CVC
CREDIT VALLEY CONSERVATION

CONTRACTOR'S & INSPECTOR'S GUIDE FOR LOW IMPACT DEVELOPMENT

Version 1.0

2014

Table of Contents

1. Introduction

The foundation of LID is to achieve stormwater control through landscaped based stormwater management. This approach is dramatically different from traditional approaches. In practice, it is apparent that a common point of failure for LID designs is poor on the ground implementation.

Due to the "newness" of LID few have had the opportunity to build LID practices. There are many reasons for practices to fail; plans and specifications without enough detail and instruction, contractors that do not understand the technology and importance of following procedures, using the wrong materials or equipment and mostly lack of erosion and sediment control throughout the entire life of the project.

Proper implementation and maintenance of erosion and sediment control practices are critical to the success of LID designs. This requires planning, scheduling and most importantly communication between contractors as the construction moves from excavation, to utility construction, to street construction, to building construction, to final landscaping and stabilization.

This guide is designed to compliment the CVC Low Impact Development Construction guide which was developed in partnership with U.S. consultant Emmons & Olivier Resources, Inc. (EOR) and is based on EOR's years of design and construction experience. It is hoped that this effort will lead to the proper construction of LID designs and ultimately the success of LID throughout the region.

Goal of this guide is that it be used on a day to day basis to ensure that LID projects are installed properly through all phases of the project. It is imperative that designers, contractors and inspectors all be aware of common LID failures throughout all phases of construction and how to avoid them. This guide has been developed as a practical field guide with guidance focused on the DOs and DONT's of LID construction techniques.

2. Related Resources

The following documents complement CVC's Designer's Guide and C&I Guide. Practitioners are encouraged to review these guidance documents as companion tools for LID planning, design and implementation. These guides will be referenced throughout CVC's Designer's Guide and C&I Guide.

Greater Goldent Horseshoe Erosion and Sediment Control Guideline for Urban Construction (ESC Guidelines)

Greater Golden Horseshoe Erosion and Sediment Control Inspection Guide (ESC Inspection Guide)

The Low Impact Development Management Planning and Design Guide (LID SWM Guide)

Landscape Design Guidelines for LID (Appendix B of the LID SWM Guide)

3. Verification of Siting and LID Practice Design

Working with the features of the site is the backbone of LID. If the designer has used the LID SWM Guide as the basis for stormwater design, they have already reduced the risk of failure. However, one of the most commonly overlooked items in the design process is physical site inspection to verify siting and design assumptions. Additionally, translation of design documents and transitioning to construction can provide new challenges that will require communication between the designers and contractors throughout the design and construction process.

Because of the inherent nature of LID that requires interactions between all aspects of the landscape, understanding the site is critical. Contractors and inspectors should be intimately familiar with the siting and design assumptions of the designer. These assumptions should be confirmed in the field. The following items represent some of the most commonly overlooked aspects of LID that have potentially led to failures in the past:

Watershed Information

Understanding the site's contributing watershed is often overlooked. Things to look for include:

- ☐ Any sources of runoff contributing to the site that weren't apparent in mapping analyses.
  - Unmarked storm sewer infrastructure
  - Roadways with curb cuts/ driveways delivering water onto the site

- Building roof leaders directing runoff onto the site

☐ Are surrounding land uses consistent with maps and survey information used for design?

- Land use changes to surrounding areas, particularly farm fields or natural areas, can create a large source of potential runoff and sediment to the site.

Topographic Information

Often times the topographic contours are created by aerial photography and/or LIDAR and should be field verified.

☐ Benchmarks should be confirmed and protected.

☐ Does the plan make sense while viewing the site on a visit?

- Any landscape features missing or exaggerated

Soils and Soil Borings

Soil mapping is many times used to give the designer a general indication of soil characteristics such a permeability and depth to groundwater. This information guides the designer in layout and placement of practices, but should always be field verified through soil borings or test pits.

☐ Location - verify that they are in the right spot - GPS coordinates should be used.

☐ Number - ensure that there are enough borings for each practice - larger features should include more than 1.

☐ Depth - they should be a minimum of 1.5 metres below the subgrade elevation of proposed practice.

Hydrologic soil group mapping.

Samples of drilled cores.

- ☐ Depth - mass grading and proposed grades should be accounted for.
- ☐ Analysis - entire length of boring should be described and areas of grain size analysis identified.
- ☐ Consistency - borehole logs should be reflective of the entire soil column or spatial changes in the soils.

Steep Slopes and Erodible Soils

Designers will often times combines soils and topographic maps to develop protection strategies for these areas during construction and to determine where to avoid putting LID practices to minimize long term problems created by erosion and sedimentation.

- ☐ Protect critical areas.
- ☐ Place erosion control features to limit off-site impacts.

Wetlands

- ☐ Ensure wetland delineation makes sense in the field.
- ☐ Ensure perimeter controls adequately setback.
- ☐ If there is evidence of draintile, address this issue in the plan.

Stream and Receiving Waters Protection

- ☐ Different receiving waters may have different restrictions/ opportunities.
- ☐ Ensure the plan adequately addresses the protection of receiving waters.
- ☐ Determine any special requirements the receiving water has for construction timing and types of SWM and ESC controls.

Tree Protection

- ☐ Complete a tree inventory and a plan for tree protection during the construction process.
- ☐ At a minimum, protect the dripline of trees from grading, traffic, parking

of equipment, and stockpiling of materials and supplies.

☐ Mark significant trees in heavy construction zones with construction fencing

Hot Spots

☐ Properly mark areas of the site where past contamination could be an issue.

☐ If an unknown contamination has been encountered during construction:

- Put in place proper protocols to test and dispose of discovered contamination.
- For affected stormwater practices, properly reroute, re-size, and/ or modify from infiltration to filtration if necessary.

Final Design Siting Issues

☐ Setbacks - Follow minimum setbacks to infrastructure and environmental resources.

- Infiltration practices to buildings should be set back at a minimum of 4 meters.
- In retrofit applications older foundations and infrastructure may require greater distance or the use of a impermeable liner.

☐ Sequencing and Access - Is the facility used as a temporary sediment basin during construction?

- If yes, see Chapter 6 for considerations on how the facility will be cleaned out and constructed.
- If no, the facility should be protected and kept offline until the contributing drainage area is stabilized.

☐ Offline Protection Strategy - Develop and include a strategy to protect the facility from sedimentation during construction.

☐ Pretreatment - Ensure pretreatment is adequate for the facility being constructed.

☐ What type of pretreatment will be used?

