



Lessons Learned in Low Impact Development Construction For Contractors



Stormwater Retrofits

This case study will save you time and money outlining lessons on:

- Planning and communication
- Protecting infiltration areas
- Grading
- Materials
- Other construction considerations

Lessons Learned

- Spending time up front to plan out the construction process and encouraging regular communication can save you time when construction is underway.
- Problems such as clay soils mixing with bioretention soil media, concrete trucks washing out in or near an LID infiltration area, or garbage around the construction site can all have an impact on the functionality of the LID feature.
- Landscaping at LID sites provides treatment of the runoff as well as creates visual appeal. As this is the most visible component of LID design, it is important to have it done well.

LID Practices



Introduction

Your clients (municipalities) are facing many stormwater challenges, including aging and deficient infrastructure, frequent extreme weather, flash flooding, and degrading water quality. Although your clients are relying on stormwater management ponds for flood control and water quality treatment, they are also looking at Low Impact Development (LID) as a way to shore up their stormwater management strategy. If you are unfamiliar, LID is a growing market in stormwater management for land development that aims to manage rainfall where it lands allowing it to soak into the ground taking pressure off the storm sewer system reducing volume and pollutant loading. Some examples of LID that you may be familiar with are: vegetated roofs, soakaway pits, rain gardens, rain barrels or bioretention.

LID is currently being implemented across Ontario, Canada, and North America. To stay competitive, it is important that you and your company understand LID function and construction to deliver a quality project on time and within budget. A thorough understanding of the LID practice can save you time, costs, materials and hopefully a few headaches.

Although LID is relatively new to Canada, it shares commonalities with stormwater management ponds common to new development that you may have experience with. Some commonalities between LID and stormwater management ponds include:

- Both will encounter common construction challenges ie. wrong materials delivered or delayed
- Both need to be constructed to the design provided
- Both can be constructed for new development
- Both must use proper erosion and sediment control (ESC)
- Both will have inspections and as-built surveys to verify the practices are built to design
- Both will require maintenance during the warranty period

Some of the ways in which LID is different from stormwater management ponds and other end-of-pipe features are as follows:

- LID requires some changes to standard construction practice, such as sequencing
- LID does not require a lot of land space, they are distributed small scale practices

- LID infiltration practices need to be protected from contamination and compaction during construction
- LID may require additional ESC as construction activities change or as the inspector sees its needed
- LID features have unique materials that cannot be substituted and must be installed as specified
- LID landscaping must meet or add to the surrounding landscape aesthetic
- LID vegetation serves both a functional and aesthetic role

Both stormwater ponds and LID projects will have their construction challenges. From recent surveys, almost half of all stormwater management ponds surveyed are not being constructed to design in Ontario¹. Similarly, in areas outside of Ontario where LID application is more wide scale, surveys have found that LID is also not being constructed to design².

There is growing provincial and municipal awareness of risk and liability of improper performance of stormwater management systems. As a result, municipalities and stakeholders are paying closer attention to assumption inspections to reduce risk and liability and ensure performance³. To help each other out, CVC since 2008, has worked with contractors and suppliers throughout the watershed to assist in the construction of over 52 LID sites and has learned many lessons along the way. The following case study outlines these lessons about LID construction. By understanding these lessons, it will help you to properly construct an LID feature and:

- Minimize time spent on site
- Minimize design drawing assumptions on site
- Minimize site deficiencies
- Minimize costly repairs
- Minimize material waste and replacement over the warranty period

Given pressure for contractors to ensure stormwater management features are functioning as designed, this case study along with CVC's *LID Construction Guide* and CVC's Construction Course *Making It Work: How to Properly Construct Low Impact Development Stormwater Management* you can gain a

¹ Lake Simcoe Region Conservation Authority (LSRCA). 2011. Stormwater Pond Maintenance and Anoxic Conditions Investigation - Final Report. http://www.lsrca.on.ca/pdf/reports/stormwater_maintenance.pdf (accessed May 27, 2014)

² Hirschman, D., Woodworth, L., Drescher, S. 2009. Technical Report Stormwater BMPs in Virginia's James River Basin: An Assessment of Field Conditions & Programs. Center for Watershed Protection

³ Zizzo, L., Allan, T., Kocherga, A. 2014. Stormwater Management in Ontario: Legal Issues in a Changing Climate

good understanding of how to ensure a LID project is successful throughout the construction process.

