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Building the one stop shop for LID guidance in Ontario: Latest enhancements to the LID Planning and Design Guide wiki

Presented by: Dean Young, Toronto and Region Conservation Authority

STEP Webinar Series
December 9, 2021

The water component of STEP is a collaborative of:

Lake Simcoe Region conservation authority

Credit Valley Conservation inspired by nature

Toronto and Region Conservation Authority

Overview

STEP is a multi-agency initiative developed to support broader implementation of sustainable technologies and practices within a Canadian context.

The water component of STEP is a conservation authority collaborative. Current partners are:

Lake Simcoe Region conservation authority

Credit Valley Conservation inspired by nature

Toronto and Region Conservation Authority

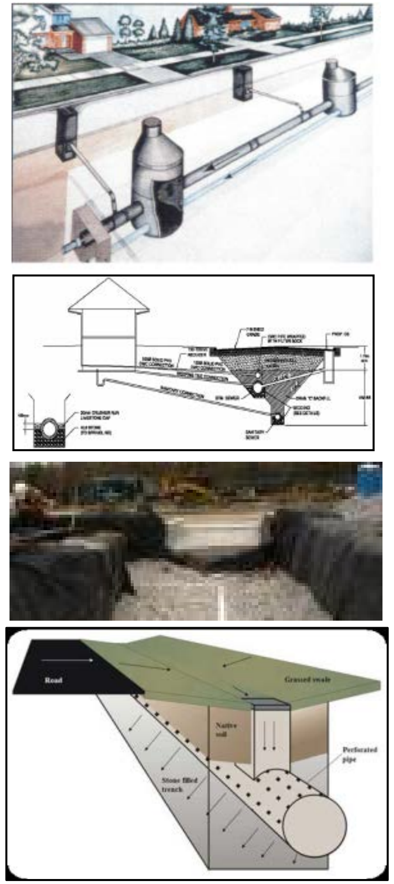
Our key areas of focus are:

- Low Impact Development
- Erosion and Sediment Control
- Road Salt Management
- Natural Features Restoration

Over 20 years of demonstration, monitoring and evaluation

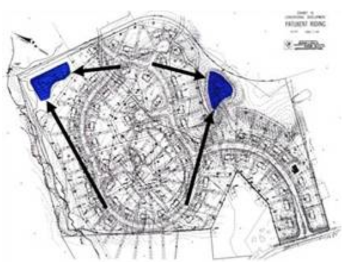
End of pipe facilities (n = 9)

Conveyance practices (n = 5)



Source controls (n = 25)

Rethinking stormwater infrastructure



Large, centralized

Small, distributed

Single function

Multi-functional

Pipes, sewers, curbs and gutters

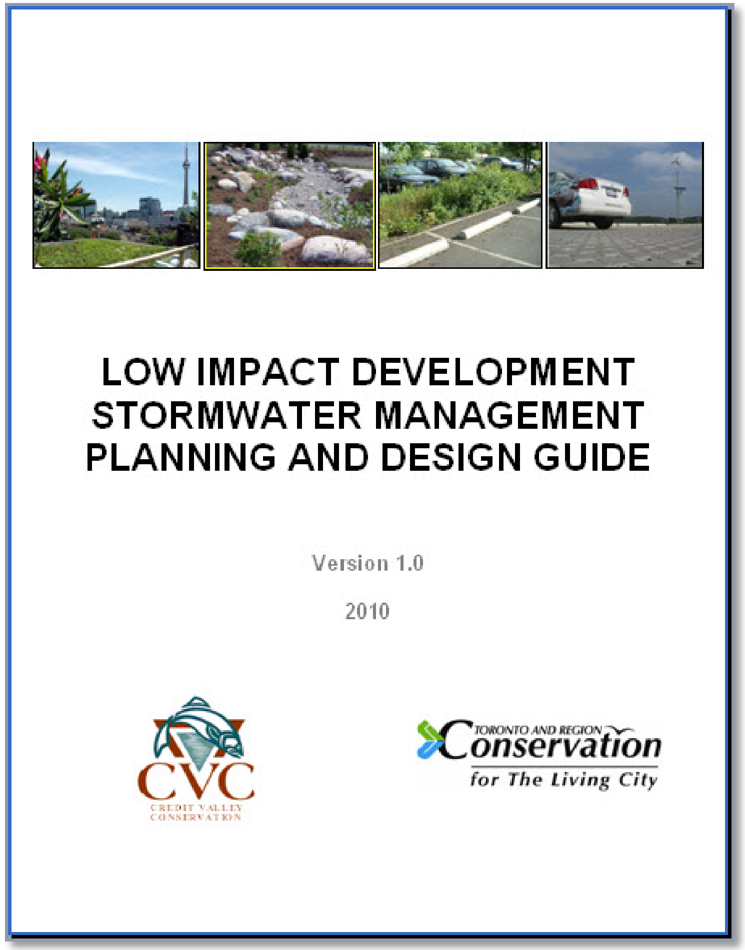
Soils, vegetation and hardscapes

Manage flow rates

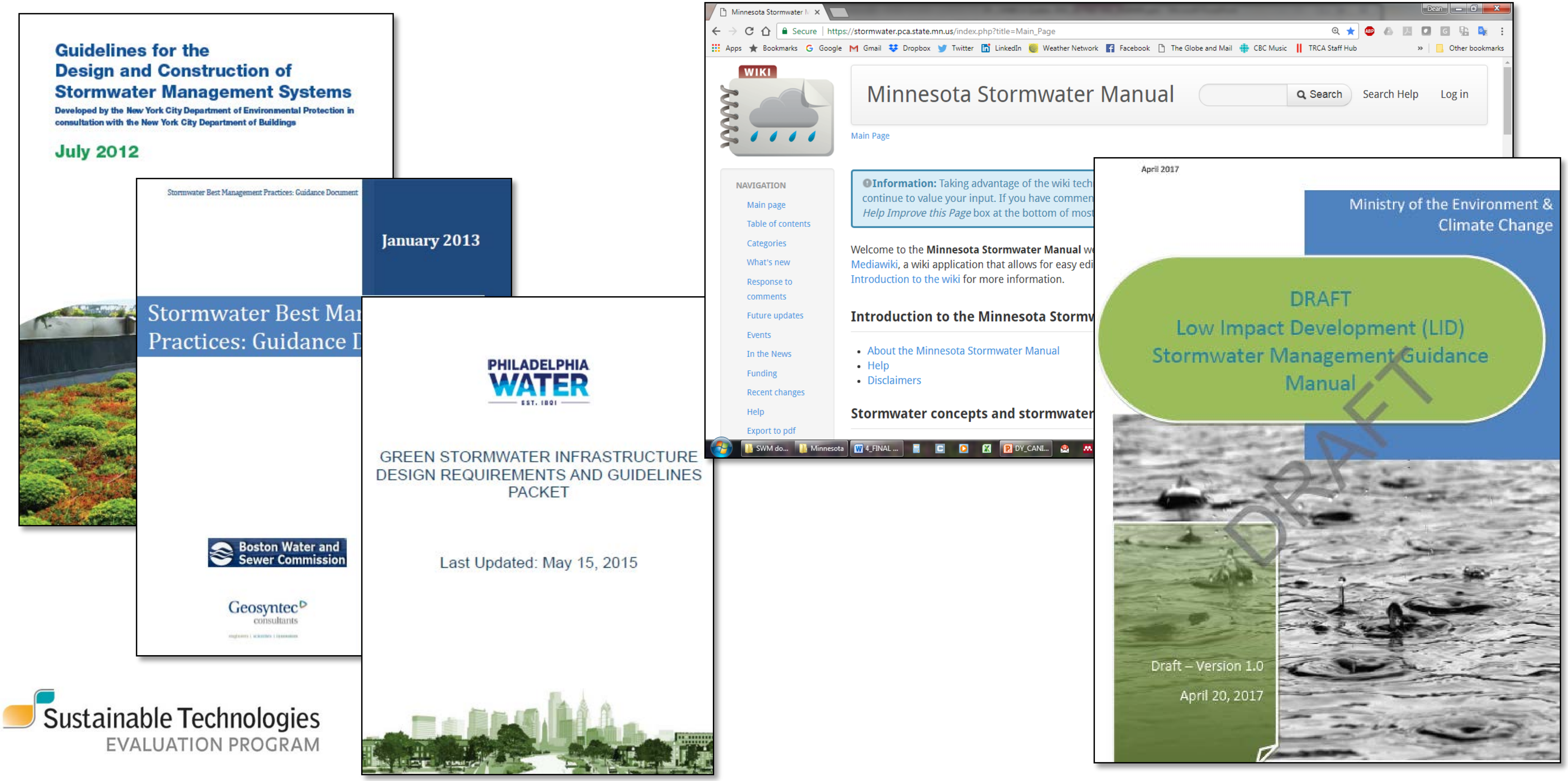
Manage the water cycle

Low Impact Development Stormwater Management Planning and Design Guide

- Version 1.0 published in 2010;
- Developed as tool to help facilitate implementation of sustainable stormwater management approaches;
- Augments MOECC 2003 SWM Planning and Design Manual;
- Widely used resource by practitioners;
- Audience: consultants, municipalities, agency review and approvals staff, NGOs.



Best practices and guides are evolving…



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How to best synthesize existing information and the latest research?

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Solution: An adaptive "living" resource for a rapidly evolving field…

