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APPENDIX B - GREEN INFRASTRUCTURE OPTIONS



# LONG LIST OF GREEN INFRASTRUCTURE OPTIONS

At the outset of this project, the Green Streets Team spent several weeks reviewing precedent manuals and guidelines from across North America to establish a comprehensive list of potential Green Infrastructure options that would be suitable for application in the City of Toronto, given geographical and climatic conditions. The precedent study produced a comprehensive 'Long List' of 40 potential Green Infrastructure options that would be feasible. As part of the long list, each Green Infrastructure option was described and the ancillary benefits of each was outlined. The suitability of each for various applications within Complete Street typologies was also considered. The following matrices set out the long list of Green Infrastructure options.



Green Streets Technical Guidelines

### TORONTO GREEN STREETS GUIDELINE - LONG LIST OF GREEN INFRASTRUCTURE OPTIONS - AIR QUALITY



								Ancillar	y Benefi	its												Suita	ble Stre	et Type	es							
Green Infrastructure / LID Option	Description	Reduced Heat Island Effect	Necapius eu Green Space	Expanded Urban Tree	Canopy Enhanced Aesthetics	SWM Quality	Pollutant Removal	Groundwater Recharge Reduced Stream Channel Erosion	Reduced Flood Risk	Energy Generation Energy Conservation	Reduced Operational Cost	Remote Monitoring	Enhanced Visibility Traffic Calming	Human Comfort - Shade	Reduction in GHG Emissions	Potential Applications	Civic Streets	Downtown & Centres Main Street	Avenues & Neighbourhood Main Street	Mixed-use Accent Street  Downtown & Centres  Residential Street	Apartment Neighbourhood Residential Street	Neighborhood Residential Street (Sub-type - Built Circa Pre Neighborhood Residential	Street (Sub-type - Built Circa Mixed-Use Connector Street	Residential Connector Street	Scenic Street	Park Street Employment Street	Mixed Use Shared Street	Residential Shared Street	Residential Lane	Considerations	Feasibility No / <u>P</u> otential / <u>Y</u> es	Rationale
Q-1 Green Wall	Green walls can provide valuable green infrastructure within confined urban spaces. They															Transit Stops	✓	✓	✓ v	/ /			✓	<b>✓</b>	✓	✓		✓		AQ-1a. Irrigation system required AQ-1b. Ownership / responsibility	N	Considerations AQ-1a - AQ-1c
	vertical modular, composite or custom substate system that is affixed directly to an existing structural wall, known as a 'living wall'. Refer to Toronto's Best Practices Manual for Green Walls for a detailed description of each.	✓ v	<b>/</b>		✓	<b>✓</b>	✓								<b>✓</b>	Bridges	<b>✓</b>	<b>✓</b>	✓ w	/ /	<b>✓</b>	✓ ,	/ /	~	✓	/ /	✓	✓		AQ-1c. Maintenance requirements AQ-1d. Microclimate AQ-1e. Sait / pollutant load	Р	Considerations AQ-1a, AQ-1c &
Q-2 Green Roof	Green roofs are comprised of vegetation planted in growing medium and installed on a concrete								Ш							Transit Stops	✓	✓	✓ v	/ /	Ш		✓	<b>✓</b>	✓	✓		✓		AQ-2a. Load bearing capacity of roof structure AQ-2b. Maintenance	N	Considerations AQ-2b & AQ-2c
	slab or over a conventional roof system. They can provide ecological benefits, reduce heat island effect and can store rainwater in the growing medium. Excess rainwater that is not taken up by plants will either evaporate or will drain away through the drainage system.	✓ V	<b>/</b>		✓	<b>/</b>	✓	✓		<b>✓</b>	✓				<b>~</b>	Rooftop (Underground Garages)	<b>√</b>	✓	✓ v	/ /	<b>√</b>		<b>√</b>	✓				<b>✓</b>		AQ-2c. Ownership / responsibility AQ-2d. Microclimate AQ-2e. Satl / polultant load AQ-2f. Pedestrian load AQ-2g. Application only to streets with strata configuration over a garage	Р	Consideration AQ-2a
Q-3A Street Trees	Street trees help to increase the overall urban forest canopy and can assist in improving air					Н			Н			H			Н	Furnishing / Planting Zone		Н			Н			Н						AQ-3A.a. Available soil volume AQ-3A.b. Soil characteristics		
	quality, reducing the urban heat island effect and providing wildlife habitat. The City prefers large								Ш							Frontage Zones					Ш			Ш						AQ-3A.c. Salt / pollutant load AQ-3A.d. Presence of overhead or underground services		
	canopy native species for street tree planting. Suitable species can be identified using the Vegetation Selection Tool.								Ш							Medians / Raised Islands					Ш			Ш			Ш			AQ-3A.e. Pedestrian load AQ-3A.f. Proximity to natural heritage system AQ-3A.g. Microclimate		
	vegenion delection root.	<b>✓</b>	•	<b>/</b>	<b>✓</b>	<b>\</b>	✓							<b>✓</b>	<b>*</b>		✓	<b>✓</b>	✓ V		<b>V</b>	<b>✓</b>	<b>✓ ✓</b>	<b>\</b>	<b>✓</b> ,	<b>✓</b>	<b>V</b>	✓		AQ-3A.h. Maintenance requirements	Y	
Q-3B Trees in Soil Cell	Soil cell systems can be used when street trees are desirable in locations where surface areas are					П			П						П	Furnishing / Planting Zone	✓	✓	✓	✓	<b>√</b>			Н		<b>✓</b>	<b>√</b>	✓		AQ-3B a. Salt / pollutant load AQ-3B b. Maintenance requirements	Y	
	limited.  Soil cells are rigid modular systems that are used								Ш							Frontage Zones	✓	✓		✓	<b>√</b>			П		✓	<b>√</b>	✓		AQ-3B.c. Underground services AQ-3B.d. Proximity to TTC underground tunnel	Y	
	to increase the soil volume under paved surfaces in ultra-urban areas. Soil cells provide the	_					_		Ш					\ \		Medians / Raised Islands	✓				П			П							Y	
	structural integrity required to support vehicular load on paved surfaces and at the same time some systems offer up to 92% porous space in		ľ						Ш						ľ	Parking Lay-Bys			✓		<b>√</b>			П				✓			Y	
	order to accommodate underground services and utilities.								Ш							Cycling Infrastructure (Separated)	✓	<b>✓</b>	✓					Ш			П				Υ	
	Open tree planters can be used where widths are generous. They are able to accommodate two or								Н							Furnishing / Planting Zone	<b>√</b>	<b>√</b>	<b>✓</b>	<b>√</b>	<b>√</b>			Н				<b>✓</b>		AQ-3C.a. Microclimate AQ-3C.b Salt/pollutant load	Y	
	more trees per planter and can be framed by a								Ш							Frontage Zones	<b>✓</b>	<b>√</b>		<b>✓</b>	Н			Н			Н	<b>✓</b>		AQ-3C.c Overhead / underground services AQ-3C.d Width of sidewalk area	Y	
	are typically the most cost effective way to plant in a hard landscape if space allows, but are not the preferred solution in areas with high pedestrian		~	<b>/</b>	<b>✓</b>		✓		Ш					✓	<b> </b>	Medians / Raised Islands	✓						✓	П							Υ	
	volumes. The soil volume can also be augmented by installing soil cells below the grade of the planter.								Ш												Ш											
Planter	Planter Boxes are available in a variety of forms and materials and can be used as accents or as a					П			П							Furnishing / Planting Zone	✓	✓	✓	✓	П				✓	✓		✓		AQ-3D.a. Operation and maintenance AQ-3D.b. Salt/pollutant load	Y	
	buffer between competing uses. Planted Boxes can enhance biodiversity and improve air quality, but have a limited ability to manage stormwater as								Ш							Frontage Zones	✓	<b>√</b>	✓	<b>✓</b>	П			П		✓	П	<b>✓</b>		-AQ-3D.c. Presence of overhead services AQ-3D.d. Microclimate AQ-3D.e. Salt / pollutant load	Y	
	they only receive direct rainfall and have a limited capacity.	<b>✓</b>	~	<b>/</b>	<b>✓</b>		•		Ш					<b>√</b>		Medians / Raised Islands	✓				П			П		✓				AQ-3D.f. Snow removal / maintenance requirements AQ-3D.g. Underground services		
									Ш							Cycling Infrastructure (Separated)	✓	✓	✓		П			П			П			1	Y	
	Precast tree planters are prefabricated impervious planters filled with bioretention media and equipped with a perforated pipe outlet for filtration					П			П							Furnishing / Planting Zone	✓	✓	✓ v	/	П			П	<b>✓</b> ,	/		✓		AQ-3E.a. Salt / pollutant load AQ-3E.b. Microclimate AQ-3E.c. Snow removal / maintenance requirements	Y	
	and conveyance of direct rainfall. Precast planters are suitable for use throughout urban street types, however they have a limited capacity for	<b>✓</b>	•	/ /	/		✓							<b>✓</b>		Frontage Zones					$\vdash \mid$			$\vdash \vdash$			Н			AQ-3E.d. Underground / overhead services AQ-3E.e. Proximity to TTC underground tunnel	Y	
	volume retention. These planters are highly effective in areas where contaminated soils are present or where a high watertable exists.															Medians / Raised Islands	✓											<b>✓</b>			Y	
Q-4 Photocatalytic Paving	Photocatalytic paving is a surface treatment that has the ability to purify outdoor air by eliminating					Н						1			Н	Vehicle Lanes	✓	✓	✓ v	/ /	<b>√</b>	✓ ,	/ /	<b>√</b>	<b>√</b> ,	/ /	<b>√</b>	✓ <b>∨</b>	/ /	AQ-4a. Still being tested for performance on high occupancy roads	N	Consideration AQ-4a
	nitrogen oxide and other airborne toxins that resul from traffic emissions. When exposed to sunlight a component of the paving material called titanium															On-Street Parking	✓		✓ v	/ /	<b>✓</b>	✓ .	/							1	Р	Consideration AQ-4a
	dioxide reacts with NOx gasses to create non- toxic soluble nitrates that will wash away in the															Cycling Infrastructure	✓	✓	✓		П	✓	<b>✓</b>	<b>✓</b>	<b>√</b> ,	/ /	П			1	Р	Consideration AQ-4a
	rain. Photocatalytic paving is available in concrete or asphalt for road surfaces and concrete stone	✓			✓		✓								<b> </b> ✓	Sidewalks	✓	✓	✓ v	/ /	<b>✓</b>	✓ .	/ /	✓	<b>√</b> ,	/ /	<b>✓</b>	✓		1	Р	Consideration AQ-4a
	for pedestrian walkways, plazas etc. Concrete stones are available in a variety of colours and comes in standard and textured finishes.															Crosswalks	✓	✓	✓ v	/ /	<b>✓</b>	✓ .	/ /	<b>✓</b>	<b>√</b> ,	/ /	<b>✓</b>	✓		1	N	Consideration AQ-4a
	and control of minoros.															Decorative Paving	✓	✓	✓ v	/ /	<b>✓</b>	✓ ,	/ /	<b>✓</b>	<b>√</b> ,	/ /	<b>✓</b>	✓		1	Y	
																Bridges	<b>√</b>	<b>√</b>	✓ v	/ /	<b>√</b>	✓ .	/ /	<b>√</b>	<b>√</b> ,	/ /	<b>√</b>	✓		1	Р	Consideration AQ-4a



### TORONTO GREEN STREETS GUIDELINE LONG LIST OF GREEN INFRASTRUCTURE OPTIONS - GHG & ENERGY EFFICIENCY



Ancillary Benefits  Suitable Street Types  Green Infrastructure / Description  Ancillary Benefits  Suitable Street Types  Proposition  Proposition  Ancillary Benefits  Suitable Street Types  Proposition  Suitable Street Types  Proposition  Proposition  Proposition  Ancillary Benefits  Suitable Street Types  Proposition  Proposition  Proposition  Feasibility  Feasibil	
Reduced Heart Island Recaptured Green Sp. Promote Habitat / Biologyment Street Canopy Conformation Commons & Centre Canopy Conformation Commons & Centre Canopy Traffic Calming Frenced Street Conformation Commons & Centre Canopy Frenced Street Frenced Street Frenced Street Frenced Operational Reduced Operational Residential Street Avenues & Neighbor Operational Reduced Operational Red	
GHG-1 LED Lighting LED (light emitting diodes) lights represent the latest in lighting technology. They are long lasting	
(30,000-60,000 hours) and are extremely energy efficient (up to 90% more efficient then conventional incandescent toulos). In addition,	
they generate very little heat and are made of non toxic materials that can be recycled. LEDs provide superior visibility with more even light dispersion and can reduce light pollution through appropriate fixture choices and targeted placement.	Considerations GHG-1a & GHG-1b
GHG-2 Solar Photovoltaic Panel Photovoltaic (PV) panels are used to harness sunlight and convert it to usable energy. Solar	
units can be used to power streetlights and parking meters, to illuminate transit stops and as decorative paving. They provide considerable GHG-2a. Which considerable GHG-2a Which considerable GHG-2a Which considerable GHG-2a. Presence of overhead or underground services    N	Considerations GHG-2a & GHG-2b
benefits over conventional grid-powered systems including energy efficiency, location flexibility and	
wireless monitoring capability.	Considerations GHG-2a & GHG-2b
Vehicle Charging Stations V V V V V V V V V V V V V V V V V V V	Consideration GHG-2b
Decorative Paving V V V V V V	Consideration GHG-2a
GHG-3 Solar Roads Solar roads comprise a modular system of photovoltaic panels designed to convert sunlight Network of GHG-3a. Presence of underground services N	Consideration GHG-3d
to usable energy. They are engineered to be an all-in-one product that will eliminate requirements of roreal surfaces.  GHG-3a Contain heated elements to prevent snow and ice accumulation in winter GHG-3d Not yet approved for road surfaces for resurfacing, repainting and even winter	Consideration GHG-3e
maintenance. LED lights are embedded within the panels to allow for lane markings, turning arrows,	Consideration GHG-3e
HOV, cycling infrastructure or any other type of marking. These markings are illuminated on the surface of the panels as required.  Crosswalks	Consideration GHG-3e
Saliable of the parties as required.  On-Street Parking	Consideration GHG-3e
GHG-4 Solar Paver Lighting Solar-powered LED paver lights are designed to withstand most vehicle traffic and are durable Neighbor 1.00 Neighbo	Considerations GHG-4a & GHG-4b
under harsh winter conditions. Each unit is self- contained and comes equipped with its own solar  Cycling Infrastructure (Separated)   Cycling Infrastructure	Considerations GHG-4a & GHG-4b
cells that charge an internal battery. A light sensor is included to activate and deactivate the LED lights at dusk and dawn.	Considerations GHG-4a & GHG-4b
Crosswalks V V V V V V V V V V V V P	Considerations GHG-4a & GHG-4b
GHG-5 Photo-luminescent Road Marking a paint product that has an embedded Photoluminescent a paint product that pai	Consideration GHG-5b
photoluminescent powder. The paint absorbs sunlight during the day and then emits a green Cycling Infrastructure VVVVVVVVVVVVVVVVVVVVVVVVVVVVVVVVVVVV	
glow at night that lasts up to 10 hours. It has been used effectively for road markings in Europe  Crosswalks  V V V V V V V V V V V V V V V V V V V	
GHG-6 Wind Energy Small-scale wind turbines can be highly versatile and can provide a renewable energy source.  Street Lights V V V V V V V V V GHG-6a. Operation and maintenance GHG-6b. Ownership / responsibility	Considerations GHG-6a & GHG-6b
Wind turbines are recommended as a sustainable option to power street lights.  Wind turbines are recommended as a sustainable option to power street lights.  GHG-6c. Presence of overhead services or tree canopy GHG-6d. Availability of consistent wind  N	Considerations GHG-6a & GHG-6b
GHG-7 Cool Pavements Pavement with higher solar reflectivity reduces local heat island effects and reduces the heat	
transferred to sformwater thereby improving water quality. The Toronto Green Standard tier 2 and LEED support an SRI of at least 29 for at	
least 75% of hardscapes.	
Curbside Spaces	
Vehicle Lanes	
Transit Lanes V V	
Medians / Raised Islands	
On-Street Parking	
Parking Lay-Bys V V V V	
Cycling Infrastructure (Separated)	
Crosswalks	
Intersections V V V V V V V V V V V V V V V V V V V	
Transit Stops V V V V V	
Decorative Paving	





