead of conventional roof rehabilitation. Similarly, permeable pavement is typically implemented when conventional pavement systems have reached the end of their life cycle. When looking to complete retrofit or rehabilitation work, compare the construction cost of LID practices to those of conventional rehabilitation projects.

While individual LID elements may add expense to a project, in general they reduce the overall project costs, since they reduce the need for conventional stormwater infrastructure such as catch basins, piping, stormwater management ponds, curbs-and-gutter systems, and other hydraulic controls.

A study by United States Environmental Protection Agency (US EPA) reports a construction cost savings ranging from 15% to 60% (average 25%) when using LID practices as compared to conventional stormwater management[40]. Since the release of the US EPA study, numerous case studies have shown that using LID practices can reduce short and long-term costs.

Case studies of new developments in Canada and the Unites States have shown significant construction cost savings associated with implementing LID practices instead of conventional practices. These cost savings are associated with decreased pavement coverage, decreased piping requirements (capacity and total length), elimination of onsite stormwater management facilities, reduction in catch basin requirements, and reduced site grading. Table 1.4.1 details realized and projected construction cost savings per hectare for several projects in Canada and the United States.

The projects highlighted in Table 1.4.1 demonstrate that the construction costs of LID techniques can be less than that of a conventional stormwater management system for new developments. When considering retrofits of your site, the cost of LID construction may be higher than those of conventional site repairs and upgrades. For example, the capital costs associated with planning, designing, and constructing a permeable pavement system is much higher than cost associated with simply repaving a deteriorated parking lot. This financial burden can be largely attributed to additional engineering and design costs not associated with a conventional project.

To compare the true financial implications of implementing LID, consider the ongoing cost savings realized over the life of your site. For the project to provide financial incentive, ongoing savings must help recoup this capital deficit. Ongoing savings can be driven by extended infrastructure lifespan, reduced or modified operations and maintenance, or by potential stormwater utility savings.

LID practices can save you money on construction. In 2011, CVC built a permeable paver parking lot. The initial capital costs for CVC permeable paver parking lot were estimated to be $91,500 less than for a conventional asphalt lot.

Table 1.4.1: Construction cost comparison for selected LID case studies

Project and location	LID Techniques	Savings (US$/ha)
Old Farm Shopping Centre*, Frederick, MD	Bioretention, infiltration trenches, reduced impervious area, filter strips	$ 9,842
270 Corporate Office Park*, Germantown, MD	Bioretention, reduced impervious area, swale, permeable pavement	$ 5,383
Credit Valley Conservation, Mississauga, ON	Enhanced grass swale, permeable pavement, rainwater harvesting	$ 91,500 (Total)
OMSI Parking Lot, Portland, OR	Bioswale	$ 32,099
Light Industrial Parking Lot*, Portland, OR	Bioswale	$ 13,884
Tellabs Corporate Campus, Naperville, IL	Bioswale, reduced site grading	$ 9,926
Vancouver Island Technical Park Saanich, BC	Swale, permeable Pavement, wetlands, amended soils	$ 37,390
Greenland Meadows Retail Shopping Center, Greenland, NH	Permeable pavement, wetlands, reduced site grading	$ 41,041

* Savings projected prior to construction

Extended lifespan

Green roofs and permeable pavement systems provide benefits by providing a longer lifespan than conventional infrastructure. Consider how infrastructure lifespan extension will effect your bottom line when deciding whether to include LID in your retrofit project.

The maintenance of pavement surfaces is a significant financial burden. To reduce long-term costs, permeable pavement is a commonly used LID practice. A major benefit associated with implementation of this LID practice is the extended lifespan of site infrastructure when compared to conventional pavement systems.

By design, permeable pavement shows more cold weather durability than conventional pavement systems. The freeze-thaw cycle of the Ontario climate is tough on pavement. Frost heaving and slumping can cause cracks and potholes as a result of the expansion and contraction of water. The expected lifespan for conventional asphalt pavement in a northern climate like Ontario's is approximately 15 years[41]. A well-maintained porous asphalt system can last for over 30 years[42] and permeable interlocking concrete pavers can have a design life of 20-25 years or greater[43].

Properly designed permeable pavements are less prone to frost heaving because of their quick-draining design. If freezing occurs before a permeable pavement system has drained, the large void spaces in the aggregate base creates a capillary barrier that prevents the vertical movement of water and pavement heaving[44]. Permeable pavement also has sufficient flexibility to withstand minor heaving without being damaged[45].

Using LID techniques to manage stormwater can also eliminate or reduce the need for an onsite storm sewer system. By eliminating piping, failure points in the pavement such as areas around catch basins and manholes can be eliminated. A design that does not use storm sewers will not need to replace on site piping thereby saving long-term infrastructure replacement costs.

Did you know major cities are investing in LID?

The City of Philadelphia estimates it will save US$1.9 billion to $4.5 billion (2009) for 25% and 100% implementation respectively of its green infrastructure strategy while Kansas City, Missouri anticipates saving $8 million ($46 million for LID solution vs. $54 million for conventional).[47]

Operations and maintenance (O&M) savings

The financial impact of an LID retrofit on O&M will vary significantly by site. In many municipalities the majority of O&M costs for stormwater management are borne by the municipality. The return-on-investment to a site owner for an LID retrofit will be greater if you are already paying to have some type of stormwater management infrastructure maintained on your property, such as a stormwater mangement pond.

You can save money if the O&M costs associated with the LID practices are less than what it costs to operate and maintain conventional systems. For example, the annual maintenance cost of an appropriately designed bioswale will be less than that of a proprietary stormwater treatment device (such as an oil and grit separator) or stormwater management pond.

When LID practices are used in series with conventional practices, existing stormwater management features will require fewer sediment cleanouts. An example would be incorporating perforated pipes and bioswales integrated into the conveyance network upstream of a stormwater management facility. Table 1.4.2 identifies where O&M cost reductions and additional expenditures are required after an LID retrofit.

Table 1.4.2: O&M costs for LID versus conventional system

LID option	O&M cost reductions	O&M cost increases
Permeable pavement	• Catch basin cleaning not required • Sanding not recommended • Reduction in salt volume required for de-icing • Less frost heave due to well drained design, therefore less patching and other minor repairs	• Vacuum assisted sweeping once or twice per year
Bioretention / bioswales	• Reduced catch basin cleaning • Reduced need for end-of-pipe water quality unit maintenance (proprietary stormwater treatment device or stormwater management pond cleaning)	• Trash removal • Sediment removal from pre-treatment and bioretention areas • Trimming of trees and shrubs • Watering of plants (until they are established)
Soakaways	• Reduced catch basin cleaning • Reduced need for end-of-pipe water quality unit maintenance (proprietary stormwater treatment device or stormwater management pond cleaning)	• Trash removal • Sediment removal from pre-treatment areas
Perforated pipe system	• Reduced need for end-of-pipe water quality unit maintenance (proprietary stormwater treatment device or stormwater management pond cleaning)	• Sediment removal from pre-treatment areas
Rainwater harvesting	• Reduced water usage	• Inspections
Landscape alternatives	• Reduced maintenance of paved or landscaped surfaces	• Trimming of trees and shrubs

A recent Canadian study conducted by the Sustainable Technology Evaluation Program (STEP) compared all costs associated with a variety of LID practices over a 50-year life cycle[48]. These costs included O&M activities expected both annually and at less frequent intervals. Figure 1.4.1 prorates these annual costs based on a 1 ha impervious drainage area. For this figure, perforated pipe systems, though not included in the STEP study, were assumed to have similar annual maintenance to that of a soakaway.

It should be noted that for soakaways, infiltration chambers and perforated pipe systems, O&M costs are greatly reduced when the catchment areas is restricted to relatively clean sources of water such as roofs and pedestrian areas. When a proprietary stormwater treatment device unit was used for pre-treatment of parking lot and road sources, costs were much higher.

The STEP study also found that although the capital cost of the asphalt and proprietary stormwater treatment device option was less than all LID options (except for the enhanced swale), the permeable pavement, infiltration trench with inlet, and enhanced swale options showed smaller life-cycle costs largely due to reduced O&M and rehabilitation costs. When the same practices are compared based on dollars spent per kilogram of annual total suspended solid load reduction, all LID options are more cost effective than conventional asphalt draining to an proprietary stormwater treatment device unit.

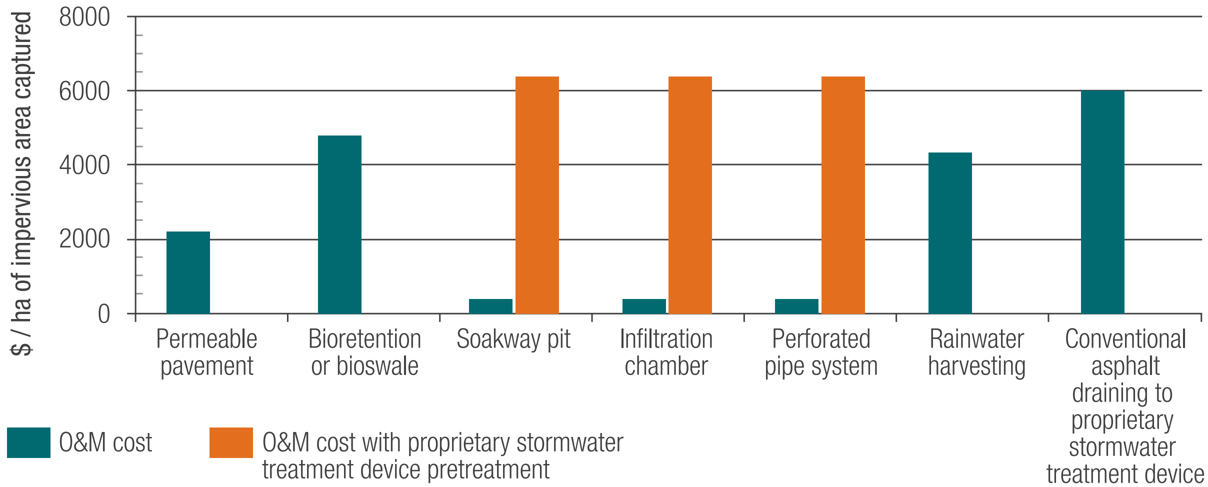


Figure 1.4.1: Annual O&M cost per ha of impervious drainage area.

1.5 How can your municipality or conservation authority support you?

There are several strategies that municipalities can use to encourage the implementation of LID stormwater techniques on sites. They may include:

- Review of existing by-laws and policies
- Awards and recognition programs
- Development incentives
- Rebates and installation financing
- Stormwater fee discounts
- Municipal project examples
- Public-private partnerships
- Training programs

Development incentives

Development incentives can include expedited permitting, decreased fees, zoning upgrades, reduced stormwater requirements and relaxing parking requirements for those who implement LID practices. This strategy has been used in Canada and United States to encourage LID practice integration as part of new development and retrofits.

The most common development incentive is expedited approvals. For new development a major motivating factor is being first to market. With LID retrofits, the same market force does not necessarily apply, but expedited approval provides quicker project turnaround which is always a benefit in the construction industry where "time is money." In many cases an individual known as the expediter within the review structure is responsible for ensuring the project is fast tracked.

Reduce parking requirements

In accordance with the Town of East Gwillimbury's Thinking Green! Development Standard, the town's standard parking requirements for a recent industrial development were relaxed when city planners conidered the actual parking requirement of the shift workers. This smaller lot reduced construction costs for the owner while also limiting the negative impacts associated with large impervious parking surfaces.

Rebates and installation financing

Rebates and installation financing include providing direct funding, tax credits or reimbursements to property owners that construct LID practices. This approach can require a large amount of administrative support, a complex system of tracking, development of metrics, and a verification program.

Municipalities throughout Ontario are recognizing the benefits of rainwater reuse. For instance, the City of Guelph offers a rebate program for residential rainwater harvesting with a value of up to $2,000[49].

Providing municipal funding opportunities to private industry

Funding programs or grants for private site owners can foster private implementation of LID stormwater practices. Municipalities may consider initiating funding programs or grants for private site owners. This typically requires a study to determine the most efficient way to allot funding. Funding may be provided in the form of tax credits, grants, or credits to stormwater utility fees.

Stormwater fee discounts

Regardless of the type of stormwater fee system (rate, utility, or other), a municipality can offer discounts on existing stormwater charges to incentivize LID retrofits.

For municipalities with stormwater utilities, rebates can incentivize LID retrofits by providing a tangible economic benefit. Potential long-term cost savings become significant during option evaluation. The most common stormwater fee system is when municipalities charge based on a percentage of potable water consumption.

The realization that an apartment or condominium building may face higher stormwater charges due to high rates of potable water consumption, while commercial properties with large parking lots generated significantly more runoff, and often paid significantly less, has popularized fee discount programs in many U.S. jurisdictions.

In 2012, Kitchener implemented a stormwater credit policy. Property owners are able to apply for stormwater credits of up to 45% of the stormwater portion of their utility bill based on the quantity of stormwater diverted away from municipal systems and the quality of water that does enter municipal systems.[50]

Public-private partnerships (P3)

Strategic partnerships between the public and private sectors can be a win-win scenario for the land holder, the municipality and the environment. Both parties can bring something to the table. In many cases, private sites may have substantial land resources with strategic areas requiring stormwater retrofits which the municipality does not have and the municipality may have the necessary implementation funds and expertise that the private landowner does not. In this case, a partnership offers an ideal opportunity to retrofit using LID. Popular in the United States and other jurisdictions, P3s are occurring in Ontario as a means to collectively achieve better environmental protection and risk management objectives.

Recognizing that public infrastructure impacts the life of every Canadian – from the water we drink to the roads we drive on, P3 Canada was established by the Government of Canada. This program improves the delivery of public infrastructure by achieving better value, timeliness and accountability to taxpayers, through public-private partnerships, or P3s. To see a map of P3 Canada Investments, visit p3canada.ca.

Municipal projects as examples of what is possible on private lands

Municipal sites, like office buildings, can be used as examples of successful LID retrofits. These municipal demonstration projects can help create confidence in LID technologies. LID projects on public property also provide municipalities with the opportunity to create media campaigns and public educational opportunities centered on the successful projects.

Existing by-laws and policies

LID practices do not necessarily conform to traditional design standards. As such, municipal by-laws and policies may need to be amended to facilitate LID implementation. Municipalities that are serious about LID implementation on private land should consider an internal review of policies including those concerning stormwater, erosion and sediment control, landscaping, and parking requirements to determine where barriers to implementation exist. Table 1.5.1 identifies typical municipal by-laws, the general provisions they include and their impact on LID retrofits. This can be used a starting point for a broader review of municipal by-laws and policies.

In a 2011 update of the City of Cambridge's Stormwater Management Policies and Guidelines, the City identified that existing policies which discourage surface storage within parking lots may pose a barrier for LID practices like bioretention. As a result, the Parking Lot Storage policy was revised to include the following statement: "Surface ponding within LID measures, such as bioretention swales, may be acceptable.[51]"

Table 1.5.1: Typical municipal by-laws for review consideration

LID option	O&M cost reductions	O&M cost increases
Nuisance weeds and tall grass by-law	Designates tall grass and nuisance weeds as a public nuisance • Defines "tall grass" as grasses over a maximum height (typically 20 - 30 centimetres) • Requires tall grass to be cut to a height not exceeding the maximum • Requires all nuisance weeds and weed seeds to be removed from a property by the owner • The municipality may carry out the work to bring properties into compliance and recover the cost from the land owner	Vegetated LID practices (specifically those with prairie or ornamental grasses) and landscape alternatives may be in violation of this existing by-law.
Property standards by-laws	Sets minimum requirements for privately owned properties: • Restricts low lying areas including those that have been excavated that accumulate water, and directs them such that they be drained, filled and graded so that water drains to a storm sewer or ditch • Requires that all landscaped areas be cut and maintained in a reasonable condition in relation to the neighbouring environment	Can preclude the implementation LID practices such as bioretention facilities as they are designed be both low lying and include 'shallow' surface ponding. May be considered prohibitive for the implementation naturalized landscape approach.
Sewer use by-laws	Although generally limited to sanitary sewers, many municipalities now include stormwater within this by-law. It generally requires all stormwater to be discharged to an approved outlet and regulates the constituents of the discharged water	May not permit direct discharge of roof water to the municipal storm sewer system, which may include overflow from rainwater harvesting tanks and other such devices.
Standing water by-law	• Prevents accumulation of water on an individual property within any depression, specific relevance to mosquito breeding and West Nile Virus concerns • Accumulation is typically defined per a determined period of time (i.e. 48 hours etc.)	May be interpreted as prohibitive for soakaways subsurface storage facilities, bioretention, bioswales etc.
Boulevard panting by-laws	Regulates the type of vegetation that can be planted within the boulevard area	May inhibit bioswales or vegetated swales due to plant type and height restrictions of planting along municipal boulevards.
Private parking lot by-laws	The minimum space requirements based on the building area of a private business	By-law creates oversized parking lots compared to actual demand. Hard surfaces and runoff are increased, leaving little area green spaces. This is especially true for warehouses and industrial facilities with minimal staff but large floor spaces.

Awards and recognition programs

Awards and recognition programs reward innovation and increase awareness of LID retrofit projects by the general public, customers, media, and policy makers. This low effort encouragement can help motivate and incentivize property owners to retrofit using LID practices. Lawn signage, marketing emblems and recognition on municipal and agency websites can be positive endorsements for businesses.

CVC's Pollution Prevention Leaders in Action Program acknowledges businesses that incorporate pollution prevention practices through profiles on its website, awards and by showcasing the sites on bus tours.

Figure 1.5.1: Armstrong Manufacturing was recognized by CVC as a Leader in Clean Water thanks to its pollution prevention retrofits. (Source: CVC)

Training programs

Local conservation authorities and other groups may offer training services and education programs. Make sure to reach out to them to see what they can offer your operation.

CVC offers many training programs in these areas:

- *Design*
- *Construction*
- *Operations and maintenance*
- *Monitoring*

For more information on our training programs, please visit Credit Valley Conservation's (CVC) Be a Leader website:

bealeader.ca

2.0 LID Options for Businesses and Multi-Residential Properties

This chapter provides an overview of the LID options that are best suited for business and multi-residential properties. Given the wide variety of options, selecting the ones that will best meet your needs may be intimidating. To help you identify the best options for your retrofit project, the following information is provided for each LID option:

- A brief description
- Photographs of the practice
- A Suitability & Considerations table that provides supplementary information
- An illustrated rendering of the LID practice showing key features

With this information you should have a better idea of the LID options that meet your needs. Further guidance on screening LID practices is provided in Chapter 4.

For further information on the LID options, see the LID Design Guide:

bealeader.ca

Pollution prevention

- Spill containment
- Material and waste storage
- Protection and designation of buffer and drainage areas

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Bioretention

- Parking lot bioretention
- Bioretention in landscaped areas

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Permeable pavement

- Pervious concrete
- Porous asphalt
- Permeable pavers

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Swales

- Enhanced grass swales
- Bioswales

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Soakaways and infiltration chambers

- Soakaways
- Infiltration chambers


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Rainwater harvesting


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Prefabricated modules

- Precast tree planters
- Soil support systems
- Phosphorus removal media
- Proprietary stormwater treatment devices


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Perforated pipe systems


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Landscape alternatives

- Tree clusters
- No-mow zones
- Xeriscaping
- Micrograding
- Soil ammendments


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Green roofs


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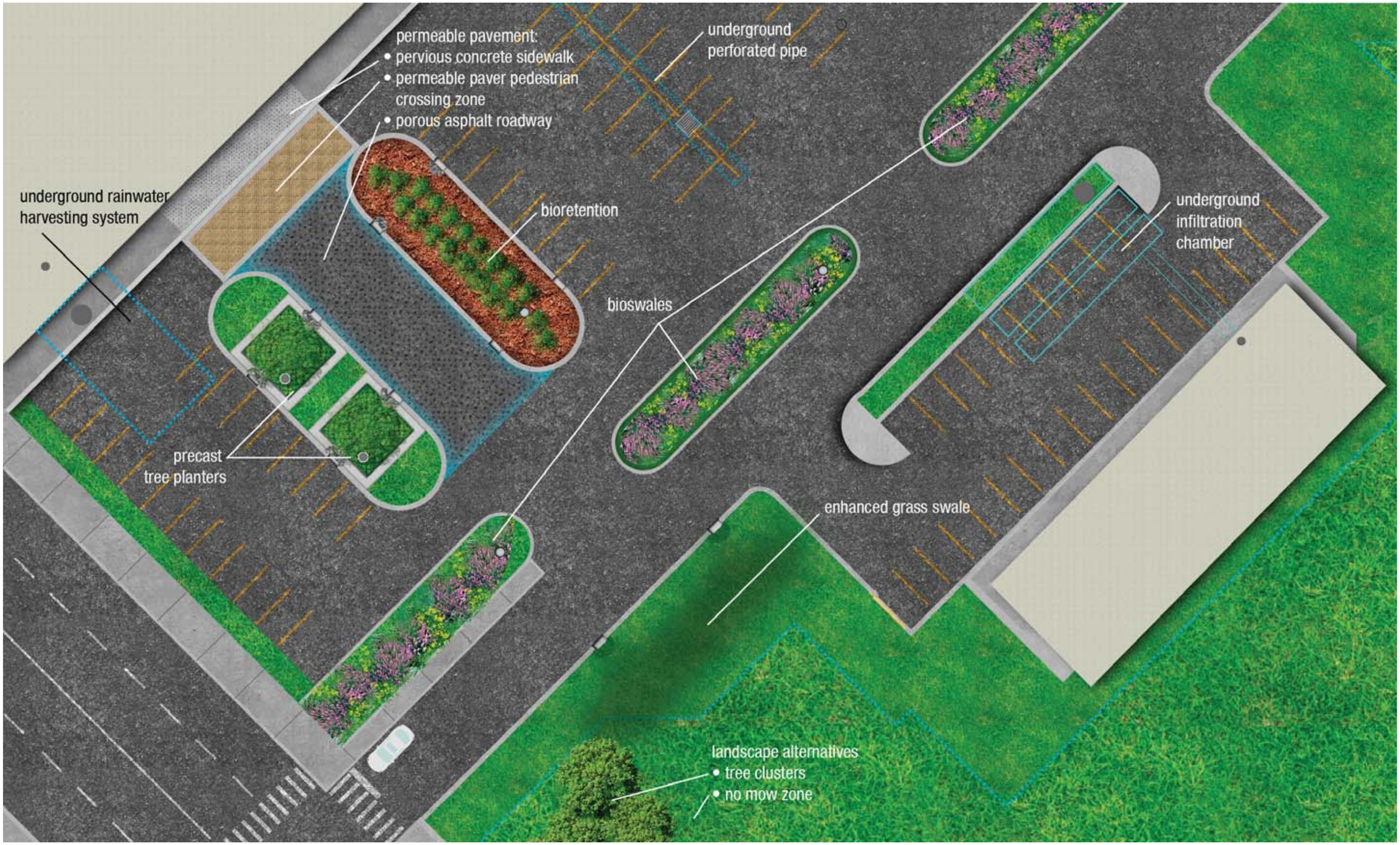
Where are the opportunities for LID retrofits on your property?



Pollution prevention

2.1 Pollution prevention

Pollution prevention (P2) is important to practice on your site regardless of the stormwater management practices you use. It should always be one of the first things to consider when retrofitting a site.

There are many things you can do on your property to ensure only clean water enters the storm drainage system. When assessing LID options on your site, identifying pollution threats is an important part of the pre-design process. P2 is the use of processes, practices, materials, products, substances or energy that avoid or minimize the creation of pollutants and waste, and reduce the overall risk to the environment and human health. Applying these principles can help eliminate those pollution threats, ensure that your business is in compliance with regulations and by-laws, and create a safer environment for staff and customers.

P2 is about anticipating and preventing pollution. It is part of an ongoing pollution management approach that is comprised of prevention, control and cleanup.

P2 opportunities can be found throughout any site or operation. For instance, installing different equipment or technology, or changing raw materials or staff routines can result in pollution prevention. The ways in which P2 is achieved varies from one sector to another, but typically there are nine common practices:

Figure 2.1.1: P2 strategies can be as simple as installing signage. On this site, illegal dumping was a serious issue. Signage indicating the water body to which the site flows educates site users and the threat of a fine is posted as a warning. (Source: CVC)

1. Dumpster management

Dumpsters can be a major source of pollutants that can affect water quality. Dumpsters are often left open to the air, allowing rainwater to mix with the trash, resulting in a leaking fluid, or "dumpster juice" that can contain toxic organic and inorganic materials. If not treated, this dumpster juice can enter the storm drain system, contributing to poor water quality.

2. Grease management

Restaurants produce grease and other wastes as a byproduct of normal food preparation. If grease is dumped or washed into sewers or storm drains, it can cause sanitary sewer overflows or stormwater runoff pollution. Restaurants can implement simple and low-cost P2 practices and train workers to properly dispose of used wastes and maintain dumpsters.

3. Parking lot maintenance

Maintenance operations have the potential to pollute stormwater runoff if sensible P2 practices are not employed. This is particularly true of power washing, which can deliver sediment, nutrients, hydrocarbons, and other pollutants to the storm drain system.

4. Building maintenance

Some building maintenance practices produce polluted wash water that can directly enter the storm drain system during dry weather, whereas others deposit fine particles or liquids that can wash off during wet weather.

5. Landscaping and grounds care

Landscaping services are generally performed by a lawn care/landscaping contractor or an in-house maintenance crew. Poor landscaping practices have the potential to create stormwater pollution, particularly in urban areas where soils are compacted.

6. Outdoor storage

The risk of stormwater pollution is greatest for operations that store large quantities of liquids or bulk materials at sites that are connected to the storm drain system. Protecting outdoor storage areas is a simple and effective P2 practice.

7. Vehicle maintenance and repair

Often, vehicles that are wrecked or awaiting repair can be a concern if leaking fluids are exposed to stormwater runoff. Vehicle maintenance and repair can generate oil and grease, trace metals, hydrocarbons, and other toxic organic compounds. When vehicles are washed on impervious surfaces, dirty wash water can contaminate stormwater with sediments, phosphorus, metals, oil and grease, and other pollutants that can degrade water quality.

8. Fuelling stations

Delivery of pollutants to the storm drain can be sharply reduced by well designed fuelling areas and improved operational procedures. The risk of spills depends on whether the fuelling area is covered and has secondary containment.

9. Snow and ice management

Ontario experiences severe winter weather with large amounts of snowfall. The common practice to deal with snow removal often includes application of de-icer. De-icer is usually made from a urea compound or rock salt. Many property managers apply the products indiscriminately, assuming that more is better. The key to de-icer usage is to apply it sparingly, and to remove most of the snow before application.

Here are three examples of how some of the nine common P2 techniques have been applied.

Fuelling stations

Activities on your site may include the loading and unloading of product or supplies which could include chemicals, fuels, or oils. Spill containment can reduce the risks of a spill draining into an LID feature, catch basin or drainage swale. Spill containment will temporarily detain any spills allowing for the spill to be cleaned and disposed of properly. Valves can be incorporated into the design of the spill containment so that it can easily be drained of rainwater or liquid.

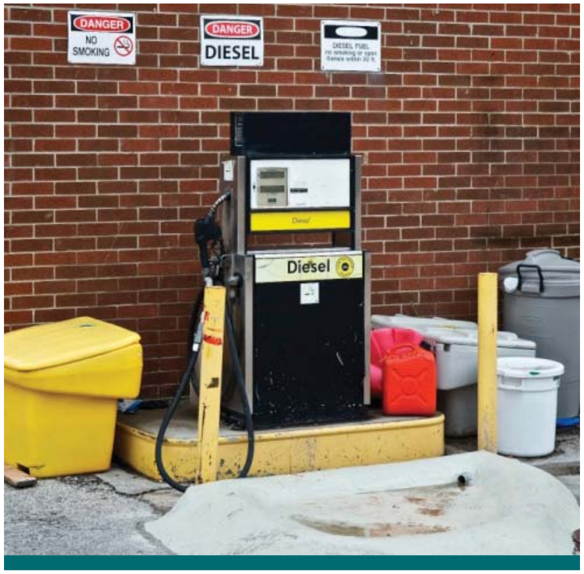


Figure 2.1.2: A fuel pump spill containment pad is recommended for all sites. In case of spill, fuel is detained within the pad until it can be safely disposed. (Source: CVC)

Outdoor storage

On many sites, outdoor areas are used for storage of excess product, materials such as winter salt, and facility waste. Outdoor storage can create potential pollution threats as rainfall or runoff comes into contact with product, materials or waste being stored outdoors. Further complications are added when property facilities (e.g. waste bins, recycling bins) can be susceptible to illegal dumping. To prevent and manage pollution threats from outdoor storage, a variety of P2 strategies can be employed.

Some simple strategies include ensuring that de-icing salt is stored in a dedicated storage container to prevent loss of salt from precipitation. Other best practices include using large storage containers to protect chemical storage drums.

Figure 2.1.3: Covered spill pallets for 100-gallon drums prevent potentially harmful chemicals from leaking into watercourses. (Source: CVC)

Maintenance of dumpsters is often overlooked. As a result, many dumpsters are in poor condition. Cracks in dumpsters will lead to toxic organic and inorganic materials leaking into catchbasins and towards waterways. Opportunities for P2 include locating dumpsters on a flat concrete surface that does not slope or drain to the storm drain system, installing a secondary containment system such as a berm or curb around the dumpster, and closing and securing lids properly when the dumpster is not being loaded or unloaded.

Figure 2.1.4: Replacement of aging, leaky dumpsters prevent harmful dumpster juice runoff from entering storm drains. (Source: CVC)

Protection and designation of buffer and drainage areas

Retrofitting existing drainage areas with LID features is an option on many sites. However, drainage areas such as swales are sometimes used for material storage or even parking. Protection and designation of buffer areas assist in preventing pollution threats from reaching the LID feature. Below are a few examples of how buffers can be designated and protected.

Looking for more information on implementing P2 techniques on your property?

Check out the Ontario Ministry of the Environment's Stormwater P2 Handbook, Environment Canada's Pollution Prevention for Business & Industry and add CVC's Pollution Prevention materials:

creditvalleyca.ca/low-impact-development/pollution-prevention/

2.2 Permeable pavement

Permeable pavement is a term used for a number of LID practices that can be used in place of conventional asphalt or concrete pavement. These alternatives contain pore spaces or joints that allow stormwater to pass through to a stone base for infiltration into underlying native soil or temporarily detained.

Permeable pavement systems are most often implemented for low-traffic areas, parking areas, and pedestrian areas. Where infiltration is not desirable an impermeable liner and perforated pipe system can be added to provide subsurface storage below the paved area. This system can provide the water quality and quantity benefits of a stormwater management pond without the surface area requirements. This will provide more developable site area.

Pervious concrete

Like conventional concrete, pervious concrete is primarily comprised of Portland cement, open-graded coarse aggregate, and water. Pervious concrete, however, contains less sand and fines than conventional concrete, creating void spaces between the material allowing stormwater to filter to the underlying aggregate layer.

The surface texture of pervious concrete is slightly rougher than conventional concrete which provides additional traction for vehicles and pedestrians. The traction and reduced standing water on the surface can reduce sanding and salting requirements. Permeable concrete can be a durable and cost-competitive alternative to conventional pavement options.

Like conventional concrete, pervious concrete can be formed into any shape or size of configuration. Pervious concrete can be used on walkways, pedestrian plazas, streets, driveways and parking lots.

Figure 2.2.1: Pervious concrete can be dyed to suit site purposes. At this site permeable pavers are used in conjunction with coloured pervious concrete to produce a unique pattern on a pedestrian walkway. (Source: CVC)

Porous asphalt

Porous asphalt is very similar to conventional hot-mix asphalt, but it has a significantly reduced percentage of sand and fines, encouraging the formation of stable, interconnected air pockets. The pockets allow stormwater to filter to the underlying aggregate layer and base.

Using permeable pavement on your property can reduce or eliminate the need for conventional stormwater infrastructure such as storm sewers and catch basins, which can reduce construction costs.

Like pervious concrete, porous asphalt requires modified application and setting. It can, however, be mixed at most conventional asphalt plants, making it a viable option for many areas. An advantage of this material is that many parking lot users will not be able to notice the difference between porous asphalt and conventional asphalt.

Figure 2.2.2: Porous asphalt can look quite similar to conventional asphalt. Site operators should track the location of permeable infrastructure to ensure that it is not paved over by future paving projects. (Source: CVC)

Permeable pavers

Permeable pavers have expanded joints that are 5% to 10% of the paved surface area and filled with a porous aggregate material. Crushed stone aggregate bedding supports the pavers and provides storage for stormwater retention, infiltration, and treatment.

An advantage of pavers is the improved aesthetics made possible by varying colour and pattern. They can help differentiate parking lanes from the travel portion of the roadway and highlight pedestrian crossings in front of site entrances. They are also ideal for sidewalks.

When considering retrofitting with permeable pavement, it is important to examine current use of the prospective site. Use of pavers in a smoking area can reduce aesthetics from cigarette butts accumulating in paver joints, for example.

Maintenance requirements entail vacuum cleaning of the paver units to prevent clogging of the pervious joints. Small sections can be targeted for repairs because of the modular nature of these systems.

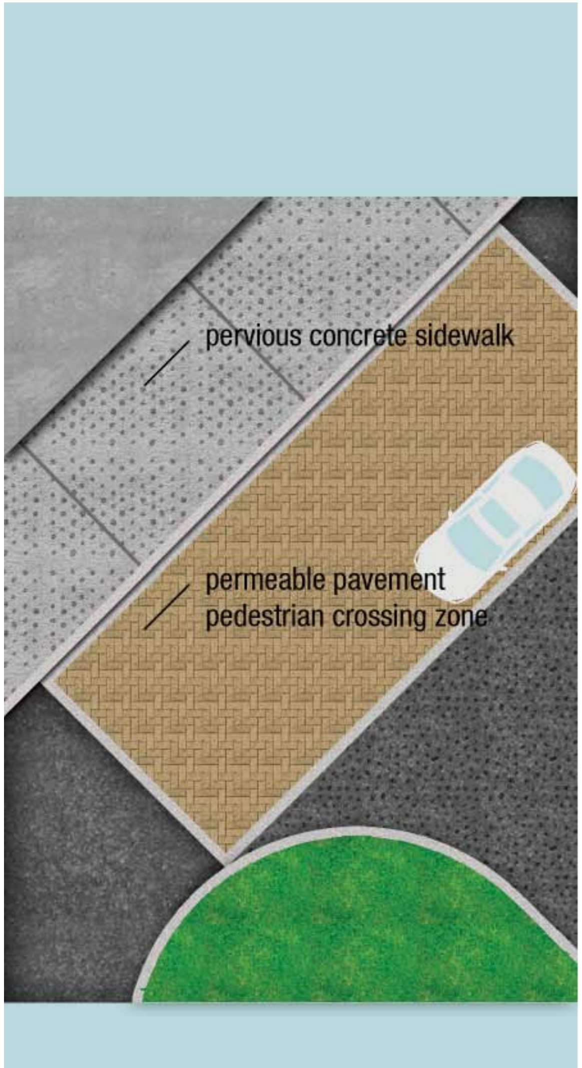
Figure 2.2.3: Permeable pavers come in a variety of shapes and sizes. They can be arranged in patterns that enhance site aesthetics. Here permeable pavers are used to mark a pedestrian crossing zone at a mall entrance. (Source: CVC)

Staff and financial considerations	
●	Design team
●	Capital cost
◉	Training
◉	Operation & maintenance costs
Design considerations	
◉	Planning complexity
◉	Design complexity
Benefits	
●	Pollutant removal (water quality)
○	Amenity & aesthetic value
◉	Flood risk reduction (water quantity)
◉	Groundwater recharge (water balance)
●	Erosion and sediment control
●	High profile with community & media

○ Low Benefit ◉ Moderate ● High

*Performance will vary based upon site characteristics and design of LID practice.

Permeable pavement



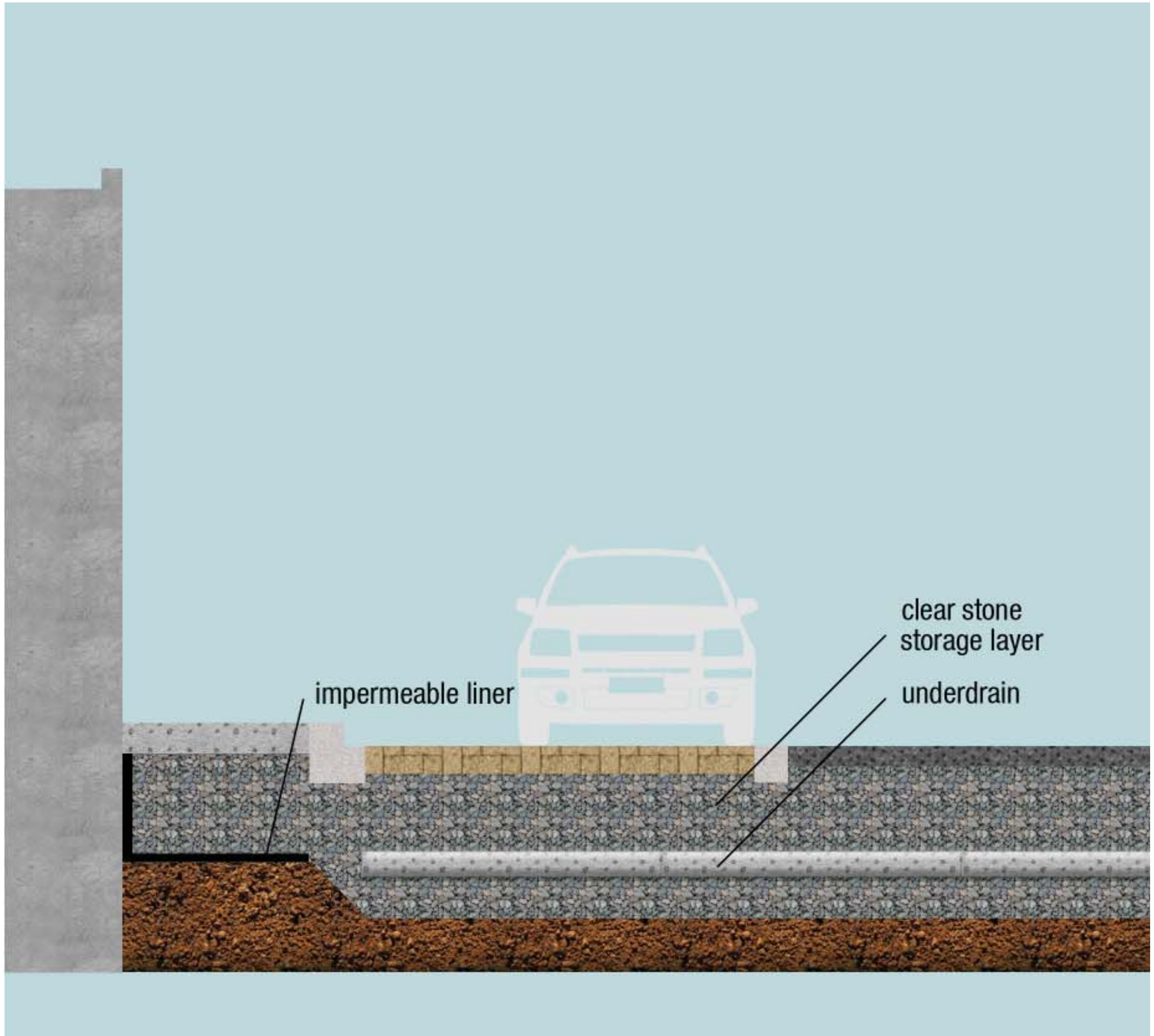


Figure 2.2.4: Aerial view [left] and cross-section [right] of permeable pavement options.

