3.2.23| Permeable Pavements

Unlike traditional impervious surfacing materials, permeable pavement allows stormwater to infiltrate through the surface into a subsurface stone reservoir rather than collecting and being conveyed as surface runoff. Stormwater is temporarily detained and, in most cases, infiltrated into the native subsoils. Similar to other infiltration-based practices, the requirement for an underdrain relates directly to the permeability of underlying native soils.

Permeable pavements are suited to several applications within streets including: Decorative Paving, Cycling Infrastructure, Parking Lay-Bys and On-street Parking areas, as well as on the roadway surfaces of low traffic streets such as Lanes and Shared streets. Permeable pavements can be used in both new and retrofit scenarios. The following types of permeable pavements are recommended for use within road rights-of-way.

3.2.23.1| Pervious Concrete

Pervious concrete has fewer fines then conventional concrete, creating void spaces (15%-35%) within the material. This material provides a suitable replacement for conventional concrete throughout all street types for use in Sidewalk applications and is ideally-suited to applications within sites where space is limited.


Photo Credit:Chesapeake Stormwater Network http://chesapeakestormwater.net/wp-content/uploads/2012/01/Porous-Concrete-Driveway.jpg

3.2.23.2| Porous Asphalt

Porous asphalt features air pockets that are created as a result of the inclusion of fewer fines and less sand content than traditional impervious asphalt. These void spaces allow water to filter through to the aggregate layer below. Porous asphalt provides a suitable alternative to conventional asphalt and can be used within road rights-of-way in areas such as Cycling Infrastructure, Parking Lay-Bys, and multi-use recreational trails.

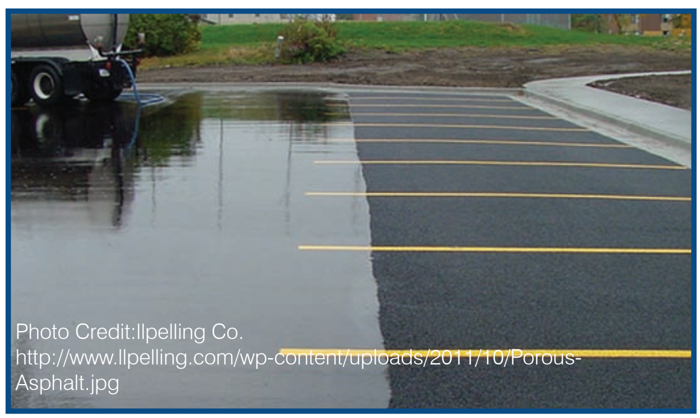
Photo Credit:Ilpelling Co. http://www.llpelling.com/wp-content/uploads/2011/10/Porous-Asphalt.jpg

3.2.23.3| Permeable Interlocking Precast Concrete Pavers

Permeable concrete paver systems have expanded joints that allow for 5%-10% of a paved surface area to be filled with porous aggregate material. These voids allow water to filter through to the aggregate layer below. Permeable concrete pavers can be used in a variety of applications such as for Lane paving, Decorative Paving treatments and Parking Lay-bys within various street types.


Photo Credit: Schollen & Company Inc.

3.3 DESIGN AND CONSTRUCTION CONSIDERATIONS

3.3.1 | Design Considerations

GI projects are complex and require the expertise of industry specialists, municipal divisions and government agencies at various stages throughout the process. The project team must comprise knowledgeable professionals with experience in GI design and construction, who understand the project objectives as well as the complexities of the site. Project team members often include: Project Managers, Municipal Planners, Civil/Environmental/Water Resource Engineers, Landscape Architects, Hydrologists, Geotechnical Engineers, Structural Engineers, Ecologist/Biologists, Product Suppliers and Government Agencies.

The first step in the design process for any Green Streets project is to establish environmental objectives based on TGS priorities. These objectives will guide the design and implementation process. Subsequently, a palette of GI options must be defined based on site specific criteria using the GI Selection Tool. Once a palette of GI options is identified, utility locates and site testing should be undertaken immediately in order to confirm the applicability of selected GI options for the given site. Testing and time requirements can vary for each GI option. These requirements are outlined in Figure 1.0 *(GI Project Timeline - Site Specific Investigations)*. The creation of an appropriate design solution will require input from team members representing the various disciplines as well as representatives from the relevant departments within the City and the TRCA prior to implementation.

3.3.2| Construction Considerations

3.3.2.1| Contractor Selection

Contractors selected to undertake work on GI projects should have extensive knowledge and experience in the design and construction of GI options.

3.3.2.2| Site Preparation

Requirements for site preparation will vary based on the types and complexity of GI options proposed and whether the work is part of an extensive reconstruction project or a less intensive retrofit project. For example:

If a proposed bioretention planter is designed to incorporate an infiltration component, then it will be important to ensure that appropriate barrier fences and erosion and sediment control measures are established around the perimeter of the site prior to construction in order to avoid any potential for compaction or contamination of the profile during construction. In addition, any contributing stormwater runoff should be diverted away from the installation until construction is complete. Finally, it will be important to have an erosion and sediment control plan in place in order to mitigate the potential effects of heavy storm events. This plan must be implemented by the contractor in order to reduce the risk of site contamination.

3.3.2.3| Construction Sequence

The following are typical steps for constructing GI practices that are aimed at achieving stormwater management objectives. This process may vary depending on the exact specifications and performance requirements of the design.

1. Verify locations of underground services and utilities;

2. Perform infiltration testing to confirm the permeability of the subsoils;

3. Confirm that the designed capacity of the GI option will accommodate the volume of stormwater anticipated from the contributing drainage area;

4. Establish an Erosion Control plan and install ESC measures;

5. Divert contributing runoff temporarily;

6. Stage construction materials in a clean and secure location in close proximity to the installation site to reduce haul distances and minimize the risk of material compaction or contamination;

7. Implement traffic controls (pedestrian and / or vehicular) where required;

8. Where applicable, isolate pretreatment installations until the main facility is complete;

9. Wherever possible, excavate installation using equipment located outside of the area of disturbance;

10. Scarify the base of the excavation for infiltration-based GI facilities;

11. Install the sub-base profile (if applicable) as per construction drawings;

12. Install premixed filter media (if applicable) in maximum 300 mm lifts. Apply water to pack material without excessive compaction;

13. Apply mulch layer (if applicable) as per construction drawings;

14. Install plant material (if applicable) as per the landscape plan;

15. Install surface material (if applicable) per construction drawings;

16. Confirm that all elevations are in accordance with the detailed design drawings including: inlets/outlets, pretreatment and overflow;

17. Ensure that the GI installation is stable prior to redirecting contributing stormwater runoff into it.

3.3.2.4| Additional Considerations

- Inspect installation weekly for 3-6 months after construction (as well as after heavy rainfall) to ensure that the facility is functioning properly.

- Consider options for reducing emissions during the construction and decommissioning phases of the project. The carbon footprint of infrastructure can be greatly reduced by sourcing local and lower carbon materials, specifying recycled materials and recycling or re-purposing project materials & components.

