ECS Lunch and Learn

Supporting internal knowledge transfer within TRCA

November 5, 2020

Toronto and Region Conservation Authority

Introduction to the LID Treatment Train Tool

Presented by – Steve Auger, Sahlla Abbasi and Yuestas David

November 5, 2020

STEP Water is a partnership between:

Toronto and Region Conservation for The Living City

Credit Valley Conservation inspired by nature

Lake Simcoe Region conservation authority

History

Background study – Remedial Actional Plan (RAP) project funding - 2015

V1 Ph1 – October 2015 - June 2016 – Beta development

V1 Ph2 – Jan 2017 – April 2018 – Beta Dev – Vs 1.0 release

V2 Ph1 – August 2018 – Feb 2019

- Wiki integration (LID Planning and Design Guide)

V2 Ph2 – October 2019 – December 2020

- Costing integration
- Trees Integration
- Better alignment to Ontario Stormwater Management and LID Guidelines

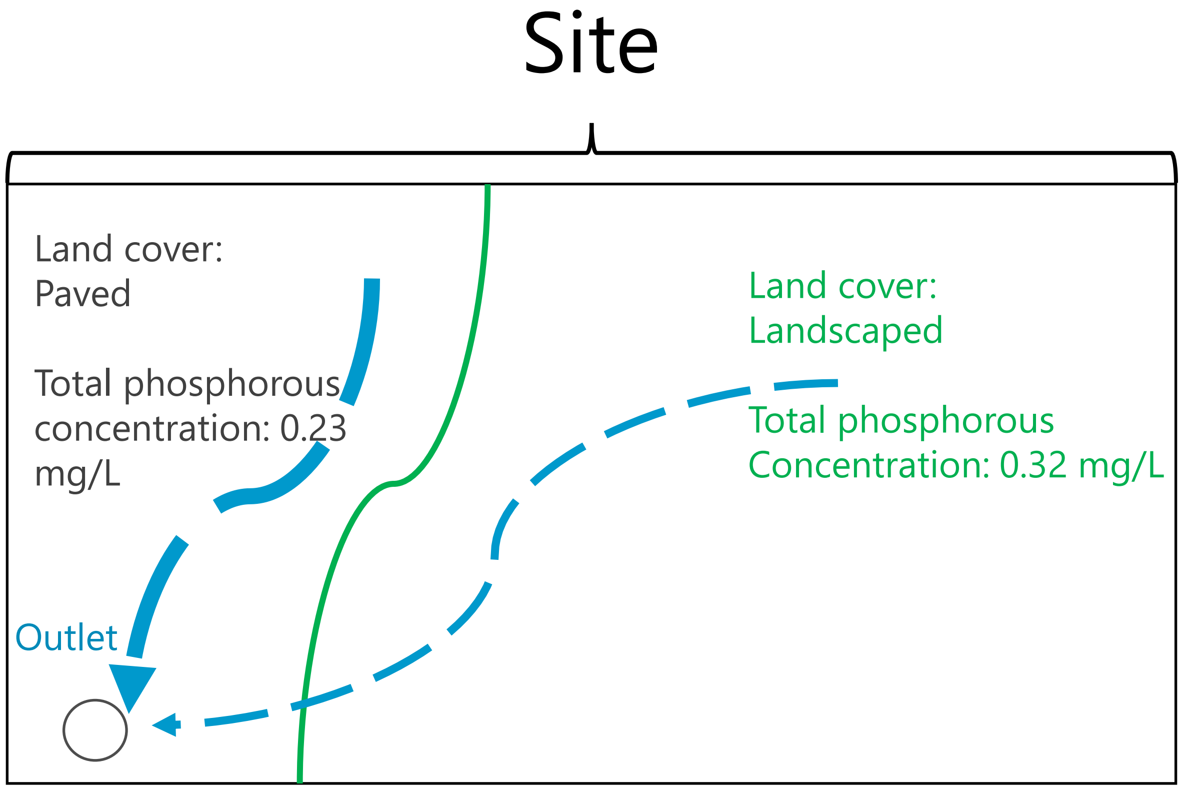
Stormwater Help Desk – Nov 2019 - present

Purpose: LSPOP a key driver

LSPOP – Lake Simcoe Phosphorous Offsetting Program

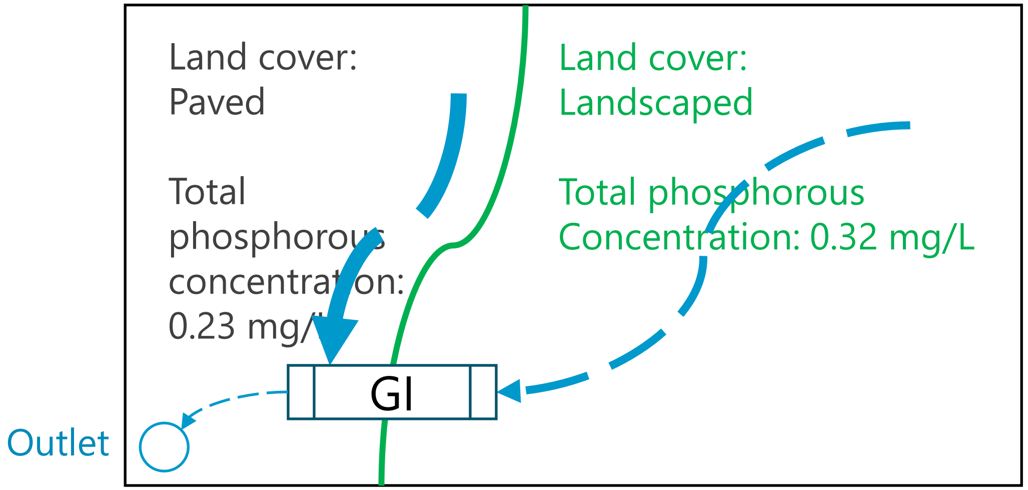
- “LSPOP requires that all new development must control 100% of the phosphorus from leaving their property. This is referred to as the Zero Export Target, a key component of the LSPOP that ensures new development or redevelopment activities do not continue to contribute to phosphorus loading to Lake Simcoe” (Phosphorus Offsetting Policy, September 2017 (Updated May 2019)

Purpose: Calculate Pollutant Load



Pollutant Wash-off Concentration (mg/L) * Runoff Volume (L) = Pollutant Load (kg)

Purpose: Calculate Pollutant Load Reduction



Green Infrastructure (GI) –*consists of natural and/or human-made elements that are designed to mimic natural environmental functions and processes.*

Pollutant Wash-off Concentration (mg/L) * Runoff Volume (L) = Pollutant Load (kg)

Reduced concentration   Reduced volume = Reduced load

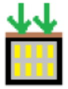
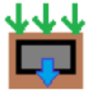
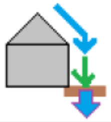
GI   GI