							Anc	illary B	enefits												Sı	uitable	Street '	Types							
Green Infrastructure / LID Option	Description	Reduced Heat Island Effect	Promote Habitat / Biodiversity	Expanded Urban Tree Canopy	Enhanced Aesthetics	SWM Quality Pollutant Removal	Groundwater Recharge	Reduced Stream Channel Erosion	Reduced Flood Risk Energy Generation	Energy Conservation	Reduced Operational Cost	Remote Monitoring	Ennanced Visibility Traffic Calming	Human Comfort - Shade	Reduction in GHG Emissions	Potential Applications	Civic Streets	Downtown & Centres Main Street Avenues & Neighbourhood	Main Street Mixed-Use Accent Street	Downtown & Centres Residential Street Apartment Neighbourhood	Residential Street Neighborhood Residential Street (Sub-type - Built Circa	Neighborhood Residential Street (Sub-type - Built Circa	Mixed-Use Connector Street	Kesidential Connector Street	Park Street	Employment Street	Mixed Use Shared Street	Kesidential Shared Street Mixed-Use Lane		easibility / <u>P</u> otential / <u>Y</u> es	Rationale
WQ-1 Bioretention Planter	Bioretention is a Low Impact Development (LID) practice that is designed to provide temporary															Furnishing / Planting Zone	✓	<b>√</b> ,	<b>✓</b>	✓	/		✓				v	/	WQ-1a. Optimal for soils with high infiltrations rates. Where rates are < 15 mm/hr an underdrain is required	Υ	
	storage, filtration and infiltration of stormwater runoff. Although the physical design of a bioretention facility can vary, the construction profile generally consists of the following: a gravel storage layer, a choker layer (optional), a bioretention media layer, a mulch layer and a vegetation layers. The physical form of bioretention practices can vary to provide a complementary aesthetic within any street typology from the rural to the ultra-urban contexts. Types of bioretention facilities include: Bioretention Planters, Bioretention/Stormwater Curb Extensions/Bump-outs, Bioretention Cells, and Rain Gardens.  Bioretention Planters are constructed structures with vertical sidewalls. They are often narrow and rectangular in shape and can be installed in close proximity to utilities, driveways, trees, light standards and other street features. Bioretention storeters are constructed structures with vertical sidewalls.	✓ V	<b>✓</b>	~	< v	/ •	<b>✓</b>	< ·	•					<b>✓</b>	✓	Medians / Raised Islands Cycling Infrastructure Bridges		✓ ×		✓ <b>、</b>			✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓						WQ-1b. Ponding time < 24hr after storm event WQ-1c. Presence and location of overhead and underground servicing WQ-1c. Located within two (2) year time-of-travel wellhead protection area WQ-1f. Contributing slopes should be between 1-5% WQ-1g. If an under drain is used, then 1-15 melevation difference is needed between inflow and downstream stormdrain invert WQ-1h. Min. one (1) metre separating seasonal high water table or top of bedrock elevation and the bottom of the practice WQ-1i, Max. recommended contributing drainage area is 0.8 hectares WQ-1j. Runoff from pollution hot spots should not be treated by bioretention facilities designed for full or partial infiltration WQ-1k. If impermeable liner is used, then no setback is required from a building. If not, a four (4) metre setback from building foundations WQ-1l. Salt / pollutant load WQ-1m. Pedestrian load WQ-1m. Snow removal / maintenance requirements WQ-1q. Underground services WQ-1p. Proximity to TTC underground tunnel WQ-1q. Conflict with traffic	Y N Y	Consideration WQ-1q
	Planters receive road runoff through curb inlets and overland flows from the surrounding sidewalk and other paved surfaces.			Ш																		Ш									
WQ-2 Stormwater Planter	Stormwater Planters are similar to Bioretention Planters in their form and function, however Stormwater Planters are designed to receive	✓ <b>∨</b>	/ /	<b>\</b>	✓ v	/ /	<b>\</b>	✓ ,	<b>√</b>					✓	_	Frontage Zones		✓		✓		П				✓	٧	/	WQ-2a. Refer to Considerations of the "Bioretention Planter" above	Υ	
	runoff from downspouts and surrounding sidewalks.															Bridges	✓	<b>√</b> ,	<b>✓</b>	<b>√</b> \		Ш								Υ	
WQ-3 Bioretention Curb Extension /Bump-Out	Bioretention Curb Extensions and Bump-outs have the same bioretention function as above, but are positioned as buffers at various locations														١.	Intersections	✓	<b>√</b> ,	<b>✓ ✓</b>										WQ-3a. Refer to Considerations of the "Bioretention Planter" above WQ-3b. Can be installed as new construction or retrofit installation WQ-3c. Ownership / responsibility	Υ	
H	throughout a block and can provide traffic calming effects.	<b>✓</b>   <b>∨</b>		<b> </b> •	<b>V</b>			·	<b>/</b>				<b>-</b>		<b>-</b>	Mid-block				<b>√</b> \		<b>V</b>								Y	
WQ-4 Bioretention	Bioretention cells provide a design variation that is															Transit stops					<b>/ /</b>								WQ-4a. Refer to Considerations of the "Bioretention Planter" above	Р	Consideration WQ-3c
R-QUALITY, QUANTITY GUANTITY CEIL	suitable for more suburban street types such as Residential Neighborhood or Connector Neighborhood streets, within Furnishing / Planting Zones' or 'Medians' where space is not as constrained. This form of bioretention often receives overland flows from the surrounding landscape and from the roadway through curb cut inlets.		/ /	<b>✓</b>	✓ w	<b>✓</b>	<b>✓</b>	✓ ,	<b>~</b>					✓	~	Furnishing / Planting Zone  Medians / Raised Islands				<b>✓</b> ,		Н			/				WQ-4b. Can be installed as new construction or retrofit installation	Y	
WQ-5 Rain Garden	Rain gardens are sunken planting beds constructed of highly permeable nutrient rich soils They can include an engineered soil layer and overflow structure to increase their stormwater management performance. Rain gardens should always be designed to drain efficiently after a storm event to avoid creating areas of standing water where mosquitoes can breed.		<b>✓</b>		✓ <b>∨</b>	/ /	<b>✓</b>	✓ ,	<b>~</b>					<b>✓</b>		Furnishing / Planting Zone  Medians / Raised Islands						✓ ✓							WQ-5a. Salt / pollutant load WQ-5b. Microclimate WQ-5c. Snow removal / maintenance requirements WQ-5d. Underground / overhead services WQ-5e. Proximity to TTC underground tunnel	P P	Considerations WQ-5d & 5e  Considerations WQ-5d & 5e
WQ-6 Enhanced Grass Swale	grass swales, however they feature a slightly															Furnishing / Planting Zone					<b>✓</b>	<b>√</b>	✓ ,	/ v	/ /	✓	-		WQ-6a. Requires 5 to 15% of contributing drainage area and min. 2 m width WQ-6b. Longitudinal slopes 0.5 - 6%, slopes > 3% require check dams	Υ	
	altered parabolic form and incorporate amended soils that slow runoff and assist in contaminant removal. Enhanced grass swales can serve as a															Medians / Raised Islands					✓	<b>√</b>	✓ ,	/ v	/ /	<b>✓</b>			WQ-6c. Conveyance capacity should match drainage area. Impervious drainage area to treatment facility area ratio = 5:1 to 10:1 WQ-6d. Highly contaminated source areas for runoff should not be treated by enhances grass swales	Υ	
WO 7 Ricourts (Day Synty I	pretreatment option for infiltration practices, particularly on low traffic volume roadways that do not receive high loads of de-lcing compounds in the winter. Check dams can be integrated into the design in order to maximize infiltration benefits.		<b>✓</b>		<b>✓ ∨</b>	<b>✓</b>	<b>✓</b>	< ·	<b>~</b>						<b>✓</b>	Bridges				✓ ,									WQ-6e. Utilities parallel should be offset from the swale centerline. Underground utilities below the bottom of the swale are a concern WQ-6f. Min. 1m separation between the bottom of swale and seasonal high water table or top of bedrock elevation WQ-6g. Min. 4m offset from building foundations WQ-6g. Min. 4m offset from building foundations WQ-6i. Salt / pollutant load WQ-6i. Pedestrian load WQ-6i. Proximity of word / maintenance requirements WQ-6i. Underground services WQ-6l. Proximity to TTC underground tunnel	Y	
WQ-7 Bioswale / Dry Swale / Infiltration Trench	Bioswales are similar to enhanced grass swales in their linear and cross-sectional surface geometry, however their subsurface profile is more reflective of a bioretention cell, with filter media and/or a storage gallery and optional underdrain (depending native soil permeability) below. Bioswales can either be planted with grasses or finished with more elaborate combinations of plan and aggregate materials. These additional components help to slow the velocity of runoff and assist in sedimentation, filtration assist in sedimentation, filtration evapotranspiration and infiltration. As a result of their bioretention profile, bioswales have the potential to be more effective at removing pollutants, reducing runoff and protecting downstream channels from erosion then enhanced grass swales. Bioswales are also referred to as dry swales or infiltration swales.		<b>✓</b>	<b>✓</b>	✓ <b>∨</b>	/ /	~	✓ ,							~	Furnishing / Planting Zone  Medians / Raised Islands  Bridges	✓ ✓	< ,		✓ ·	✓	✓ ✓	✓ ,	/ v	/ /	<b>✓</b>	√ <b>,</b>		WQ-7a. Requires 5 to 15% of contributing drainage area and >5m swale length between culverts WQ-7b. Longitudinal slopes 0.5 - 4%, 6% max. Slopes > 3% require check dams WQ-7b. C. Treat drainage areas of <2 hectares or less. Impervious drainage area to treatment facility area ratio = 5.1 to 15.1  WQ-7d. Located over any soil type, but hydrologic soil group A and B soils are best for achieving water balance benefits. WQ-5e. Located in portions of the site with the highest native soil infiltration rates. Where infiltration rates are less than 15 mm/hr an under drain is required.  WQ-7f. Facilities receiving road or parking lot runoff should not be located within 2 year time-of-travel wellhead protection area.  WQ-7g. Min. I'm separation between the bottom of swale and seasonal high water table or top of bedrock elevation.  WQ-7h. Min. 4m offset from building foundations  WQ-7i. Runoff from pollution hot spots should not be treated in bioswales designed for full or partial infiltration. Facilities designed with an impermeable liner (filtration only facilities) can be used to treat runoff from pollution hot spots.  WQ-7k. Salt / pollutant load  WQ-7h. Solt / pollutant load  WQ-7h. Sonv removal / maintenance requirements	Y	





								And	illary	Benefit	ts													Suit	able St	treet "	Types									
Green Infrastructure / LID Option	Description	Reduced Heat Island Effect Recaptured Green Space	Promote Habitat / Biodiversity	Expanded Urban Tree Canopy	Enhanced Aesthetics	SWM Quality	Pollutant Removal	Groundwater Recharge	Reduced Stream Channel Frosion	Reduced Flood Risk	Energy Generation	Energy Conservation	Remote Monitoring	Enhanced Visibility	Traffic Calming	Human Comfort - Shade	Paduction in OHO Enissions  Potential Application	ns	Civic Streets  Downtown & Centres  Main Street	Avenues & Neighbourhood	Mixed-Use Accent Street	Oowntown & Centres Residential Street	Apartment Neighbourhood Residential Street	Neighborhood Residential street (Sub-type - Built Circa Maighborhood Besidential	veginormou residental street (Sub-type - Built Circa	Mixed-Use Connector Street	Residential Connector Street	Scenic Street	Employment Street	Mixed Use Shared Street	Residential Shared Street	Mixed-Use Lane Residential Lane	Residential Lane	Considerations	Feasibility № / <u>P</u> otential / <u>Y</u> es	Rationale
WQ-8 Bioswale with Stone Well	Bioswales with stone wells provide a formal aesthetic that can be integrated into urban street types such as Civic and Main streets. They feature the longitudinal surface geometry and subsurface profile of a bioswale, but also include stone filled wells (min. 300mm dia.) installed at equidistant spacing along the length of the bioswale to draw stormwater into highly permeable (>15mm/hr) native subsoils more efficiently. This type of bioswale can also be fitted with curb outlets to direct oveflows downstream to an existing catch basin. A variation on this design can also include a stormwater inlet at the upstream end that funnels runoff directly to the stone layer of the cell.	<b>→</b>	~		✓	<b>√</b>		<b>✓</b>	✓	<b>✓</b>							Furnishing / Planting Zone  Medians / Raised Islands  Bridges		\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	✓	,		√ ·	2 0, 2	,	/ ,	/ v	/ v					WQ- WQ- WQ- WQ- WQ- WQ-	8a. Operation and maintenance 8b. Stone columns require min 5' penetration into permeable soil layer 8c. Soil permeability 8c. Soil permeability 8d. Presence of underground utilities 8e. Salt / pollutant load 8f. Pedestrian load 8g. Snow removal / maintenance requirements 8h. Underground services 8l. Proximity to TTC underground tunnel	Y	
WQ-9 Green Gutter	Green gutters are shallow planters that extend the full length of a street section which may			H													Transit Lanes		/ /	<b>✓</b>			1		,	/ ,	/			Н				9a. Operation and maintenance 9b. Ownership / responsibility	Р	Considerations WQ-9a & WQ-9b
	incorporate breaks at intervals to accommodate pedestrian movement. Green gutters can be																Curbside Space		/ /	<b>✓</b>			1				~	/ •	/				WQ-	9c. Cannot be used at transit stop locations due to pedestrian traffic; 9d. Relatively new and unproven technology. 9e. Salf / politant load	Р	Considerations WQ-9a, 9d & 9f
	installed as separation between conflicting uses such as between cycling infrastructure and vehicle lanes within street types where space allows. They can also be installed as GI within dedicated LRT lanes. Green gutters are typically planted with low-growing grasses or sedums and are designed to attenuate, filter and infiltrate stormwater runoff.	<b>✓</b> ✓	<b>✓</b>		<b>✓</b>	<b>✓</b>	✓	<b>✓</b>	✓	<b>✓</b>		ı					<b>✓</b>																WQ-	99. Snow removal / maintenance requirements 99. Underground services		
WQ-10 Filter Strip / Buffer Strip	Filter strips are gently-sloping, heavily-vegetated areas that treat runoff from adjacent impervious surfaces including roadways, sidewalks and driveways. They can be stand-alone stormwater management practices or they can function as pretreatment for other infiltration practices. Filter strips are well-suited to streets with a suburban cross-section or connector streets where no curbs presently exist.  Filter strips should be planted with native material in order to provide maximum ecological and water quality benefits. In the winter months, these areas are well-suited to provide snow storage capacity as they have an excellent capability to filter and infiltrate snow melt in the spring. Filter strips are also referred to as buffer strips.	<b>✓</b>	✓	•	<b>✓</b>	<b>✓</b>	✓	<b>√</b>	<b>✓</b>	<b>✓</b>						✓	Furnishing / Planting Zone								•	,							WQ- WQ- WQ- WQ- WQ- WQ- WQ- WQ- WQ-	<ul> <li>10a. The flow path across the vegetated filter strip should be min. 5m to provide substantial water quality benefits. Vegetated filter strips incorporated as pre-treatment to another BMP may be designed with shorter flow path lengths</li> <li>10b. Filter strips are best used to treat runoff from ground-level impervious surfaces that generate sheet flow (e.g., roads and parking areas). Recommended filter strip slope is 1% - 5%</li> <li>10c. Max. flow path length across a contributing impermeable surface should be &lt; 25m</li> <li>10c. Max. flow path length across a contributing impermeable surface should be &lt; 25m</li> <li>10c. Filter strips are suitable on all soil types. If soils are highly compacted, or of such low fertility that vegetation cannot become established, they should be tilled to a depth of 300 mm and amended with compost to achieve an organic content of 8%- 15% by weight or 30%- 40% by volume</li> <li>10e. Facilities receiving road or parking lot runoff should not be located within 2 year time-oftravel wellhead protection area</li> <li>10f. Min. 1m separation between the bottom of swale and seasonal high water table or top of bedrock elevation</li> <li>10g. Runoff from pollution hot spots should not be treated by filter strips</li> <li>10h. Salt / pollutant load</li> <li>10i. Snow removal / maintenance requirements</li> <li>10j. Underground / overhead services</li> <li>10k. Proximity to TTC underground tunnel</li> </ul>	P	Consideration WQ-10i
WQ-11 Drainage Well	Drainage wells are vertical perforated pipes that are installed under the surface of a roadway and																Furnishing / Planting Zone		/ /											<b>√</b>			WQ-	.11a. Operation and maintenance .11b. Min. 600mm separation between bottom of well and seasonal high ground water & min.	Y	
	gradually allow stormwater to discharge into the surrounding native soils. They are connected to inlets along the street and because they treat roadway runoff, a pretreatment system is required. Due to their relatively small surface footprint, frainage wells can easily be implemented throughout a variety of street types including ultra-urban contexts, in both new construction and retrofit scenarios. Care must be taken throughout the design and construction processes to ensure that there are no conflicts with existing utilities in retrofit scenarios.					<b>✓</b>		<b>✓</b>	✓	<b>✓</b>							Vehicle Lanes		/ /	<b>√</b>	✓	<b>✓</b>	<b>√</b>	<b>√</b>	√ <b>v</b>	,	V V	/ w		<b>√</b>	<b>√</b>	√	WQ- WQ- WQ-	1m clearance to bedrock  11c. Min 6m between well and building foundation  11d. Must be designed in combination with pre-treatment system.  11e. Maintenance requirements  11f. Underground services  11g. Proximity to TTC underground tunnel		
WQ-12 Perforated Pipe	Perforated Pipe Systems is an underground infilirations system that is connected to catch beginning the state of the state																Vehicle Lanes		/ /	<b>✓</b>	<b>✓</b>	<b>✓</b>	✓	<b>✓</b>	✓ <b>,</b>	/ ,	/ v	/ v	/ /	<b>✓</b>	✓	✓ <b>∨</b>	✓ WQ- WQ-	.12a. Designed with an impervious drainage area ratio of 5:1 to 10:1  12b. Perforated pipe systems can be located over any soil type, but hydrologic soil group A  12c. Perforated pipe systems can be located over any soil type, but hydrologic soil group A	P	Considerations WQ-12i & WQ-12j
	basins installed within vehicle lanes or planting zones. This type of system receives runoff from sidewalks, driveways and roadways. The system itself consists of perforated pipes that are installed horizontally along a gently-sloping subsurface trench that is filled with granular and wrapped in geotextile fabric. They can be used in place of, or as a complement to, conventional pipe systems. Due to their relatively small surface footprint, perforated pipe systems can be implemented in almost any street type. However, because of the many constraints inherent to the retrofit scenario, perforated pipe systems are ideally-suited to new construction projects.					<b>✓</b>		<b>✓</b>	✓	✓							Furnishing / Planting Zone			<b>✓</b>	✓ ✓	<b>✓</b>	✓	<b>✓</b>	✓ <b>∨</b>	,	✓ w	/ <b>*</b>		✓ I	<b>✓</b>		WQ- WQ- WQ- WQ- WQ- WQ-	and B soils are best for achieving water balance benefits. Facilities should be located in portions of the site with the highest native soil infiltration rates 12c. Facilities receiving road or parking lot runoff should not be located within 2 year time-of-travel wellhead protection area 12d. Min. I'm separation between the bottom of swale and seasonal high water table or top of bedrock elevation 12e. Min. 4m offset from building foundations 12f. Runoff from pollution hot spots should not be treated by perforated pipe systems 12g. Salt / pollutant load 12h. Maintenance requirements 12i. Underground services 12j. Proximity to TTC underground tunnel		