	Number	Name	Geotechnical Testing (Lead Time: 3 weeks-months)	Infiltration Testing (Lead Time: 3 weeks - months)	Utility Locates (Lead Time: 1-2 weeks)	Average Wind Speed Testing (Lead Time: 2-3 weeks)	Sun Angle Analysis (Lead Time: 2 -3 weeks) ✱ refers to Bridge applications
WATER QUANTITY, QUALITY & EFFICIENCY	WQ-1.1	Bioretention Planter w/o Pre-treatment or Underdrain	✓	✓	✓		✱
	WQ-1.1	Bioretention Planter with Pre-treatment w/o Underdrain	✓	✓	✓		✱
	WQ-1.1	Bioretention Planter with Underdrain	✓		✓		✱
	WQ-1.1	Bioretention Planter with Pre-treatment & Underdrain	✓		✓		✱
	WQ-1.1	Biofilter Planter (Filtration Only Bioretention) - Impervious Bottom	✓		✓		✱
	WQ-2.1	Stormwater Planter w/o Pre-treatment or Underdrain	✓	✓	✓		✱
	WQ-2.1	Stormwater Planter with Pre-treatment w/o Underdrain	✓	✓	✓		✱
	WQ-2.1	Stormwater Planter with Underdrain	✓		✓		✱
	WQ-2.1	Stormwater Planter with Pre-treatment & Underdrain	✓		✓		✱
	WQ-2.1	Stormwater Biofilter (Filtration Only Bioretention) - Impervious Bottom	✓		✓		✱
	WQ-3.1	Bioretention Curb Extension/Bump-out w/o Pre-treatment or Underdrain	✓	✓	✓		
	WQ-3.1	Bioretention Curb Extension/Bump-out with Pre-treatment w/o Underdrain	✓	✓	✓		
	WQ-3.1	Bioretention Curb Extension/Bump-out with Underdrain	✓		✓		
	WQ-3.1	Bioretention Curb Extension/Bump-out with Pre-treatment & Underdrain	✓		✓		
	WQ-3.1	Biofilter Curb Extension/Bump-out (Filtration Only Bioretention) - Impervious Bottom	✓		✓		
	WQ-4.1	Bioretention - Cell w/o Pre-treatment or Underdrain	✓	✓	✓		
	WQ-4.1	Bioretention - Cell with Pre-treatment w/o Underdrain	✓	✓	✓		
	WQ-4.1	Bioretention - Cell with Underdrain	✓		✓		
	WQ-4.1	Bioretention - Cell with Pre-treatment & Underdrain	✓		✓		
	WQ-4.1	Biofilter - Cell (Filtration Only Bioretention) - Impervious Bottom	✓		✓		
	WQ-5.1	Rain Gardens	✓	✓	✓		
	WQ-6.1	Enhanced Grass Swale	✓	✓	✓		✱
	WQ-6.1	Enhanced Grass Swale with Check Dam	✓	✓	✓		✱
	WQ-6.1	Enhanced Grass Swale with Check Dam & Underdrain	✓		✓		✱
	WQ-7.1	Dry Swale/Bioswale w/o Pre-treatment or Underdrain	✓	✓	✓		✱
	WQ-7.1	Dry Swale/Bioswale with Pre-treatment w/o underdrain	✓	✓	✓		✱
	WQ-7.1	Dry Swale/Bioswale with Underdrain	✓		✓		✱
	WQ-7.1	Dry Swale/Bioswale with Pre-treatment & Underdrain	✓		✓		✱
	WQ-7.1	Dry Swale/Bioswale with Pre-treatment, Underdrain & Impermeable Liner	✓		✓		✱
	WQ-7.2	Bioswale with Well	✓	✓	✓		✱
	WQ-8.1	Green Gutter	✓	✓	✓		
	WQ-9.1	Filter Strip / Buffer Strip with Underdrain	✓		✓		
	WQ-9.1	Filter Strip / Buffer Strip as Pre-treatment Option	✓	✓	✓		
	WQ-10.1	Drainage Well with Pre-treatment	✓	✓	✓		
	WQ-11.1	Perforated Pipe System - with Pre-treatment	✓	✓	✓		
	WQ-12.1	Soakaway/infiltration Gallery/Dry Well/Soakaway Pit with Pre-treatment	✓	✓	✓		
	WQ-13.1	Infiltration Trench/Linear Infiltration Gallery/Linear Soakaway	✓	✓	✓		✱
	WQ-13.1	Infiltration Trench/Linear Infiltration Gallery/Linear Soakaway with Pre-treatment	✓	✓	✓		✱
	WQ-13.1	Infiltration Trench/Linear Infiltration Gallery/Linear Soakaway w Pre-treatment & Underdrain	✓		✓		✱
	WQ-14.1	Infiltration Chamber/Infiltration Tank	✓	✓	✓		✱
	WQ-14.1	Infiltration Chamber/Infiltration Tank with pre-treatment	✓	✓	✓		✱
	WQ-15.i	Permeable Paving - Pervious Concrete	✓	✓	✓		
	WQ-15.i	Permeable Paving with underdrain - Pervious Concrete	✓		✓		
	WQ-15.i	Permeable Paving with underdrain & Impermeable Liner - Pervious Concrete	✓		✓		
	WQ-15.ii	Permeable Paving - Porous Asphalt	✓	✓	✓		
	WQ-15.ii	Permeable Paving with underdrain - Porous Asphalt	✓		✓		
	WQ-15.ii	Permeable Paving with underdrain & Impermeable Liner - Porous Asphalt	✓		✓		
	WQ-15.iii	Permeable Paving - Interlocking Precast Concrete Pavers	✓	✓	✓		
	WQ-15.iii	Permeable Paving with underdrain - Interlocking Precast Concrete Pavers	✓		✓		
	WQ-15.iii	Permeable Paving with underdrain & Impermeable Liner - Interlocking Precast Concrete Pave	✓		✓		
	WQ-16.1	Stormwater Tree Pits	✓		✓		
	WQ-17.1	Stormwater Tree Trenches	✓		✓		
	WQ-18.1	Rainwater Cistern with Pre-treatment	✓		✓		

Figure 1.0 - Green Infrastructure Project Timeline - Site Specific Investigations

	Number	Name	Geotechnical Testing (Lead Time: 3 weeks-months)	Infiltration Testing (Lead Time: 3 weeks - months)	Utility Locates (Lead Time: 1-2 weeks)	Average Wind Speed Testing (Lead Time: 2-3 weeks)	Sun Angle Analysis (Lead Time: 2 -3 weeks) ✱ refers to Bridge applications
ECOLOGY	E-1	Natural Canopy					
	E-2	Native Herbaceous Planting					
	E-3	Ecopassages			✓		
	E-4	Light Limitation					
AIR QUALITY	AQ-1	Green Wall					
	AQ-2	Street Trees			✓		
	AQ-2A	Trees in Soil Cell	✓		✓		
	AQ-2B	Tree in Open Planter	✓		✓		
	AQ-2B	Tree in Open Planter with Soil Cells	✓		✓		
	AQ-2C	Planter Boxes/Movable Planters					
	AQ-2D	Precast Tree Planters					
	AQ-3	Photocatalytic Paving					
GHG & ENERGY EFFICIENCY	GHG-1	LED Lights			✓		
	GHG-2	Solar Photovoltaic Panels			✓		✓
	GHG-3	Solar Roads			✓		✓
	GHG-4	Solar Paver Lights			✓		✓
	GHG-5	Photo-luminescent Road Markings			✓		✓
	GHG-6	Wind Energy			✓	✓	
	GHG-7	Cool Pavements					✓

3.4 GUIDELINE DRAWINGS

Guideline Drawings have been prepared for most of the options listed in the GI Selection Tool. It is important to note that these drawings are NOT City of Toronto Standard Drawings. However, they do contain all of the information necessary to develop site specific construction details. Figure 2.0 illustrates the layout and content of a typical GSTG Guideline Drawing.

Area #1 provides a drawing reference number. This number correlates with the reference numbers beside each GI option in the GI Selection Tools.

Area #2 provides the name of the GI option and the permutation of the options (if applicable).

Area #3 provides a graphic illustration of the components and assembly of the GI option. A range of depths for materials and dimensions are also provided.

Area #4 outlines design guidance for the GI option. This section describes:

- Materials - Standards and Depth/Sizing Calculations
- Geometry and Site Layout
- Underdrains
- Conveyance / overflow
- Monitoring Wells
- Plant Material

The Guideline Drawings are organized according to TGS priorities and are located in Appendix C.