Filtration (Removal Efficiencies)   Infiltration (Hydrological Properties)

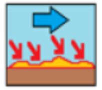
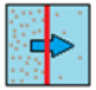
Purpose: Calculate Pollutant Load Reduction

Filtration (Removal Efficiencies)

$$\%\ \text{removal efficiency} = \frac{\text{influent (mg/L)} - \text{effluent (mg/L)}}{\text{influent (mg/L)}} \times 100\%$$

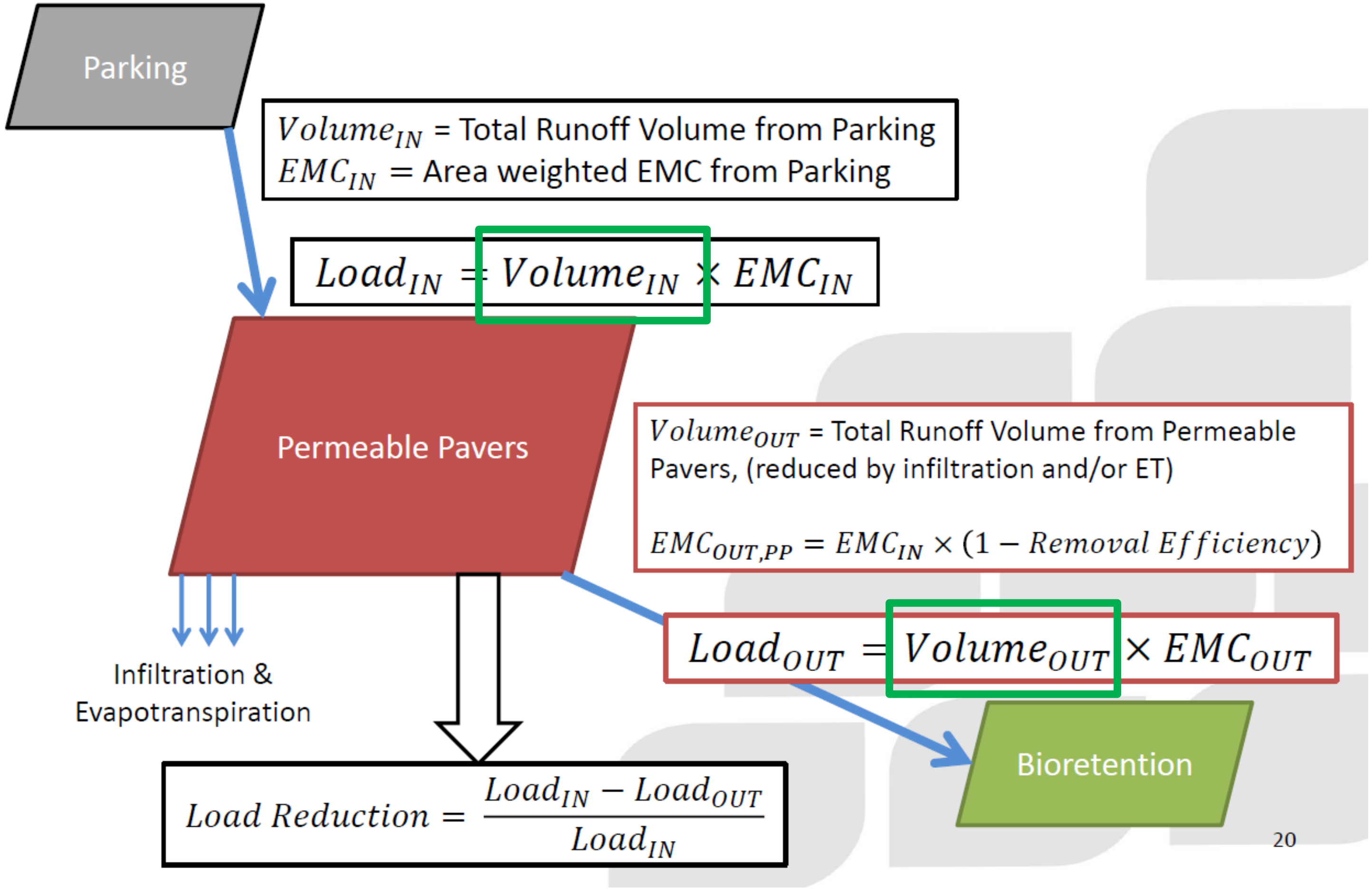
LID	TSS Removal Efficiency %	TP Removal Efficiency %	Icon
Bioretention	75	25	
Green Roof	0	-45	
Infiltration / Exfiltration Systems	75	60	
Permeable Pavement	75	60	
Vegetated Filter Strips / Buffer Strips	30	20	
Enhanced Swale	40	25	

Storage	TSS Removal Efficiency %	TP Removal Efficiency %	Icon
Constructed Wetland	80	60	
Wet Retention Ponds	80	60	
Dry Detention Ponds	60	20	

Junction	TSS Removal Efficiency %	TP Removal Efficiency %	Icon
Specializaed Phosphorus Media Filter	75	70	
Sand or Media Filter	75	40	
Oil Grit Separator	50	0	