				Ancillary	Benefits	;									Suitab	le Street T	ypes						
Green Infrastructure / LID Option	Description	Seducad Heat Island Effect Recaptured Green Space Floronic Habitat / Biodiversity Canopy	Enhanced Aesthetics SWM Quality Pollutant Removal	Sroundwater Recharge Reduced Stream Channel Erosion	Reduced Flood Risk	Energy Conservation	Cost Remote Monitoring	Enhanced Visibility Traffic Calming	Human Comfort - Shade Reduction in GHG	Potential Applications	Civic Streets	Main Street Wenues & Neighbourhood	Mixed-Use Accent Street	treet kpartment Neighbourhood tesidential Street	Sub-type - Built Circa Pre-1950)  Veighborhood Residential Street	Mixed-Use Connector Street	Scenic Street	Park Street Employment Street	Mixed Use Shared Street Residential Shared Street	Mixed-Use Lane	Considerations  Considerations	Feasibility	
VQ-13 Soakaway	Soakaways are rectangular excavations, lined with geotextile and filled with clear stone created									Vehicle Lanes										<b>√</b>	WQ-13a. Designed with an impervious drainage area ratio of 5:1 to 20:1. Max. ratio of 10:1 is recommended for facilities receiving road or parking lot runoff	Р	Considerations WQ-13i & WQ-
	under a hard or a soft landscape area. They receive, attenuate and infiltrate runoff from									Furnishing / Planting Zones					<b>√</b> ✓	√ v	/ /	<b>√</b> ✓	✓ ✓		WQ-13b. Soakaways, infiltration trenches and infiltration chambers can be constructed over any soil type, but hydrologic soil group A or B soils are best for achieving water balance and	Р	Considerations WQ-13i & WQ
	sidewalks and other paved surfaces and are ideally-suited for application within the planting zones of residential streets or under low volume									Bridges					<b>√</b> ✓	√ v	/ /	<b>✓</b> ✓	✓ ✓		channel erosion control objectives. Facilities should be located in portions of the site with the highest native soil infiltration rates  WQ-13c. Facilities receiving road or parking lot runoff should not be located within 2 year time-of-	Р	Considerations WQ-13i & W0
	vehicle lanes (i.e. multi-use or residential lanes). Soakaways are also referred to as infiltration galleries, dry wells or soakaway pits.		<b>✓ ✓</b>	<b>✓</b> ✓	<b>✓</b>	I	ı														travel wellhead protection area; WQ-13d. Min. 1m separation between the bottom of swale and seasonal high water table or top of bedrock elevation; WQ-13e. Min. 4m offset from boulding foundations WQ-13f. Runoff from pollution hot spots should not be treated soakaways, infiltration trenches or infiltration chambers WQ-13g. Salt / pollutant load WQ-13h. Maintenance requirements WQ-13l. Underground services WQ-13j. Proximity to TTC underground tunnel		
Q-14 Infiltration Trench /	Infiltration trenches are a design variation of a soakaway that consists of a linear trench lined									Vehicle Lanes										<b>√</b>	WQ-14a. Designed with an impervious drainage area ratio of 5:1 to 20:1. Max. ratio of 10:1 is recommended for facilities receiving road or parking lot runoff	Р	Considerations WQ-14i & W
	with geotextile fabric and filled with clear granular stone. Infiltration trenches are well-suited for areas where space is limited to a narrow strip									Furnishing / Planting Zones					<b>√</b> ✓	√ v	/ /	<b>√</b> ✓	✓ ✓		WQ-14b. Soakaways, infiltration trenches and infiltration chambers can be constructed over any soil type, but hydrologic soil group A or B soils are best for achieving water balance and channel erosion control objectives. Facilities should be located in portions of the site with	Р	Considerations WQ-14i & W
	including medians, planting zones or low volume vehicle lanes (i.e. multi-use or residential lanes).									Cycling Infrastructure	✓ .	/ v	/		<b>✓</b>	✓ v	/ /	<b>√</b> ✓			the highest native soil infiltration rates  WQ-14c. Facilities receiving road or parking lot runoff should not be located within 2 year time-of-	Р	Considerations WQ-14i & V
	They can be covered with stone, vegetation or paving depending on context. Infiltration trenches		<b>✓</b> ✓	✓ <b>✓</b>	<b> </b>					On-Street Parking		~	/ /	<b>√</b>	<b>√</b> ✓						travel wellhead protection area WQ-14d. Min. 1m separation between the bottom of swale and seasonal high water table or top of	Р	Considerations WQ-14i & V
	are also referred to as linear infiltration galleries of linear soakaways.									Parking Lay-Bys				✓	<b>√</b> ✓						bedrock elevation WQ-14e. Min. 4m offset from building foundations WQ-14f. Runoff from pollution hot spots should not be treated soakaways, infiltration trenches or	Р	Considerations WQ-14i & \
										Bridges					<b>√</b> ✓	√ v	/ /	<b>√</b> ✓			infiltration chambers WQ-14g. Salt / pollutant load	Р	Considerations WQ-14i & V
										Medians / Raised Islands						✓ v	/	✓		П	WQ-14h. Snow removal / maintenance requirements WQ-14i. Underground / overhead services WQ-14i. Proximity to TTC underground tunnel	Р	Considerations WQ-14i & V
Q-15 Infiltration Chamber (Oil & grit separator,	Infiltration chambers are another design variation on soakaways that incorporate prefabricated									Vehicle Lanes										<b>√</b>	WQ-15a. Designed with an impervious drainage area ratio of 5:1 to 20:1. Max. ratio of 10:1 is recommended for facilities receiving road or parking lot runoff	Р	Considerations WQ-15i & V
sedimentation chamber or goss trap)	modular chambers that are installed under medians, planting zones or low volume vehicle									Furnishing / Planting Zones					<b>√</b> ✓	√ v	/ /	<b>√</b> ✓	✓ ✓		WQ-15b. Soakaways, infiltration trenches and infiltration chambers can be constructed over any soil type, but hydrologic soil group A or B soils are best for achieving water balance and	Р	Considerations WQ-15i & V
	lanes (i.e. multi-use or residential lanes) to store runoff temporarily before infiltrating it into the underlying native soils. The chambers typically									Cycling Infrastructure	✓ .	/ v	/		<b>√</b>	✓ v	/ /	<b>√ √</b>			channel erosion control objectives. Facilities should be located in portions of the site with the highest native soil infiltration rates  WQ-15c. Facilities receiving road or parking lot runoff should not be located within 2 year time-of-	Р	Considerations WQ-15i & V
	have an open bottom and perforated side walls and are usually placed over a stone reservoir.		<b>✓</b> ✓	✓ <b>✓</b>	<b>/</b>					On-Street Parking		~	/ /	<b>√</b>	<b>√</b> ✓	-					travel wellhead protection area WQ-15d. Min. 1m separation between the bottom of swale and seasonal high water table or top of	Р	Considerations WQ-15i &
	They can be installed individually or in series depending on available space. Infiltration chambers are well-suited to new construction									Parking Lay-Bys				<b>✓</b>	<b>√</b> ✓						bedrock elevation WQ-15e. Min. 4m offset from building foundations WQ-15f. Runoff from pollution hot spots should not be treated soakaways, infiltration trenches or	Р	Considerations WQ-15i &
	scenarios, but can also be integrated into retrofit projects with careful planning. Infiltration									Bridges					<b>√</b> ✓	√ v	/ /	<b>√</b> ✓	<b>✓</b>		infiltration chambers WQ-15g. Salt / pollutant load	Р	Considerations WQ-15i &
	chambers are also be referred to as infiltration tanks.									Medians / Raised Islands						✓ v	/	✓			WQ-15h. Maintenance requirements WQ-15i. Underground services WQ-15j. Proximity to TTC underground tunnel	Р	Considerations WQ-15i & V



								Ancilla	ry Bene	fits												Su	table S	treet T	ypes									
Green Infrastructure / LID Option	Description	Reduced Heat Island Effect	Recaptured Green Space	Promote Habitat / Biodiversity Expanded Urban Tree	Canopy Enhanced Aesthetics	SWM Quality	Pollutant Removal	Groundwater Recharge Reduced Stream Channel	Erosion Reduced Flood Risk	Energy Generation Energy Conservation	Reduced Operational Cost	Remote Monitoring	Enhanced Visibility	Human Comfort - Shade	Reduction in GHG Emissions	Potential Applications	Civic Streets	Downtown & Centres Main Street	Avenues & Neighbourhood Main Street	Mixed-Use Accent Street Downtown & Centres	Residential Street Apartment Neighbourhood	Neighborhood Residential Street (Sub-type - Built Circa Pre-	Neighborhood Residential Street (Sub-type - Built Circa	Mixed-Use Connector Street	Residential Connector Street	Park Street	Employment Street	Mixed Use Shared Street	Residential Shared Street	Mixed-Use Lane	Residential Lane	Considerations	Feasibility № / <u>P</u> otential / <u>Y</u> es	Rationale
WQ-16i Permeable Pavement Pervious Concrete	Pavement allows stormwater to infiltrate through															Vehicle Lanes							_ v/					✓	✓	✓	<b>√</b> V	WQ-16a. Surface should be at least 1% and no greater than 5% WQ-16b. Impervious area treated should not exceed 1.2 times the area of permeable pavement	Р	Considerations WQ-16I, 16m & 1
	the surface into a subsurface stone reservoir rather than collecting and being conveyed as surface runoff. Stormwater is then temporarily		1			Ш						Ш				On-Street Parking		П	✓	✓ v	/ /	✓	✓									WQ-16c. Systems located in native soils with an infiltration rate of < 15 mm/hr require a perforated pipe underdrain WQ-16d. Facilities receiving road or parking lot runoff should not be located within 2 year time-of-	Р	Considerations WQ-16I, 16m & 1
	detained and, in most cases, infiltrated into the native subsoils. Similar to other infiltration-based		1			Ш						Ш				Parking Lay-Bys			✓	✓ v	/ /	✓	✓									travel wellhead protection area WQ-16e. Min. 1m separation between the bottom of swale and seasonal high water table or top of	Р	Considerations WQ-16I, 16m & 1
	practices, the requirement for an underdrain relates directly to the permeability of underlying native soils. Permeable Pavements can be used		1			Ш						Ш				Cycling Infrastructure		✓				✓				/ /						bedrock elevation  WQ-16f. Min. 4m offset from building foundations  WQ-16g. Runoff from pollution hot spots should not be treated by Permeable Paving	Р	Considerations WQ-16I, 16m & 1
	in both new and retrofit scenarios.		1		✓	<b> </b> ✓		<b>√</b> ✓	<b>/</b>			Ш				Sidewalks	✓	<b>✓</b>	✓	<b>√</b> •	<b>✓</b>	✓	✓ ,	/ •	/ •	/ /	<b>/</b>	✓	✓		٧	WQ-16h. Porous asphalt and pervious concrete will not properly pour and set in extremely high and low temperatures	Р	Considerations WQ-16I, 16m & 1
	Pervious Concrete has fewer fines then conventional concrete, creating void spaces (15% 35%) within the material. This materials 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.																														V V V V	WQ-16i. Properly installed permeable pavement requires trained and experienced producers and construction contractors WQ-16j. Treatment area should be fully protected during construction so that no sediment reaches the permeable pavement system. Construction traffic should be blocked from the permeable pavement and its drainage areas once the pavement has been installed WQ-16k. Salt / pollutant load WQ-16i. Snow removal / maintenance requirements WQ-16m. Underground services WQ-16n. Proximity to TTC underground tunnel		
WQ-16ii Permeable Pavements Porous Asphalt	Porous asphalt features air pockets that are created as a result of the inclusion of fewer fines															Vehicle Lanes				v	/ /	✓	✓			<b>✓</b>	1	✓	✓	✓	✓.	Refer to Considerations of the "WQ-16i Permeable Pavements - Pervious Concrete" above	Р	Considerations WQ-16I, 16m & 1
	and less sand content than traditional impervious asphalt. These void spaces allow water to filter through to the aggregate layer below. Porous		1			Ш						Ш				On-Street Parking		П		•	/ /	✓	✓										Р	Considerations WQ-16I, 16m & 1
	asphalt provides a suitable alternative to conventional asphalt and can be used within road		1			<b> </b>		<b>✓</b> ✓	<b>/</b>			Ш				Parking Lay-Bys				•	<b>✓</b>	✓	✓										Р	Considerations WQ-16I, 16m & 1
	rights-of-way in areas such as cycling infrastructure, Parking Lay-Bys, and multi-use recreational trails.		1			Ш						Ш				Cycling Infrastructure	✓	<b>✓</b>	✓	✓		✓	•	/ v	/ v	/ /	✓						Р	Considerations WQ-16I, 16m & 1
																Sidewalks										✓							Р	Considerations WQ-16I, 16m & 1
WQ-16iii Permeable Pavement Permeable	Permeable concrete paver systems have expanded joints that allow for 5%-10% of a paved surface area to be filled with porous aggregate	1	1			Ш						Ш				On-Street Parking			✓	<b>√</b> •	<b>✓</b>	✓	✓					✓	✓		•	<ul> <li>Refer to Considerations of the "WQ-16i Permeable Pavements - Pervious Concrete" above</li> </ul>	Р	Considerations WQ-16I, 16m & 1
Interlocking Precast Concrete	material. These voids allow water to filter through to the aggregate layer below. Permeable concrete		1			Ш						Ш				Parking Lay-Bys			✓	<b>√</b>   •	<b>✓</b>	✓				<b>✓</b>		✓	✓				Р	Considerations WQ-16I, 16m & 1
Pavers	pavers can be used in a variety of applications such as for laneway paving, decorative paving		1		1			✓ <b>✓</b>				Ш	Π,			Decorative Paving		<b>✓</b>		✓					٧	/ /	✓	✓	✓				Р	Considerations WQ-16I, 16m & 1
	treatments and Parking Lay-Bys within various street types.		1						Ľ			Ш				Sidewalks		<b>✓</b>		✓					•	/ /	<b>✓</b>	✓	✓				Р	Considerations WQ-16I, 16m & 1
			1			Ш						Ш				Crosswalks	✓	<b>✓</b>	✓	<b>√</b> •	<b>/</b>	✓	✓		٧	/ /	✓	✓					Р	Considerations WQ-16I, 16m & 1
																Vehicle Lanes														✓				
Open Cell Concrete	Open cell concrete blocks provide a permeable paving system designed to withstand the load of a vehicle, but with large enough open spaces to	9	1			Ш						Ш				Vehicle Lanes														✓	✓	<ul> <li>Refer to Considerations of the "WQ-16i Permeable Pavements - Pervious Concrete" above</li> </ul>	N	Considerations WQ-16I, 16m & 1
Block	allow drainage and grow grass.	✓			✓	<b> </b>	✓	<b>✓</b>	<b>\</b>				١,			Parking Lay-Bys		Ш			<b>✓</b>	✓	✓			<b>✓</b>							N	Considerations WQ-16I, 16m & 1
																Decorative Paving		Ш							•	/ /							N	Considerations WQ-16I, 16m & 1
Reinforced Grid	Reinforced grid systems are made from recycled high density polyethylene that can be filled with aggregate to provide a surface with 90% porosity															Vehicle Lanes														✓	✓	Refer to Considerations of the "WQ-16i Permeable Pavements - Pervious Concrete" above	N	Considerations WQ-16k & 16l
Paving	that can withstand heavy traffic loads. Reinforced grids are suitable in all soil conditions and not only infiltrate stormwater runoff, but also stabilize the ground surface.	<b>y</b>			✓			<b>✓</b>	<b>/</b>			Ш	,			Sidewalks									•	<b>✓</b> ✓							N	Considerations WQ-16k & 16l