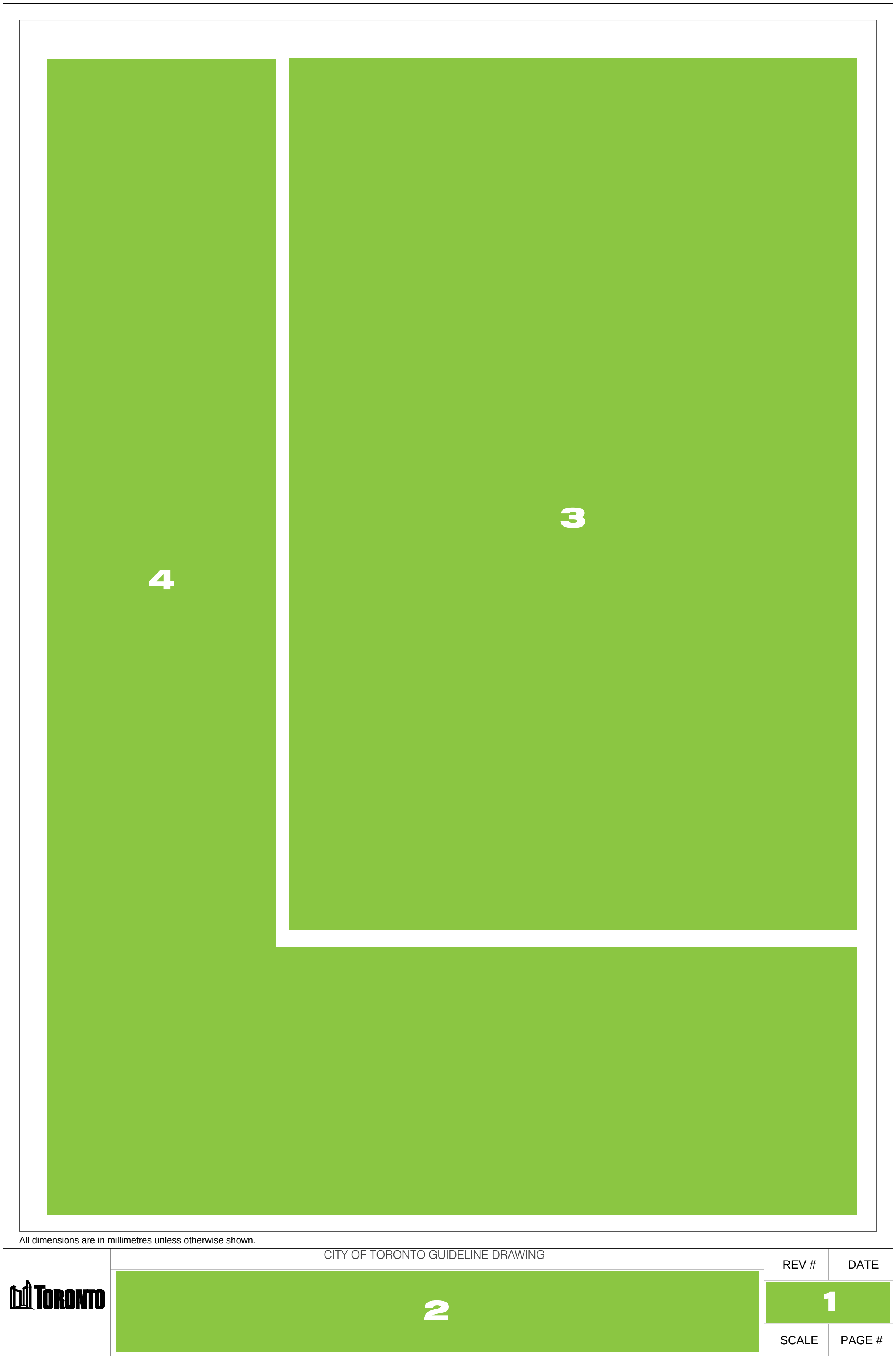

Figure 2.0 - Typical Guideline Drawing Format

Photo Credit: Schollen & Company Inc.

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4.0

SELECTION TOOLS

Photo Credit: Schollen & Company Inc.

4.1 THE SELECTION TOOL

The GI Selection Tool assists users to identify a palette of GI options for a site given its specific characteristics. A sub-tool called the Vegetation Selection Tool has also been provided as part of this guideline to identify appropriate plant material for vegetated options.

The GI Selection Tool is excel-based system that comprises the following four tabs:

Tab1.0 | How to Use the Tool
This is a quick reference that provides a detailed description of the Tools and guidance on their use. Refer to Appendix D of this guideline document for a complete description of methods for utilizing the Selection Tool.

Tab 2.0 | Key Criteria
An additional quick reference that defines each of the screening parameters that are built into the Selection Tool.

Tab 3.0 | New Projects Selection Tool
This tab should be used for initial screening of new or full street reconstruction projects.

Tab 4.0 | Retrofit Projects Selection Tool
This tab should be used for initial screening of rehabilitation or retrofit projects.

New Projects & Retrofit Projects Selection Tools
The New Projects & Retrofit Projects Selection Tools provide comprehensive databases of all possible GI options that could be implemented within Toronto rights-of-way. The data can be filtered based on any single, multiple or all 11 key selection parameters. This screening process allows for a palette of viable GI options to be identified based on specific site criteria. Criteria relevant to a specific GI option (or permutation) are denoted by an 'X' in the appropriate cell. As the database is progressively filtered, a refined list of relevant GI options is provided.

4.1.1 | Green Infrastructure Options

GI options have been selected for their compatibility with the City's climate and context and are listed according to their relationship with TGS drivers. Each potential GI practice is described in detail in Section 3.0. Several of the GI practices listed include various permutations of the same option. For example, in the category of Pervious Concrete the following permutations exist:

1. Pervious concrete without underdrain
2. Pervious concrete with underdrain
3. Pervious concrete with underdrain and impervious liner

Each of these variations exist because they provide a functional solution related to certain specific conditions, therefore each has been listed as a separate line item. In addition, each GI option can be used in various street 'Applications', therefore individual line items have also been created for the various permutations of a GI option within each relevant 'Application'.

4.1.2 | Screening Criteria

Relevant GI options are identified through a screening process using the 'filter' function. Users are to work from left to right through the screening parameters to arrive at a suite of GI options that are suitable to specific site conditions. The balance of this chapter focuses on describing the screening parameters incorporated within the GI Selection Tool.

GREEN STREETS TECHNICAL GUIDELINES - GI SELECTION TOOL PROCESS FLOWCHART

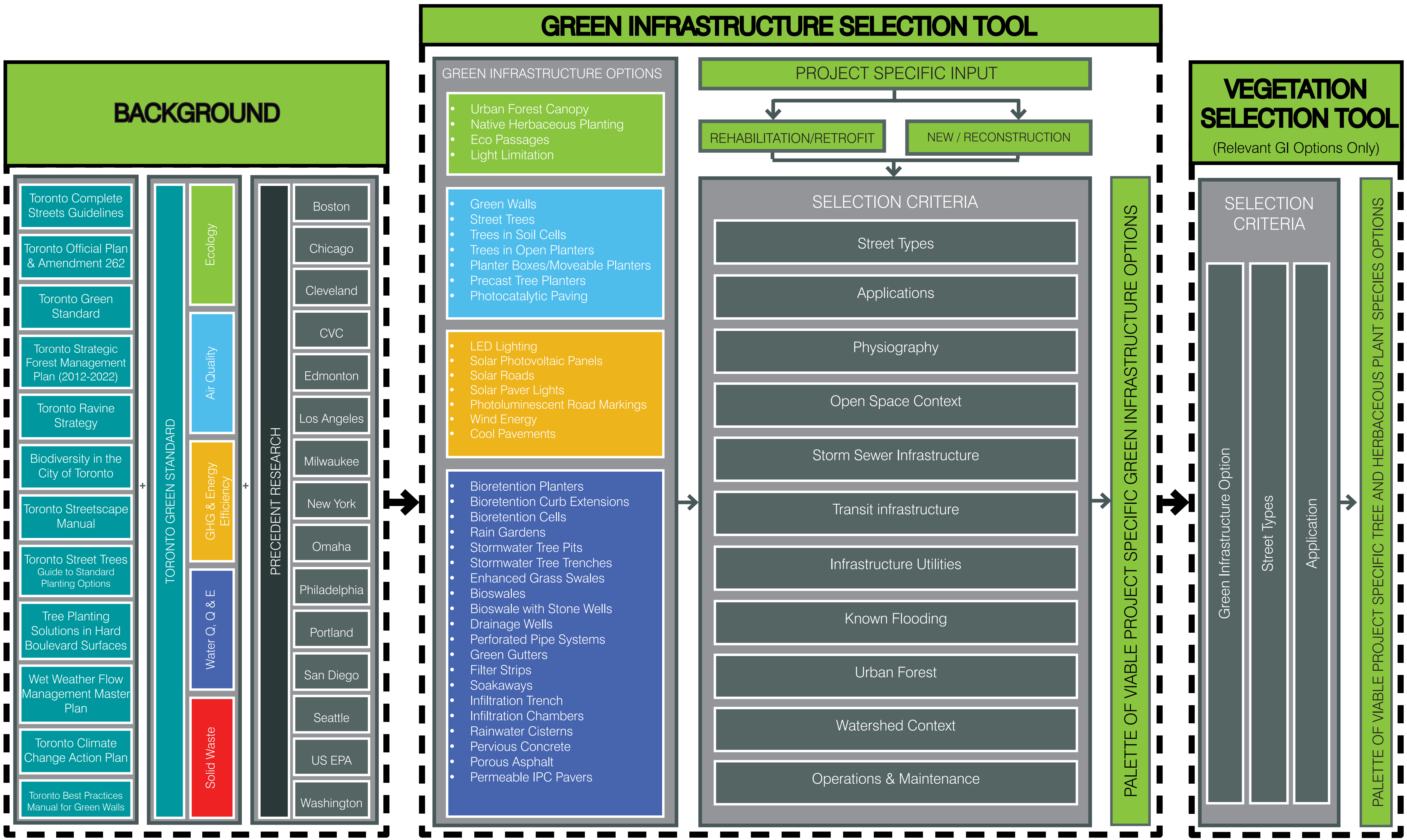

Figure 3.0 - GI Selection Tool Process Flowchart

4.2 SELECTION PARAMETERS

4.2.1 | Type of Work

The first step in using the GI Selection Tool is to identify whether the proposed work is a new / reconstruction or a retrofit / rehabilitation project. Variations on the GI Selection Tool have been developed for each scenario since there are different opportunities and constraints that apply to each. In a reconstruction project, both surface and subterranean facilities are affected. This presents opportunities to relocate utilities and services to accommodate various GI options in the right-of-way. Renovation and retrofit projects tend to be more surficial in nature, therefore GI options must sometimes be modified in order to be implemented.