- Vegetation

- Integrated infrastructure - forebays, catch basin sump or gravel diaphragms
- Proprietary devices

☐ Ensure pretreatment infrastructure is the proper size for contributing watershed area and expected loading.

☐ Develop a suitable maintenance schedule and plan that utilizes the designed pretreatment.

☐ Site pretreatment infrastructure correctly to receive runoff and disperse to BMP facility.

- Runoff does not bypass pretreatment.

☐ Ensure infrastructure can be easily accessed for maintenance.

Facilities can be kept offline during construction and vegetation establishment. A wooden board placed behind the curb cut keeps runoff away during construction.

Underground Storage Pretreatment - A header row used for pretreatment in larger scale below ground systems. (image courtesy of Triton Stormwater System)

4. Tendering and Ownership

Many of the critical construction techniques and elements of a LID project are new to experienced and inexperienced designers and contractors alike, and easily misinterpreted and/or inappropriately executed. A clear set of plans, knowledge of intent, and experience with execution are necessary to create long lasting, highly effective BMP's. Communication between all members of the team throughout the project is another important aspect of successful LID.

Team Selection

An experienced, competent contractor is one of the most important factors in addressing design and construction issues in order to build a successful LID project. Designers and owners will be looking to select a contractor with the experience and communication skills to complete the multi-faceted LID process. Pre-qualification of team members is usually the first step in ensuring a high quality team and contractors bidding on the project may be required to include:

- ☐ Pre-qualifications of team including:
  - Prime Contractor
  - Sub-Contractors
  - Proposed Vendors
- ☐ Project experience with references
- ☐ Bid Bond
- ☐ Attendance at pre-bid meeting

Erosion and Sediment Control Report (ESC Report)

The ESC Report is a critical communication tool between all parties in the project. The report will be a living document that is reviewed and updated throughout the project. The contractor and inspector will be working with this document continuously throughout the life of the project and should review prior to their bid to identify deficiencies or ask any pertinent questions. Things to look for in an ESC Report:

4

- ☐ Identify all of the potential sediment sources and other pollutants.
- ☐ Identify the areas of likely concentrated flow.
- ☐ Identify responsibilities of implementation and maintenance activities for each facility.
- ☐ Provide a chain of responsibility, or allow room for the team to define the chain of responsibility between the owner, general contractor, subcontractors, and vendors.
- ☐ Identify the temporary sediment basin locations, as well as management strategies.
- ☐ Identify the permanent stormwater management system and management responsibilities.
- ☐ Identify all erosion protection practices that may include:
    - ☐ Minimization of land disturbance
    - ☐ Construction phasing
    - ☐ Tree/ natural resource preservation
    - ☐ Temporary seeding
    - ☐ Vegetative buffers
    - ☐ Sod stabilization
    - ☐ Horizontal slope grading
    - ☐ Natural vegetation
    - ☐ Temporary and permanent vegetation establishment
- ☐ Identify all sediment control practices that may include:

- ☐ Installation and maintenance of perimeter controls
- ☐ Vehicle tire mud tracking control
- ☐ Temporary soil stockpile protection
- ☐ Storm drain inlet protection

☐ Identify dewatering and basin draining practices.

☐ Establish the maintenance and inspection practices schedule, along with repair and replacement activities and responsibilities.

☐ Provide pollution prevention management measures for applicable waste products that may include:

- ☐ Solid wastes
- ☐ Concrete washout
- ☐ Oil
- ☐ Paint
- ☐ Gasoline - fueling and maintenance areas
- ☐ Other hazardous materials

☐ Identify the responsibility and strategy of record keeping.

Emergency Erosion and Sediment Control

Unforeseen issues such as large storm events and other emergencies taking place during construction can negatively affect all parties. Identifying the potential for these risks and responsibilities for action and payment at the beginning of the project are beneficial to all. Contractors should look for the following strategy in bidding documents:

☐ Separate line items to establish a unit price and/or maximum amount of additional payment if additional erosion control is needed.

If emergency erosion and sediment control is not addressed in the bidding process, it should be discussed during contract negotiations, and/or the pre-construction meeting.

Maintenance Responsibilities and Ownership

Clearly defined and accepted ownership roles are necessary to improve the aesthetics, function and life-span of all LID practices. Roles prior to, during and after construction should be clearly articulated and understood

by all parties and stakeholders. Contractors should discuss and establish the following maintenance and ownership issues prior to construction commencing:

- ☐ When the owner will take over final ownership and maintenance.
- ☐ Any warranties or establishment periods that extend several years.

The vegetation establishment period usually extends beyond the final construction time line stringing out the contractor's obligation, increasing bid prices, and potentially creating an unmotivated contractor. To address this extended timeline a separate vegetation establishment contract may be used as a separate line item.

- ☐ Separate vegetation establishment specification can keep bid costs down, protect the owner and contractor, and properly incentivize quality work.

If a project is being constructed during the rainy season or adjacent to sensitive receiving waters, it is always a good idea to have extra materials on hand in case of an emergency. Some of the more common needs are: additional aggregate for construction entrances, erosion control blankets and silt fence.

Emergency Erosion and Sediment Control.

Perimeter Controls

Perimeter controls protect off site areas, natural resource features and BMP sites from disturbances that generate sediment laden runoff and compaction from vehicle traffic. Drip lines of trees, soil stockpiles and infiltration areas are a few of the key features that must be protected to prevent sedimentation and soil compaction during the construction process. Perimeter controls continue to be necessary through the entire construction process, even after pavement is in place. Until the site is stabilized and vehicle tracking of sediment is no longer an issue, LID practices should be protected and kept off line.

The plan should clearly identify areas to be protected during the construction process:

- ☐ Receiving waters
- ☐ Adjacent properties
- ☐ Infiltration areas
- ☐ Drip lines of trees
- ☐ Soil stockpiles
- ☐ Porous pavement areas
- ☐ Bioretention areas

Pervious pavement LID practice – Top: showing good perimeter control protecting porous asphalt. Lower: Perimeter control requiring maintenance, sediment potentially clogging porous asphalt

5. Site Preparation

Biorentention clogged with construction sediment which could have been prevented with effective ESC implementation. Source: LID Center

Maintaining site stability is one of the primary targets to strive for throughout the construction process for successful implementation of LID practices. There are 2 major pitfalls for contractors and inspectors to review that are associated with clearing and grubbing activities:

1. Clearing more area than is essential at the time
2. Insufficiently marking areas to be protected

Review Existing Materials

The GGHA Erosion and Sediment Control Guideline for Urban Construction (ESC Guidelines) provides valuable information on planning for and construction activities designed to protect the site and surrounding natural features.