Let's Learn from Each Other

We want to hear from you if you've encountered any challenges during your LID project and how you overcame them, please send your lessons learned to sustainability@creditvalleyca.ca

Tools and Resources - Through our experience with LID projects, CVC has developed:

- *Low Impact Development Stormwater management Planning and Design Guide* (particularly *Appendix B: Landscape Design Guide for Low Impact Development*)
- *LID Construction Guide*
- *Grey to Green LID Retrofit Guides*
- *LID Case Studies*
- *CVC's Stormwater Management Certification Protocols*
- *CVC's Making It Work: How to Properly Construct Low Impact Development Stormwater Management*

See www.bealeader.ca to download guides and learn about upcoming LID training workshops.

Construction

Any construction project has its challenges. You will find that the characteristics and challenges of good construction for a stormwater pond are the same for LID projects. However, you may have more initial challenges if you have not completed an LID construction project before. But that's ok, that is why this case study and the *LID construction guide* is available. We want to help you and the whole contractor community with LID construction. The following sections will detail issues and solutions when constructing LID practices to help you avoid the mistakes CVC has made.

Planning & Communication

- Sequence construction effectively
- Encourage communication during construction

Protect the LID Project Area

- Use signage and fencing
- Designate routes for heavy equipment and wash-out areas for concrete trucks
- Maintain a clean workspace

Grading

- Ensure grades meet design specifications
- Ensure paving direction is consistent with flow paths to LID features

- Ensure positive flow to the LID feature
- Ensure fine grading of soil is performed after the plant materials and mulch has been laid down.

Materials

- Avoid equipment or material substitutions
- Ensure bioretention soil media meets specifications
- Have a designated material storage area
- Use of new curb standards

Other Construction Considerations

- Work around unmarked utilities

Landscaping

- Choose the best time to plant
- Maintain final grades throughout landscaping
- Inspect plants and use proper planting practices

CVC's *LID Construction Guide* and future *Contractor/Inspector LID Construction Handbook* provides comprehensive detail and guidance on LID construction. Stay tuned to www.bealeader.ca

Planning & Communication

Similar to any construction project, it is important to develop effective construction and communication plan at the beginning of the LID project. Spending time up front to plan out the construction phases and communication process can help the project run smoother, especially when the LID project is probably new for yourself or many of your laborers. The follow sections will look lessons learned that include:

- Sequencing construction effectively
- Encouraging communication during construction

Sequence Construction Effectively

CVC has been involved with a number of LID projects. When poor sequencing takes place it can affect quality of work, project duration, and success. When providing timeline estimates to your client, it is important to account for poor weather, material delays and any other typical challenges you encounter. When timelines are tight, it can lead to corners being cut or labor costs adding up to meet the project deadline. Giving yourself and your crew sufficient time to complete a project will help to ensure that manufactured materials and construction are built to specification.

Poor sequencing can also cause materials to be moved unnecessarily or sit on site for extended periods. LID features can be clogged easily by dirt. Remember, the purpose of several types LID features is to filter and absorb water into their soil and gravel

layers below the surface. Thus, their success hinges on the integrity of these specified soil and gravel materials such as, ¾" clear stone or bioretention media. If these types of materials sit at the construction site for longer than two days, there is an increased chance of materials being contaminated, and made unusable. Once materials are contaminated they can no longer be used within the LID feature.

To help avoid costly mistakes, consult with the client or inspector and develop a material schedule as to when materials are to be ordered and delivered to site. When on site, pay careful attention to any specified materials being delivered, and when it will be installed. Also, make sure you and your client confirm appropriate material storage areas, in order keep specified materials like bioretention media or ¾" clear stone separate from other landscape materials (ie. top soil).



Poor construction sequencing can cause materials to be moved multiple times.