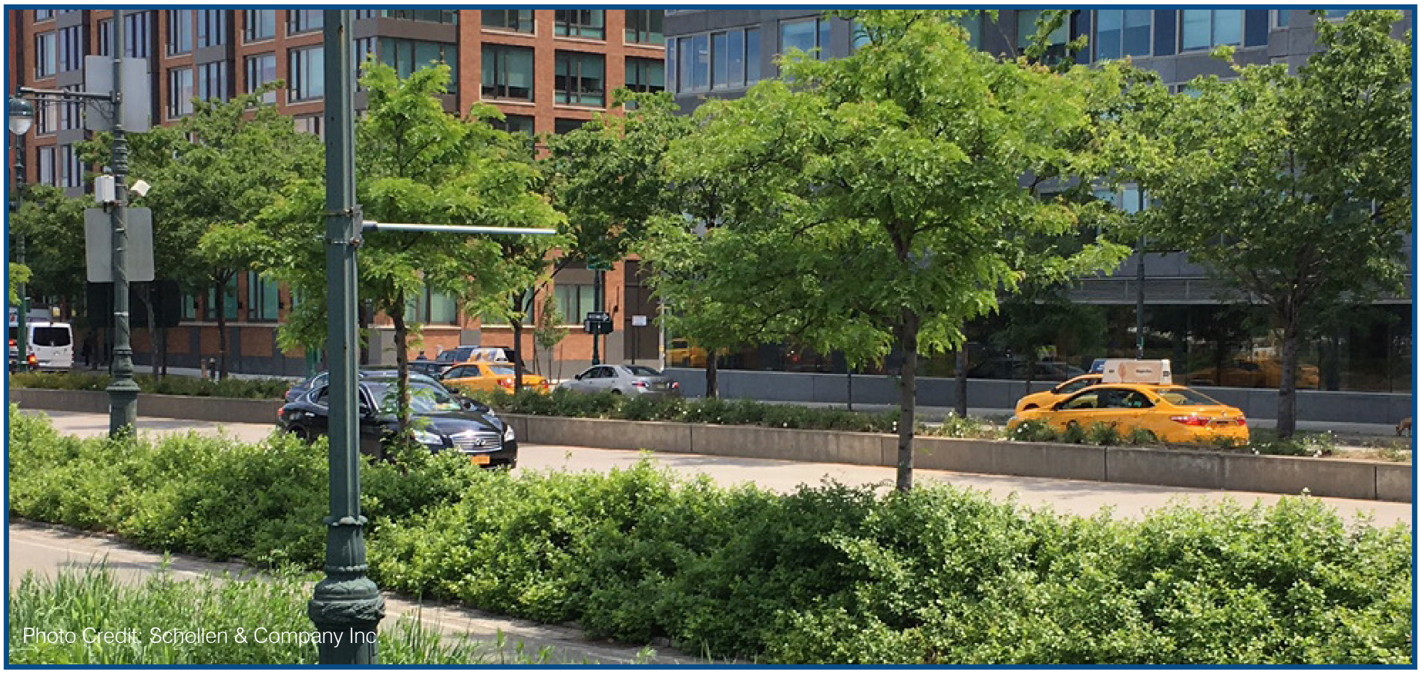

Photo Credit: Schollen & Company Inc.

4.2.2 | Selection Parameter A - Street Types

Street Types are of critical importance to the selection process as they not only dictate the types of applications within a street, but also the form and aesthetics of viable GI techniques. As such, Street Type is the first parameter addressed in the GI Selection Tools. Street types are adopted from the Toronto Complete Streets manual and include the following categories:

1. Civic Street
2. Downtown & Centres Main Street
3. Avenues & Neighbourhood Main Street
4. Downtown & Centres Residential Street
5. Apartment Neighbourhood Residential Street
6. Neighborhood Residential Street
7. Mixed-Use Connector Street
8. Residential Connector Street
9. Scenic Street
10. Park Street
11. Employment Street
12. Mixed-Use Access Street
13. Mixed-Use Shared Street
14. Residential Shared Street
15. Mixed-Use Lane
16. Residential Lane

The key characteristics of each street type include the following:

Civic Streets
Design Objectives: Design quality and workmanship, high quality materials, furnishings and details, wide Furnishing/Planting Zone and Pedestrian Clearway (both sides of the street), high visibility pedestrian crossings, pedestrian-scale lighting, transit priority corridor and enhanced transit stops, separated cycling infrastructure, high density bicycle parking, on-street parking possible, distinctive planting and enhanced tree canopy and integrated SWM facilities.

Downtown & Centres Main Streets
Design Objectives: Design quality and workmanship, wide Frontage/Marketing Zones, wide / flexible Furnishing/Planting Zone and Pedestrian Clearway (both sides of the street), transit priority corridor and enhanced transit stops, separated cycling infrastructure and generous bicycle parking areas, outdoor retail space and cafe seating, parklets possible, enhanced tree canopy and integrated SWM facilities.

Avenues & Neighbourhood Main Streets
Design Objectives: Design quality, workmanship and street furnishing, wide / flexible Furnishing/ Planting Zone and Pedestrian Clearway (both sides of the street), pedestrian level lighting, transit priority corridor and enhanced transit stops, separated cycling infrastructure and generous bicycle parking areas, on-street parking possible on one or both sides, café seating and gathering areas, parklets possible, enhanced tree canopy and integrated SWM facilities.

Downtown & Centres Residential Streets
Design Objectives: Wide Frontage/Marketing Zone and Pedestrian Clearway (both sides of street of the street), transit route, integrated cycling infrastructure and increased bicycle parking, on-street parking possible, street lighting, traffic calming possible, enhanced tree canopy and integrated SWM facilities.

Apartment Neighbourhood Residential Streets
Design Objectives: Frontage Zone - large with buildings set back from street. Can include vehicle drop-off and/or private short-term parking, transit route, integrated cycling infrastructure and increased bicycle parking, wide Pedestrian Clearway and Furnishing/Planting Zone (both sides of the street), on-street parking available (at least one side of the street), traffic calming, street lighting, enhanced tree canopy and integrated SWM facilities.

Neighborhood Residential Streets (Sub-type - Built Circa Pre-1950)
Design Objectives include: Narrower pavement widths, traffic calming, on-street parking available (at least one side of the street), Pedestrian Clearway/Sidewalk beside Edge Zone (both sides of street), landscape between sidewalk and building, on-street parking possible, dedicated bicycle routes possible (one direction), enhanced tree canopy and integrated SWM facilities.

Neighborhood Residential Streets (Sub-type - Built Circa Post 1950)
Design Objectives: Pedestrian Clearway/Sidewalk (at least one sides of the street), landscaped Furnishing/Planting Zone, on-street parking possible, traffic calming, integrated bicycle routes, enhanced tree canopy and integrated SWM facilities.

Mixed-Use Connector Streets
Design Objectives: Separated cycling infrastructure, transit priority route, enhanced transit stops, Pedestrian Clearway/Sidewalk (both sides of the street) scale to volume, wide landscaped Furnishing/ Planting Zone, high visibility pedestrian crossings, HOV lanes, enhanced tree canopy in Frontage/ Marketing Zone and in Furnishing/Planting Zone and integrated SWM facilities. No on-street parking

Residential Connector Streets

Design Objectives: Separated cycling infrastructure, transit priority route, enhanced transit stops, Pedestrian Clearway/Sidewalk (both sides of the street) scale to volume, landscaped Furnishing/ Planting Zone to buffer Sidewalk, enhanced tree canopy and integrated SWM facilities, No on-street parking.

Scenic Streets

Design Objectives: Separated cycling infrastructure and Pedestrian Clearway/Sidewalk or multiuse trail (at least one side of the street), landscaped median, transit priority route, landscaped boulevard to buffer sidewalk, enhanced tree canopy and integrated SWM facilities.

Park Streets

Design Objectives: Enhancing environmental quality, enhanced tree canopy, integrate SWM facilities, separated cycling infrastructure and Pedestrian Clearway/Sidewalk or multiuse trail (at least one side of the street), traffic calming and street lighting.

Employment Streets

Design Objectives: Vehicle Travel Lanes designed to accommodate larger vehicle types, separated cycling infrastructure, transit priority route and enhanced transit stop design, Pedestrian Clearway/ Sidewalk (both sides of the street) scale to volume, wide boulevards where possible, enhanced tree canopy and integrated SWM facilities. No on-street parking.

Mixed-Use Access Streets

Design Objectives: Pedestrian Clearway (both sides of the street), limited Furnishing Zone on both sides, design quality and workmanship to compliment adjacent Main & Civic Streets, secondary pedestrian route, integrated cycling infrastructure, street lighting, durable materials, on-street parking possible, enhanced tree canopy and integrated SWM facilities. Transit is rare on mixed-use streets.

Mixed-Use Shared Streets

Design Objectives: Design quality, workmanship and street furnishing, pedestrian only zone adjacent buildings, pedestrian only streets possible, universal accessibility, uniform grade for flexible use, low vehicle volumes at low travel speeds, on-street parking possible, safe accommodation for cyclists and pedestrians and higher density bicycle parking.

Residential Shared Streets

Design Objectives: Design quality, workmanship and street furnishing, pedestrian only zone adjacent buildings, uniform grade for universal accessibility, low vehicle volumes at low travel speeds, on-street parking possible, safe accommodation for cyclists and pedestrians, higher density bicycle parking, enhanced tree canopy and landscape Furnishing/Planting Zone.

Mixed-Use Lanes

Design Objectives: Access for delivery, garbage removal and residents, durable paving materials, safe accommodation for cyclists and pedestrians, minimal Furnishing Zone and appropriate lighting.