2.3 Bioretention

Bioretention consists of vegetated practices that temporarily store, treat, and infiltrate stormwater runoff. The most important component of these practices is the bioretention soil media. The bioretention soil media is made up of a specific ratio of sand, fine soils and organic material.

Bioretention areas can be integrated into a diverse range of landscapes and land uses. They can be constructed in place of conventional traffic islands, incorporated into decorative plant beds at building entrances, along building or parking lot perimeters, in landscaped areas and many other locations. Bioretention areas are easily integrated into parking lot resurfacing and parking lot reconstruction projects. Bioretention units are versatile in size, shape and aesthetic.

Depending on the native soil infiltration rate and site constraints, bioretention practices may be designed without an underdrain for full infiltration, with an underdrain for partial infiltration, or with an impermeable liner and underdrain for filtration only (i.e., a biofilter).

Vegetation maintenance requirements of bioretention are similar to those of other landscaped areas and include trash removal, weeding, replacing dead vegetation, and checking for clogged of inlets and outlets. The effort will vary based upon the type of vegetation – bioretention with only grass requires the least amount of effort, while formal garden designs need more maintenance.

Selecting either grass or plants for a particular bioretention depends on a variety of factors. In general, planted bioretention areas are recommended for higher-profile settings where sufficient resources (financial and manpower) can be dedicated to building community buy-in and conducting regular inspection and maintenance of these practices.

Perception: Plants are the only source of vegetation in bioretention.

Reality: In fact, the term bioretention refers to the bioretention soil media that forms the base for the practice. The landscaped area can include turf or plants.

Figure 2.3.1: Bioretention areas can be planted with a wide variety of grasses flowers, shrubs, and trees. Here native trees and grasses were installed for easy maintenance. (Source: CVC)

Parking lot bioretention

Parking lots produce the most significant pollutant loads and runoff volumes per unit area on business and multi-residential sites. Targeting runoff from these areas for bioretention practices produces a significant benefit to the local water balance and improves water quality.

Parking lot medians and islands represent excellent opportunities for bioretention practices. Adding these features to a parking lot can calm traffic, direct vehicle flow, and improve pedestrian safety. Bioretention practices located in parking lots are often surrounded by curbs to prevent damage from cars. Cuts allow for the inflow of runoff. Bioretention planters may be used to provide better separation between bioretention practices and surrounding land uses. Bioretention planters use vertical concrete sidewalls as opposed to the sloping banks of typical bioretention practices, allowing them to be used in constrained areas.

Another benefit of parking lot bioretention practices is that established practices can require very little irrigation, which can reduce water costs and labour costs from maintenance.

Don't block pedestrian flow!

Consider pedestrian movement through a parking lot when planning a bioretention feature.

Figure 2.3.2: This parking lot bioretention area treats runoff from a conventional asphalt parking lot. It incorporates additional proprietary stormwater treatment devices within the bioretention to provide even greater water quality treatment. (Source: CVC)

Figure 2.3.3: This parking lot bioretention is incorporated into the pedestrian walkway at the entrance to a building. Bioretention can not only manage stormwater but also improve the aesthetics of your site. (Source: CVC)

	Staff and financial considerations
High	Design team
Moderate	Capital cost
Moderate	Training
High	Operation & maintenance costs
	Design considerations
High	Planning complexity
Moderate	Design complexity
	Benefits
High	Pollutant removal (water quality)
High	Amenity & aesthetic value
Moderate	Flood risk reduction (water quantity)
High	Groundwater recharge (water balance)
High	Erosion and sediment control
High	High profile with community & media

○ Low Benefit ◉ Moderate ● High

*Performance will vary based upon site characteristics and design of LID practice.

Bioretention in landscaped areas

Landscaped areas like lawns and gardens are less labour intensive to retrofit with bioretention practices than parking lots because material will not have to be removed during construction. Many businesses, colleges, universities and multi-residential properties have landscaped spaces located adjacent to impervious surfaces such as roadways, parking lots, buildings, and pathways. These can be targeted for LID stormwater retrofits.

Bioretention practices can add significant aesthetic value to your property and should be considered in high-profile locations such as walkways and building entrances.

Figure 2.3.4: Bioretention areas located at an entrance can provide a welcoming atmosphere to employees, customers, residents and other site users. (Source: CVC)

Interpretive signage is especially valuable for bioretention projects in landscaped areas. Signage can promote project benefits, educate, highlight contributions by project partners, and advertise your environmental credentials. Without signage, a bioretention facility may be mistaken for a conventional garden by employees, residents or other site users.

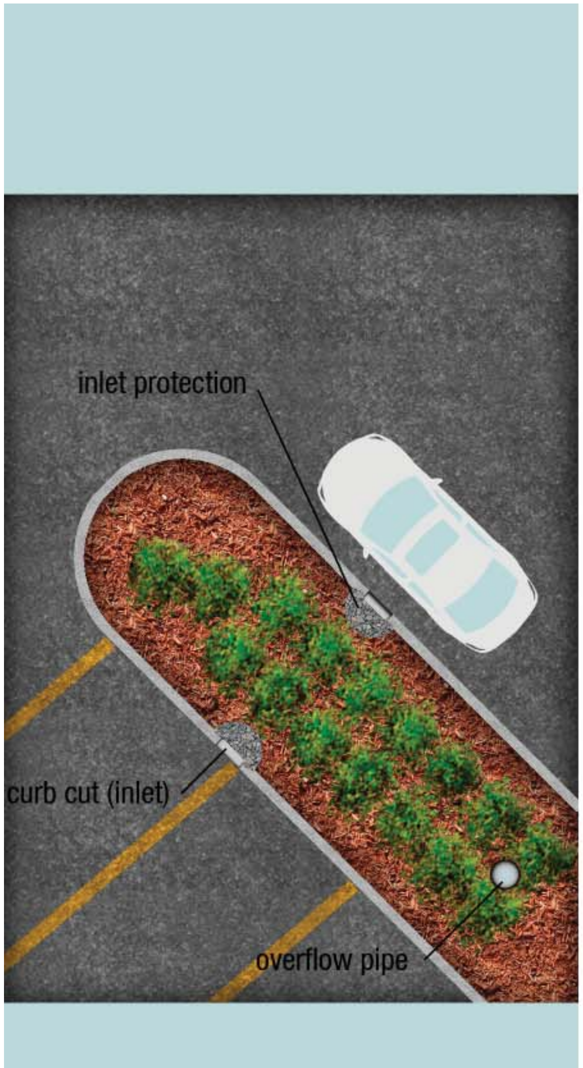
It is possible to incorporate functional and recreational opportunities into bioretention designs. Benches, picnic tables, and trail systems can be planned around bioretention facilities to take advantage of the garden-like settings.

Figure 2.3.5: When installing a bioretention feature on your property, be sure to install interpretive signage nearby. Signage can help raise your green credentials among employees, customers, residents or other site users. (Source: CVC)

	Staff and financial considerations
◉	Design team
◉	Capital cost
◉	Training
◉	Operation & maintenance costs
	Design considerations
◉	Planning complexity
◉	Design complexity
	Benefits
●	Pollutant removal (water quality)
●	Amenity & aesthetic value
◉	Flood risk reduction (water quality)
●	Groundwater recharge (water balance)
●	Erosion and sediment control
●	High profile with community & media

○ Low Benefit ◉ Moderate ● High

*Performance will vary based upon site characteristics and design of LID practice.



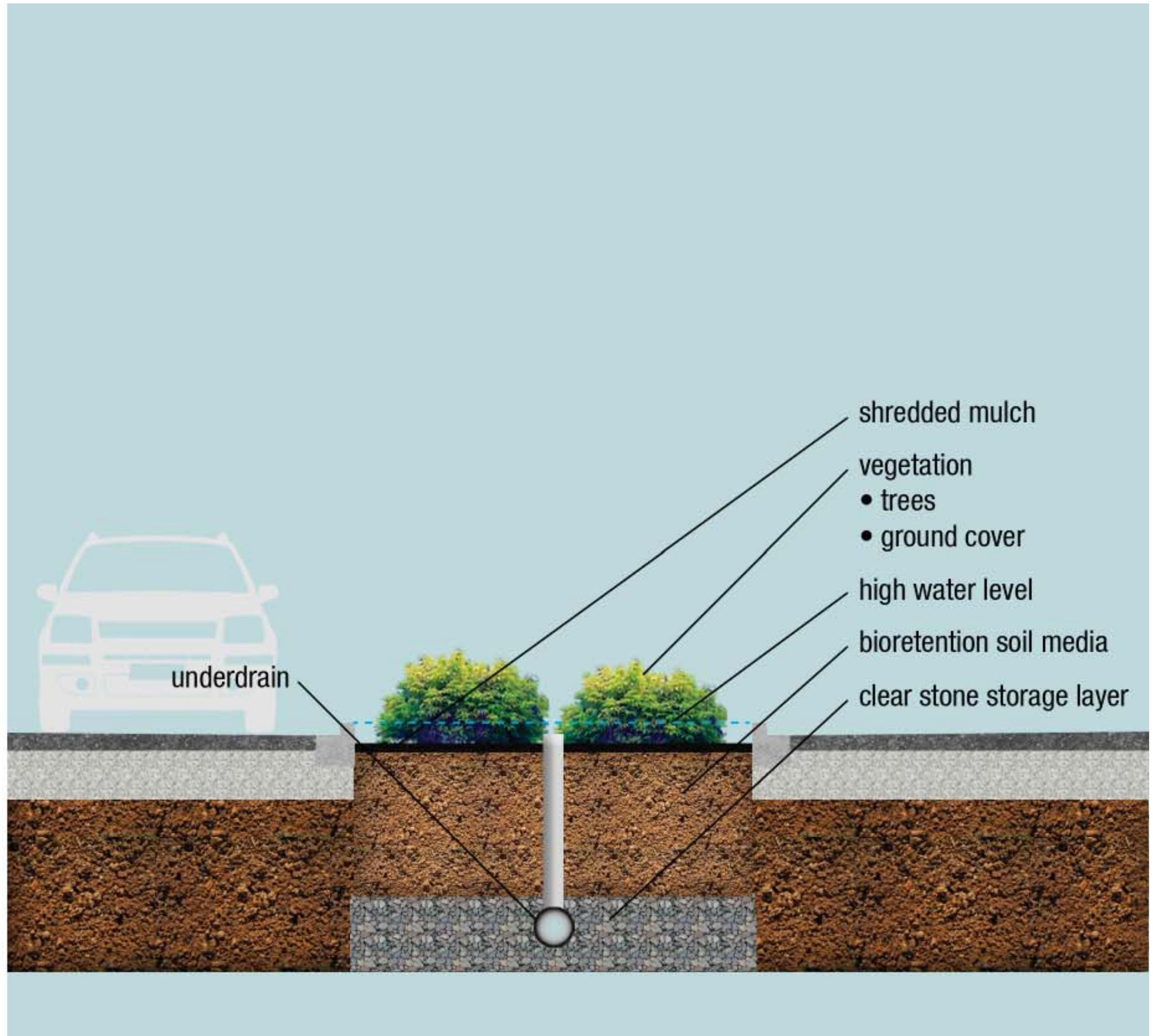


Figure 2.3.6: Aerial view [left] and cross-section [right] of parking lot bioretention.

2.4 Swales

Simple grass channels, often called ditches, have been used for stormwater conveyance along the perimeter of a parking lot or along roadways. Swales incorporate a number of simple modifications to the standard ditch design to substantially improve pollutant removal and runoff reduction capability. Swale design features can include modified geometry (a wider channel base coupled reduced side slopes), check dams, vegetation, and/or bioretention soil media.

Unlike bioretention areas, swales are designed for the primary purpose of conveying stormwater from one location to another (they are longitudinally sloped). Stormwater retention and treatment are secondary objectives of these designs.

What's in a name?

The term bioswale is often mistakenly applied to any type of vegetated conveyance practice, but there are different types of swales, each providing their own level of stormwater treatment.

Bioswales are vegetated open channels that incorporate engineered bioretention soil media and optional perforated pipe underdrains. Just like bioretention units, there are two variations of bioswales based on the type of vegetation: grass and planted.

Enhanced grass swales are vegetated open channels designed to convey, treat and attenuate stormwater runoff. They do not have bioretention media or underdrains.

Enhanced grass swales

Enhanced grass swales are vegetated open channels designed to convey, treat, and attenuate stormwater runoff. Check dams and vegetation in the swale slows the water to allow sedimentation, filtration through the root zone and soil, evapotranspiration, and infiltration into the underlying native soil.

As a stormwater conveyance system, an enhanced grass swale is a preferred alternative to curb-and-gutter installations and storm drains. When incorporated into a site design, swales can reduce impervious cover, accent the natural landscape, and provide aesthetic benefits. Since they lack the engineered soil media and storage capacity, enhanced grass swales are not capable of providing the same water balance and water quality benefits as bioswales.

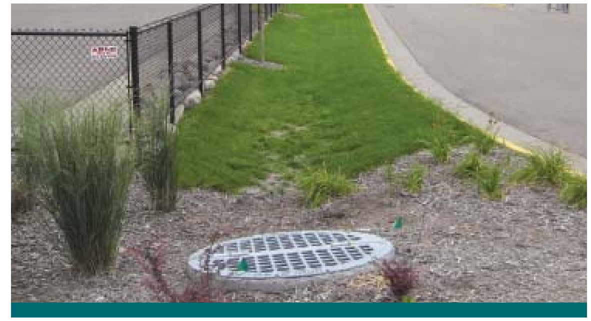


Figure 2.4.1: A long island separating an entranceway and parking lot is used to treat runoff with a bioswale. (Source: CVC)

Rating	Staff and financial considerations
High	Design team
Moderate	Capital cost
Moderate	Training
Moderate	Operation & maintenance costs
	Design considerations
Moderate	Planning complexity
Moderate	Design complexity
	Benefits
Moderate	Pollutant removal (water quality)
Moderate	Amenity & aesthetic value
Low	Flood risk reduction (water quantity)
Moderate	Groundwater recharge (water balance)
Moderate	Erosion and sediment control
Moderate	High profile with community & media

○ Low Benefit ◉ Moderate ● High

*Performance will vary based upon site characteristics and design of LID practice.

Bioswales

Bioswales are similar to enhanced grass swales in terms of the design of their surface geometry, slope, and optional use of check dams. Bioswales also incorporate aspects of bioretention cells—they have bioretention soil media, a gravel storage layer, and optional underdrain components.

In many designs, bioswales are used in a treatment train as a conveyance system between the runoff source areas and a stormwater management facility, such as a stormwater pond. A bioswale can be thought of as a bioretention area configured as a linear channel.

Bioswales may be planted with grasses or more elaborate native plantings. When incorporated into a site, bioswales enhance property aesthetics significantly compared to curb and gutter or conventional ditch conveyance systems. Bioswales are most appropriate for sites with continuous lengths of impervious surface that are often found along the perimeter of parking lots.

Selecting either grass or plants for a particular bioswale depends on a variety of factors. In general, planted bioretention areas are recommended for higher profile settings where sufficient resources (financial and staff time) can be dedicated to conducting regular inspection and maintenance.

Some of the pros and cons of grass- and plant-based bioretention areas include:

Grass	
Pros	• Lower O&M requirements • Looks like typical street turf • Landscaping
Cons	• Lower aesthetic value • Lacks visual cues that infiltration features are present • Reduced performance compared to planted bioretention areas[77]

Plants	
Pros	• Greater visual appeal • Greater profile in the community • Achieve multiple objectives (stormwater management, community greening)
Cons	• Greater O&M requirements

Figure 2.4.2: Turf can be used in place of plantings for easy integration with existing maintenance programs. (Source: Aquafor Beech)

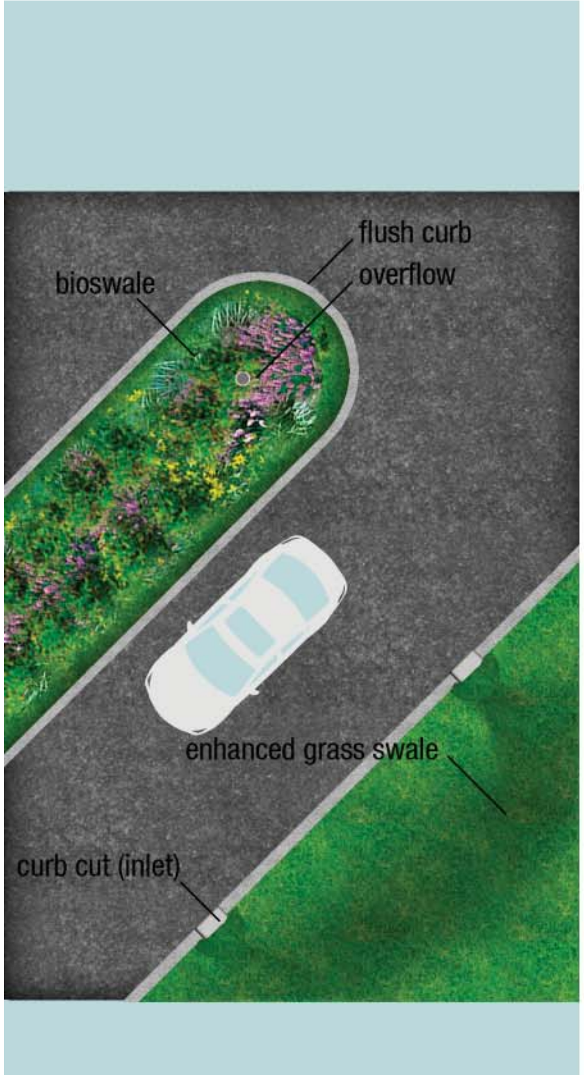
Rating	Staff and financial considerations
High	Design team
Moderate	Capital cost
Moderate	Training
Moderate	Operation & maintenance costs

Rating	Design considerations
Moderate	Planning complexity
Moderate	Design complexity

Rating	Benefits
High	Pollutant removal (water quality)
High	Amenity & aesthetic value
Low Benefit	Flood risk reduction (water quantity)
Moderate	Groundwater recharge (water balance)
Moderate	Erosion and sediment control
High	High profile with community & media

○ Low Benefit ◉ Moderate ● High

*Performance will vary based upon site characteristics and design of LID practice.



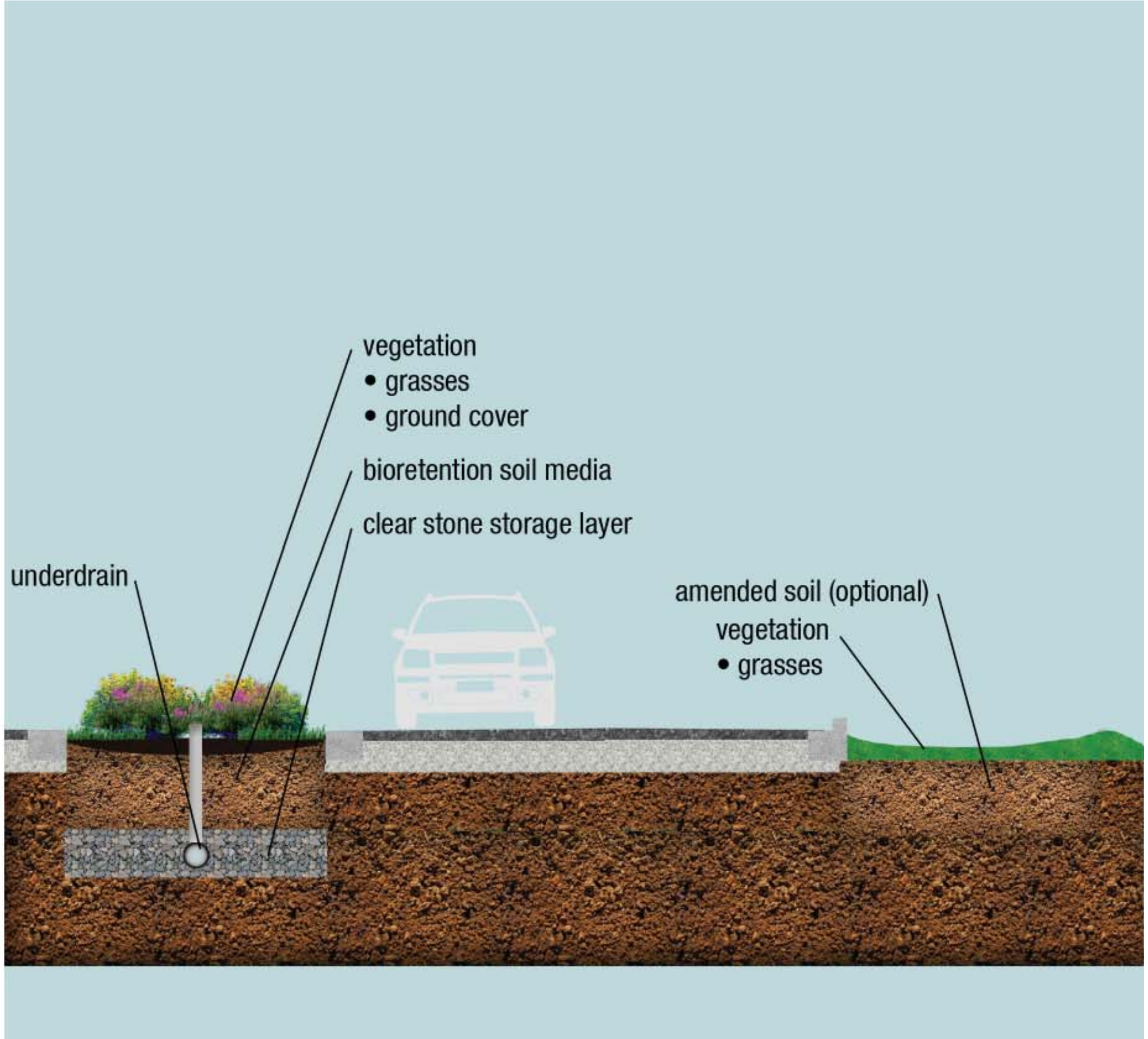


Figure 2.4.3: Aerial view [left] and cross-section [right] of bioswale and an enhanced grass swale.

2.5 Soakaways and infiltration chambers

Infiltration practices take advantage of the natural infiltration capacity of a site by providing temporary storage to allow stormwater to infiltrate over time and by maximizing the contact between the stormwater and the native soil. Infiltration practices are easily scalable and are ideal for sites with limited operation and maintenance resources. The two most common types of infiltration practices are soakaways and infiltration chambers.

Soakaways

Soakaways, also known as infiltration trenches and dry wells, are excavations in the native soil that are filled with clean granular stone. Water typically enters a soakaway through a perforated pipe inlet from a relatively clean water source, such as a roof or pedestrian area. Captured water is stored and allowed to infiltrate over time.

To prevent clogging, parking lots and roads should not drain directly to soakaways without pre-treatment. Where possible, soakaways should be located in areas where the soils have high permeability to maximize the amount of infiltration. Underdrains can be used in cases where clay soils are present.

Soakaways can be designed in a broad range of shapes and sizes. A linear variation of a soakaway is known an infiltration trench. This technique may be appropriate for sites where space for a retrofit is limited to long strips between buildings or along property lines.

Soakaways should not receive runoff from areas where large amounts of de-icing salts are used due to the potential to contaminate shallow groundwater. When retrofitting a site, provide at least 4 m separation to building foundations and properly design overflow pipes to areas graded away from the building.

Figure 2.5.1: Redirecting roof drainage to a soakaway pit is a simple but effective way of reducing the volume of water from your site. For roof runoff, pre-treatment is not required. (Source: Aquafor Beech)

Retrofitting your site with soakaways requires significant excavation; however, since these practices are located in lawn areas, minimal disruption of site operations can be expected during construction. After construction they are generally hidden and not noticeable by site users.

	Staff and financial considerations
◉	Design team
◉	Capital cost
○	Training
○	Operation & maintenance costs
	Design considerations
◉	Planning complexity
◉	Design complexity
	Benefits
◉	Pollutant removal (water quality)
○	Amenity & aesthetic value
○	Flood risk reduction (water quantity)
●	Groundwater recharge (water balance)
●	Erosion and sediment control
○	High profile with community & media

○ Low Benefit ◉ Moderate ● High

*Performance will vary based upon site characteristics and design of LID practice.

Infiltration chambers

Infiltration chambers use prefabricated modular structures. These structures are installed over a granular base to provide maximum void space for stormwater storage and structural support for site features located above. These systems typically have open bottoms and perforated plastic walls to allow for storage and infiltration.

Infiltration chambers provide more storage capacity than equivalently sized soakaways and have minimal surface footprint. Infiltration chambers are ideal for sites with limited space because they can be installed below parking lots, landscaped areas or other surface features. Infiltration chambers can be designed in many configurations to suit site constraints.

Installing an infiltration chamber below hard site infrastructure such as a parking lot requires excavation and complete reconstruction of the pavement system. Consider retrofitting with this practice when parking areas require major repairs and upgrades or in landscaped areas. Adequate pre-treatment should be provided where infiltration chambers receive parking lot or road runoff.

Given the effectiveness of infiltration chamber at reducing the quantity of stormwater leaving the property, these types of LID features are ideal for sites in cities that have (or will be) implementing a stormwater rate program.

With proper engineering design and construction, there are few limitations on where you can infiltrate stormwater on your site. Infiltration chambers have been constructed beneath small accessory buildings, rail stations, and even airport runways.

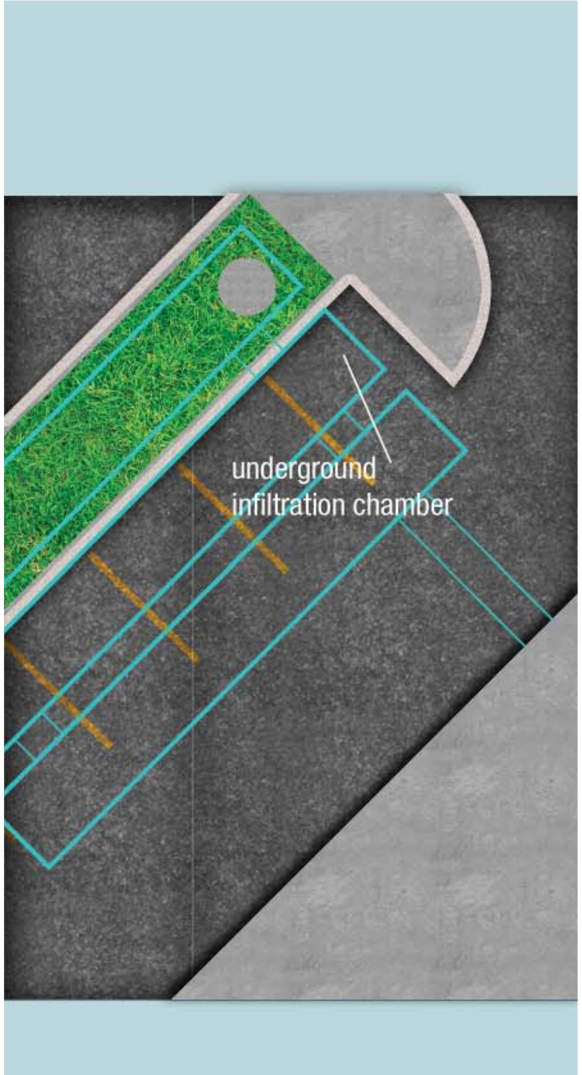
Figure 2.5.2: Infiltration chamber retrofits require significant excavation. (Source: Aquafor Beech)

Staff and financial considerations	
◎	Design team
◎	Capital cost
○	Training
○	Operation & maintenance costs
Design considerations	
◎	Planning complexity
◎	Design complexity
Benefits	
◎	Pollutant removal (water quality)
○	Amenity & aesthetic value
◎	Water quantity
●	Groundwater recharge (water balance)
●	Erosion and sediment control
○	High profile with community & media

○ Low Benefit ◎ Moderate ● High

*Performance will vary based upon site characteristics and design of LID practice.

Soakaways and infiltration chambers



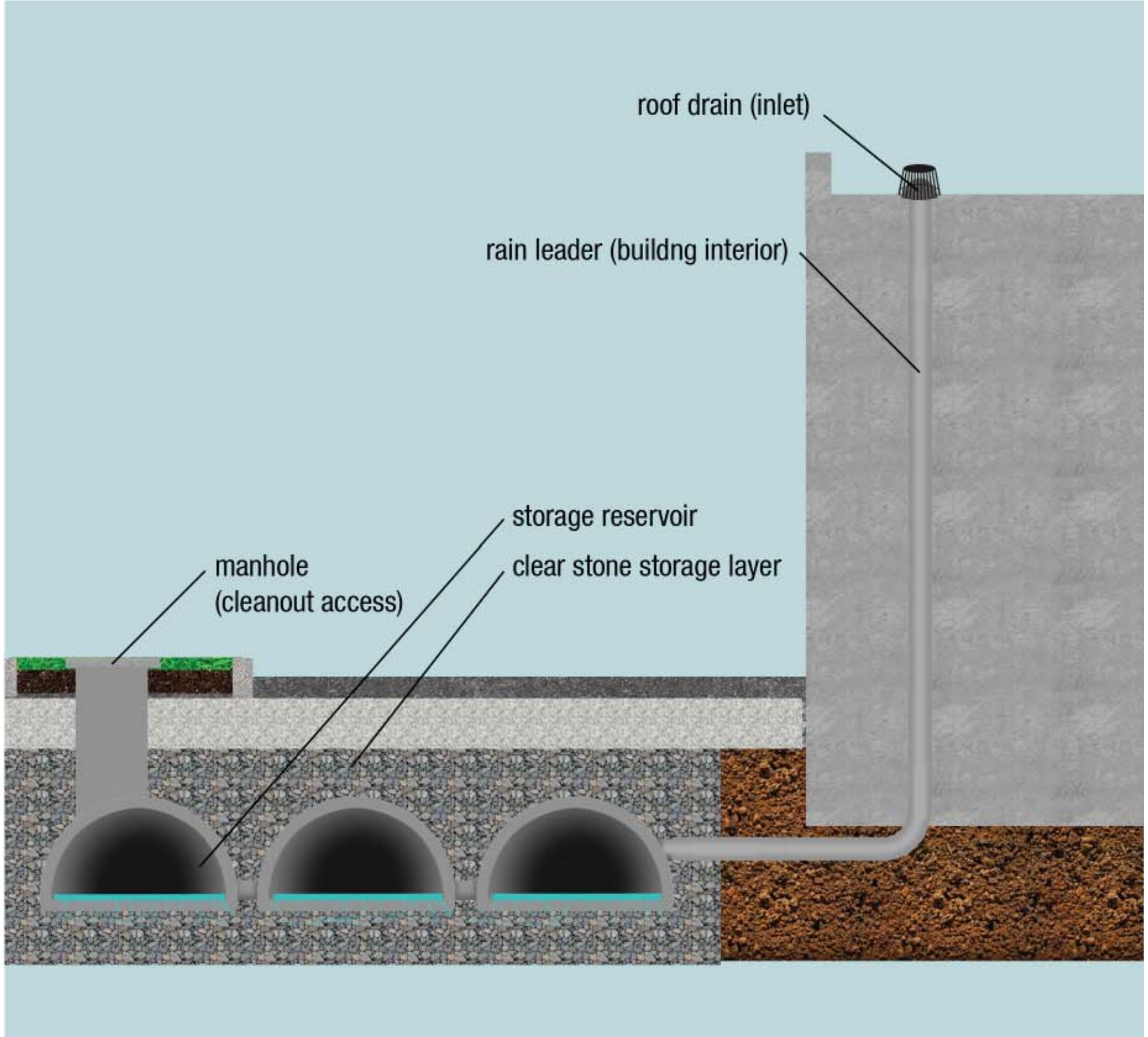


Figure 2.5.3: Aerial view [left] and cross-section [right] of underground infiltration chamber.

2.6 Perforated pipe systems

Perforated pipe systems, also called exfiltration systems, can be thought of as long infiltration trenches that are designed for both conveyance and infiltration of stormwater runoff. They are underground stormwater conveyance systems composed of perforated pipes installed in gently sloping granular stone beds lined with geotextile fabric that allows infiltration of runoff into the gravel bed and underlying native soil.

Perforated pipe systems can be used in place of conventional storm sewer pipes where topography, water table depth, and runoff quality conditions are suitable. In perforated pipe systems, stormwater is carried to a receiving system downstream. When the infiltration capacity of a perforated pipe system is reached, the perforated pipe behaves like a conventional storm sewer by conveying excess stormwater.

On your retrofit site, considering using perforated pipe systems in place of conventional storm sewers. They are capable of handling runoff from roofs, walkways, parking lots, and low-to-medium traffic roads. A significant benefit of perforated pipe systems is that they occupy little to no surface footprint. Parking lots and internal roadways should be provided with sedimentation pre-treatment devices.

With proper location and runoff pre-treatment, these systems can be extremely low maintenance. Performance evaluations of these systems have shown that 20-year-old systems are still able to provide significant pollution and flow reductions.[52]

Figure 2.6.1: A perforated pipe is installed in a granular trench to encourage infiltration. (Source: Aquafor Beech)

Figure 2.6.2: Perforated pipe systems employ many of the same materials and construction practices as conventional storm sewer pipes. Note the perforations in the blue pipe. (Source: Aquafor Beech)

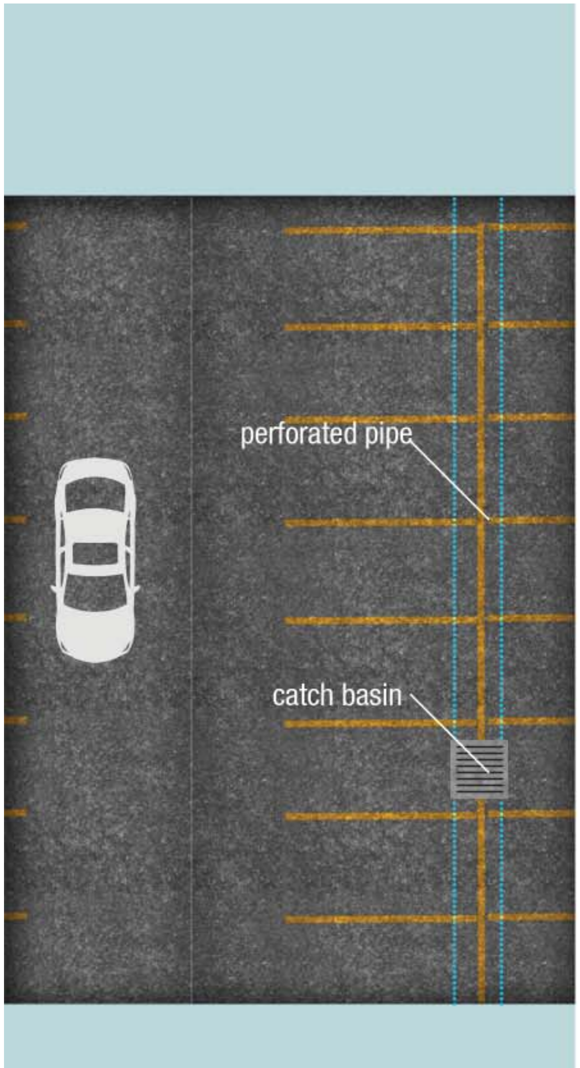
Perforated pipe systems do not require maintenance beyond that of a conventional storm sewer (e.g. catch basin sump clean-outs and inspection of grates). Perforated pipes have been installed in several Ontario communities and have been operating successfully with little-to-no-maintenance.[53]

Staff and financial considerations	
◎	Design team
◎	Capital cost
○	Training
○	Operation & maintenance costs
Design considerations	
◎	Planning complexity
◎	Design complexity
Benefits	
◎	Pollutant removal (water quality)
○	Amenity & aesthetic value
◎	Water quality
◎	Water quantity
●	Erosion and sediment control
●	Groundwater recharge
○	High profile with community & media

○ Low Benefit ◎ Moderate ● High

*Performance will vary based upon site characteristics and design of LID practice.