If delays are expected, ensure that you account for any additional erosion and sediment control measures to protect both the LID features and construction materials. The use of filter cloth to wrap or cover infiltration areas is a quick and effective practice.

Encourage Communication during Construction

In addition to construction planning, regular communication between you, inspector, sub-contractors, landowners, site users, and general public can help to eliminate many potential hiccups during the construction process. When all parties involved are kept up to date on project developments, there is less potential for overlap, errors, misunderstandings, and costs.

It is recommended that construction meetings are held on a routine basis. This ensures that all parties are on the same page. Everyone will be up-to-date on the status of the project (i.e. what has been completed, projected timelines etc.) These meetings can also serve as training and education sessions to ensure that your workers are aware of critical project elements, such as the protection of infiltration areas, avoiding any potential problems. It is critical that messages move down from your client, yourself, to your laborers.



Involve residents in public information sessions to educate homeowners on plant choices and maintenance practices

CVC's documentation of a LID parking lot retrofit site found construction meetings were extremely helpful. This particular parking lot needed to remain open to use throughout the construction process for employee parking. The parking lot had to be built in phases, with one portion remaining opening while other portions were under construction. Regular construction meetings allowed the contractor, project manager, and the landowner to coordinate appropriately. This ensured that there was always space for employees to park and that site owners could communicate with employees regularly about construction status.



Communication can help to eliminate problems before they happen at construction sites

For your liability, keep a record of communications during the construction process. This record should include meeting minutes as well as emails and telephone conversations. Having a physical record of what was said between project managers, yourself, workers, and site owners can help to eliminate confusion and misunderstandings.

If your LID project is near a residential area or at a public site, expect interaction with the public. As the public are primary users of these spaces, they have a vested interest in understanding what is happening, what is the purpose, and how long construction will affect them. A LID road retrofit led to several confrontations with residents during the construction phase. To make things easier on yourself, in addition to public meetings and signage, have a list of contacts ready that can direct the resident to appropriate staff if you cannot provide the right information.

Protect the LID Project Area

Often you may have used a stormwater pond as a temporary sediment trap during construction. Although that is possible with some types of LID, it should be avoided due to the sensitive nature of LID infiltration practices. In general, it is extremely important for your LID features to be protected from sediment. If sediment or dirt gets into the LID feature, it can reduce performance, cause failure, lead to a work stop order and costly repairs to correct the matter. ESC will play a major factor until final vegetation is established. An adaptive ESC plan is critical and review of it is important. Apart from construction sediments, you also need to consider the impact of construction activities. Heavy equipment driving into the LID project area, the location of concrete trucks wash out, stone cuttings and dust, and garbage around the construction site can all impact the function of the LID feature. If the LID feature gets clogged up, repair is needed to remove clogged materials costing money and time. Consider the following lessons learned to help you along:

- Use signage and fencing
- Designate routes for heavy equipment and wash-out areas for concrete trucks
- Maintain a clean workspace

Use Signage and Fencing

One way to help protect the infiltration area is through signage and fencing. In the figure below, using signage that is clearly marking the infiltration area is a simple and easy way of protecting the LID feature.



Fencing and geotextile protecting infiltration area

Signage combined with temporary fencing can provide further protection to infiltration areas. Fencing reduces access to both workers and equipment and creates a small buffer between the feature and the storage of materials.



Two underground soakaway pits protected and fenced off

Designate Routes for Heavy Equipment and Wash-Out Areas for Concrete Trucks

Concrete trucks and heavy equipment can impact your LID feature by tracking dirt, compacting soil and washing out in or near your infiltration area. To minimize impacts of heavy equipment and concrete trucks, two methods were used.

The first method was to designate separate routes for heavy equipment. At an LID parking lot retrofit, a large permeable parking lot required protection from dirt and dust during construction. A route was mapped out and explained to drivers of large vehicles. The route prevented both trucks and heavy equipment from driving on the large permeable paver parking lot and prevented both compaction and tracking of materials.



Routes on construction sites should be developed for heavy equipment to avoid transferring dirt into permeable pavers or other infiltration practices.