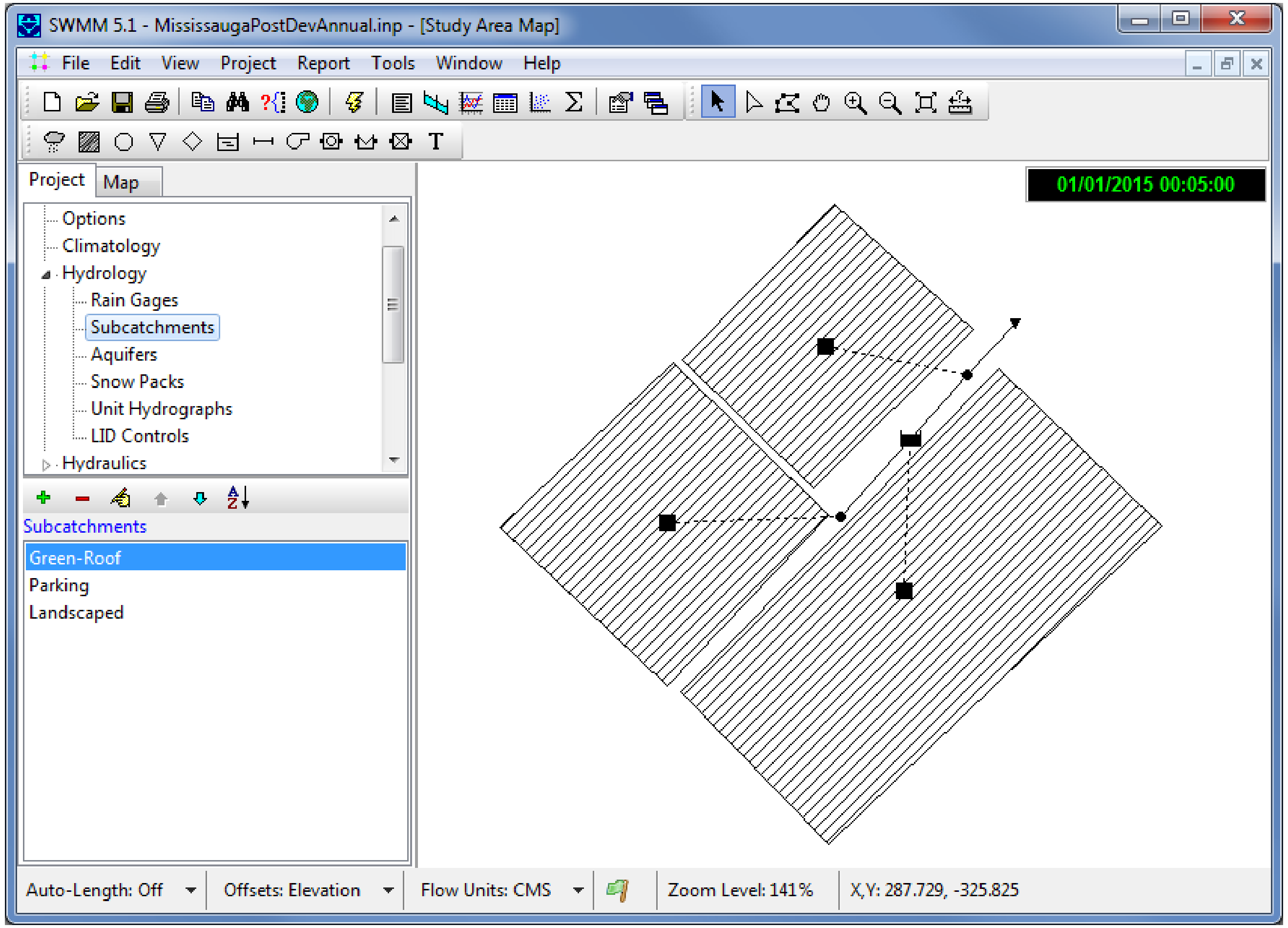
Established based on field measurements

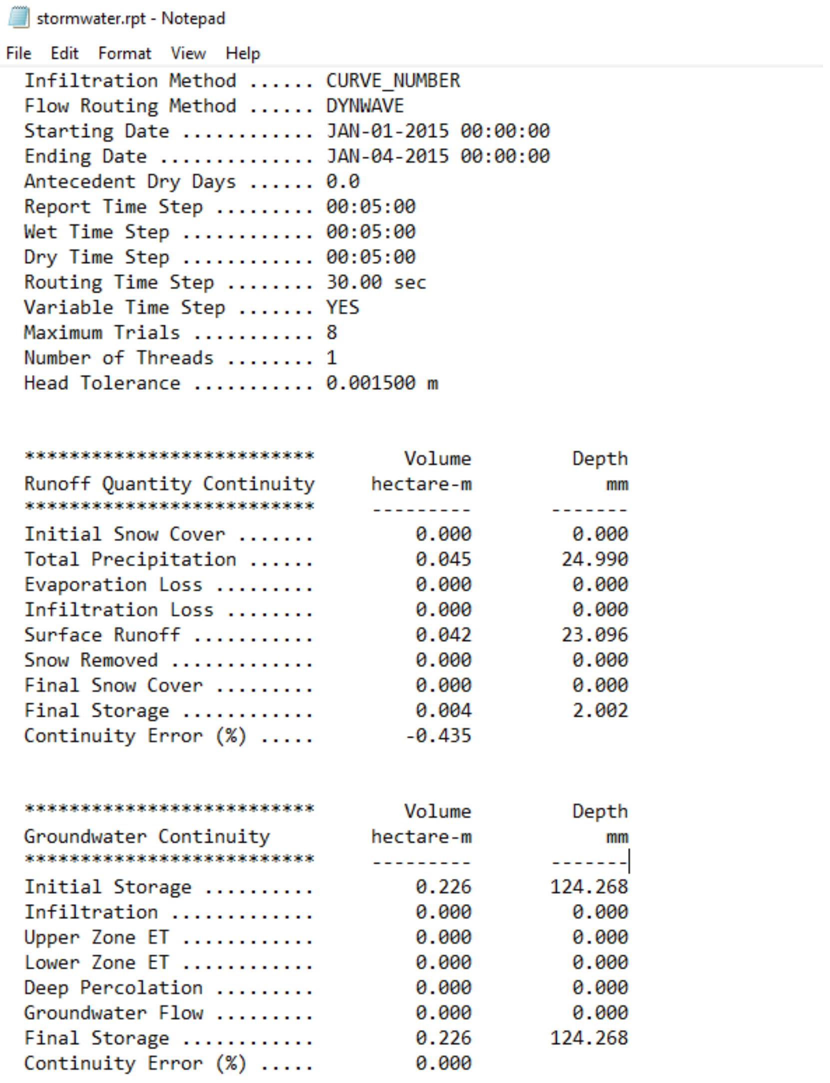
Purpose: Calculate Pollutant Load Reduction and …



Purpose: Fulfilled using existing models?

- EPA-SWMM (released 1971)





stormwater.rpt - Notepad

File Edit Format View Help

```
Infiltration Method ...... CURVE_NUMBER
Flow Routing Method ...... DYNWAVE
Starting Date ............ JAN-01-2015 00:00:00
Ending Date .............. JAN-04-2015 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:05:00
Wet Time Step ............ 00:05:00
Dry Time Step ............ 00:05:00
Routing Time Step ........ 30.00 sec
Variable Time Step ....... YES
Maximum Trials ........... 8
Number of Threads ........ 1
Head Tolerance ........... 0.001500 m


**************************        Volume         Depth
Runoff Quantity Continuity     hectare-m            mm
**************************     ---------       -------
Initial Snow Cover .......         0.000         0.000
Total Precipitation ......         0.045        24.990
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.000         0.000
Surface Runoff ...........         0.042        23.096
Snow Removed .............         0.000         0.000
Final Snow Cover .........         0.000         0.000
Final Storage ............         0.004         2.002
Continuity Error (%) .....        -0.435


**************************        Volume         Depth
Groundwater Continuity         hectare-m            mm
**************************     ---------       -------
Initial Storage ..........         0.226       124.268
Infiltration .............         0.000         0.000
Upper Zone ET ............         0.000         0.000
Lower Zone ET ............         0.000         0.000
Deep Percolation .........         0.000         0.000
Groundwater Flow .........         0.000         0.000
Final Storage ............         0.226       124.268
Continuity Error (%) .....         0.000
```