Perforated pipe systems



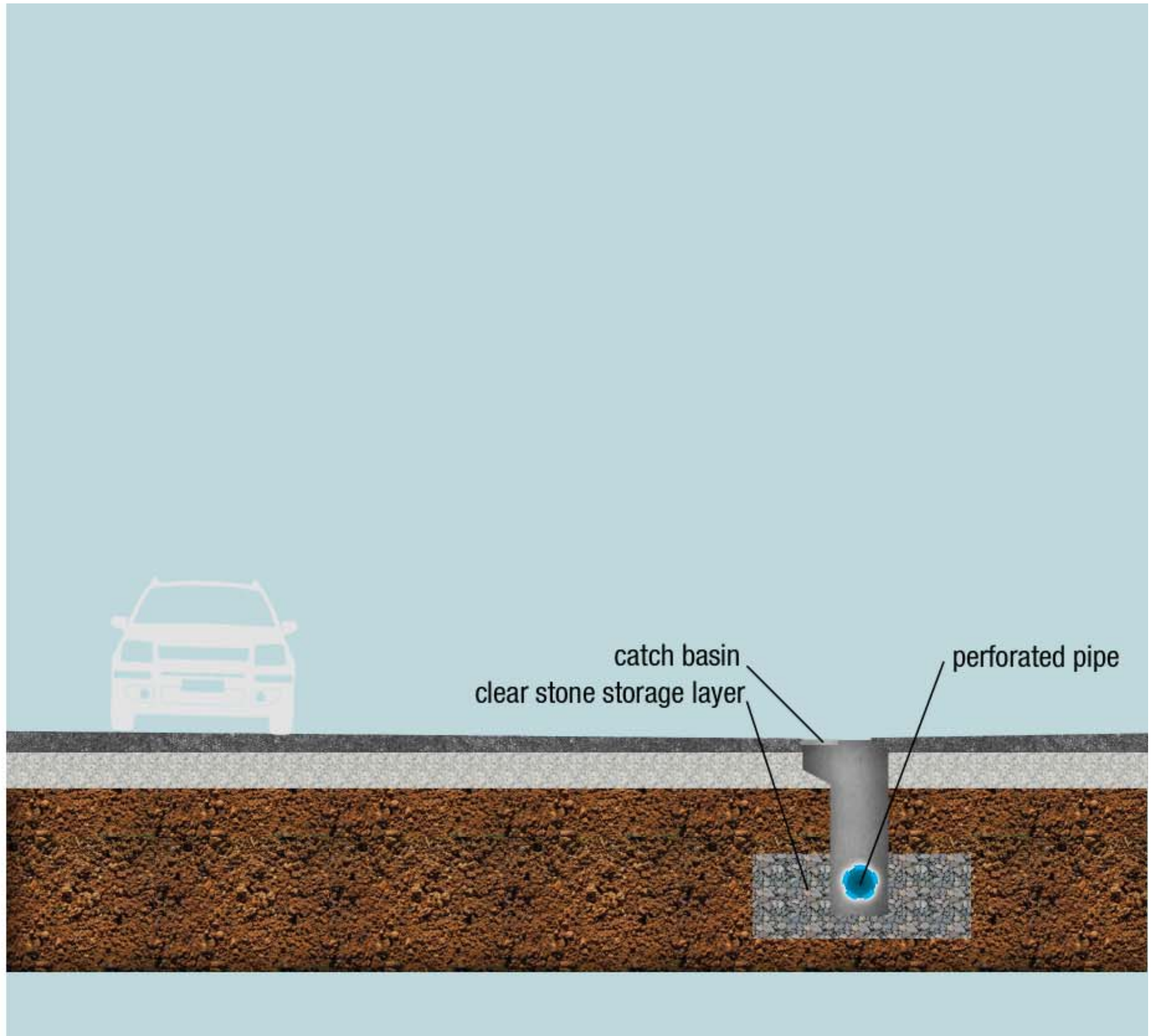


Figure 2.6.3: Aerial view [left] and cross-section [right] of a perforated pipe system.

Rainwater harvesting

2.7 Rainwater harvesting

Rainwater harvesting is the process of capturing and storing rainwater for future use. Rainwater harvesting not only reduces the volume of runoff that is conveyed offsite, but also reduces the onsite use of potable water (and reduces water bills). Landscape irrigation and other outdoor uses such as vehicle washing are common uses of harvested rainwater. Indoor applications, such as toilet and urinal flushing, also present opportunities for use.

These systems typically collect only roof runoff, as this water source is much higher quality than runoff from surface sources like parking lots. A rainwater harvesting system installed on a large commercial roof of 0.25 ha can capture approximately 850,000 litres of water for reuse per year.[54]

Rainwater storage tanks can be placed in a variety of different locations on your property, including indoors (a freestanding tank placed in a mechanical room or as a built-in tank incorporated into the building's foundation, parking garage, or other structure) or outdoors (above ground or below ground). Tanks can range in size from a few hundred litres for small roofs to tens of thousands of litres for larger facilities.

If the water supply from an outdoor rainwater storage tank is to be used year-round, the tank should be buried below the frost penetration depth. Cisterns can be located above the frost penetration depth if water demand is strictly from warm weather uses like irrigation.

Figure 2.7.1: Rainwater can be stored in a variety of different locations, either outdoors or indoors. For instance, CVC's rainwater storage tank is located in the basement of its head office. (Source: CVC)

Figure 2.7.2: In this design, rainwater is collected in a modular subsurface system and used for emergency fire suppression. (Source: Aquafor Beech)

	Staff and financial considerations
●	Design team
◉	Capital cost
◉	Training
○	Operation & maintenance costs
	Design considerations
◉	Planning complexity
◉	Design complexity
	Benefits
○	Pollutant removal (water quality)
◉	Amenity & aesthetic value
◉	Flood risk reduction (water quantity)
○	Groundwater recharge (water balance)
◉	Erosion and sediment control
◉	High profile with community & media

○ Low Benefit ◉ Moderate ● High

*Performance will vary based upon site characteristics and design of LID practice.

Rainwater harvesting

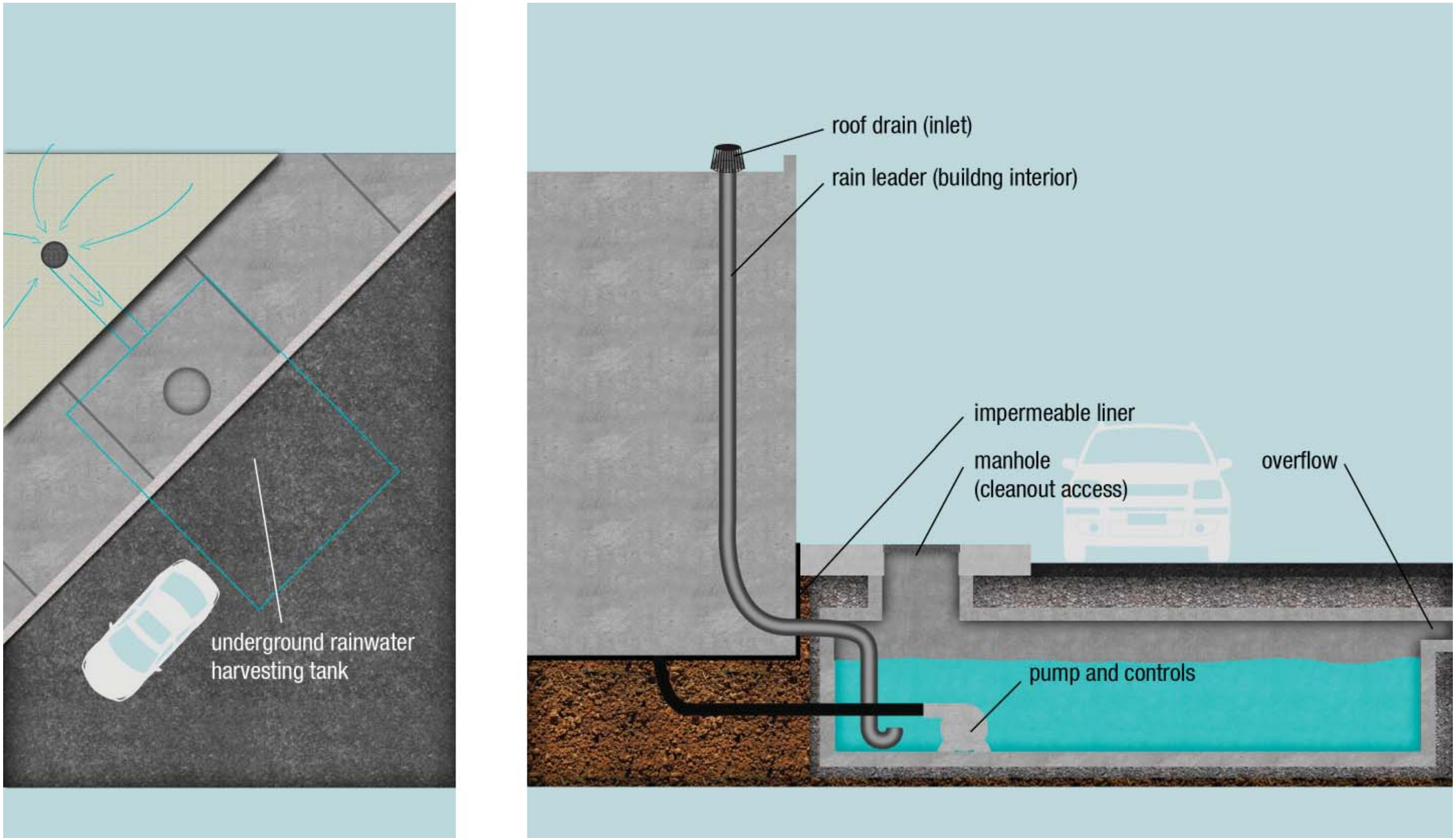


Figure 2.7.3: Aerial view [left] and cross-section [right] of a rainwater harvesting system.

2.8 Landscape alternatives

Natural landscapes provide important functions that are lost when development occurs. The focus of landscape alternatives is to reintroduce these natural features on your property to restore some of benefits associated with these landscapes. Benefits of landscape alternatives include promoting infiltration and evapotranspiration, filtration of pollutants, erosion protection, retention and detention of stormwater, and the creation of habitat for birds, animals and insects.

To replicate the function of natural landscapes, there are a variety of landscape alternatives that can improve site aesthetics, provide recreational amenities for site users, and even reduce maintenance work and costs. These options are presented in the following sections.

Tree clusters

Tree clusters function similarly to forested areas by intercepting rainfall and allowing the processes of evapotranspiration and infiltration to reduce stormwater runoff. Tree clusters can consist of trees conserved within a pervious areas during construction or new trees planted within a pervious area.

Tree clusters improve water quality, generate organic soils, absorb greenhouse gasses, create wildlife habitat, and provide shading.

No-mow zones

No-mow zones are areas of turf where mowing and other lawn maintenance activities do not occur on a frequent basis. These areas can be previously manicured lawns that are returned to their natural state or can be planned as part of construction/reconstruction activities.

Creating no-mow zones is an appropriate strategy for sites that have large areas of unused lawn. The cost of maintaining these lawn areas can be a significant financial burden. No-mow zones reduce the need for expensive fertilizers, irrigation and the fossil fuels required to maintain manicured turf areas, in turn reducing O&M costs on your property.

No-mow areas create healthy soils increase infiltration and better support plant life, in turn supporting pollinators and bird populations.

Figure 2.8.1: No-mow zones reduce stormwater runoff while reducing site maintenance costs. (Source: CVC)

Xeriscaping

Xeriscaping refers to landscaping, plantings and gardening practices that reduce or eliminate the need for irrigation or supplemental water after establishment. Synonymous with terms such as water-conservative landscapes, drought-tolerant landscaping and smart-scaping, xeriscaping was originally promoted in areas with perennial water shortages.

In a xeriscaped landscape, plants are selected based on their ability to survive with little water. The additional benefits include the elimination of the need for automated irrigation system, lower maintenance requirements, better plant survivability and aesthetics during drought periods, and lower costs.

Figure 2.8.2: Xeriscaped landscapes don’t just conserve water—they can also be aesthetically pleasing with bright vibrant colours and a variety of textures. Proper plant selection is crucial. (Source: Athyrium Images)

Micro-grading

Site grading typically refers to large-scale grading of a construction site to specified contours, elevations or slope (e.g. 2% slope). Grading done at this scale usually creates a uniform ground surface on which a building may be built. As a result the uniform slope directs runoff quickly and efficiently – sometimes too quickly.

Micro-grading is extremely detailed grading on a much smaller scale than site grading. Micro-grading focuses on individual spaces such as individual land parcels or sub-components like parking lots, walkways or landscaped areas. By creating subtle rolling slope changes, micro-grading disperses runoff and optimizes the potential for temporary runoff detention and infiltration in open spaces and landscaped areas.

Figure 2.8.3: Micro-grading can create subtle and organic landforms like gently rolling hills that help reduce stormwater runoff. (Source: Aquafor Beech)

Soil amendments

Although your site may have grassed areas, the soils may have very little infiltration and filtration capacity due to the stripping, stockpiling, grading and compaction of the underlying native soil that occurs during site development. Consider soil amendments when establishing alternative landscaping. Soil amendments are generally organic materials added to the native soil to provide nutrients for plants, control soil pH, and allow for greater interaction between runoff and soils.

Natural hydrologic performance is one of the objectives of landscape alternatives. Sites that have undergone retrofits using soil amendments produce a smaller volume of runoff and contribute less to the loading of stormwater pollutants into our urban watersheds.

Figure 2.8.4: During the Bernardi retrofit the buffer strips were excavated and compacted topsoils were disposed. (Source: Aquafor Beech)

Staff and financial considerations	
◉	Design team
◉	Capital cost
○	Training
○	Operation & maintenance costs
Design considerations	
◉	Planning complexity
○	Design complexity
Benefits	
◉	Pollutant removal (water quality)
◉	Amenity & aesthetic value
○	Flood risk reduction (water quantity)
○	Groundwater recharge (water balance)
○	Erosion and sediment control
●	High profile with community & media

○ Low Benefit ◉ Moderate ● High

*Performance will vary based upon site characteristics and design of LID practice.

Figure 2.8.5: Aerial view of a street using different landscaping alternatives.

Prefabricated modules

2.9 Prefabricated modules

Prefabricated modules are another option for implementing LID retrofits. The main benefit of this option is product specifications are readily available from manufacturers, along with design guidance, installation considerations, and expected performance. This support can help provide confidence to property managers not experienced with LID retrofits who are seeking a more off-the-shelf retrofit process.

Many prefabricated modules are designed primarily for stormwater treatment, so these practices may not address quantity and water balance. The following prefabricated stormwater management units below are examples of modular practices that can be used as pre-treatment options for LID systems or as integral parts aspects of the LID design.

Additionally, site constraints may require stormwater designers to incorporate prefabricated products to provide required water quality objectives. Prefabricated modules can also be implemented in series with the other options identified in this chapter to provide an extra level of water quality protection and allow for easier maintenance activities.

Due to the rapid evolution of prefabricated modules, contacting the suppliers directory for up-to-date product information is strongly recommended.

Precast tree planters

Precast tree planters are prefabricated enclosures that contain trees or shrubs, bioretention soil media, and a perforated pipe underdrain outlet. These systems are designed to collect stormwater runoff from paved areas like parking lots, roads and sidewalks and treat it using bioretention. Tree planters can be dropped in place, but, unlike bioretention areas, they cannot be custom-sized and designed for a particular site.

Due to the concrete bottom, these planters do not provide water balance benefits; however, when combined as pretreatment for a downstream perforated pipe system, these planters can provide comprehensive watershed water balance protection.

Figure 2.9.1: Precast tree planters can be used independently or as part of a treatment train with other LIDs to treat stormwater runoff. Here they are incorporated into a parking lot curb-and-gutter system. (Source: CVC)

	Staff and financial considerations
◎	Design team
●	Capital cost
○	Training
◎	Operation & maintenance costs
	Design considerations
◎	Planning complexity
○	Design complexity
	Benefits
◎	Pollutant removal (water quality)
◎	Amenity & aesthetic value
○	Flood risk reduction (water quantity)
○	Groundwater recharge (water balance)
◎	Erosion and sediment control
●	High profile with community & media

○ Low Benefit ◎ Moderate ● High

*Performance will vary based upon site characteristics and design of LID practice.

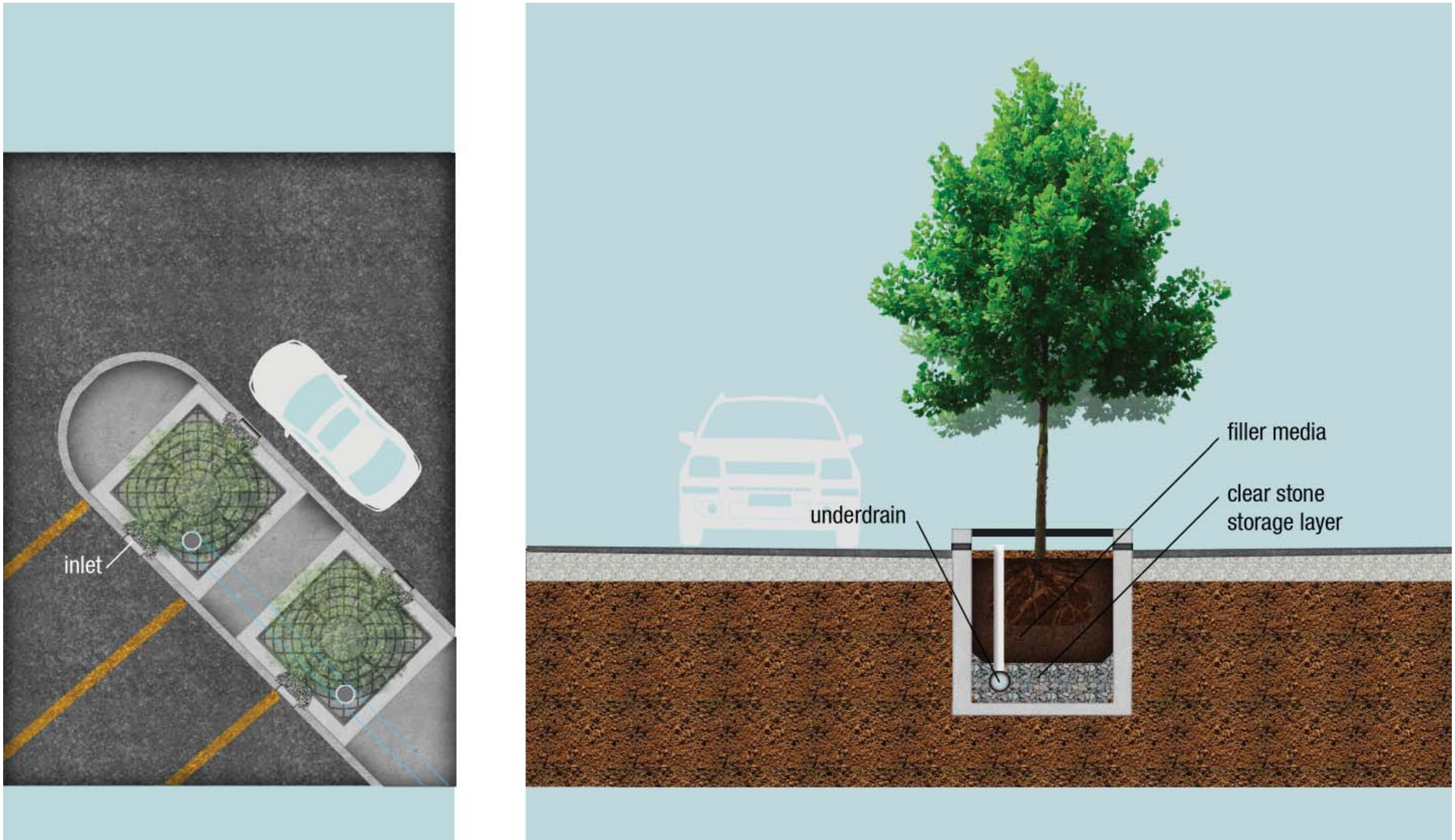


FIgure 2.9.2: Aerial view [left] and cross-section [right] of pre-cast tree planters.

Prefabricated modules

Soil support systems

When implementing an LID practice in a heavily urbanized landscape, some major concerns include providing adequate soil volumes for urban trees and avoiding unnecessary soil compaction while providing structural support of nearby urban surfaces like sidewalks. When soils are heavily compacted, water does not percolate effectively. As a result, urban tree growth can be severely stunted. Conversely, soil that is not sufficiently compacted can result in settling and failure of the infrastructure above it.

Soil support systems address both of these issues. These systems consist of modular frames (or cells) that provide structural support for paved surfaces without the need for a compacted soil base within the tree root zone.

Each cell can hold a specified volume of soil. Cells can be spread across a wide surface area and stacked on top of each other to a specified depth, creating very large tree root zones and infiltration areas beneath infrastructure, particularly sidewalks and pedestrian areas. These systems are particularly beneficial for sites aiming to improve the health and canopy of trees on their property.

Figure 2.9.3: During installation of a soil support system, significant excavation will be required. Modular units allow for design flexibility, such as this long configuration. (Source: DeepRoot)

Staff and financial considerations	
◎	Design team
●	Capital cost
○	Training
○	Operation & maintenance costs
Design considerations	
◎	Planning complexity
●	Design complexity
Benefits	
●	Pollutant removal (water quality)
◎	Amenity & aesthetic value
◎	Flood risk reduction (water quantity)
●	Groundwater recharge (water balance)
●	Erosion and sediment control
◎	High profile with community & media

○ Low Benefit ◎ Moderate ● High

*Performance will vary based upon site characteristics and design of LID practice.

Phosphorus removal media

Phosphorus is a pollutant of concern in many Ontario watersheds. Excess phosphorus loading can result in the growth of nuisance algae, loss of prey fish, degradation of drinking water, and beach closures. The potential cost of annual beach closures in Ontario has been estimated at $38.4 million to $76.8 million annually[55]. For catchments where phosphorus loading has been targeted as a significant concern, phosphorus removal media can be used as a tool to help address this issue.

One type of phosphorus removal media that is available is an oxide-coated, high surface area reactive engineered media. There is a variety of different products available that use this (or other) means for phosphorus removal and the field is evolving rapidly. It is recommended that you consult manufacturers for guidance on selecting the appropriate material.

Figure 2.9.4: Photograph of an engineered phosphorus removal media. Engineered media use a variety of mechanisms to absorb and retain dissolved phosphorus. (Source: Aquafor Beech)

Another means for reducing phosphorus loading is through the use of natural products or industrial byproducts. One natural product is red sand filter media. Red sand has been found to have a phosphorus retention capability, and the Lake Simcoe Region Conservation Authority (LSRCA) is currently evaluating its performance. For further details on using a red sand filter for phosphorus removal, refer to the George Richardson case study in Appendix A.

Proprietary stormwater treatment devices

Proprietary stormwater treatment devices refer to a broad range of different technologies and processes that are used to meet various objectives such as flood and erosion control and water quality.

Figure 2.9.5: To maximize treatment and water balance benefits, proprietary stormwater treatment devices can be installed upstream of LID practices. (Source: CVC)

In general, they are comprised of a prefabricated enclosure in which proprietary technologies are used to treat stormwater runoff flowing through the device. Some of the treatment approaches include hydrodynamic systems, commonly referred to as oil and grit separator (OGS) devices, wet vaults and media filters. The suspended solids, metals and oils/floatables removal characteristics of proprietary stormwater treatment devices can vary widely. Like all stormwater management practices, their performance also depends heavily upon regular inspection and maintenance.

Staff and financial considerations	
◉	Design team
◉	Capital cost
◉	Training
○	Operation & maintenance costs
Design considerations	
◉	Planning complexity
○	Design complexity
Benefits	
●	Pollutant removal (water quality)
○	Amenity & aesthetic value
○	Flood risk reduction (water quantity)
○	Groundwater recharge (water balance)
○	Erosion and sediment control
○	High profile with community & media

○ Low Benefit ◉ Moderate ● High

*Performance will vary based upon site characteristics and design of LID practice.

2.10 Green roofs

Large, flat roofs are ideal targets for green roof retrofits. Green roofs often consist of a thin layer of growing media installed on top of a conventional flat or sloped roof. The vegetation planted on the growth media is selected based on climate conditions, desired aesthetics, and maintenance considerations.

Green roofs provide multiple benefits – they not only improve stormwater management by encouraging uptake and evaporation by plants, they also reduce building heating and cooling costs by acting as natural insulation. Green roofs also tend to protect the roofing membranes from exposure to UV and temperature extremes – extending the life expectancy of the roof itself.

Figure 2.10.1: Green roofs can also be incorporated in other types of structures. In this case a green roof (turf) was installed on top of a parking garage.

Other components of green roofs include a waterproofing membrane designed to protect the roof, specially designed drainage layers that allow for storage of water for plant uptake, and a filter layer to prevent clogging of the drainage system. Green roofs are also equipped with overflows and underdrains connected to the roof drainage system to prevent excessive ponding of water during major storm events.

Structural assessment of your roof is required before any green roof retrofit can take place. This ensures suitable load bearing capacity exists to support all media, plants, water / snow volumes, and live loads associated with maintenance and operations

Figure 2.10.2: High-rise condominiums represent excellent opportunities for green roofs due to their large flat rooftops and the opportunity to create amenity space for residents. (Source: Aquafor Beech)

The City of Toronto has a Green Roof By-law that applies to new commercial, institutional and many residential development applications. To find out more about Toronto's green roof initiatives, including guidelines and construction standards, visit toronto.ca/greenroofs

	Staff and financial considerations
High	Design team
Moderate	Capital cost
Moderate	Training
Low Benefit	Operation & maintenance costs
	Design considerations
Moderate	Planning complexity
Moderate	Design complexity
	Benefits
Moderate	Pollutant removal (water quality)
Moderate	Amenity & aesthetic value
Moderate	Flood risk reduction(water quantity)
High	Groundwater recharge (water balance)
Moderate	Erosion and sediment control
Moderate	High profile with community & media

Low Benefit Moderate High

*Performance will vary based upon site characteristics and design of LID practice.

LID Business and Multi-Residential Retrofit Implementation Process

The following is an overview of the nine steps of implementing an LID retrofit. You can use this page as a quick reference or checklist to make sure your project is staying on track.

Each step falls into one of the following three categories:

Key Activities
These actions must be completed for your LID project to move forward.

Project Team Members and Expertise
A list of which teams members you will require to complete each step.

Key Considerations
A few key details that you should keep in mind during each step of your retrofit.

page 62

Building the Project Team

- [ ] Identify core and support project team members and at which project phases their expertise will be required
- [ ] Gather site-specific knowledge

- [ ] Project manager
- [ ] Site owners and operators

- [ ] Look ahead to future phases of the project to determine what team members will be required. Consider the skill set, expertise, and site usage information you will need at later stages of the project

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Screening the Options

- [ ] Screen the LID options based on land use group, feasibility, site needs, and financial assessment
- [ ] Evaluate all options using direct and indirect project costing table.

- [ ] Project manager
- [ ] Site owners and operators
- [ ] O&M staff

- [ ] Screening should include non-engineering/ technical requirements, multi-disciplinary team is recommended

page 70

Site Evaluation and Reconnaissance

- [ ] Review all relevant background documents from agencies, municipality, and regions
- [ ] Conduct a site reconnaissance to verify site conditions and identify constraints and data gaps

- [ ] Project manager
- [ ] Site owners and operators
- [ ] O&M staff

- [ ] Thorough background review can provide future project cost savings

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Pre-design

- [ ] The pre-design phase includes the collection of field measurements which builds upon information gathered during the field reconnaissance and background document review

- [ ] Project manager
- [ ] Site owners and operators

- [ ] Confirm feasibility based on field activities and adjust project schedule as required

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Detailed Design

- [ ] Review LID Stormwater Planning and Design Guide for guidance
- [ ] Develop detailed design drawings

- [ ] Project manager
- [ ] Site owners and operators
- [ ] O&M staff

- [ ] Consult all site users to determine preferred alternative
- [ ] Consult with municipalities and agencies

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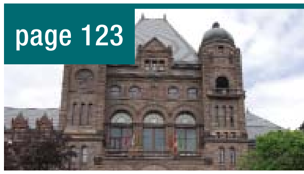

Approvals

- [ ] Review municipal, government and agency policies and local bylaws
- [ ] Identify application processes for obtaining approvals

- [ ] Project manager
- [ ] Site owners and operators
- [ ] Agencies

- [ ] Pre-consult with approvals agencies so there are no surprises during the approvals phase

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Tenders and Contract Documents

- [ ] Review detailed design
- [ ] Develop detailed cost estimates, schedule of items, and contractual documents.
- [ ] Develop tender package for submission

- [ ] Project manager
- [ ] Site owners and operators
- [ ] Purchasing and legal departments

- [ ] Tender submissions should reference applicable provincial standards and municipal by-laws

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Construction Supervision and Administration

- [ ] Supervise work of contactor and provide guidance as necessary
- [ ] Document site activities and maintain client relations

- [ ] Project manager
- [ ] Site owners and operators
- [ ] O&M staff
- [ ] Site users
- [ ] Product suppliers

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Life-cycle Activities

- [ ] Review operation and maintenance requirements
- [ ] Provide owners with guidelines detailing short and long term operation and maintenance strategies

- [ ] Project manager
- [ ] Site owners and operators
- [ ] O&M staff
- [ ] Product suppliers

- [ ] Undertake periodic inspections to determine general operation and maintenance needs

3.0 Upfront Requirements

Like any construction project, installing LID features on your property requires considerable planning before you get started. You must consider team members, hiring the right consultant, and pre-consulting with appropriate municipal and agency contacts. Considering these factors before beginning the project can lead to costs savings through resource sharing, funding opportunities, and better implementation. This section describes important steps to take before you select LID options and deal with the technical project requirements.

3.1 Project stakeholders

It is critical that all project stakeholders are included within the retrofit process. Smaller businesses may find this task simple, but larger organizations may find it more complicated. Larger organizations may need to consult with staff from various departments, including facilities maintenance, environment health and safety, and finance, as well as site users (customers, employees or residents). Preliminary consultation with these internal and external stakeholders should help to identify opportunities for moving forward with the LID retrofit. It is important to include these stakeholders within your project team.

3.2 The core and support team

Your retrofit project team should include a broad range of professionals with different fields of expertise. The team members should provide unique perspectives on the project and allow you to understand the interaction between the LID project, existing site programs, infrastructure, the public, and the natural environment. The project team can be divided into core team members and support team members.

Considering a retrofit of a property that you lease?

LID retrofits enhance the aesthetics of a property, can make your business a better place to work, and can attract new customers. These benefits may help your business, but can be a tough sell for the property owner. When discussing a retrofit with the property owner, be sure to mention that LID stormwater retrofits can provide long-term financial incentives over the life cycle of the site while helping to protect site infrastructure and minimize risks to site users. See Chapter 1 for more details.

Core team

The core team should provide practical support with the development of the terms of reference or tender, request for proposal (RFP), and review and comment on site design. The members should also assist in LID construction, administration, and oversight. Members will be able to make project decisions based on their in-depth knowledge of the retrofit site and their understanding of project objectives.

Support team

The purpose of the support team is to provide information to assist with key decisions. The team also provides a functional role that falls outside the expertise of the core project team. Your support team will likely include co-workers and team members that are external to your business but can offer support to the project. A support team may not be required for smaller scale projects.

The core and support teams will vary depending on the type of site you are retrofitting. Table 3.2.1 provides team selection guidance based on site type.

Table 3.2.1: Suggested core and support team members

Site type	Core team	Support team
Condos and apartments	Superintendant, facility manager, operations staff	Condo boards, residents associations, accessibility groups
Office buildings	Facility managers, operations staff	Health and safety board, communications staff, accessibility groups
Commercial sites	Facility managers, operations staff, business owners	Customer relations, deliveries manager, communications staff, accessibility groups
Post-secondary campuses	Facility managers, operations staff	Student associations, technical experts, accessibility groups
Institutional residential (retirement homes and long-term care homes)	Facility managers, operations staff	Accessibility groups, residents associations, community members
Light industrial	Facility managers, operations staff, business owners	Customer relations, deliveries manager, communications staff, accessibility groups, professional/industry associations

Your project support team may also include experts or representatives from local environmental organizations, agencies, or governments. Before starting your project, consider if any of the following groups will be a valuable asset to your support team:

- Local councillors
- Conservation authorities
- Business improvement associations
- Commercial or industrial associations

Forming partnerships is a great way to share resources and knowledge. Consider partnering with other business and organizations with similar site greening goals.

Business Partnerships: Partners in Project Green

The business community surrounding Toronto Pearson International Airport has partnered with the Region of Peel, the City of Toronto, the City of Mississauga, the City of Brampton, Toronto and Region Conservation, Credit Valley Conservation, and the Greater Toronto Airports Authority to form the Pearson Eco-Business Zone. Businesses within this zone are being supported by a public-private partnership called Partners in Project Green (PPG). By collaborating together through PPG, the businesses can better achieve sustainability goals in energy performance, waste management and water stewardship by sharing resources and seeking support from experienced partners. For more information on this initiative, see partnersinprojectgreen.com

3.3 Multidisciplinary design team requirements

Members of the project team should possess a general understanding of goals and targets associated with stormwater management. Your consultant will provide the technical expertise, but it is important that the core project team understand the hydrologic and water quality benefits that are possible with LID retrofits.

Municipal stormwater incentive programs can be a catalyst for retrofitting a site. If incentive programs exist in your area, core team members should contact their representatives. In most cases representatives from these programs can provide you with contacts and expertise that will be extremely valuable for your project.

To ensure the design of your LID retrofit meets all stakeholder and regulatory agency requirements, you should consult several external organizations early in the planning process. External organizations can include:

- Municipal planning department
- Municipal engineering department
- Ministry of the Environment
- The local conservation authority
- Utilities companies

These organizations can provide details about regulatory requirements and restraints. They can also be a resource for information on similar projects and funding opportunities. Involving them early in the retrofit process will allow them to include or excuse themselves from the project team as they see fit. The approval process will likely require close communication with these organizations. Early discussions may clarify requirements and reduce design iterations.

Site-specific criteria will determine the extent of the required project team. The expertise you will require may depend on the LID practices your team is considering. Table 3.3.1 highlights important project team member disciplines in relation to the LID options.

As your retrofit project progresses, the necessary team members will change. Additional project expertise may be required based on retrofit area characteristics and the LID practices under consideration.

Table 3.3.1: Suggested expertise to be included within the project team

Discipline	Permeable pavement	Bioretention / bioswales	Soakaways	Perforated pipe systems	Rainwater harvesting	Landscape alternatives	Prefabricated modules	Green roofs	Pollution prevention
Water resources engineering	✓	✓	✓	✓	✓	✓	✓	✓	✓
Structural engineering					✓			✓	
Soil sciences	✓	✓	✓	✓		✓			
Hydrogeology	✓	✓	✓	✓					
Landscape design		✓				✓			
Botany		✓				✓		✓	

3.4 Integration with existing site activities

Your project team must be familiar with the operations and maintenance activities that each LID option requires after the construction phase. Common forms of maintenance on LID practices include the pruning of plants in bioretention facilities and the removal of sediment from permeable pavement surfaces and pre-treatment areas. Specific operations and maintenance requirements for each LID practice can be found in Chapter 10.

Your project team should also understand how these ongoing processes will be integrated into existing operations and maintenance programs. If the site is run by a facility or property manager, it is essential that this person be involved in the planning and design process. Continued success of the LID project will depend on how onsite programs such as snow removal, sanding, salting, landscaping, and construction projects will be managed. It is also important to take stock of the site actualities at this stage. Informal operations and standards such as smoking areas, neighbouring landscapes, and traffic patterns can help to illustrate site usage and inform decisions about the design. The background review should capture this information so it is important to include team members that are able to speak to site usage.

LID retrofit project managers must consider how the proposed works will affect all users of the site. One member of the project team should be responsible for communication with these stakeholders. Site users often include customers, employees, and contractors. If your retrofit site is leased to multiple operators (e.g. shopping plazas, office buildings or big box centres), each should be consulted early in the process to ensure the LID project proceeds as smoothly as possible and does not interfere with business operations.

After the LID practice is installed, site staff and contractors will likely have the most interaction with the new site feature. As members of your retrofit team they should be informed of the general objectives of implementation. Their understanding of site activities will help the team choose an option that can best be integrated with existing operations. When the LID practice is chosen, it is important to show them what the system is expected to look like as it responds to precipitation events. This will help avoid any misconceptions. For example, a person who is not used to permeable pavement might think the relative lack of sheet flow on the parking lot surface indicates that the system is not working. Explaining that permeable pavement reduces sheet flow will help them understand what they see after construction is complete.

The site responsibilities for land management activities such as inspections, maintenance, and replacement of infrastructure can vary considerably. Understanding these responsibilities is essential for the smooth integration of the LID practice. The roles and responsibilities for land management on your site may heavily depend on whether you own your site or it is leased from a property management company.

Owned and operated

If you own and operate your retrofit site, the responsibility and financial burden associated with site inspections, operations, maintenance, and construction activities is clearly defined.

Owned and leased

For sites where the property is owned by a property management company and leased to a business operator, the roles and responsibilities for land management may be shared or rest with one party. This will be indicated in the lease agreement. Table 3.4.1 summarizes responsibilities for various land management tasks on a site that is leased. Although the responsibility to maintain LID practices may ultimately rest with the site owner, people who are on the property on a daily basis need to understand the basic hydrologic and hydraulic function of the practice and be able to identify problems.

Figure 3.4.1: Employees at the Co-operators planting and cleaning the swales bordering their property. (Source: CVC)

Table 3.4.1: Land management responsibilities on leased properties

Task	Responsible group
Site inspections	Property owner
Regular maintenance (mowing and trimming of landscape features, sweeping of parking lot and roads, minor pavement patches)	Property owner or tenant
Construction projects requiring major capital expenditures (parking lot paving, roof rehabilitation)	Property owner

3.5 Choosing the right consultant

An engineering consultant experienced in LID design and construction can provide great value to your project team and make all phases of the project more successful. Consultants specializing in stormwater design can be found throughout the province. Consultants specializing in LID designs are not as common due to lack of widespread implementation of LID practices.