								Α	ncillar	Bene	fits															:	Suitable	Stree	t Type:	s								
Green Infrastructure / LID Option	Description	Reduced Heat Island Effect	Recaptured Green Space	Promote Habitat / Biodiversity	Expanded Urban Iree Canopy	Enhanced Aesthetics	Pollitant Removal	Groundwater Recharge	Reduced Stream Channel	Reduced Flood Risk	Energy Generation	Energy Conservation	Reduced Operational Cost	Remote Monitoring	Eminanced Visibility  Traffic Calmina	Human Comfort - Shade	Reduction in GHG Emissions	Po	tential A	pplicatio	ons	Civic Streets Downtown & Centres	Main Street Avenues & Neighbourhood	Main Street Mixed-Use Accent Street	Downtown & Centres Residential Street	Residential Street	Sub-type - Built Circa Pre-1950) Veighborhood Residential Street Sub-type - Built Circa Post 1950)	Mixed-Use Connector Street	Residential Connector Street	Scenic Street	Fark Street Employment Street	Mixed Use Shared Street	Residential Shared Street	Mixed-Use Lane	Residential Lane	Considerations	Feasibility <u>N</u> o / <u>P</u> otential / <u>Y</u> et	Rational
	Rainwater cisterns intercept, convey and store rainfall for future use. Within the right-of-way there	ere						Ť										Fronta	ge Zones			✓ ✓	/ /	<u> </u>	<b>✓</b>	<u>-</u> ✓	223	_	-						٧	VQ-17a. Storage tanks can be placed underground, indoors, on roofs, or adjacent to buildings depending on intended uses of the rainwater	Р	Considerations WQ-17k,
Num Burror & Glotom	are opportunities to capture runoff in prefabricated cisterns below grade and then to reuse rainwater for irrigation and maintenance purposes. This type of system can be effective in reducing demands on the municipal potable water system.	ted er /pe				~			<b>✓</b>	~																									V V V V V V V V V	VQ-17a. Site topography influences the placement of the storage tank and design of the distribution and overflow systems VQ-17a. Underground cistems should be placed on or in native, rather than fill soil VQ-17b. Rain barrels or above ground cistems with gravity distribution systems should be sited up-gradient from landscaping areas to which rainwater is to be applied VQ-17c. Can be an effective BMP for roof runoff from sites where land uses or activities at ground level have the potential to generate highly contaminated runoff VQ-17d. Can be used throughout the winter if located below the local frost penetration depth VQ-17f. Underground utilities may constrain location of underground storage tanks VQ-17f. Code allows the use of harvested rainwater for toilet and urinal flushing, but systems require installation of backflow prevention devices VQ-17g. If improperly managed, tanks can create habitat suitable for mosquito breeding, so screens should be placed on inlets and outlets to prevent entry VQ-17h. Cisterns with openings large enough for children to enter must have lockable covers VQ-17i. Tanks should be water tight to avoid ponding or saturation of soils VQ-17i. Underground tanks sited in areas without vehicular traffic VQ-17i. Maintenance requirements VQ-17i. Minitenance requirements VQ-17i. Operation / maintenance VQ-17i. Operation / maintenance VQ-17i. Operation / maintenance		
	Stormwater tree pits are a variation of the traditional tree pit that receives stormwater runoff																	Furnisl	ning / Plant	ng Zones		<b>√</b> ✓	/ /		✓	/		✓	✓		✓	✓	✓		V	VQ-18a. Operation and maintenance VQ-18b. Salt/pollutant load	Р	Considerations WQ-18c
	from the road through curb inlets. They consist of a tree installed in filter media with an open bottom to promote infiltration into the surrounding native soils.	om 🗸		✓	<b>✓</b>	V V	•	<b>~</b>	<b>✓</b>	<b>✓</b>						~	<b>/</b>	Media	ns / Raised	Islands		✓						✓	✓		<b>✓</b>				V V V	VQ-18c. Overhead / underground services VQ-18d. Proximity to TTC underground tunnel VQ-18e. Plants selected for tolerance to short periods of inundation and prolonged dry periods VQ-18f. Steel guards recommended for protection of pedestrians VQ-18g. Suitable in areas of steep topography	Р	Considerations WQ-18c
VQ-19 Stormwater Tree Trenches	Stormwater tree trenches consist of a series of stormwater tree planters connected through the																	Furnisl	ning / Plant	ng Zones		✓ <b>✓</b>	/ /		✓	<b>✓</b>		✓	✓		<b>✓</b>	✓	✓		V	VQ-19a. Operation and maintenance VQ-19b. Salt/pollutant load	Р	Considerations WQ-19c
	underground trench system. The excavated trenches are backfilled with engineered soil. Soil volumes can be further augmented by installing soil cells.			✓	<b>✓</b>	V	•	<b>~</b>	<b>✓</b>	✓						~	<b>/</b>	Media	ns / Raised	Islands		<b>√</b>						✓	✓		<b>✓</b>				V	WQ-19d. Overhead / underground services WQ-19d. Proximity to TTC underground tunnel WQ-19e. Plants selected for tolerance to short periods of inundation and prolonged dry periods WQ-19f. Steel guards recommended for protection of pedestrians	Р	Considerations WQ-19c

# TORONTO GREEN STREETS GUIDELINE LONG LIST OF GREEN INFRASTRUCTURE OPTIONS - ECOLOGY / SOLID WASTE



B10

							Ancilla	ary Bene	fits													Suitable	e Street	t Types								
Green Infrastructure / LID Option	Description	Reduced Heat Island Effect Recaptured Green Space	Promote Habitat / Biodiversity	Expanded Urban Tree Canopy	Enhanced Aesthetics SWM Quality	Pollutant Removal	Groundwater Recharge Reduced Stream Channel	Frosion Reduced Flood Risk	Energy Generation	Energy Conservation	Remote Monitoring	Enhanced Visibility	Traffic Calming	Human Comfort - Shade Reduction in GHG Emissions	Potential Applic	cations	Civic Streets Downtown & Centres	Main Street Avenues & Neighbourhood	Nain Street Mixed-Use Accent Street	Jowntown & Centres Residential Street	Apartine reignbournood Residential Street	Street (Sub-type - Built Circa Neighborhood Residential Street (Sub-type - Built Circa	Mixed-Use Connector Street	Residential Connector Street	Scenic Street Park Street	Employment Street	Mixed Use Shared Street	Residential Shared Street Mixed-Use Lane	Residential Lane	Considerations	Feasibility <u>N</u> o / <u>P</u> otential / <u>Y</u> es	Rationale
E-1 Curbside Parklets	Parklets require the conversion of one or more On Street Parking spaces into a seasonal extension of the sidewalk. They are typically installed where existing sidewalk widths are too narrow to accommodate street activity and features furnishings like benches, tables, chairs, umbrellas greenscape (green walls), bicycle parking and even public art. Parklets would not extend beyond the dimensions of an existing parking space and are a way to recapture green space seasonally.	<b>√</b>	<b>✓</b>		<b>✓</b>								~		On-Street Parking			<b>▼</b>												E-1a. Traffic Flow E-1b. Ownership / Responsibility E-1c. Operation / Maintenance	N	Considerations E-1b & E-1c
E-2 Natural Tree Canopy	The natural (urban) tree canopy is composed of all the layers of leaves, branches and stems that cover the ground. Tree canopy performs critical ecological functions within the urban environment such as managing stormwater, reducing the urban heat island effect and air pollution and providing wildlife habitat. An enhanced tree canopy also has an aesthetic value, improves quality of life and increases property values.  The City of Toronto seeks to increase tree canopy cover to 40% (Toronto's Strategic Forest Management Plan 2012-2022), therefore designers should look for opportunities to integrate trees within the City's rights-of-way. Tree planting is appropriate within all street types with the exception of residential and mixed-use lanes. Large canopy native species are preferred.	<b>✓</b>	<b>✓</b>		✓ ✓	· •	✓ v	/ /					,	<b>/ /</b>	Furnishing / Planting Zo	ones	✓ ,	<b>✓</b>		<b>✓</b>	✓ <b>∨</b>		<b>✓</b>	✓ ,		<b>✓</b>	✓ .	<b>✓</b>		E-2a. Available soil volume E-2b. Soil characteristics E-2c. Salf / pollutant load E-2d. Overhead or underground services E-2e. Pedestrian load E-2f. Proximity to natural heritage system E-2g. Microclimate E-2h. Maintenance requirements	Y	
E-3 Native Herbaceous Plantings	Native herbaceous plants are indigenous to the Toronto region and are characterized by their lack of woody stems above ground level. Herbaceous plant material can be integrated into a variety of Gl options to promote pollinator habitat and enhance biodiversity within Toronto's streets. Plant material should not only be selected for its aesthetic quality and habitat value, but also based on site specific requirements and tolerance to drought and urban conditions.	<b>✓</b>	<b>✓</b>		✓ ✓	<b>✓</b>	✓ w	/ /							Furnishing / Planting Zo	ones	<b>√</b> ,	<b>✓</b> ✓		<b>✓</b>	√ <b>∨</b>	/ /	<b>✓</b>	<b>√</b> ,		✓	✓ .	<b>√</b>		E-3a. Available soil volume E-3b. Soil characteristics E-3c. Salt / pollutant load E-3d. Pedestrian load E-3e. Microclimate E-3f. Maintenance requirements	Y	
E-4 Ecopassages	Ecopassages are bridges and tunnel systems that guide animals and reptiles safely over or under roads and highways. Within the City of Toronto, ecopassages can be particularly valuable on streets that bisect the Natural Heritage System (NHS) by facilitating wildlife migration and aiding in the reduction of road mortality. The Toronto and Region Conservation Authority's (TRCA) Crossings Guideline document address ecopassage design in detail and should be referenced whenever ecopassages are considered for implementation as part of a Green Street project.		<b>✓</b>												Vehicle Lanes						•		✓	✓ ,	/ /	✓				E-4a. Traffic Flow E-4b. Available soil volume E-4c. Underground services E-4d. Proximity to natural heritage system E-4e. Maintenance requirements	Р	Considerations E-4c & E-4d
E-5 Light Limitation	Excessive light stray from street lights can impact wildlife and wildlife habitats. Limiting light dispersion at night can assist in maintaining native wildlife populations, habitats and ecological functions. Every effort should be made on all new street and street retrofit projects to limit light dispersion by making appropriate fixture choices and providing targeted luminaire placement. This is particularly critical on streets that bisect the City's NHS.		<b>✓</b>														<b>√</b> ,	/ •	<b>✓</b>	<b>✓</b>	<b>√</b> •	/ /	<b>✓</b>	<b>✓</b> ,	/ /	· •	✓ .	<b>√</b> ✓	<b>✓</b> ✓	E-5a. Proximity to tributaries and natural heritage systems	Y	
Green Infrastructure / LID Option	Description	Reduced Heat Island Effect Recaptured Green Space	Promote Habitat / Biodiversity	Expanded Urban Tree Canopy	Enhanced Aesthetics SWM Quality	Pollutant Removal	Groundwater Recharge	Reduced Flood Risk	Energy Generation still	Energy Conservation	Remote Monitoring	Enhanced Visibility	Traffic Calming	Human Comfort - Shade Reduction in GHG Emissions	Potential Applic	cations	Civic Streets Downtown & Centres	Main Street Avenues & Neighbourhood	Main Street Mixed-Use Accent Street	Downtown & Centres Residential Street	Residential Street Neighborhood Residential Street	(Sub-type - Built Circa Pre-1950) Chaptype - Built Circa Pre-1950 Chaptype - Built Circa Post 1950)	Mixed-Use Connector Street	Residential Connector Street	Scenic Street Park Street	Employment Street	Mixed Use Shared Street	Residential Shared Street Mixed-Use Lane	Residential Lane	Considerations	Feasibility <u>N</u> o / <u>P</u> otentia / <u>Y</u> es	Rationale
SW-1 Smart Receptacles	Solar powered trash compactors and recycle bins provide increased capacity, prevent debris from being blown away and discourages disposal of household garbage in street receptacles. Newer models can also come equipped with Wi-Fi in order to provide status updates (remaining capacity) to maintenance teams.								<b>✓</b>	•	<b>/</b>				Furnishing / Planting Zo		✓ <b>、</b>	/ /	<b>/</b>					,	/ /	✓		<b>✓</b>		SW-1a. Operation and maintenance SW-1b. Width of sidewalk area SW-1c. Ownership / responsibility	N	Considerations SW-1a & SW-1c



# LONG LIST OF GREEN INFRASTRUCTURE OPTIONS

A Short List of Green Infrastructure options was distilled from the Long List as a result of an analysis of each option. The Short Listed options in the following section form the foundation (and 'y'-axis) of the Green Infrastructure Selection Tool.