…suited to the new era of digital communication and collaboration

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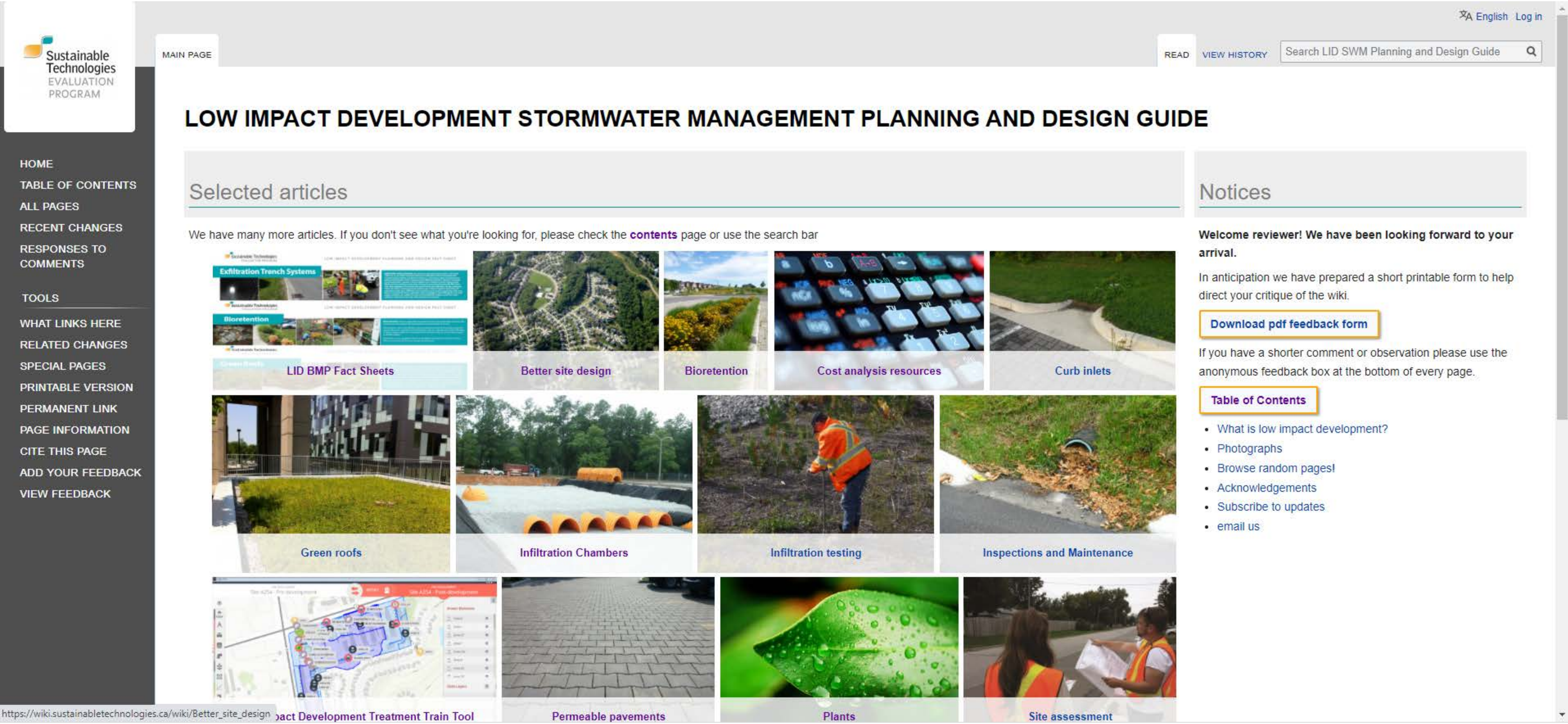
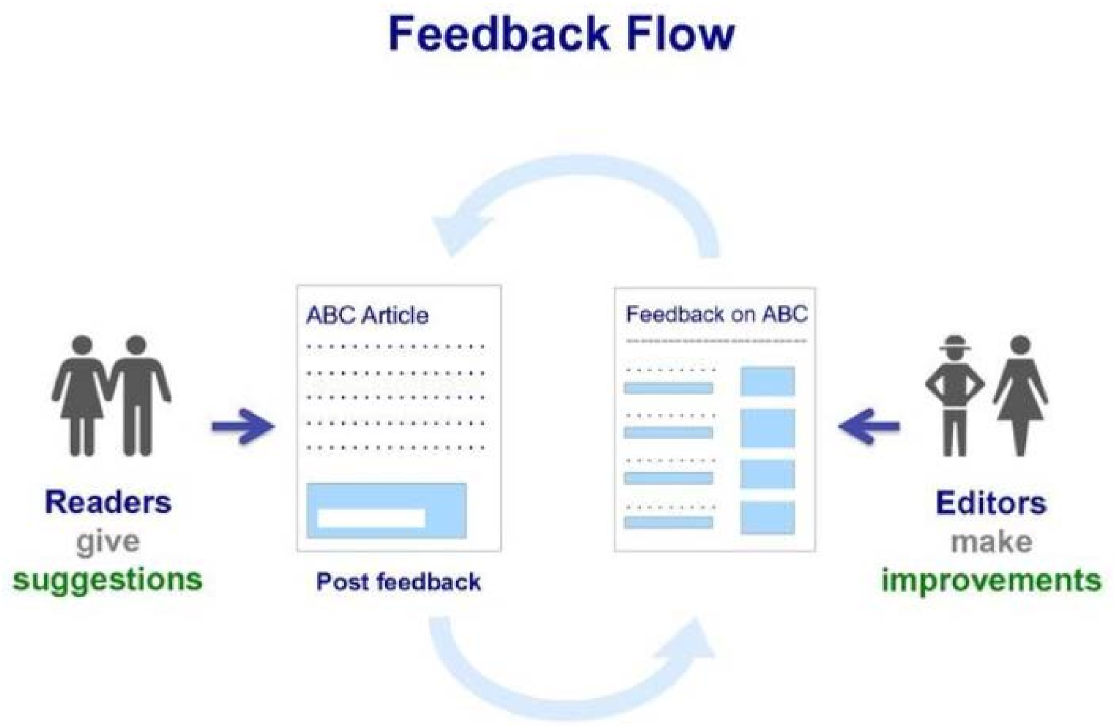


Strengths of the wiki format

- Powerful search capabilities (by topic, keyword, embedded links)
- Users can provide feedback on content and topics of interest;
- MediaWiki platform/simple coding language well-suited to text-heavy content like best practice guides;
- Allows inclusion of tools and external links;
- Built in tools provide…
  - administrators quick and easy ways to update/improve/add content and cite sources;
  - users ways to quickly find information, generate page citations and track changes.

Stakeholder and user feedback on enhancing the wiki

- Stakeholder and peer review 2019/20 involving representatives of key organizations and audiences;
  - Government (provincial ministries, municipalities, conservation authorities);
  - Industry associations;
  - Professional associations;
  - Academia;
  - Planning and design professionals;
  - Water management expert practitioners;
  - Non-governmental organizations.
- Comments and feedback submitted on the wiki by users.



Stakeholder and user feedback on enhancing the wiki

- Update LID Planning and Design Fact Sheets and ensure all guidance from 2010 is included or updated on wiki;
- Improve clarity in terminology and equations for sizing infiltration practices (e.g., porosity vs. void ratio);
- Improve guidance on approaches to LID design on spatially constrained sites.

New and improved LID Planning and Design Fact Sheets

Improved

1. Bioretention;
2. Enhanced grass swales;
   - Includes bio-swales; Replaces “Dry Swales”
3. Exfiltration trench systems;
   - Replaces “Perforated Pipe Systems”
4. Green roofs;
5. Permeable pavement;
6. Rainwater harvesting;
7. Site design strategies;
8. Soakaways, infiltration trenches & chambers.

New

9. Stormwater tree trench;

Coming soon

10. Absorbent landscapes
    - Includes planting soil restoration and vegetated filter strip guidance.
    - Replaces “Downspout Disconnection” and “Vegetated Filter Strips”.

https://wiki.sustainabletechnologies.ca/wiki/LID_BMP_Fact_Sheets

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LID BMP Fact Sheets

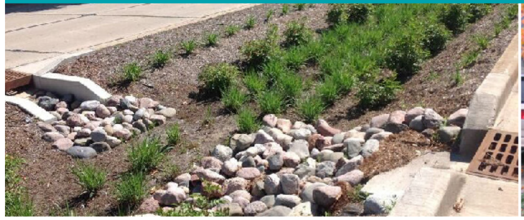
Contents [hide]

Overview [edit]

Please find below a collection of the most common LID Best Management Practices for both Development, Planning and Design. These fact sheets provide helpful details on:

- Design Considerations
  - Geometry and Site Layout
  - Pre-Treatment (if applicable)
  - Conveyance and Overflow
  - Proper Landscaping Techniques
  - Access Structures, etc.
- Construction
  - Soil Disturbance and Compaction
  - Erosion Sediment Control (ESC)
  - Excavation
  - Base Construction (if applicable), etc.
- Planning Considerations
  - Soil
  - Wellhead Protection (if applicable)
  - Karst (if applicable)
  - Site Topography

Enhanced Grass Swales



Enhanced Grass Swales are vegetated open channels designed to convey, treat and attenuate stormwater runoff. Simple grass channels or ditches have long been used for stormwater conveyance, particularly for road drainage. Enhanced grass swales incorporate design features such as modified geometry and check dams that improve the contaminant removal and runoff reduction functions of simple grass channel and roadside ditch designs. Bioretention swales (i.e. bioswales, dry swales) incorporate filter media and possibly a perforated pipe underdrain to ensure they drain within the required drawdown time. Where development density, topography and depth to water table permit, swales are a preferable alternative to curb and gutter and storm drains as a stormwater conveyance system.

DESIGN

GEOMETRY AND SITE LAYOUT

Swales typically treat drainage areas of two hectares or less. Minimum planting soil or filter media bed footprint area is based on the design storm runoff volume and effective surface ponding depth behind check dams. Recommended impervious drainage area to pervious facility footprint area ratios (I:P ratios) range from 5:1 on low permeability soils, such as hydrologic soil group (HSG) C and D, to 20:1 on high permeability soils (HSG A & B). Cross-section shape may be parabolic or trapezoidal, but parabolic is preferable for aesthetics, maintenance and hydraulics.

INLETS

Distribute concentrated inflows between multiple inlets or facilities to reduce risk of failure. Configurations include overland sheet flow, concentrated overland flow and concentrated underground (i.e. pipe) flow.

PRE-TREATMENT

Pre-treatment captures sediment before it reaches the filter bed. It is typically necessary unless runoff sediment load is very low (e.g. roof drainage). Pre-treatment options include: level spreaders, stone filter inlets with geotextile fabric and catch basins with sump. See Specifications section for more information.

PLANTING SOIL / FILTER MEDIA

Planting soil or filter media should come pre-mixed from an approved vendor. See Specifications section for more details.

UNDERDRAIN

Underdrains are recommended for bioswales where native soil infiltration rate < 15 mm/h (hydraulic conductivity < 1×10^{-6} cm/s), and needed for non-infiltrating designs. They are comprised of a length of perforated pipe embedded near the top of the storage reservoir, with an overlying choker layer of medium-sized aggregate, and structures to provide inspection and maintenance access. Alternatively, the perforated pipe could be installed on the reservoir bottom and connected to an upturned pipe assembly or riser. Another option is to include a flow restrictor (e.g. orifice cap or valve) on the underdrain outlet pipe, to optimize infiltration while meeting the required drainage time.

PERFORATED PIPE

Continuously perforated, smooth interior HDPE or PVC pipe with diameter ≥ 200 mm to reduce freezing risk and facilitate access by camera and cleaning equipment. Perforated pipe extends length of facility and solid pipe is used to connect to storm drain system.

ACCESS STRUCTURES

Used for inspection and flushing. May be a maintenance hole or vertical standpipe connected to the perforated pipe. Couplings used for standpipe connections should be 45° to facilitate pipe access by camera or cleaning equipment.

CONVEYANCE AND OVERFLOW

Swales can be designed to be inline or offline from the drainage system. Inline swales accepts all flow from the drainage area and conveys large event flows through an overflow outlet. Overflow structures must be sized to safely convey large event flows out of the facility. Options include flat, dome or ditch inlet catch basins connected to a storm sewer.

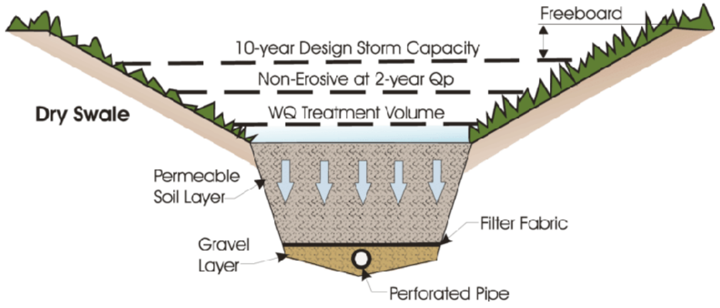
MONITORING WELLS

A vertical standpipe consisting of an anchored 100 to 150 mm diameter pipe with perforations along the length within the reservoir, installed to the bottom of the facility, with a lockable cap. The well allows monitoring of inter-event drainage times.

PLANTS

Planting should be dense to help maintain surface infiltration and improve sediment settling and retention of dissolved contaminants. See Specifications section for more information.

Swale Design	Ability to meet stormwater criteria		
	Water balance	Water quality	Stream erosion control
Swale with no underdrain or full infiltration	Partial – based on storage volume and soil infiltration rate	Yes – size for water quality storage requirement and max. flow rate of 0.5 m/s	Partial – based on storage volume and soil infiltration rate
Swale with underdrain or partial infiltration	Partial – based on storage volume beneath the underdrain and soil infiltration rate	Yes – size for water quality storage requirement	Partial – based on storage volume, soil infiltration rate, and if flow restrictor is used
Swale with underdrain and impermeable liner or no infiltration	Partial – some volume reduction through evapo-transpiration	Yes – size for water quality storage requirement	Partial – based on available storage volume and if flow restrictor is used



PLANNING CONSIDERATIONS

Native Soil | Swales can be located over any soil type, but HSG A and B soils are best for achieving water balance objectives. Facilities should be located in portions of the site with the highest native soil infiltration rates. Where infiltration rates are less than 15 mm/hr (hydraulic conductivity less than 1×10^{-6} cm/s) an underdrain is recommended. Native soil infiltration rate at the proposed facility location and depth should be confirmed through in-situ measurements of hydraulic conductivity under field saturated conditions.