- ☐ Review the ESC Guidelines for strategies and techniques to create your ESC Plan.
- ☐ Your ESC Plan should limit the size (and duration) of disturbed areas by minimizing nonessential clearing and grading; minimize slope length and gradient of disturbed areas.
- ☐ The plans and/or contractors must identify, properly mark, and protect Natural Heritage Features per the ESC Guidelines.

Winter Construction Clearing

Overwintering is an important concept of LID construction that is often overlooked due to scheduling pressures, unpredictable weather, and lack of foresight. Numerous issues can be created by multiple freeze thaw cycles and potential erosion that may occur from late fall through the spring melt-water. One of the major concerns of conducting late season work is running into work-stopping weather before the drainage area is stabilized. In this case spring snowmelt will almost without fail result in sedimentation of LID practices.

- ☐ Winter construction clearing - limit winter clearing construction activities to areas in which work is to occur during the next 14 days and that can be mulched in 1 day prior to any weather event.
- ☐ Protect natural resources with a double row of sediment barriers.

Left: Caution fencing prevents traffic and building materials storage within the BMP.
Right: A double row of silt fence, the first row is on the verge of being overwhelmed and requires immediate maintenance.

6. Mass Grading

Temporary sediment basin.

It is critical off and on-site drainage be managed and that LID practices be protected during the mass grading process. Treatment of off site drainage should be considered prior to beginning the construction of on-site facilities. Keep clean water clean water!

- ☐ Consider off-site drainage onto the site and develop a management plan using diversions or ponding with slope drains.
- ☐ Stabilize incoming channels, emergency overflows (EOF's) and outfalls.

Construction practices typically utilize a limited number of large scale sedimentation ponds to limit sediment impacts. LID moves away from this concept by decentralizing SWM practices to mimic natural hydrology. Smaller BMP's spread throughout the site requires intensive management of on site drainage, a multi barrier protection plan, staged grading, and timely temporary or permanent cover establishment. Ensure the plan addresses:

- ☐ Limiting the amount of exposed soil through effective staging.
- ☐ Protection of practices through perimeter controls.
- ☐ Establishment of temporary or permanent cover in a timely manner.

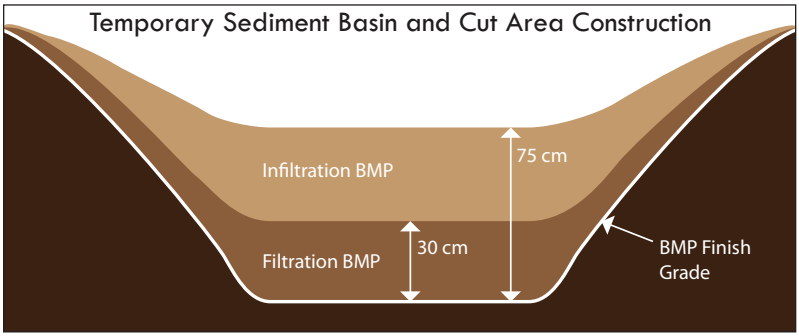
Unless a practice is being used as a temporary sediment basin during construction, it is recommended that all practices be kept off-line until the contributing drainage area is stabilized. Below ground facilities constructed

during the mass grading process must be protected by barriers or bulkheads.

Using permanent LID stormwater BMPs as temporary sediment basins is generally discouraged. However, a facility's location in the landscape may often require its use for sediment control during construction. If this is the case, success can be achieved by:

- ☐ Limiting the depth of the initial excavation to finish grade or higher.
- ☐ Providing a vegetated buffer to reduce sediment loads.
- ☐ Providing a stabilized temporary outlet and emergency overflow.

Project sequencing and timely stabilization is critical to the success of every project. The steeper the slope, the more important this becomes.



- ☐ Cut and stabilize access and staging areas.
- ☐ Cut and stabilize channels and slopes. Stabilize prior to connection to a surface water source and as soon as possible preferably within 14 days in other situations.
- ☐ Excavated topsoil, if suitable for reuse in final landscaping, should be separated from subsoils.
- ☐ Once graded, inspect and establish/reestablish perimeter controls.
- ☐ Provide temporary vegetative cover – See Appendix C and D of the ESC Guide for recommended practices and seed mixtures.
- ☐ Protect BMPs, particularly infiltration practices with suitable perimeter controls until contributing drainage areas are established.

Infiltration Practice Grading

Fill Areas

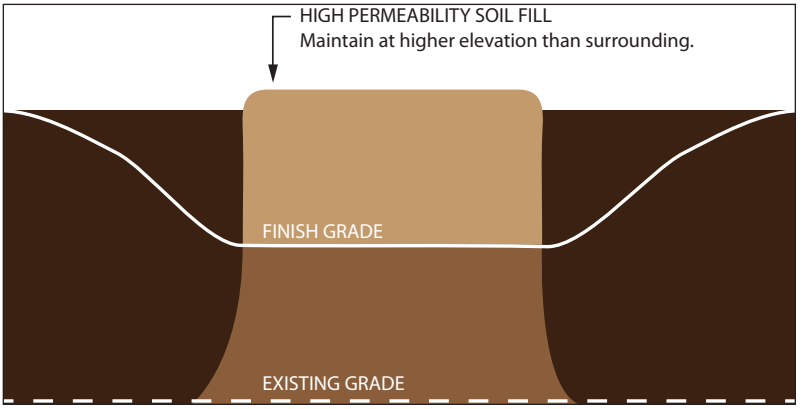
By maintaining the elevation of the infiltration practice above the elevation of the surrounding area, mixing of soils and runoff from construction activities is prevented.

- ☐ Remove topsoil and lower permeability soils above the target infiltration soils where the practice is designed to function.
- ☐ Fill area over the target soils with soils of a higher permeability than the target soils – typically sand – to a height greater than the surrounding grades.
- ☐ Raise the height of the surrounding grades to the height of the infiltration feature, but do not exceed the height of the fill material.
- ☐ Fill additional higher permeability soils to the infiltration feature to a height greater than the surrounding grades.
- ☐ Repeat until finish grade is achieved.

Cut Areas (See image on page 17)

- ☐ Excavate the basin and the surrounding area to finish grade.
- ☐ Following stabilization of the contributing drainage area, the infiltration practice can be cut to designed subgrade elevation and brought back to finish grade with clear stone and/or filter media.