Purpose: Alignment with Ontario Stormwater Management Guidance

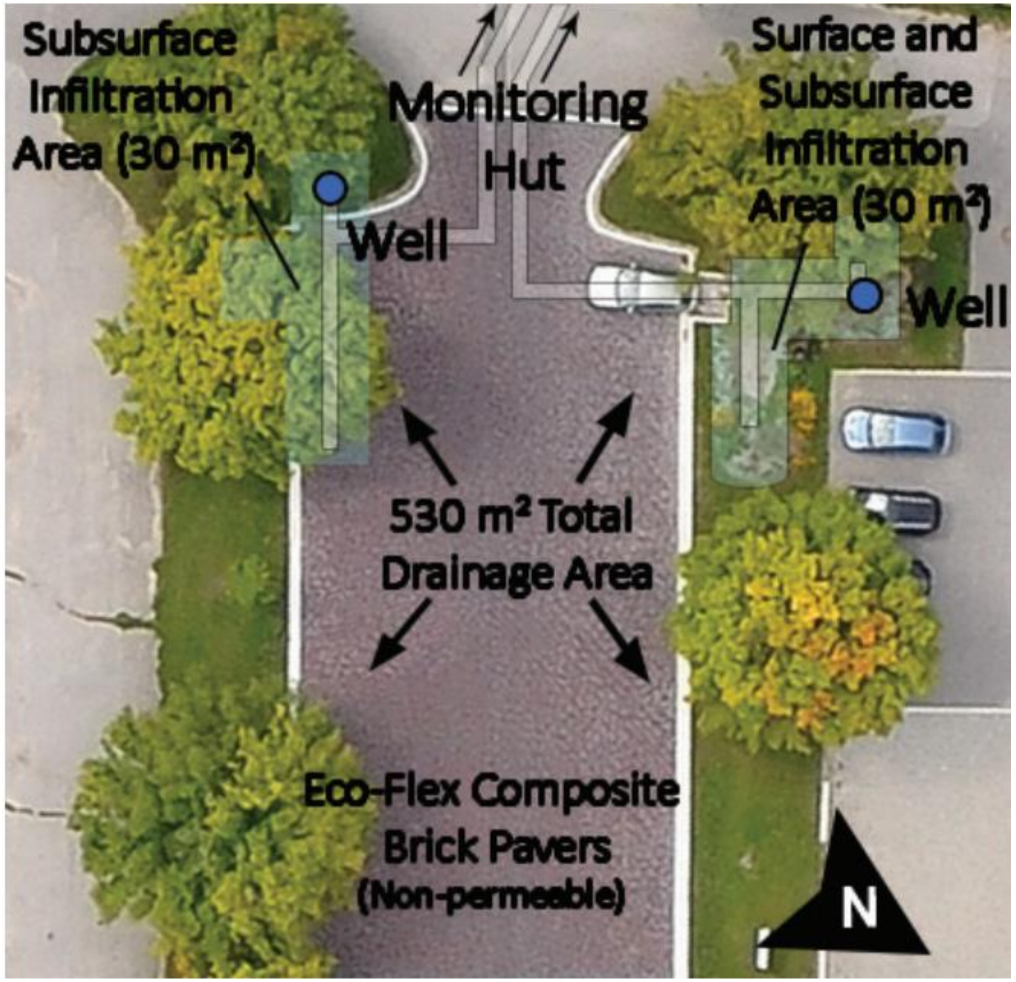
Objectives of Stormwater Management- 2003 MOECC Stormwater Manual

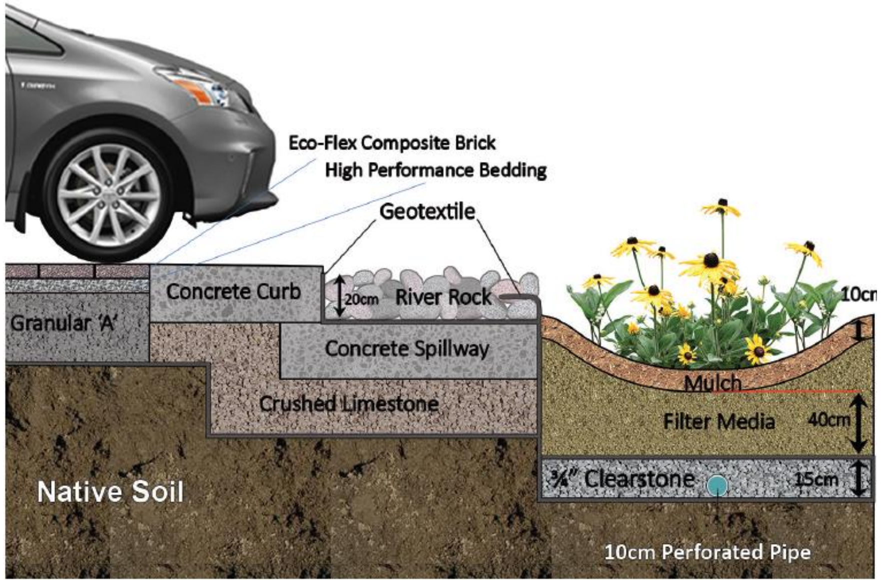
1. Maintain appropriate diversity of aquatic life and human uses – *Water Quality*
2. Protect water quality – *Water Quality*
3. Preserve groundwater flow and base flow – *Water Balance*
4. Maintain natural hydrologic cycle – *Water Balance*
5. Reduce combined sewer overflow – *Volume Control*
6. Reduce flood damage- *Volume Control*
7. Reduce undesirable geomorphic change (erosion) – *Peak Flow*
8. Increase climate change resiliency – *All of the above for a change in climate*

Bioretention Demo

Kortright Bioretention

Kortright Bioretention





Kortright Bioretention

STEP

Performance Comparison of Surface and Underground Stormwater Infiltration Practices

TECHNICAL BRIEF

Low Impact Development Series

Bioretention and infiltration trenches are two of the most common Low Impact Development (LID) stormwater management practices. Bioretention consists of a shallow, excavated depression with layers of stone, prepared soil mix, mulch and native vegetation that is tolerant to salt and periodic inundation. Infiltration trenches are underground excavations filled with clear stone that occupy little to no space on the surface. Both practices treat runoff and promote infiltration, but only bioretention reduces runoff through evapotranspiration and utilizes the natural properties of soils and plants to remove pollutants.