### TORONTO GREEN STREETS GUIDELINE SHORT LIST OF GREEN INFRASTRUCTURE OPTIONS - AIR QUALITY



									Ancilla	ary Ben	efits												Sui	table Str	eet Ty	es							
	Green Infrastructure / LID Option	Description	Reduced Heat Island Effect	Recaptured Green Space	Promote Habitat / Biodiversity Expanded Urban Tree	Canopy Enhanced Aesthetics	SWM Quality	Pollutant Removal	Groundwater Recharge	Reduced Stream Chainer Erosion	Energy Generation	Energy Conservation	Reduced Operational Cost Remote Monitoring	Enhanced Visibility	Traffic Calming Human Comfort - Shade	Reduction in GHG Emissions	Potential Applications	Civic Streets	Downtown & Centres Main Street Avenues & Neighbourhood	Main Street	Mixed-Use Accent Street Downtown & Centres Residential Street	Apartment Neighbourhood Residential Street	Neighborhood Residential Street (Sub-type - Built Circa Pre-1950)	Neighborhood Residential Street (Sub-type - Built Circa Post 1950) Mixed-Use Connector Street	Residential Connector Street	Scenic Street	Park Street	Employment Street Mixed Use Shared Street	Residential Shared Street	Mixed-Use Lane		<b>easibility</b> (otential / <u>Y</u> es	Rationale
		Green walls can provide valuable green infrastructure within confined urban spaces. They can feature plants rooted in the ground and trained to grow up a vertical wall, known as a "green facade" or plants that are rooted in a vertical modular, composite or custom substrate system that is affixed directly to an existing structural wall, known as a "living wall". Refer to Toronto's Best Practices Manual for Green Walls for a detailed description of each.	✓	<b>√</b>	<b>✓</b>	•	/ /	<b>✓</b>								<b>✓</b>	Bridges	✓	✓ ·	✓ ·	<b>✓</b> ✓	✓	✓	✓ <b>∨</b>	<u> </u>	<b>✓</b>	<b>√</b>	<b>✓</b> ✓	<b>✓</b>		AQ-1a. Irrigation system required AQ-1b. Ownership / responsibility AQ-1c. Maintenance requirements AQ-1d. Microclimate AQ-1e. Salt / pollutant load	Р	Considerations AQ-1a, AQ-1c & AQ-1e
	AQ-2 Street Trees	Street trees help to increase the overall urban forest canopy and can assist in improving air quality, reducing the urban heat island effect and providing wildlife habitat. The City prefers large canopy native species for street tree planting. Suitable species can be identified using the Vegetation Selection Tool.	<b>✓</b>		✓ ,	<   •	/ /	<b>✓</b>							<b>✓</b>	\ \ 	Furnishing / Planting Zone Frontage Zone Medians / Raised Islands	✓	✓ ·	•	<b>✓</b> ✓	<b>✓</b>	✓	<b>✓</b> ✓		✓	<b>√</b>	<b>✓</b>	<b>✓</b>		AQ-2.a. Available soil volume AQ-2.b. Soil characteristics AQ-2.c. Salt / pollutant load AQ-2.d. Presence of overhead or underground services AQ-2.e. Pedestrian load AQ-2.f. Proximity to natural heritage system AQ-2.g. Microclimate AQ-2.h. Maintenance requirements	Y	
		Soil cell systems can be used when street trees are desirable in locations where surface areas are limited.  Soil cells are rigid modular systems that are used															Furnishing / Planting Zone Frontage Zone	<b>✓</b>	<ul><li>✓</li><li>✓</li></ul>	<b>/</b>	<b>✓</b>	<ul><li>✓</li><li>✓</li></ul>							<b>✓</b>		AQ-2A a. Salt / pollutant load AQ-2A b. Maintenance requirements AQ-2A c. Underground services AQ-2A c. Proximity to TTC underground tunnel AQ-2A e. Maintenance of adequate pedestrian clearway	Y	
Lλ		to increase the soil volume under paved surfaces in ultra-urban areas. Soil cells provide the structural integrity required to support vehicular load on paved surfaces and at the same time some systems offer up to 92% porous space in order to accommodate underground services and	✓		•	<b>✓</b>   <b>▼</b>		<b>✓</b>				ı			<b>✓</b>	<b>\</b>	Medians / Raised Islands Parking Lay-Bys	<b>√</b>	,	<b>/</b>		✓							✓			Y	
NALI		utilities.  Open tree planters can be used where widths are															Cycling Infrastructure (Separated)	<b>v</b>	<b>v</b> ,	/		<b>√</b>									AQ-2B a. Microclimate	Y	
AIR G		generous. They are able to accommodate two or more trees per planter and can be framed by a low curb or higher seat wall. Open tree planters are	,														Furnishing / Planting Zone Frontage Zone	<b>∨</b>	<b>v</b> ,			<b>∨</b>		•					<b>v</b>		AQ-2B b Salt/pollutant load AQ-2B c Overhead 'underground services AQ-2B d Width of sidewalk area	Y	
		typically the most cost effective way to plant in a	✓		✓ ,	/ /		<b>✓</b>							<b>✓</b>	/	Medians / Raised Islands	<u> </u>				•		_	/				•		AQ-2B.e. Maintenance of adequate pedestrian clearway	Y	
		preferred solution in areas with high pedestrian volumes. The soil volume can also be augmented by installing soil cells below the grade of the planter.										ı			ı		incording / reliced islands		1					ĺ								'	
	Planter	Planter Boxes are available in a variety of forms and materials and can be used as accents or as a															Furnishing / Planting Zone	✓	✓ ,	/	✓					✓		<b>✓</b>	✓		AQ-2C.a. Operation and maintenance AQ-2C.b. Salt/pollutant load	Υ	
		buffer between competing uses. Planted Boxes can enhance biodiversity and improve air quality, but have a limited ability to manage stormwater as they only received fixed reinfall and have a limited.															Frontage Zone	✓	<b>√</b> ,	/	✓							<b>✓</b>	✓		= AQ-2C. A Microclimate   AQ-2C. & Salt / pollutant load	Υ	
		they only receive direct rainfall and have a limited capacity.	<b>✓</b>		•	<b>/</b>		<b>✓</b>							✓		Medians / Raised Islands	✓										<b>✓</b>			AQ-2C.S. Snow removal / maintenance requirements AQ-2C.J. Underground services	Υ	
																	Cycling Infrastructure (Separated)	<b>✓</b>	✓,	/												Υ	
	AQ-2D Precast Tree Planters	Precast tree planters are prefabricated impervious planters filled with bioretention media and															Furnishing / Planting Zone	<b>✓</b>	<b>√</b> ,	/ .	<b>√</b> ✓	<b>√</b>						✓ ✓	<b>✓</b>		AQ-2D.a. Salt / pollutant load AQ-2D.b. Microclimate	Y	
		equipped with a perforated pipe outlet for filtration and conveyance of direct rainfall. Precast planters															Frontage Zone	<b>✓</b>	<b>√</b> ,	/									✓		AQ-2D.c. Snow removal / maintenance requirements AQ-2D.d. Underground / overhead services	Υ	
		are suitable for use throughout urban street types, however they have a limited capacity for volume retention. These planters are highly effective in areas where contaminated soils are present or where a high watertable exists.	<b>✓</b>		•	•		<b>✓</b>							<b>✓</b>		Medians / Raised Islands	<b>✓</b>	1												AQ-2D.e. Proximity to TTC underground tunnel	Y	
	AQ-3 Photocatalytic Paving	Photocatalytic paving is a surface treatment that has the ability to purify outdoor air by eliminating															On-street Parking	✓	,	/ .	<b>√</b> ✓	<b>√</b>	✓	✓							AQ-3a. Still being tested for performance on high occupancy roads	Р	Consideration AQ-3a
		nitrogen oxide and other airborne toxins that result from traffic emissions. When exposed to sunlight															Cycling Infrastructure	<b>✓</b>	<b>√</b> ,	/			✓	~	<b>✓</b>	✓	<b>√</b>	<b>✓</b>			1	Р	Consideration AQ-3a
		a component of the paving material called titanium dioxide reacts with NOx gasses to create non-toxic soluble nitrates that will wash away in the rain.						_								/	Sidewalks	✓	<b>√</b> ,	/	<b>√ √</b>	✓	✓	<b>√ √</b>	<b>✓</b>	✓	✓	<b>✓ ✓</b>	<b>✓</b>		1	Р	Consideration AQ-3a
		Photocatalytic paving is available in concrete or asphalt for road surfaces and concrete stone for															Decorative Paving	✓	✓ ,	/	<b>√</b>	✓	✓	<b>√ √</b>	<b>✓</b>	✓	✓	<b>✓ ✓</b>	✓		1	Y	
		pedestrian walkways, plazas etc. Concrete stones are available in a variety of colours and comes in standard and textured finishes.															Bridges	✓	✓ ,	✓ .	<b>✓</b>	✓	✓	<b>✓</b>	✓	<b>✓</b>	<b>√</b>	✓ <b>✓</b>	✓			Р	Consideration AQ-3a

Y = Feasible P = Potentially Feasible



B12

### TORONTO GREEN STREETS GUIDELINE SHORT LIST OF GREEN INFRASTRUCTURE OPTIONS - GHG & ENERGY EFFICIENCY



B13

							,	Ancillar	y Bene	fits												Su	itable	Street '	Types								
Green Infrastructure / LID Option	Description	Reduced Heat Island Effect	Recaptured Green Space	Expanded Urban Tree	Enhanced Aesthetics	SWM Quality	Pollutant Removal	Groundwater Recharge Reduced Stream Channel Erosion	Reduced Flood Risk	Energy Generation Energy Conservation	Reduced Operational Cost	Kemote Monitoring	Ennanceu visibility Traffic Calming	Human Comfort - Shade	Reduction in GHG Emissions	Potential Applications	Civic Streets	Nowntown & Centres  Main Street  Nenues & Neighbourhood	Aain Street	Mixed-Use Accent Street	Apartment Neighbourhood	Veighborhood Residential Street Sub-type - Built Circa Pre-1950)	Veighborhood Residential Street Sub-type - Built Circa Post 1950)	Nixed-Use Connector Street	Lesidential Connector Street Scenic Street	Park Street	Employment Street	Mixed Use Shared Street	Residential Shared Street	Mixed-Use Lane	Considerations	Feasibility Potential / Yes	Rationale
GHG-1 LED Lights	LED (light emitting diodes) lights represent the latest in lighting technology. They are long lasting														s	treet Lights	✓	√ ·	✓ ·	✓ <b>✓</b>	<b>√</b>	✓	√	✓ ,	✓ <b>✓</b>	<u>−</u>	✓	<u>-</u>	✓ <b>、</b>	/ •	G1G-1b. Ownership / Tesponsibility	Y	
	(30,000-60,000 hours) and are extremely energy efficient (up to 90% more efficient then conventional incandescent bulbs). In addition, they					Ш									D	ecorative Lights	✓	✓ ,	<b>✓</b>	<b>✓ ✓</b>	<b>√</b>				<b>✓</b>	<b>/</b>	✓	✓ .	<b>✓</b>		GHG-1c. Presence of overhead or underground services GHG-1d. Width of sidewalk area	Υ	
	generate very little heat and are made of non-toxic materials that can be recycled. LEDs provide superior visibility with more even light dispersion and can reduce light pollution through appropriate fixture choices and targeted placement.					Ш				•	<b>✓</b>	٧			<b>√</b> _	ignage (Bus Shelters, Street Signs)	✓	<b>✓</b> ,	✓	Ī				<b>✓</b>	<b>✓</b>	· •	<b>✓</b>	✓ ·	<b>✓</b>			N	Considerations GHG-1a & GHG-1b
GHG-2 Solar Photovoltaic Panel	Photovoltaic (PV) panels are used to harness sunlight and convert it to usable energy. Solar					П									s	treet Lights	✓	<b>√</b> ,	<b>✓</b>	<b>✓</b> ✓	<b>√</b>	✓	✓	✓ ,	/ /	<b>✓</b>	<b>✓</b>	<b>√</b> .	✓ <b>、</b>	/ v	GITO 20.0 WINCIGING / TOOPONDONING	Y	
	units can be used to power streetlights and parking meters, to illuminate transit stops and as	9				Ш			Ш						D	ecorative Lights	✓	<b>√</b> ,	✓ .	<b>✓</b> ✓	<b>√</b>				~	<b>✓</b>	<b>✓</b>	✓ .	<b>√</b>		GHG-2c.Presence of overhead or underground services GHG-2d.Width of sidewalk area GHG-2e. Photovoltaic paving tiles not suitable for vehicular traffic	Y	
	decorative paving. They provide considerable benefits over conventional grid-powered systems including energy efficiency, location flexibility and					Ш			Ш	<b>✓</b> ✓	✓				<b>√</b> P	arking Meters	✓	<b>√</b> ,	<b>✓</b>	<b>✓</b>											Gro-ze. Priotovoliaic paving lies not suitable for vehicular transc	Р	Considerations GHG-2a & GHG-2b
	wireless monitoring capability.					Ш			Ш						V	ehicle Charging Stations	✓	<b>√</b> ,	<b>✓</b>	<b>✓</b>	<b>√</b>						✓	✓ .	✓			Р	Consideration GHG-2b
OHO 2. Calar Banda						Ш			Ш						D	ecorative Paving	✓	<b>√</b> ,	<b>✓</b>	<b>✓</b> ✓	✓						ľ	✓ .			Olo 2- Quefa administra	Р	Consideration GHG-2a
GHG-3 Solar Roads	Solar roads comprise a modular system of photovoltaic panels designed to convert sunlight to usable energy. They are engineered to be an all-in-					Ш			Ш						S	idewalks	<b>√</b>	<b>√</b> ,	•	<b>/ /</b>	<b>✓</b>					·	<b>✓</b>	<b>√</b>	✓		GHG-3a. Operation and maintenance GHG-3b. Presence of underground services GHG-3c Contain heated elements to prevent snow and ice accumulation in winter	Р	Consideration GHG-3e
	one product that will eliminate requirements for resurfacing, repainting and even winter maintenance. LED lights are embedded within the					Ш			Ш	✓	. ,	/ •			✓ C	ycling Infrastructure	<b>√</b>	<b>√</b> ,	<b>✓</b>			✓			<b>/ /</b>						GHG-3d.Not yet approved for road surfaces GHG-3e.New technology - durability unknown	Р	Consideration GHG-3e
	panels to allow for lane markings, turning arrows, HOV, cycling infrastructure or any other type of					Ш			Ш						С	rosswalks	<b>√</b>	<b>√</b> ,						<b>√</b> ,	<b>/ /</b>	<b>\</b>	<b>✓</b>	<b>√</b>	<b>√</b>			Р	Consideration GHG-3e
GHG-4 Solar Paver Lighting	marking. These markings are illuminated on the surface of the panels as required.  Solar-powered LED paver lights are designed to					Ш			Ш						0	In-street Parking	<b>√</b>			<b>✓ ✓</b>	<b>√</b>	<b>√</b>	✓					4			GHG-4a.Operation and maintenance	Р	Consideration GHG-3e
Ono-4 Colai Faver Eighting	withstand most vehicle traffic and are durable under harsh winter conditions. Each unit is self-					Ш			Ш						-	cycling Infrastructure (Separated)	<b>√</b>	✓ ·												-	GHG-4c.Durability GHG-4c.Can function in temperatures from - 40°C to +60°C	P	Considerations GHG-4a & GHG-4b
	contained and comes equipped with its own solar cells that charge an internal battery. A light sensor is included to activate and deactivate the LED					Ш			Ш	•		v				rosswalks	<u> </u>	✓													-	P	Considerations GHG-4a & GHG-4b  Considerations GHG-4a & GHG-4b
GHG-5 Photo-luminescent	lights at dusk and dawn.  Photoluminescent road markings are created from					Н										ehicle Lanes	<u> </u>	✓ ,										•	<u> </u>		GHG-5a.Maintenance	Р	Consideration GHG-5b
Road Marking	a paint product that has an embedded photoluminescent powder. The paint absorbs sunlight during the day and then emits a green					Ш			Ш	<b>✓</b>		v			-		<u>√</u>	√ ,			Ė	✓			/ /			Ħ		H	GHG-5b Durability	Y	
	glow at night that lasts up to 10 hours. It has been used effectively for road markings in Europe.					Ш			Ш						С	rosswalks	<b>√</b>	<b>√</b> ,	<b>✓</b>	✓ <b>✓</b>	<b>√</b>	✓	✓	✓ ,	/ /	<b>/</b>	<b>✓</b>	<b>√</b> .	<b>√</b>			Υ	
GHG-6 Wind Energy	Small-scale wind turbines can be highly versatile and can provide a renewable energy source. Wind turbines are recommended as a sustainable option to power street lights.					П				<b>✓</b> ✓	<b>✓</b>				<b>√</b> s	treet Lights	✓	✓ ,	·	✓ <b>✓</b>	<b>~</b>	✓	<b>✓</b>	✓ .	/ /	<b>/</b>	✓	<b>√</b>	<b>✓</b>		GHG-6a. Operation and maintenance GHG-6b. Ownership / responsibility GHG-6c. Presence of overhead services or tree canopy GHG-6d Availability of consistent wind	Р	Considerations GHG-6a & GHG-6b
GHG-7 Cool Pavements	Pavement with higher solar reflectivity reduces local heat island effects and reduces the heat transferred to stormwater thereby improving water														F	rontage Zone	✓	✓		<b>✓</b>	<b>√</b>			✓			✓	✓ .	✓			Y	
	quality. The Toronto Green Standard tier 2 and LEED support an SRI of at least 29 for at					Ш			Ш						P	edestrian Clearways / Sidewalks	✓	<b>√</b> ,														Y	
	least 75% of hardscapes.					Ш			Ш						F	urnishing / Planting Zones		<b>√</b> ,														Y	
						Ш			Ш							urbside Spaces	<b>√</b>	✓ ·												_		Y	
						Ш			Ш							ehicle Lanes ransit Lanes	<b>∨</b> ✓	<b>v</b> ,	•	V V	<b>'</b>	•	<b>V</b>	•	V V	•	•	<b>V</b>	<b>V</b> \	/ \ \	<u> </u>	Y	
						Ш			Ш							ledians / Raised Islandsss	<u> </u>	•						✓ ·	/ /	_	✓	+				Y	
		<b>✓</b>				<b> </b>		✓	<b> </b> ✓			•			-	In-street Parking		,	<b>✓</b> .	✓ ✓	<b>/</b>	<b>✓</b>						+			T	Y	
						Ш									P	arking Lay-Bys		,	<b>✓</b>	<b>✓</b>	<b>√</b>	<b>✓</b>	<b>√</b>					t				Y	
						Ш									С	ycling Infrastructure (Separated)	✓	<b>√</b> ,	<b>✓</b>		ı	✓	П	✓ .	/	<b>✓</b>	<b>✓</b>		<b>✓</b>			Y	
						Ш									С	rosswalks	✓	<b>√</b> ,	<b>✓</b>	/ /	<b>√</b>	✓	✓	✓ .	/ /	<b>✓</b>	✓	✓ .	<b>✓</b>			Y	
						Ш									In	ntersections	✓	<b>√</b> ,	<b>✓</b>	<b>/</b>	<b>✓</b>	✓	✓	✓ .	/ /	✓	✓	✓ .	<b>√</b>			Y	
						Ш									Ti	ransit Stops		<b>√</b> ,							/ /	1	✓					Υ	
															D	ecorative Paving	✓	<b>√</b> ,	<b>✓</b>	<b>✓</b>	<b>√</b>	✓	<b>✓</b>	✓ .	<b>✓</b>	<b>✓</b>	<b>√</b>	✓	<b>√</b>			Y	