Residential Lanes

Design Objectives: Access for residents, low vehicle volumes at low travel speeds, durable paving materials, safe accommodation for cyclists and pedestrians and appropriate lighting.

For a detailed description of Street Types, please refer to Toronto Complete Streets Guideline (2017).

4.2.3| Selection Parameter B - Applications

Applications refer to the various component areas within a typical right-of-way where GI practices may be suitable. These areas include:

1. Frontage and Marketing Zones (refer to CSG)
2. Pedestrian Clearway Zone (refer to CSG)
3. Furnishing and Planting Zones (refer to CSG)
4. Edge Zones (refer to CSG)
5. Curbside Space (refer to CSG)
6. Vehicle Lanes (refer to CSG)
7. Transit Lanes (refer to CSG)
8. Medians/Raised Islands (refer to CSG)
9. On-street Parking (refer to CSG)
10. Parking Lay-bys (refer to CSG)
11. Cycling Infrastructure (refer to CSG)
12. Crosswalks (refer to CSG)
13. Intersections (refer to CSG)
14. Mid-Block (refer to CSG)
15. Transit Stops (refer to CSG)
16. Bridges
17. Feature Paving
18. Street Lights
19. Decorative Lights
20. Parking Meters
21. Vehicle Charging Stations

If the objective of a particular screening exercise is to identify a palette of GI options that would be suitable within a given Street Type, then the 'Applications' parameter will be omitted as a filter because it would limit the search results. This parameter should only be used to isolate a specific Application as a primary search criterion, or to withdraw an Application as a potential result candidate.

Key characteristics of the various applications include the following:

Frontage/Marketing Zone
Part of the Sidewalk Zone that is directly adjacent to private property within an urban street type. This area can accommodate cafe seating, window shopping etc.; minimum width varies depending on Street Type.

Pedestrian Clearway Zone
Part of the Sidewalk Zone that facilitates a clear unobstructed path of travel; minimum width varies depending on Street Type.

Furnishing/Planting Zone
Part of the Sidewalk Zone between the Pedestrian Clearway and the Edge Zone that can include planting, SWM facilities, street furniture and utilities.

Edge Zone
The Edge Zone separates the Sidewalk Zone from the Roadway Zone; and comprise a standard curb or a decorative curb edge depending on the street type; the Edge Zone can accommodate traffic/ parking regulation signage poles, transit stop poles, etc.

Curbside Space
The Curbside Space is the area adjacent the curb within the Roadway Zone that can be used for bicycle parking, on-street parking, parking lay-bys, cycling infrastructure etc.

Vehicle Lane
Main travel lanes of the Roadway Zone. The number of lanes and lane width can vary based on Street Type.

Transit Lane
These are dedicated transit lanes within the Roadway Zone. The width of the Transit Lane can vary based on Street Type.

Median / Raised Island
These are the formalized areas between two opposing directions of travel or at the centre of a directional change.

On-Street Parking
Part of the Curbside Space that is identified by street signage. On-Street Parking areas are not applicable within all CSG street types.

Parking Lay-By
Part of the Curbside Space that is formalized by the curb alignment. Parking Lay-By areas are not applicable within all CSG street types.

Cycling Infrastructure - Separated/Integrated
Part of the Curbside Space that is identified by road markings / colour and are sometimes formalized with barriers. Cycling infrastructure is not applicable within all CSG street types.

Crosswalk
Formalized pedestrian crossings identified by pavement markings and in some instances by alternative materials.

Intersection
Within the Curbside Space, where Vehicle Lanes intersect one another.

Mid-Block
Within the Curbside Space, between intersections.

Transit Stop
Within the Curbside Space, at a transit stop.

Bridge
At bridge walls or abutments.

Feature Paving
Paved areas that do not comprise standard concrete and can be located in Edge Zone, Parking Lay-By, or Civic spaces.

Street Light
The GSTG addresses the potential for efficiency, but not the aesthetic or material characteristics.

Decorative Lighting
The GSTG addresses the potential for efficiency, but not the aesthetic or materials characteristics.

Parking Meter
The GSTG addresses the potential for efficiency, but not the aesthetic or materials characteristics.

Vehicle Charging Station
The GSTG addresses the potential for efficiency, but not the aesthetic or materials characteristics.

4.2.4| Selection Parameter C - Physiography

An understanding of the landscape character of a site provides direction critical to the development of functional GI options that complement the neighbourhood and fulfill the City's environmental objectives.

The physiographic, biophysical and hydrologic conditions of a site will not only determine the types of GI options that are possible, but also the permutation of the option that will produce a functional solution. For example, on sites with highly permeable soils, infiltration-based GI options will provide the optimal solution. However, on a site with impervious soils, a practical permutations to the option would include an underdrain (and impervious barrier when required) to provide a solution that relies on a combination of attenuation, conveyance and filtration practices.

4.2.4.1| Characterization Parameters

The physiographic, topographic and hydrogeological characteristics determine the palette of potential GI options (or permutations thereof) that would be viable within a given site.

Physiographic factors such as soil permeability and depth to bedrock determine whether infiltration-based GI options would be viable on a particular site. If certain tolerances are not met then alternative permutations (underdrains) are considered.

Topography refers to the change in gradient over a site and can affect factors such as discharge rates, runoff velocities and flow patterns. Certain GI options are not well-suited to steep slopes and therefore can be excluded from consideration based on this parameter.

Hydrogeological factors, including depth to water table and bedrock, can also impact the design and function of various GI options.

4.2.4.2| Reference Maps

In order to expedite the screening process, reference maps have been developed for each of the following parameters:

- Topography
- Depth to Water Table
- Depth to Bedrock
- Soil Permeability
- Contamination

These maps were developed based on City GIS data and are included in Appendix E.0 to allow for quick referencing throughout the process. Reference maps should only be used for preliminary screening purposes. Site specific investigations will be required in order to produce optimized site specific design solutions.

A. Topography

Topography is another key factor in determining whether infiltration-based GI options are appropriate for a given site. Topographical gradients are divided into the following range classes:

- Area TG-1 = Slope 0-5%
- Area TG-2 = Slope 5-10%
- Area TG-3 = Slope >10%

The topographic gradient ranges throughout the City are illustrated on Map 1.0 in Appendix E.0.

B. Depth to Water Table

Shallow water table conditions (<1m) can present challenges for the location, design and function of infiltration-based GI options. The potential for discharge of contaminated runoff into ground water resources is the primary concern, however this does not eliminate the opportunity to implement GI options. Infiltration-based GI options will require design adjustments that will allow the facility to perform attenuation, filtration and conveyance functions, rather than infiltration. Depth to Water Table has been subdivided into the following three categories in the GI Selection Tool:

- Area WT-1 = <1m
- Area WT-2 = 1-2m
- Area WT-3 = >2m

Water table depths throughout the City are illustrated on Map 2.0 in Appendix E.0.

C. Depth to Bedrock

Depth to Bedrock influences the ability to implement infiltration-based options and options that require deeper excavation. Depth to Bedrock has been subdivided into the following three categories in the Selection Tool:

- Area BE-1 = <1m
- Area BE-2 = 1-2m
- Area BE-3 = >2m

Bedrock depths throughout the City are illustrated on Map 3.0 in Appendix E.0.

D. Soil Permeability

Soil Permeability is a key factor in determining whether infiltration-based GI options are suitable for a given site. Where native soil infiltration rates are >15mm/hr, GI options can be designed without an underdrain, however, where infiltration rates are <15mm/hr, an underdrain will be required. Soil Permeability throughout the City is illustrated on Map 4.0 in Appendix E.0.

E. Contamination

Contamination refers to areas of existing soil contamination within the City. Contamination could be on private property, within the road right-of-way or on sites associated with former landfills. The screening options for this category are simply 'Yes' or 'No'. Contaminated sites generally provide limited Water Quantity, Quality and Efficiency GI options, but can provide benefits related to Ecology, Air Quality and Energy Efficiency GI options.

Site contamination mapping for the City of Toronto is represented on Map 6.0 in Appendix E.0.

4.2.5| Selection Parameter D - Open Space Context

Ecological benefits from a Natural Heritage System (NHS) can extend well beyond its physical boundaries into adjacent streets and communities through integration of appropriate GI practices within adjacent rights-of-way. These GI options can also serve to protect and enhance existing wildlife habitat within open spaces and the NHS. It is therefore important to consider the relationship between the road right-of-way and natural heritage / open space systems as a component of the selection process. The following natural heritage and open space parameters are addressed with the GI Selection Tool:

i. Natural (Map #, Appendix E)
- Adjacent to a Ravine or Natural Area
- Traversing a Ravine or Natural Area

ii. Open Space
- Adjacent to a Park
- Adjacent to a Hydro / Utility Corridor

Map 5.0 illustrates the NHS within the City. Major hydro and utility corridors are illustrated on Map 8.0 in Appendix E.0.


Photo Credit: Schollen & Company Inc.