Infiltration Practice Grading in Fill Areas



7. Utility Installation

Because there are a variety of utilities and specialized utility subcontractors, assuring that all installers are cognizant of the LID features and that they are protected is critical. The function of the stormwater feature, particularly an infiltration feature, can be hindered by the compaction and mixing of the subsurface soils while installing utilities. Contractor awareness and a plan to prevent and/or mitigate the issues is crucial and should be reviewed, updated and discussed frequently at construction meetings.

Communication

Utility installation is usually a point in the project where the site is handed over several times to a new subcontractor/ subcontractors. LID protection measures must be clearly communicated again.

- ☐ Communicate LID techniques and requirements to all sub-contractors at a mandatory pre-construction meeting.
- ☐ Ensure that all sub-contractors understand design intent of utilities AND the LID design.
- ☐ If there are BMP facility-utility conflicts, the appropriate subcontractor must create a construction plan to address these conflicts prior to commencing construction.

Design - Modifications to Design

- ☐ Contact the appropriate utility companies and government agencies and alert to any potential LID-utility conflicts.
- ☐ Contact the designer/owner about any utility conflicts they were not previously aware of.

Construction Considerations

- ☐ Ensure the stabilization of mass grading areas has been completed by the excavation contractor. Communicate/coordinate with any utility contractors traveling through areas that are not yet stabilized.
- ☐ Utility contractors must properly control any small scale excavation materials with proper erosion control.
- ☐ Ensure material staging areas for utilities are located and sized appropriately for delivery quantity and traffic.
- ☐ Provide and protect concrete washout areas in appropriate locations.
    - ☐ BMP facilities should never be used as a concrete washout area.
    - ☐ If a BMP facility is compromised with concrete, contact the designer and create an agreed upon plan to rectify.

Lighting base installation.

- ☐ Develop and approve an appropriate plan for utilities that are within/over BMPs.
- ☐ Ensure the electrical contractor understands water conveyance routes and standing water locations and elevations.
- ☐ Ensure the electrical contractor understands the need for additional footing depth if lighting standards are installed in areas of pervious pavement.
- ☐ If dewatering of trenches is required, it should be discharged to stabilized areas and not bare soils.

8. Buildings and Pavement

Often the building contractor is not concerned with the area outside of the building envelope. The general contractor, project manager, or grading/ utility contractor must communicate the location of all sensitive areas of the site to the building contractor who in turn is responsible for communicating to his subcontractors and vendors. This phase of construction often offers unexpected challenges, sites can quickly become a quagmire as tools and materials are moved around the site.

Communication

Building related construction contractors usually have the least amount of site related BMP knowledge. Erosion control and protection of LID features during building pad construction is often difficult as contractors will vary in the method of construction and how they will handle the most common issues. An erosion control plan should be developed and reviewed with the building contractor frequently and modified to respond to changes in the construction process.

A number of items should be considered and discussed with the contractor to limit the likelihood of a negative impact to the LID features during building construction.

- ☐ Demarcate BMP's and protect with erosion and sediment control measures.
- ☐ Site conditions can change in an instant which requires that the erosion control plan continues to be a living document.
- ☐ Provide a secure, stabilized storage/staging area that minimizes

distances that materials need to be moved and avoids compaction or contamination of LID areas.

- ☐ Inspect the site at least once a week and after every rainfall to assure LID practices are working and protected.

Commercial Development

Building construction can have a considerable impact on stormwater facilities function. Typically parking lots, roads and most of the areas surrounding the building will be complete prior to building construction.

- ☐ Do not complete grading of LID features within the building staging area until after heavy construction equipment has left the site.
- ☐ Aerate soils to at least 1.5 meters below existing grade in areas of infiltration practices.
- ☐ Permeable Pavement
    - ☐ Erect jersey barriers or fences to protect areas from construction traffic.
    - ☐ Place perimeter controls or filter socks (compost/rock/wood chip) to protect facilities from sedimentation.
- ☐ Roof Drains and Leaders

- ☐ Install plastic pipe as a temporary means to safely direct water to a stabilized area,
- ☐ or, stabilize scupper or gutter outfalls and direct water to a turf or geotextile lined channel.

Residential Development

Due to the finer scale associated with residential construction and wider variety of variables, even more caution and communication will be required for a successful LID project. Each builder and subcontractor on the site must be made aware of their responsibilities. Developing a written Builders Agreement that is signed by each builder and his subcontractors has been found to be beneficial.

- ☐ See the LID Construction Guide Section 8.3 Residential Development for Example Conditions in a Builders Agreement.
- ☐ For example Developer Agreement see Section 8.4 Developer Agreement/Letter of Credit in the LID Construction Guide.

9. Finish Grading

The finish grading process is another critical handoff moment as a number of elements such as curbs, sidewalks, roadways, soils, and vegetation start to come together to create the functional and aesthetic value of a site. The same care and communication that was put into controlling sediment and erosion in earlier stages is also required during finish grading. In many cases, greater attention to detail is required for elements in this phase that will make or break the success of the final product.

Communication

- ☐ Communicate with the paving, curbing, and other sub-contractors regarding LID construction.
    - ☐ Weekly construction meetings should take place with appropriate parties present.

Design Verification and Construction Adjustments

The finish grading phase of construction is very important to the overall function of the practice, but is often the portion of work that diverges furthest from the original design intent. This phase is directly influenced by construction mistakes and adjustments made in previous phases.

- ☐ Verify the sub-grades in relation to surrounding infrastructure - e.g. roads, curbs, walkways, etc.
- ☐ If grades are different than design, contact the designer to work toward resolution.

- ☐ Inform the designer and/or inspector of grading modifications during finish work.

Construction Techniques - Contributing Drainage Area

- ☐ Install and properly maintain all erosion and sediment controls prior to the start of finish grading.
- ☐ Properly correct compacted soils throughout the contributing drainage area by the appropriate technique:
  - ☐ Soil amendments
  - ☐ Tilling
  - ☐ Deep tilling
- ☐ Stabilize and finalize the contributing drainage area with landscaping or hardscaping prior to finishing work on the LID practice.
- ☐ Properly install and maintain inlet protection for online practices prior to and during remaining construction.
- ☐ Block inlets for offline practices prior to and during construction.
- ☐ Remove water and/or sediment introduced during previous stages.