							Ar	ncillary I	Benefit	s										Suit	table Str	eet Ty	pes							
Green Infrastructure / LID Option	Description	Reduced Heat Island Effect	Recaptured Green Space Promote Habitat / Biodiversity	Expanded Urban Tree Canopy	Enhanced Aesthetics	ovim Guality Pollutant Removal	Groundwater Recharge	Reduced Stream Channel Erosion	Reduced Flood Risk	Energy Generation Energy Conservation	Reduced Operational Cost Remote Monitoring	Enhanced Visibility	Traffic Calming	Reduction in GHG Emissions	Potential Applications	Civic Streets Jowntown & Centres	Vain Street Avenues & Neighbourhood Main Street	Mixed-Use Accent Street	Downtown & Centres tesidential Street Apartment Neighbourhood tesidential Street	Neighborhood Residential Street (Sub-type - Built Circa Pre-	Veighborhood Residential  street (Sub-type - Built Circa  Vilxed-Use Connector Street	Residential Connector Street	Scenic Street	Park Street	Employment Street Mixed Use Shared Street	Residential Shared Street	Mixed-Use Lane	Oursiderations  Considerations	Feasibility Potential / Yes	Rationale
Q-1 Bioretention Planter	Bioretention is a Low Impact Development (LID) practice that is designed to provide temporary						J							-	Furnishing / Planting Zone	✓ v	<u> </u>	-	<b>√</b> ✓	2 0 1	<b>∠</b>	/	0,		<u>-</u>	<b>✓</b>		WQ-1a. Optimal for soils with high infiltrations rates. Where rates are < 15 mm/hr an underdrain is required	Y	
	storage, filtration and infiltration of stormwater runoff. Although the physical design of a														Medians / Raised Islands	<b>✓</b>					<b>✓</b>	-						WQ-1b. Ponding time < 24hr after storm event WQ-1c. Presence and location of overhead and underground servicing	Y	
	bioretention facility can vary, the construction profile generally consists of the following: a grave	el													Bridges	✓ v	/ /		<b>✓</b> ✓		<b>✓</b>	/						WQ-1e. Located within two (2) year time-of-travel wellhead protection area WQ-1f. Contributing slopes should be between 1-5% WQ-1g, If an under drain is used, then 1-1.5m elevation difference is needed between inflow and	Y	
	storage layer, a choker layer (optional), a bioretention media layer, a mulch layer and a vegetation layers. The physical form of																										-	downstream stormarian invert  WQ-1h. Min. one (1) metre separating seasonal high water table or top of bedrock elevation and the		
	bioretention practices can vary to provide a complementary aesthetic within any street																										-1	bottom of the practice  WQ-1i. Max. recommended contributing drainage area is 0.8 hectares		
	typology from the rural to the ultra-urban contexts Types of bioretention facilities include: Bioretentio	s. on 🗸				/ /									,												-1	WQ-1j. Runoff from pollution hot spots should not be treated by bioretention facilities designed for full or partial infiltration		
	Planters, Bioretention/Stormwater Curb Extensions/Bump-outs, Bioretention Cells, and				ľ				`					ľ													-1	WQ-1k. If impermeable liner is used, then no setback is required from a building. If not, a four (4) metre setback from building foundations		
	Rain Gardens.																										-1	WQ-1I. Salt / pollutant load WQ-1m. Pedestrian load		
	Bioretention Planters are constructed structures with vertical sidewalls. They are often narrow and	t																									-1	WQ-1n. Snow removal / maintenance requirements WQ-1c. Underground services		
	rectangular in shape and can be installed in close proximity to utilities, driveways, trees, light standards and other street features. Bioretention																										-1	WQ-1p. Proximity to TTC underground tunnel WQ-1q. Conflict with traffic		
	Planters receive road runoff through curb inlets and overland flows from the surrounding sidewall																										-1			
Q-2 Stormwater Planter	and other paved surfaces.  Stormwater Planters are similar to Bioretention														Frontage Zone				-/							-/		WQ-2a. Refer to Considerations of the "Bioretention Planter" above	Y	
	Planters in their form and function, however Stormwater Planters are designed to receive rune from downspouts and surrounding sidewalks.	off 🗸	<b>✓</b>	<b> </b>	✓ v	/ /	/   ~		✓				•	<b>✓</b>	Bridges	✓ V			<b>√</b> ✓							•			1	
Q-3 Bioretention Curb Extension /Bump-Out	Bioretention Curb Extensions and Bump-outs have the same bioretention function as above, but are	ve													Intersections	✓ v	✓ ✓	<b>√</b>	<b>✓ ✓</b>	✓	<b>√</b>							WQ-3a. Refer to Considerations of the "Bioretention Planter" above WQ-3b. Can be installed as new construction or retrofit installation	Y	
	positioned as buffers at various locations throughout a block and can provide traffic calmin		<b>√</b> ✓	<b> </b> ✓	✓ v	/ /	/ /		<b>✓</b>				✓ ,	/ /	Mid-block				<b>✓</b> ✓	<b>✓</b>	<b>√</b>						-	WQ-3c. Ownership / responsibility	Y	
	effects.														Transit stops				<b>✓</b>	<b>✓</b>	✓								Р	Consideration WQ-3c
Q-4 Bioretention Cell	Bioretention cells provide a design variation that suitable for more suburban street types such as														Furnishing / Planting Zone				✓ ✓	✓	<b>√</b> ✓	✓ ✓	✓	✓ .	/			WQ-4a. Refer to Considerations of the "Bioretention Planter" above WQ-4b. Can be installed as new construction or retrofit installation	Y	
	Residential Neighborhood or Connector Neighborhood streets, within 'Furnishing / Plantin Zones' or 'Medians' where space is not as	ng /	./ ./			/ ./	/ /							/ ./	,															
	constrained. This form of bioretention often receives overland flows from the surrounding		V	$\  1 \ $	V	V			<b>*</b>				)	ľ	Medians / Raised Islands						<b>✓</b>	<b>✓</b>	✓	✓.	<b>✓</b>		-1		Y	
	landscape and from the roadway through curb cu inlets.	it																									-1			
Q-5 Rain Garden	Rain gardens are sunken planting beds constructed of highly permeable nutrient rich soils	s.													Furnishing / Planting Zone					<b>✓</b>	<b>√</b> ✓	<b>✓</b>	✓	✓ .	/			WQ-5a. Salt / pollutant load WQ-5b. Microclimate	Р	Considerations WQ-5d & 5e
	They can include an engineered soil layer and overflow structure to increase their stormwater management performance. Rain gardens should														Medians / Raised Islands					<b>✓</b>	<b>√</b> ✓	<b>✓</b>	✓	✓ .	/			WQ-5c. Snow removal / maintenance requirements WQ-5d. Underground / overhead services WQ-5e. Proximity to TTC underground tunnel	Р	Considerations WQ-5d & 5e
	always be designed to drain efficiently after a storm event to avoid creating areas of standing	•	V   V		V	′   ′			<b>'</b>				`	~														wQ-be. Proximity to 11C underground tunnel		
	water where mosquitoes can breed.																													
Q-6 Enhanced Grass Swale	Enhanced grass swales are similar to traditional grass swales, however they feature a slightly														Furnishing / Planting Zone					<b>✓</b>	<b>√</b> ✓	<b>✓</b>	✓	✓ .	/		1	WQ-6a. Requires 5 to 15% of contributing drainage area and min. 2 m width WQ-6b. Longitudinal slopes 0.5 - 6%, slopes > 3% require check dams	Y	
	altered parabolic form and incorporate amended soils that slow runoff and assist in contaminant														Medians / Raised Islands					<b>✓</b>	<b>√</b> ✓	<b>✓</b>	<b>✓</b>	✓ .	/		7	WQ-6c. Conveyance capacity should match drainage area. Impervious drainage area to treatment facility area ratio = 5:1 to 10:1	Y	
	removal. Enhanced grass swales can serve as a pretreatment option for infiltration practices,														Bridges				<b>✓</b> ✓	<b>✓</b>	<b>√</b> ✓	/ /	<b>✓</b>	✓ .	/		1	WQ-6d. Highly contaminated source areas for runoff should not be treated by enhances grass swales WQ-6e. Utilities parallel should be offset from the swale centerline. Underground utilities below the	Y	
	particularly on low traffic volume roadways that d not receive high loads of de-icing compounds in		✓		✓ v	/ /	/ /	<b>✓</b>	<b>✓</b>					<b>✓</b>	<u> </u>												+	bottom of the swale are a concern  WO-6f. Min. 1m separation between the bottom of swale and seasonal high water table or top of		
	the winter. Check dams can be integrated into the design in order to maximize infiltration benefits.	6																										bedrock elevation WQ-6g. Min. 4m elfvation building foundations WQ-6h. Salt / pollutant load		
																												WQ-6i. Pedestrian load WQ-6i. Prodestrian load WQ-6j. Snow removal / maintenance requirements		
																												WQ-6k. Underground services		