Wellhead Protection | Facilities receiving road or parking lot runoff should not be located within year 2 year time-of-travel wellhead protection areas (see local drinking water source protection plan).

Available Space | Reserve open space of about 5 to 20% of the size of the contributing drainage area.

Site Topography | Contributing slopes should be between 1 to 5%. Swale longitudinal slopes may range from 0.5 to 6%. On slopes steeper than 3%, check dams should be used.

Water Table | Maintaining a separation of 1 m between the elevations of the base of the practice and the seasonally high water table, or top of bedrock is recommended. Lesser or greater values may be considered based on groundwater mounding analysis. See STEP LID Planning and Design Guide wiki page, Groundwater, for further guidance and spreadsheet tool.

Pollution Hot Spot Runoff | To protect groundwater from possible contamination, runoff from pollution hot spots should not be treated by swales designed for infiltration. Facilities designed with an impermeable liner (filtration only) can be used to treat runoff from hot spots.

Proximity to Underground Utilities | Designers should consult local utility design guidance for the horizontal and vertical clearance between storm drains, ditches and surface water bodies.

Karst | Swales designed for infiltration are not suitable in areas of known or implied karst topography.

Setback from Buildings | Should be set back 4 m from building foundations.

OPERATION AND MAINTENANCE

Routine Maintenance | Routine maintenance consists of mowing, weeding, pruning and mulching vegetation, and checking and cleaning trash, debris and sediment from pre-treatment devices, inlets, check dams and outlets twice a year in the spring and/or late fall, or when pre-treatment device sump is half full. Use a hydro-vac truck to remove sediment from catchbasin and oil and grit separator sumps and check dams. Grassed swales should be mown at least twice yearly to maintain grass height between 75 and 150 mm. Watering may be required during the first two years until vegetation is established. Other maintenance activities include replacing dead vegetation and repairing eroded areas as needed. Remove accumulated sediment when it is dry and has reached a depth > 25 mm.

Inspection | Routine inspections should be done twice annually in the spring and late fall and after major storm events. Inspect for vegetation density (at least 80% coverage), damage by foot or vehicular traffic, channelization, accumulation of debris, trash and sediment and damage to pre-treatment devices.

Monitoring | Monitoring of storage reservoir water level during and after natural or simulated storm events using the monitoring well should be performed periodically to verify the facility drains within the required drainage time (typically 72 hours). Monitoring should be performed as part of inspections following construction or major rehabilitation prior to assumption, and every 15 years at a minimum, to track drainage performance over time and determine when replacement is needed.

CONSTRUCTION

Soil Disturbance and Compaction | Before site work begins, locations of swales should be clearly marked. Ideally, swale locations should remain outside the limit of disturbance until construction of the facility begins to prevent soil compaction by heavy equipment.

Erosion and Sediment Control | Swale locations should not be used as sediment basins during construction. To prevent sediment from clogging, erosion and sediment controls should remain in place and runoff should be diverted from the swale until the contributing drainage area is fully stabilized and vegetation cover is established.

The water component of the Sustainable Technologies Evaluation Program is a collaboration of:

Toronto and Region Conservation Authority,
Credit Valley Conservation, and
Lake Simcoe Region Conservation Authority

For more information:

Visit the online Low Impact Development Stormwater Management Planning and Design Guide for more information including links to all sources cited: wiki.sustainabletechnologies.ca.

LID Stormwater Inspection and Maintenance Guide (TRCA, 2016): sustainabletechnologies.ca.

LID Construction Guide (CVC, 2012): sustainabletechnologies.ca.

GENERAL SPECIFICATIONS

Material	Specification
Site Layout	• Enhanced swales typically treat drainage areas of two hectares or less. • Swale total width should be 2 metres or greater and bottom width between 0.75 and 3.0 metres. Swale length between check dams should be ≥ 5 m. • Side slopes should be no steeper than 1:3 (33%) for mowing maintenance. Gentler slopes (e.g. 1:4 or 25%) are encouraged where runoff enters the swale as sheet flow. • A maximum flow depth of 0.1 m is recommended during the design storm event.
Inlets	• For concentrated overland flow: (i) Catch basins or other inlet structures should be located at all sag points in the gutter grade and immediately upgrade of median breaks, crosswalks and street intersections. (ii) Inlet types include curb openings (modified curbs, spillways), side inlet catch basins, trench drains or other pre-fabricated inlet structures. (iii) Spillways aid in turning flow 30, 45 or 90 degrees into the practice. (iv) Incorporate concrete aprons at curb opening or spillway locations to increase inflow effectiveness. (v) If the inlet structure itself does not provide sedimentation or filtration pre-treatment, incorporate a pre-treatment feature at curb opening or spillway location to isolate sediment, trash and debris for ease of removal. (vi) Provide a 75 to 150 mm drop in elevation between the inlet invert and grass or mulch surface, pre-treatment feature or concrete apron.
Pre-Treatment	• Level spreader: A shallow trench structure (with concrete, metal or wood lip), graded to be level and installed parallel to the pavement edge or flush curb. Recommended sizing: (i) 1.4 m of length for every 0.01 m^3/s of inflow during the design storm event, (ii) width of 300 mm or 3 times inflow pipe diameter, (iii) depth of 200 mm or half the inflow pipe diameter. Used with overland sheet flow inlets. • Geotextile and stone filter inlets: Square or rectangular curb openings located directly over the practice, filled with clean aggregate, covered with a layer of geotextile filter fabric and stone, graded level or gently sloped and installed at concentrated overland flow inlets (e.g. curb cuts). Elevation change of 75 to 100 mm from pavement to top of the stone cover. Stone cover may be 50 to 150 mm diameter crushed angular stone, river rock/beach stone or rip rap. • Catch basin, manhole, or other inlet structure sumps in combination with a shield, baffle, trap, or filter insert device, or goss trap are used to pre-treat concentrated overland flow. They can be designed to retain both coarse and fine particulate sediments in the sump, and floatables (hydrocarbons, trash and debris). A variety of proprietary pre-treatment devices are available. • Forebay: Constructed with 2:1 length to width ratio and sized to accommodate ponding volume of 25% of the surface ponding storage requirement. Used with concentrated overland flow inlets.
Planting Soil/ Filter Media	• Planting soil: (i) use for enhanced grass swales (ii) hydraulic conductivity, saturated (ASTM D2434) at 85% maximum dry density (ASTM D698) should be of 15 - 300 mm/h. • Filter Media Blend A – Drainage rate priority: (i) Use when I:P ratio ≥15:1, (ii) 3 parts sand to 1 part organic material or additives, (iii) Porosity of 0.4, (iv) hydraulic conductivity, saturated (ASTM D2434) at 85% maximum dry density (ASTM D698) should be of 75 - 300 mm/h. • Filter Media Blend B – Water quality treatment priority: (i) Use when improved metals and phosphorus retention and/or more diverse planting options are desired, (ii) 3 parts sand to 2 parts topsoil to 1 part organic material or additives, (iii) porosity of 0.35, (iv) hydraulic conductivity, saturated (ASTM D2434) at 85% maximum dry density (ASTM D698) should be 25 to 300 mm/h. • Sand: Should be coarse and have a fineness modulus index between 2.8 and 3.1 according to ASTM C33/C33M. • Topsoil: Must contain at least 9%, and not greater than 36% clay-sized particles and have a sodium absorption ratio less than 15. • Organic material: Should be material low in available phosphorus such as leaf and yard waste compost, untreated wood chips, shredded paper or coir. Organic matter (ASTM F1647) should make up 3 to 10% of the filter media by dry weight. • Additives: Typically 5 to 10% by volume of the filter media blend (follow product manufacturer instructions where applicable). • Particle-size distribution (ASTM D7928): <25% silt-and clay-sized particles combined (smaller than 0.05 mm); 3 to 12% clay-sized particles (0.002 mm or smaller). • Other parameters: Phosphorus (Plant Available or Extractable) should be between 10 and 40 ppm, and cation exchange capacity (ASTM D7503) >10 meq/100 g.
Check Dams	• Low head dams to slow concentrated flow and promote settling and infiltration. Dam height depends on depth of ponded water that will infiltrate in the required drainage time. May be constructed of any resilient and waterproof material including concrete, metal and stone (typically <150mm rip rap) and may have spillways incorporated into their profile to direct water to the centre of the swale. Should include stone cover on the down-gradient side for erosion control. • Check dam spacing should be based on the slope and desired ponding volume. They should be spaced far enough apart to allow access for maintenance equipment (e.g., mowers).
Plants	• Enhanced grass swales may be planted with sod or seed. • If using seed, stabilize swale with erosion control blanket. • Bioswale planting plans should feature a mixture of deeply rooting perennials adapted to both wet and dry conditions and local climate. • If using a native seed mix, include a cover crop of oats, winter wheat, or rye to stabilize the swale in the short term. • Road salt tolerance should be considered if facility will receive pavement runoff.

Stormwater Tree Trench




Stormwater Tree Trenches are linear bioretention practices that manage stormwater while also promoting healthy tree growth. They are most often located behind the curb in the road right-of-way and consist of a series of tree planting pits connected to subsurface trenches filled with special engineered soils and/or structural soil support systems that support the surrounding pavement and foster root growth. Tree trenches offer solutions to multiple urban environmental challenges: they improve urban tree health by providing irrigation and allowing them to survive longer in harsh conditions, while also reducing roadway flooding, contributing to stormwater pollutant removal, and decreasing the volume of runoff entering local waterways. Tree trenches consist of planting soil, stormwater piping, structural soil media or filter media contained within a modular soil support system, and trees. The engineered soil (or soil support system) may extend under paved surfaces next to the tree planting pit to provide more soil volume for water storage and tree growth.

DESIGN

GEOMETRY AND SITE LAYOUT

Tree trenches are most often modular systems that are connected hydrologically through a sub-surface drainage pipe network, however road runoff may also be directed to the surface via curb cuts or surface drains. In both cases, inlets are offset from the root ball to avoid accumulation of road salt during early tree establishment.

INLETS

Water can enter the tree trench in a variety of ways from surface drainage into the tree well from adjacent sidewalks and from the road through curb cuts or depressed drains, to direct vertical drainage through permeable pavers, and from catch basin inlets in the roadway that direct runoff into the trench through distribution pipes. It is recommended that each tree trench have multiple inlets to keep any one drainage area relatively small, which provides redundancy to the system.

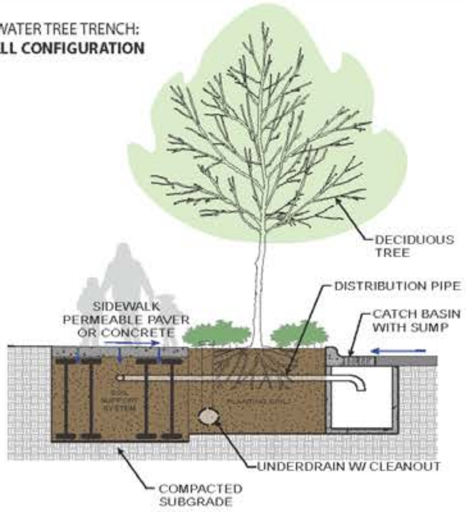
PRE-TREATMENT

If water enters the trench via a catchbasin, a structural pre-treatment device, like a catch basin shield or filter, should be included to collect silt and sediment from the runoff before it enters the trench. Surface inlet systems should have a sump or stone diaphragm to dissipate energy and spread flows. Pre-treatment devices should be easy to access and clean out, as maintenance of these devices is key to the long-term success of tree trenches.