The second method was designated wash-out stations for concrete trucks. Without a designated area, most drivers will wash out their trucks in the closest area of convenience. At an LID road retrofit a concrete truck was washed out by the sub contractor adjacent to an infiltration area. Concrete washout can clog infiltration areas and impact the performance of the LID feature. In the image below, the inspector had the driver clean up the washout before it drained into the LID feature.



Cement truck washes out in an undesignated area.

Some trucks now have an on board chute washing system that captures any washout and pumps it back into the barrel (see picture below). If space does not exist for a designated washout, check with your concrete supplier to see if their trucks have an on board chute washing system.



Sub-contractors using a chute-wash system with no concrete runoff

Maintain a Clean Workspace

Due to the sensitive nature of LID infiltration areas, it is important to keep them clear of dust, dirt or debris. Thus, designated working areas may need to be provided to ensure that tasks can be completed without affecting infiltration areas.

In the photo below, the contractor cut permeable pavers on top of the LID feature. Both cuttings and fine dust can clog infiltration areas as its flows downward. Cutting pavers in place has been noted at several sites. It is recommended that permeable pavers be cut away from the LID feature. You can also install a temporary sacrificial piece of filter cloth underneath to capture any of the cuttings or dust.



Permeable pavers being cut and trimmed in place creating a fine dust

Grading

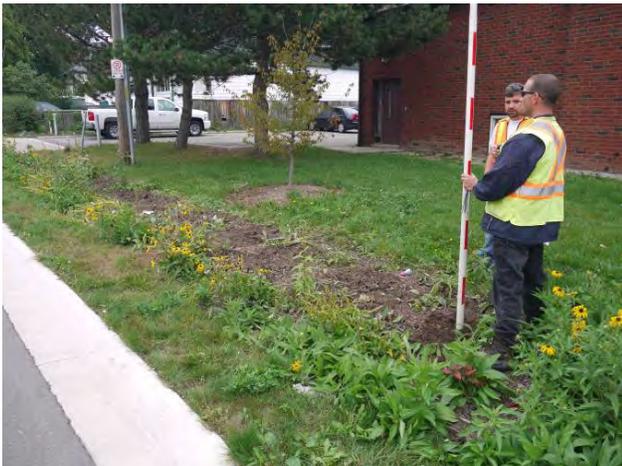
Often in new development, you may have one or two central stormwater management ponds from which surface and sub-surface grades are directed to. However, achieving designed grades with multiple distributed LID practices in can take more time and effort. Specified grades also do not always account for

unforeseen variables such as soil compaction or the addition of landscape materials. Proper oversight and verification of grades by surveying regularly is critical. The following will discuss some of the challenges you may encounter with grading during your LID project that CVC has encountered:

- Ensure grades meet design specifications
- Ensure positive flow to the LID feature
- Ensure paving direction is consistent with flow paths to LID features

Ensure Grades Meet Design Specifications

Grading is a critical element to the success of an LID project. Improper benchmarks or infrequent surveying at hand off points in the construction process can impact the LID features functionality or aesthetics. It is important that the site is surveyed regularly and properly during the construction phase.



Improper grading of bioretention cell hinders runoff from distributing to the entire cell, or bypassing it completely.

Changing grades after construction can cost you money and time. At one LID construction project, grades were assumed correct as it was handed off from the contractor to the landscaper. After planting, issues arose with blocked inlets and short circuiting. When the mistake was discovered through an as-built survey, plants had to be dug up and the site re-graded to meet correct grades. This wasted both time and money for the contractor. If the surveyors checked grades during rough grading and fine grading, re-grading could have been avoided.

Ensure Positive Flow to the LID Feature

LID practices depend on unobstructed flow for optimal performance. Grass is often used as a filter strip. Filter strips remove debris and dirt from water before entering the LID feature. As pre-filter strips are applied (sod strips), you must ensure that a positive grade or the design grade remains from the

inlet through to the infiltration area of the LID feature.

At the site pictured below, the pre-filter sod strip was too high creating a blockage at the inlet. The consultant and contractor expected settling to occur. However, settling did not occur and runoff was unable to flow into the LID feature. The pre-filter sod strip had to be lowered and the practice regraded to ensure positive flow and appropriate pond depth.