							A	ncillary	Benefits														Suitab	le Stre	et Type	s								
Green Infrastructure / LID Option	Description	Reduced Heat Island Effect	Recaptured Green Space	Expanded Urban Tree	Enhanced Aesthetics	SWM Quality	Pollutant Removal	Reduced Stream Channel Erosion	Reduced Flood Risk	Energy Conservation	Reduced Operational Cost	Enhanced Visibility	Traffic Calming	Human Comfort - Shade	Reduction in GHG Emissions	Potential Applications	Civic Streets	Downtown & Centres Main Street	Avenues & Neighbourhood Main Street	Mixed-Use Accent Street	Downtown & Centres Residential Street Apartment Neighbourhood	Residential Street Neighborhood Residential Street	(Sub-type - Built Circa Pre-1950) Neighborhood Residential Street	Sub-type - Built Circa Post 1950) Mixed-Use Connector Street	Residential Connector Street	Scenic Street	Park Street	Mixed Use Shared Street	Residential Shared Street	Mixed-Use Lane	Residential Lane	Considerations	Feasibility Potential / Yes	Rationale
WQ-7.1 Bioswale	Bioswales are similar to enhanced grass swales in their linear and cross-sectional surface geometry, however their subsurface profile is more reflective of a bioretention cell, with filter media and/or a storage gallery and optional underdrain (depending native soil permeability) below. Bioswales can either be planted with grasses or finished with more elaborate combinations of plant and aggregate materials. These additional components help to slow the velocity of runoff and assist in sedimentation, filtration and infiltration. As a result of their bioretention profile, bioswales have the potential to be more effective at removing pollutants, reducing runoff and protecting downstream channels from erosion then enhanced grass swales. Bioswales are also referred to as dry swales or infiltration swales.		×	<b>√</b>	<b>*</b>	<b>√</b>	✓ v	√	✓ ·					-		Furnishing / Planting Zone  Medians / Raised Islands  Bridges	√ ✓	✓ ×	∢ ≥ ✓	2		œ z	<b>/ /</b>	<b>✓</b>	<ul><li></li></ul>	✓	✓ v		✓ ·		v v v v v	NQ-7.1a. Requires 5 to 15% of contributing drainage area and >5m swale length between culverts WQ-7.1b. Longitudinal slopes 0.5 - 4%; 6% max. Slopes > 3% require check dams VQ-7.1b. Creat drainage areas of <2 hectares or less. Impervious drainage area to treatment facility area ratio = 5:1 to 15:1  NQ-7.1d. Located over any soil type, but hydrologic soil group A and B soils are best for achieving water balance benefits. WQ-5e. Located in portions of the site with the highest native soil infiltration rates. Where infiltration rates are less than 15 mm/hr an under drain is required.  NQ-7.1f. Facilities receiving road or parking lot runoff should not be located within 2 year time-of-travel wellhead protection area.  NQ-7.1g. Min. 1m separation between the bottom of swale and seasonal high water table or top of bedrock elevation  NQ-7.1h. Min. 4m offset from building foundations  NQ-7.1h. Runoff from pollution hot spots should not be treated in bioswales designed for full or partial infiltration. Facilities designed with an impermeable liner (filtration only facilities) can be used to treat runoff from pollution hot spots.  NQ-7.1p. Presence of underground and overhead utilities  NQ-7.1p. Presence of underground and overhead utilities  NQ-7.1p. Sow removal / maintenance requirements  NQ-7.1m. Snow removal / maintenance requirements  NQ-7.1m. Underground services	Y Y	
WQ-7.2 Bioswale with Stone Well	Bioswales with stone wells provide a formal aesthetic that can be integrated into urban street types such as Civic and Main streets. They feature the longitudinal surface geometry and sub-surface profile of a bioswale, but also include stone filled wells (min. 300mm dia.) installed at equidistant spacing along the length of the bioswale to draw stormwater into highly permeable (>15mm/hr) native subsoils more efficiently. This type of bioswale can also be fitted with curb outlets to direct overflows downstream to an existing catch basin. A variation on this design can also include a stormwater inlet at the upstream end that funnels runoff directly to the stone layer of the cell.		✓ <b>∨</b>		<b>✓</b>	<b>✓</b>	*	<i>'</i> ✓	<b>✓</b>			I				Furnishing / Planting Zone  Medians / Raised Islands  Bridges	✓ ✓	✓ ·	<b>✓</b>		✓ ,	<b>V</b>	< v	✓	✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓	✓	✓ v	/			V V V V V	VQ-7 2a. Operation and maintenance WQ-7 2b. Stone columns require min 5' penetration into permeable soil layer WQ-7 2c. Soil permeability WQ-7 2c. Soil permeability WQ-7 2c. Soil permeability WQ-7 2c. Stone Columnia require min 5' penetration into permeable soil layer WQ-7 2c. Stone (pollutant load WQ-7 2c. Stone) Foolitant load WQ-7 2f. Pedestrian load WQ-7 2f. Pedestrian load WQ-7 2h. Underground / maintenance requirements WQ-7 2h. Underground services WQ-7 2h. Proximity to TTC underground tunnel	Y Y Y	
	Green gutters are shallow planters that extend the full length of a street section which may incorporate breaks at intervals to accommodate pedestrian movement. Green gutters can be installed as separation between conflicting uses such as between cycling infrastructure and vehicle lanes within street types where space allows. They can also be installed as GI within dedicated LRT lanes. Green gutters are typically planted with low-growing grasses or sedums and are designed to attenuate, filter and infiltrate stormwater runoff.	· ·	✓ <b>∨</b>		✓	✓	√ v	<b>✓</b>	~			I			✓	Transit Lanes Curbside Space	✓ ✓	✓ ✓						<b>√</b>	✓	<b>√</b>	✓				V V V V	VQ-8a. Operation and maintenance WQ-8b. Ownership / responsibility WQ-8c. Cannot be used at transit stop locations due to pedestrian traffic; WQ-8d. Relatively new and unproven technology. WQ-8c. Salt / pollutant load WQ-8f. Snow removal / maintenance requirements WQ-8g. Underground services	P	Considerations WQ-8a & WQ-8b  Considerations WQ-8a, 8d & 8f
WQ-9 Filter Strip	Filter strips are gently-sloping, heavily-vegetated areas that treat runoff from adjacent impervious surfaces including roadways, sidewalks and driveways. They can be stand-alone stormwater management practices or they can function as pretreatment for other infiltration practices. Filter strips are well-suited to streets with a suburban cross-section or connector streets where no curbs presently exist.  Filter strips should be planted with native material in order to provide maximum ecological and water quality benefits. In the winter months, these areas are well-suited to provide snow storage capacity as they have an excellent capability to filter and infiltrate snow melt in the spring. Filter strips are also referred to as buffer strips.	✓	*		<b>✓</b>	<b>✓</b>	<b>✓</b> ✓	<i>'</i>	<b>✓</b>					<b>✓</b>	<b>✓</b>	Furnishing / Planting Zone						•			✓ I	<b>✓</b>	V V				v v v	VQ-9a. The flow path across the vegetated filter strip should be min. 5m to provide substantial water quality benefits. Vegetated filter strips incorporated as pre-treatment to another BMP may be designed with shorter flow path lengths VQ-9b. Filter strips are best used to treat runoff from ground-level impervious surfaces that generate sheet flow (e.g., roads and parking areas). Recommended filter strip slope is 1% – 5% VQ-9c. Max. flow path length across a contributing impermeable surface should be < 25m VQ-9c. Max. flow path length across a contributing impermeable surface should be < 25m VQ-9c. Max. flow path length across a contributing impermeable surface should be < 25m VQ-9c. Max. flow path length across a contributing impermeable surface should be < 25m VQ-9c. Max. flow path length across a contributing impermeable surface should be < 25m VQ-9c. Max. flow path length across a contributing impermeable surface should be < 25m VQ-9c. Allow for suitable on all soil types. If soils are highly compacted, or of such low fertility that vegetation cannot become established, they should be tilled to a depth of 300 mm and amended with composit to achieve an organic content of 8%- 15% by weight or 30%- 40% by volume VQ-9c. Facilities receiving road or parking lot runoff should not be located within 2 year time-of-travel wellhead protection area VQ-9f. Min. 1m separation between the bottom of swale and seasonal high water table or top of bedrock elevation VQ-9g. Runoff from pollution hot spots should not be treated by filter strips VQ-9h. Salt / pollutant load VQ-9i. Snow removal / maintenance requirements VQ-9i. Underground / overhead services	P	Consideration WQ-9i
WQ-10 Drainage Well	Drainage wells are vertical perforated pipes that are installed under the surface of a roadway and gradually allow stormwater to discharge into the surrounding native soils. They are connected to inlets along the street and because they treat roadway runoff, a pretreatment system is required. Due to their relatively small surface footprint, drainage wells can easily be implemented throughout a variety of street types including ultra-urban contexts, in both new construction and retrofit scenarios. Care must be taken throughout the design and construction processes to ensure that there are no conflicts with existing utilities in retrofit scenarios.					<b>✓</b>	v	<b>/ /</b>	<b>✓</b>							Furnishing / Planting Zone Vehicle Lanes		✓ ✓										/ /			✓ v	WQ-10a. Operation and maintenance WQ-10b. Min. 600mm separation between bottom of well and seasonal high ground water & min. 1 m clearance to bedrock WQ-10c. Min 6m between well and building foundation WQ-10c. Min 6m between well and building foundation WQ-10d. Must be designed in combination with pre-treatment system. WQ-10e. Maintenance requirements WQ-10f. Underground services WQ-10g. Proximity to TTC underground tunnel	Y	



Technical Guidelines

B15



								Ancillar	y Benet	its												Suit	able Str	eet Ty	pes									
Green Infrastructure / LID Option	Description	Reduced Heat Island Effect	Recaptured Green Space	Promote Habitat / Biodiversity Expanded Urban Tree	Canopy Enhanced Aesthetics	SWM Quality	Pollutant Removal	Groundwater recharge Reduced Stream Channel Erosion	Reduced Flood Risk	Energy Generation	Reduced Operational Cost	Remote Monitoring	Enhanced Visibility	Traffic Calming Human Comfort - Shade	Reduction in GHG Emissions	Potential Applications	Civic Streets	Downtown & Centres Main Street	Avenues & Neignbournood Vlain Street	Mixed-Use Accent Street  Downtown & Centres  Residential Street	Apartment Neighbourhood Residential Street	Neighborhood Residential Street Sub-type - Built Circa Pre-1950)	(Sub-type - Built Circa Post 1950)	Residential Connector Street	Scenic Street	Park Street	Mixed Use Shared Street	Residential Shared Street	Mixed-Use Lane	Residential Lane	Considerations	Feasibility Potential / Yes		Rationale
WQ-11 Perforated Pipe	Perforated Pipe Systems is an underground infiltrations system that is connected to catch basins installed within vehicle lanes or planting															Vehicle Lanes													✓ .	✓ WO	Q-11a. Designed with an impervious drainage area ratio of 5:1 to 10:1 Q-11b. Perforated pipe systems can be located over any soil type, but hydrologic soil group A and B soils are best for achieving water balance benefits. Facilities should be located in	Р	Conside	derations WQ-11i & WQ-11j
	zones. This type of system receives runoff from sidewalks, driveways and roadways. The system itself consists of perforated pipes that are installed					П						Ш				Furnishing / Planting Zone	✓	✓	✓	<b>✓ ✓</b>	<b>✓</b>	✓	<b>✓ ✓</b>	<b>✓</b>	<b>✓</b>	✓ v	<b>✓</b>	✓			portions of the site with the highest native soil infiltration rates Q-11c. Facilities receiving road or parking lot runoff should not be located within 2 year time-of- travel wellhead protection area			
	horizontally along a gently-sloping subsurface trench that is filled with granular and wrapped in geotextile fabric. They can be used in place of, or as a complement to, conventional pipe systems. Due to their relatively small surface footprint, perforated pipe systems can be implemented in almost any street type. However, because of the many constraints inherent to the retroft scenario, perforated pipe systems are ideally-suited to new construction projects.		ı			<b>✓</b>	,	<b>✓</b>	<b>/</b>									ı												WG WG WG WG	Q-11d. Min. 1m separation between the bottom of swale and seasonal high water table or top of bedrock elevation Q-11e. Min. 4m offset from building foundations Q-11f. Runoff from pollution hot spots should not be treated by perforated pipe systems Q-11g. Salt / pollutant load Q-11h. Maintenance requirements Q-11i. Underground services Q-11j. Proximity to TTC underground tunnel			
WQ-12 Soakaway	Soakaways are rectangular excavations, lined with geotextile and filled with clear stone created under											П				Vehicle Lanes													✓ .		Q-12a. Designed with an impervious drainage area ratio of 5:1 to 20:1. Max. ratio of 10:1 is recommended for facilities receiving road or parking lot runoff	Р	Conside	derations WQ-12i & WQ-12j
ND EFF	a hard or a soft landscape area. They receive, attenuate and infiltrate runoff from sidewalks and other paved surfaces and are ideally-suited for											Ш				Furnishing / Planting Zones										✓ v				VVC	Q-12b. Soakaways, infiltration trenches and infiltration chambers can be constructed over any soil type, but hydrologic soil group A or B soils are best for achieving water balance and channel erosion control objectives. Facilities should be located in portions of the site with	Р	Conside	derations WQ-12i & WQ-12j
гу, аиампту а	application within the planting zones of residential streets or under low volume vehicle lanes (i.e. multi-use or residential lanes). Soakaways are also referred to as infiltration galleries, dry wells or soakaway pits.		ı				<b>\</b>									Bridges						<b>✓</b>	<b>✓</b> ✓	<b>✓</b>	<b>✓</b>	✓ <b>v</b>	<b>✓ ✓</b>			W	the highest native soil infiltration rates Q-12c. Facilities receiving road or parking lot runoff should not be located within 2 year time-of- travel wellhead protection area; Q-12d. Min. 1m separation between the bottom of swale and seasonal high water table or top of bedrock elevation; Q-12e. Min. 4m offset from building foundations	P	Conside	derations WQ-12i & WQ-12j
WQ-13 Infiltration Trench	Infiltration trenches are a design variation of a soakaway that consists of a linear trench lined with															Vehicle Lanes													✓ .		Q-13a. Designed with an imperious drainage area ratio of 5:1 to 20:1. Max. ratio of 10:1 is recommended for facilities receiving road or parking lot runoff	Р	Conside	derations WQ-13i & WQ-13j
ATER	geotextile fabric and filled with clear granular stone. Infiltration trenches are well-suited for areas where space is limited to a narrow strip including								Ш			Ш				Furnishing / Planting Zones						✓	<b>√</b> ✓	<b>✓</b>	<b>✓</b>	✓ v	/ /	✓		VVC	Q-13b. Soakaways, infiltration trenches and infiltration chambers can be constructed over any soil type, but hydrologic soil group A or B soils are best for achieving water balance and channel erosion control objectives. Facilities should be located in portions of the site with	Р	Conside	derations WQ-13i & WQ-13j
\$	medians, planting zones or low volume vehicle lanes (i.e. multi-use or residential lanes). They can be covered with stone, vegetation or paving								Ш			Ш				Cycling Infrastructure	<b>✓</b>	<b>√</b>				✓	<b>✓</b>	<b>✓</b>	<b>✓</b>	✓ v				wo	the highest native soil infiltration rates Q-13c. Facilities receiving road or parking lot runoff should not be located within 2 year time-of- travel wellhead protection area	P	Conside	derations WQ-13i & WQ-13j
	depending on context. Infiltration trenches are also referred to as linear infiltration galleries or linear					<b>✓</b>	<b>✓</b>	<b>/</b>				Ш				On-street Parking			✓	<b>✓</b>		✓									Q-13d. Min. 1m separation between the bottom of swale and seasonal high water table or top of bedrock elevation	Р	Conside	derations WQ-13i & WQ-13j
	soakaways.								Ш			Ш				Parking Lay-Bys					<b>V</b>	<b>√</b>				✓ v					Q-13e. Min. 4m offset from building foundations Q-13f. Runoff from pollution hot spots should not be treated soakaways, infiltration trenches or infiltration chambers	P		derations WQ-13i & WQ-13j
																Bridges  Medians / Raised Islands						•	v v	<b>V</b>		V				W	Q-13g. Salt / pollutant load Q-13h. Snow removal / maintenance requirements Q-13i. Underground / overhead services	P		derations WQ-13i & WQ-13j
WQ-14 Infiltration Chamber	Infiltration chambers are another design variation								H			H				Vehicle Lanes													<b>√</b> .		Q-13j. Proximity to TTC underground tunnel Q-14a. Designed with an impervious drainage erea ratio of 5:1 to 20:1. Max. ratio of 10:1 is	P		derations WQ-14i & WQ-14i
(Oil & grit separator, sedimentation chamber or goss trap)	on soakaways that incorporate prefabricated modular chambers that are installed under medians, planting zones or low volume vehicle															Furnishing / Planting Zones						<b>✓</b>	✓ ✓	<b>✓</b>	✓	✓ v	/ /	<b>✓</b>		W	recommended for facilities receiving road or parking lot runoff Q-14b. Soakaways, infiltration trenches and infiltration chambers can be constructed over any soil type, but hydrologic soil group A or B soils are best for achieving water balance and	P		derations WQ-14i & WQ-14j
3	lanes (i.e. multi-use or residential lanes) to store runoff temporarily before infiltrating it into the underlying native soils. The chambers typically															Cycling Infrastructure	<b>✓</b>	✓	<b>✓</b>			✓	<b>✓</b>	<b>✓</b>	✓ <b>✓</b>	✓ v	/			\A/(	channel erosion control objectives. Facilities should be located in portions of the site with the highest native soil infiltration rates	Р	Conside	derations WQ-14i & WQ-14j
	have an open bottom and perforated side walls and are usually placed over a stone reservoir.						<b>√</b> \	/								On-street Parking			✓	<b>✓</b>	<b>✓</b>	✓	<b>√</b>							W	Q-14c. Facilities receiving road or parking lot runoff should not be located within 2 year time-of- travel wellhead protection area Q-14d. Min. It m separation between the bottom of swale and seasonal high water table or top of	Р	Conside	derations WQ-14i & WQ-14j
	They can be installed individually or in series depending on available space. Infiltration chambers are well-suited to new construction															Parking Lay-Bys					<b>✓</b>	✓	<b>✓</b>								bedrock elevation Q-14e. Min. 4m offset from building foundations Q-14f. Runoff from pollution hot spots should not be treated soakaways, infiltration trenches or	Р	Conside	derations WQ-14i & WQ-14j
	scenarios, but can also be integrated into retrofit projects with careful planning. Infiltration chambers															Bridges						✓	<b>✓</b> ✓	<b>✓</b>	<b>✓</b>	✓ v	/			wo	infiltration chambers Q-14g. Salt / pollutant load	Р	Conside	derations WQ-14i & WQ-14j
	are also be referred to as infiltration tanks.															Medians / Raised Islands							<b>✓</b>	<b>✓</b>		•				W	Q-14h. Maintenance requirements Q-14i. Underground services Q-14j. Proximity to TTC underground tunnel	Р	Conside	derations WQ-14i & WQ-14j