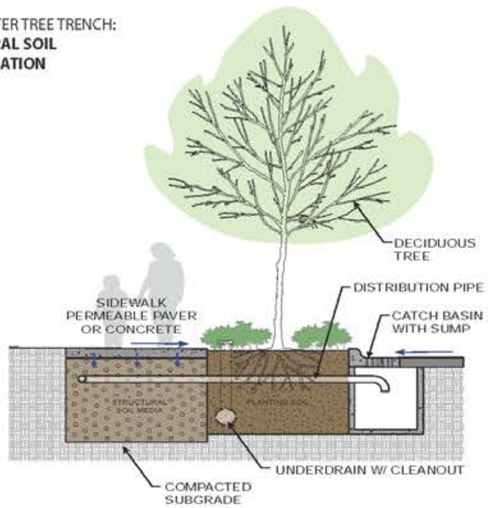
SOIL VOLUME

Each tree planted should have minimum 30 m^3 soil volume. This can be 30 m^3 of soil within the planting pit or 16 m^3 within the planting pit, with root access to an additional 14 m^3 of engineered structural soil media or planting soil under adjacent supported pavements. If more than one tree shares the same trench a minimum 20 m^3 per tree is acceptable as the roots will still have ample room to spread.

STORMWATER TREE TRENCH:
SOIL CELL CONFIGURATION



STORMWATER TREE TRENCH:
STRUCTURAL SOIL CONFIGURATION



BMP	Ability to meet stormwater criteria		
	Water balance	Water quality	Stream erosion control
Tree Trench	Partial, based on native soil infiltration rate and if flow restrictor is used	Yes - size for water quality storage requirement	Partial - based on native soil infiltration rate, available storage and if flow restrictor is used

STRUCTURAL SOIL MEDIA

Structural soil is an engineered soil medium that can be compacted to support sidewalk or roadway pavement installation requirements while also permitting tree root growth. Structural soil media is used adjacent to tree pits to provide more room for tree roots to spread out under paved surfaces that surround the tree trench.

MODULAR SOIL SUPPORT SYSTEMS

Modular soil support systems consist of modular frames (or cells), in a variety of sizes, that provide structural support for paved surfaces without the need for a compacted soil base within the root zone. Modular soil support systems are an alternative to structural soil media and are used adjacent to tree pits to provide room for tree roots to spread out under paved surfaces surrounding the tree trench. Growing media in soil support systems typically has higher organic content than structural soils. The looser structure and higher nutrient content of the soil in modular support systems provides the most favourable environment for healthy tree growth in the urban setting.

STRUCTURAL CONCRETE PANEL

A structural concrete panel configuration is an alternative to modular soil support systems that uses a "bridge deck" over bioretention or growing media that extends into the pedestrian clearway, and is supported on each side by concrete supports and compacted granular material. The benefit of this approach is that the soil under the drainage media does not need to be compacted, allowing for greater infiltration.

CONVEYANCE AND OVERFLOW

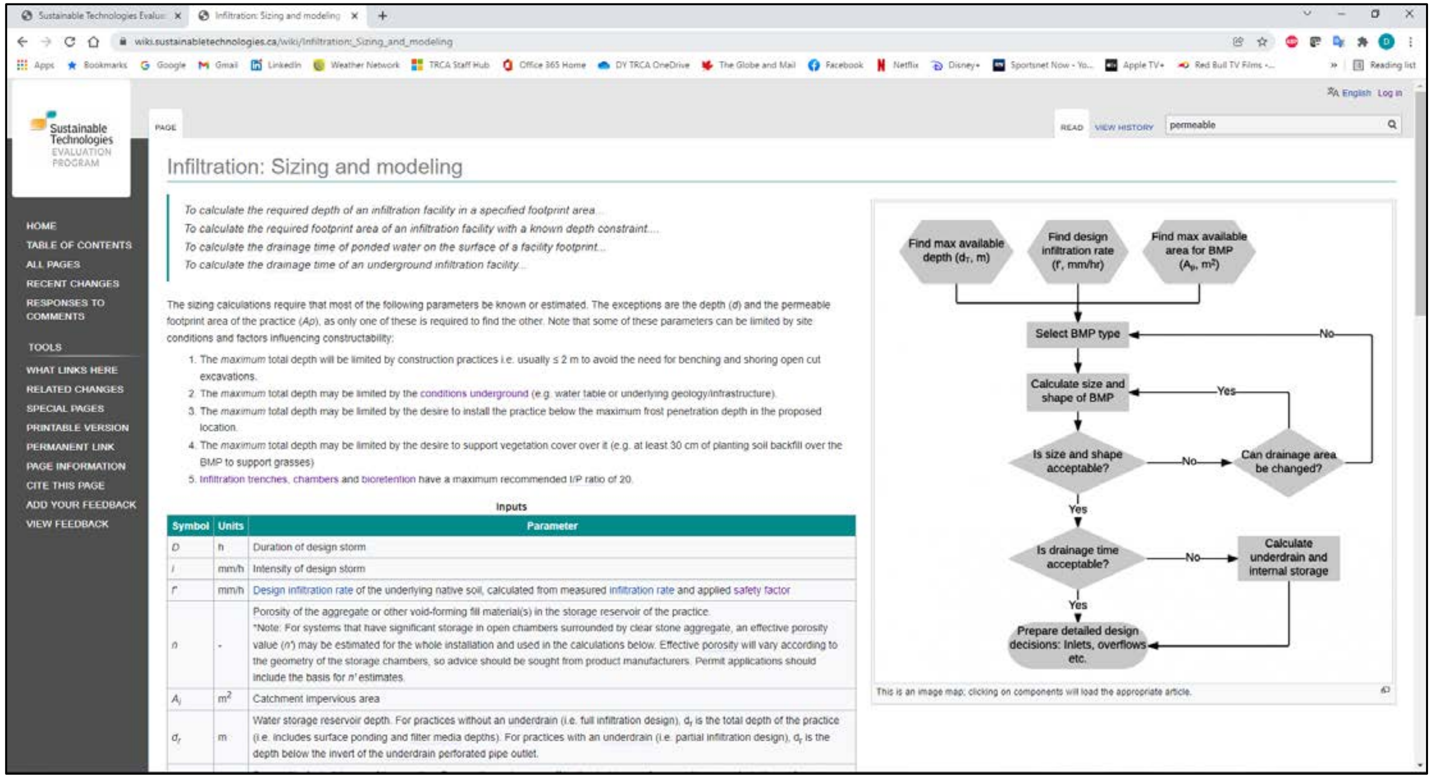
Runoff is directed from surrounding impervious surfaces through curb cuts and surface drains to the tree trench where it percolates through the soil media to the underlying ground or underdrain. If the runoff exceeds the design capacity, the underdrain directs the excess filtered stormwater to a storm sewer or downstream LID practices. During intense storm events, excess runoff will overflow directly to the storm sewer either through an outlet in the catchbasin or via a surface overflow within the tree trench.

CONFIGURATION

Liners and gravel storage areas below the trench should be avoided to maximize infiltration and to encourage tree roots to penetrate the sub-soil.

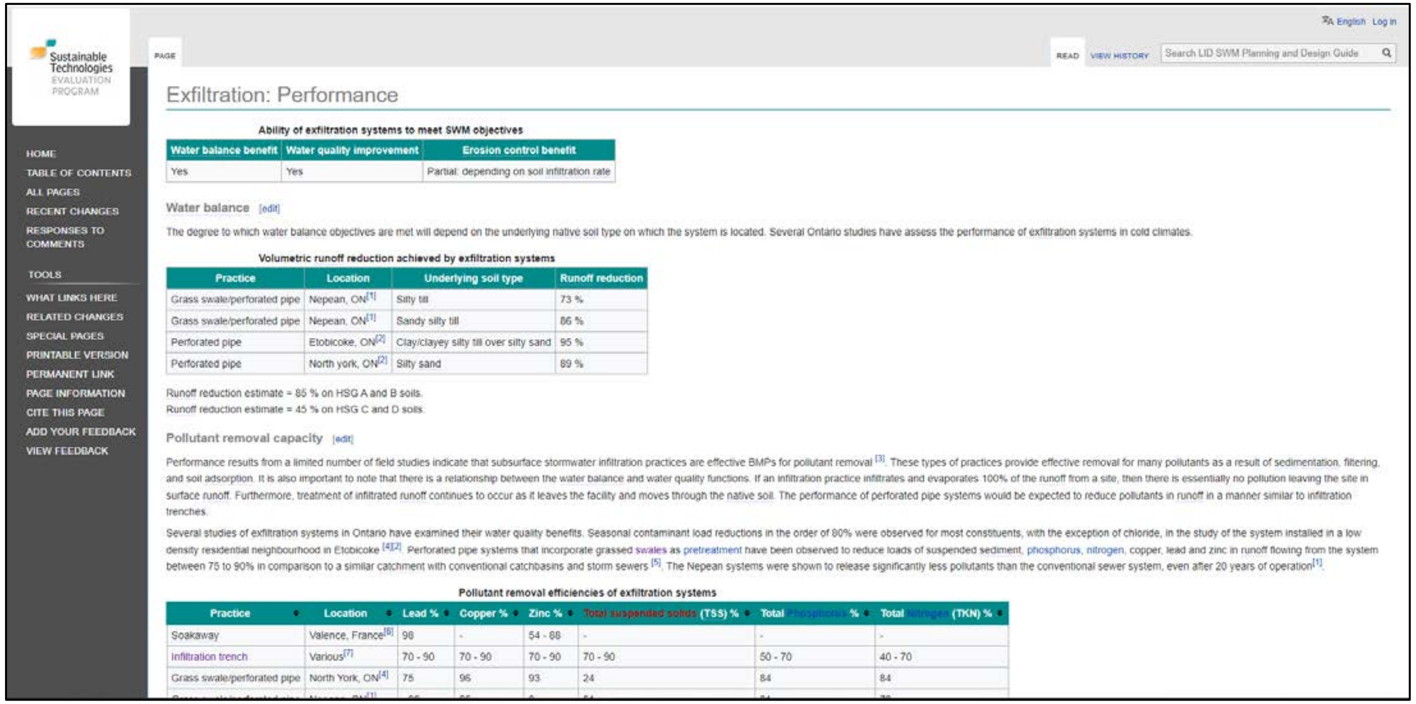
Enhanced guidance on sizing infiltration practices

- Improved consistency in terminology and nomenclature used in sizing equations and tools;
- Decision-tree and stepwise guidance that factors in site constraint considerations and design variations.
  - Infiltration: Sizing
  - Bioretention: Sizing



Stakeholder and user feedback on enhancing the wiki

- Enhance content on **treatment performance** of LID practices based on Canadian studies and those from similar climates;
- Integrate updated information on **life cycle costs** of LID practices and cost estimation tools;
- Enhance content on **construction, inspection and maintenance** from other STEP guides and professional training courses.



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Exfiltration: Performance

Ability of exfiltration systems to meet SWM objectives

Water balance benefit	Water quality improvement	Erosion control benefit
Yes	Yes	Partial: depending on soil infiltration rate

Water balance [edit]

The degree to which water balance objectives are met will depend on the underlying native soil type on which the system is located. Several Ontario studies have assess the performance of exfiltration systems in cold climates.

Volumetric runoff reduction achieved by exfiltration systems

Practice	Location	Underlying soil type	Runoff reduction
Grass swale/perforated pipe	Nepean, ON[1]	Silty till	73 %
Grass swale/perforated pipe	Nepean, ON[1]	Sandy silty till	86 %
Perforated pipe	Etobicoke, ON[2]	Clay/clayey silty till over silty sand	95 %
Perforated pipe	North york, ON[2]	Silty sand	89 %

Runoff reduction estimate = 85 % on HSG A and B soils.
Runoff reduction estimate = 45 % on HSG C and D soils.

Pollutant removal capacity [edit]

Performance results from a limited number of field studies indicate that subsurface stormwater infiltration practices are effective BMPs for pollutant removal [3]. These types of practices provide effective removal for many pollutants as a result of sedimentation, filtering, and soil adsorption. It is also important to note that there is a relationship between the water balance and water quality functions. If an infiltration practice infiltrates and evaporates 100% of the runoff from a site, then there is essentially no pollution leaving the site in surface runoff. Furthermore, treatment of infiltrated runoff continues to occur as it leaves the facility and moves through the native soil. The performance of perforated pipe systems would be expected to reduce pollutants in runoff in a manner similar to infiltration trenches.