While many technical skills are shared between conventional stormwater and LID practice design, the contractor should be aware of some unique components. These include:

- The dependence of many LID techniques on suitable native infiltration rates
- The importance of appropriate erosion and sediment control during construction and the affect it will have on the long-term functionality of LID design
- The approaches to LID operations and maintenance
- The integration of LID practices with existing site programs

When determining which consultant is right for your project, look at the experience they have with similar sites. The project managers may consider pre-qualifying consultants based on experience and training. Examples of pre-qualification requirements include, but are not limited to:

- Minimum of two LID retrofit projects successfully completed
- Completion of permeable interlocking concrete pavement (PICP) training (for projects involving permeable block pavers)
- Completion of Canadian Standards Association – Sustainable Stormwater Practices Training
- Membership with Consulting Engineers of Ontario
- Membership with Landscape Ontario (for projects involving bioretention and bioswales)
- Certification as an Inspector of Erosion and Sediment Control (CISEC)
- Training through local conservation authorities

You may choose to use an RFP process when hiring a consultant to join your retrofit team. This process is recommended for projects that include multiple sites (i.e. multiple properties operated by the same property management company) or will span more than one construction season.

If using the RFP process, modifying the proposal scoring system to value related project experience over cost might be a suitable method for making your choice. Remember: The least expensive proposal does not always result in the best consultant for your LID retrofit project.

4.0 Site Screening of LID Options

4.1 Background review

You have now assembled a project team and consulted with project stakeholders to understand the regulatory requirements and the needs of site users. At this stage of the retrofit process the project becomes more technically demanding. Your consultant will need to use skills and experience to better understand the opportunities and constraints on your property. Background information will help scope technical investigations for the site and determine project targets.

Given the wide variety of LID options available, an important step in identifying the LID option(s) best suited to a particular site is to apply a systematic screening process. This process first involves a review of background materials and field reconnaissance, both conducted by core project team members. Armed with this information informed decisions can be made. This section of the guide identifies specific project issues to watch for during site reconnaissance and outlines a screening procedure that will narrow down your LID options.

It's best to collect and review this information prior to choosing an LID option. Relevant background information may include:

- Construction drawings from site and adjacent properties
- Mechanical drawings identifying rain leader piping
- Structural reports and plans (to assess green roof suitability)
- Servicing drawings (hydro, phone, gas, cable, and other utilities)
- Grading plans
- Stormwater management and drainage reports
- Sump-pump and/or foundation drain connection information
- Local stormwater management criteria
- Hydrologic models
- Hydraulic models
- Aerial photos
- Surveys
- Local Digital Elevation Model (DEM)
- Surficial soils and geology data
- Geotechnical investigations and reports
- Relevant local policies, by-laws and standards
- Snow plow/salting operations
- Snow storage
- Smoking areas
- Neighbouring landscapes
- Company vision

The consultant should complete a preliminary analysis of site opportunities and constraints through site reconnaissance. This information will allow you to implement LID source controls in the most effective manner.

Site reconnaissance should be performed once a thorough background review has been completed. During this phase, the team should identify site conditions that may cause conflicts with LID design alternatives and identify any data gaps. These are some key considerations and activities to perform during site reconnaissance.

Mapping

There are several web-based mapping tools available for free (e.g. Google Maps, Google Earth, Bing Maps, MapQuest). A printed map can provide spatial context for a site visit, especially if you find the engineering drawings difficult to understand. Existing conditions and features that you find during site reconnaissance may be recorded by preliminary mapping or aerial photography. A map provides a visual record of the general locations of important site features, infrastructure, drainage features, utilities, trees, and other potential obstructions that are integral to the site design.

Photo log

Keep a photographic record of the existing conditions. During the design phase, these photos provide reference when options and design details are being considered. Photos also provide a record of the pre-retrofit conditions that can be beneficial once construction activities commence.

Opportunities for pollution prevention

Look for areas of your site that can be targeted for P2. These areas include material storage areas, waste disposal areas, loading/unloading facilities, fueling stations, areas prone to dumping activities, and open-channel drainage courses lacking appropriate buffer zones or barriers. This can be very common in light industrial sites. Targeting these pollution hot spots with simple pollution prevention strategies will provide a significant reduction of pollutants from your site during runoff events.

Figure 4.1.1: Bernardi Building Supplies retrofit its property with various pollution prevention strategies. Pictured above are material storeage solutions that reduce the chances of a spill. (Source: CVC)

Obstructions

Take note of any obstructions that might impact the way in which the LID retrofit is designed. Think about the construction phase of the project and the long-term operations and maintenance activities that will be required for design alternatives. Identify physical barriers to construction. These can include natural features, infrastructure, and utilities. The background information may not accurately depict where these barriers exist.

Figure 4.1.2: Utilities are major barrier to construction. The pipes pictured above were not listed in the background information and caused construction delays as excavation had to work around them. (Source: CVC)

Layout

Evaluate the layout of your property and include the size and location of the various features. Sidewalks, road widths, ditch systems, catch basins, and manholes all should be noted along with their apparent condition (e.g. damaged, not functioning, good condition, etc.). It is important to envision how and where LID practices will integrate into the existing landscape.

Figure 4.1.3: The layout of the site will determine the placement of practices on a site. Features like priority parking and wheelchair access can inform a retrofit design. (Source: CVC)

Drainage

Evaluate the existing drainage system. Investigate manholes, culverts, and catch basins to verify surface and lot drainage. This evaluation can provide valuable information, such as potential tie-in locations and external drainage sources contributing to the study area that were not identified in the background information.

Figure 4.1.4: Improper surface grading can reduce a site's drainage capabilities. At this site, most rainfall causes significant ponding and interferes with day-to-day operations. (Source: CVC)

Approach site users

Talk to staff, residents, customers, students, and any other group of site users present during your field assessment. They may provide valuable information regarding site use characteristics and infrastructure problems. These comments and concerns could provide relevant information you can integrate into your design.

Figure 4.1.5: Site users can provide valuable information during a site visit. They can highlight problems and provide insight into actual site usage. (Source: CVC)

4.2 Screening the options

Now that you have reviewed background site information and conducted site reconnaissance to determine site-specific opportunities and constraints, it is time to screen your site to determine which LID options will provide the greatest benefits. This section will help your project team select the appropriate LID practices to implement on your retrofit site.

Many things will influence selection of LID practices for your retrofit site. They can include (but are not limited to):

- Underground utilities
- Accommodation of surface elements (such as light standards, storage areas or other items)
- Transportation requirements
- Site aesthetics
- Shipping and receiving requirements
- Spill containment plans
- Operations and maintenance capabilities
- Municipal engineering standards
- Traffic safety issues
- Pedestrian safety and accessibility
- Snow removal and fire access requirements (minimum access road width and turning radius requirements)
- Parking availability and access

The site types considered in this guide are grouped into six general categories based upon site similarities. This chapter discusses common features that will help the designer categorize a site as part of one of these six land use groups. If the listed site features do not unanimously apply to your site, select the most appropriate category or use a combination of two or more categories to screen LID options. Please note that LID practices are scalable and applying alternate LID practices to those identified for each land use group may be a possibility upon a more detailed evaluation of site constraints (i.e. field testing conducted during pre-design). Choosing an appropriate LID practice can be an iterative process as additional site information becomes available in the pre-design phase.

For each land use group, this chapter identifies source areas typically found on these sites. Source areas are features such as parking lots, roofs, pedestrian areas, common areas, and landscape areas. The chapter also discusses LID retrofit opportunities and constraints within these source areas, and provides a table for each land use group that identifies common, possible, and unlikely retrofit options. Aerial photographs highlight retrofit opportunities on a representative site for each land use group.

Later parts of this chapter will discuss additional site-specific design and financial considerations.

Keep a copy of the aerial photo or plan of your site close at hand to help you identify source areas as you read about each land use group.

Land use groups

The following icons will help you find the topics that pertain to your particular site.

High and mid-rise

- Condominiums
- Apartments
- Office buildings

Low rise

- Townhouse condominiums
- Apartments
- Office buildings

Light industrial

- Light manufacturing
- Warehouses
- Food production Laboratories

Large commercial

- Big box
- Warehouses
- Shopping malls
- Grocery stores

Small commercial

- Individual enterprises
- Strip malls
- Residential converted to commercial

Institutional

- Universities
- Colleges
- Long-term care homes
- Retirement homes

4.3 High-rise and mid-rise sites

Mid- and high-rise sites (four storeys or more) share common features. These buildings are often for residential use and include apartments or condominiums. They may be operated by residential leasing companies or condominium associations. Many office buildings belong to this site category. Office buildings may be operated by an independent site owner, but they are often owned and operated by commercial land management groups.

Mid- and high-rise buildings have higher user occupancy densities than other sites and therefore require significant parking area. To conserve the site area, these parking areas are typically located underground. Mid- and high-rise buildings most commonly have flat roofs that drain internally to onsite storm sewer networks. These sites typically have common areas, but their size and function vary.

Common areas

Pedestrian and common areas are outdoor features that can be found on most mid- and high-rise sites. They provide access and egress to buildings and allow pedestrian movement around the property. Most mid- and high-rise buildings will have common areas at their entrance that can include garden features, planters and benches. On residential sites, common areas may include parks or parkettes, playgrounds, sports facilities, sidewalks, and pathways.

Landscaped areas

Landscaped areas commonly surround mid- and high-rise buildings They can also be found adjacent to parking lots and internal roads. These areas are often grassed and may include plantings. Landscaped areas are ideal for establishing bioretention areas, soakaways, or bioswales where conveyance is preferred. If grading allows, landscaped areas adjacent to the parking lot can easily be retrofitted to provide quality control and water balance benefits. Landscaped areas may also be located within the pedestrian areas adjacent to a building. These areas can be targeted to accept and infiltrate clean roof drainage. Cisterns for rainwater harvesting can also be located in these areas, either buried or above ground. Utilities may be buried within landscaped areas on your site (not just adjacent to the building). Locates are required before digging occurs. For more information on locates, see Chapter 9.

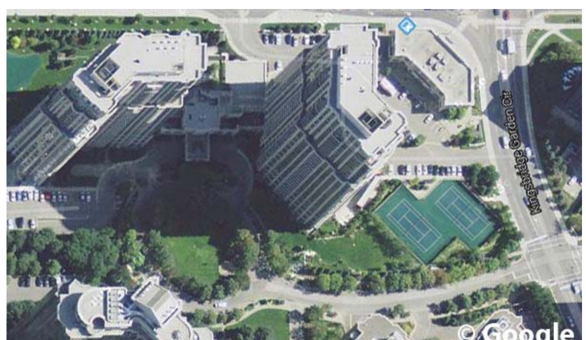


Figure 4.3.1: These high-rise condominiums have large parkettes and common areas behind the buildings. (Source: Aquafor Beech)

Roof areas

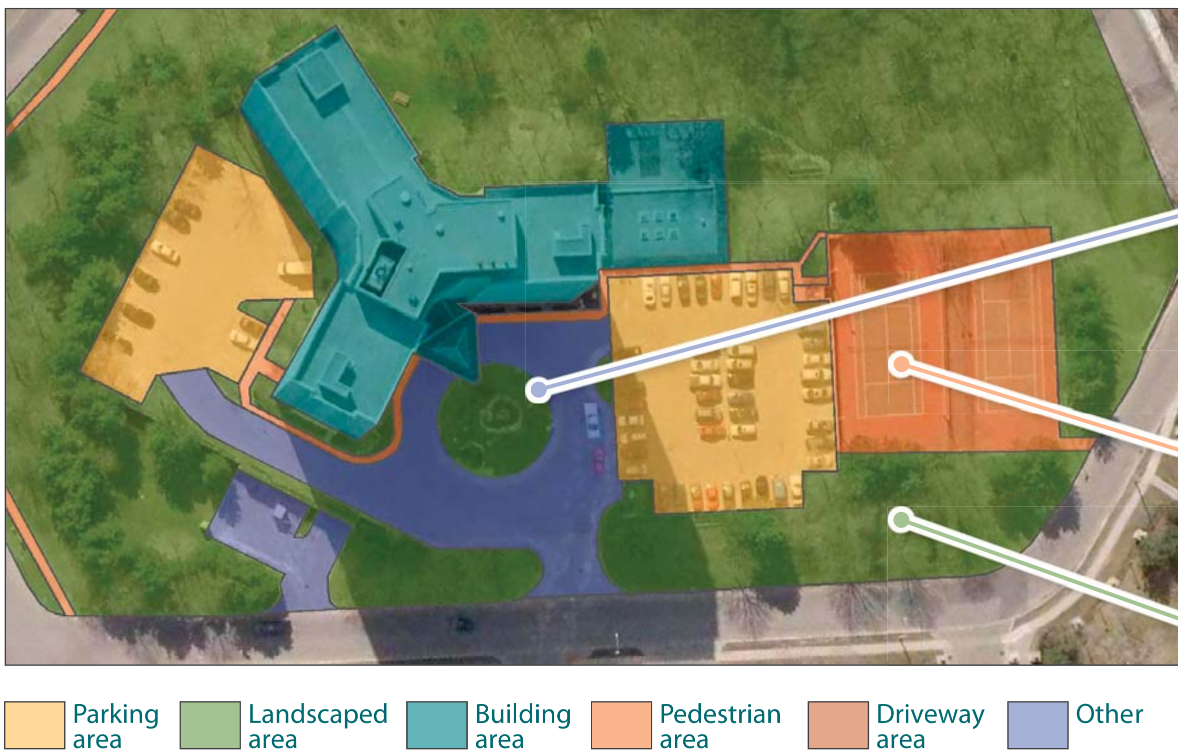
In most municipalities, the rooftops of mid- and high-rise buildings are not very visible. Developing LID practices on these surfaces will provide benefits but will be more difficult to promote. The exception is major urban centres where a significant number of high rises have been developed and sometimes look onto each other.

Figure 4.3.2: A tiered rooftop presents unique retrofit opportunities on mid and high rise sites. Tiers can be thought of as catchment areas and can be used as pilot projects before implementing the entire roof area of the building. Here a green roof allows condo owners to have a landscaped font yard, even on the 15th floor. (Source: Aquafor Beech)

LID options for high-rise and mid-rise sites

Source area	Permeable pavement	Bioretention	Bioswales	Soakaways	Perforated pipe systems	Rainwater harvesting	Landscape alternatives	Prefabricated modules	Green roofs	Pollution prevention
Roof area	○	○	○	○	○	●	○	○	●	○
Pedestrian / landscaped / common areas	●	●	◎	◎	◎	○	●	●	○	◎
Parking area	●	◎	◎	◎	◎	○	○	●	○	●

● common option ◎ possible option ○ unlikely



This landscaped area is in a high-profile location that vistors and residents will pass on their way to the building. It is also adjacent to a well-traveled driveway that likely contributes significant pollutant loads to the site runoff. A bioretention practice in this location will enhance site aesthetics and provide water quality and water balance benefits. Also, these high value landscapes already receive frequent maintenance and converting them to bioretention would add few additional tasks.

This tennis court represents a significant impervious percentage on this site. A infiltration chamber located below would encourage groundwater recharge.

This unused green space is ideal for a bioretention or bioswale retrofit to provide stormwater management for parking lot runoff.

4.4 Low-rise residential sites

Low-rise residential sites include townhouses and apartment complexes that are fewer than four storeys. These sites can be operated by property management groups or by condominium boards. Common landform features of low-rise residential sites include small parking lots, and significant pedestrian and landscaped areas. Townhouses have peaked roofs with external drainage while low-rise apartment complexes have flat roofs with internal drainage.

Landscaped areas

Low-rise residential sites typically have significant landscaped areas. On townhouse sites landscaped areas tend to be spread across the complex as gardens, parking islands, and strips of lawn. Park or community green spaces areas may also be present on these sites.

Due to lot grading, it may not be practical to convey road and parking lot runoff to landscaped areas to the building's perimeter. These areas can, however, be retrofitted to provide water balance benefits by infiltrating roof runoff via bioretention, soakaways, or bioswales.

On sites with larger green spaces LID practices that accept runoff from more substantial catchment areas will likely be feasible. Parks can be retrofitted with most LID options. Subsurface LID options like infiltration chambers can be used without sacrificing park function, while highly visible practices like bioswales or bioretention enhance the aesthetic value.

Figure 4.8.2: In many low-rise residential developments, a portion of the roof drainage is directed to conveyance features (ie. rear-yard catchbasins). In the Ganonoque townhouse complex in Mississauga, homes and common elements are built on top of the parking garage, extending the life of the parking lots. (Source: CVC)

Parking areas

Parking areas on low-rise residential properties are often small and well used by residents. Low-rise apartment sites often have parking lots that are graded to catch basins which connect to onsite storm sewers. Due to their smaller, decentralized design, parking areas for townhouse developments typically convey runoff overland to internal roadways equipped with storm sewers.

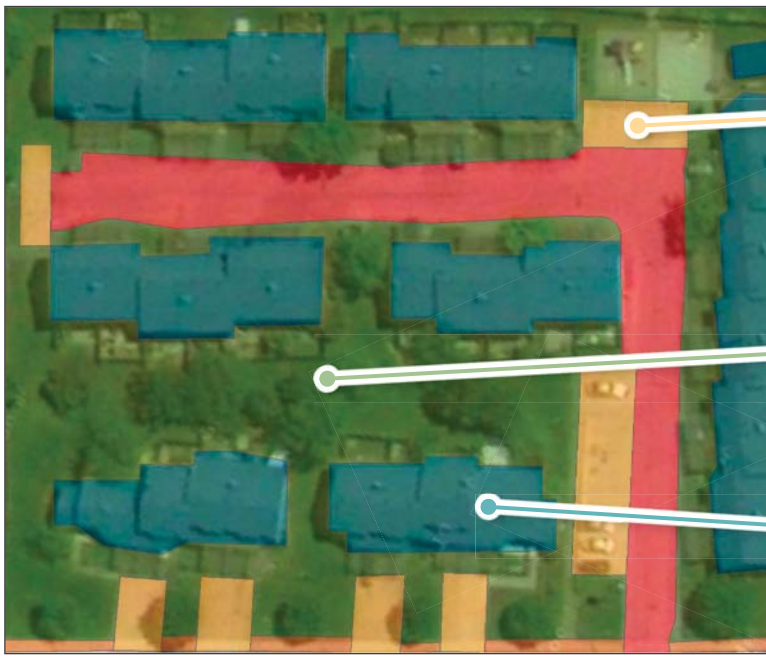
Permeable pavement is a retrofit option for both types of parking facilities. Internal roadways can also be retrofitted with permeable pavement.

Figure 4.8.3: This parking area could be retrofitted with permeable pavement. The green area on the opposite side of the curb provides a suitable location for a small bioretention planter accepting roof runoff. (Source: Aquafor Beech)

LID options for low-rise land use

Source area	Permeable pavement	Bioretention	Bioswales	Soakaways	Perforated pipe systems	Rainwater harvesting	Landscape alternatives	Prefabricated modules	Green roofs	Pollution prevention
Roof area	○	○	○	○	○	●	○	○	○	○
Pedestrian / landscaped / common areas	○	○	○	○	○	◉	●	○	○	○
Parking area	●	●	◉	◉	◉	○	○	●	○	◉

● common option ◉ possible option ○ unlikely



Many retrofit options can be considered for this parking area. Permeable pavement could be used to encourage infiltration and reduce runoff volumes. The adjacent green space could be retrofitted with bioretention or bioswale features. During the initial stages of a retrofit, the feasibility of treating runoff from the adjacent driveway should be assessed.

Green spaces between buildings often contain shallow grassed swales designed to convey runoff from frequent rainfall events to catch basins. With a few modifications, including the addition of bioretention soil media, the conveyance feature can be transformed into a bioswale. This LID practice applied across the site would greatly reduce runoff volumes and improve water quality.

The peaked roofs with downspouts in this townhouse complex are ideal for small rain garden retrofits. Rain gardens can be spread throughout the complex to collect rooftop runoff from one or two downspouts.

Parking area | Landscaped area | Building area | Pedestrian area | Driveway area | Other

4.5 Large commercial sites

Large commercial sites include big box stores, warehouses, and shopping malls. These sites are often located in highly urbanized commercial centres. They are commonly owned and operated by land management companies.

Large commercial sites are rarely more than two storeys in height. These sites typically have large parking lots that may be underused. Roof areas are often flat and drain internally through the building to onsite storm sewers. Though these sites are expansive, they rarely have complex networks of pedestrian walkways and often rely on vehicular traffic to get site users onsite.

Parking areas

Not all parking areas are used equally. At large commercial sites parking spots may be reserved for people with disabilities, visitors to the site, expectant mothers, families with young children, specific employees, deliveries, motorcycles, electric cars, taxis and/or public transportation. When considering parking areas for LID retrofit locations, identify and respect these special areas during the design process. The retrofit team should also be aware of how site parking is used throughout the week.

Parking spaces close to building entrances are used more frequently than those in moderate and peak demand areas. If grading and other site-specific factors allow it, the designer may choose to install permeable pavement in the infrequently used areas to extend the life of the system. Conversely, the social benefits of green features may be underappreciated in areas that are not frequented by site users. Developing practices like bioswales or bioretention areas closer to the entrance of the building may be more practical. On many sites existing drainage patterns will dictate where parking lot source controls can be located.

Roof areas

The roof areas of large commercial buildings account for large impervious surfaces. Controlled roof drains have become a widely utilized tool for stormwater management with the commercial development industry. While these devices do attenuate flows, they do not significantly reduce runoff volumes. By simply directing roof runoff to a soakaway pit, you can provide a great amount of volumetric stormwater control. Consider going one step further and storing this water in a cistern for future use. Commercial rooftops are relatively clean and complex filtration is not required prior to most non-potable uses.

Enhance your site with a beautifully planted bioretention area. Establish these areas where garden parking islands are currently located.

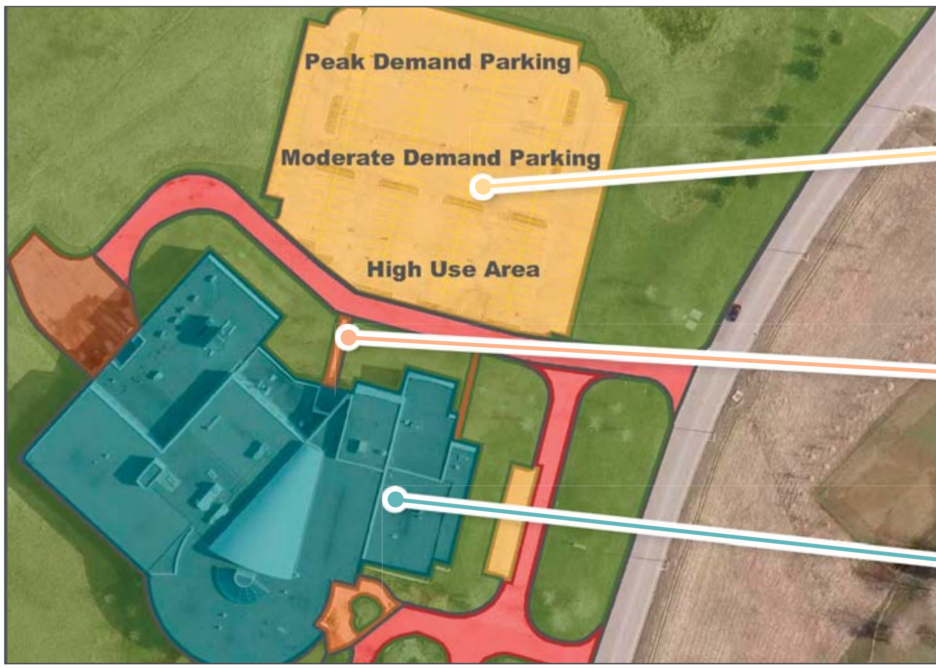
Figure 4.4.1: Large pedestrian areas, such as mall entrances, are ideal targets for LID retrofits. (Source: CVC)

Figure 4.4.2: Look for existing features that can be modified to include LID practices without compromising site function. This parking lot island is an ideal location for a bioretention planter. (Source Aquafor Beech)

LID options for large commercial sites

Source area	Permeable pavement	Bioretention	Bioswales	Soakaways	Perforated pipe systems	Rainwater harvesting	Landscape alternatives	Prefabricated modules	Green roofs	Pollution prevention
Roof area	○	○	○	○	○	●	○	○	●	○
Pedestrian / landscaped / common areas	●	●	●	◉	○	○	●	●	○	◉
Parking area	●	●	●	●	◉	○	○	●	○	●

● common option ◉ possible option ○ unlikely



These parking lot islands are ideal targets for retrofits. The islands are located between moderate demand and high use areas which allows for project promotion opportunities with site users. Retrofitting with bioretention practices will preserve the traffic calming effect of the existing islands and meet municipal landscaping requirements.

Pathways adjacent to the building entrance can be beautified with bioretention areas that accept runoff from adjacent impervious surfaces. Plantings can be selected based on the desired aesthetic and maintenance effort.

Structural plans from the building's development can be an excellent tool to make sense of complex commercial roof drainage patterns.

Parking area | Landscaped area | Building area | Pedestrian area | Driveway area | Other

4.6 Small commercial sites

Small commercial sites include strip malls, small private enterprises, car dealerships, and residential sites converted to commercial facilities. While site features can vary significantly with these small sites, typical features include small parking areas and limited pedestrian and common areas. On these sites roof areas can be flat with internal drainage or peaked with external drainage.

These sites can be owned and operated by the site user, though land management companies also own and operate a significant portfolio of small commercial sites in Ontario.

Landscaped areas

Landscaped area retrofits on small commercial sites are limited due to high impervious surface coverage. Landscaped areas can often be found near the site perimeter. Where open channel conveyance systems like ditches and swales exist, bioswales are often a suitable retrofit option. Bioretention may also be a suitable option along green site perimeter areas. On many sites, drainage will be conveyed towards site perimeters/away from the building. This allows for the capture of parking lot runoff.

Roof areas

The roof areas of small commercial buildings account for large impervious surfaces. Whether internal or external roof drains are present, rainwater harvesting is a viable option to achieve water balance benefits. Harvested water can be used for most outdoor uses including irrigation and pressure washing of hard surfaces. Indoor non-potable uses like toilet flushing can most easily be integrated into flat-roof systems with internal roof drainage pipes.

Small commercial building roofs offer excellent opportunities to intercept runoff. Directing roof leaders to bioretention areas, soakaways or even permeable pavement is an option. Alternatively, you could establish a green roof or collect water with a rainwater harvesting system and use it for onsite irrigation or other non-potable uses.

Parking areas

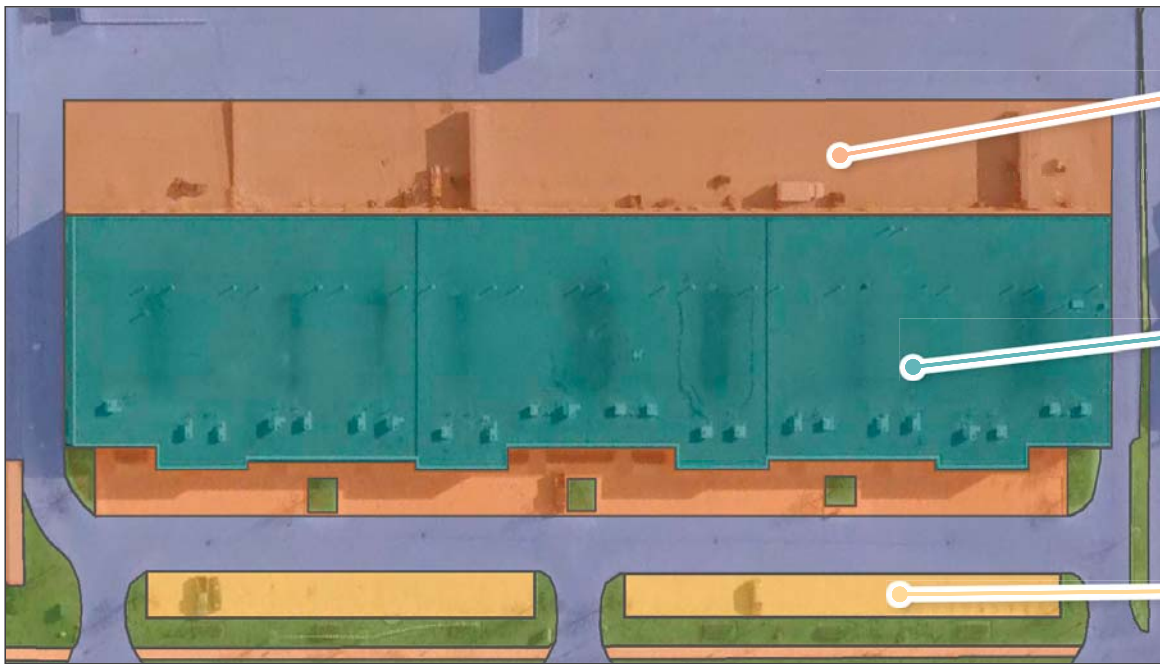
Like large commercial sites, parking patterns on small commercial sites will include areas of high use that are close to the buildings, as well as areas that are used only during periods of peak demand. Due to lower vehicle speeds and fewer heavy loads, parking lots are ideal locations for permeable pavement installations. Bioretention areas may also be located in parking lot areas and are typically enclosed by curbing. Runoff from parking lots can also be directed to LID practices external to the parking lot areas such as perimeter bioswales or soakaways. Infiltration chambers can also be placed under parking lots to provide infiltration or required detention volumes for roof and/or parking areas. Utilities may be buried within parking lots. These are frequently electrical lines for parking lot lighting. Locates are required before digging occurs.

Figure 4.5.1: Unlike residential properties, commercial sites rarely have green space immediately adjacent to the buildings. Parking islands or perimeter swales may be the only outside irrigation demand suitable for rainwater harvesting. (Source: Aquafor Beech)

LID options for small commercial sites

Source area	Permeable pavement	Bioretention	Bioswales	Soakaways	Perforated pipe systems	Rainwater harvesting	Landscape alternatives	Prefabricated modules	Green roofs	Pollution prevention
Roof area	○	○	○	○	○	●	○	○	●	○
Pedestrian / landscaped / common areas	●	●	◎	◎	◎	○	○	●	○	◎
Parking area	●	◎	◎	◎	◎	○	○	●	○	●

● common option ◎ possible option ○ unlikely



The rear area of this building is not ideal for LID retrofits. In this area delivery trucks may require large unobstructed paths to accommodate deliveries.

This rooftop covers nearly a third of the site. This is common for commercial properties. The flat rooftop is ideal for establishing a green roof. Rainwater harvesting is another option for the roof area, however there does not appear to be significant outdoor demand for irrigation given the small amount of landscaping. Instead, non-potable indoor uses such as flushing of toilets could be considered for harvested rainwater.

This unused green space is ideal for a bioretention or bioswale retrofit to provide stormwater management for parking lot runoff.

Parking area | Landscaped area | Building area | Pedestrian area | Driveway area | Other

4.7 Light industrial sites

Light industrial sites include light manufacturing, warehouse, warehouse-manufacturing multiuse, laboratories, as well as food production and processing facilities. Common landform features of light industrial sites include fewer than four storeys of building height, maintenance yards, shipping and receiving areas, flat roofs with internal drainage, and vast but often underused parking lots.

Light industrial sites present unique challenges and opportunities. When evaluating the LID retrofit opportunities on a light industrial site, give preliminary consideration to pollution prevention, especially in and around shipping and receiving areas, and product or waste storage areas.

Storage / shipping and receiving

Light industrial lands often have storage and/or shipping and receiving areas located immediately adjacent to the building in the front or rear of the property. Due to the intensive use of these areas, they are significant contributors to pollutant loading.

Often, the simplest and most inexpensive way to reduce pollutant loading from these areas is implementing P2 practices. P2 includes non-structural solutions that reduce pollutant loading by changing site practices. For example, reducing the amount of de-icing salts used in the winter can significantly improve runoff quality. Changing the location of product or waste storage from the perimeter of the site to a controlled catchment area or within the building can also improve runoff quality. Modifying loading and unloading practices by changing equipment or implementing weather policies can also be extremely effective in reducing the stormwater impact of a site.

Structural P2 practices for these areas could include spill containment structures used to temporarily detain materials or liquids until collection and disposal can occur. Spill containment structures should be part of a site-specific spill response plan. These systems may include subsurface vaults or oversized pipes with shut off valves. Staff training is mandatory for operating these systems.

Outdoor material and waste storage areas can be upgraded with covered storage bins, shelters, or containers to prevent rain from coming into contact with materials that impact stormwater quality.

Figure 4.7.1: Here a loading bay and waste storage area drain to the road. P2 practices could improve runoff quality from this site. (Source: Aquafor Beech)

Establishing buffers around surface conveyance features can also provide significant improvements to runoff quality. These buffers may include physical barriers like bollards or curbs to prevent conveyance features from being used as storage areas.

Staff parking areas and rooftops

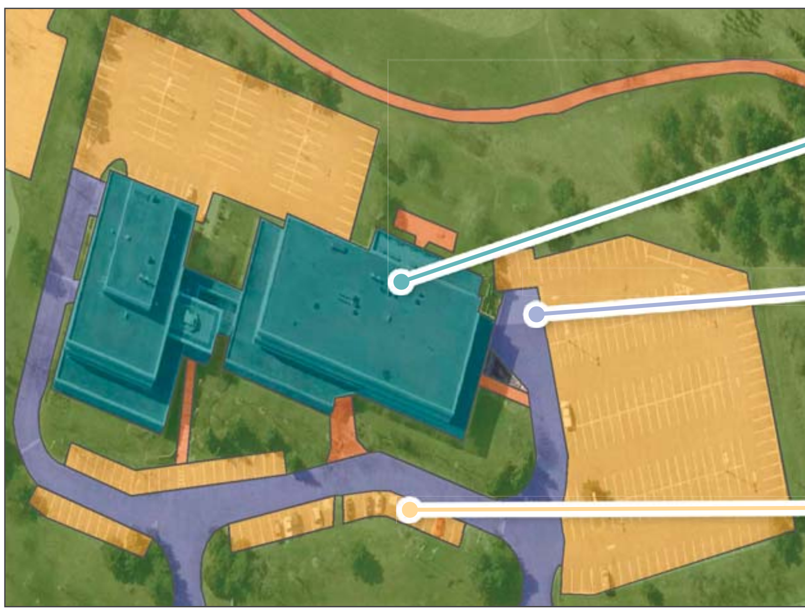
These areas represent the best opportunity for establishing LID practices on light industrial sites. Runoff from these catchment areas can be treated with the same suite of LID options for commercial lands.

Figure 4.7.2: This landscaped area receives runoff from the adjacent staff parking lot, but not from loading bays. Bioretention is a suitable retrofit option in this area. (Source: Aquafor Beech)

LID options for light industrial sites

Source area	Permeable pavement	Bioretention	Bioswales	Soakaways	Perforated pipe systems	Rainwater harvesting	Landscape alternatives	Prefabricated modules	Green roofs	Pollution prevention
Roof area	○	○	○	○	○	●	○	○	●	○
Pedestrian / landscaped / common areas	○	○	○	○	○	◎	○	○	◎	◎
Parking area	●	◎	◎	◎	◎	○	○	●	○	●
Storage / loading / unloading areas	●	◎	◎	◎	◎	○	○	●	○	●

● common option ◎ possible option ○ unlikely



Runoff from this roof is relatively clean compared to other onsite impervious surfaces. Roof runoff can be collected and stored form non-potable uses or conveyed to a soakaway pit with minimal pretreatment.

Study of the site operations around this storage pad is recommended before retrofitting this area with LID practices. Non-structural pollution prevention then structural pollution prevention practices should be considered before LID practices utilizing infiltration are considered. This precaution prevents possible contamination of groundwater and avoids clogged and degraded of the LID practices.

This visitor parking lot and internal roadway is unlikely to be used by heavy vehicles or storage of materials. Permeable pavement is an option, though the large grassed area immediately to the south presents a simple and cost effective water quality and water balance solution in the form of bioretention.

Parking area | Landscaped area | Building area | Pedestrian area | Driveway area | Other

4.8 Institutional sites

Institutional sites include colleges, universities, long-term care homes, and retirement homes. While site features can vary significantly, typical features include multiple-storey buildings, large parking areas that comprise a smaller percentage of overall area than commercial sites, flat roofs with internal drainage, and significant pedestrian and common areas for public interaction. Some institutional sites, including university campuses, will include vast networks of buildings and interconnected pathways.

Institutional sites typically have dedicated landscaping and/or operations and maintenance staff that can be trained to provide the required long-term maintenance.

Parking areas

Parking lots on institutional sites represent a large source of stormwater pollutants. LID designers should target these areas to improve runoff quality and reduce runoff volumes. LID options suitable for parking lot runoff include bioretention areas within parking lot islands or along the perimeter of the parking lot, bioswales along the perimeter of the parking lot, and infiltration chambers buried underneath the parking lot or along adjacent green space. Consider modular units, especially as part of a treatment train with other LID practices. Permeable pavement is another viable option for institutional parking lot retrofits.

On sites with several parking lots, consider the feasibility of modifying operations for LID practices. A site partially retrofitted with permeable pavement will likely require two separate parking lot maintenance plans: one for the conventional asphalt and one for the permeable pavement.

Landscaped areas

Institutional sites present many opportunities for landscaped area retrofits. Landscaped areas are often found along pedestrian pathways connecting the site's high-use areas. These areas are ideal to establish highly visible LID practices like bioretention areas or bioswales. Landscaped areas may also be found adjacent to buildings where they provide break areas for site users. Enhancing these areas with highly visible LID practices is another option. Gardens and parking islands in close proximity to buildings can be converted to bioretention areas and/or irrigated via a rainwater harvesting system.

To reduce site maintenance costs on large properties, site owners can consider alternative landscaping to a high maintenance lawn. No-mow or naturalized areas require minimal maintenance compared to mown grass areas and can greatly reduce site runoff by encouraging interception by tree canopies and evapotranspiration by green vegetation. Naturalized areas with cleanly mowed edges and colourful plant species can still give the impression of an orderly and attractive landscape.