This study compares the hydrologic, water quality and functional performance of a bioretention cell and infiltration trench that drain runoff from a parking lot at the Living City Campus in Vaughan, Ontario. The practices have identical drainage and subsurface infiltration areas, and both receive runoff through geotextile-lined stone inlets. Key parameters examined include runoff volumes, runoff volume reduction, surface ponding and infiltration, water quality, effluent water temperatures, soil moisture and operation and maintenance requirements. Results showed that the bioretention cell and infiltration trench reduced runoff volumes by 90 and 80%, respectively. Effluent water quality from the two practices was not statistically different for most variables, with the exception of phosphorus and iron, which were exported from the bioretention cell at higher concentrations. Loads of most pollutants from the LID practices were significantly lower than asphalt due primarily to lower outflow volumes. Loading the inlets with street sweepings from other busy parking lots did not have a measurable effect on the quality of effluent from either practice over the short duration of testing. The results of this study suggest that infiltration systems with pre-treatment via a geotextile-lined stone inlet can provide comparable treatment and runoff reduction benefits to traditional bioretention systems while reducing costs and occupying substantially less surface area.

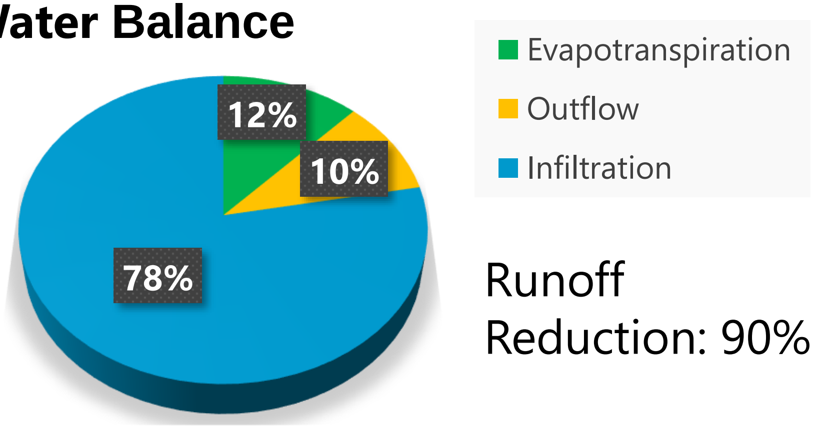
Proper design and regular inspections are required to ensure facilities are not ponding water for extended durations after rain events. Rectifying clogging issues in well designed systems can usually be done cheaply and effectively by non-specialized maintenance personnel.

Sustainable Technologies Evaluation Program
www.sustainabletechnologies.ca

An Initiative of: Toronto and Region Conservation for The Living City

https://sustainabletechnologies.ca/app/uploads/2016/08/BioVSTrench_TechBrief__July2015.pdf

Water Balance



Runoff Reduction: 90%

Water Quality

Water Quality Variable	Bioretention Cell Loads In (g)	Loads Out (g)	Contaminant Load Reduction (%)
Total Suspended Solids	7766.3	207.2	97
Ammonia+ammonium - N	16.3	1.5	91
Nitrate + nitrite - N	34.3	31.9	7
Total Kjeldahl - N	71.7	24.9	65
Total Nitrogen	101.8	56.4	45
Total Phosphorus	21.8	1.9	91

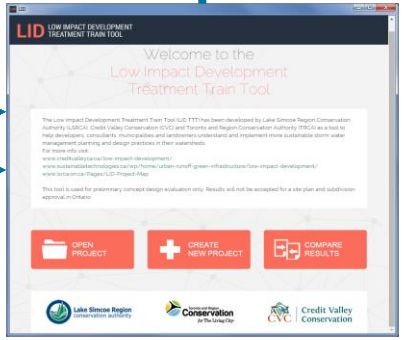
Function

- A conceptual design tool to help developers, consultants, municipalities and landowners implement sustainable stormwater management practices including LID.
- Reports on Water Quality, Peak flows (erosion control), Runoff Volume Control (Flood control); responds to changing climate inputs
- A more streamlined SWM tool for permitting and compliance process, utilizing EPA-SWMM.
- SWM Tool Tailored to Ontario Climate, Geology, and Stormwater Management Guidelines

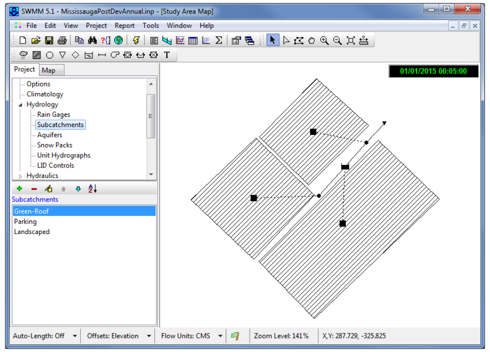
Function: Integration

Provincial, Municipal, CA Stormwater Management Guidelines

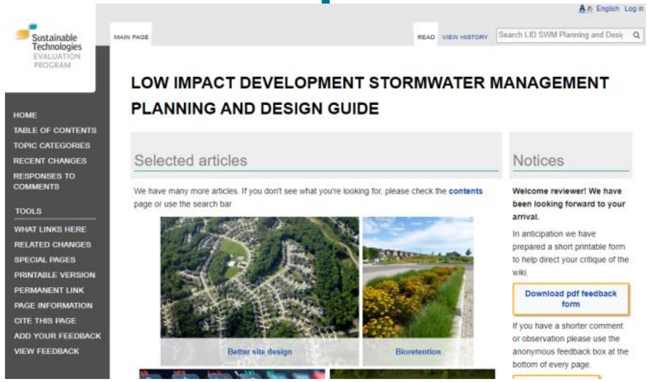
"Co-benefits"



LID TTT



EPA SWMM5



Developments

1. LID/GI Costing
2. Trees as GI/LID option

Developments: TTT with Costing Abilities

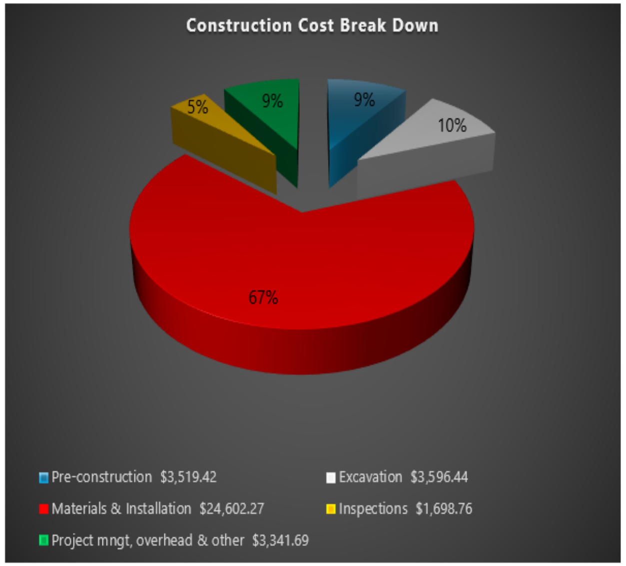
GI Costing

- Estimates construction and maintenance costs for Green Infrastructure (GI) practices within TTT
- Sets TTT apart from other SWM by assessing LIDs on both performance and cost
- Costing data and methodology derived from LID Life Cycle Costing Tool (STEP-2019)
  - RSMeans (widely-used construction and maintenance database), supplier quotes, experienced construction managers, LID Guide, literature sources
- Costing curves produced by LCCT express relationship between GI area and unit cost ($/footprint area (m2))