Tilling: Up to 30cm in depth (small rototiller, chisel plow, harrow)

Deep Tilling: Greater than 30cm in depth (depth chisel plow, larger mechanical rototiller)

BMP Construction

- ☐ Identify a limited construction access for construction of each BMP.
- ☐ Delineate access to avoid steep slopes and channels and establishing vegetation.
- ☐ Establish a restoration plan for access areas to be restored immediately after completion of construction.
- ☐ Finish grading for infiltration areas should only be performed during dry conditions to prevent soil smearing and compaction.
- ☐ Ensure the right equipment is available for construction of the BMP.
    - ☐ For infiltration facilities an excavator with a toothed bucket or ripper tool attachment should be provided so once subgrade elevation is established the surface can be scarified to alleviate compaction caused by excavation.
    - ☐ If equipment is needed inside the facility, lightweight wide track or marsh track equipment should be used to minimize compaction.
- ☐ Once subgrade elevation is established, scarify or till the bottom and side slopes to alleviate compaction.
- ☐ Once subgrade elevation is established, confirm the design parameters and assumptions. This may require permeability testing and should be reviewed by the designer.
- ☐ If necessary, field adjust to install underdrains, filter media, aggregates, observation wells and overflows.
- ☐ Provide a stabilized emergency overflow, if applicable.

Curb Cuts

- ☐ Ensure the curbing contractor fully understands the curb cut design and elevations.
- ☐ Ensure curb cuts have been properly installed as designed.
- ☐ Make sure the pavement grading and back slope of the curb direct runoff into the inlet.

Turf blocking inlet (CVC).

Pretreatment Areas

- ☐ Pretreatment area and planting bed finish elevations should be below the elevation of the adjacent pavement or curb cut.
    - ☐ Turf grass pretreatment areas should be installed with the top of the sod a minimum of 4-5 cm below the top of the adjacent surface.
    - ☐ Rip-rap, gravel diaphragms, splash pads and other pretreatment measures should be installed a minimum of 5 cm below the adjacent surface.

Bioretention Media

- ☐ The bioretention media should arrive on site pre-mixed.
- ☐ Each batch must be tested by the supplier, and the site engineer must review the lab report and verify that the soil meets the bioretention specification before being placed.
- ☐ The bioretention media should be installed in 300 mm lifts.
- ☐ If possible, equipment should not be operated within the practice. Materials should be placed by blower, slinger truck or backhoe. If necessary, lightweight wide track equipment can enter after at least 45 cm of bioretention media has been installed.

Slinger truck evenly placing bioretention soil in a large cell.

Finish Grade

- ☐ Settlement as much as 15-20% of the bioretention media should be expected. Natural settlement is preferred, but soils can be saturated and allowed to drain between each 300 mm lift to speed up the process.
- ☐ The top of the mulch should be used as the finish grade, not the top of the bioretention media.

Final Stabilization

- ☐ Installation of mulch, vegetation establishment of access areas and additional erosion control protection should be installed immediately.
- ☐ If possible, offline protection is recommended until vegetation is established, watering or irrigation will be necessary and should be planned for at this point.

Housekeeping

The finish grading phase introduces a number of new sources of sediment and pollution to the site. Good housekeeping is essential!

- ☐ Provide additional sediment control for stockpiled materials.
- ☐ Provide and use concrete washouts facilities.
- ☐ Develop an updated dewatering plan.
- ☐ Protect and establish perimeter control for any landscape materials temporarily stored on hard surfaces.
- ☐ Provide regular sweeping.
- ☐ Bioretention facilities should be excavated and the underdrain systems in place before bioretention media, mulch and plant materials are delivered to the site.

10. LID Practice Materials

Inappropriate material substitutions are common causes of failure for LID practices. All substitutions should be approved in writing by the project engineer.

Image-silt fence incorrectly lining BMP (Source: LID Center).

Bioretention Soil Mix

Proper mixing is essential. Bioretention materials should be premixed and delivered to the site. Mixing of materials on site should be avoided.

Grain Size Distribution	
Particle Size	Percent by Weight
Coarse to Medium Sand (2.0-0.25 mm dia. or between sieve #10 and #60)	71 - 92%
Fine Sand (0.25-0.050 mm dia. or between sieve #60 and #270)	0 - 17%
Silt and Clay (<0.050 mm dia. or passing through #270)	8 - 12% (5% clay max)

- ☐ Soil sample submittals and lab should be completed before delivery to the site. Tests should address:
  - ☐ Phosphorous – P Index value between 10-30 ppm
  - ☐ Cationic Exchange Capacity – CEC – greater than 10 milliequivalents per 100 grams (10 meq/100 g)
  - ☐ pH – between 5.5-7.5
  - ☐ Mixture should be free of plastic, stones, stumps, and other similar

objects larger than 50mm

- ☐ Infiltration Rate – greater than 25 mm/hr
- ☐ Organic Content - between 3 - 5%

Compost

- ☐ Fully mature compost must be used, preferably organic leaf compost or other organic matter from local sources
    - Mature compost will smell like a forest.
    - Immature compost will have a strong ammonia smell.

Geotextiles

- ☐ Woven silt film (typically used for silt fence), subgrade stabilization fabrics, and heat bonded fabrics should not be used for separating infiltration practice. Infiltrating bioretention practices do not need to be lined with geotextile drainage fabric.
- ☐ Appropriate drainage geotextiles should be used to separate a finer material from migrating into a coarser material. For example, drainage geotextile should be used to separate the clear stone used around the underdrain from bioretention media.
- ☐ See LID SWM Guide for guidance on application. Materials should conform to Ontario Provincial Standard Specification (OPSS) 1860 for Class II geotextile fabrics.

Top: Mulch blown-in. Left bottom: Wood chips float. Right bottom: Shredded hardwood mulch.

Mulch

- ☐ Mulch should be well shredded. Depth should be no greater than 75 mm. Mulch shall be free of bark, soil, green material and debris.

Underdrains

- ☐ 100mm, 150mm and 200 mm diameter single wall, corrugated plastic or smooth-wall plastic pipe should be provided. 200 mm is recommended if freezing is anticipated. Pipes should be wrapped or surrounded by washed gravel (clear stone).
- ☐ A clean-out standpipe is recommended at the upstream end of the underdrain pipe for the purpose of inspection and maintenance of the underdrain.

Rock

- ☐ Drainage Applications such as Bioretention and Soakaways
  - ☐ Clean washed aggregate or clear stone must be used in filtration and infiltration practices. Aggregate fines will prematurely clog these practices.
- ☐ Porous Paver or Structural Applications
  - ☐ Clean washed granitic material is recommended. If limestone is specified, no files shall be associated with the material and hardness should meet the following criteria:
    - The Los Angeles Rattler (LAR) loss on the course aggregate fraction (material retained on the 4.75 mm (no.4) seive) shall not exceed 40% for any individual source used within the mix. Composite maximum LAR loss shall not exceed 35.
  - ☐ All aggregates shall have a maximum wash loss of 1.5%.
  - ☐ Material shall be 80% crushed (one fractured face).
  - ☐ The use of recycled materials shall not be permitted.