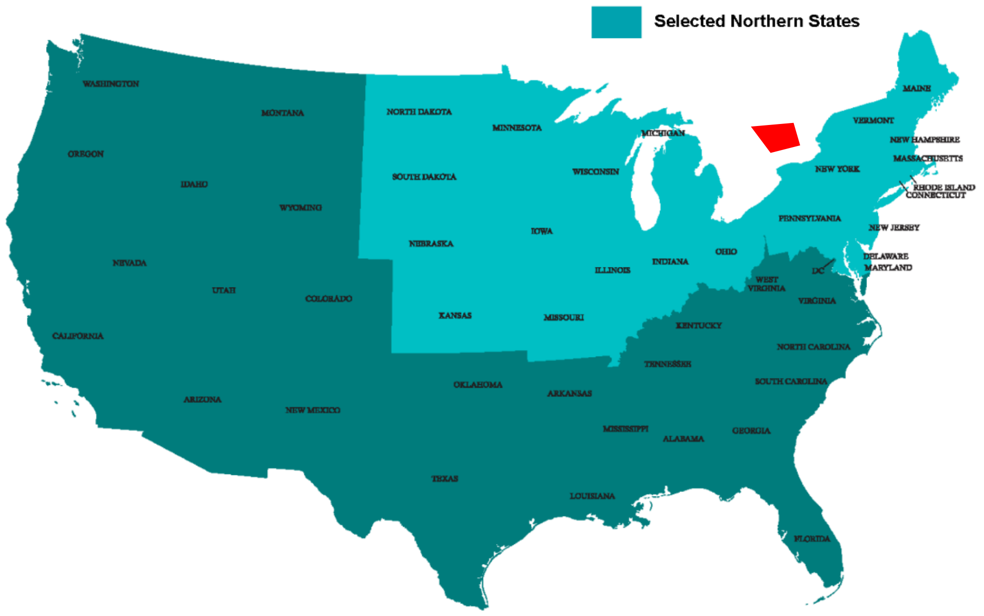
Several studies of exfiltration systems in Ontario have examined their water quality benefits. Seasonal contaminant load reductions in the order of 80% were observed for most constituents, with the exception of chloride, in the study of the system installed in a low density residential neighbourhood in Etobicoke [4][2]. Perforated pipe systems that incorporate grassed swales as pretreatment have been observed to reduce loads of suspended sediment, phosphorus, nitrogen, copper, lead and zinc in runoff flowing from the system between 75 to 90% in comparison to a similar catchment with conventional catchbasins and storm sewers [5]. The Nepean systems were shown to release significantly less pollutants than the conventional sewer system, even after 20 years of operation[1].

Pollutant removal efficiencies of exfiltration systems

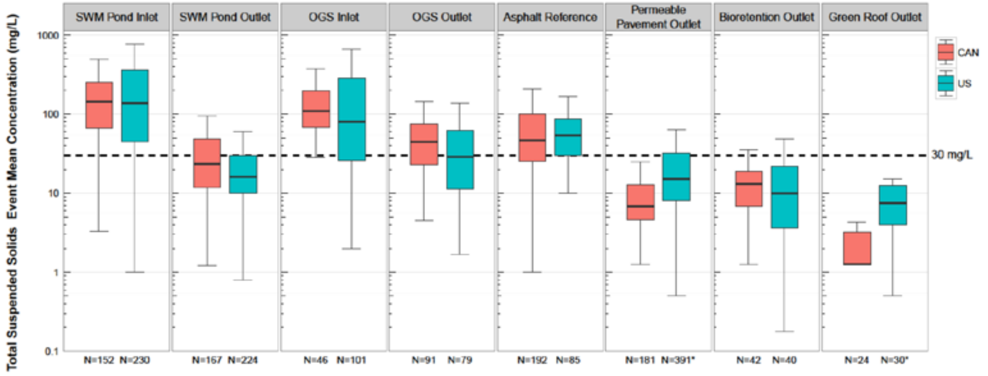
Practice	Location	Lead %	Copper %	Zinc %	Total suspended solids (TSS) %	Total Phosphorus %	Total Nitrogen (TKN) %
Soakaway	Valence, France[6]	98	-	54 - 88	-	-	-
Infiltration trench	Various[7]	70 - 90	70 - 90	70 - 90	70 - 90	50 - 70	40 - 70
Grass swale/perforated pipe	North York, ON[4]	75	96	93	24	84	84

Enhance content on treatment performance

Canadian and United States Water Quality Data Comparison



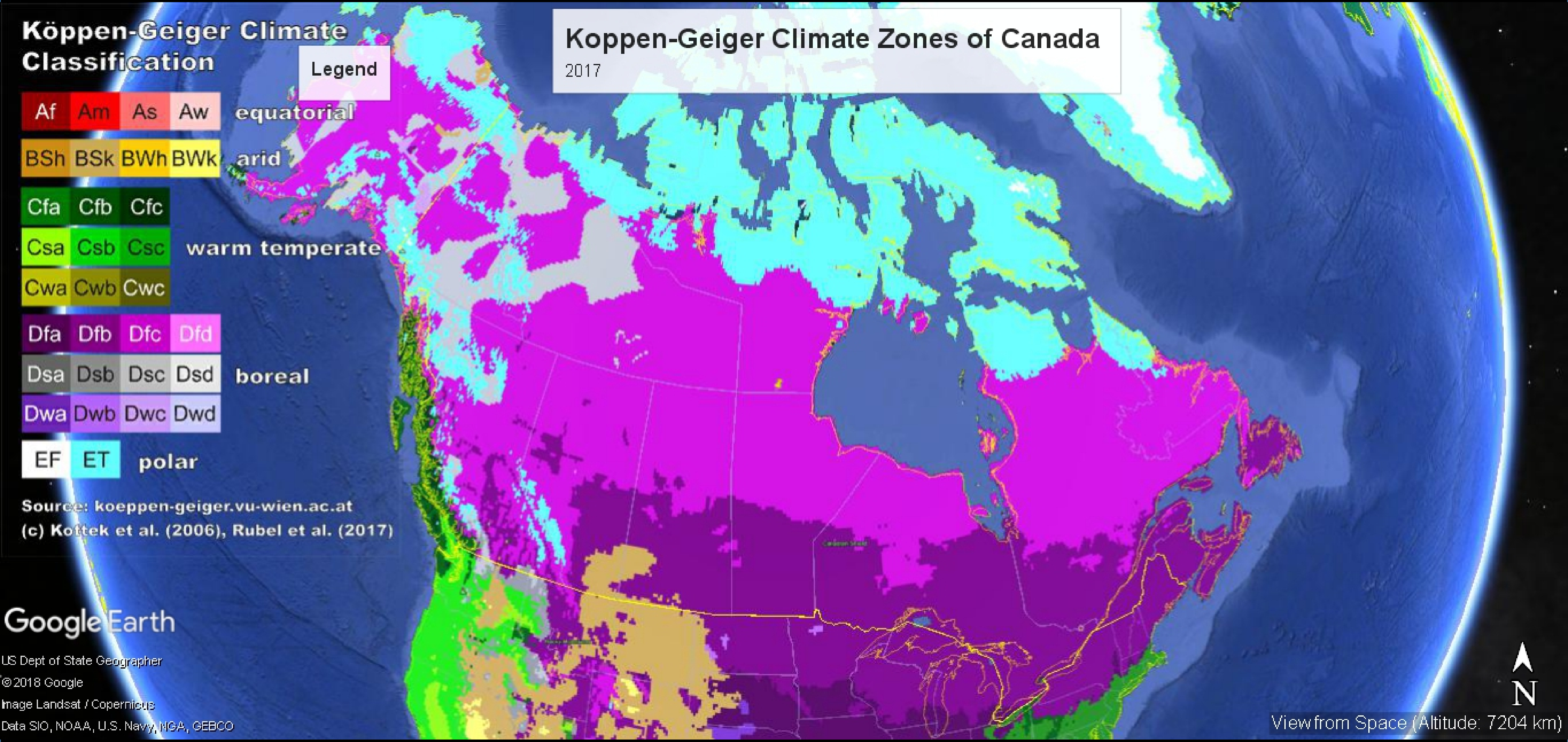
Solids; suspended

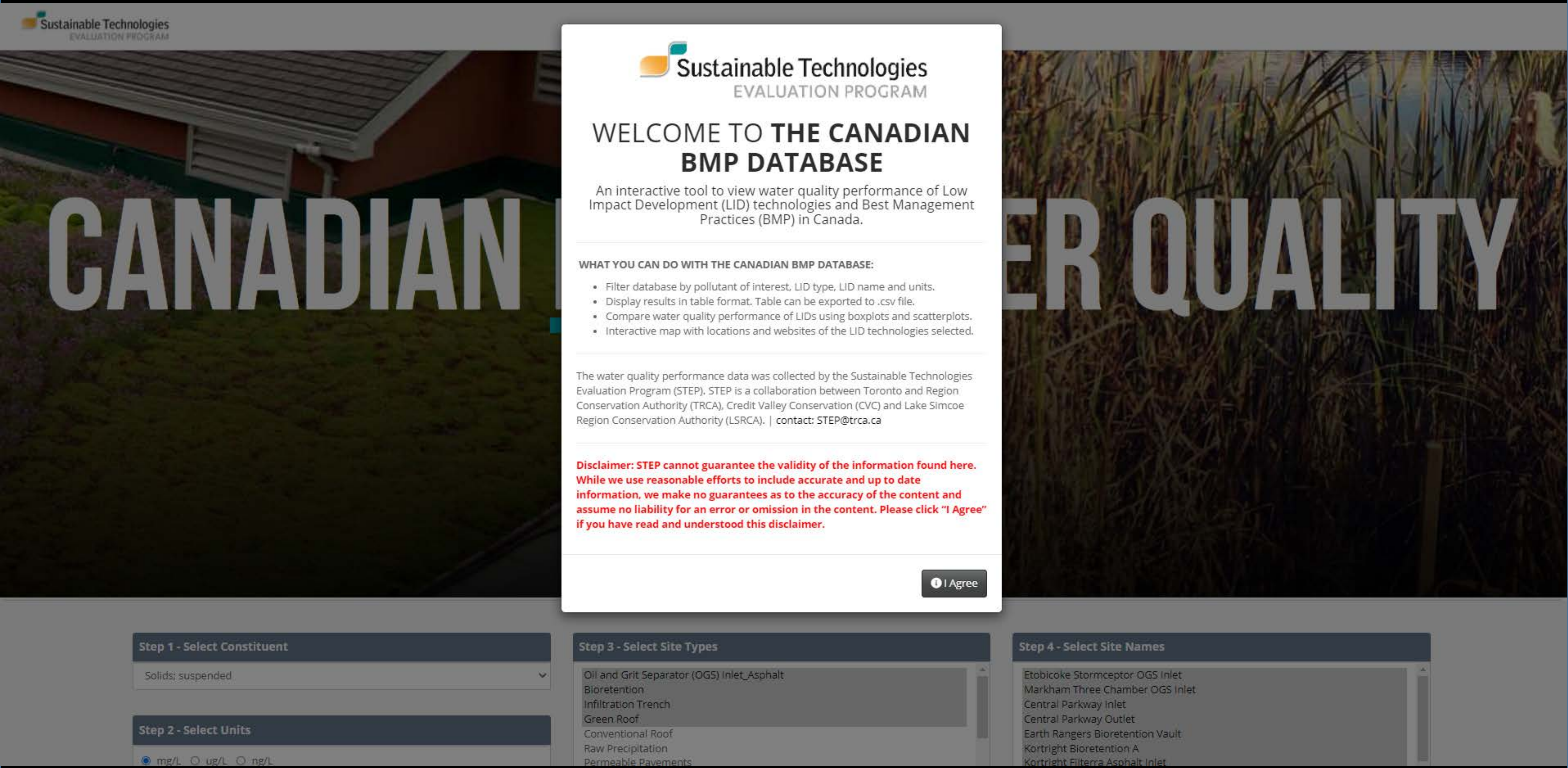


Site Type	Raw or Transformed	Both Samples Normally Distributed	Equal Variances	Test	Test Statistic	p Value	Statistical Significant Difference (alpha = 0.05)
SWM Pond Inlet	Log10	No	No	Wilcoxon rank sum test with continuity correction	17707	0.830	No[a]
SWM Pond Outlet	Log10	Yes	No	Welch Two Sample t-test	3.153	0.002	Yes
OGS Inlet	Log10	Yes	No	Welch Two Sample t-test	1.601	0.111	No
OGS Outlet	Raw	No	Yes	Wilcoxon rank sum test with continuity correction	4340	0.02	Yes
Asphalt Reference	Raw	No	Yes	Wilcoxon rank sum test with continuity correction	7801	0.56	No
Permeable Pavement Outlet	Reciprocal Square Root	No	Yes	Wilcoxon rank sum test with continuity correction	50950	2.50E-17	Yes
Bioretention Outlet	Fourth Root	Yes	No	Welch Two Sample t-test	0.348	0.729	No
Green Roof Outlet	Raw	No	Yes	Wilcoxon rank sum test with continuity correction	166	0.001	Yes

[a]Normality and homogeneity of variances assumptions are not met.