LID Life Cycle Costing Tool (2019)

STEP 4: DESIGN SUMMARY	Value	Units
Drainage Area (DA)	1000	m^2
Native Soil Infiltration Rate	15	mm/hr
Surface Area	66.7	m^2
Design type	artial Infiltratic	unitless
Storage Volume	49.2	m^3

COST SUMMARY		Value
Construction Cost Break Down		
Pre-construction	$	3,519.42
Excavation	$	3,596.44
Materials & Installation	$	24,602.27
Inspections	$	1,698.76
Project mngt, overhead & other	$	3,341.69
Total Construction Cost	$	36,758.58
Life Cycle Totals		
50 Year Evaluation Period		
Present Value of maintenance and rehabilitation	$	37,361.66
Present Value of all costs	$	74,120.24
25 Year evaluation period		
Present Value of maintenance and rehabilitation	$	20,281.12
Present Value of all costs	$	57,039.70
Estimated Retrofit Cost		
Percentage of total cost		16%
Total Construction Cost	$	5,881.37



ion | TableOfContents | Bioretention | EnhancedSwale | VegFilterStrip | GreenRoof | InfiltrationChamber | InfiltrationTrench

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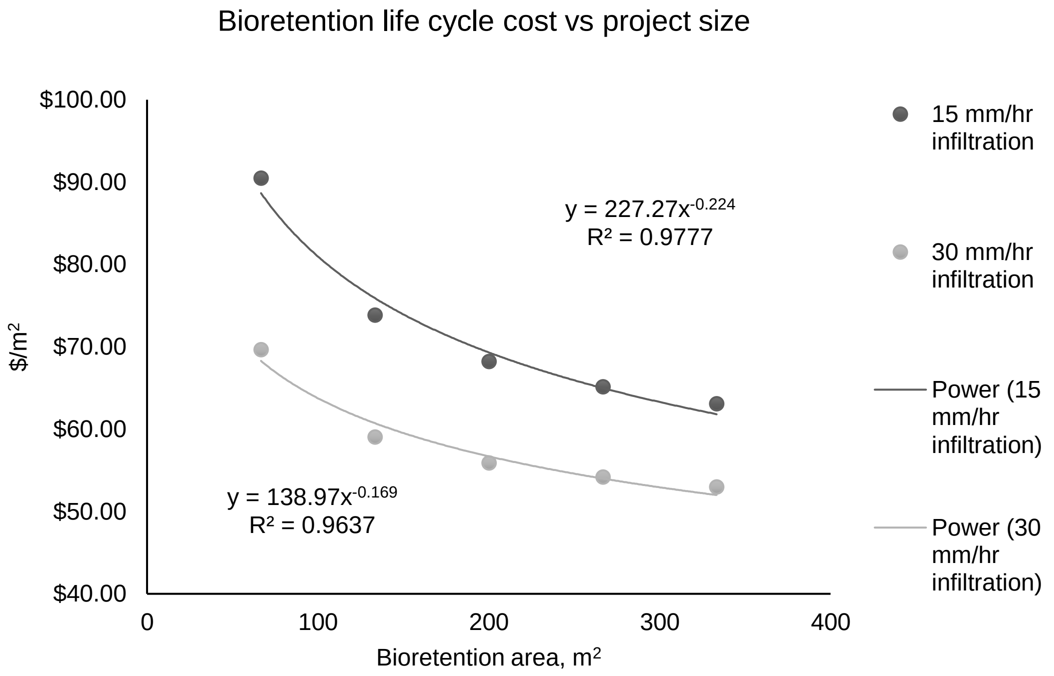
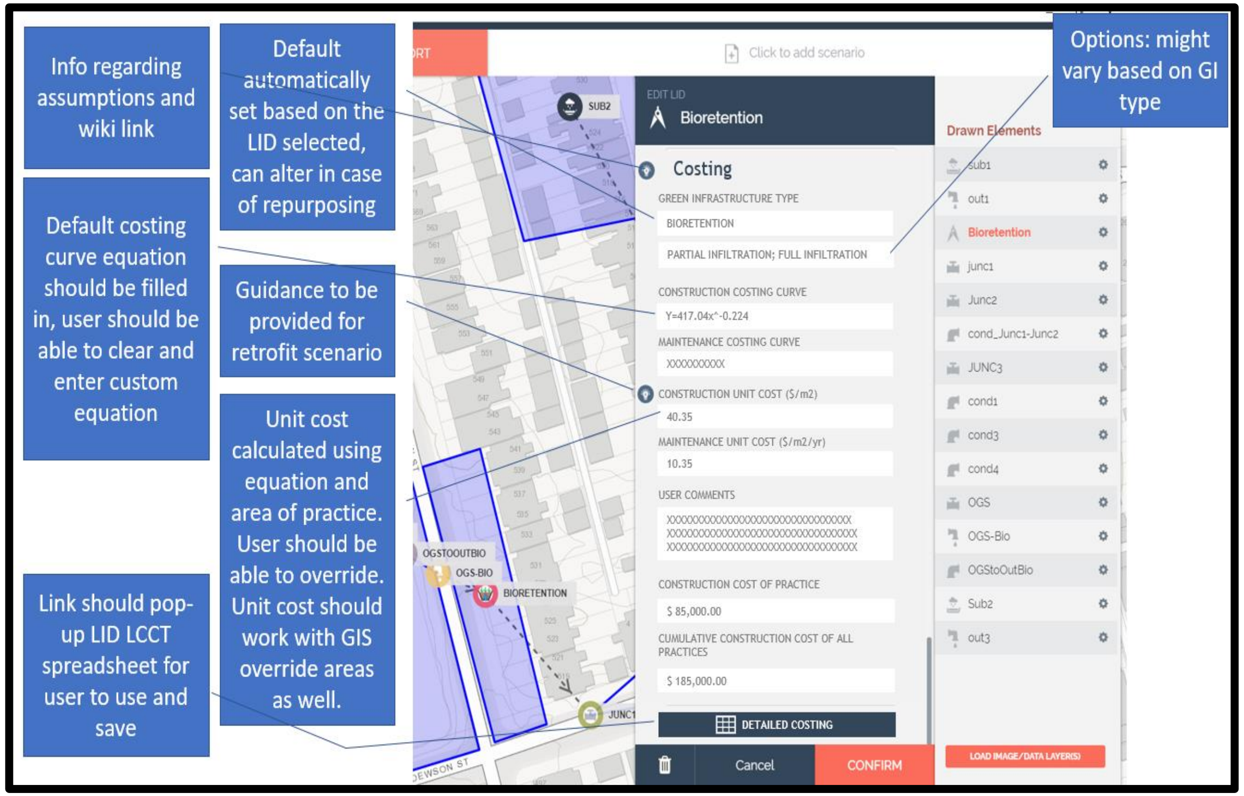