Figure 4.6.1: This picnic area provided onsite for employees is an ideal location to establish bioretention. Flowers planted in the bioretention area will enhance the site's aesthetic while at the same time providing quality and volumetric stormwater control. (Source: Aquafor Beech)

Figure 4.6.2: If your retrofit site includes a pathway from the parking lot to the main entrance, consider a retrofit using permeable pavement. Most permeable pavement meets accessibility standards and reduces the risk of slips and falls by preventing standing water and ice from forming on walking surfaces. (Source: CVC)

LID options for institutional land use

Source area	Permeable pavement	Bioretention	Bioswales	Soakaways	Perforated pipe systems	Rainwater harvesting	Landscape alternatives	Prefabricated modules	Green roofs	Pollution prevention
Roof area	○	○	○	○	○	●	○	○	◎	○
Pedestrian / landscaped / common areas	●	●	◎	◎	◎	○	○	●	○	◎
Parking area	●	◎	◎	◎	◎	○	○	●	○	●

● common option ◎ possible option ○ unlikely

Parking area | Landscaped area | Building area | Pedestrian area | Driveway area | Other

Targeting runoff from this large parking lot should be considered to provide significant stormwater quality and runoff volume benefits. The large green space adjacent to the parking lot presents opportunities for bioretention areas and/or bioswales.

This landscaped area is at the hub of several pedestrian walkways. This area is ideal for promoting LID practices with highly visible plantings and educational signage. The adjacent pathways could be retrofit with permeable pavement to reduce standing water and ice formation.

A rainwater harvesting system could be incorporated into this flat rooftop. Using harvested water can reduce water bills by reducing the volume of potable water used for flushing toilets and irrigating gardens. A green roof is another option for this roof. Windows on the floors overlooking this roof tier could be provided with a garden-like setting to improve the well-being of occupants.

4.9 Other design considerations

After conducting high-level screening for LID retrofit opportunities for your site, an examination of background materials and field reconnaissance will determine site-specific conditions and the feasibility of these options. Consider these factors when deciding between several LID options and how the practice will be incorporated into the site.

Infrastructure replacement planning and forecasting

Site use and exposure to the elements causes your site to weather over time. While regular maintenance does prolong the lifespan of structures like roofs and parking lots, they eventually need to be replaced. In a northern climate like Ontario, the expected lifespan of an asphalt parking lot that has received the appropriate level of maintenance is 15 years before it must be repaved[56]. Roofs that have received an appropriate level of maintenance have an expected lifespan of approximately 30 years before they need to be replaced[57]. Based on these infrastructure replacement timeframes, many of the properties developed in the mid-to-late 1980s are in urgent need of significant capital investment in order to maintain regular business operations.

If your retrofit site is a small or medium enterprise with an owner/operator business structure, infrastructure forecasting is likely a simple process. For these sites, major maintenance is often a reactionary process that is not forecasted. For these businesses the capital cost associated with a significant LID retrofit may be a major deterrent if it is greater than the capital cost of conventional maintenance or a required rehabilitation project. The benefit of a site owned by the business operator is that a long-term payback period is more acceptable as there is less uncertainty with respect to long-term site use and occupation.

If your retrofit site is owned by a property management company, major maintenance projects such as roof rehabilitation and parking lot paving are typically forecast well in advance. As such funds may be set aside prior to the project planning phases with some budget flexibility. For these sites, long-term forecast budgets may be available for you to asses when evaluating retrofit options. These budget forecasts provide opportunity for you to compare the capital and life-cycle costs and benefits of the conventional construction project to that of a LID retrofit. A barrier associated with these sites is that the property lease may expire before a return on invest is demonstrated. In these cases the uncertainties associated with future property demands and buy-in from future tenants may prevent implementation even if an analysis shows favourable results. Land management companies should consult with clients and potential clients to determine if the market forces associated with their businesses align with implementing LID stormwater management onsite. The impact of LID on tenant retention, customer satisfaction, and real estate value is discussed in Chapter 1 of this guide. This is another factor that should be considered when determining if LID practices are right for a leased site.

Site users

Who are the users and how will they use the site? A benefit of a retrofit or redevelopment over new construction is the potential to see how users currently use the site. LID retrofits should be designed not to interfere with site function and if possible to enhance the experience of site users. The interests of site users will vary dramatically from site to site. Groups to consider on residential properties (e.g. families, children, maintenance staff) will differ significantly from commercial properties (e.g. delivery people, staff, customers).

Figure 4.9.1: Further consideration of user behaviour may have resulted in a different LID solution for this location. This section of sidewalk is a preferred smoking location for the adjacent business and the cigarette butt waste stuck between the permeable pavers will be an ongoing maintenance problem. (Source: CVC)

Surrounding land uses

Surrounding land uses may affect the function of LID practices on your site. For example, if material from an adjacent site has a tendency to blow onto your parking lot, permeable pavement may not be a good alternative.

Project support

Success is more likely visible or high-maintenance practices where site users, owners, or residents are likely to support initiatives and become engaged in the project.

Mature vegetation

Mature trees are a valuable amenity, providing stormwater benefits and aesthetic appeal. However, they can also be a constraint, particularly in municipalities with tree protection by-laws. Large trees may necessitate a tree inventory and preservation plan.

Underground and overhead utilities

Utility conflicts may eliminate certain LID options; however, there are workarounds (see Chapter 9).

Existing maintenance protocols and equipment

Some LID practices will more easily fit into existing maintenance programs; others may require training and equipment purchases. Hiring experienced contractors is another option to ensure LID practices are properly maintained.

Accommodation of surface elements

Surface features such as light standards, transit shelters, and fire hydrants must be accommodated. Avoiding these features can sometimes be easier than trying to move the utility. Also consider the structural support of these features. For example, a light standard near bioretention may require a deeper base.

Existing aesthetic character of the site

Properties and neighborhoods with established gardens, mature trees, and professionally landscaped frontages may be more receptive to a higher landscape aesthetic of vegetated LID practices like bioretention or bioswales.

Figure 4.9.2: If these parking islands were to be retrofitted with bioretention, these light standards would need to be accommodated. (Source: Aquafor Beech)

To reduce design and construction costs, O&M, and inspection requirements, consider using lower maintenance plantings like perennial grasses or substitute perennials for grass.

Snow removal and winter operations

Remember that some LID options will require modified winter maintenance programs. Before retrofitting your site, consider how existing de-icing, snow removal, and snow storage operations are performed. Vegetated practices taking road or sidewalk runoff will need to be designed with salt-tolerant plants.

Figure 4.9.3: This curb cut had to be cleared to allow water to flow into the practice. (Source: CVC)

Shipping and receiving requirements

Shipping and receiving areas are common on many industrial and commercial sites. Shipping and receiving practices should be assessed prior to the retrofit to ensure practices do not create barriers to existing and planned operations.

Emergency vehicle access

Municipal fire codes require minimum access road width and turning radius to allow for fire trucks to access a site safely during emergencies.

Spill containment plans

Industrial sites in Ontario are subject to Spill Prevention and Contingency Plans per O.Reg. 224/07. Pollution prevention practices identified in Chapter 2 should be key components of prevention and contingency.

Impacts to local drinking water wells

Where they are available, consult source protection plans developed for public drinking water wells prior to the implementation of infiltration practices. Contact your local conservation authority for more information on these plans.

Traffic safety issues

Examine site traffic complaints (speeding, visibility, etc.) or collision reports kept for your property. Consider how a well-placed LID practice can be used to calm or direct traffic through parking lots and internal roadways.

Parking availability and access

Consider permeable pavement for locations where parking must be preserved. Impervious parking areas can be replaced with green LID features including bioretention areas or naturalization where parking is underused. Consult municipal parking lot requirements for your property before reducing parking area.

Additional benefit opportunities

Other site-specific opportunities can include park improvements, trail connections, drainage improvements, pedestrian safety improvements, tree and planter health improvements, and educational signage potential.

Existing municipal policies and by-laws

The existing policies and by-laws review is not a project barrier; it provides important points of discussion for the retrofit project team. Typical municipal codes, standards and by-laws may include:

Noxious weed by-laws

These by-laws can exclude native species and limit plant selection. Redefinition and reevaluation of plants within these lists may be warranted.

Property standards by-laws

These by-laws can prevent implementation of LID practices, such as permeable pavements (gravel or turf stone driveways) or bioretention or bioswales that incorporate temporary surface ponding.

Standing water by-laws

These by-laws can prevent implementation of LID practices that incorporate temporary surface storage. The definition (or redefinition) of standing water to allow for up to 48 hours of ponded water within LID practices may be warranted.

Parking by-laws

These by-laws will specify the number of and type of parking stalls required based on site characteristics. In some municipalities the number of parking spaces is based on the building area. For many sites, especially warehouses and other industrial properties, basing parking requirements on building area as opposed to occupation, results in parking spaces that are too large for even peak demand periods.

Municipalities should consider a review of such policies to reduce impervious surfaces in highly urbanized industrially zoned lands.

4.10 Financials: Capital cost, ROI, and ongoing benefits

After the screening procedures outlined in Sections 4.2 through 4.8, the next step in the selection process is a high-level financial screening of the remaining LID practices. This step determines if savings can be realized by choosing one option over another.

Capital cost

When comparing the capital cost associated with LID practices to conventional site rehabilitation projects like repaving a parking lot, it is important to consider the additional stormwater quantity control and associated property protection associated with the project. Implementing only a proprietary stormwater treatment device will treat the stormwater but will not typically help to manage the volume of runoff being generated on the site.

An example of the retrofit options for a typical office parking lot located in the GTHA is provided in Table 4.10.1. In this example, a 3,000 m^2 parking lot is in need of replacement.

A conventional asphalt installation would cost approximately $68,000. This estimate is based on pavement surface area and estimated curb length and includes design, materials, and construction.

Adding a proprietary stormwater treatment device (such as an oil and grit separator) to the design to meet water quality requirements for a contributing drainage area of 1 hectare would increase the capital cost by $100,000 including installation, but would not provide water balance or quantity control. The capital cost, including design, materials, and construction of a permeable paver parking lot has a cost of $180,000. Upon initial consideration the conventional asphalt appears to be the financially sound decision. When life-cycle and potential stormwater incentives are considered, however, alternative options may provide a financial benefit.

Stormwater utilities

If stormwater utility incentives are available where your retrofit site is located, find out which LID practices, if any, qualify for the rebate and the ongoing rebate value.

In our example, a rebate of $300 per month is available for the permeable pavement system as a result of meeting all criteria (water quality, water quantity, and education), but only $100 for the proprietary stormwater treatment device as a result of meeting only the water quality criteria. Analyze this ongoing savings over the life cycle of the site.

Table 4.10.1 shows the financial screening comparison of the conventional asphalt system, conventional asphalt system with proprietary stormwater treatment device and the permeable pavement system. Based on previous paving cycles, it is known that repaving is required every 10 years. The permeable interlocking concrete pavers were assumed to have a life cycle of 20 years before replacement is necessary.

Table 4.10.1: Financial screening

Option	Capital cost	Life cycle (years)	SWM incentive (per month)	Life-cycle incentive ($)	Water quality	Water quantity	Water balance
Asphalt	$68,000	10	0	N/A	No	No	No
Asphalt and proprietary stormwater treatment device	$168,000	10	$100	12,000	Yes	No	No
Permeable pavers	$180,000	20	$300	7,200	Yes	Yes	Yes

*Payback period is compared to conventional asphalt

Using the same values from our parking lot example and comparing the costs and savings associated with 40 years of repaving cycles, the true value of the permeable pavement option is realized. For our comparison, it is assumed that the capital costs and stormwater management incentives will remain constant. It is also assumed that the site will be decommissioned after 40 years of use.

In Table 4.10.2, permeable pavement has a saving of $56,000 over a conventional asphalt system in addition to providing water quality, water quality, and water balance benefits. This type of comparison is meant to be high level to help screen options. Conduct a more detailed life-cycle costing analysis that incorporates operations and maintenance costs expected for your site.

Installing LID practices on your property can save operation and maintenance costs over its life cycle. LID options like landscape alternatives, perforated pipes, and soakaways require very little annual maintenance. Replacing existing hard infrastructure with these options can significantly reduce your site operations and maintenance budget. When compared to existing landscape amenities, bioswales and bioretention areas can also present maintenance cost savings, especially when native plantings are used. These plantings tend to be well adapted to the climate conditions and require little upkeep. Existing operations and maintenance costs should be compared to expected costs after the retrofit. Operations and maintenance costs are provided in Chapter 10.

Table 4.10.2: Long-term financial screening

Option	Capital cost	Rehabilitation costs through 40 years	Stormwater management incentive ($/month)	Stormwater management incentive through 40 years	40-year cost minus savings
Asphalt	$68,000	$204,000	$0	$0	$272,000
Asphalt and proprietary treatment device	$168,000	$204,000*	$100	$48,000	$324,000
Permeable pavers	$180,000	$180,000	$300	$144,000	$216,000

*Assumes proprietary treatment device remains viable over a 40-year period

5.0 Pre-design

Based on site screening, your project team has now selected a preferred LID retrofit option. It is now time to assess the technical feasibility of this design based on site investigations and testing. This phase of the project is known as pre-design. The pre-design phase builds on the information gathered during the reconnaissance and background review phase. It involves the collection of field measurements. Pre-design tasks are intended to further quantify the physical characteristics of each LID retrofit site. This assists in identifying potential design constraints and opportunities for consideration during the detailed design phase.

The following steps provide the types and sequence of activities that are part of the pre-design process. Further details of each activity are provided in subsequent sections.

Information is essential to creating a detailed design. Pre-design activities should be coordinated by an LID design professional to ensure sufficient information is gathered.

Step 1: Utility locates
Always conduct utility locates prior to geotechnical investigations and infiltration testing. Locates are generally obtained by companies scheduled to complete the geotechnical investigations.

Step 2: Geotechnical investigations
Review the valuable information from geotechnical investigations prior to conducting infiltration testing.

Step 3: In-situ infiltration testing
In-situ infiltration testing helps characterize the hydraulic properties of the site's existing native material.

Step 4: Tree inventories
Conduct these inventories at any time during the pre-design process.

Step 5: Topographic survey
Include trees, locate markings, borehole and infiltration testing locations in surveys along with municipal infrastructure and topographic features.

5.1 Utility locates

Avoid buried utilities like sewers, gas lines, and communications cables when possible. Remember that the engineering plans uncovered during the background analysis phase may be incorrect or not indicative of current as-built conditions. Utility locates are undertaken prior to geotechnical investigations and related drilling activities. The company hired to complete the geotechnical investigation obtains these locates by contacting the Ontario One-Call service.

Call before you dig or drill!

Ontario One Call can be reached 24/7 at 1-800-400-2255.

5.2 Geotechnical investigation

Geotechnical investigations are necessary for most LID practices with the exceptions of green roofs, rainwater harvesting, pollution prevention, and landscape alternatives. The scope of work required varies depending on the practice selected during the screening level process. Table 5.2.1 provides a summary of the necessary geotechnical investigation activities for the detailed design of LID practices.

Activities for implementing LID practices at a site

Boreholes

Boreholes are typically specified to extend a minimum of three metres or to bit refusal. It is recommended that boreholes be advanced a minimum of 1.5 m below the proposed invert of proposed LID practices. The resolution of the investigation (i.e. quantity and spacing between boreholes) will vary from site to site. A detailed design requires sufficient information from borehole investigations, including:

- Soil horizon
- Soil texture and colour
- Soil colour patterns
- Depth of water table (if encountered)
- Depth of bedrock (if encountered)
- Observations of pores or roots
- Estimated type and percent of coarse fragments
- Hardpan or other limiting layers
- Strike and dip of soil horizons

Soil samples should be taken at various levels. Analysis of soil samples will provide details on soil characteristics, which will help tailor designs to site conditions. Better detail at this stage can introduce cost efficiencies. For example, it may be possible to use native soils instead of imported soils if they meet the design requirements of the LID feature.

Table 5.2.1: Geotechnical investigation activities required for implementing LID practices

Option	Geotechnical investigation activities			
	Boreholes	Piezometers	Laboratory soil testing	Soaked CBR test
Permeable pavement	●	●	●	●
Bioretention	●	●	●	
Bioswales	●	●	●	
Soakaways	●	●	●	
Infiltration chambers	●	●	●	
Perforated pipe systems	●	●	●	
Rainwater harvesting (subsurface storage)	●			
Naturalization			●	●
Prefabricated modules	●		●	

Figure 5.2.1: A drill rig being used for a geotechnical investigation. On a busy site, consider how the public will interact with drilling activity. (Source: Aquafor Beech)

Piezometer/monitoring wells

Monitoring wells determine the pre- and post-construction seasonal high water table and groundwater flow direction. They consist of 50 mm diameter piezometers installed to depths of 3.65-4.5 meters and encased in a lockable, above ground steel housing. Monitoring wells may be implemented when data from background documentation or previous investigations is not available. The Low Impact Development Stormwater Management Planning and Design Guide includes design criteria regarding the groundwater clearance requirements for LID practices.

Geotechnical laboratory soil testing

Soil samples are collected as part of geotechnical investigations. These samples characterize soil properties including natural moisture content, plasticity characteristics, particle size distribution, and analytical results for contaminates. Geotechnical investigations should include recommendations regarding soil disposal alternatives.

Common misconceptions about geotechnical investigations:

- *They do not include in-situ infiltration testing.*
- *In-situ testing is a separate activity with different equipment, procedures, and requirements.*
- *They are not sufficient for LID design.*

Soaked California bearing ratio (CBR)

Soaked CBR is required only for the design of permeable pavement. Geotechnical investigations must include recommendation for base and sub-base requirements and other measures required to ensure adequate structural strength such as compaction or geosynthetic requirements. Find detailed design requirements for permeable pavement in the Low Impact Development Stormwater Management Planning and Design Guide.

In-situ infiltration testing

In-situ infiltration testing helps characterize the hydraulic properties of the site's existing native material. Sharing utility locate information with the geotechnical company can help to create savings within the project budget. Utility locates do expire, so conducting infiltration testing in parallel with the geotechnical investigation is suggested. Otherwise, utility locates may have to be updated at additional costs.

Locates generally expire in 90 days, so be sure to coordinate infiltration testing soon after geotechnical work is completed.

The Guelph Permeameter test can determine the in-situ saturated hydraulic conductivity and the design infiltration rate per the LID Stormwater Planning and Design Guide, (Appendix C). Testing should be performed within the approximate location and invert of proposed LID practices.

Need more guidance on soil and infiltration testing? Refer to Appendix C of the LID Stormwater Management Planning and Design Guide at bealeader.ca

Figures 5.2.1: Fast-draining soils full of gravel and cobble will use a lot of water during testing and augering such material is difficult. Be well equipped with shovels, a sufficient water supply, and other equipment when testing. When testing clay materials, a comfortable chair is recommended. (Source: Aquafor Beech)

5.3 Tree inventories

A tree inventory determines the significant trees which should be preserved and accommodated within the design or deemed eligible for removal. A certified arbourist or botanist should conduct the tree inventory assessment. A comprehensive tree assessment will include the following:

- Tree health
- Crown reserves
- Diameter at breast height (DBH) (minimum of 10 cm DBH for preservation)
- Record GPS coordinates or note approximate tree locations on available mapping.

Most municipalities have tree by-laws and policies which detail assessment, preservation, and compensation criteria. Consult local tree by-laws prior to conducting tree inventories. If no by-laws are available, work with a local municipality representative to determine tree inventory criteria. In the absence of municipal by-laws, consider this criteria:

- Preserve trees with 10 cm or greater DBH
- Compensate for removed trees with a DBH of 10cm or greater at a rate of 3 to1.

Figure 5.3.1: Unlike new development, tree inventories for site retrofits will not be overly time-consuming. (Source: Aquafor Beech)

5.4 Topographic survey

A topographic survey of the site is necessary to produce base mapping for the detailed design phase. Total station survey or GPS equipment are typically used to conduct topographic surveys (Figure 5.4.1). Surveys should include these site features:

- Topography of the proposed site
- Identification of above ground and below ground services
- Utility locate markings
- Inverts and sizes for existing sewers, catch basins, manholes, etc.
- Location and description of on-site structures
- Available legal monuments
- Borehole locations (Figure 5.4.2)
- Infiltration testing locations
- Significant vegetation (coordinated with tree inventory assessment)
- Existing parkland features
- Fence lines and existing landscaping
- Local benchmarks

Municipalities generally have GIS or AutoCAD layers of existing utilities, land parcels and property lines for study areas of interest. Such information may be requested from the municipality, specifically from the engineering or capital works departments, and integrated with the survey information to create base mapping for the detailed design. Surveying utility locate markings is recommended.

You may need to establish local benchmarks to provide the horizontal and vertical controls required by the contractor during construction. Survey temporary nails or markings etched into existing structures like curbs or headwalls to determine local benchmarks.

Figure 5.4.1: Topographic surveys ensure catchment areas are properly defined. Sites with flat catchment areas require high-precision equipment with GPS capability. (Source: Aquafor Beech)

Figures 5.4.2: A neon mark indicates a borehole location. Consider how this borehole location will impact day-to-day operations on your site. (Source: Aquafor Beech)

5.5 Detailed pollution prevention evaluation

The pre-design phase of a retrofit project is also a good time to better assess the opportunities for pollution prevention on your site. This assessment should include a thorough analysis of materials shipped and stored on your site. Conduct interviews with operations staff to form a comprehensive understanding of procedures that could reduce pollution.

After the topographical survey is complete, a detailed drainage assessment of your existing site will help identify where pollution hot spots are draining. On sites that do not have existing drainage plans, you may require scoping, dye testing, or partial excavation of pipe networks to fully understand predevelopment drainage patterns.

6.0 Detailed Design

The detailed design process of LID practices involves a multi-step approach. The information from the pre-design and background review processes guides the development of the detailed design. The final product typically consists of design drawings and briefs that the contractor uses during construction. The process includes:

Step 1: Review design guidelines and requirements

Consider municipal, regional, and agency design guidelines and criteria.

Step 2: Catchment area development

Develop base mapping and delineate drainage areas to proposed LID features.

Step 3: Hydrologic and hydraulic assessments

Quantify site hydrology including runoff volumes using standard hydrologic/hydraulic method and models.

Step 4: Design optimization

Evaluate other design considerations that may enhance the primary design objective. Creative thinking and simple solutions to design problems often save costs and reduce construction efforts.

Step 5: Design drawing and brief development

Develop the detailed design drawings and brief for contractors to use during construction.

6.1 Review design guidelines and requirements

Review and consider municipal, regional, and agency design guidelines and criteria during the detailed design of LID practices. These documents provide design criteria and targets for LID practices with regards to water quality and quantity and erosion control.

The CVC LID Stormwater Planning and Design Guide provides specification, sizing criteria, design examples, typical details, and requirements for the majority of LID practices discussed in this guide. Other reference documents include:

- Ontario Ministry of the Environment Stormwater Planning and Design Manual (2003)
- CVC Low Impact Development Construction Guide (2012)
- CVC Landscape Design Guide for Low Impact Development (2010)
- Local municipal standards for stormwater management and development criteria
- Agency standards for stormwater management (i.e. governing conservation authority)
- Ontario Building Code (2012) – for green roof and rainwater harvesting designs

6.2 Catchment area development

The catchment area of an LID practice includes all areas that drain into the practice. For example, the catchment area of a rainwater harvesting system is the roof area draining to the leaders that are directed to the cistern. Catchment areas for your site may include parking lots, pedestrian areas, landscaped areas, and roofs.

Roof catchments

The delineation of catchment areas is a simple process for LID practices that accept runoff exclusively from roof areas. If you are implementing a rainwater harvesting system, green roof, or infiltration practice that accepts only roof runoff, engineering reports required during construction or expansion of the facility may be the best place to look for catchment area development information. Confirm this information by examining roof leader connections and flow testing where feasible.

Figure 6.2.1: This figure from a stormwater management report identifies two large catchments and four roof leaders on this site. (Source: Aquafor Beech).

Figure 6.2.2: Here roof drainage is discharged onto the ground surface surrounding a building. This information can be found on mechanical plans. (Source: Aquafor Beech)

Figure 6.2.3: A view of a roof leader from inside a warehouse. Check for leader locations in mechanical drawings and stormwater reports. (Source: Aquafor Beech)

Surface catchments

You will need to develop base mapping for LID practices that accept drainage from surface features such as parking lots, pedestrian areas, and landscape areas. Base mapping defines catchment areas. Using topographic survey data and background information provides the foundation for developing detailed design drawings with delineated catchments. Base mapping should include:

- Municipal mapping layers (utility, property line, land parcel, watercourse, infrastructure, etc.)
- Survey points including symbols/descriptions of features
- Locates information
- Borehole and infiltration testing locations
- Structures and utilities
- Contours
- Aerial photos

Most LID retrofits will require modifying site drainage to allow targeted catchment areas to drain to proposed LID practices. For example, when establishing a bioswale along the perimeter of a parking area, water that was once directed internally to catch basins must be redirected to the perimeter of the parking lot.

The retrofit of conventional stormwater systems with LID practices often alters existing flow patterns and drainage areas. As such, drainage areas and flow patterns must be updated to determine post retrofit runoff volumes.

Existing and proposed drainage areas and overland flow patterns must be illustrated on base maps. During detailed design, these drainage areas will be used for hydraulic and hydrologic assessments to determine the pre- and post-retrofit runoff volumes from the respective drainage areas.

Figures 6.2.4 and 6.2.5 demonstrate the delineation of the existing and proposed drainage networks and flow patterns developed during the detailed design of the IMAX Project.

Figure 6.2.4: This pre-retrofit drainage area figure at the IMAX Project site identifies curbs, catch basins, and flow paths. Refer to the IMAX case study in Appendix A for further details. (Source: Aquafor Beech)

Figure 6.2.5: This proposed drainage area figure illustrates flow patterns and LID practices implemented at the IMAX Project site. Refer to the IMAX case study in Appendix A for further details. (Source: Aquafor Beech)

6.3 Hydrologic and hydraulic assessments

As site surfaces change and runoff retention practices are added, the quantity of runoff during rainfall events decreases. This reduces the flows discharged to downstream municipal storm sewers. When there have been significant alterations to the hydrologic characteristics of site drainage areas, it is recommended that a hydrologic and then hydraulic assessment of proposed LID drainage networks be performed.

To properly assess the hydrologic performance of a retrofit site, you must use the physical characteristics of the land surface and appropriate rainfall intensities to predict expected runoff volumes and losses to other hydrologic processes. Most municipalities have design standards for drainage and stormwater works which detail Intensity-Duration-Frequency curves for 1-in-2 year through 1-in-100-year design storms. Municipal standards usually specify the minor system sizing requirements for storm pipes and swales. Using applicable design storms, runoff coefficients, and contributing drainage areas will provide estimations of the runoff flows and volumes expected for relative drainage areas.

During the hydraulic assessment, use the hydrologic assessment results and applicable design standards to size underdrains, inlets, and overflows and ensure there is sufficient capacity to convey the runoff peak flow rates produced from the applicable design storms.

Depending on municipal and agency submission requirements, you may use desktop analysis or a more sophisticated computer-based modeling approach to model the hydrologic and hydraulic characteristics of a given LID design.

6.4 Design considerations

The design of LID practices does not end with sizing. Retrofitting individual LID practices within a retrofit site requires designers to be cognizant of other design objectives. Some design obstacles include integrating LID practices with existing landscapes, creating opportunities for LID implementation when none exist, addressing constraints, and fulfilling other design objectives.

In addition to the detailed design guidance provided by the LID Stormwater Planning and Design Guide, Table 6.4.1 provides an overview of common detail elements to consider when retrofitting LID practices on your property. The table provides the design considerations and relevant sections to reference when designing an LID practice. Subsequent sections elaborate on the design considerations and detail how they influence the design of LID practices.

Curb type

Curbs are generally used to separate LID practices and landscape areas from surface catchments such as parking, driveway, and pedestrian areas. Depending on the LID practice, different types of curb have unique benefits and drawbacks

Table 6.4.1: LID practice detailed design considerations

LID Practice	Curb type	Inlet type	Overflow type	Parking stall layout	Sub-base requirements	Pretreatments	Infrastructure and utilities	Snow storage	Manufacturer specifications	Plant material	Structural assessment
Permeable pavement	●		●	●	●		●	●			
Bioretention	●	●	●	●		●	●	●		●	
Bioswales	●	●	●	●		●	●	●		●	
Soakaways	●	●	●	●		●	●	●			
Infiltration chambers	●	●	●	●		●	●	●			
Perforated pipe systems	●	●	●	●		●	●	●			
Rainwater harvesting							●		●		●
Landscape alternatives										●	
Prefabricated modules				●			●		●	●	
Green roofs									●	●	●
Pollution prevention						●		●	●		

(see Table 6.4.2). OPS standards of the presented curb types are available on the Ministry of Transportation website.

Inlet type

Inlet types are generally as simple as letting runoff sheet flow into LID practices or collect and enter at a designated inlet structures such as a curb cuts. Table 6.4.2 demonstrates the benefits and drawbacks of each inlet type and its design options.

The following illustrations and photos detail the most common ways that runoff enters surface LID practices and provide key considerations for the design process.

Figure 6.4.1: This notched curb cut at the City of Calgary's City Hall provides flow to a bioretention area from a parking area. More notches may be required to match the inlet capacity of a curb cut. (Source: Aquafor Beech)

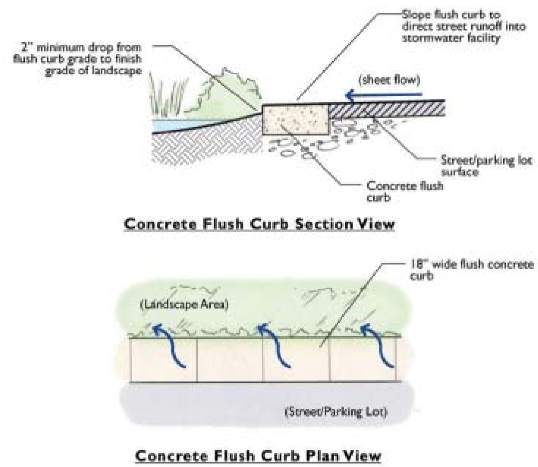


Figure 6.4.2: A flush curb is a simple way to promote sheet flow into a bioretention or bioswale area. (Source: San Mateo County Sustainable Green Streets and Parking Lots Guidebook)

Curb cut design considerations:

- *Curb cuts should be as wide as possible to accept flow and be spaced frequently to distribute the water flow evenly.*
- *Covered or notched curb cuts may require more maintenance, but they protect curbs during snow removal operations.*
- *On steeper parking lots, guide flow by building a small, low-profile asphalt or concrete berm at each curb cut inlet. Otherwise, runoff may bypass LID practices during intense storm events.*

Table 6.4.2: Benefits and drawbacks of curb types

Curb Type	Benefits	Drawbacks
No curb	• Better during snow removal operations as no curb damage is suffered • No overflow structure required for parking areas. Excess flows sheet flow overland to adjacent areas • Even flow distribution – less erosion and minimal energy dissipation required • Vehicles overhang curb reducing required parking area	• Plastic edge restraints required for permeable pavement. Generally leads to the degradation of pavement boundaries • Damage to vegetated areas likely in areas with high traffic volumes • No gutter function, if required
Band curb	• Curb damage is minimal during snow removal operations • No overflow structure required for parking areas. Excess flows sheet flow overland to adjacent areas • Provides structural support for pavement • Even flow distribution • Vehicles overhang vegetated area reducing required parking area	• Damage to vegetated areas likely in areas with high traffic volumes • No gutter function, if required
Mountable curb	• Minor barrier for parking vehicles • Gutter function, if required • Parking area overflow or inlets to LID practices may be simple such as low profile curb cuts • Provides structural support for pavement boundaries • Vehicles overhang curb reducing required parking area	• Curb damage more than band curbs during snow removal operations • Overflow from parking areas via sheet flow not possible • Concentration of flows and volumes at overflow/inlet locations – susceptible to erosion
Semi mountable curb	• Barrier for parking vehicles • Gutter function, if required • Parking area overflow or inlets to LID practices may be simple such as low profile curb cuts • Provides structural support for pavement boundaries	• Significant damage can occur during snow removal operations • Overflow from parking areas via sheet flow not possible • Concentration of flows and volumes at overflow/inlet locations – susceptible to clogging and erosion • Reducing required parking area by allowing vehicles to overhang not possible
Barrier curb	• Barrier for parking vehicles • Gutter function, if required • Parking area overflow or inlets to LID practices may be full curb cuts • Provides structural support for pavement boundaries	• Significant damage can occur during snow removal operations • Overflow from parking areas via sheet flow not possible • Concentration of flows and volumes at overflow/inlet locations – susceptible to clogging and erosion • Reducing required parking area by allowing vehicles to overhang curb not possible

Table 6.4.3: LID inlet type and associated benefits and drawbacks

Curb Type	Benefits	Drawbacks	Options
Sheet flow inlet	• Even flow distribution • Minimal risk of clogging • No energy dissipation measure required • Less maintenance	• Damage to vegetated areas likely in areas with high traffic volumes	• Concrete band edging • No curb • Sidewalk
Curb cut inlet	• Barrier for vehicular traffic • Better for pavement surfaces with higher traffic volumes • Better for slowing traffic • Prevents parked vehicles from encroaching on boulevard or median space • Barrier cheapest curb type	• Concentration of runoff flows • Sediment build up • Energy dissipation recommended to reduce erosion • More maintenance required	• Mountable • Barrier • Semi-mountable
Inlet structures	• Allow for a continuous curb line • May have an easily maintainable pretreatment sump	• Higher cost option • May require an elevation drop or subject to grading issues • Inlet may require more frequent maintenance	• Catch basins • Trench drain

Sheet Flow Design Considerations

- *Concrete flush curbs allow stormwater to flow evenly into LID practices*
- *Energy dissipation methods like pea gravel or round stone reduce erosion.*

Figure 6.4.3: Flush curbs on both sides of this street allow for drainage from left to the bioswale on the right. (Source: City of Vancouver)

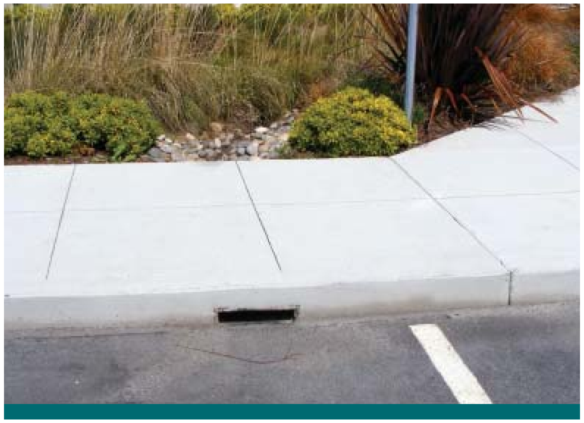


Figure 6.4.4: The covered curb inlet is a common feature of conventional and LID designs. (Source: Aquafor Beech)

Figure 6.4.5: A standard curb cut is a simple yet effective means of providing drainage and protection. (Source: Aquafor Beech)

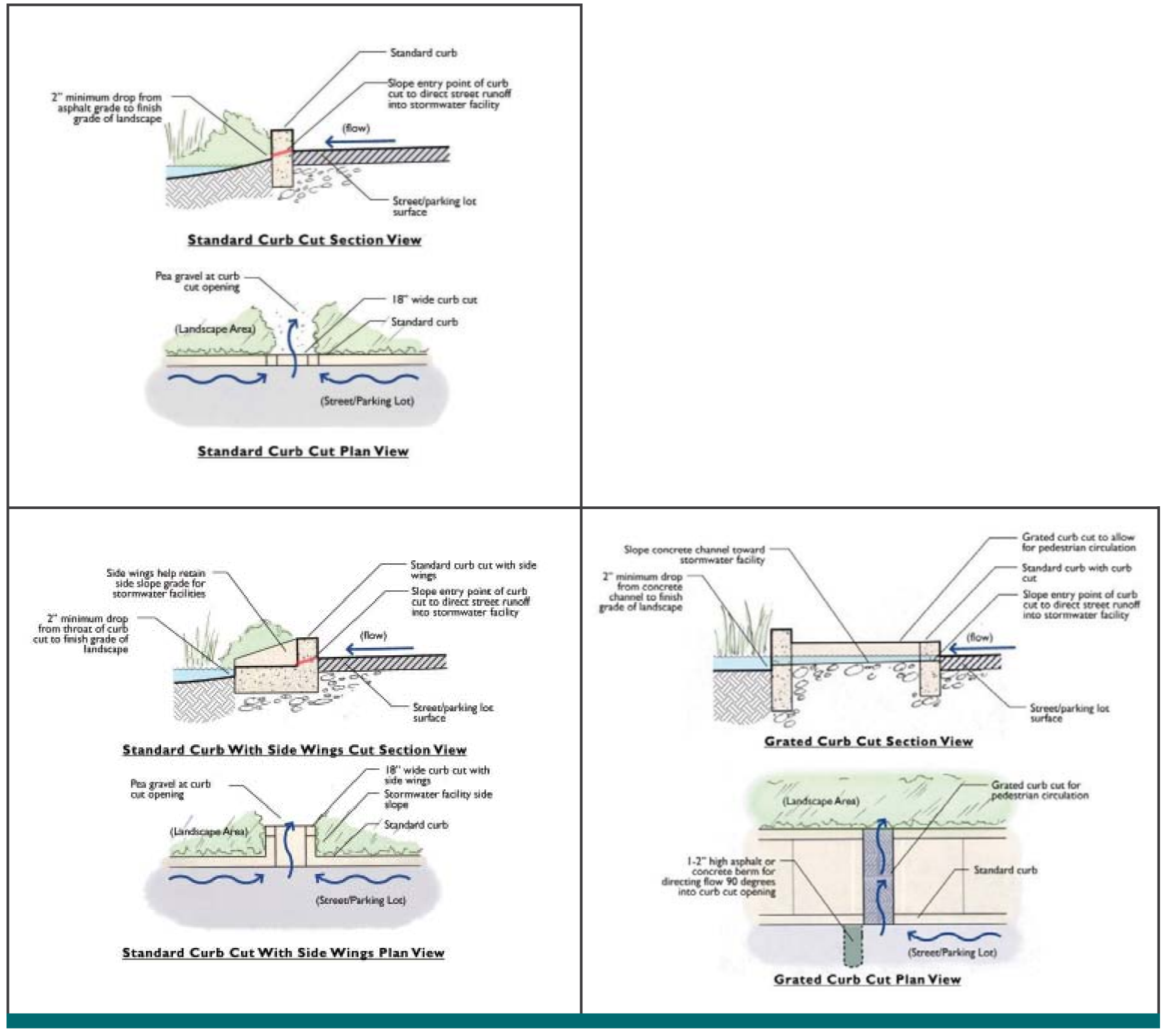


Figure 6.4.6: These figures illustrate curb cut options. Wing walls and grates can be added to conventional curb cuts to meet design objectives. (Source: San Mateo County Sustainable Green Streets and Parking Lots Guidebook, 2009)

Figure 6.4.7: Grated strip drains ensure onsite control at parking lot entrances. (Source: Aquafor Beech)

Figure 6.4.8: This grated curb cut is textured to prevent pedestrian slips. Grates should also be corrosion resistant. (Source: Aquafor Beech)

Figure 6.4.10: A cover on a curb cut can provide a barrier that prevents damage from snow removal operations. (Source: Aquafor Beech)

Figure 6.4.9: A gate has been added to this grated curb cut design to allow the facility to be closed during the winter. (Source: Aquafor Beech)

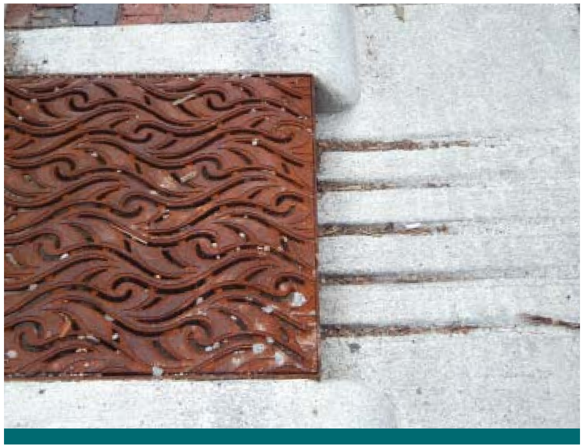


Figure 6.4.11: Inlets with grooves etched into the gutter and concrete apron help slow and direct runoff into LID practices. (Source: Aquafor Beech)

Overflows

Overflows from LID practices can be managed in several ways. For example, overflow volumes can be allowed to exit through a curb cut where they can eventually be captured by a downstream storm drain or overflow directly to a proposed underdrain or existing storm sewer. Table 6.4.4 lists the benefits and drawbacks of several LID overflow options. These overflow types are available from manufacturers in a variety of sizes, shapes, and materials. When deciding between plastic and metal overflows, remember that while plastic products are less expensive, they do not offer the same robustness or resistance to weathering. Metal overflows are also less likely to be damaged by vandalism.