Height of sod blocks flow into the bioretention cell.

Ensure Paving Direction is Consistent with Flow Paths to LID Features

LID features have been used extensively in treating parking lot runoff. An important step prior to parking lot LID project begins is to consider flow paths to drainage features. Paving direction can impact flow paths towards the LID features. An incorrect paving direction (perpendicular to flow) can inhibit flow into the LID features. When water ponds, it prevents runoff from flowing into the feature and can create slip and fall hazards in the winter time. This can ultimately put you at risk of liability or require costly repairs.



Improper paving direction causes ponding in a parking lot during the original base coat

In the picture above, following the installation of the asphalt base coat, ponding was observed. The

ponding was due to the very mild slope (0.5%) of the parking lot. This caused a minor lip to form with each pass of the paver machine. This is typically not an issue for surfaces with slopes >1.0%, but in this case it caused water to pool throughout the parking lot. Prior to the final asphalt layer, ponding areas were marked on a parking lot map so that the contractor was well aware and could provide a thicker application of asphalt.

Materials

Incorrect choice of material is often a design issue, but can sometimes occur during the construction phase as different materials are substituted from the original design. LID unlike stormwater ponds, typically have several material component layers, particularly if they are an infiltration practice providing water treatment or storage. Use of the wrong materials or materials that do not meet specification can have direct impacts on the functionality of the LID practice. Correcting the matter can cost time and money.

There are several reasons why incorrect materials may be used during the construction phase:

- You may not be able to find the product specified in the design in the time frame needed
- You may substitute material with a product you are more familiar with
- You may find an alternative that may seem similar to the specified product or provide similar functionality

Although these may be good reasons, we want you to avoid this at all cost. The following section will provide the reasons why.

Avoid Equipment or Material Substitutions

Several LID practices are infiltration practices that rely on clean gravel sub layers such as ¾" clear stone and high performance bedding (HPB). Many LID designs call for clean wash stone placed within the practice. This is particularly common in bioretention cells and permeable pavement designs. These stones are installed to store and filter drainage within the LID feature. Double wash stone should always be used, as it includes less fine material than single wash stone. In the picture below the contractor accidentally received single wash stone. While the single wash stone can still be effective, it can clog much faster than the double wash stone leading to reduced performance of the LID feature.



Single washed stone on the right has more fine material than the double washed stone on the left.

Ensure Bioretention Soil Media Meets Specifications

Many types of LID practices will use a bioretention soil media. Bioretention soil media is essentially a predesigned soil mixture of sand and compost mix that support plant life and allow for good infiltration. LID bioretention media needs to meet specification to ensure good infiltration and the ability to support healthy plant life. Typically it takes several attempts for manufacturers to meet engineer soil specification. Often the manufacturer hand mixes first and then determines how to mechanically mix the specified soil mixture. The manufacturer must complete a soil analysis test to ensure that the mixture meets specification and this takes extra time to complete.



Media delivered on site should always be tested whether they meet the same specifications as the test samples

The soil analysis test ensures that the mixtures meet the standards outlined in the *Low Impact Development Stormwater management Planning and Design Guide*. Lab analysis will look at the ratio of:

- Sand
- Fines
- Organic material
- CEC
- pH

In some cases, several samples need to be tested to ensure that the bioretention media has been mixed to specifications. Manufacturers must be given ample time in order to create a properly mixed product. It is recommended that material be tested prior to delivery at the manufacturing plant, as well as on the construction site. If you start the process early on in the project and give the supplier ample time to create the mixture, you will stay on time and on budget while saving yourself the hassle of scrambling at the last minute. The soil should also be installed from the outside in, with a slinger truck (as seen in bottom photo of next column). Heavy equipment and foot traffic should be minimized once the soil is installed.



Bioretention media that did not meet specification ponding



Photo above: Excavation and replacement of incorrect bioretention soil media



A correct sample brought on site to verify delivered media

If the bioretention media does not meet specification once installed, it can lead to failure of the LID feature. In the picture below, soil analysis was not completed prior to installation. However, the LID feature failed to infiltrate runoff ponded over a 24 hour period. Later analysis showed that the bioretention media failed to meet specification. It was removed, along with plant material and reinstalled which was both time consuming and costly for the contractor.