Developments: TTT with Costing Abilities

Look-Up Table

	Element in LID TTT	Options	Construction Cost Equation ($/m2)	Oper./Maint. Cost Equation ($/m2)
LID	Bioretention	No Underdrain With Underdrain	195 + 12328/A 230 + 17020/A	170 + 3038.9/A 170 + 3038.9/A
	Enhanced grass swale		79 + 6292/A	104 + 3554/A
	Vegetated filter strips		59 + 6555/A	90 + 1352/A
	Infiltration chamber	No Underdrain	238 + 12141/A	69 + 5581/A
	Infiltration trench	With Underdrain	321 + 11374/A	156 + 14731/A
	Permeable pavement	No Underdrain With Underdrain	235 + 27088/A 242 + 27088/A	34 + 321/A 45 + 321/A
Storage Node	Wet pond	Enhanced WQ protection	372 + 1543/A	445+ 0.00071/A
	Dry pond	No pre-treatment	178 + 1543/A	45 + 506/A
Junctions	OGS		157419 + 44318/A	Fixed cost: $35,600
New additions to LID TTT	Trees in ground		TBD	TBD
	Trees in soil cells		TBD	TBD

User-Interface



Developments: TTT with Costing Abilities

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	Trees in soil cells		TBD	TBD

Model Results

Table should be designed such that "copy and paste" into excel would maintain structure

Can be filtered by columns: catchment number, green infrastructure type, and default values/user edited; total dynamically sums costs of elements filtered

post-development
debug_2.0.14_outletToCatchment
GIS
Click to add scenario

Peak Flow | debug_2.0.14_outletToCatchment

Loading TSS | debug_2.0.14_outletToCatchment

Loading TP | debug_2.0.14_outletToCatchment

Costing
Evaluation period 25 years

Name	Catchment Number	Green Infrastructure Type	Default Values/User Edited	Construction cost	Annual Average Maintenance cost	25-year Maintenance Cost	Total life-cycle cost (excludes rehab)	Comments
Bioretention1	1	Bioretention		$85,143.34	$1,620.72	$40,518.00	$125,661.00	
Swale1	1	Enhance Swale		$23,029.00	$968.68	$24,217.00	$47,247.00	
Total				xxxx		xxxx	xxxx	

Developments: TTT with Trees

Trees as a new GI/LID Option

Trees are a cost-effective GI with stormwater advantages + co-benefits (habitats, mitigate heat stress)

No other tool provides trees + LID at site scale in the Ontario context

Processes to model:

Canopy Interception

Canopy Drip

Canopy Throughfall

Canopy Evaporation

Soil Infiltration

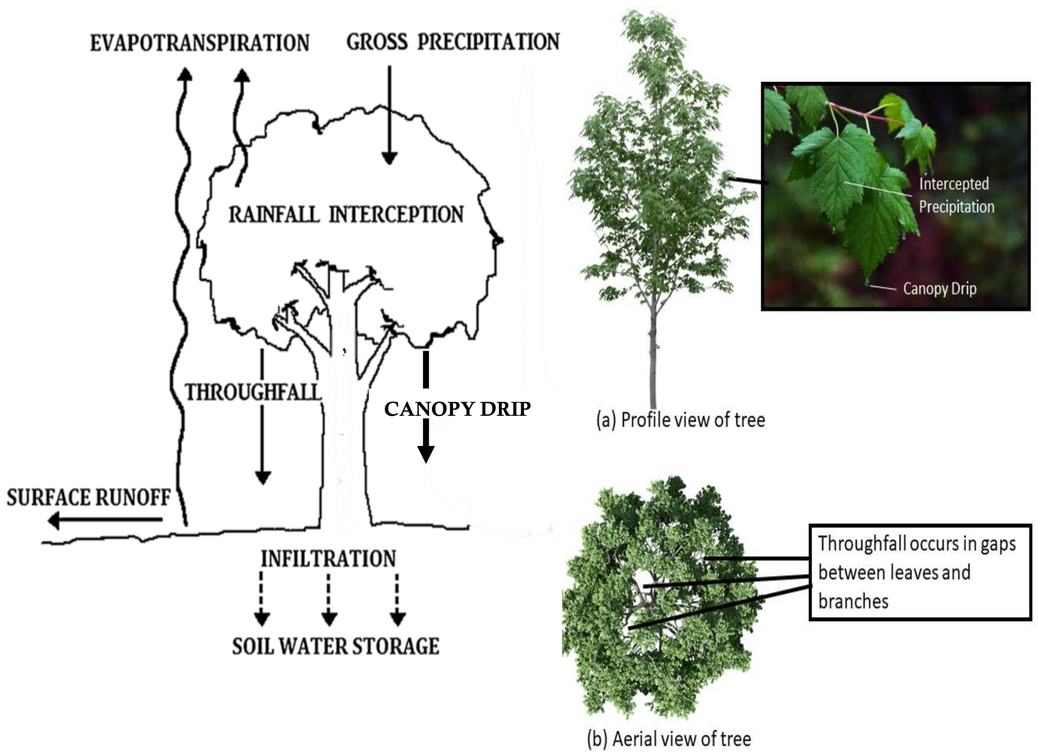
Surface Runoff

Soil /Surface Evaporation

Canopy Processes

Surface/Soil processes

Tree Water Balance



Developments: TTT with Trees

Tree Canopy

Throughfall Area

- The percentage of tree canopy area generating throughfall can be estimated from the equation below (Wang, Endreny, & Nowak, 2008).