4.2.6| Selection Parameter G - Transit Infrastructure

Transit Infrastructure refers to all fixed transit routes above and below grade throughout the City including Subways and LRT lines (Dedicated or Integrated). The existence of this infrastructure within or under a proposed site can preclude the implementation of certain GI options and can provide opportunities for others.

For example: infiltration is prohibited above subway tunnels, therefore, GI options that are compatible with this context include bioretention, dry swales and permeable paving, all designed with an impervious barrier. This will allow for runoff to be filtered and attenuated but not infiltrated. Other suitable options fulfill ecological priorities in the form of planter boxes and planting beds using structural soils or soil cells.

The presence of dedicated LRT infrastructure provides opportunities for implementation of green gutters and permeable paving since the surface of the LRT right-of-way does not require the same load-bearing capacity as a regular city street. These options will require support by Metrolinx.

Map 7.0 illustrates existing subway, streetcar and LRT lines in the City.

4.2.7| Selection Parameter H - Utilities

Utility infrastructure forms a large and complex part of the composition of a road right-of-way and provides one of the greatest barriers to the implementation of GI options. New and reconstruction projects offer flexibility in locating utilities and services and priority should be placed on locating GI practices first in order to maximize ecological and hydrological benefits. In addition, overhead wires are rare on new streets, therefore the establishment of a robust tree canopy is a priority.

In rehabilitation and retrofit situations, ingenuity will be required in order to modify GI options to suit existing site conditions. This parameter considers whether or not a specific GI option can exist over, under or in proximity to the following utility installations, and if so what modifications might be necessary for installation within retrofit or rehabilitation projects.

i. Natural Gas
- Type/Size

ii. Hydro / Electrical
- Underground
- Overhead
- Transformer / Switchgear

iii. Bell Canada
- Overhead
- Underground

iv. Rogers
- Overhead
- Underground

v. Enwave
vi. Oil
vii. Water
viii. Sanitary Sewer
ix. Street Lights
x. Service Laterals

Map 8.0 illustrates the location and alignment of major hydro, natural gas, diesel fuel, aviation fuel and heating fuel pipelines within the City. Regardless of whether or not a given site is located above or in close proximity to one of these major utilities, it is essential to have the site surveyed to confirm the location and type of underground utilities that exist prior to initiating both the detailed design and construction processes.

Photo Credit: Schollen & Company Inc.

4.2.8 | Selection Parameter E - Storm Sewer Infrastructure

Traditional stormwater drainage systems were designed to collect runoff from impervious surfaces and convey it as quickly as possible through a system of underground pipes or surface ditches to outlet in the nearest river, stream or water body. The two common types of conveyance infrastructure include combined sewer systems and separated sewer systems. Combined systems collect and transport sewage water and runoff within the same pipe, whereas separated systems convey sewage independently from stormwater runoff. Combined systems are of particular concern since flows that exceed the capacity of the system in large storm events discharge untreated effluent into the receiving watercourse or water body.

GI can help to relieve pressure on conventional conveyance infrastructure through the implementation of options that control and treat stormwater runoff as close to the source as possible. In areas where combined sewers exist, stormwater management priorities include attenuation and infiltration in order to reduce runoff volumes, therefore GI options identified through application of the GI Selection Tool are focused on quantity control.

Rural systems comprise open swales or ditches that are well-suited to retrofitting to include bioretention, infiltration or storage. Urban streets generally employ piped systems and therefore different GI options are more appropriate due to the presence of curbs and catch basins (CBs).

Areas services by combined and separated sewers are illustrated on Map 9.0. in Appendix E.0.

4.2.9| Selection Parameter I - Known Flooding

The risk of flooding and property damage is critical in determining the most appropriate selection of GI options. This parameter is subdivided into three categories in the GI Selection Tool:

i. Proximity to Basement Flooding
- Within Flood Prone Area
- Outside Flood Prone Areas
- Contributing to Flood Prone Area

In areas where chronic basement flooding risk exists, the priority will be to select GI options that will attenuate runoff and optimize quantity control. In areas directly adjacent, quantity control is important but not a specific priority. In areas outside of chronic flood risk zones, quantity control is not a specific priority.

Reported basement flooding areas are illustrated on Map 10.0. Flood risk areas are illustrated on Map 12.0 in Appendix E.0.

4.2.10| Selection Parameter H - Urban Forest

An enhanced urban forest canopy is a key priority since it will improve air quality and help to reduce urban heat island effect. Within the GI Selection Tool, Urban Forest canopy is considered in terms of its general health and abundance in an area. In areas where the quality and extent of the Urban Forest canopy is low, GI options that incorporate extensive tree planting are a priority. Where Urban Forest canopy quality is high, priorities may shift to focus on other higher priority GI options.

4.2.11| Selection Parameter K - Stream Restoration

Watershed context is a parameter that is used to identify GI options that will help to mitigate erosion in a receiving watercourse. Map 11.0 (Appendix E.0) illustrates areas of erosion vulnerability within the City.

Where erosion vulnerability is high, the priority is to be placed on quantity control and focus will be on implementation of GI options that provide attenuation and infiltration. In areas that have medium to low vulnerability, quantity control may not be as important as quality control or other environmental priorities.

4.2.12| Selection Parameter L - Operations and Maintenance

Siting for GI options must consider existing operations and maintenance regimes in order to be practical. Therefore the following maintenance and operations criteria have been incorporated into the GI Selection Tool.

i. Garbage /Solid Waste
- Curbside Waste Removal – GI options cannot obstruct access for garbage removal
- Other – No limitations

ii. Winter Maintenance Protocol
- Salt Application
- Sand Application
- Snow Removal Hierarchy

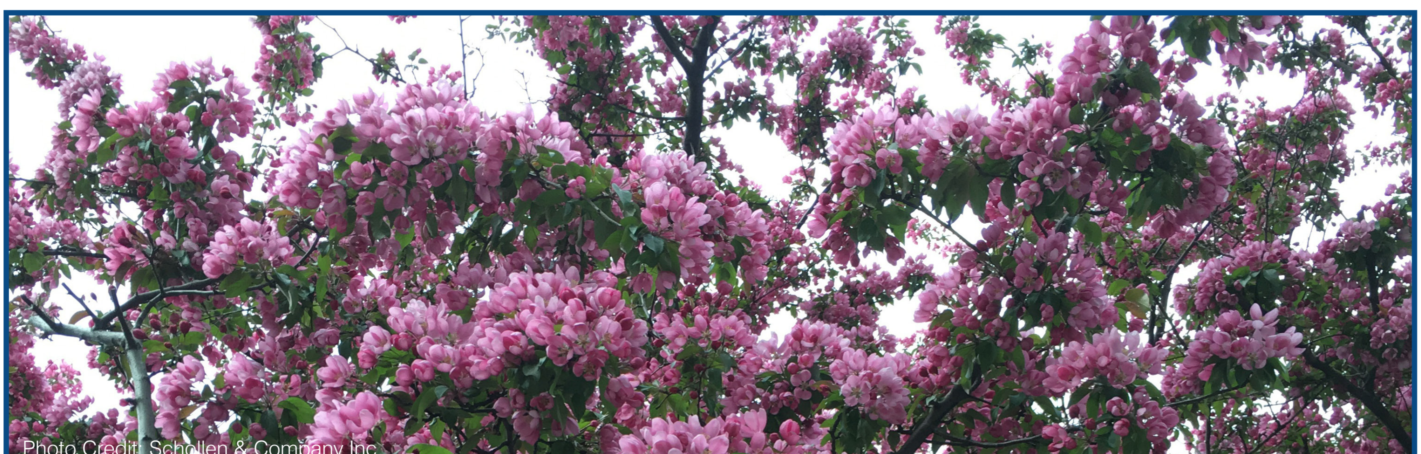
Photo Credit: Schollen & Company Inc.

4.3 GI SELECTION TOOL NIL RESPONSE

The GI Selection Tool is designed to provide no 'nil' response. In other words, there should be at least one GI option available for every site. If the tool provides a 'nil' response, then adjustments to the following selection parameters should be considered:

1. Soil amendments
2. Alterations to site grading
3. Use of impervious liners
4. Relocation of utilities

4.4 SELECTION PRIORITIES

Objectives related to TGS priorities should be established prior to application of the Selection Tool on any GI project. Once City staff or the project designers have arrived at a site-appropriate palette of GI options using the GI Selection Tool, options should be assessed to determine the relative priority based on their ability to satisfy the TGS related project objectives. The selection of a preferred option should not simply default to the least expensive solution, but rather should optimize benefits while achieving cost efficiency.