Source: Synthesis of stormwater monitoring studies in Ontario (STEP 2015)


Koppen-Geiger Climate Zones of Canada
2017
Köppen-Geiger Climate Classification
Legend
Af Am As Aw equatorial
BSh BSk BWh BWk arid
Cfa Cfb Cfc
Csa Csb Csc warm temperate
Cwa Cwb Cwc
Dfa Dfb Dfc Dfd
Dsa Dsb Dsc Dsd boreal
Dwa Dwb Dwc Dwd
EF ET polar
Source: koeppen-geiger.vu-wien.ac.at
(c) Kottek et al. (2006), Rubel et al. (2017)
Google Earth
US Dept of State Geographer
© 2018 Google
Image Landsat / Copernicus
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
View from Space (Altitude: 7204 km)
N


Sustainable Technologies
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CANADIAN
ER QUALITY
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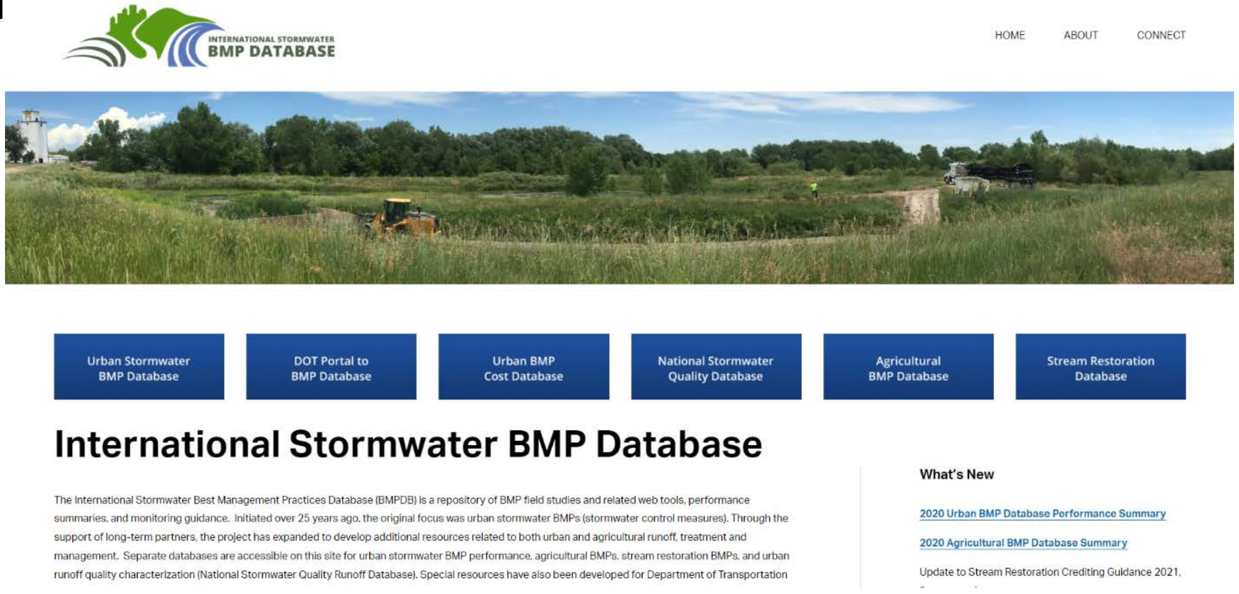
WELCOME TO THE CANADIAN BMP DATABASE
An interactive tool to view water quality performance of Low Impact Development (LID) technologies and Best Management Practices (BMP) in Canada.
WHAT YOU CAN DO WITH THE CANADIAN BMP DATABASE:
Filter database by pollutant of interest, LID type, LID name and units.
Display results in table format. Table can be exported to .csv file.
Compare water quality performance of LIDs using boxplots and scatterplots.
Interactive map with locations and websites of the LID technologies selected.
The water quality performance data was collected by the Sustainable Technologies Evaluation Program (STEP). STEP is a collaboration between Toronto and Region Conservation Authority (TRCA), Credit Valley Conservation (CVC) and Lake Simcoe Region Conservation Authority (LSRCA). | contact: STEP@trca.ca
Disclaimer: STEP cannot guarantee the validity of the information found here. While we use reasonable efforts to include accurate and up to date information, we make no guarantees as to the accuracy of the content and assume no liability for an error or omission in the content. Please click "I Agree" if you have read and understood this disclaimer.
I Agree
Step 1 - Select Constituent
Solids; suspended
Step 2 - Select Units
mg/L
ug/L
ng/L
Step 3 - Select Site Types
Oil and Grit Separator (OGS) Inlet_Asphalt
Bioretention
Infiltration Trench
Green Roof
Conventional Roof
Raw Precipitation
Step 4 - Select Site Names
Etobicoke Stormceptor OGS Inlet
Markham Three Chamber OGS Inlet
Central Parkway Inlet
Central Parkway Outlet
Earth Rangers Bioretention Vault
Kortright Bioretention A

Enhance content on treatment performance

- Statistical analyses of International Stormwater BMP Database records from same Koppen-Geiger climate zones as in Ontario and Canada (northernmost US states);
- Review of recent research literature (since 2010) on performance of LID practices and climate influences;
  - LID performance (multiple BMPs) review articles (7)
  - BMP specific reviews for bioretention (7*); green roofs (1); permeable pavement (3); rainwater harvesting (1);
  - Influence of climate on performance (4).



Sustainable Technologies
EVALUATION PROGRAM

TECHNICAL BRIEF

Comparative Performance Assessment of Bioretention in Ontario

This study compares the performance of nine different bioretention facilities monitored by Toronto and Region Conservation Authority (TRCA) and Credit Valley Conservation (CVC) in the Greater Toronto Area. The monitored facilities of varying shape, size and design were constructed to manage runoff from parking lots, public roads and residential areas. Key performance variables assessed included peak flows, runoff volume, water quality, water temperature and functional characteristics. Results showed runoff volume reductions for the seven systems not wrapped in an impermeable liner of between 60 and 92%, despite the presence of fine textured native soils. The two lined bioretention cells reduced runoff volumes by 15 and 34%. Load reductions of total suspended solids across all nine facilities ranged from 73 to 99%. The primary design and catchment characteristics explaining site to site variations in water quantity and quality control were the size of the facility relative to its drainage area and the capacity of native soils to infiltrate runoff. The influence of plant surface cover and filter media type and depth on overall performance was not discernable.

The terms bioretention and rain gardens are often used interchangeably. While the two have similar functional characteristics, bioretention often treats larger areas than rain gardens, and is engineered to meet site specific goals for pollutant removal, runoff control and plant health.

Managing stormwater runoff with bioretention has become more common in Ontario over the past decade, with new facilities appearing on city street corners, along residential roads, in commercial parking lots and on front lawns. While design guidelines for bioretention have been developed based on monitoring and research across North America, varying perspectives on how bioretention should be configured to meet different site specific objectives has led to a wide diversity of field designs and applications.

Table 1. Study area catchment characteristics.

Site Name	Location	Land Use	Time of Year monitored	Effective Impervious to Pervious Ratio	Cover type	Underlying native soils	Filter media texture
Kortright Centre (S)	Vaughan, ON	Parking lot	Apr - Nov	9:1	Shrubs and herbaceous plants	Silty clay	Sandy
Kortright Centre (N)	Vaughan, ON	Parking lot	Apr - Nov	10:1	Shrubs and herbaceous plants	Silty clay	Sandy
Honda Canada Campus*	Markham, ON	Parking lot	Apr - Nov	9:1	Trees, shrubs with gravel inlet	Silty clay	Gravel
Earth Rangers at Kortright Centre	Vaughan, ON	Parking lot	Year round	11:1	Shrubs, herbaceous plants and cobbles	Silty clay	Clay, silt, sand mix
Seneca College	King City, ON	Parking lot	Year round	10:1	Shrubs and plants	Silty clay	Garden loam
County Court (CC) Blvd.**	Brampton, ON	Residential road	Year round	5:1	Shrubs, plants and stone	Clayey silt	Sandy
Community of Lakeview	Mississauga, ON	Residential road	Year round	Approx. 10:1	Shrubs, plants and grass	Fine textured	Sandy
IMAX Corporate Office	Mississauga, ON	Parking lot	Apr - Nov	30:1	Shrubs and plants	Fine textured	Sandy
Elm Drive	Mississauga, ON	Residential road	Apr - Nov	6:1	Shrubs and plants	Fine textured	Sandy

*A smaller version of the Honda Canada Campus biofilter was reconstructed at the Kortright Centre for Conservation in Vaughn, ON in order to evaluate the stomwater benefits of the practice. The hydrologic performance of several biofilters connected in series were evaluated at the Honda Canada Campus site in Markham, ON. **The County Court Blvd bioretention was lined to prevent infiltration of water onto a water main below the system.

INTRODUCTION

An increasing number of bioretention facilities in Ontario have been, or are currently being monitored for stormwater management performance and other co-benefits. Each bioretention facility is designed and configured to meet specific site objectives and performance criteria. This study compares stormwater monitoring data from nine facilities to assess overall effectiveness of the practice and evaluate relationships between practice design features and performance.

STUDY SITES

The nine study sites selected for investigation are presented in Table 1. The sites consisted of plant or plant/cobble surface covers with relatively sandy filter media and low permeability native soils. The effective impervious to pervious ratio (I:P ratio) represents the size of the drainage area relative to the area occupied by the facility. Since impervious areas (e.g. roads, roof) generate more runoff than pervious areas (e.g. gardens, lawns), they are assigned a larger area weight in the drainage area calculation. Table 1 shows that monitored installations had a wide range of I:P ratios. Design guidelines in Ontario suggest a maximum I:P ratio of 20:1.

The Honda Canada Campus biofilter study consisted of two parts. The hydrologic performance was monitored at the site, and the water quality component was monitored at the Kortright Centre for Conservation through a scaled down version of the biofilter system, which was the primary LID feature on the site. The biofilter differs from other bioretention facilities in that runoff does not drain onto the planted surface, but instead drains through a gravel inlet into the gravel storage reservoir below the facility. Plants and trees on top of the trench access the moisture from above.

STUDY FINDINGS

Bioretention facilities that were not lined to prevent infiltration into the native soils were found to reduce runoff volumes by 60 to 92% over the monitoring period (Figure 1). In all cases, these large volume losses occurred despite the presence of fine textured native soils (hydrologic C type soils). On an individual event basis, the event size was found to exert a significant impact on volume reductions. That is, rainfall events less than 10 mm generated very little runoff while larger rainfall events, greater than 30 mm, generated considerably more runoff. In the latter case, a portion of the inflows were often bypassed through the surface overflow drains, either because the infiltration capacity of the filter media was exceeded or available storage in the facility was insufficient to contain all of the runoff. During the events monitored, overflows typically accounted for less than 5% of total flow volumes routed through the facilities.