Monitoring Wells

- ☐ Monitoring wells shall be a capped vertical standpipe consisting of an anchored 100-150 mm diameter perforated pipe with a lockable cap installed to the bottom of the facility.

Outlets and Outlet Structures

- ☐ Where possible, outlets should be elevated from the bottom of the facility by at least 100 mm. Bioretention practices are designed to have temporary ponding.
- ☐ Dome shaped grates shall are preferred to protect against clogging. Grates should lock or screw into place.

Plant Materials

- ☐ Plant materials should not be delivered to the site until areas have been prepared for planting. Plant materials should be tagged for identification and matched to the design planting plan and schedule.

Monitoring Wells are a valuable tool for long term maintenance and monitoring.

11. Permeable Pavement

- ☐ Sub-base and base
  - ☐ Unlike conventional pavements, the base and subbase of permeable pavements are used to store and drain stormwater.
  - ☐ Use granite when possible.
  - ☐ Limestone must meet specific requirements (see page 30 under Rock).
  - ☐ Maximum wash loss of 1.5%
  - ☐ 80% crushed with one fractured face
  - ☐ Recycled material not allowed.

Porous asphalt

Porous asphalt and pervious concrete have tighter climate considerations for installation than typical pavements, such as temperature and level of humidity.

- ☐ For lower traffic areas only – not for heavy truck routes.
- ☐ Allowable temperatures are tighter for porous asphalt than typical asphalt mixes.
- ☐ Allowable binders and oils for porous asphalts are different, especially between base and wear lifts.
- ☐ Place porous base and wear courses before wear course of surrounding pavement.

Pervious concrete

- ☐ Ideal conditions for paving: 15°C, overcast, no wind, some humidity.
- ☐ Mist or dampen the subbase prior to placement to ensure that the subbase does not suck moisture out of the pervious concrete.
- ☐ Continually check concrete for correct moisture requirements.
    - ☐ If water is added, ensure uniformity; this may be best accomplished by spraying water from the top of the truck into the mix while mixing.
    - ☐ An expert should certify the moisture content prior to placement.
- ☐ Forms need a 10 mm vertical spacer; remove prior to rolling.
- ☐ Use vibratory screed atop 1.27 cm spacer.
- ☐ Proper consolidation is difficult if concrete sits too long prior to being screeded.
- ☐ Compacting final 1.27 cm – use 30 cm, schedule 40 PVC pipe filled with water.
- ☐ Plastic cover (white, 6 mil) prevents moisture loss.
    - ☐ Use pressure mister – NOT mix truck hose – to moisten concrete before placing cover.

Left: Installation of pervious concrete; community recreation application.
Right: Installation of permeable pavers.

Example of porous turf used for excess parking area.

- ☐ Place cover within 15 minutes of placing pervious concrete.
- ☐ Timing is critical in hot, dry or windy conditions.
- ☐ Secure plastic with lumber or nails – not dirt.
- ☐ Leave for 7 days – no traffic allowed.

Permeable Pavers

- ☐ Proper leveling course is critical to level paver surface.
- ☐ Set edges into concrete curb or other abutment.
- ☐ To eliminate handwork, it is helpful to design the project around the equipment that will be used to install it. Typically, the blocks come palletized and are installed with an attachment that lifts them off the pallet and drops them in place. Matching the dimensions to the size of the pallet square will dramatically reduce the time of installation.
- ☐ Surface voids – use rock chips (not sand) to fill.
- ☐ If pavers must be saw cut, then saw cut away from pavement structure to avoid dust collecting between the pavers or in the clear stone base.
- ☐ Maintenance – vacuuming is necessary. Replace rock chips after maintenance.

Porous Turf/Cellular Confinement

- ☐ Overfill cells by 25 – 50 mm.
- ☐ Hydroseeding and irrigation speed establishment in dry conditions.
- ☐ Vegetation harmed by:
  - ☐ Heat generated by asphalt parking lot – maintain sufficient distance.
  - ☐ De-icing salts.
  - ☐ High traffic volume; vehicle turning.

Construction Techniques and Timing

- ☐ Install permeable pavement last.
- ☐ Before installation, protect porous area from sediment and compaction.
- ☐ Stabilize tributary areas with at least a base course.
- ☐ Use toothed backhoe for excavation down to subgrade.
- ☐ Install geotextile drainage fabric if necessary.
  - ☐ Use along sidewalls to limit soil mixing and protect the adjacent area from sloughing into the infiltration bed.
  - ☐ Use along bottom of feature if soils are poor or underdrain used.
  - ☐ Leave geotextile 50 cm long on all sides.
- ☐ Install and compact infiltration bed and choker coarse; create smooth level base.

A maintenance plan clarifying maintenance responsibility must be developed for every project.

- ☐ Fold 50 cm of geotextile on top of infiltration/choker course.
- ☐ For porous asphalt, place porous base and wear courses before wear course of surrounding pavement.

Permeable Pavement Maintenance

- ☐ Ongoing maintenance
  - ☐ Prevent soil from washing onto porous pavement.
  - ☐ Do not stockpile materials on pavement.
  - ☐ Stabilize drainage area with vegetation.
  - ☐ Clean inlets regularly.
  - ☐ Maintaining permeability
    - Vacuum sweep twice a year – do not use regenerative air sweepers or broom sweepers.
    - Perform low-pressure washing.
    - Disassemble pavers in clogged sections.
  - ☐ Winter operation
    - Avoid sand as anti-skid agent.
    - Salt is allowed; non-chloride deicers are preferred.
    - Plow blade should be raised 2.5 cm.

12. Permanent Vegetation Establishment

Site Conditions

- ☐ Reference the *LID Landscape Design Guide* for more information.
- ☐ Ensure facility is offline (if intended) prior to planting - see Chapter 9 for discussions on offline vs. online.
- ☐ Eliminate all weeds from planting bed prior to planting.
- ☐ Soil must be appropriately dry for planting activities - notify designer if the facility is not draining, as designed, prior to planting.
- ☐ Ameliorate any compaction to growing medium that occurred due to planting activities.

Environmental Factors

- ☐ Plant substitutions - BMP vegetation is chosen for specific hydrology and stressor conditions. Substitutions should not be used unless approved by designer - both species and sizes.
- ☐ Vegetation should be planted at the location, and elevation, shown in plans - notify designer if discrepancies occur.
- ☐ Spring planting after the last frost is preferred.
- ☐ Summer planting will require frequent inspection and diligent watering.