4.5 IMPLEMENTATION

The process of generating the GSTG included a review of the various implementation programs that have been adopted by several municipalities within Canada and the United States. The review identified a number of commonly adopted initiatives, including the following:

a) Dedicated Green Infrastructure (GI) Team
- Every city studied had assembled a GI team that is dedicated to implementing GI projects.

b) Interdepartmental Communication and Coordination
- Interdisciplinary coordination was identified as a key objective to address multi-departmental implementation and operations/maintenance issues.

c) Consistent Funding
- All of the municipalities that were researched had allocated consistent and appropriate funding to complete the design, implementation and monitoring of GI installations.

d) Policy Support
- All of the municipalities that were researched had implemented policies to support the implementation of GI works.

e) Partnerships
- The establishment of partnerships with BIAs, stakeholder groups and community groups was identified as a necessary step to catalyze the implementation, maintenance and monitoring of GI.

f) Cost/Benefit
- Many of the municipalities had identified a need to confirm the cost and benefit of each GI option.

g) Training
- The need to implement a comprehensive education and training program was identified as essential to ensure that City/municipality staff that are involved in the design, construction and maintenance of GI are fully aware of the objectives, functions and unique attributes and requirements associated with GI.

In addition to these general findings the following specific implementation initiatives have been identified for consideration to support the implementation of GI.

1| Coordination

- Develop a dedicated Green Streets team to administer the GSTG;
- Confirm infrastructure ownership/responsibility;
- Update design and construction standards to include GI specifications;
- Refine the approvals process to accommodate GI applications;
- Coordinate GSTG implementation with utility and infrastructure life-cycle estimates to ensure that new GI installations are not damaged or destroyed due to scheduled maintenance or replacement;
- Review and update the GSTG and Selection Tools as required;
- Create and maintain a concise inventory database of GI projects throughout the City.

2| Education and Training

- Undertake outreach to engage consultants and contractors;
- Investigate the potential to require mandatory professional training and certification for consultants and contractors involved in GSTG projects;
- Investigate the potential to develop professional training and certification programs in cooperation with CVC and the TRCA;
- Develop demonstration projects to showcase different GI options.

3| Public Consultation

- Enable community engagement and education to enhance public awareness of the number and locations of GI options implemented throughout Toronto as well as and environmental benefits of each;
- Promote participation in conferences and workshops that heighten public awareness and youth engagement;
- Explore expanded partnerships with community and resident groups for management of GI installation.

4| Design Process

- Identify project objectives (based on TGS priorities) from the outset;
- Integrate GI projects with the CSG as well as the GSTG;
- Investigate the merits of ensuring that all GI landscape plans are stamped and signed by an OALA member certified in GI practices. As this certification does not currently exist, acceptable certification criteria would need to be established.

5| Operations and Maintenance

- Develop of an appropriate operations and maintenance plan for each GI option;
- Explore the merits of alternative methods that could assist with maintenance of GI practices such as citizen reporting (via an app), maintenance agreements with neighborhood residents or community groups.

6| Monitoring and Tracking

- Explore the potential to implement post construction monitoring and evaluation programs for each GI solution;
- Pursue integrating monitoring practices with TRCA's Sustainable Technologies Evaluation Program (STEP) to ensure universality of data and reports;
- Monument each GI installation (refer to detail G-1) and record the location of GI installations in the database.

5.0

OPERATIONS AND MAINTENANCE GUIDELINES

5.1 OPERATIONS & MAINTENANCE

5.1.1 | Operations and Maintenance Considerations

It is critical that the requirements for the operations and maintenance (O&M) of GI options be considered from inception of the conceptual design through the extent of their life-cycle. Designers must understand the capabilities of O&M staff and the available inventory of equipment and should design GI facilities in accordance with these considerations. At the same time, GI will soon become the 'new normal' within Toronto's road rights-of-way, therefore, adjustments will be required to O&M policies and procedures, budgets, staffing and equipment in order to accommodate these evolving technologies moving forward.

Key areas of focus will include:

- The creation of a comprehensive and up-to-date inventory of Green Streets installations throughout Toronto. This inventory will enable the implementation of enhanced maintenance, monitoring and engagement programs throughout the City;
- Education and training for staff so that they are equipped to address GI related maintenance requirements such as proper operation, maintenance, monitoring and inspection;
- Updating of the City's O&M strategies, policies and procedures (including winter maintenance);
- Development of inspection, monitoring and maintenance plan templates for each GI option. Design professionals should refer to the TRCA's LID Inspection and Maintenance Guide (I&M) and the CVC's LID Monitoring and Performance Assessment Guide for direction on producing site / GI specific plans. A maintenance and monitoring strategy must be confirmed for each GI project prior to implementation/installation; and,
- Updating of the City's inventory of equipment

A level-of-service model should also be developed in order to identify maintenance requirements throughout Toronto's Green Streets. Appendix F provides a general outline of O&M requirements for each GI option listed within the Selection Tool. The database identifies tasks, timing/frequency, equipment, personnel and training that will be required. Inspection & monitoring; repair & replacement, access to utilities infrastructure and life-cycle requirements are also addressed.

5.1.2 | O&M Costs

O&M costs are a significant consideration for the City. The Sustainable Technologies Evaluation Program (STEP) LID Life Cycle Costing Tool provides an effective mechanism to assist City staff in generating planning-level estimates of life-cycle costs including construction, inspection, maintenance and rehabilitation. Additional budget considerations should include:

- Any increase in costs to maintain GI options over and above what would have been required in a "business-as-usual" case;
- Opportunities to synthesize GI and routine maintenance regimes;
- Additional equipment and staffing requirements; and,
- Education and training for all O&M staff.

Opportunities exist for cost savings through creative partnerships with neighborhood residents and volunteer community groups, where resident groups might care for the plant material, while the City would be responsible for inspections, flushing, vacuuming, etc. In order to capitalize on these partnership opportunities, an initial investment would be required to address outreach and education, however with established maintenance expectations identified and partnership agreements in place, this initial effort and investment can prove beneficial to reduce maintenance efforts.

5.2 GI REPAIRS, REPLACEMENT, EXPANSION

5.2.1 | Repairs

Repairs are inevitable throughout the life-cycle of most GI options. Repairs are typically required less frequently than routine maintenance and are often discovered during annual visual or performance inspection of the GI installation as a result of a resident complaint. In rare cases, repairs can be required due to impacts from outside forces including:

- Extreme weather events;
- Contamination of the contributing runoff area;
- Failure of erosion and sediment control systems associated with an adjacent exposed site;
- Failure of drainage, inlet or pretreatment devices; and,
- Requirements to access utilities that are in need of repair, replacement and augmentation.

5.2.2 | Replacement

Replacement refers complete reinstatement of the GI option at the end of it's life-cycle, however full or partial replacement may also be required in rare cases partway through the life-cycle due to a failure of a key component. During replacement some structural elements can be salvaged and reused however materials such as soils, geotextiles, pavements, aggregates, plant materials & pipe generally cannot.

Other elements such as plant material and mulch may be required to be replaced throughout the normal course of an GI life-cycle without disrupting the function of the GI feature.

Appendix F outlines routine repair and replacement items that can be anticipated throughout the life-cycle of each GI option.

5.2.3 | Expansion

Unlike conventional stormwater management systems, some GI options have the potential to be expanded to provide additional storage capacity. This will be of critical importance for ensuring that Toronto remains a resilient City in spite of potential future changes in precipitation volumes and weather patterns that may occur as a result of climate change.

6

6.0 MONITORING RECOMMENDATIONS

Photo Credit: Schollen & Company Inc.

6.1 MONITORING

6.1.1 | Objectives

The implementation of effective monitoring programs is critical to ensuring that Green Streets objectives are met. Data garnered through the monitoring process should:

- Provide a baseline for performance tracking and evaluation of design standards and construction specifications;
- Evaluate the performance of GI options against indicators outlined in the TRCA's LID I&M Guide;
- Ensure that GI facilities are installed according to design details and specifications, are adequately maintained through establishment/warranty periods and are functioning properly prior to assumption. This can also inform refinement of design and construction specifications;
- Provide testing/monitoring work as part of assumption and performance verification inspections, to be compliant with ECA conditions for drainage performance;
- Demonstrate the effectiveness of the management strategy, plan and practices to reduce risk and liability in association with GI options in the future;
- Assist in developing the basis for appropriate and cost effective asset management by City staff through an understanding of how to extend operating life spans and make prudent decisions regarding repair and replacement;
- Illustrate success and provide a business case to promotes broad-scale acceptance and to inform future policies; and,
- Create a standardized database of performance information, maintenance and life-cycle.

The monitoring program for GI options should be designed to address the following parameters:

1. Regulatory compliance related to policy targets and objectives (TGS, WWFMMP, ODWQS, PWQO & MOECC ECA);
2. The performance and effectiveness of techniques that are interrelated with various GI options;
3. Effectiveness in mitigating urban heat island effect;
4. Effectiveness in achieving pollutant reduction;
5. Rates of infiltration in facilities that employ infiltration as a tool;
6. Energy efficiency and reduction in GHG emissions;
7. Effectiveness in flood mitigation; and,
8. Water quality enhancement performance

6.1.2 | Monitoring Approach

Depending on the type of GI, monitoring may be undertaken as part of inspection work prior to assumption and periodically throughout the operating phase to comply with ECA conditions, support the City's (stormwater) infrastructure asset management program and inform revisions to improve design standards/specifications.