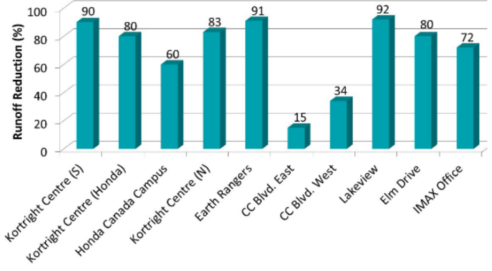


Figure 1. Runoff volume reductions for monitored events

Integrate updated content on life cycle costs

Bioretention
Construction and Life Cycle Costs

Step 1: LID Overview | **Step 2:** Design & Construction Estimates | **Step 3:** Operation & Maintenance Estimates | **Step 4:** Design & Cost Summary

Back End
Table of Contents

BIORETENTION OVERVIEW

Design Guidance

- Bioretention is an ideal technology for fitting functional vegetation into urban landscapes and treating runoff collected from nearby impervious surfaces.
- Components include: a 'filter bed' with filter media, storage layer of resovoir aggregate, planting and a finishing surface layer of mulch and/or stone.
- Additional components include an underdrain to remove excess water and soil additives to enhance pollutant removal.
- Tool defaults based on STEP recommendations:
  - Maximum drainage area to surface area ratio of 20:1
  - Default depth of 0.75 meters.
  - Default mulch depth of 75 millimeters.
  - An underdrain (minimum 200 mm perforated pipe) is only needed when native soil infiltration is less than 15 mm/hr or infiltration is percluded.

Bioretention cell capturing / treating runoff from adjacent parking lot. Kortrig
Source: https://wiki.sustainabletechnologies.ca/images/b/be/IMG_245

Tool Instructions and Assumptions

- **Green cells** are for mandatory user-input values. Do not leave green cells blank.
- **Purple cells** are where users can edit defaults. The defaults are based on STEP's LID Planning & Design Guide.
- **Red cells** indicate Tool conditions are not being met. Adjust user-input values in accordance with the error message.
- **Orange Cells** highlight the top 5 construction costs.
- Designs include pretreatment through stone diaphragms at curb inlets. Pretreatment through settling forebay and vegetated filter strip not included.
- The tool calculates costs for new designs and includes costs for contractor overhead and profit, material, delivery, labour, equipment (rental, operating and operator costs), hauling and disposal. Mobilization and demobilization costs not included. The tool adds 10% contingency and additional overhead.
- **Design and Engineering cost estimates are not calculated by the tool and must be supplied by the user.**
- Unit costs are based on 2018 pricing; the tool automatically adds inflation. See the Assumptions sheet for details.
- The cost of retrofitting is ~16% higher than the cost of new construction.
- Retrofit costs are included in the 'Costs Summary' section and can be added to the Total Construction Cost for increased accuracy.

For more information on design guidance, please review STEP's LID Planning and Design Guide at: www.wiki.sustainabletechnologies.ca

For further instructions on how to use the tool, please review the STEP Lifecycle Costing Tool User Guide.

Introduction | TableOfContents | Bioretention | EnhancedSwale | VegFilterStrip | GreenRoof | InfiltrationChamber | InfiltrationTrench | PermeablePavers | PorousAsphalt | RainWHarvest

STEP LID Life Cycle Costing Tool, version 3

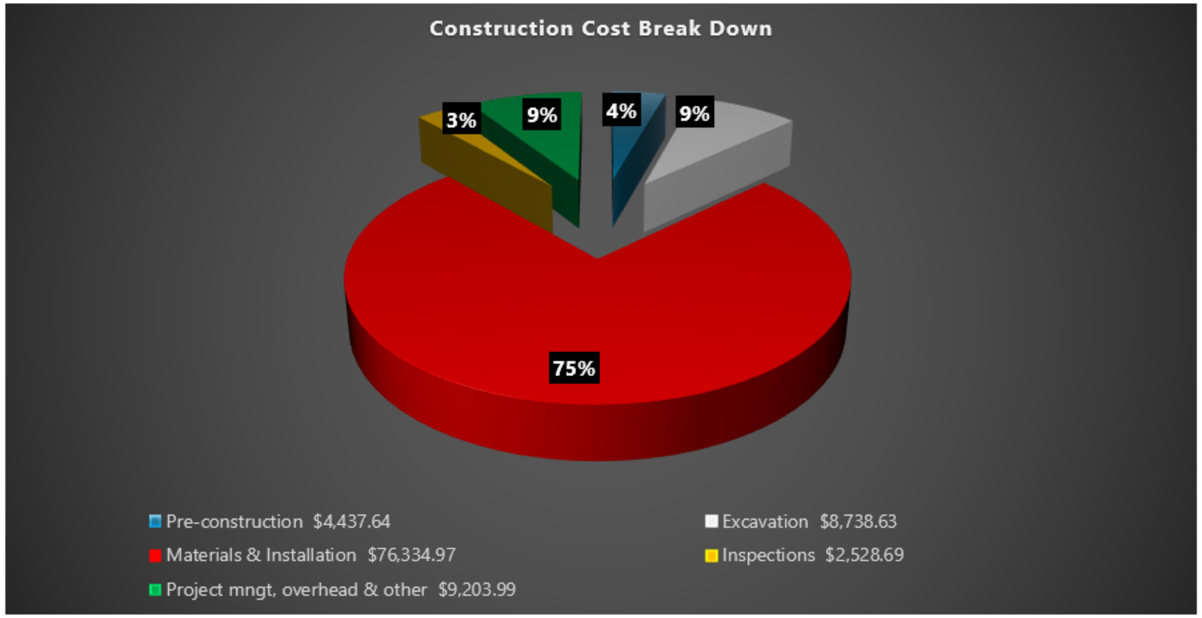
Integrate updated content on life cycle costs

Bioretention
Construction and Life Cycle Costs

Step 1: LID Overview | Step 2: Design & Construction Estimates | Step 3: Operation & Maintenance Estimates | Step 4: Design & Cost Summary | Back End | Table of Contents | LID T... Eq...

STEP 4: DESIGN SUMMARY	Value	Units
Drainage Area (DA)	2000	m^2
Native Soil Infiltration Rate	25	mm/hr
Surface Area	250.00	m^2
Design type	Partial Infiltration	unitless
Storage Volume	197.50	m^3

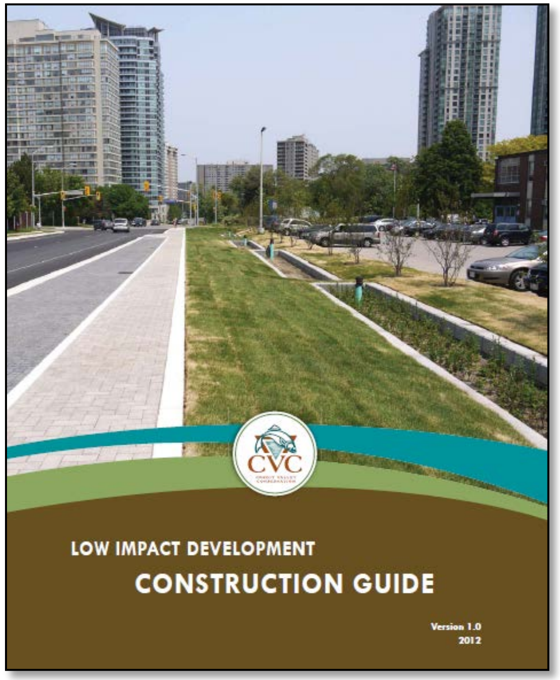
COST SUMMARY		Value
Construction Cost Break Down		
Pre-construction	$	4,437.64
Excavation	$	8,738.63
Materials & Installation	$	76,334.97
Inspections	$	2,528.69
Project mngt, overhead & other	$	9,203.99
Total Construction Cost	$	101,243.92
Life Cycle Totals		
50 Year Evaluation Period		
Present Value of maintenance and rehabilitation	$	50,238.97
Present Value of all costs	$	151,482.89
25 Year evaluation period		
Present Value of maintenance and rehabilitation	$	31,231.56
Present Value of all costs	$	132,475.49
Estimated Retrofit Cost		
Percentage of total cost		16%
Total construction cost with retrofit	$	117,442.95

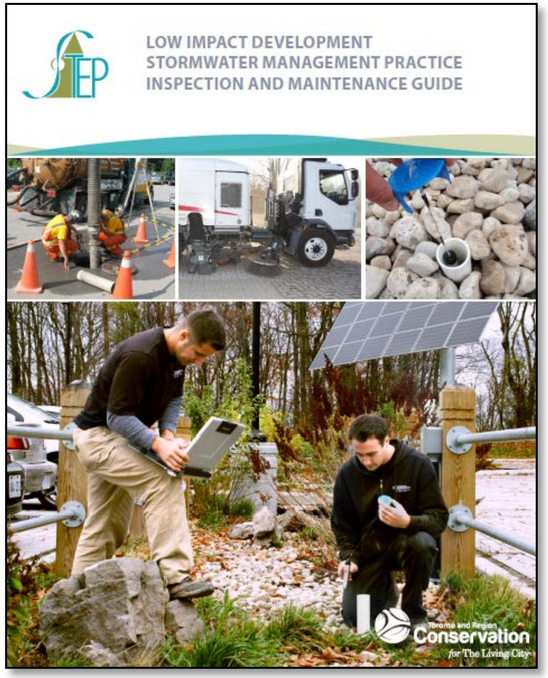


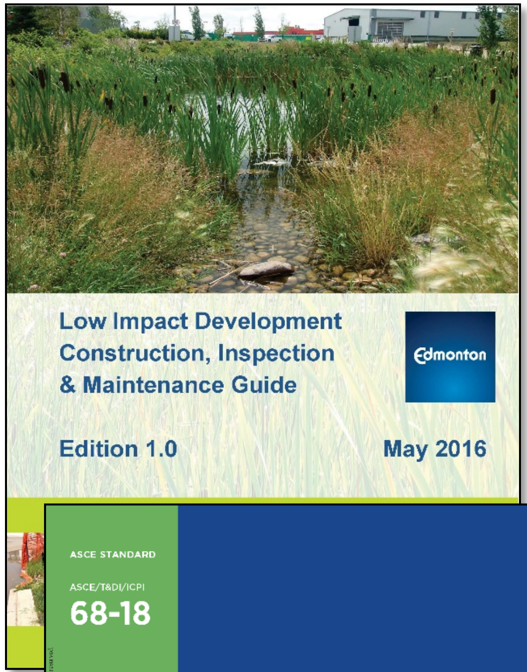
Introduction | TableOfContents | Bioretention | EnhancedSwale | VegFilterStrip | GreenRoof | InfiltrationChamber | InfiltrationTrench | PermeablePavers | PorousAsphalt | RainWHarvest ...