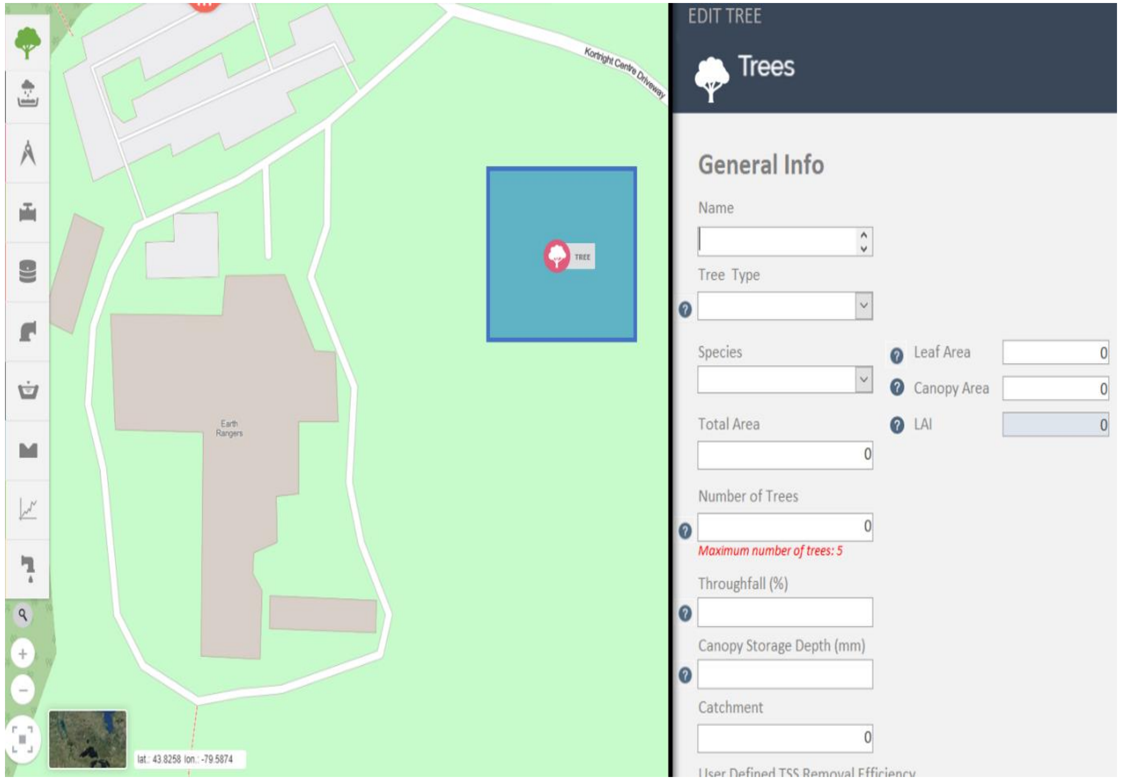
$$\%\,Throughfall = 100(e^{-0.7*LAI})$$

Intercepted Area

- Intercepted precipitation is temporarily stored on leaf surfaces (canopy storage) and eventually evaporated.
- The depth of canopy storage can be estimated using the equation below (Wang, Endreny, & Nowak, 2008).

$$Canopy\ Storage\ Depth\ (mm) = 0.2mm * LAI$$

User Interface



Developments: TTT with Trees

Soil Parameters

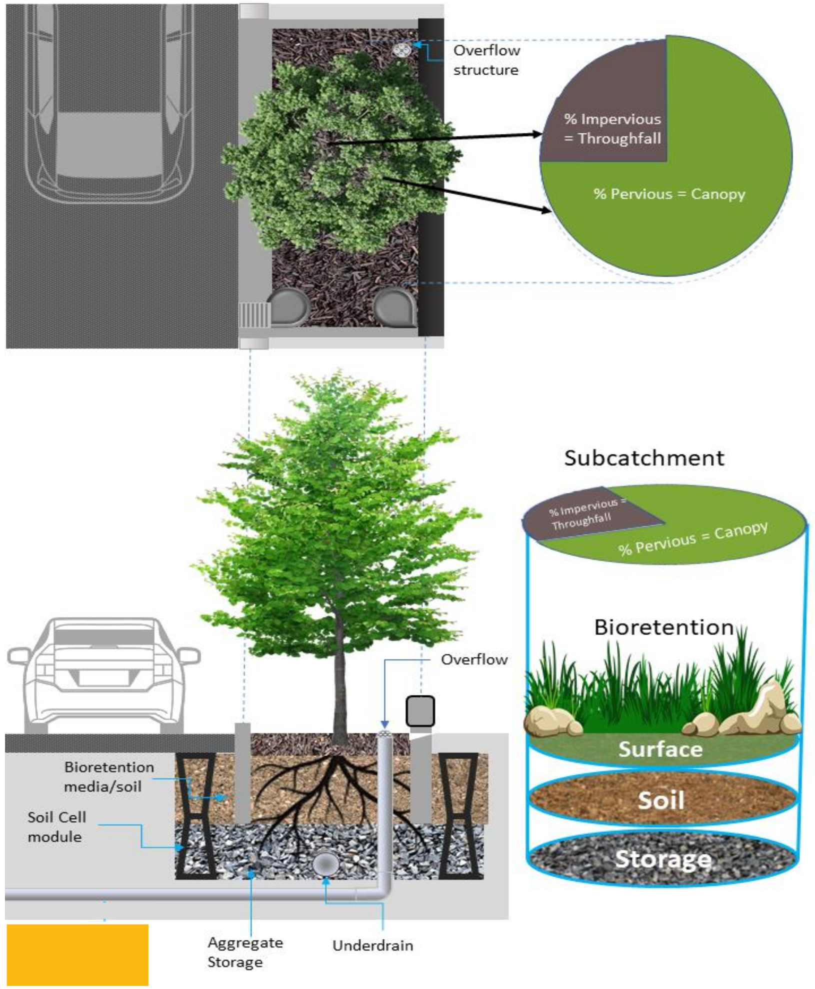
Two types of trees presented:

1. Trees planted in regular soil
2. Trees planted in soil cells

Defaults for surface/soil properties of regularly planted trees based on local guidance (soil type, depth of soil, etc.)

Defaults for soil properties of soil cells similar to bioretention guidance. Additional storage and underdrain functionalities available.

canopy parameters not affected by tree type selected



Developments: TTT with Trees

Model Output

Below the LID Summary in Output screen, table to provide for each tree element the amount:

- Infiltrated
- Runoff
- Evaporated
- Stored (bioretention and in pervious depression storage of the subcatchment)

Tree Element Name	Area (ha) (m^2)	Infiltration (mm) (m^3)	Evapotranspired (mm) (m^3)	Runoff (mm) (m^3)	Stored (mm) (m^3)	Rainfall Reduction (mm) (m^3)

Project Team

Steve Auger – LSRCA
Alana Vandersluis – (LSRCA)
Amanjot Singh – CVC
Sakshi Saini – (CVC)
Tim Van Seters – TRCA
Sahlla Abbasi – TRCA
Yuestas David – TRCA
Wilfred Ho – TRCA

Thank You/ Questions?

Toronto and Region Conservation Authority

Upcoming Lunch and Learns

Tuesday, November 10
11:30am-12:30pm

Latest Flood Plain Mapping Updates

By Wilfred Ho, Christina Bright and Mike Todd

Tuesday, November 17
11:30am-12:30pm

Working with Indigenous Communities

By Tony Morris

Tuesday, December 8
11:00am-12:00pm

Green Infrastructure Asset Management

By Michelle Sawka and Tracy Timmins

Thank you

For questions about the ECS Lunch and Learn Series, please contact:

Sharon Lam
sharon.lam@trca.ca

Toronto and Region Conservation Authority