The TRCA LID I&M Guide (TRCA, 2016) is the definitive resource document on the topic of LID operation, inspection and maintenance in Ontario. The guide provides detailed guidance on indicators to inspect / test / monitor, standard sampling procedures and testing methods, acceptance criteria / triggers for follow-up action and repair / rehabilitation work required for each type of LID BMP through construction and operating phases of their life cycles.

The Guide recommends continuous performance monitoring for stormwater infiltration practices as part of assumption inspections during the establishment / warranty period and performance verification inspections every 15 years post-construction at a minimum. The recommended framework is designed to rely on visual indicators that can be assessed by all levels of staff and includes inspection types, frequencies and testing indicators.

6.1.3 | Inspection and Monitoring Plan

An inspection and monitoring plan should be developed from the inception of a street reconstruction or retrofit project. The LID I&M Guide is a valuable resource that provides advice on designing monitoring programs for assumption and performance verification inspection and includes checklists / field data forms for performing inspection, testing and monitoring work, broken down by BMP type.

6.1.4 | Monitoring Costs

Since monitoring is an integral part of a GI system, the cost of developing and implementing a comprehensive monitoring plan should be should be incorporated into the overall project budget. Monitoring costs throughout the life of the project are proportional to the scale and lifespan of the system and include:

1. Staff Resources - Salaries and training;
2. Equipment - Purchase, installation, maintenance and replacement;
3. Laboratory Testing and Data Analysis;
4. Maintenance of the Information Database and GIS Mapping;
5. Supplies; and,
6. Reporting and Communication Costs - (Reports, fact sheets case studies and bulletins).

The STEP LID Life Cycle Costing Tool provides a valuable resources for generating planning level estimates related to construction, inspection, maintenance and rehabilitation costs for LID practices.

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Photo Credit: Schollen & Company Inc.

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Photo Credit: Schollen & Company Inc.

GLOSSARY OF TERMS

Photo Credit: City of Toronto

Aggregate | a broad range of particulate material used in construction and available in various size gradations. These materials include: sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates.

Berm | a compacted mound of earth that diverts or creates shallow ponding areas for runoff. In some cases, runoff can pond behind a berm and will gradually infiltrate or flow through it.

Check Dam | a structure used in dry or enhanced grass swales to slow the velocity of runoff, allowing for sedimentation, filtration, evapotranspiration and infiltration. Check dams can be constructed from aggregate, wood, gabions, riprap or concrete,

Cistern | a tank or vessel that is used to store rainwater.

Detention | temporary storage of stormwater runoff to reduce flooding and remove pollutants.

Evapotranspiration | the process of water being lost from land and plant surfaces to the atmosphere through evaporation and transpiration.

Filter Media | engineered soil with limited fines, that is used to filter runoff.

Filtration | the process of removing fine particles and pollutants from runoff. In the context of GI this can occur as stormwater runoff infiltrates through the rootzone of plant material.

Fines | are fine-grained soils with a particle size of less than 0.050 mm diameter.

First Flush | the initial flow of surface runoff into the stormwater system. This runoff will typically contain greater pollutant concentrations as compared to runoff that is generated throughout the rest of a storm since 'first flush' runoff has picked up all of the surface pollutants accumulated during the dry period between storms.

Geotextile | a permeable fabric used to separate fine-textured soils from course gravel beds to prevent clogging. Geotextiles can also be used to filter runoff and reinforce LID components.

Granular | gravel or crushed stone used in the construction of bedding and stone storage reservoirs in certain LID installations. This material is available in various particle sizes to suit specific infiltration, filtration and conveyance requirements.

Gravel Diaphragm | a pretreatment and level spreading device that is installed perpendicular to the runoff flow path to dissipate the velocity of flows; distribute runoff evenly throughout an LID practice; and intercept suspended sediments.

Green Infrastructure (GI) | as defined in the PPS (2014) includes: *"natural and human-made elements that provide ecological and hydrological functions and processes. Components may include natural heritage features and systems, parklands, stormwater management system, street trees, urban forests, natural channels, permeable surfaces and green roofs".*

In the context of the Green Street Technical Guidelines, GI includes various ecological solutions, LID techniques and other technologies that support the environmental initiatives and priorities outlined in the TGS including: ecology, air quality, green house gas (GHG) reduction and energy efficiency as well as water quality and quantity.

Groundwater Recharge | the infiltration of surface water to an aquifer.

Hydrologic Soil Groups | a classification system that categorizes soil types based on their infiltration, filtration and conveyance capabilities. Hydrologic soil groups are categorized as:

Type A | well-drained sands and gravel, high infiltration capacity, high leaching potential and low runoff potential;

Type B | moderately-drained fine to coarse grained soils, moderate infiltration capacity, moderate leaching potential and moderate runoff potential;

Type C | fine grained soils with a low infiltration capacity, low leaching potential and high runoff potential; and,

Type D | clay soils with a very low infiltration capacity, very low leaching potential and very high runoff potential.

Impervious | a surface that prevents infiltration into the native soil.

Infiltration | the flow of surface water into the surrounding native soils.

Landscape-Based Approach | the philosophy that biophysics, hydrology and ecology should drive design form and function.

Low Impact Development (LID) | is a design approach that focuses on restoring and preserving water quality and maintain pre-development hydrologic processes by implementing LID techniques to manage stormwater as close to its source as possible. LID techniques can reduce or even eliminate pollutants in stormwater runoff from impervious surfaces; can regulate surface flow patterns and recharge rates; and, can be connected to form a 'treatment train' that can replicate a natural system.

Mulch | typically consists of shredded woody material or leaf compost. Mulch can be applied over soil to provide nutrients, remove pollutants and retain moisture.

Native Soil | a combination of minerals, organic matter and organisms that exist on a site or within a geographic region.

Off-Line | an LID practice that is not in the direct route of flow of stormwater runoff. Flows are typically diverted into off-line systems by a flow splitter or a bypass channel that restricts the volume entering the facility. Off-line practices are design for a target capacity, therefore, overflows are diverted away from these practices.

On-Line | an LID practice that is in the direct route to receive surface flows. In large storm events flows would be conveyed through an overflow outlet.

Physiography | the physical geography of a site that can include: topography, soil permeability, soil contamination and depth to bedrock or water table.

Pollution Hot Spot | areas where land uses have the potential to generate highly contaminated runoff (e.g. gas stations, demolition, hazardous materials storage and heavy industry).

Pollutant Load | the measurement of the mass of an individual pollutant entering a stormwater system in a given rainfall event.

Pretreatment | a device used to capture and remove sediments, debris and contaminants from runoff prior to it reaching an LID practice

Runoff | is excess water from rain, snow melt, or irrigation that flows over pervious and impervious surfaces.

Sedimentation | the settling out of particles suspended in liquid.

Soil Amendment | organic matter (mulch or compost) that is added to soils in order to improve fertility, alleviate compaction and restore hydrological functions.

Standing Water | water that has stopped flowing and cannot infiltrate through the ground surface.

Stone Reservoir | a layer of aggregate material that can temporarily store stormwater before it is infiltrated into the native soil or conveyed through an underdrain.

Stormwater Management (SWM) | refers to quantity and quality controls for storm water runoff.

Treatment Train Approach | a combination of LID, conveyance, and end-of-pipe stormwater management practices.

Underdrain | perforated pipe used to convey excess water from soils.

Water Balance | the annual inflows and outflows within a site typically consisting of runoff, infiltration and evapotranspiration. Water balance can impact erosion vulnerability, ground water recharge and downstream habitat protection.

Water Budget | the measurement of water balance.

Water Quality | the level of contaminants present in stormwater runoff. Controlling levels of Total Suspended Solids (TSS)and E. coli are the primary concern within the City of Toronto.

Water Quality Volume | the amount of stormwater runoff required to be attenuated by LID practices in order to reduce pollutant loads.

Water Quantity | the amount of runoff entering a downstream system. The management of water quantity focuses on minimizing impacts on downstream flooding, stream bank erosion and impacts on infrastructure.

Water Table | the level at which water pressure is equal to atmospheric pressure. Below this level the ground becomes saturated. The region below the water table is referred to as the saturated zone.

Watershed | A geographic area, defined by topography, that drains into a lake or river system.

REFERENCE DOCUMENTS

HYPRERLINKS

Click the text below to link to the reference documents:

Best Practices Manual for Green Walls

Biodiversity in the City of Toronto

Complete Streets Guidelines for Toronto

Toronto Climate Change Action Plan

Toronto Green Standard

Toronto Official Plan

Tree Planting Solutions in Hard Boulevard Surfaces

Toronto Pollinator Protection Strategy

Toronto Ravine Strategy

Toronto's Strategic Forest Management Plan 2012-2022

Toronto Streetscape Manual

Toronto Street Trees: Guide to Standard Planting Options

Wet Weather Flow Management Master Plan

TRCA Living Cities Policies

TRCA's LID Inspection and Maintenance Guide (I&M)

CVC/TRCA Low Impact Development Stormwater Management Planning and Design Guide

CVC SWM and LID Monitoring and Performance Assessment Guide

Sustainable Technologies Evaluation Program (STEP) LID Life Cycle Costing Tool

Toronto Green Streets

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DPM