Figure 6.4.12: This metal atrium/dome overflow system is less susceptible to clogging than a flat grate. (Source: Aquafor Beech)

Figure 6.4.14: A plastic flat top overflow is cost-effective but susceptible to damage. (Source: Aquafor Beech)

Figure 6.4.13: A grated ditch inlet catch basin can be used at the downstream extent of a bioswale. (Source: Aquafor Beech)

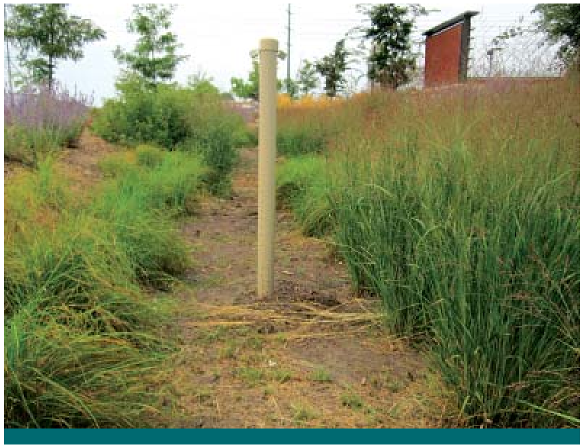


Figure 6.4.15: A plastic perforated standpipe is a simple, cost-effective, and low-maintenance overflow method. Starting the perforations at the desired elevation may meet surface storage requirements. (Source: Aquafor Beech)

Table 6.4.4: Overflow types and their benefits and drawbacks

Overflow type	Discharge point	Applicability	Benefits	Drawbacks
Atrium grate	Underdrain or storm sewer	• Bioswales • Bioretention	• Less clogging • Self-cleaning as water levels recedes • Higher aesthetics	• More expensive compared to flat grates
Flat grate	Underdrain or storm sewer	• Bioswales • Bioretention • Permeable pavement	• Less expensive compared to atrium grates • Less visible	• Susceptible to clogging
Catch basins	Underdrain or storm sewer	• Bioswales • Bioretention • Permeable pavement • Perforated pipes • Soakaways	• Anti-vandalism • Robust and resistant to weathering especially if coated • Less visible • Pre-treatment sump	• Expensive • Susceptible to clogging
Ditch inlet catch basins	Underdrain or storm sewer	• Bioswales • Bioretention • Permeable pavement • Perforated pipes • Soakaways	• Anti-vandalism • Robust and resistant to weathering especially if coated • Pre-treatment sump	• Expensive • Low aesthetics
Perched pipe	Storm sewer	• Soakaways • Perforated pipes	• Low costs • Easy installation • Buried with infrastructure	• Applicable to infiltration trenches and soakaways
Curb cut	Overland to downstream outlet point	• Bioswales • Bioretention • Permeable pavement • Perforated pipes • Soakaways	• Anti-vandalism • Self-cleaning • Low cost • Easy construction	• Only possible if curb and available surface outlet is available
Swale	Overland to downstream outlet point	• Bioswales • Bioretention • Permeable pavement • Perforated pipes • Soakaways	• Low costs • Low maintenance	• Periodic periods of standing water
Perforated stand pipe	Underdrain or storm sewer	• Bioswales • Bioretention • Perforated pipes • Soakaways	• Low cost • Low maintenance • Easy installation	• Low aesthetics • Easily vandalized

Table 6.4.5: Benefits and drawbacks of parking lot layouts for LID implementation

Parking angles	Benefits	Drawbacks	Impact to bioretention/bioswale installation if area is limited
45°	• Better for situations where lots size restricts dimensions available for aisles and stalls • Permits narrower aisles • Only acceptable angle for a herringbone parking pattern	• Reduces the total number of parking spaces the most	• Significantly increase available areas for medians and bull nose by reducing aisle width and stall length. • Suitable for implementing bioretention or bioswales within medians between stalls situated face-to-face
60°	• Most common angle due to the ease of operation it provided • Permits reasonable traffic lane widths • Easy entry and exit	• Reduces the total number of parking spaces the more than 90° parking	• Increase available areas for medians and bull nose by reducing aisle width and stall length
90°	• Provides the greatest amount of parking stalls	• The high degree of difficulty for entering and leaving these parking stalls makes this type of parking more suited to all-day parking, such as employee parking	• Not conducive for implementing area between stalls situated face-to-face • Suitable for implementing bioretention or bioswales within medians or bull noses at the end of parking stall rows

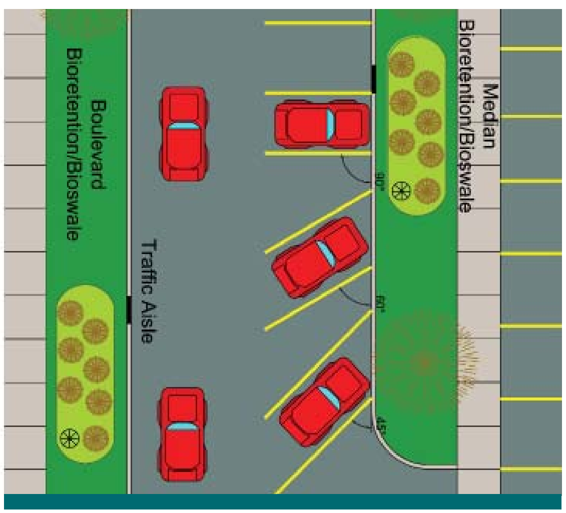


Figure 6.4.16: 90°, 60°, and 45° parking stall configurations. (Source: Aquafor Beech)

Other Layout and Configuration Considerations:

- *Reduce driveway and pedestrian walkway widths to maximize available area LID practices and landscape areas*
- *Separate building, parking, and walkways with landscape area which are functional LID practices*
- *Integrate LID practices within pedestrian and landscape areas.*

Parking stall layout and configuration

On many sites, LID practices are most easily implemented on lands situated along the borders of parking lots or within island structures like medians or bull noses. Medians and bull noses occupy valuable space within parking and pedestrian areas and present excellent opportunities for LID practices since they are generally used as landscaped areas. The existing drainage pattern of your property will dictate whether directing runoff to medians is economically feasible. Too much grading on your site will add significant cost to your project.

Optimizing parking lot configuration and layout for better parking and LID opportunities should be part of the design process.

Parking configurations vary. The most popular angles for parking stalls are 60º, 45º, and 90º. The Asphalt Paving Association of Iowa Parking Lot Design Guidelines evaluates the various parking configurations and their benefits and drawbacks. Table 6.4.5 summarizes these benefits and drawbacks and how they impact LID implementation. Parking stall and aisle dimensions may be reduced to increase the available lot area for LID practice installation.

However, consider the use of the parking lot and the business it is servicing. For "in-and-out" lots like shopping centres, parking stalls and aisles must be large enough to allow vehicles to enter and exit with ease. Smaller parking stalls and aisle are more suitable for all-day parking situations like office buildings and condominiums.

Also consider curb selection to reduce overall parking requirements. Non-barrier and semi-barrier curbs allow vehicles to overhang boulevard and median areas and can effectively reduce the size of parking stalls facing such features (refer to Table 6.4.5).

Figure 6.4.17: Bike racks and tree planters break up a pedestrian walkway at the University of Minnesota. (Source: Aquafor Beech)

Figure 6.4.18: On this site, the road, bike lanes, pedestrian walkway and building are separated by three separate LID practices. (Source: Aquafor Beech)

Sub-base design

In general, the design of permeable pavement cross-sections and associated aggregate depths should include a structural analysis, then a hydrologic analysis. These structural and hydrologic analysis resources can help:

- AASHTO 1993 Guide for Design of Pavement Structure
- The Interlocking Concrete Pavement Institute (ICPI) Design Guide, 4th edition, D.R. Smith (2011)
- LID Stormwater Planning and Design Guide

The structural design method for the structural analysis of permeable pavement design should use the AASHTO flexible pavement design methodology, specifically the empirically based AASHTO 1993 Guide for Design of Pavement Structure in combination with the Interlocking Concrete Pavement Institute (ICPI) Design Guide, 4th edition. The 1993 guide emerged from tests in the 1950s that established relationships among material types, loads, and serviceability using a structural number (SN) given the traffic load (ESALs), soil type, climatic, and moisture conditions. Through this process, the designer finds the appropriate combination of pavement surface and base material to meet or exceed the required SN. Layer coefficients for the various open-graded aggregates commonly used in permeable interlocking concrete pavers (PICP) construction are lower (approximately 30%) than standard dense-graded materials, as such sub-base courses of PICP "will typically need to be thicker to compensate for lower strength and stiffness associated with the less dense grading."

Consult geotechnical engineers during the geotechnical investigation and determination of the structural integrity of native base materials.

PICP structural design for vehicular applications assumes a minimum soil CBR (soaked 96-hour per ASTM D 1883 or AASHTO T 193) of 4%. In southern Ontario it is common to encounter low-bearing silty clay soils that have soaked CBR value typically <4%. To augment low soil stability, consider these design elements:

- Low-bearing soils should always be free draining via the designed underdrain system. Accumulated water within the sub-base should be held for a maximum of period of 24 hours.
- High-strength woven multi-layered geotextiles or other geosynthetics may be incorporated into the design to provide reinforcement strength and sub-base course confinement. When selecting a reinforcing geosynthetic, consider the product's permeability properties. Are high flow rates for infiltration and soil retention capabilities sustained? In general, previous generations of high-strength woven geotextiles sacrifice flow rates to attain the required strength characteristics. Newer models can provide three times the flow rates of other woven geotextiles with similar ultimate strengths.
- Use alternative sub-base aggregate materials.

The hydrologic analysis consists of water quality storage requirement calculations used to size the stone storage bed (reservoir) of the permeable pavers. Sizing equations are demonstrated in the LID Stormwater Planning and Design Guide.

The greater of the two sub-base requirements determined by the structural and hydrologic analyses ultimately determines the permeable pavement cross-sections and associated aggregate depths. In most cases, the depth of aggregate material required for structural stability will exceed the depth necessary for the stormwater storage reservoir.

Sub-base materials can effectively reduce the quantity of granular material required while maintaining structural integrity. For an example of how a geosynthetic grid and Granular "O" material was used to effectively reduce the required sub-base material while maintaining required storage volumes refer to the IMAX case study located in Appendix A.

Pre-treatment

Pre-treatment measures are additional design considerations that will increase the longevity of LID practices. They include:

- Catch basins
- Grassed filter strips
- Stone diaphragms
- Leaf screens
- Downspout filters and hydrodynamic separators
- Prefabricated modules

For further information on maintenance activities associated with LID practices, see Chapter 10. Additional guidance is also provided in the LID Stormwater Planning and Design Guide.

Catch basins

Catch basins are as simple and easy way to provide pre-treatment to subsurface LID practices. These structures provide a cost-effective solution for preventing coarse sediment and leaf litter from entering LID practices.

Figure 6.4.19: Coarse materials like leaf debris will collect in catch basins and obstruct flow. They require monitoring and regular maintenance. (Source: Aquafor Beech)

Grassed filter strips

Grassed filter strips provide a buffer between the runoff surface and LID practice. These buffers act as strainers to capture fine and coarse sediment from overland flow runoff. In areas where there is significant concern about erosion due to high flow velocities, grassed filter strips are not suitable.

Figure 6.4.20: At the Marlowe Street retrofit project in the City of Calgary, grassed filter strips were used as a pre-tretment option between the inlet and bioretention area. (Source: Aquafor Beech)

Stone diaphragms

Stone diaphragms are trenches situated between the runoff surface and LID practice. They capture coarser sediment from overland flow runoff before it can enter LID practices and also slow runoff velocities. Stone diaphragms are suitable where sheet flows are concentrated to LID practice inlets.

Figure 6.4.21: A stone diaphragm was used at a bioretention area in the Town of Oakville. (Source: Aquafor Beech)

Leaf screens

Leaf screens are installed along downspouts of eavestroughs to prevent leaf litter and other debris from accumulating in rainwater harvesting storage tanks.

Downspout filters and hydrodynamic separators

More sophisticated pre-treatment measures for rainwater harvesting systems are available to effectively screen, separate and trap debris, sediment, oil, and grease. Downspout filters and hydrodynamic separators are connected in line with downspouts and can be installed either above or below ground. Typical products types and specifications are available from product manufacturers and suppliers.

Prefabricated modules

Oil and grit separators, tree pits, and OGS variants such as Jellyfish® and SorbtiveVault units provide effectively screen, separate and trap debris, sediment, oil, and grease. Typically, prefabricated modules discharge treated stormwater below ground (to subsurface utilities). In these cases, prefabricated modules are only suitable as pre-treatment measures for subsurface LID practices like infiltration chambers and soakaways. Customized pre-treatment measures that discharge stormwater above ground may be suitable for LID practices with surface inlets.

Pollution prevention

Pollution prevention is not a pre-treatment alternative; however, establishing appropriate pollution prevention on your site can also extend the lifespan and maintenance cycle of your LID practices and greatly reduce the volume of pollutants washed off your site and into LID practices. See Chapter 2 for further details regarding pollution prevention practices.

Figure 6.4.22: A Jellyfish® filter pre-treats stormwater within the bioretention area at the IMAX Project site. (Source: Aquafor Beech)

Table 6.4.6: Summary of the pre-treatment measures and their applicability

LID practice	Catch basins	Grassed filter strips	Stone diaphragm	Leaf screens	Downspout filters and hydrodynamic separators	Prefabricated modules
Permeable pavement						
Bioretention	✓	✓	✓			✓
Bioswales	✓	✓	✓			✓
Soakaways	✓	✓	✓			✓
Infiltration chambers	✓	✓	✓			✓
Perforated pipe systems	✓	✓	✓			✓
Rainwater harvesting				✓	✓	
Landscape alternatives						
Prefabricated modules		✓	✓			
Green roofs						
Pollution prevention						

Infrastructure and utilities

During any redevelopment or retrofit project, conflicts with utilities and other infrastructure is a possibility. As a general rule, LID design should aim to avoid utilities as much as possible. In a conflict, LID practices can be adjusted to avoid utilities. In cases where area is limited, you may need to consider alternative LID practices.

Management strategies adopted from the San Mateo County Sustainable Green Streets and Parking Lots Guidebook address design issues related to utilities and infrastructure conflicts. Figure 6.4.23 shows management strategies including avoidance, mitigation, and replacement.

Infrastructure and utility conflicts are almost always associated with existing infrastructure and utilities. However, in some cases, proposed infrastructure may cause conflicts during construction that the design phase couldn't foresee. The installation of curbs, maintenance holes, and other infrastructure adjacent to or within LID practices is a typical example. Figures 6.4.24 and 6.4.25 provide examples of how proposed infrastructure can impact design.

Figure 6.4.23: Management strategies for utility and infrastructure conflicts. (Source: San Mateo County) [51]

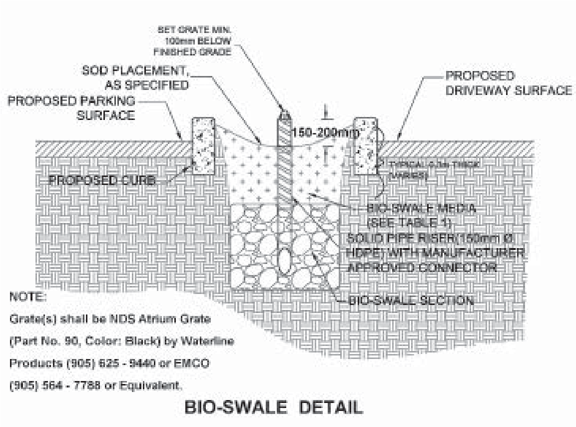


Figure 6.4.24: This bioswale detail shows the location of proposed bioretention soil media adjacent to an existing curb. (Source: Aquafor Beech)

Figure 6.4.24 shows the design of the proposed bioswales for the IMAX Project. The detail shows the extent of the bioretention soil media being installed directly beside the curb. During curb installations adjacent to LID practices where the areas behind the curb are excavated, sub-base aggregate material often extends beyond the back of the curb for structural support. If not done carefully, this can effectively reduce the size of the treatment area. During the IMAX Project much of the excess aggregate was removed.

Plan for possible infrastructure encroachments. As a general rule, LID practices adjacent to infrastructure such as curbs and maintenance holes should be a minimum of 3.0 m wide to accommodate possible encroachments.

Figure 6.4.25: The bioswale and new curbing being installed at the IMAX Project. (Source: Aquafor Beech)

Snow storage

During the design process, it is critical to consider the operation and maintenance of the site during winter conditions – particularly with respect to snow storage. Including a designated snow storage area in your design is recommended as after a retrofit LID practices may be the only unoccupied areas on your site adjacent to parking, building, and pedestrian areas. These areas are often used for snow storage during winter months. Here are some key snow storage considerations for LID practices:

- Do not overload LID practices with snow. This can lead to clogged overflows and inlets. Identify other areas for snow storage.
- Select proper plant material. Heavy snow piles can damage woody plant material. Perennials may be more suitable.
- Incorporate grassed filter strips around LID practice to provide pre-treatment benefits and a snow storage area.

Manufacturer specifications

Prefabricated modules and rainwater harvesting system components are proprietary units that have specific design, installation, and maintenance specifications. During detailed design phases, consult product manufacturer and suppliers to develop design details and specifications unique to the site design and application.

Rainwater harvesting systems often consist of storage tanks, treatment components, pumping systems, and control systems. These elements must be compatible. Rainwater harvesting systems can be pieced together using separate proprietary parts, but that will significantly increase design complexity and efforts. To ensure the system operates properly, outsource design work to rainwater harvesting design and prefabricated unit professionals.

Landscaping

The LID Landscape Design Guide (Appendix B of the LID Stormwater Planning and Design Guide) provides land managers and professional practitioners with the guiding principles of LID planting design, implementation and management. The guide provides insight to planting standards, general site conditions, fundamentals of plant selection, direction for construction and planting, and full plant species list with plant characteristics.

The LID Landscape Design Guide provides professional practitioners with the guiding principles of LID planting design, but it does not replace the value of consulting a landscape architect during the development of landscape plans.

When developing landscape plans for LID retrofits, pay close attention to plant species selection and the proximity of these features to snow removal and storage operations. In southern Ontario, snow piles weigh heavy with wet snow pack. If not properly managed, these sites can cause significant damage to plant material within LID practices.

Larger shrubs and woody plantings should not be planted within snow storage areas. Heavy snow piles are likely to damage the crown of plant material and kill the vegetation. Perennials are more suitable for snow storage areas as they heavy snow loads will not impact them. In addition to proper plant selection, installing grassed buffers plantings and parking areas will provide adequate snow storage outside of the limits of vegetation.

Figure 6.4.26: Well-vegetated bioswales at the University of Minnesota. (Source: Aquafor Beech)

Structural assessments

Structural assessment can be applied to many different areas of design and construction. For example, a geotechnical investigation often includes a structural analysis of the sub-soils to recommend a paving structure suitable for the existing conditions.

LID practices like green roofs require an entirely different degree of structural analysis that involves a multi-disciplinary project team. Depending on the green roof function, size, and location, your team may require a structural engineer to determine the existing, or required, loading capacity of the roof. With the combined weight of wet soils, plant material, potential snow accumulation, green roof components, and maintenance infrastructure a structural analysis would be required. Given the complexity of green roof design, design work should be outsourced to the appropriate professionals.

Green roof design may require assessments by mechanical engineers, landscape architects and horticulturalists.

6.5 Detailed design drawing standards

This section provides an overview of the detailed design drawing standards to consider for LID practices.

The typical detail design sheets included as part of an LID design drawing package include:

- General plans and profiles
- Cross-sections
- Construction details
- Landscape plans
- Phasing plan
- Erosion and sedimentation control plan

General plans

Elements that should be incorporated into general plans:

- Street names - if applicable
- LID feature locations and numbering
- Land parcels and address numbers
- Encroachments, trees, other features
- Cross section location identifiers
- Removal items
- Limit of construction
- Scale
- Tie-in elevations
- Pipe slopes, type, size, inverts, grade changes
- Manholes, catch basins, other structures including size and type (sanitary, storm etc. - indicate pipe direction , inverts and size)
- Utilities (invert, obverts, slopes, type and size)

Cross-sections

At locations identified on the general plan, respective cross-sections can provide a scaled conceptual of design features located at specific locations.

Cross-section details may include:

- Parking lot and building areas and any expansion areas
- LID features including their components and respective dimensions
- Notes and details
- Tie-in locations
- Property lines/construction limits
- Cross section number
- Scale
- Utilities and structures (type, size, and invert elevation)

Cross-sectional views should not span the entire site since much of the information detailed becomes repetitive. Limit cross-sections to specific features that provide valuable information for construction. In most cases, incorporating construction details with sufficient detail of the design feature can replace the need for cross-sectional views.

Many municipalities and agencies have design drawing and drafting standards for design drawing submissions.

Figures 6.5.1 and 6.5.2 provide an example of simple cross-sectional detail used during the IMAX Project to provide detail for a Bentofix barrier that separated two sub-base materials. The example demonstrates that full cross-sections are not necessary. Those that appear in design drawings should provide effective direction without overcomplicating the cross-section. Refer to the IMAX Project case study in Appendix A for additional information.

The cross-section detail in Figure 6.5.2 is localized. It does not span the entire width of the parking lot; instead, it focuses on the design element that requires further detail. The resulting cross-section acts more like a construction detail.

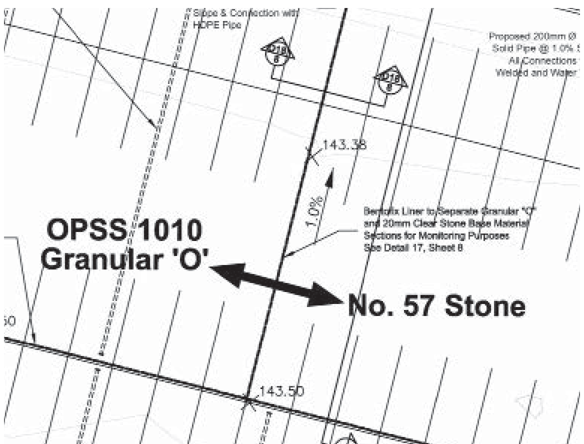


Figure 6.5.1: This construction plan used at the IMAX Project site shows a typical cross-section of permeable pavement. (Source: Aquafor Beech)

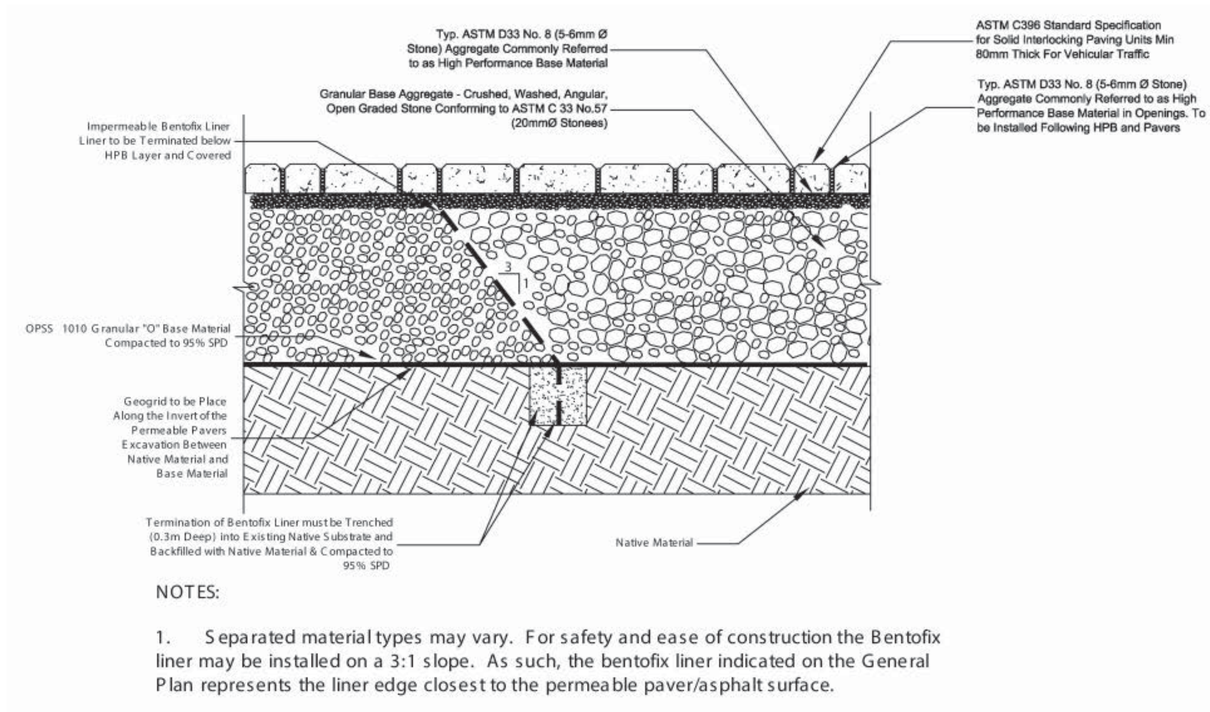


Figure 6.5.2: A cross-section detail from the construction plan used at the IMAX Project site. (Source: Aquafor Beech)

Construction details

Construction detail drawings generally include important details and specifications. This section provides information and examples of the types of design details, both general and LID specific, that may be included as part of design drawings for LID projects on your retrofit site. Most construction details for LID practices are provided within the CVC Low Impact Development Stormwater Management Planning and Design Guide.

These details, along with notes to include on design drawings for various LID practices are provided in Appendix B.

Construction sequencing and phasing plans

A phasing plan is a construction plan for the entire design that details the installation sequence of the individual design elements and overall site logistics. Installation and construction sequencing notes are step-by-step procedures that contractors must follow when installing LID practices. Table 6.5.7 provides a few examples of the various notes included as part of typical phasing plans. The following example is specific to permeable paver and bioswale installations.

Table 6.5.7: Construction sequencing and phasing plan considerations: example of bioswale and permeable paver installations

Note category	Reasoning
Phase 1 - Site preparation	• Delineate construction limits to be inspected by the engineer before construction works begin. • Remove all removal items including curbs, asphalt, and trees. • Apply sediment control and/or temporary construction fencing along work area as defined on the erosion and sedimentation control sheet
Phase 2 – Construction of permeable pavers	• Excavate & grade permeable paver area to proposed grades • Install geogrid and filter fabric • Install Granular 'O' and clear stone subbase • Install all proposed subsurface infrastructure including underdrains • Install curb underdrains • Install curbs • Install No. 8 bedding material and permeable pavers
Phase 3 – Construction of bioswale	• Excavate & grade proposed asphalt and bioswale areas. • Install all proposed subsurface infrastructure within the proposed base material and bioswale areas including underdrains • Install filter cloth • Backfill bioswale trench with clear stone • Install bioretention soil media as approved by Engineer

Landscape plans

A landscape plan details the design's landscaping features and include the planting procedures, installation details, maintenance requirements, and restoration activities. The plan also provides details of the plant types, densities, planting locations, and quantities.

Landscape plans and plant selections are important elements of LID practices. The general public places a high value on aesthetically pleasing landscaping – this should be a key design element of any LID design incorporating vegetation. Typically, landscape architects or landscape designers produce the plan. These professionals have the experience and creative vision required to effectively beautify LID practices and integrate them into the existing landscape.

There are numerous resources for developing landscaping plans, such as the CVC Low Impact Development Stormwater Management Planning and Design Guide. Other resources include:

- Ontario Ministry of the Environment Stormwater Planning and Design Manual (2003)
- Landscape Design Guide for Low Impact Development (2010)
- Local municipal requirements for landscape plans

Design briefs

Design briefs accompany detail design drawings and provide detailed explanation of the design and its function. The document walks reviewers and contractors through the design elements and activities step-by-step.

Design briefs include:

- A summary of background review and site reconnaissance findings including dates performed and methodologies, as well as a summary of the site's existing condition.
- Results of pre-design activities, the dates they were performed, and the methodologies the team used.
- A summary of existing and future drainage areas and corresponding hydrologic and hydraulic assessments.
- A summary of design calculations, criteria, reference material, assumptions, and methodologies used to design each LID feature. This should include how pre-design activities influenced the design.
- A summary of resulting design of each LID feature including component details such as materials types and dimensions.
- A discussion of approval requirements.
- Operation and maintenance requirements for each LID practice.

7.0 Approvals

Like many types of construction projects on business and multi-residential properties, LID requires different approvals at the municipal, watershed, provincial, and/or federal level. As LID adoption is still slow in many parts of Ontario, you may encounter policies or by-laws that present a barrier to the implementation of LID retrofits. Staff unfamiliar with LID can lead to resistance or delays in the processing approvals.

In order to ensure timely approvals of LID retrofits, develop a strong understanding of the legislation, policies and by-laws that apply to your retrofit project. This chapter will provide an overview of the typical municipal policies and by-laws, conservation authority requirements, and provincial legislation that can apply to LID retrofits.

Approval requirements often differ between jurisdictions. For this reason, a pre-consultation with the appropriate parties is strongly recommended to avoid discovering that the completed design does not conform to the applicable legislation, policies and/or by-laws and has to be redesigned.

Pre-consulting with the appropriate federal, provincial, municipal and agency representatives ahead of time ensures that there is support for a proposed design. This minimizes re-design – a critical factor in keeping LID implementation costs low.

7.1 Municipal policies and by-laws

Approvals for LID retrofits of businesses, universities, colleges and multi-residential properties will typically be in the form of permits issued by the municipality in conformance with their policies and by-laws.

As such, it is important to conduct a review of policies and by-laws that can affect your project. To assist with this review process the typical municipal by-laws that apply to LID retrofit projects are presented in Table 7.1.1.

Special provisions and agreements for storm water management facilities

On private sites where LID practices will be constructed, operated and maintained by the landowner municipalities can require assurances and long standing arrangements to ensure that these facilities continue to perform as designed into the future. As part of an LID retrofit, a municipality can require:

- Agreements which make annual maintenance and reporting a requirement. In some municipalities this is standard for conventional practices such as ponds and proprietary stormwater treatment devices.
- Placement on title of on-site LID practices
- Maintenance agreements that assign long-term maintenance responsibility
- Placement of controls (valves and or flow control structure) for on-site LID practices within easements and providing adequate access for inspection and maintenance

Covenants placed on the title of privately owned lots requiring owners to maintain, repair and replace infrastructure are enforced through Municipal Property Standards By-laws. This allows the municipality to lawfully enter private property, inspect and maintain on-site LID practices when necessary.

Table 7.1.1: Common municipal by-laws affecting LID for businesses, universities, colleges and multi-residential properties

By-law	General Components of By-law	Barriers/Issues Affecting LID Implementation	Techniques for Overcoming Barriers/Issues
Nuisance weeds and/ or tall grass	• Lists nuisance weeds • Defines a height above which grasses are considered nuisance • Requires cutting tall grasses • Requires a property owner to remove all nuisance weeds • Gives municipality the right to bring properties into compliance at cost of owner	LID practices like bioretention systems can utilize a variety of landscape types, some of which can use a natural landscape approach that may be in violation of height restrictions or nuisance weeds lists	Work with regulatory officials to permit the construction of projects that may violate the letter of the by-law, but not its intent. Emphasize that they provide a pleasing aesthetic in the community.
Property standards	• Requires low-lying areas to be filled or graded to a storm sewer • Requires all landscaped areas to be cut and maintained	LID practices like bioretention systems use shallow surface ponding areas that may not be graded to storm sewers and may be left to naturalize	Emphasize to regulatory officials that ponding in LID practices is limited to 24 hours, and that plantings are intended to be aesthetically pleasing
Parking requirements (within zoning by-laws)	• Sets requirements for parking on private property • Specifies the required number of parking spaces based upon the building type	The removal of parking spaces to accommodate LID features may be restricted by zoning by-laws	Work with regulatory officials to determine if all spaces required under the by-law are necessary for the particular business or multi-residential site being retrofitted
Erosion and sediment control	• Requires an erosion and sediment control permit be obtained prior to undertaking any land disturbing activities of a minimum size or greater (typically ½ to 1 hectare), or on sites of any size that are adjacent to a body of water • Retrofit activities below the minimum area requirement may not require this type of permit	N/A	N/A
Plumbing, connection or water & wastewater	• A permit is required to establish a new connection to municipal systems, including the storm sewer network • Rainwater harvesting systems require plumbing permits if any piping enters the building	The Ontario Building Code restricts the type of fixtures that can be supplied by rainwater	If the existing storm sewer connection is to be maintained as the primary discharge point (i.e. no new connections are required) and any new discharge pipes do not cross property lines, a permit may not be required. Check with your local municipality regarding obtaining a plumbing permit for rainwater harvesting systems and permitted rainwater uses
Area specific requirements (within zoning by-laws)	Individual areas of a municipality can have specific requirements relating to rooftop controls, parking lot storage, inlet controls or maximum discharge, and are generally associated with zoning requirements or previously completed studies	These requirements may restrict the type, size and/or the location of LID features that can be implemented at your site	Contact your local municipality to determine the type(s) and number of permits that will be required

7.2 Provincial legislation and regulations

Ontario Water Resources Act

The *Ontario Water Resources Act* (OWRA) regulates sewage disposal and “sewage works” and prohibits the discharge of polluting materials that may impair water quality. The OWRA requires that all sewage discharges (including stormwater) be approved by means of an Environmental Compliance Approval (ECA), unless exempted by the OWRA or another regulation. ECAs are issued by the Environmental Approvals Branch of the Ministry of the Environment.

Not sure whether you need an ECA or not?

Schedule a pre-consultation meeting with the Ministry of the Environment and other appropriate parties to clarify whether your site requires an ECA or is exempt under the Water Resources Act.

It is important that site zoning per the Municipal Official Plan be confirmed as the exemption is related to the Official Plan designation and not the type of business being undertaken on the site. Do not assume you are exempt.

If your site already has an Environmental Compliance Approval (formerly known as a Certificate of Approval) an amendment is likely required for any alterations and or upgrades to the existing conditions of your approval.

The Ministry of the Environment Environmental Approvals Branch provides ECA pre-consultation for all projects to clarify exemptions and or approval requirements.

Questions related to ECAs should be directed to the Environmental Approvals Branch:

2 St. Clair Avenue West, Floor 12A
Toronto ON M4V 1L5
Phone: 416-314-8001
Toll free: 1-800-461-6290
Fax: 416-314-8452
E-mail: EAASIBgen@ontario.ca

Ontario Stormwater Management Planning and Design Manual

The Ontario Ministry of the Environment’s 2003 *Stormwater Management Planning and Design Manual* is used as a baseline reference document in the design of stormwater management facilities, and in the review of stormwater management applications for approval under section 53 of the OWRA.

A common concern among practitioners is using LID to provide enhanced water quality protection in low-permeability (clay) soils. This concern stems from some practitioners’ interpretation of guidance provided in the manual, specifically whether LID can meet enhanced protection water quality objectives and whether lot-level infiltration on clay soils is permitted.

In the manual, enhanced protection is defined as the long-term average removal of 80% of suspended solids. In Table 3.2 Water Quality Storage Requirements based on Receiving Waters of the manual, it is noted that “SMW [stormwater management practice] type that that can be demonstrated to the approval agencies to meet the required long-term suspended solids removal for the selected protection levels under the conditions of the site is acceptable for water quality objectives.” As Table 3.2 of the manual lists infiltration (one of the primary mechanisms of LID practices) as one of the options available to meeting the enhanced protection requirements, this indicates that LID is a viable option for meeting the criteria.

With respect to clay based soils (predominant throughout much of Ontario), section 4.2 and Table 4.1 provides guidance that relates to “physical constraints which could limit the use of lot level, conveyance and end-of-pipe controls.” Although the guide provides caution on the use of infiltration practices on clay soils, it does not in any way indicate that soils with lower relative infiltration rates be excluded from infiltration practices.