- ☐ Fall planting is acceptable but some loss of smaller stock should be expected. Trees, shrubs, and potted perennials larger than 1 gallon pots can be planted up until the first frost.
- ☐ Overwintering plant bed - planting areas should be stabilized over the winter with mulch, appropriate erosion control blankets, and/or temporary seeding.
    - ☐ If temporary seeding is used for overwintering planting beds, eliminate any live vegetation or regermination from planting bed before vegetation installation.

Planting Considerations

- ☐ When feasible a minimum 60 cm turf buffer between pavement and rain garden is recommended to reduce erosive runoff, filter particulates, and provide functional space and a visual frame.
- ☐ Water plants during establishment per specifications or warranty requirements.
- ☐ Mulch is necessary in most planting scenarios to limit growth of volunteer species, but its mobility can be troublesome in stormwater facilities.
    - ☐ Utilize double-shredded hardwood mulch for its binding characteristic to reduce floating and transport.
    - ☐ Avoid mulch in high-flow areas. Use river-run stone, bio-filter socks and erosion control blankets.

The vegetation establishment period is a significant factor in the overall success and performance of BMPs.

Vegetation Maintenance

- ☐ Most important maintenance goals: soil's ability to drain; the survival of desirable plants
- ☐ Typical Maintenance Sequencing - review specifications for project specific information:
  - ☐ Establishment (installation to 18 months)
    - Water regularly during first growing season.
    - Water as needed in subsequent seasons.
    - Protect and replace plants as needed.
    - Weed monthly.
  - ☐ Development (18 month to 3 years)
    - Replace dead plants – change species if necessary.
    - Add mulch as needed.
    - Weed as needed.
  - ☐ Maturity (Beyond 3 years and after large storms)
    - Remove sediment from BMP, filter strip and curb cut.
    - Remove mulch from outlet; redistribute consolidated mulch.
    - Pick up litter and debris.
    - Remove and replace dead plants; remove weeds.
    - Repair erosion at inflow points.

Left: Establishment phase. Right: Vegetation in maturity phase (same location).

- ☐ High profile sites require more maintenance attention than low profile / natural sites, which require mostly weeding and removal of non-native species.
- ☐ In spring: groom perennials, prune woody plants, remove dead plants.
- ☐ The issue of water standing in BMP for over 48 hours may require the following:
  - ☐ Remove mulch layer.
  - ☐ Check underdrain for clogging.
  - ☐ Remove and replace top 75 mm of soil.
  - ☐ Apply core aeration or deep tilling.
  - ☐ Mix sand or compost into soil
  - ☐ Retesting of the bioretention soil for specification criteria and if necessary full replacement of soil and/or addition of underdrain.

Species and sizes are chosen for specific hydrology and stressor inputs - Substitutions should not be used unless approved by designer.

13. Overwintering

Spring melt contributes to sedimentation and poor performance of BMPs.

October 15th – BMP site must be stabilized by one of the following:

- ☐ Pavement
- ☐ Properly compacted gravel base
- ☐ Rip rap
- ☐ Minimum 85% healthy vegetation cover
- ☐ Compost blanket
- ☐ Other appropriate control measures

Winter Construction – October 15th to April 1st

- ☐ Maximum exposed area: 0.4 hectare.
- ☐ Set up erosion control on previous work area before exposing new soil.
- ☐ Inspect sites after snow melt event (when temperature rises above 4°C).
- ☐ Temporary stockpiles must be vegetated or otherwise stabilized.

- ☐ Excavated frozen soils must be stockpiled separately from other stockpiles. Do not transport off site until soil is completely thawed.

Stabilization techniques

- ☐ Straw mulch – during winter construction use double the amount as used in other seasons.
- ☐ Mulch must be anchored in winter.
- ☐ Seeding and Sodding
  - ☐ Scenario 1 – finish grading completed and temperatures are above freezing

LID practice are effective in winter and early spring if constructed properly and the contributing drainage area is stabilized.

- Use mulch, or
- Seed and mulch.

☐ Scenario 2 – after October 15th and vegetated area has less than 85% cover
- Slope of less than 15% - seed and cover with straw mulch and anchored netting.
- Slope of greater than 15% - seed and cover with straw mulch and anchored erosion control blanket.

☐ Scenario 3 – snow cover is greater than 2.5 cm
- Do not seed and mulch.

☐ Scenario 4 – Erosion control blanket installed in frozen conditions
- Use 15 cm long nails (not staples) with washers.

☐ Scenario 5 – Grass lined ditches
- September 1st – Grass lined ditches must be constructed and stabilized.
- October 15th – Grass lined ditches without 85% vegetative growth – temporarily stabilize with stone or erosion control blanket (take flow conditions into account).

☐ Scenario 6 – Sodding
- November 15th – Sod must be installed and anchored.

Facilities Online during Winter

☐ If drainage area is stabilized before overwintering, infiltration BMP can be online in winter.

☐ Otherwise, keep BMP offline.

14. Certification

Certification occurs at all stages of project construction. Field verification of LID design assumptions should occur at the beginning of construction, materials should be verified/certified (e.g., engineered soil media, plants), and LID features should be inspected throughout project construction, and, ultimately, the form and function of LID practices should meet standards of construction prior to return of the contractor's performance bond.

The following list of items should be inspected and certified during construction.

Prior to Construction

- ☐ Divert runoff from adjacent areas.
- ☐ Clear the area where the LID practice will be constructed.
- ☐ Establish and protect a nearby project benchmark.
- ☐ Stake out and confirm grades of the practice location.
- ☐ In infiltration areas, test the soil for permeability to confirm design assumptions.
- ☐ Verify groundwater and bedrock design assumptions.
- ☐ Ensure temporary erosion and sediment controls have been properly installed.

Excavation

- ☐ Ensure the contractor has the right equipment.
- ☐ Discuss the goals of the project and purpose of the LID practices with the operators and crew.
- ☐ Ensure side slopes are stable and within design range.
- ☐ Stabilize stockpile locations with vegetation and/or silt fence. Stopckpiles must not be adjacent to excavation area.
- ☐ Scarify soils compacted during excavation.
- ☐ If necessary, adjust the facility's depth to meet soil type and permeability design assumptions.
- ☐ Put sufficient perimeter controls in place to protect the practice.