Have a Designated Material Storage Area

As noted in construction sequencing section, a designated material storage area should be set aside at the beginning of construction. We recommend that material should be used as soon as it arrives on site, however it is not always possible. Without designated storage, it is easy to contaminate materials like bioretention media or incur extra costs as material is damaged by onsite construction activities. At a road retrofit project, material storage areas were provided but changed locations. This led to materials being accidentally mixed therefore becoming unusable for the LID feature. It is critical that you properly designate any LID material storage areas to prevent costs due to material contamination and loss.



Designated material storage areas should ideally be covered from potential contamination

Use of New Curb Standards

LID road right of way retrofits will typically include replacement of a standard curb with roll curbs and curb cuts. Design drawings will call for a specific curb height that you must adhere to. Curb height has an impact both on the visual appeal of the final product, as well as final grading. This can impact the function of a site significantly, as flows may not be conveyed properly and assumption requirements will not be met.

At one right-of-way site, the design called for a 2" rounded OPSD curb mold. The sub-contractor was unable to find and inexperienced with the specified mold in the 2" size, and ordered a 4" curb mold instead. The increased height of the curb forced a change in grading so that the grass would not sit below the curb line.



4" curb standard used instead of 2" creating grading issues at this right-of-way retrofit.

Curb removal can be costly. Take the time needed to locate appropriate molds or ask your client for an appropriate alternative.

Other Construction Considerations

Stormwater management ponds typically are built strictly with new development. Ponds require large parcels of land to meet design volume requirements. LID being small scale and distributed in nature is often used in retrofit situations to enhance the stormwater management of existing development. CVC has documented LID features installed in areas with development that is 80 to 90 years old. As such, challenges may arise when working in older development areas.

Work around Unmarked Utilities

Often LID projects are installed as retrofits, with utility locates typically acquired during the pre-design stage to ensure that construction does not interfere with pre-existing utility lines. Ideally, LID designs will avoid utilities, as moving them can prove quite costly. However, unmarked utility lines can end up being exposed during construction. When this happens, the consultant, contractor, inspector, and supervisor must determine an alternative solution quickly to prevent delays.



Unmarked fiber optic utility lines exposed during construction

Landscaping

LID landscaping provides water quality treatment and visual appeal to the site. The landscape needs to be designed to account for time of inundation of both drought and moist conditions. In addition, the overall look needs to either meet or improve the existing overall look of the site and surrounding area. If you do not have the expertise of planting or maintaining LID landscapes, we recommend that a landscape professional be involved. By involving a landscaper, you can avoid the challenges of maintaining landscapes in extreme growing conditions and with high aesthetic standards that require frequent maintenance visits. Overall, LID landscaping is the

most visible component and it is important to have it done well. If you have LID landscape experience or want to garner that experience, pay attention to the following lessons that CVC notes which are:

- Choosing the best time to plant
- Maintain final grades throughout landscaping
- Inspect plants and use proper planting practices

Choosing the Best Time to Plant

In order for vegetation to have the best chance for survival, planting should take place during the spring or fall months. High heat and lack of rainfall during the summer months can adversely affect plant life.

At one LID site pictured below, the plants were installed during a significant summer drought period. This made it very difficult for the plants to establish, as they were not receiving enough water. Even drought tolerant plants require water, especially during their initial 2 years in order to establish roots. A plan must be made to ensure that plants are watered regularly if they receive no rain during the establishment period. If you hold the warranty on the plants, it will be your responsibility to replace any dead material.



Bioretention cell during a summer drought

To avoid that challenge, planting in the spring and fall is highly recommended. By planting in the cooler, wetter months you will avoid added cost of watering and replacing dead plants. Speak with your client if you foresee planting taking place in the heat of June, July or August to determine the appropriate action is taken, such as delaying planting or ensuring a watering program is in place.