The infiltration rate of soils will have an obvious effect on the drawdown time of the facility between events, as well as have an effect on the system's performance during an event if the rate of runoff entering the system exceeds the infiltration event. Therefore, should be sized accordingly based on design guidance from sources such as the Low Impact Development Stormwater Management Planning and Design Guide or others. As such, soil infiltration capacity guidance in the manual should not be interpreted as a prohibition but as a caution that controls relying primarily on infiltration may not be as effective as they could be on soils with higher relative rate of infiltration.

Provided that the proposed LID techniques incorporate the appropriate runoff storage volumes, empty within inter-event periods and are otherwise appropriately sited, designed, monitored and maintained (similar to all other stormwater management facilities), there should be no impediment to the application of LID infiltrating practices to meeting water quality objectives in the manual. As such, it does not prohibit the use of LID practices to meet stormwater requirements.

Ontario Conservation Authorities Act

Permits from conservation authorities may or may not be required for LID retrofits. Permits may be required for sites located within the Regulated Area per the Ontario's *Conservation Authorities Act* or work that triggers a site plan review. Contact your local conservation authority to determine if approvals are required.

Conservation authorities can help

Many conservation authorities have expert staff that can provide advice and guidance on implementing LID projects. Be sure to contact your local conservation authority to see what approvals are required, if any, and if they can provide guidance, comment on the design or provide other assistance.

Ontario Condominium Act

The retrofit of a condominium (multi-unit and or single lot freehold) is governed by Ontario's *Condominium Act*. The act requires that common stormwater management infrastructure (including LID practices) must be governed and maintained by a member-elected Board of Governors. This act requires all owners of parcels of tied lands to automatically become members, provides for mandatory mediation and arbitration, and is enforced by the Condominium Board. All property improvement must be approved per condominium agreements.

Ontario Clean Water Act

Ontario's *Clean Water Act* requires source protection plans, which are locally-driven, watershed based strategies that have been developed through intensive scientific study of drinking water sources in communities across Ontario. Source protection plans address activities and land uses around municipal wells and surface water intakes to protect existing and future sources of drinking water. The requirements outlined in these plans are specific to the drinking water source. The goals of LID stormwater management practices are aligned with those of source water protection. These plans should be consulted to determine if specific requirements pertain to your site. Contact your local conservation authority for more information on source water protection.

7.3 Industrial lands

Industrial lands can have specific requirements from provincial, regional and/or municipal levels of government. Retrofits involving stormwater management (quantity control, quality control, or both) on lands zoned Industrial under a Municipal Official Plan will require an ECA through the Environmental Approvals Branch of the Ministry of the Environment. This requirement applies regardless of whether the property has an existing ECA (or Certificate of Approval). The information required to be submitted for an industrial ECA includes but is not limited to:

- Identification of drainage area and effluent receiver
- Design criteria and identification of design criteria sources (e.g. *Master Drainage Plan, Municipal Stormwater Master Plan*, *Sub-Watershed Study, Watershed Study*, etc.) or names of authorities that approved the criteria (Municipalities, CAs, MNR, MOE, etc.)
- Summary of design storms, flows (before and after proposed works) and methodology used
- Hydraulic capacity of receiver (includes storm sewers)
- Type of stormwater management practices proposed (both quality and quantity)
- Description of design and calculations associated with stormwater management works
- Hydraulic routing for required major storm event through the stormwater works
- Detailed description of proposed operation and maintenance procedures

Municipal and regional policies and stormwater by-laws can also dictate stormwater management requirements within industrial lands. Municipal or regional policies may require specific stormwater management practices to be used within industrial lands. These policies often include pollution prevention but generally do not include other LID practices as primary stormwater management options for industrial lands. This is due to pollution hot spots such as fuelling stations, vehicle washing areas, hazardous material storage and delivery areas that are frequently located on industrial sites. These hot spots can cause significant damage to LID practices and contaminate local groundwater if not properly managed.

Understanding municipal policies and the intent behind them is important when retrofitting an industrial site. As always, pre-consultation is important to establish what is permitted. Municipalities may allow specific LID practices such as rainwater harvesting, green roofs, and prefabricated units to be installed on industrial lands due to fact that they introduce no groundwater contamination risk. Municipalities may also allow specific catchment areas to be targeted with LID infiltration practices. These areas may include roofs and staff parking areas because they present little incremental environmental risk beyond that of an institutional or commercial property.

8.0 Tender and Contract Documents

Within the private sector, there is no formal bidding process required to procure goods and services unless requested by the property owner or manager. Owners implementing LID practices on their properties may acquire any contractor they wish. However, a formal competitive bidding process is strongly recommended for LID projects. Competitive bidding acts as a screening process and will help you find a contractor with adequate means and competency to complete the work. Designers and product suppliers often can provide a list of recommended contractors with relevant experience to undertake the work.

The competitive process often requires a public request for the submission of sealed tenders from interested bidders. Tenders are a written formal offer submitted in response to the invitation, in a particular form, to supply the stipulated goods or services at a particular price.

Tender documents for LID projects will generally incorporate resources from the Ministry of Transportation's Ontario Provincial Standards (OPSS) for Roads and Public Works, in addition to any municipal amendments (i.e. by-laws) or legal requirements provided by the site owner.

These sections provide an overview of the common elements of tender documents, including:

- Tender documentation and front matter
- Standard specifications
- Materials
- Testing
- Maintenance
- Construction supervision requirements
- Level of input required by municipal representatives, design consultants, manufactures, and suppliers

The terms "tenderer" and "bidder" are used interchangeably throughout these sections to refer to the contractor(s) bidding on the tender. Correspondingly, "owner" refers to the owner of the site.

8.1 Tender document elements

The information included in tender documents released by or on behalf of your business, university, college, or condominium depends on many factors. The size and type of project, accessibility to resources, internal policies, municipal by-laws, and availability of funds all impact the comprehensiveness of tenders and the degree of external resources utilized to assist with their development.

- Tender information
- Form of tender
- Form of agreement
- General conditions
- Special provision and specifications
- Contract documents

Refer to Appendix C for more information on the following components of tender documents.

8.2 Special provisions and technical specifications

Special provisions are technical specifications of products, procedures, and techniques to be followed during construction. Construction supervisors use these technical specifications to ensure contractor compliance with the minimum standards.

This guide provides suggestions for developing special provisions for LID techniques. Use discretion when interpreting and applying these suggestions.

General

All special provisions have common elements. Each special provision outlines:

- The work and items to be included as part of installation
- Installation procedures
- Applicable standards and specifications
- Material and product information
- Testing requirements
- Payment structure and decommissioning
- Maintenance requirements before, during and after construction

This section provides a step-by-step process for developing special provisions for LID practices.

Special provisions numbers within the tender generally correspond with the Spec # detailed within the Schedule of Items. This structure links the items and associated quantities detailed within the Schedule of Items with the work details provided in the Special Provisions section.

Step 1: Clearly outline the work required for each special provision item and list the activities involved

The work expectation should be clearly detailed as part of the special provision item. For example:

"The contractor shall supply all equipment, labour, and material necessary to construct the bioretention planters as per the design grades as shown on contractor drawings."

In addition to clearly outlining the work involved, include a list of activities that may be part of installation. Here is a sample work outline for a bioretention practice:

- Below grade infiltration gallery and perforated exfiltration pipe (if required)
- Surface bioswale inlets within the street (curb-cuts) consisting of curbing and apron
- Perforated pipe to outlet: connection of perforated pipe to a permanent positive outlet (if required)
- Supply and install non-perforated pipe sections underneath road crossings (if required)
- Install manufacturer-approved connectors for all piping
- Placement of bioswale aggregate (if required)
- Placement of bioretention soil media

Step 2: Detail the products and materials and whether approved equivalents are permissible

Include any manufacturer and supplier product specifications, installation procedures, maintenance, testing protocols or other details in the tender documents. Prior to issuing approval, the field engineer should review any equivalents the contractor requests. Also include all relevant OPSS and other applicable standards.

Specifications for bioretention and bioswales

This section provides examples of the various design components of bioretention and bioswale construction as well as product information. Consider and clearly state any site-specific regulations, policies, laws, and amendments in this section to ensure enforcement.

Technical specifications of products and materials are dynamic and constantly updated. Technical specifications may also vary by supplier, even when the products seem the same. It is your responsibility to prescribe the correct and most recent specifications. For new or special technologies, specifications should include supplier's name and contact information so contractors can easily find and obtain products.

Bioswale infiltration trench stone

20 mm double-washed clear stone is often used as the embedding material when an underdrain or subsurface storage is required. 20 mm clear stone is a standard description recognized by most quarries. It is also recognized as ASTM C33 No. 57 stone.

Double-washed clear stone is typically recommended to reduce the percentage of fines within the bioswale unit. Single washed clear stone may be requested as additional processing generally influences costs.

Pipe and fittings

Selected piping should be rated to satisfy the requirements of the design and application. The applicable pipe specification must be listed. List information related to the pipe types, sizes, material types, and intended purpose within the design.

For example:

Perforated pipe:

> Perforated 300-375 mm dia. HDPE smooth walled collection pipe within bioswale trench.

Non-perforated pipe:

> 300-375 mm dia. HDPE smooth walled collection pipe 3.0m from connection with structures.
>
> 150 mm dia. HDPE overflow riser extending form collection pipe to bioswale surface invert.

Bioretention soil media

Bioretention soil media is an essential component of bioretention practices. The performance of constructed LID features depends upon a specific ratio of sand, organics and fines for them to be effective. Table 8.2.1 outlines the media specifications as stated in the CVC Low Impact Development Stormwater Management Planning and Design Guide for a successful bioswale or bioretention design.

Table 8.2.1: CVC bioretention soil media specifications

Media	Size	% by weight
Sand	2.0-0.05 mm	85-88%
Fines	less than 0.05 mm	8-12%
Organic Matter	-	3-5%
Additional: • Cation Exchange Capacity greater than 10 meq/100 g • pH = 5.5 – 7.5 • Hydraulic Conductivity (Ksat) greater than 25 mm/hr **Soil Texture Classification:** • No objects greater than 50 mm		

Specifications for infiltration chambers, soakaways, and perforated pipe systems

The components of infiltration chambers, soakaways, and perforated pipe systems are similar to bioretention systems asthey include underdrains and open void aggregates as part of their construction. The primary difference is that bioretention practices also require bioretention soil media.

NOTE: A separate special provision for the type of underdrains and aggregate material may be necessary. Each provision should identify the product specifications and related standards for construction.

Specifications for permeable pavement

Block pavers

All permeable block pavers will have product specifications from the manufacturer or supplier that includes physical properties, standard specifications, bedding and base requirements, edge restraints, underdrain requirements, and recommendations regarding delivery, storagem and handling. Include this information in tender documents.

Guidance for permeable block paver specifications is available from the Interlocking Concrete Pavement Institute: icpi.org

Pervious concrete

The effectiveness of pervious concrete as stormwater technology is dependent on product-specific installation requirements. Be sure to provide all information supplied by the concrete manufacturer in the tender package. Information should include:

- Transportation and staging
- Preparation of sub-base before application
- Details on moisture content requirements and how to augment if necessary
- Forming requirements
- Compaction and vibration requirements
- Application timing restrictions
- Screening requirements
- Tamping requirements
- Jointing requirements
- Instruction for contact structures such as manholes and catch basins
- Covering after application (specify for different weather scenarios)

Porous asphalt

Due to the reduced fines content, applying porous asphalt is significantly different from applying conventional asphalt. Manufacturer-specified installation procedures must be followed, and all information supplied by the asphalt manufacturer must be provided in the tender package. Information should include:

- Transportation and staging
- Preparation of sub-base before application
- Required temperature ranges for installation
- Lift depths
- Screening requirements
- Edging instructions
- Instruction for contact structures such as manholes and catch basins
- Rolling instructions
- Timing instructions
- Layering requirements
- Finishing requirements

In addition, the grading requirements of any base material and bedding material, geotextiles, geogrids, liners, or other base related requirements (e.g. Granular "O" and bedding grading requirements) for permeable pavements may be specified under the special provision.

Table 8.2.2: Grading requirements

Granular base grading requirements	
OPSS 1010 Granular "O"	
Sieve Size	Percent Passing
1 ½ in (37.5 mm)	100
1 in (26.5 mm)	95 to 100
¾ in (19.0 mm)	80 to 95
½ in (13.2 mm)	60 to 80
⅜ in (9.5 mm)	50 to 70
No. 4 (4.75 mm)	20 to 45
1.18mm	0 to 15
75µm	0 to 5

Bedding and void opening agregate grading requirements	
ASTM C 33 No 8	
Sieve Size	Percent Passing
½ in (12.5 mm)	100
⅜ in (9.5 mm)	85 to 100
No. 4 (4.75 mm)	10 to 30
No. 8 (2.36 mm)	0 to 10
No. 16 (1.18 mm)	0 to 5

Step 3: Outline the execution procedures for installation

As LID practices may be new to members of the construction team, construction guidance and installation procedures should be provided. Execution procedures should provide a clear overview of the installation and emphasize critical elements. Incomplete or poorly communicated details may cause confusion. All relevant OPSS and other applicable standards should be included where applicable.

Execution for bioretention and bioswale installation

This list provides typical execution procedures associated with bioswale and bioretention construction. When compiling execution details, consider site-specific details.

1. Follow contract drawings and details for the layout of gravel trenches and sub-drain.
2. Execute excavating trench and backfilling in accordance with design drawings and notes. Do not place bedding or sub-base material prior to approval of trench excavation by field engineer.
3. Line trench with filter fabric, backfill trench with clear gravel and consolidate in lifts as specified in details.
4. Line top of gravel trench with filter cloth to provide separation between soil media and aggregate.
5. Ensure pipe interior and coupling surfaces are clean before laying. Do not use any type of shim to establish pipe slope.

6. Construct trenches to assure a uniform slope ensuring trench bottoms have clean, firm and uniform grade, sloped as indicated on plan.
7. Keep the sub-grade elevations parallel with finished elevations.
8. Properly slope perforated sub-drains and lead them to a permanent positive outlet in accordance with connection details.
9. Place standpipes and overflow risers as shown in the details. Prior to placement of this pipe, the subsoil drainage system for the bioswales must be complete and functioning.
10. Connect standpipe riser at bottom of system. Use standard manufactured approved pipe couplings. Cut pipe accurately and work into place without springing or forcing. Ream pipe ends and free pipe and fittings from burrs.
11. Extend the standpipes and overflow risers above finished level as specified.

Specify installation procedures for plant material including trees, perennials, sod, and seeding. Obtain these installation requirements from the landscape designer or architect responsible for the landscaping plan.

Execution for infiltration chambers, soakaways, and perforated pipe system installations

The execution procedures for infiltration chambers, soakaways, and perforated pipe systems are similar to bioretention systems in that they also have underdrains and open void aggregates as part of their construction. The primary difference is that they do not require bioretention soil media. For execution details see the execution for bioretention and bioswale installation section.

Execution for permeable pavement installations

Most permeable pavement products have installation procedures available from the manufacturer or supplier and should be integrated into the special provision section. Information may include procedures and required equipment for installation of the pavement structure, bedding and base, edge restraints, and underdrain. Block patterns for pavers should be part of the tender drawings.

Step 4: State any testing requirements

Any testing of material or products required by the engineer or owner should be clearly stated in the tender.

Bioretention and bioswale media testing

Filter media is an essential component of bioretention and bioswale design as it is responsible for the filtration and percolation of stormwater runoff and overall water quality benefits. Filter media that does not meet specifications can cause bioretention practices to fail. Testing filter media prior to installation is highly recommended. This list provides detailed testing requirements and language that you may choose to include in the tender documents to ensure that the desired bioretention soil media mixes are achieved:

1. The vendor must provide a hand-mixed sample of the proposed filter media for analysis. Hand-mixed samples can roughly gauge the proportions of materials required to satisfy the specifications. Depending on the soil manufacturer or vendor, hand-mixed samples may have to be submitted several times to obtain a passing sample. Analytical results must be submitted to and approved by the engineer prior to beginning mechanical mixing operations.
2. Hand-mixing and mechanically mixing filter media are entirely different operations. In fact, it is rare that mechanically mixed samples will meet specifications in the first submission. Media samples from mechanically mixed operations must be submitted for analysis and satisfy the media specifications. To minimize contamination prior to sampling, pass a minimum of 10 cubic metres of soil media through the system and properly dispose it. Collect a minimum of three samples from the next 10 cubic metres of material, including one from the bottom of the pile (1-3 m^3 of material), the middle (4-6 m^3 of material), and top (7-10m^3 of material). Approved mechanically mixed samples provide confidence that the vendor can successful produce filter media to the desired specifications.
3. All hand and mechanically mixed samples should be submitted to a certified laboratory. The engineer should assemble a Chain of Custody to detail the required testing and provide it to the contractor. These forms ensure that required tests are performed, and ensure additional quality assurance and quality control (QA/QC). Laboratories provide Chain of Custody forms.
4. Either the contractor or the engineer can obtain media samples. If the contractor is responsible for obtaining samples, provide guidance to ensure the contractor follows QA/QC practices.

5. Engineers should observe the mechanical mixing operations and the source material being used for media development. The contractor must ensure that the engineer has access to the site for sampling.
6. The delivered media should originate from the same location and use the same materials as the approved samples.
7. Media installed without clearance from the field engineer shall be removed at the contractor's expense if the field engineer deems it necessary.
8. The contractor is solely responsible for all required media testing expenses.
9. The contractor is responsible for any delays as a result of testing. No compensation will be provided for delays due to media analysis.

Start testing bioretention soil media early. Using the wrong filter media is one of the main reasons bioretention practices fail. Media testing results can take up to two to three weeks. Start testing early to ensure that the correct bioretention media mix is ready when needed.

Other testing/submission requirements may include:

- Submit full-size samples of permeable concrete paving units to the engineer to indicate colour and shape selections.
- Submit sieve analysis for grading of bedding and joint opening aggregates to the engineer.
- Submit test results from an independent testing laboratory to the engineer to confirm compliance of paving unit requirements.
- Include the layout, pattern, and relationship of paving joints to fixtures and project formed details in the tender drawings.
- Submit bioswale planting product data including anti-desiccant, mulch, guying assembly, including clamps, collar, guying wire, anchors, and wire tightner in the tender drawings.
- Submit ssphalt, porous asphalt, and porous concrete mix records from manufacturer.
- Complete compaction testing of base and sub-base materials.

Figure 8.2.1: Mechanical mixing operations. (Source: Aquafor Beech)

Figure 8.2.2: Mechanically mixed soil media. (Source: Aquafor Beech)

Step 5: Outline any maintenance specifications procedures

Any maintenance and decommissioning procedures and requirements should be made available to the contractor and site owner.

Maintenance of LID practices and plant material during and following construction is required for success. Sediment washed into LID practices from construction areas can greatly impact performance. Detailed site maintenance and erosion and sedimentation requirements are recommended.

Several examples of erosion and sedimentation requirements preventing contamination from sediment include:

- Excavate final grade immediately prior to backfilling with specified aggregate and media to avoid premature facility clogging.
- Store all construction materials down-gradient of the excavated site whenever possible. Enclose materials stored up-gradient of the excavated site with appropriate sediment control fencing.
- Direct overland and roof drainage away from facilities during construction to avoid contamination from fines.
- Lay pipes in a true line and gradient on a firm bed, free from loose material. Do not lay pipes on soil backfill or in a slurry. Pipes must be securely positioned to avoid displacement before backfilling.

Plant material, seeding, and sodding are important features of LID design. They provide aesthetic value, which is critical for public acceptance and support.

As previously stated, installation, handling, and storage requirements are generally obtained from the landscape designer or architect responsible for the landscaping plan (if included). In addition to specifications, detailed maintenance and warranty clauses will ensure plant material has the greatest chance for survival and establishment.

Bioretention soil media shall remain free from contamination from clay, in-situ soils or other debris throughout the duration of the construction period. To optimize quality control between stockpiles and loads delivered to construction sites, obtain all media premixed from vendors.

The warranty on the plant material should state that the plant material will remain free of defects for two full growing seasons from the date of substantial completion. The warranty should include the replacement or maintenance of the material. The contractor is responsible for maintenance during the establishment period. This includes the following maintenance operations from time of planting to substantial completion:

1. Water to maintain soil moisture conditions for optimum establishment, growth, and health of plant material without causing erosion.
2. For evergreen plant material, water thoroughly in late fall prior to freeze-up to saturate soil around root system.
3. Remove weeds monthly.
4. Replace or re-spread damaged, missing or disturbed mulch.
5. For non-mulched areas, cultivate as required to keep top layer of soil friable.
6. Apply pesticides in accordance with federal, provincial and municipal regulations and when required by the project manager to control insects, fungus and disease. Obtain product approval from the project manager prior to application.
7. Remove dead or broken branches from plant material.
8. Keep trunk protection and guy wires in proper repair and adjustment.
9. Remove and replace dead plants and plants not in healthy growing condition. Make replacements in same manner as specified for original plants.

Step 6: Outline the payment structure for the installation

The payment structure for the item to be constructed or installed should be detailed. By providing a payment structure for each item, payment certificates will be much easier to assemble and track based on the degree of construction completed up until the issuance of the payment certificate.

For example:

"Payments made to the contractor under this item shall be compensation in full for all labour, material, and equipment per the applicable unit prices tendered."

Other special provisions

In addition to LID specific special provisions, all other elements of the design including those related to pavement surface works and appurtenances, earth works, miscellaneous items, concrete works, structures, etc. shall have individual special provision sections detailing the information specific to each item. The detail of each special provision items will vary, but should provide all relevant information in order to ensure the products and materials are constructed and installed as desired.

9.0 Construction Supervision and Administration

The construction phase is a make-or-break time for LID retrofits. Progress is rapid and the budget is spent quickly. During construction, the team often has to make on-the-spot decisions to deal with unforeseen circumstances. Changes to soil media, improper installation of permeable pavers, and improper installation of erosion and sediment control are only a few of the challenges that you may encounter in the field which can impact the success of an LID project.

For these reasons, a professional with LID construction experience (preferably in a commercial institutional, industrial and/or multi-residential setting) should lead the project team. Supervisors and administrators should be resources for the team, sharing insight from past experience with landowners and staff and helping the team avoid costly oversight during construction.

LID construction practices in Ontario are constantly evolving based on new technology development and lessons from installed sites, making it difficult to keep up with best practices.

These sections provide an overview of construction supervision of LID measures, obstacles of LID construction, and supervision strategies. They are based on experience from the field.

A valuable resource for LID construction in Ontario is the CVC Low Impact Development Construction Guide. The guide has information on construction phase resources, best practices, common mistakes to avoid and other guidance. To download the guide, go to:

bealeader.ca

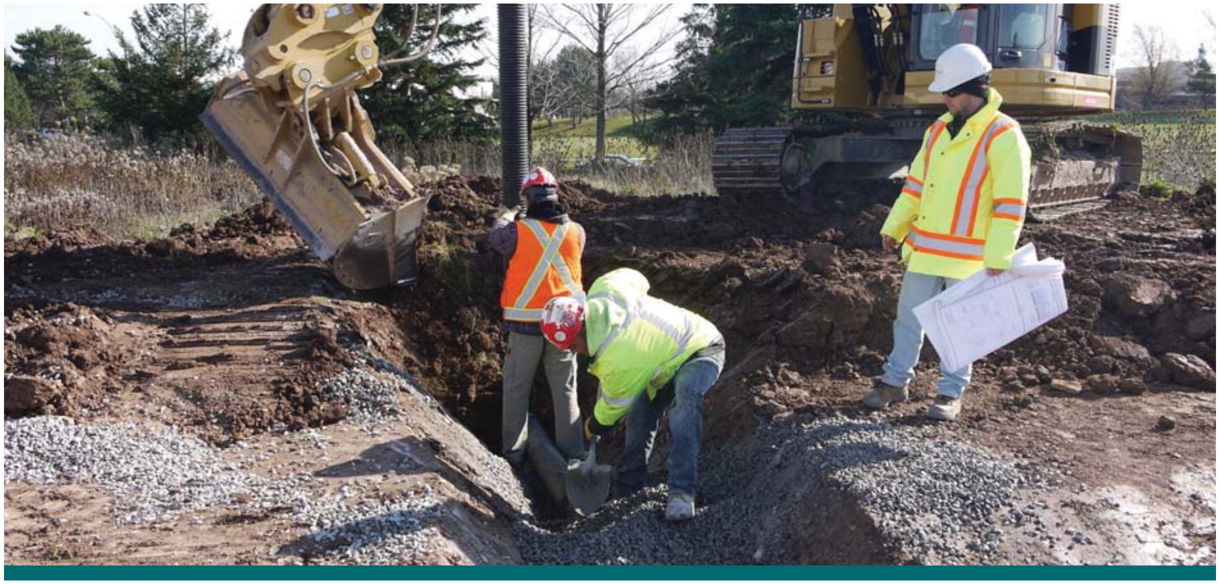


Figure 9.0.1: During construction decisions are often made onsite in meetings with consultants, contractors, and municipal staff. (Source: Aquafor Beech)

9.1 Construction supervision and administration tasks

The typical construction supervision and administration activities associated with LID projects are similar to most conventional construction projects. Table 9.1.1 provides a list of general construction administration and supervision tasks.

Table 9.1.1: Typical construction supervision and administrative duties of LID construction

Construction administration	Construction supervision
• Schedule, coordinate, and attend pre-construction meeting • Prepare construction progress reports • Oversee the day-to-day construction and provide interpretation of the drawings (and supplementary details if required) to the contractor as necessary • Ensure that contractor's methodology complies with requirements of design and confirm alternative construction methods are appropriate • Validate charges for addition or deletions and make recommendations on change orders • Arrange and attend meeting with utility companies • Respond to inquiries and requests for information from external agencies, adjacent landowners, members of the public and staff • During construction, monitor the traffic control measures to ensure they are consistent with traffic control plans and that they provide satisfactory levels of safety for workers and motorists • Notify the contractor of any deficiencies. Perform traffic control/lane closures notifications, coordinating traffic management and public communications with other roadway work in the vicinity. Provide a record of traffic accidents, public notifications and complaints that occur in the work zone • Coordinate all aspects of the construction works with municipal staff and other related agencies. Affected utility companies, area businesses, residents and other regulatory agencies as required • Enforce the Erosion and Sediment Control Plan • Prepare daily diaries	• Provide full-time site inspection during construction period • Inspect all layout and construction work to ensure compliance with the contract specifications and drawings • Provide advice to the contractor regarding the interpretation of the contract drawings and specifications and the preparation of supplemental details, instructions, and clarifications as required • Notify the contractor of any deficiencies in the construction of the work, directing them to take appropriate corrective measures, confirm and report results of the corrective measures during construction • Review, monitor and ensure compliance with contractor environmental submissions as appropriate in the provisions of the contract document • Investigate, report, and provide recommendations on unusual circumstances that may arise during construction • Prepare progress payment certificates • Record material quantities that enter or leave the site • Undertake a complete and thorough inspection of the contractor's work. Prepare a list of all outstanding deficiencies at the end of the warranty period and ensure the contractor corrects all issues quickly and to the satisfaction of the client

9.2 Construction supervision of LID projects

Mistakes made by the contractor or designer, conflicts with utilities, unforeseeable events, weather, encroachments, and equipment failure are all common occurrences during construction projects. The purpose of construction supervision is to address these situations professionally in order to resolve issues as soon as possible.

Supervision strategies

Construction supervision provides an opportunity for the owner, designer, and contractor to develop a working relationship that can help solve problems quickly. When problems occur, having the owner, supervisor, and contractor working together is the ideal situation. When this is not possible, the construction supervisor is ultimately responsible for enforcing the contract documents and must make decisions in the best interests of the owner. There are several approaches for addressing on-site problems.

Passive approach: A passive approach evaluates the issue of concern and uses professional discretion to decide whether to accept it. Should a mistake be so insignificant that it does not impact the function or integrity of the design, pose a risk to the public or property, or fail to meet the approval of the owner/agencies, the supervisor may opt to note the change and move on with construction.

Active approach: An active approach involves actively engaging the situation to ensure problems are corrected. It involves fully enforcing the contractual drawings and documents.

Adaptive approach: An adaptive approach is the ability to make quick decisions on-site. Utilities, encroachments, and weather all cause problems which may require improvisation and quick decisions on design alterations.

Figure 9.2.1: Contractors, construction supervisors, designers, project managers, site inspectors, and surveyors meet at weekly site meetings to discuss issues and develop solutions. (Source: CVC)

Prior to adopting any of these approaches, the construction supervisor must exercise due diligence to ensure that their decisions and alterations will not have negative impacts. The supervisor should consult the owner, agencies, and their superiors for advice and input, if necessary.

While full-time construction supervision is highly recommended, budget constraints may make this difficult. There will be critical points of the project where a supervisor should be onsite. These can be identified during the project scheduling phase. Some of these critical activities include:

- Verifying ESC measures are installed per design
- Excavation depth verification
- Inspection of materials and installation
- Invert and pipe grade verification
- Verification of slope grades
- Fine grading and planting

Due to the nature of construction, dates often need to be shifted. Using one or two construction supervisors allows the schedule to be flexible but keeps everyone informed of decisions and progress. Communication with contractors is the most critical aspect of a successful project when full-time supervision is not feasible. The supervisor will need to speak with the contractor daily to be informed of schedule changes.

Contractor / designer mistakes

Construction projects often follow tight timeframes and budgets. As such, details can be missed; however, the success of LID practices often depends on these small details. The construction supervisor is responsible for catching mistakes and quickly addressing them before they are buried out of sight.

It's easy to overlook seemingly minor details. For example, the contractor may not understand that a difference in overflow pipe size can be critical. The construction supervisor should be able to spot the mistake, inform and educate the contractor, and replace the pipe with the correct diameter from the specifications.

Construction supervisors should conduct regular walk-arounds to evaluate the work. The supervisor must verify critical elements such as grades, invert elevations, pipe slopes, and installation procedures. Depending on the error, the construction team can use passive or active approaches to solve the problem.

Figure 9.2.2: In this photograph, the contractor is verifying the depth of excavation while under supervision. (Source: CVC)

Surveys are assumed to be exact measurements. Entire projects are based on these critical survey points. To keep the project on track, surveyors must be thorough and visit the site often to verify every aspect of the project.

Figure 9.2.3 The granular base of the permeable pavers extends into an adjacent trench constructed for a perforated pipe system installed during the IMAX Project. In the design, the two features were to be hydraulically separated by a clay plug. (Source: Aquafor Beech)

Figure 9.2.4: The granular base has been removed from the perforated pipe area. (Source: Aquafor Beech)

9.3 Product quality assurance and control

Construction supervisors must be aware of the materials and products being delivered to the site. They must conduct quality assurance assessment to ensure that all items meet specifications.

To ensure the correct products are delivered to the site, the supervisor can: request product and material specifications from the contractor; weight tickets; read product labels, purchase orders, release forms; test materials, and perform visual inspections. Conducting product and material quality assurance will often involve active or passive approaches. The consultant or contractor may need to meet with material suppliers prior to installation to provide guidance and ensure materials are exactly as specified.

Figure 9.3.1: Check product labels prior to installation. (Source: Aquafor Beech)

It's not unusual to see the wrong materials delivered to a construction site. If the construction supervisor does not keep track of incoming materials, the contractor is not likely to catch the mistake.

Bioretention soil media testing

During construction bioretention soil media testing must be conducted to determine that the product meets desired specifications prior to installation. Approved media should be installed immediately after delivery and not stockpiled onsite, since it is easily contaminated from exposure to dust and sediment. Media installation should occur once sources of sediment, such as exposed aggregate bases, are limited and erosion and sedimentation control measures are installed.

Figure 9.3.2: Approved bioretention soil media is installed at the IMAX Project site. (Source: Aquafor Beech)

Test bioretention soil media!

Analysis results must meet the desired specifications prior to installation. Approved media should also be installed immediately and not stockpiled onsite as it can easily become contaminated during exposure to dust and sediment.

9.4 Utilities

Construction teams will often encounter utilities when retrofitting sites to incorporate LID practices. During construction, supervisors should encourage contractors to proceed cautiously during excavation works and ensure operators have utility locate reports and drawings with them at all times. Supervisors should ensure that a spotter is present and available to daylight utilities by hand whenever excavation is in close proximity to utilities.

If utilities are damaged during construction and repairs are required, an active approach can help repair the damage as soon as possible. In addition, the owners of the utilities should be informed immediately for two reasons:

1. The owner of the utility is aware of the damage and can log the incident in their records.
2. The owner of the utility can conduct the repair, or at least supervise the repair works to enforce their own internal procedures and protocols.

An adaptive approach can typically be used in situations where utilities interfere with design components. Moving utilities is rarely a good idea due to the construction costs. As such, encountering conflicts with utilities often requires some ingenuity and on-site decision making to avoid or accommodate existing utilities. Simplicity and common sense work best for such situations. For example, to avoid an existing gas line during the Lakeview Project in Mississauga, the construction team notched a section of perforated underdrain to allow the gas line to transect the pipe. This way they avoided having to revise the design or move the utility. For further details on strategies used to accommodate existing utilities, refer to the Lakeview Project case study in Appendix A.

Locates are estimates. Determine the exact location of utilities by hand digging or another form of daylighting. Here are a few general rules for working around utilities:

- Before exposure, mechanical equipment should not be used within one metre of the estimated utility location.
- Once located by hand digging, mechanical equipment should not be used within 0.5 m of the utility until fully exposed.
- Once the utility is fully exposed within 0.3 m, excavation should be done by hand digging and not with mechanical equipment.

Figure 9.4.2: The construction team cuts a notch a perforated pipe to accommodate a gas line. (Source: Aquafor Beech)

Figure 9.4.3: The team adds a section of perforated pipe to the top of the notch to prevent granular material from creating a blockage in the pipe. (Source: Aquafor Beech)

9.5 Roof components

Flat roof systems include a wide range of mechanical, structural, and electrical systems. As you would utilities on the ground, give special attention to installation around these features.

Figure 9.5.1: Mechanical and structural components may interfere with installation on flat roofs. Here contractors work around ventilation components and skylights. (Source: CVC)

Figure 9.5.2: Contractors installed planks to avoid walking on delicate roofing components. (Source: CVC)

9.6 Erosion and sedimentation control

The construction supervisor should always take an active approach when enforcing erosion and sedimentation control during LID construction. Many of the design components are sensitive to sediment contamination. Supervisors should monitor erosion and sedimentation control measures continuously, ensure proper installations are achieved, and request dust control and general site cleanup as necessary. Cleanup should be part of the daily routine.

Several other typical erosion and sedimentation control measures may be used during LID construction to prevent contamination of LID practices. These include:

- Barriers placed in front of curb cuts to prevent sediment from washing into bioswale prematurely
- Sacrificial pieces of filter cloth placed on top of the filter fabric-wrapped gravel filled trench. The filter cloth collects dust and debris during construction and is discarded before the filter media is installed
- Filter media installed once all open aggregate works are completed
- Filter socks and fencing are suitable for controlling erosion and sedimentation during LID construction

Figure 9.6.1: Infiltration areas are covered with sacrificial strips of geotextile when filled with media to protect them from contamination. Contractors can then clean out debris without affecting the infiltration area. (Source: CVC)

Figure 9.6.2: A filter sock installed at the IMAX Project site as part of the erosion and sedimentation control plan. (Source: Aquafor Beech)

The installation of physical measures is the first step to providing erosion and sedimentation control during construction. Proper construction phasing and site logistics may reduce erosion and sedimentation without installing additional physical controls.

During the IMAX Project it was most difficult to control the amount of sediment deposited on the permeable pavers after they became the primary parking area during construction of the adjacent asphalt parking areas.

During construction of the asphalt areas, vehicular traffic was forced to travel over open aggregate to access the permeable pavers for parking. It was a concern that the dust and mud from vehicular traffic would clog the permeable pavers. The team decided to direct vehicles over washed clear stone and a temporary asphalt access strip to allow dust and debris from their tires to deposit of the asphalt surface before they parked on the permeable pavers.

In addition, access to the permeable pavers was limited to a single location so contamination would be limited to a single point that could be managed, monitored, and maintained more efficiently. Refer to the IMAX Project case study in Appendix A for further details.

Figure 9.6.3: Consider site function during construction when planning a temporary asphalt road or any other erosion and sedimentation control. (Source: Aquafor Beech)

Figure 9.6.4: A temporary asphalt road used for construction access is one way to reduce onsite erosion caused by constant traffic from heavy vehicles and equipment. (Source: Aquafor Beech)

10.0 Life-cycle Activities

The continued success of your new LID feature(s) depends on continued appropriate operation and maintenance (O&M) activities. These sections describe O&M approaches, typical activities, and costs associated with life-cycle activities.

Follow these steps to develop an O&M program for LID practices on your site.

Step 1: Establish an O&M approach outlining who will be responsible for conducting life-cycle activities on your site. The approach determines the level of maintenance assumed by the site owner, site operator, contractors, and/or the municipality.

Step 2: Develop a "Level of Service" model that details the maintenance program activities and efforts based on the selected maintenance approach. Evaluation of the maintenance requirements of individual LID practices is required at this stage of implementation.

10.1 Establishing O&M approaches

In general there are four O&M approaches for LID features on your site. The correct approach will be based on budget, staffing, equipment, and experience. Ideally, you should involve the parties responsible for O&M on your site in the process.

Approach 1: Contractor maintenance

Contracting maintenance like asphalt repairs, mowing, and landscaping is a common practice for sites of all sizes. On sites where contractors perform O&M, it can be advantageous to provide site-specific training and incorporate LID O&M into existing programs.

Approach 2: Site owner maintenance

This approach is common for smaller sites where internal staff is responsible for most day-to-day operations on the property. This approach is also common for sites owned by property management companies and leased to tenants. In these cases O&M approaches can remain consistent despite the short-term leases common on industrial and commercial land uses.

Approach 3: Site operator maintenance

Though not as common as approaches 1 and 2, this approach is sometimes used for leased industrial and commercial sites or in apartment settings. With this approach the site owner may have little (annual inspections) to no involvement with O&M.