Structural Components

- ☐ Ensure materials (aggregate, perforated pipe, etc.) are per specifications.
- ☐ Ensure forms are adequately sized.
- ☐ Place and install geotextile drainage fabrics or impervious liners per plan.
- ☐ Install underdrain system to grade.
- ☐ Install anti-seep collars per plan.
- ☐ Install inlets/outlets and emergency overflows at correct elevations per plans.
- ☐ Install pretreatment measures per plans.
- ☐ Install materials, spacing and grade of check dams per plans.

Soils

- ☐ Ensure common borrow complies with specification for fill areas.
- ☐ Ensure topsoil complies with spec in composition and placement.
- ☐ Ensure the engineered soil composition and texture conform to specification.

Vegetation Establishment

- ☐ Stabilize the surrounding drainage area for permanent erosion control.
- ☐ Ensure seed or plants to be used conform to planting specifications.

Final Inspection

- ☐ Ensure the practice has been installed per plans.
- ☐ Ensure the pretreatment is operational.
- ☐ Ensure the inlet/outlet is operational and at the correct elevation.
- ☐ Verify the soil/filter medium permeability.
- ☐ Ensure vegetation been established to 85% cover.
- ☐ Remove construction generated sediments.
- ☐ Ensure the contributing watershed is stabilized before flow is diverted to the practice.
- ☐ Address any erosion around the practice slopes or channels.

Left: BMP holding water longer than design drawdown time. Right: Double-ring infiltrometer.

15. Avoiding Common Mistakes

Verification of Siting and LID Practice Design:

Physical site inspection is often the most overlooked aspect of LID. Surveys, aerial photography, and incomplete or old mapping is often unsatisfactory for a fully functional LID design and construction.

- ☐ Soil borings and test pits
- ☐ Understanding the site's context
- ☐ Knowing contributing watersheds

Tendering and Ownership:

Emergency Erosion Control Measures to address major storm events and flooding are difficult to predict, and allocate money for. A separate line item for emergency erosion control is one strategy to ensure EC is performed properly and contractors are paid for their additional work.

Site Preparation:

Insufficient marking of protected areas can lead to natural resource destruction and mass sediment loss due to large, unprotected areas of bare soil exposed to storm events. Clearing activities must be coordinated with the construction schedule to limit the duration and size of disturbed areas. Down gradient perimeter control must be in place prior to conducting any up gradient activities.

The placement and maintenance of perimeter controls is critical throughout the construction process:

- ☐ Infiltration practices are resources that should be protected with perimeter controls.
- ☐ A failure of a single portion of any perimeter control can cause sedimentation of the LID practice.
- ☐ Perimeter controls are only effective with routine inspection & maintenance.

Mass Grading:

Mass grading can occur in LID with precautions to protect future BMPs.

- ☐ Below ground BMP facilities can be constructed during mass grading if bulkheaded for remainder of construction.
- ☐ Using BMPs as temporary sediment basins during mass grading requires planning and contractor communication.

Utility Installations:

If possible, avoid locating utilities within LID features. Communication and coordination with utility companies is critical to integrating LID and utility corridors:

- ☐ Lighting installations within or above BMPs which may require special structural support considerations.
- ☐ Water and sewer utilities in or below BMPs may require insulation and/or anti-seepage measures.
- ☐ Electrical utility routes that conflict with water conveyance and standing water/ ponding areas.

Buildings and Pavement:

Building contractors generally have the least amount of knowledge and concern for stormwater BMPs.

- ☐ Clearly mark all BMPs in plans and on site; avoiding compaction or contamination of LID areas from machinery or materials storage over BMP footprints.
- ☐ Inspect the site at least once a week and after every rainfall to ensure LID protection measures are in place.

Finish Grading:

Conveyance of runoff into BMPs is one of the most common errors in LID:

- ☐ Inlets (sod, rip rap, or pretreatment measure) are installed higher than the contributing impervious surface - runoff then bypasses the practice.
- ☐ Inadequate scour protection is provided at the practice's inlet leading to erosion and scouring.
- ☐ Pretreatment can prolong the life of a practice and make maintenance easier.
- ☐ Inlet, outlet, and emergency overflow elevations are often only centimeters apart - requiring precise grading.

LID Practice Materials:

Bioretention soil medium and installation is new to many contractors.

- ☐ Soil medium should be premixed, and samples should be pre-approved to ensure proper material.
- ☐ Settling should be accounted for, both in quantities and process.

Permeable Pavement:

Permeable paving should be protected in all phases of construction:

- ☐ Protect paving area from surrounding drainage area with perimeter controls.
- ☐ Keep all construction equipment off permeable areas - sediment tracking can clog permeable pavement.

Permanent Vegetation Establishment:

Plant establishment is often overlooked but is critical to long term LID success:

- ☐ Seed is difficult to establish in online stormwater practices.
- ☐ Establishment of vegetation is often more successful if facilities are kept offline the first growing season.
- ☐ The first few years of establishment will require greater maintenance.
- ☐ The right plant - beware of un-communicated plant substitutions.

Overwintering:

The winter construction period October 15th - April 1st will require special measures for construction.

- ☐ Areas cleared and exposed should be limited to 0.4 hectares.
- ☐ Seeding is not recommended during winter construction, unless dormant seeding.
- ☐ Mulch should be applied at higher rates and anchored when overwintering.

Certification:

Final certification is the last chance to identify and solve potential issues before the owner takes over:

- ☐ Issues should be resolved before the owner takes over maintenance responsibilities.
- ☐ The assessment and maintenance of stormwater treatment practices can be divided into four main categories: visual inspection, capacity testing, synthetic runoff testing, and monitoring.

Funding Provided By:

- Region of Peel
- Credit Valley Conservation
- Toronto and Region Conservation Authority
- Lake Simcoe Region Conservation Authority

Project Team:

- Credit Valley Conservation Authority
- Emmons & Olivier Resources, Inc.
- Sabourin Kimble & Associates Ltd.

Reviewing Organizations:

- Credit Valley Conservation
- Toronto and Region Conservation Authority
- Town of Halton Hills
- Lake Simcoe Region Conservation Authority
- City of Mississauga
- City of Toronto
- Aquafor Beech Ltd.
- Urbantech Consulting
- R & M Construction
- Con-Drain Company Ltd

Publication Information:

Comments on this document should be directed to:

Robb Lukes
Water Resources Specialist

Credit Valley Conservation
1255 Old Derry Road
Mississauga, Ontario L5N 6R4

(905) 670-1615 ext 414
Email: rlukes@creditvalleyca.ca
www.creditvalleyca.ca

Cover Photo: Permeable pavement and bioretention planter retrofit to Elm Drive in the City of Mississauga.