Maintain Final Grades throughout Landscaping

As discussed in the grading section of this case study, grade is a critical component to the success of an LID practice. Grades can be adversely affected

during the landscaping process. Soil, sod, plantings and mulch can all affect grade whether you are doing the landscaping or not. You must be made aware of the grading requirements prior to planting. This will ensure that the proper grading that has been designed and constructed is not altered during the landscaping process. If grades are altered, this can impact how water enters and flows through the LID feature. Corrections to grade can be costly if plants and soil need to be removed.



Grades can be altered by soil, sod, plantings, or mulch

Inspect Plants and Use Proper Planting Practices

Prior to planting, the nursery stock should be inspected to ensure all plants are in good health. You should also verify that the right plant species was delivered. The nursery stock should appear well watered and leaves should be green. They should also show no signs of disease.



Properly planted site with careful consideration of plant choice

Plants should be removed from their containers prior to planting. Planting in plastic containers or failing to remove the top of wire basket and burlap will restrict the growth of the plant by blocking the roots.

Planting to the proper root depth is an important part of planting practices. If plants are placed too shallow, roots will not have enough soil depth to establish themselves. If the plants are placed too deep in the soil, they will suffocate. Different plants have different soil depth requirements, so it is important to be familiar with what you are planting and what resources they will require. The soil can also settle after digging so plant a little higher to account for this.

Once plants are placed, soil will need to be compacted around the plant. If soil is not compact enough, it will leave air pockets. Air pockets around roots can hinder their growth.

Plants should be watered immediately after they are planted. Following the initial plantings, they must continue to receive water regularly in order for them to establish. Depending on the selection of plants, this could be weekly or biweekly.

At some LID sites, poor planting practices have led the majority of plants to die out. Since these plants make the site look nice and treat the water, they had to be replaced. It is important to follow proper planting practices, and be knowledgeable about the requirements of the plants that are installed at the site. This will ensure that no extra cost is incurred from replanting.

For more information on landscaping see CVC's *Low Impact Development Stormwater management Planning and Design Guide* (particularly *Appendix B: Landscape Design Guide for Low Impact Development*), *Low Impact Development Construction Guide*, and LID construction training course. See www.bealeader.ca to download guides and learn about upcoming LID training workshops.

Summary

This case study provided lessons about LID construction. By understanding these lessons, it will help you to properly construct an LID feature and will help you:

- Minimize costly maintenance over the warranty period
- Minimize costly, time consuming repairs
- Minimize post construction site deficiencies
- Minimize design assumptions
- Minimize time spent on site

This case study should not be used as a standalone guide for the construction of LID practices. When paired with CVC's LID construction courses and guidance documents, you can gain a comprehensive

understanding of how to ensure an LID project is successful throughout the construction process.

Tools and Resources

CVC is using their experience in constructing LID sites to develop several resources for you to use when constructing LID sites. These include:

- **CVC's Low Impact Development Construction Guide** – a document for contractors, design consultants, municipal engineers, plan reviewers and construction project managers. It addresses the common LID construction failures and how to avoid them, to bridge the gap between the design and construction of LID. Available at www.bealeader.ca
- **Grey To Green Retrofit Guides** – these five guides are tailored to specific land-uses, including road right-of-ways, private lands, public lands, residential lands and an overarching guide to assist municipalities on how to implement city-wide retrofit programs. These guides include sections on tender and contractor, as well as construction supervision. These guides are available for download at www.bealeader.ca
- **CVC's LID Case Studies** - these case studies document LID projects from across Ontario. Learn from the barriers, issues, and challenges that were encountered, and how they were overcome. All case studies include sections on planning, design, and construction. They are available at www.bealeader.ca/casestudies
- **CVC's Stormwater Management Certification Protocols** – Bioretention will be the first series of LID certification protocols released. The series provides guidance regarding the assumption protocols of an LID feature to certify the project. They will be available at www.bealeader.ca beginning in June 2014.
- **CVC's LID Construction Course and other Making it Work events** – CVC has designed an LID construction course for contractors, municipalities, engineers, site inspectors and plan reviewers. CVC also offers regular LID training opportunities through a variety of bus tours, workshops and seminars.

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indicate endorsement by the Government of Ontario
of the contents of this material.

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