Approach 4: Municipal maintenance

While municipal maintenance is common for traditional end-of-pipe facilities, it is not as feasible for LID practices established on private sites, especially if extensive implementation has occurred across a municipality. In some instances partnerships may be developed with municipal departments during demonstration projects. In these cases municipal O&M agreements may be feasible. A variation on this approach where the municipality accepts a portion of the O&M responsibilities may also be feasible.

Figure 10.1.1: At this stormwater management facility, a municipal-private partnership approach to maintenance was established. The municipality is responsible for life-cycle activities that are critical to maintaining the facility, including outlet inspections and dredging. The land management company that owns the adjacent property is responsible for maintaining landscape features. (Source: CVC)

Table 10.1.1: O&M approaches for LID measures

Maintenance approach	Typical requirements /steps	Advantages	Disadvantages
1. Contractor maintenance	1. Develop and adopt program documents 2. Mandatory maintenance plan for site plan approval 3. Develop inspection procedures 4. Train contractors / require training or certification 5. Establish compliance enforcement procedures	• Consistent scheduling • Easy integration with other site O&M	• Quality assurance necessary via inspections
2. Site owner maintenance	1. Develop and adopt program documents 2. Mandatory maintenance plan for site plan approval 3. Develop inspection procedures 4. Establish tracking system 5. Establish compliance enforcement procedures	• Reduced costs to the municipality • Program consistency • Decision made based on extensive site knowledge	• Particular aspects of O&M program can be neglected in favour of other site responsibilities • Training and enforcement often lacking
3. Site operator maintenance	1. Develop and adopt program documents 2. Mandatory maintenance plan for site plan approval 3. Develop inspection procedures 4. Train site operators 5. Establish compliance enforcement procedures	• Reduced costs to the municipality • Decision made based on extensive site knowledge	• No long-term agreements if property is on a short-term lease • Programs can be neglected in favour of other site responsibilities
4. Municipal maintenance	1. Jointly develop and adopt program documents 2. Mandatory maintenance plan for site plan approval 3. Jointly develop inspection procedures 4. Establish compliance enforcement procedures	• Flexibility to split O&M requirements between parties based on ease of integration and equipment	• High cost to municipality • Not feasible on large scale (watershed or municipality-wide)

Each operation and maintenance approach has its advantages and disadvantages. Many sites use a hybrid approach, often a combination of contractor maintenance and site owner maintenance or site operator maintenance. In all cases adequate training and assembly of maintenance program documents is strongly advised. For an example of a public-private partnership involving municipal maintenance, refer to the Elm Drive Project case study in Appendix A.

Figure 10.1.2: The landscape amenities around the facility include gardens, benches, and a walking path. These amenities provide valuable recreation opportunities for employees in the adjacent office. The features make the office a desirable location to work and result in lease and employee retention. These features might even increase the property value. (Source: CVC)

10.2 O&M requirements

Regardless of the selected O&M management model, the typical tasks for LID practices differ from those of traditional stormwater management practices. Conventional stormwater management practices include outlet inspections, pond dredging, and vacuum trucks to empty proprietary stormwater treatment devices (i.e. OGS devices).

To ensure LID practices function properly throughout their entire life cycle, O&M personnel and those responsible for inspections must be well-versed in the design and intended function of the practices

On the other hand, maintenance requirements for many LID practices are similar to most turf, landscaped, or natural areas and do not typically require new or specialized equipment. However, LID techniques are green infrastructure and they provide necessary functions, such as water quality treatment. Maintenance personnel and inspectors must be well versed in the design, intended function, and maintenance requirements of each system.

Table 10.2.1 provides a summary of the maintenance requirements for the LID practices suitable for business, university, college, and multi-residential retrofits. Consider these requirements when developing your maintenance. Additional details with respect to each individual practice are provided in subsequent sections.

Table 10.2.1: Summary of maintenance requirements of LID practices

	Maintenance requirements				
LID practice	**Post-installation period (varies by practice and design)**	**Regular maintenance**	**Annual maintenance**	**Long-term maintenance**	**Notes**
Perforated pipe	• Inspection after each storm >10mm or min. of two visits	• Vacuum debris and litter from catch basins • Replace damaged or missing catch basin grates • Lawn maintenance	N/A	• Ongoing maintenance and inspections are complaint-driven only	• Ensure that perforated piping, grating, catch basins are not clogged with sediment or debris • Inspection of perforated pipes may include scoping. Use high-pressure sprayers or vacuums to remove pipe obstructions and clear debris
Bioretention/ bioswales	• Inspection after each storm >10mm or min. of two visits • Irrigate until established (weekly for 1st yr and bi-weekly for 2nd year; as needed based on rainfall) • Include maintenance clauses in tender documents to ensure contractor is responsible for maintenance for first two years following construction.	• Weed, prune and irrigate as required based on plant species and weather • Trash removal as needed based on local accumulation	• Inspect each spring and events >60mm • Replace mulch as required • Reinforce planting as required	• Long-term maintenance and inspections are complaint-driven only	• Replace lost plants to maintain desired density • Core aerating or deep tilling may be required to alleviate clogging due to fines accumulation
Permeable pavement	• Inspection after each storm >10mm or min. of twice	• Surface cleaning - Integration into existing street sweeping/vacuuming programs • Check for surface cracking or spalling.	N/A	• Long-term maintenance and inspections are complaint-driven only	• Complaints regarding ponding or poor drainage may require fully removal and reestablishment of aggregate and/or liner
Soakaways	• Inspection after each storm >10mm or min. of two visits	• Vacuum debris and litter from catch basins	N/A	• Infiltration Chambers: Vacuum accumulated sediment from isolator row (see chamber manufacturers details)	• Public open house(s) • Questionnaires
Rainwater harvesting	• Verify connections and component integrity	N/A	• Inspection • Clean or replace inline filter	• Replacement of pump • Replacement of pressure tanks (if system uses) • Cleaning our tank	• For prefabricated rainwater harvesting systems, follow the manufacturer's O&M specifications
Landscape alternatives	• Irrigate as required • Monitor for coverage, density and specified species	• Weed, prune and irrigate as required based on plant species and weather	N/A	N/A	• Properly selected plant species for naturalization will require little O&M as their natural state will reflect desired site aesthetics
Green roofs	• Irrigate daily or as needed based on rainfall until fully established • Inspection after each storm >10mm until fully established • Weed every two weeks until fully established	• Irrigate and weed as necessary based on plant species and weather	• Inspect drains, membrane and flashing each spring and events >30mm • Replace plants as required • Clear drains as required	• Test membrane and repair as necessary	• Preventing roof leaks is essential for maintaining your buildings structural integrity. If standing water exceeds design parameters test drains. • If significant drainage deficiencies persist after routine maintenance, have the roof system inspected by a qualified structural engineer
Prefabricated modules	Varies based on product type and manufacturer				

Bioretention and bioswales

Bioretention and bioswales share common routine maintenance requirements that include:

- Inspections
- Watering
- Removal of litter and debris
- Sediment removal
- Weeding and pruning

Maintenance of bioretention, bioswales, and enhanced grass swales generally involves maintenance of the vegetative cover. Two or three growing seasons may be required to establish vegetation to the desired level. As such, contract documents often specify that the contractor is responsible for undertaking a minimum of two years maintenance. This ensures that the contractor is responsible for the health of the plant material before, during, and after installation. As a condition of the contract documents, the contractor must replace vegetation that does not survive.

Inspections

Inspections confirm the LID practice is functioning and identify maintenance or rehabilitation issues. Conduct regular inspections schedule routine maintenance operations, such as sediment removal, spot re-vegetation, and inlet stabilization. For the first six months following construction, inspect the site after each storm event greater than 10 mm, or a minimum of two visits. If staffing and budget allow, consider scheduling two inspections per year, one of which should occur after snow is melted and ground is thawed. At the minimum, schedule annual inspections for the spring of each year. Inspections should also occur after all rainfall events in excess of 60 mm.

During inspections look for inconsistencies in vegetation density, evidence of foot or vehicular traffic through the practice, channelization, erosion, debris accumulation, sedimentation, and structural damage to concrete curbing and condition of pretreatment device.

Watering

Plant irrigation is necessary for the first two years or until plants are established. Watering requirements may differ with selected plants but is typically required on a weekly basis during this period. The season between May and August is a critical period for plant survival. During this hot and dry season, increase watering to twice per week. When planning watering operations, consider how much precipitation has fallen. During overly wet periods, modify watering schedules.

Removal of litter and debris

Trash and large debris tends to collect around pre-treatment devices and at the inlets of LID practices. Trash may also become stuck in outlet areas affecting the hydraulic function of the facility. The removal of trash and debris should occur at least once a month but will be heavily dependent on accumulation rates.

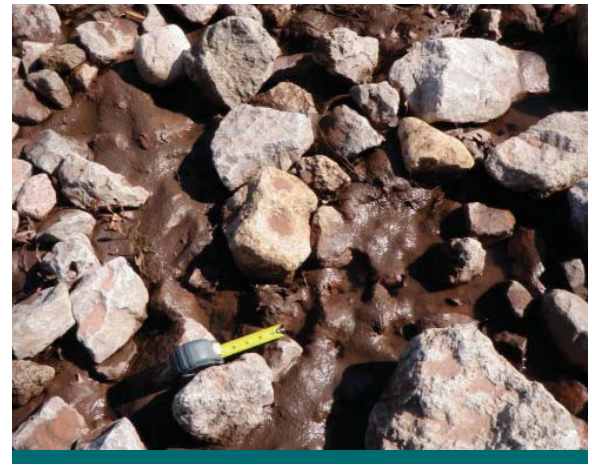


Figure 10.2.3: Closely inspect any pre-treatment areas for excessive sediment accumulation from exposed soil during construction. In this photo a riprap spillway between the forebay and bioretention facility has been subject to clay deposition from upstream construction practices. (Source: Aquafor Beech)

Sediment removal

Pre-treatment devices are designed to provide a buffer area where sedimentation occurs before it can reach the vegetated area of the bioretention, bioswale, or enhanced grass swale practice. These areas must be cleaned out before they lose their functionality. Sediment removal techniques will differ by pre-treatment practice but may involve hand tools, or high-pressure washers and vacuum trucks. The frequency of sediment removal will also vary depending on pre-treatment practice and catchment conditions. Monitor sediment accumulation on an annual basis and conduct them as needed.

Weeding and pruning

Maintaining compliance with municipal by-laws regarding nuisance weeds and plant growth requires weeding and pruning. Pruning is typically required only once per year, while weeding may be more frequent dependent on local conditions.

Additional first-year maintenance

Bioretention, bioswale, and enhanced grass swale practices are most prone to failure during the first year of establishment. Additional maintenance practices will be required and they typically include:

- Adding reinforcement planting to maintain desired vegetation density. The construction contract should include a care and replacement warranty to ensure vegetation is properly established and survives during the first growing season following construction.
- Removing sand that may accumulate on the filter bed surface following snowmelt and replacing vegetation that is impacted.
- Checking inflow and overflow points for clogging and remove any sediment.
- Inspecting grass filter strips for erosion or gullies and reseeding as necessary.
- Examining the drainage area for bare soil. These areas should be stabilized immediately. Silt fence or other measures may be needed until the area is reseeded.
- Identifying plant material stressed due to salt contamination following the spring melt and replacing dead vegetation as necessary. (Note: reduce salt loadings from de-icing practices if possible.)
- Inspecting overflows to ensure that snow blockages are prevented.

If you've identified these problems during the first year, make them part of further annual inspections and maintenance schedules until the issue no longer persists.

Perforated pipe

With appropriate pre-treatment, perforated pipe systems do not require additional maintenance beyond that of a conventional storm sewer. These routine maintenance items include:

- Vacuum debris and litter from catch basins
- Replace damaged or missing grates
- Lawn maintenance

Perforated pipes have been installed in several Ontario communities to high levels of success. Conveyance systems consisting of grassed swales and underlying perforated pipes were installed in Ottawa during the 1980s and 1990s. After more than 20 years of performance, these systems were found to retain their water quality and water balance benefits[58].

If site users and/or members of the public identify problems, you may need more extensive inspection and maintenance efforts, such as scoping pipes to locate obstructions and debris. If available, inspect observation ports extending from the surface to perforated pipes or stone galleries. Once the problem has been identified obstructions can be removed or dislodged using vacuums or high-pressure water sprayers.

If inspections identify problems like broken pipes, defects, or other pipe structure issues, full repairs may be necessary.

Figure 10.2.4: Video inspection (pipe scoping) is a rapid means of identifying issues with buried pipe. Look for indications of pipe collapse, blockages, or sediment buildup. This photograph from an Ottawa perforated pipe shows it to be in excellent condition even after more than 20 years of performance. (Source: City of Ottawa)

Permeable pavement

Permeable pavement (including permeable interlocking concrete pavers, pervious concrete and porous asphalt) can become clogged with sediment over time, thereby slowing infiltration rate and decreasing storage capacity.

All types of permeable pavement have initial infiltration rates of hundreds of millimetres per hour. The long-term infiltration capacity remains high even with clogging. When clogged, surface infiltration rates usually well exceed 25 millimetres per hour, which is sufficient in most circumstances[59]. Table 10.2.2 identifies warning signs of common permeable pavement maintenance issues.

Table 10.2.2: Identifying permeable pavement maintenance issues

Issues	Activity
Slow draining	• Surface should drain immediately. Verify with infiltration testing or observation after rainfall
Ponding	• Rule of Thumb: if more than a nickel deep one minute after a rainfall event, maintenance is necessary • Remove debris and clogging from surface
Surface crusting	• Occurs when sediment accumulates • Remove debris immediately • Increase cleaning frequency of problem areas
Weeds	• Weeds will not germinate without soil and moisture • Removed weeds immediately • Clean out jointing material
Sediment covered joint material	• Identify problem and correct • Clean sediment from joint material
Chips or cracking	• Remove and replace affected paving stones • Saw cut porous asphalt or concrete and replace

Along with maintenance issues identified during inspections, the following actions will ensure the pavement system continues to function:

- Remove debris from pavers following landscape activities with hand blower or mechanical sweeper (as needed).
- Collect debris, dirt, topsoil or mulch which has accumulated within the paver joints and replenish joint aggregate material (as needed).
- Sweep entire paver surface with rotary brush or mechanical sweeper and replenish joint aggregate material (annually).
- Inspect for potholes, cracked or damaged pavers and remove and replace as necessary (following spring thaw).

Additional preventative activities include:

Inlet structures: Drainage pipes and structures within or draining to the subsurface bedding beneath porous pavement should be cleaned out on regular intervals.

Heavy vehicles: Trucks and other heavy vehicles can compact dirt into the porous surface and lead to clogging. These vehicles should be prevented from tracking or spilling dirt onto the pavement. Signage and training of facilities personnel is suggested.

Drainage areas: Areas contributing to the permeable pavers site need to be mowed and bare areas should be seeded.

De-icers: Non-toxic organic deicers are preferable and can be applied either as blended magnesium chloride-based liquid products, or as pretreated salt. In any case, all de-icers should be used in moderation.

Snow plowing: Snow plowing should be done carefully on permeable pavement surfaces by reducing plowing speeds. Operators should be aware of permeable pavement locations and adjust operations as required. Abrasive sands should not be applied on or adjacent to the pavement surfaces.

Table 10.2.3 demonstrates preventative and restorative maintenance techniques and equipment for larger-scale projects like roads and parking lots. A preventative maintenance approach removes debris before it becomes trapped within the paving surface. The restorative approach requires more extensive debris removal techniques to restore performance.

Figure 10.2.5: Vacuum sweepers will remove accumulated debris between block pavers, but can also remove aggregate from paver joints (note the voids behind the sweeper truck). Always replenish any lost joint aggregate following vacuum sweeping. (Source: Aquafor Beech)

Table 10.2.3: Maintenance equipment for permeable pavers.

	Technique	Effect
Preventative	Rotary brush	• Removes debris from joints of permeable concrete pavers and surface of porous asphalt and concrete • Will require slight refilling of permeable concrete paver joint material • May force sediment into pores of porous asphalt and concrete causing clogging
	Broom sweepers	• Typical Street Sweeper Type • Do not use water to clean surface • Best for seasonal cleaning such as fall for leaf litter
	Regenerative air sweepers	• Light duty suction cleaning. • Conducive for all types of permeable pavement
Restorative	Riding litter vacuum	• Can be used as a preventative technique • Will evacuate most debris from joint except for aggregate material.
	Vacuum sweeper	• Complete evacuation of joint aggregate material • Replenish removed joint aggregate material • Conducive for all types of permeable pavement
	Pressure washer	• Complete evacuation of joint aggregate material • Replenish removed joint aggregate material • Conducive for all types of permeable pavement

Prefabricated modules

Maintenance of prefabricated modules such as soil support systems, proprietary stormwater treatment devices, or other standalone stormwater management practices will vary from product to product. All prefabricated products have O&M manuals from their manufacturers that detail specific maintenance and inspection requirements in addition to frequency and costs. In some cases manufacturers will offer to conduct annual inspection and maintenance activities for a nominal fee or offer maintenance training sessions for users. Prior to installing prefabricated modules, research the product's maintenance requirements and the manufacturer's offers with regard to maintenance and training. In general, the following sections provide relevant inspection and maintenance recommendations for prefabricated modules.

Precast tree planter inspection and maintenance

Similar to bioswales, bioretention, and enhanced grass swales, most of the routine maintenance activities of precast tree planters revolve around vegetation. All other maintenance issues are generally addressed through annual or seasonal inspections. Table 10.2.4 demonstrates the maintenance activities associated with precast tree planters.

Soil support system inspection and maintenance

Soil support system maintenance activities typically occur as part of other capital work projects in which proposed utilities and associated excavation activities damage the soil support systems. Inspect the units and remove and replace damaged ones.

Since these products are buried under permanent surfaces like asphalt or concrete, annual and routine inspections does not occur. Deficiencies or defects are usually noticed as a result of degradation or settling of the surface treatment caused by lack of support. Surface issues should trigger inspections. Those inspections will require surface treatment removal and support system excavation.

Table 10.2.4: Maintenance activities for precast tree planters

Maintenance activities		
Regular maintenance	**Annual maintenance**	**Long-term maintenance**
• Remove debris and litter from inlets and overflows • Replace damaged or missing catch basin grates • Trash removal • Pruning and weeding • Weekly watering during first year	• Remove large sediment deposits after spring melt • Mulch removal and replacement • Identify plant material stressed due to salt contamination. Replace dead vegetation as necessary • Add reinforcement planting to maintain desired vegetation density.	• Ongoing maintenance and inspections are complaint driven only • Inspect underdrains for clogging and clean as required via vacuum or high-pressure water sprayers • Evaluate soil media for performance. Remove and replace soil media as required

For more information regarding the maintenance and operation activities involved with tree pits, visit precast tree pit manufacturers' websites.

Proprietary stormwater treatment device inspection and maintenance

Proprietary stormwater treatment devices (oil and grit separators or similar devices) may not require annual maintenance. Generally, these devices are inspected on two occasions during the first year to determine oil and sediment accumulation rates. Subsequent inspection schedules are developed based on the accumulation rates. Table 10.2.5 demonstrates the inspection and maintenance activities associated with such devices.

Figure 10.2.6: Along with measuring sediment depth in a proprietary stormwater treatment device, check the outlet structure (if accessible). If the device is functioning as intended this sedimentation should not be occurring, unlike this device. (Source: Aquafor Beech)

Table 10.2.5: Inspections and maintenance activities of proprietary stormwater treatment devices

Activity	Frequency
Inspect sediment accumulation depths within treatment devices or sumps. If approaching capacity limits per manufacturer's specifications (generally 15%) remove via vacuum	Annually or following significant rainfall event (>25mm)
Examine the drainage area for bare soil. These areas should be stabilized immediately. Silt fence or other measures may be needed until the area is reseeded.	Spring (Onset of construction season)
Inspect units immediately after oil, fuel or chemical spill	As needed
Remove debris from inlets, pretreatments and overflows	Annually or following significant rainfall event (>25mm)

For more information regarding the maintenance and operation activities involved with proprietary stormwater treatment devices, contact local manufacturers or suppliers.

Enhanced proprietary stormwater treatment device inspection and maintenance

Due to the sophisticated filtering components of proprietary devices, you should conduct inspections for floatables and debris annually and perform full clear outs every three to five years or as needed depending on contaminate loading rates. Similar to typical proprietary devices, units should be inspected on two occasions during the first year following construction to determine oil and sediment accumulation rates. Subsequent inspection schedules are developed based on the accumulation rates.

Table 10.2.6 provides maintenance determination and associated maintenance activities for enhanced treatment variants.

To ensure proprietary stormwater treatment devices do not become clogged during construction:

- *Cover catch basins with geotextile fabric Examine the drainage area for bare soil. Stabilize these areas immediately. Silt fence or other measures may be needed until the area is reseeded.*
- *Install internal components once the site has stabilized. Housings should be clean prior to installation of internal components to prevent premature clogging.*

Table 10.2.6: Inspections and maintenance activities of enhanced proprietary stormwater treatment devices

Issues	Activity
Hazardous material or oil is present	Attempt to manually backwater cartridges or external rinse to regain performance. If unsuccessful, replace cartridges.
Greater than 12 inches (300 mm) of accumulated sediment at the bottom of the sump	Removal of accumulated floatable litter and sediment is performed from grade by inserting a vacuum hose or net downward into the maintenance access opening.
Three inches (75 mm) or more of standing water is present in the backwash pool during dry weather	Attempt to manually backwater cartridges or external rinse to regain performance. If unsuccessful replace cartridges.
Excessive floatables and debris are present	Removal of accumulated floatable litter and sediment is performed from grade by inserting a vacuum hose or net downward into the maintenance access opening.
The system has not been maintained for three years	Inspect units for performance. If inadequate, attempt to manually backwater cartridges or external rinse to regain performance. If unsuccessful replace cartridges.

Contact product manufacturers for more specific inspection and maintenance protocols.

Soakaways and infiltration chambers

Soakaways

Soakaways that receive runoff from parking lots and roadways should always be provided with suitable pre-treatment. Pre-treatment options such as leaf screens, proprietary stormwater treatment devices, filter strips, and grass swales provide filtration of debris and sediment from stormwater runoff. If these pre-treatment options are appropriately sized and designed, O&M tasks associated with soakaways will be cleaning these pre-treatment areas.

Maintenance of pre-treatment areas typically consists of removing leaves, large debris, and accumulated sediment. Soakaway pits that receive only roof drainage are less prone to clogging and do not require pre-treatment.

In facilities where monitoring wells have been installed, perform inspections to confirm that the soakaway drains within the maximum specified design time. If the system does not drain sufficiently, remediation works involving removal and replacement of granular material and geotextile fabric may be necessary. Sediment removal from perforated pipe underdrains may also be necessary via high-pressure sprayers and vacuum systems.

Infiltration chambers

Infiltration chambers typically include built-in inspection ports and sediment capture areas or isolator rows. Inspections are performed via an inspection port riser using a stadia rod to measure sediment depth. If sediment depth exceeds manufacturer's specifications for clean out, use a high-pressure sprayer with vacuum attachment. The frequency of this maintenance will vary based on system design and sediment loading from the site. The inspection port should also be used to confirm system drains in the maximum specified time after significant rainfall events.

Rainwater harvesting

Rainwater harvesting systems can be broken down into three component areas. All areas should be inspected on an annual basis. These areas include:

- The catchment surface: Roof area from which runoff is collected
- The conveyance network: The pipes and occasionally gutters that convey runoff from the roof to the storage area
- Reservoir area: The tank area, where water is stored until the pump is initiated due to a demand

Maintenance activities typically associated with rainwater harvesting systems include removal of sediment from settling chambers and filters and removing debris from screens, pump maintenance, and conveyance system repairs of valves and joints. The frequency of maintenance on filters and screens will depend on site-specific conditions including the size of the roof and pollutant loading. Include inspections of all components into the annual O&M schedule. For prefabricated rainwater harvesting designs, the manufacturer will specify maintenance items. Prefabricated rainwater harvesting systems are often under warranty by the manufacturer for at least the first year.

Landscape alternatives

With landscape alternatives maintenance programs must be implemented with an understanding of the long-term plan for the landscape. These objectives can serve as the basis for developing a landscape maintenance program:

- Promote the succession of naturally occurring species and associations.
- Support the process of natural succession.
- Manage for the control of non-native invasive or undesirable species.
- Manage to ensure public safety with respect to preservation of sightlines, removal of hazards and control of noxious species.
- Ensure that the primary stormwater management function of the facility is achieved.

With respect to the landscape components of LID techniques, inspection and maintenance activities focus on gauging the sustainability, performance, and evolution of the vegetation community to identify remedial maintenance activities. Table 10.2.7 provides a description of the recommended vegetation community inspection activities.

Maintenance activities of vegetation communities within LID practices include, but are not limited to:

Tree and shrub maintenance

- Adjust stakes and guys to prevent girdling.
- Ensure rodent protection remains in contact with the ground.
- Prune out any dead or damaged limbs.
- Water trees to maintain health as required.
- Top off mulch to ensure soil moisture is maintained.

Seeded area maintenance

- Monitor after initial seeding to ensure that adequate cover density has been achieved.
- Overseed to eliminate bare patches as required.
- Repair and reseed any rills or gullies that may form during the grow-in period.
- Remove weeds that have become established during the germination and grow-in periods.
- Monitor to ensure that established species correspond with specified seed mix species composition. Overseed to achieve specified composition and distribution as required.
- For areas designed to be maintained, mow to maintain a height of 60-75 mm.
- Irrigate seeded areas to ensure germination and establishment as required.

Shrubs and shrub bed maintenance

- Prune dead or damaged branches.
- Remove weeds from mulched beds.
- Water shrubs to ensure healthy growth in consideration of soil, meteorological and site conditions as well as species requirements.

Table 10.2.7: Vegetation community inspection activities

Vegetation community	Inspection description	Frequency
Trees and shrubs	Visual inspection to identify dieback, stress or presence of disease.	Biannually: Spring - after leaf out Fall - after leaf drop
Aquatic vegetation	Visual inspection to confirm desired species composition.	Annually (mid-summer)
Groundcover	Visual inspection to confirm adequate	Biannually: Spring - after leaf out Fall - after leaf drop
Presence of noxious weeds/ invasives	Visual inspection to identify undesirable species and requirements for control	Biannually: Midsummer and early fall

11.0 Tracking and Reporting Your Post-retrofit Successes

A successful LID retrofit will provide a number of economic, environmental, and social benefits for you and the wider community. To properly promote your successes to customers, residents, clients, employees, and other groups, it is important to track indicators of success on your site. Promoting a successful LID retrofit project is essential for continued support and builds support for implementing further sustainability initiatives on your property.

It is likely that you are already tracking and reporting on many of these indicators through annual reports or other metrics tracking tools. You can conduct the tracking strategies recommended in these sections with little additional effort.

Condominiums

Condominium boards must answer to owners of individual units who pay condominium fees. These owners will want verification that their decision to implement a LID retrofit was well-founded. If you are the project manager of a retrofit on a condominium site, you will want to present the condominium board with proof that the benefits targeted during the planning phase are now being achieved.

Environmental sustainability is a selling feature of many new condominiums. Older condominiums looking to improve property value and maintain or attract preferred tenants may want to promote energy reduction (reducing carbon footprint) and water stewardship (water conservation and improved stormwater management). Make the link for current owners

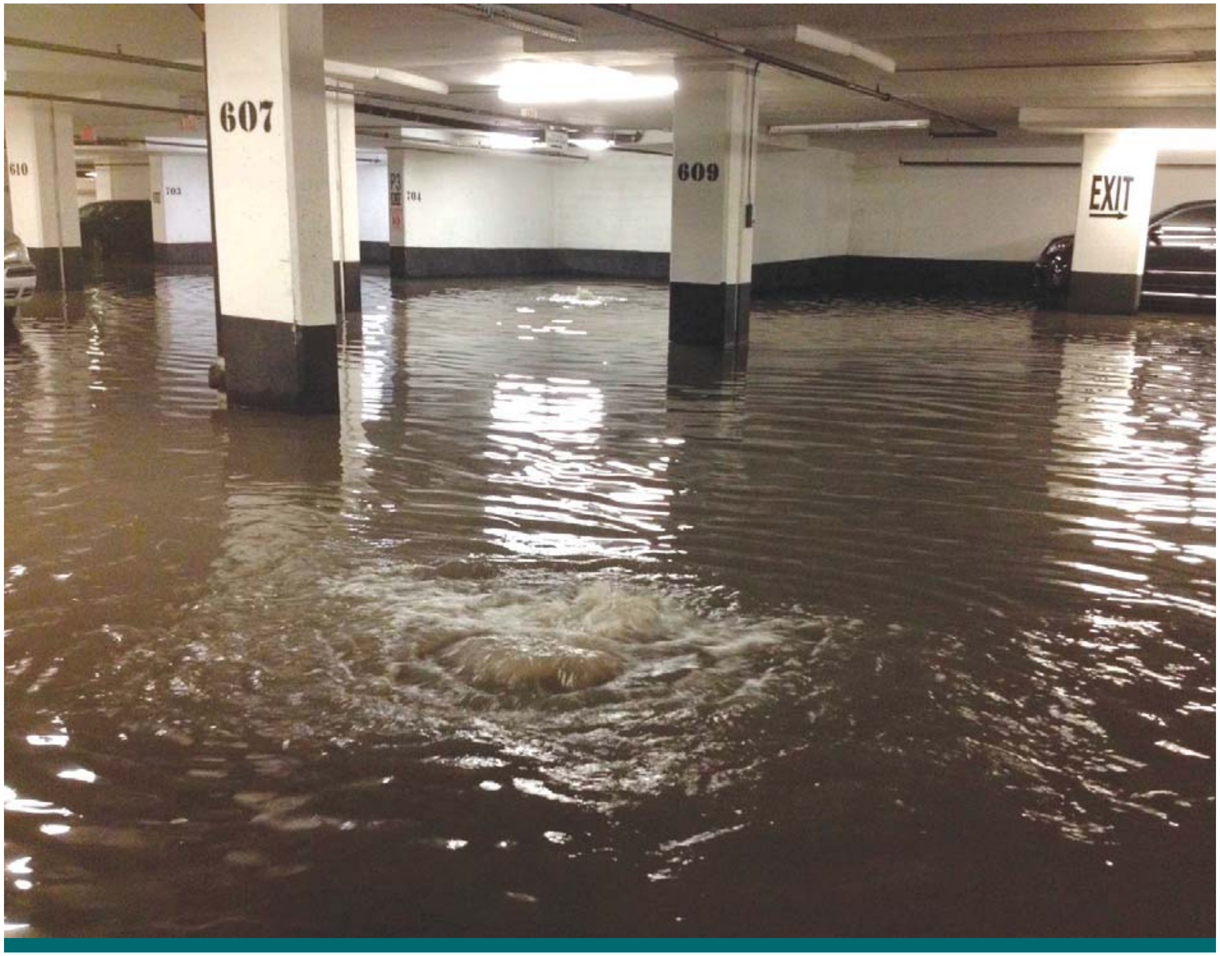


Figure 11.0.1: Reducing risk is another indicator of project success. An apartment building in Mississauga was evacuated due to structural deficiencies as a result of the July 8, 2013 flood. Improved site drainage can prevent costly infrastructure failures and may avoid insurance premium increases. (Source: CVC)

and prospective buyers—how are LID retrofits saving costs and keeping condominium fees low? Tracking and reporting those savings is essential.

Apartments

Residential land management companies that rent apartments will be looking for indicators demonstrating that LID practices are saving money and providing the company with a competitive advantage in the long-term. You will lay the groundwork for future retrofits on other properties by providing positive indicators from your retrofit site.

Highlight operations and maintenance savings if they are applicable to your apartment property retrofit. Even small property maintenance cost savings, such as reduced salt application on pavement or reduced grass cutting as a result of landscape alternatives, can equal significant cost savings when applied across multiple properties. If there is a noticeable uptake in occupancy rates after the retrofit, make note of it, because it will positively affect long-term profitability.

Small and medium commercial sites

If you run a small or medium commercial enterprise, you must maximize the efficiency of your staff, financial, and site resources to survive in a competitive marketplace. Comparing financial indicators before and after a LID retrofit will help you determine whether the retrofit was a reasonable financial decision and help you decide whether to retrofit other areas of the property.

Commercial sector indicators can include trends in the number of slips, trips, and falls in a retrofitted parking lot. Reducing the number of accidents on site can result in reductions to your commercial liability insurance.

Has an LID practice that also beautifies your site increased your business? Tracking customer activity after a highly visible LID practice is installed can provide valuable information on customer preferences.

Another important benefit for commercial sector properties is the reduction in unexpected closures as a result of reduced susceptibility of site stormwater infrastructure to failures from extreme weather. If your business is no longer forced to close during heavy rainfall events and their impacts (flooding, power outages, site damage, etc.), be sure evaluate the positive economic impact.

Large commercial enterprises

After the completion of a large commercial property retrofit, be sure to present cost savings and indictors of competitive advantage to property management company representatives and investors.

These cost savings may be the result of municipal stormwater incentives programs and reduced operations and maintenance expenditures. Competitive advantages can be the result of increased lease retention and less susceptibility to property closures as a result of flooding and associated hazards. Signs of LID retrofit success also include increases in property value.

Figure 11.0.2: This shopping centre was forced to temporarily shut down due to significant urban flooding. In addition to lost business, flooding can result in the loss of goods. Improving drainage and reducing the amount of impervious surface could help alleviate urban flooding in this area. (Source: CVC)

Industrial properties

If you have used pollution prevention techniques on your industrial property, one of the most obvious benefits is the reduced risk of fines and costly cleanup procedures after spills. Reducing the number of spills also makes your industrial property a safer place to work. When reporting on financial benefits to company representatives, shareholders, and clients, be sure to highlight insurance incentives resulting from the reduced risk of spills.

Changes to site layout, equipment, and procedures for handling materials on your site to reduce environmental

Figure 11.0.3: Fines can significantly impact the profitability of industrial operations. Implementing pollution prevention measures can reduce fines and lower cleanup bills. (Source: CVC)

risk may also save money. For example, the properly containing de-icing products and introducing a more efficient application will reduce losses of these materials. Additionally, products and raw materials stored indoors or in containment areas are not prone to weathering caused by rain and freeze-thaw cycles.

Colleges and universities

If you have completed a retrofit on an institutional property, board members will want to hear about the indicators of project success. These indicators can be used to promote the facility or to sustain support for further implementation on the site.

Many of the retrofit options for institutional sites can beautify public spaces like courtyards, building entrances, and other amenity areas. If people appear to be using these features as a result of the LID retrofit, make note of the positive change in your report.

Due to the large property sizes of most institutional sites, operations and maintenance savings can be substantial. For example, a retrofit could reduce the need to mow an area or maintain a parking lot. Be sure to highlight these cost savings when you are reporting the success of your project.

Measuring project success

Where possible, measure indictors of project success in a quantitative manner. Table 11.0.1 provides several indicators of project success and guidance on how to track them.

CVC offers many training programs in these areas:

- *Design*
- *Construction*
- *Operations and maintenance*
- *Monitoring*

For more information on our training programs, please visit Credit Valley Conservation's (CVC) Be a Leader website:

bealeader.ca

Table 11.0.1: Indicators of LID benefits

	Benefit	Indicators
Minimizing your risk	As a private business or institution, you will pay several types of insurance, including policies that cover property, liability, and commercial automotive, as well as paying into Workplace Safety and Insurance Board premiums. If your retrofit project reduces the risk of on-site injuries to workers or the public, mitigates the risk of environmental damage, or reduces the occurrence of property damage from flooding, it is likely that your insurance rates will be reduced. In some cases insurance companies offer rebates to customer upon the completion of projects that reduce site risk. Others may reduce rates after a period of time without claims.	• Increased number of days without an accident • Reduced occurrence of hazardous spills • Fewer slips, trips, and falls • Reduced occurrence of onsite urban flooding • Reduced product/materials/equipment write-offs due to flooding • Reduced occurrence of WSIB claims
Competitive advantage	LID stormwater management practices that prevent onsite flooding can allow your business to stay open when others are forced to close. LID retrofits may also attract customers or tenants to your business by providing a more desirable green setting to work, visit, live or shop.	• Reduced occurrence of forced closures as a result of urban flooding • Increased lease retention • Increased number of customers • Increased customer satisfaction • Reduced employee sick days taken • Increased employee retention
Operations and maintenance cost savings	Saving time and cost associated with operations and maintenance is a benefit of many LID options. To determine annual cost savings, should continue to monitor the cost of equipment, time, and materials necessary for these tasks after implementation.	• Decreased time spent and gas used for mowing (landscape alternatives) • Decreased potable water used for irrigation (landscape alternatives, rainwater harvesting) • Reduced usage of de-icing products (permeable pavement, pavement reductions to landscape alternatives)
Construction cost savings	Compared to conventional site rehabilitation, there may be cost savings associated with the retrofit of LID stormwater alternatives. Savings are typically associated with reduction in sizing or elimination of conventions stormwater infrastructure such as storm sewers, catch basins, and onsite water quality units.	• Reduced materials and construction cost when compared to conventional rehabilitation alternatives
Energy savings	The most significant energy savings that LID retrofits can achieve are associated with green roofs. These systems provide insulation which reduces the demand for air conditioning and heating. Green roofs cool your building during the summer via the process of evaporative cooling. You may want compare the cost savings on a seasonal basis to determine when the largest savings are achieved.	• Reduced utility bills
Property value	LID retrofits can significantly increase the value of your property. This is a major benefit when it comes time to sell your business or condominium unit. Properties in Ontario are assessed every four years by the Municipal Property Assessment Corporation. Assessments consider renovations and additions to the property. Increases in value cannot be attributed to a LID retrofit solely, but comparing your assessment to trends in the area can help determine the impact of the retrofit.	• Increased property value upon assessment • Increased property value when selling • Comparisons with similar properties in your area
Municipal stormwater incentives	Some municipalities, offer stormwater incentives for reducing the impervious cover on your site and providing quality and quantity control. These fees typically appear on your water bill. Comparing costs is as simple as comparing pre-retrofit bills to post-retrofit bills.	• Reduced municipal stormwater utility fees

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