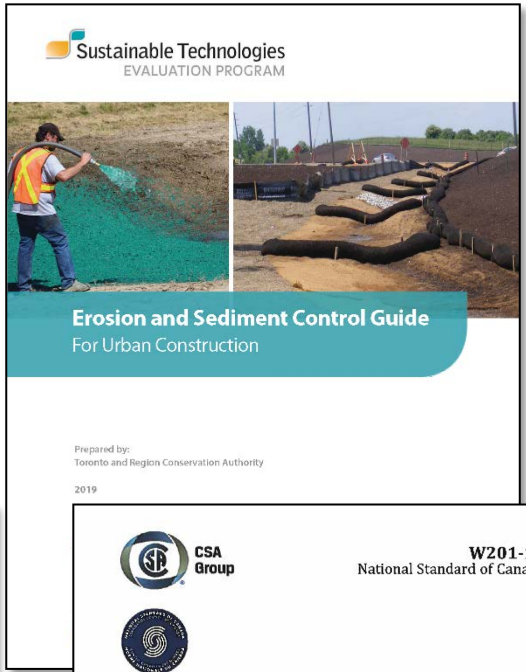
STEP LID Life Cycle Costing Tool, version 3

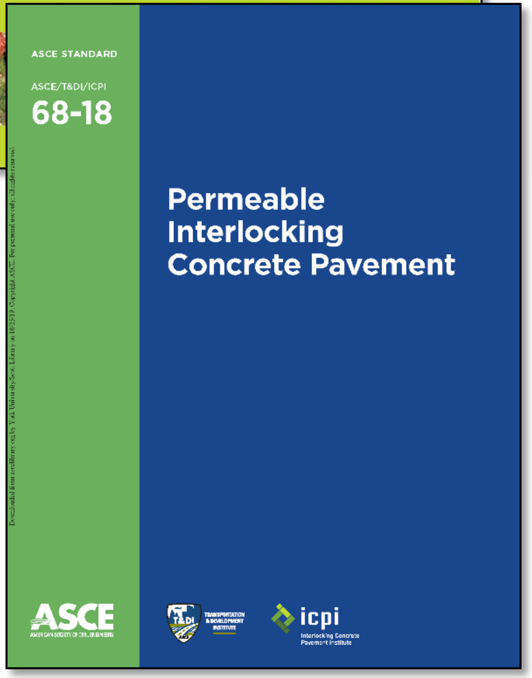
Enhance guidance on construction, inspection and maintenance

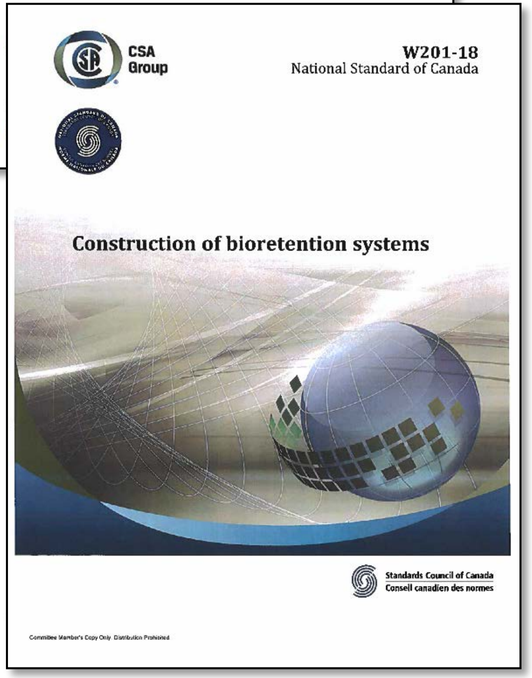












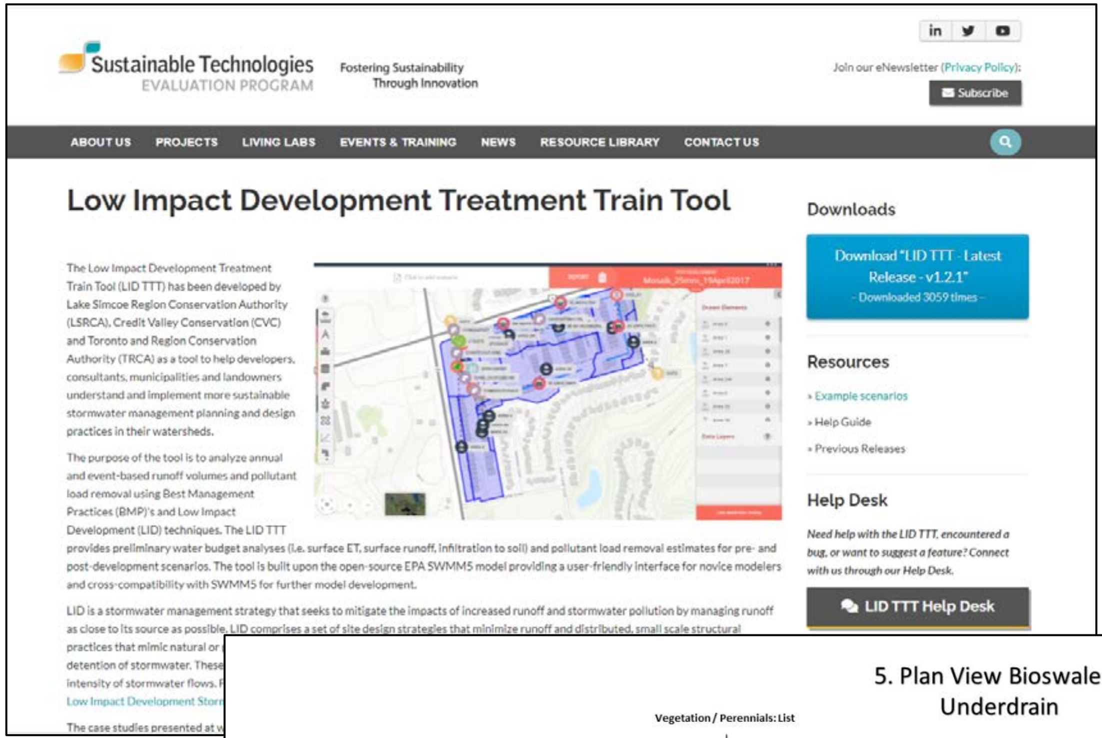
Sustainable Technologies
EVALUATION PROGRAM

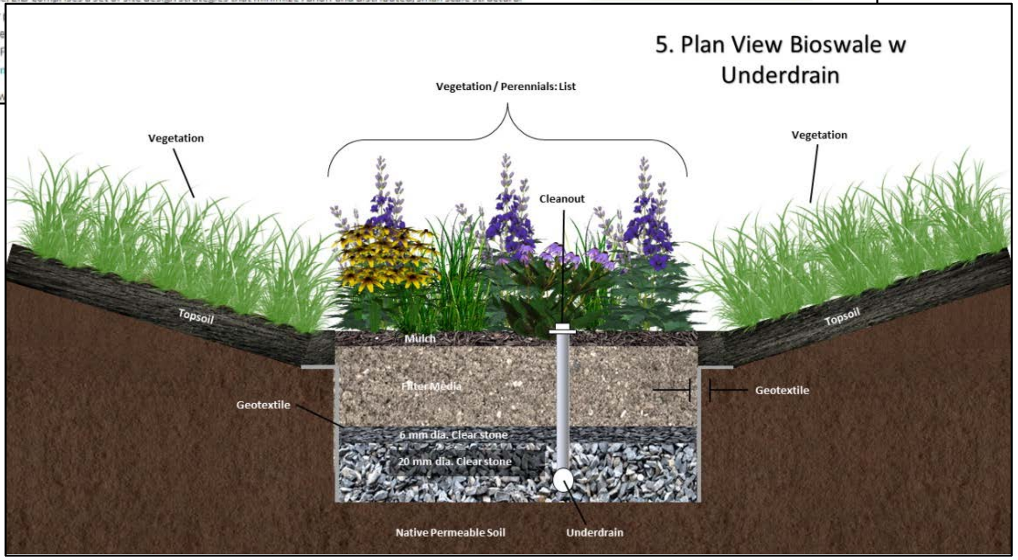
Enhance content on drinking water source protection

Building the "one stop shop" for LID guidance

Enhancements to come in 2022:

- New Absorbent Landscapes page and fact sheet;
- Enhance content on treatment performance and climate influences;
- Integrate updated information on life cycle costs;
- Integrate guidance on construction, inspection and maintenance;
- Enhance content on drinking water source protection;
- Update and enhance guidance on BMP modelling with LID Treatment Train Tool (LID TTT), version 3;
- New and improved schematic diagrams (image maps);
- BMP-specific plan review checklists;
- Enhance content on salt management and thermal mitigation.





Sustainable Technologies
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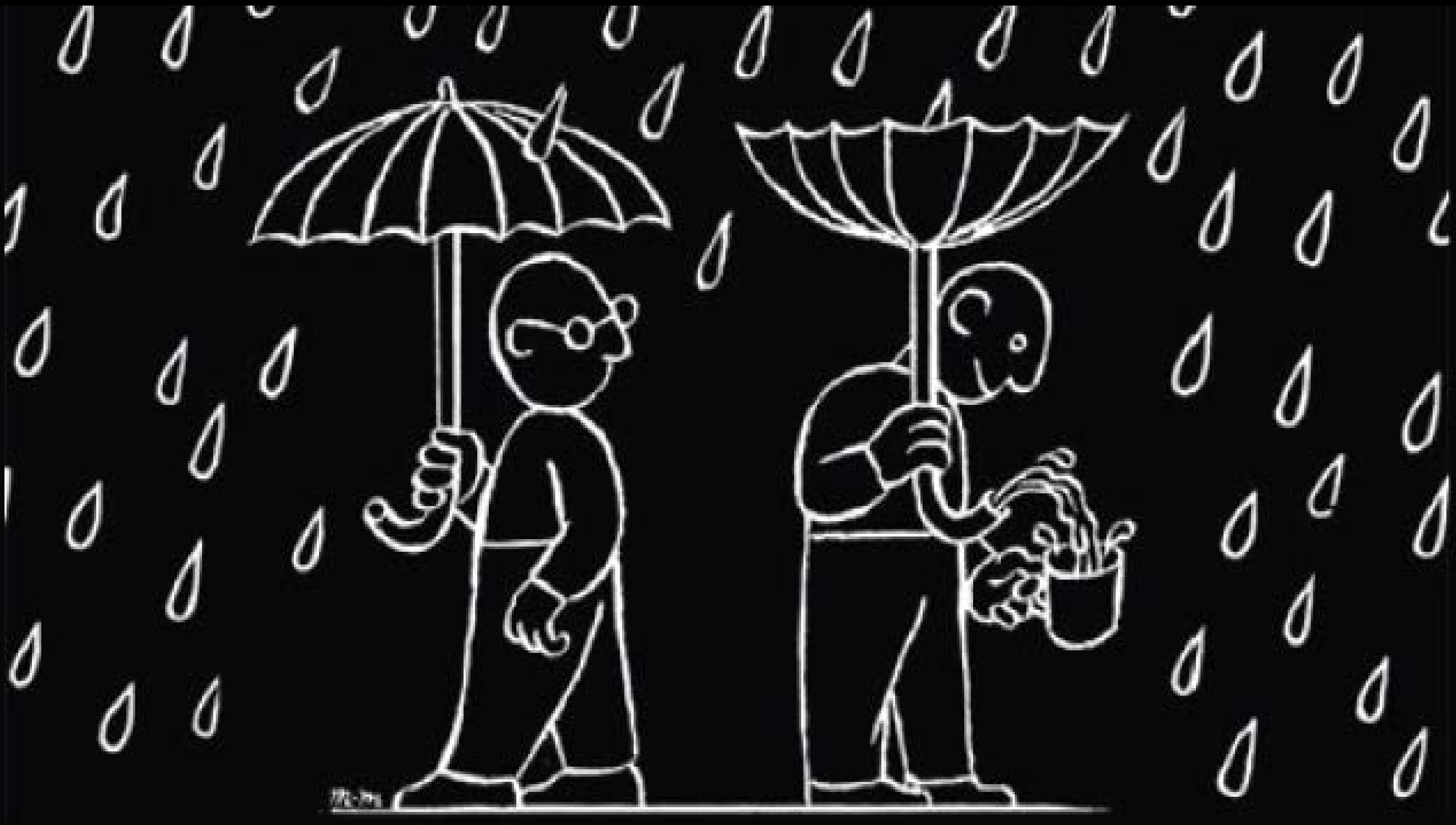

INNOVATION IS A STATE OF MIND

Questions? Concerns? Complaints?

The water component of STEP is a partnership between:

Thank you

For more information:

LID P&D Guide wiki:
https://wiki.sustainabletechnologies.ca

STEP website:
https://sustainabletechnologies.ca

STEP Canadian BMP Water Quality Database:
https://stepapps.shinyapps.io/WQ_Interactive4/

Contact:

Dean Young
Toronto and Region Conservation Authority
416-661-6600 ext. 5794
dean.young@trca.ca

The water component of STEP is a partnership between:

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Lake Simcoe Region conservation authority
Credit Valley Conservation inspired by nature
Toronto and Region Conservation Authority

www.sustainabletechnologies.ca