					Ancillary Bei	nefits									Suitable St	reet Typ	es						
Green Infrastructure / LID Option	Description	Reduced Heat Island Effect Recaptured Green Space Promote Habitat / Biodiversity	Expanded Urban Tree Canopy Enhanced Aesthetics SWM Quality	Pollutant Removal	Groundwater Recharge Reduced Stream Channel Erosion Reduced Flood Risk	Energy Generation	Energy Conservation Reduced Operational Cost Remote Monitoring	Enhanced Visibility Traffic Calming	Human Comfort - Shade Reduction in GHG Emissions	Potential Applications	Civic Streats Downtown & Centres Main Street	Avenues & Neighbourhood Main Street	Mixed-Use Accent Street  Downtown & Centres Residential  Street	Apartment Neighbourhood Residential Street Neighborhood Residential Street	(Sub-type - Built Circa Pre-1950) Neighborhood Residential Street (Sub-type - Built Circa Post 1950)	Residential Connector Street	Scenic Street	Park Street Employment Street	Mixed Use Shared Street Residential Shared Street	Mixed-Use Lane	Considerations  Considerations	Feasibility Potential / Yes	Rationale
	Unlike traditional impervious surfaces, Permeable Pavement allows stormwater to infiltrate through									Vehicle Lanes									✓ v	/ /	WQ-15.a. Surface should be at least 1% and no greater than 5% WQ-15.b. Impervious area treated should not exceed 1.2 times the area of permeable pavement	Р	Considerations WQ-15I, 15m & 15n
	the surface into a subsurface stone reservoir rather than collecting and being conveyed as surface runoff. Stormwater is then temporarily									On-street Parking		✓ .	<b>√</b> ✓	✓ .	<b>✓</b> ✓						WQ-15.c. Systems located in native soils with an infiltration rate of < 15 mm/hr require a perforated pipe underdrain  WQ-15.d. Facilities receiving road or parking lot runoff should not be located within 2 year time-of-	Р	Considerations WQ-15I, 15m & 15n
	detained and, in most cases, infiltrated into the native subsoils. Similar to other infiltration-based									Parking Lay-Bys		✓ .	<b>√</b> ✓	✓ .	<b>✓</b> ✓						travel wellhead protection area  WQ-15.e. Min. 1m separation between the bottom of swale and seasonal high water table or top of	Р	Considerations WQ-15I, 15m & 15n
	practices, the requirement for an underdrain relates directly to the permeability of underlying									Cycling Infrastructure	✓ ✓	✓ .	<b>√</b>		✓ v	✓ ✓	✓	✓ ✓	,		bedrock elevation WQ-15.f. Min. 4m offset from building foundations	Р	Considerations WQ-15I, 15m & 15n
	native soils. Permeable Pavements can be used in both new and retrofit scenarios.		<b> </b>		<b>√</b>					Sidewalks	✓ ✓	✓ .	<b>√</b> ✓	✓ .	✓ <b>✓</b> ,	✓ ✓	✓	✓ ✓	<b>√</b> ∨	/	WQ-15.g. Runoff from pollution hot spots should not be treated by Permeable Paving WQ-15.h. Porous asphalt and pervious concrete will not properly pour and set in extremely high and low temperatures	Р	Considerations WQ-15I, 15m & 15n
	Pervious Concrete has fewer fines then conventional concrete, creating void spaces (15%-35%) within the material. This materials provides a suitable replacement for conventional concrete throughout all street Typesfor use in sidewalk applications and is ideally-suited to applications within sites where space is limited.																				WQ-15.i. Properly installed permeable pavement requires trained and experienced producers and construction contractors WQ-15.j. Treatment area should be fully protected during construction so that no sediment reaches the permeable pavement system. Construction traffic should be blocked from the permeable pavement and its drainage areas once the pavement has been installed WQ-15s. Salt / pollutant load WQ-15. Snow removal / maintenance requirements WQ-15m. Underground services WQ-15n. Proximity to TTC underground tunnel		
	Porous asphalt features air pockets that are created as a result of the inclusion of fewer fines									Vehicle Lanes			✓	✓ .	<b>✓</b> ✓			✓	✓ <b>∨</b>	<b>✓</b>	Refer to Considerations of the 'WQ-15i Permeable Pavements - Pervious Concrete' above	Р	Considerations WQ-15I, 15m & 15n
1 orodo Alopridat	and less sand content than traditional impervious asphalt. These void spaces allow water to filter through to the aggregate layer below. Porous									On-street Parking			✓	✓ .	<b>✓</b>							Р	Considerations WQ-15I, 15m & 15n
	asphalt provides a suitable alternative to conventional asphalt and can be used within road		/		<b>√</b>   <b>√</b>   <b>√</b>					Parking Lay-Bys			✓	✓ .	<b>✓</b> ✓							Р	Considerations WQ-15I, 15m & 15n
	rights-of-way in areas such as cycling infrastructure, parking lay-bys, and multi-use									Cycling Infrastructure	<b>✓ ✓</b>	✓ .	<b>✓</b>	•	✓ v	✓ ✓	✓	<b>✓</b> ✓				Р	Considerations WQ-15I, 15m & 15n
	recreational trails.									Sidewalks								✓				Р	Considerations WQ-15I, 15m & 15n
Permeable	Permeable concrete paver systems have expanded joints that allow for 5%-10% of a paved									On-street Parking		✓ .	<b>√</b> ✓	✓ .	<b>✓</b> ✓				✓ v	/	Refer to Considerations of the "WQ-15i Permeable Pavements - Pervious Concrete' above	Р	Considerations WQ-15l, 15m & 15n
Precast Concrete	surface area to be filled with porous aggregate material. These voids allow water to filter through to the aggregate layer below. Permeable concrete									Parking Lay-Bys		✓ .	<b>✓</b> ✓	✓ .	<b>✓</b>			✓	✓ v	/		Р	Considerations WQ-15I, 15m & 15n
Pavers	to the aggregate layer below. Permeable concrete pavers can be used in a variety of applications such as for laneway paving, decorative paving				✓ <b>/</b> ✓					Decorative Paving	✓ ✓	✓ .	<b>✓</b>				✓	<b>√</b> ✓	<b>√</b> ∨	/		Р	Considerations WQ-15I, 15m & 15n
	treatments and parking lay-bys within various street types.				v V V					Sidewalks	✓ ✓	✓ .	<b>✓</b>	7			✓	✓ ✓	<b>√</b> ∨	/		Р	Considerations WQ-15I, 15m & 15n
										Crosswalks	<b>✓</b> ✓	✓ .	<b>✓</b> ✓	✓ .	<b>✓</b> ✓		<b>✓</b>	<b>√</b> ✓	<b>√ ∨</b>	/		Р	Considerations WQ-15I, 15m & 15n
										Vehicle Lanes										<b>✓</b>	<b>✓</b>	Р	Considerations WQ-15I, 15m & 15n



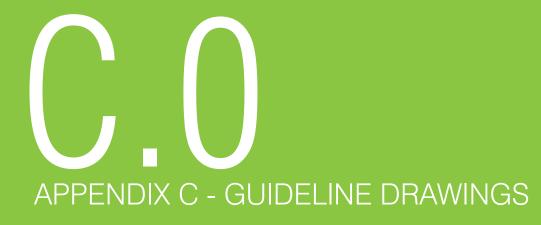
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Green Infrastructure / LID Option	Description	Reduced Heat Island Effect Recaptured Green Space	Promote Habitat / Biodiversity	xpanded Urban Tree Canopy	Enhanced Aesthetics	Pollutant Removal	Broundwater Recharge	Reduced Stream Channel Erosion	Reduced Flood Risk	Energy Conservation	Remote Monitoring	Enhanced Visibility	raffic Calming luman Comfort - Shade	Reduction in GHG Emissions	Potential Applications	Civic Streets	owntown & Centres Aain Street venues & Neighbourhood	Aain Street Mixed-Use Accent Street	owntown & Centres Residential treet partment Neighbourhood	tesidential Street leighborhood Residential Street Sub-type - Built Circa Pre-1950)	Sub-type - Built Circa Post 1950)  Gub-type - Built Circa Post 1950)  Guined-Use Connector Street	esidential Connector Street	Scenic Street	Park Street	Mixed Use Shared Street	Residential Shared Street	Mixed-Use Lane	Considerations	Feasibility Potential / Yes	Rationale
	Stormwater tree pits are a variation of the traditional tree pit that receives stormwater runoff		Ť	ш о			J								Furnishing / Planting Zones	✓	√ \	/	✓ <b>,</b>	/ 23.	<u>∠</u>	<u>~</u> ✓			<u>-</u>	<b>✓</b>		WQ-16a. Operation and maintenance WQ-16b. Salt/pollutant load	Р	Considerations WQ-16c & WQ-16d
	from the road through curb inlets. They consist of a tree installed in filter media with an open bottom to promote infiltration into the surrounding native	<b>✓</b>	✓	<b>✓</b>	<b>√</b>	\[ \square \] \[ \square \	<b>✓</b>	✓ .	<b>✓</b>				~	<b>/</b>	Medians / Raised Islands	✓					<b>✓</b>	<b>✓</b>		~				WC-16c. Overhead / underground services WC-16d. Proximity to TTC underground tunnel WC-16e. Plants selected for tolerance to short periods of inundation and prolonged dry periods	Р	Considerations WQ-16c & WQ-16d
	soils.																											WC-16: Flants selected on obligations of solid periods of infinitiation and prototiged dry periods WC-16: Steel quards recommended for protection of pedestrians WC-16g. Suitable in areas of steep topography		
WQ-17 Stormwater Tree Trenches	Stormwater tree trenches consist of a series of stormwater tree planters connected through the														Furnishing / Planting Zones	✓	<b>√</b> ,	/	✓ 、		✓	✓ ✓		~	✓ ✓	✓		WQ-17a. Operation and maintenance WQ-17b. Salt/pollutant load	Р	Considerations WQ-17c & WQ-17d
	underground trench system. The excavated trenches are backfilled with engineered soil. Soil volumes can be further augmented by installing	✓	✓	<b>√</b>	✓ ✓	<b>✓</b>	<b>✓</b>	✓	✓				~	′ ✓	Medians / Raised Islands	✓					<b>✓</b>	✓ ✓		<b>✓</b>				WC-17c. Overhead / underground services WC-17d. Proximity to TTC underground tunnel WC-17e. Plants selected for tolerance to short periods of inundation and prolonged dry periods	Р	Considerations WQ-17c & WQ-17d
	soil cells.																											WQ-17f. Steel guards recommended for protection of pedestrians		
WQ-18 Rainwater Harvesting - Rain Barrel & Cistern	Rainwater cisterns intercept, convey and store rainfall for future use. Within the right-of-way there are opportunities to capture runoff in prefabricated														Frontage Zone	✓	<b>√</b> ,	/ /	✓ ,									WQ-18a. Storage tanks can be placed underground, indoors, on roofs, or adjacent to buildings depending on intended uses of the rainwater	P	Considerations WQ-18k, 18n & 18o
	cisterns below grade and then to reuse rainwater for irrigation and maintenance purposes. This type																											WQ-18a. Site topography influences the placement of the storage tank and design of the distribution and overflow systems WQ-18a. Underground cisterns should be placed on or in native, rather than fill soil		
	of system can be effective in reducing demands on the municipal potable water system.																											WQ-18b. Rain barrels or above ground cisterns with gravity distribution systems should be sited up-gradient from landscaping areas to which rainwater is to be applied		
	and manuspar potable water system.																											WQ-18c. Can be an effective BMP for roof runoff from sites where land uses or activities at ground level have the potential to generate highly contaminated runoff		
																												WQ-18a. Can be used throughout the winter if located below the local frost penetration depth WQ-18e. Underground utilities may constrain location of underground storage tanks		
					✓			<b>✓</b>	✓																			WQ-18f. Code allows the use of harvested rainwater for toilet and urinal flushing, but systems		
																												require installation of backflow prevention devices WQ-18g. If improperly managed, tanks can create habitat suitable for mosquito breeding, so		
																												screens should be placed on inlets and outlets to prevent entry  WQ-18h. Cisterns with openings large enough for children to enter must have lockable covers		
																												WQ-18i. Tanks should be water tight to avoid ponding or saturation of soils WQ-18j. Underground tanks sited in areas without vehicular traffic		
																												WQ-18l. Maintenance requirements		
																												WQ-18m. Underground services		
																												WQ-18n. Operation / maintenance WQ-18o. Ownership / responsibility		

### TORONTO GREEN STREETS GUIDELINE SHORT LIST OF GREEN INFRASTRUCTURE OPTIONS - ECOLOGY



							A	ncillary	Benefit	s												Suit	table	Street Ty	oes							
	Green Infrastructure / LID Option	Description	Reduced Heat Island Effect Recaptured Green Space	Promote Habitat / Biodiversity Expanded Urban Tree	Canopy Enhanced Aesthetics	SWM Quality	Pollutant Removal Groundwater Recharde	Reduced Stream Channel Erosion	Reduced Flood Risk	Energy Ceneration	Reduced Operational Cost	Remote Monitoring	Enhanced Visibility Traffic Calming	Human Comfort - Shade	Reduction in GHG Emissions	Potential Applications	Civic Streets	Downtown & Centres Main Street Avenues & Neighbourhood	Main Street	Mixed-Use Accent Street  Downtown & Centres Residential  Street	Apartment Neighbourhood Residential Street	Neighborhood Residential Street (Sub-type - Built Circa Pre-1950)	Neighborhood Residential Street (Sub-type - Built Circa Post 1950)	Mixed-Use Connector Street Residential Connector Street	Scenic Street	Park Street	Employment Street Mixed Use Shared Street	Residential Shared Street	Mixed-Use Lane	Considerations Feasib Potential I		Rationale
٨	E-1 Natural Tree Canopy	The natural (urban) tree canopy is composed of all the layers of leaves, branches and stems that cover the ground. Tree canopy performs critical ecological functions within the urban environment such as managing stormwater, reducing the urban heat island effect and air pollution and providing wildlife habitat. An enhanced tree canopy also has an aesthetic value, improves quality of life and increases property values.  The City of Toronto seeks to increase tree canopy cover to 40% (Toronto's Strategic Forest Management Plan 2012-2022), therefore designers should look for opportunities to integrate trees within the City's rights-of-way. Tree planting is appropriate within all street types with the exception of residential and mixed-use lanes. Large canopy native species are preferred.	<b>✓</b>	✓	<b>✓</b>	<b>✓</b>	<b>✓</b> ✓	✓	<b>✓</b>					<b>✓</b>	✓	Furnishing / Planting Zones	<b>√</b>	✓ .	•		~	<b>✓</b>	<b>√</b>	<b>✓</b> ✓	<b>✓</b>	✓ ✓		✓		E-1a. Available soil volume E-1b. Soil characteristics E-1c. Salt / pollutant load E-1d. Overhead or underground services E-1e. Pedestrian load E-1f. Proximity to natural heritage system E-1g. Microclimate E-1h. Maintenance requirements		
ECOLOGY	E-2 Native Herbaceous Plantings	Native herbaceous plants are indigenous to the Toronto region and are characterized by their lack of woody stems above ground level. Herbaceous plant material can be integrated into a variety of Gl options to promote pollinator habitat and enhance biodiversity within Toronto's streets. Plant material should not only be selected for its aesthetic upity and habitat value, but also based on site specific requirements and tolerance to drought and urban conditions.	<b>✓</b>	<b>✓</b>	<b>✓</b>	<b>✓</b>	✓ <b>✓</b>	✓	~						F	Furnishing / Planting Zones	✓	✓ .	<b>√</b> •		✓	<b>√</b>	✓	<b>✓</b> ✓	<b>✓</b>	√ v		<b>√</b>		E-2a. Available soil volume E-2b. Soil characteristics E-2c. Salt / pollutant load E-2d. Pedestrian load E-2e. Microclimate E-2f. Maintenance requirements		
	E-3 Ecopassages	Ecopassages are bridges and tunnel systems that guide animals and reptiles safely over or under roads and highways. Within the City of Toronto, ecopassages can be particularly valuable on streets that bisect the Natural Heritage System (NHS) by facilitating wildlife migration and aiding in the reduction of road mortality. The Toronto and Region Conservation Authority's (TRCA) Crossings Guideline document address ecopassage design in detail and should be referenced whenever ecopassages are considered for implementation as part of a Green Street project.		<b>✓</b>											V	/ehicle Lanes						<b>√</b>	✓	<b>✓</b> ✓	<b>✓</b>	<b>√</b> •				E-3a. Traffic Flow E-3b. Available soil volume E-3c. Underground services E-3d. Proximity to natural heritage system E-3e. Maintenance requirements	Cc	onsiderations E-3c & E-3d
	E-4 Light Limitation	Excessive light stray from street lights can impact wildlife and wildlife habitats. Limiting light dispersion at night can assist in maintaining native wildlife populations, habitats and ecological functions. Every effort should be made on all new street and street retrofit projects to limit light dispersion by making appropriate fixture choices and providing targeted luminaire placement. This is particularly critical on streets that bisect the City's NHS.		<b>✓</b>													✓	<b>✓</b> .	· ·	✓ ✓	<b>✓</b>	<b>✓</b>	<b>✓</b>	✓ ✓	~	✓ v	/ /	<b>✓</b>	✓ <b>∨</b>	E-4a. Proximity to tributaries and natural heritage systems		

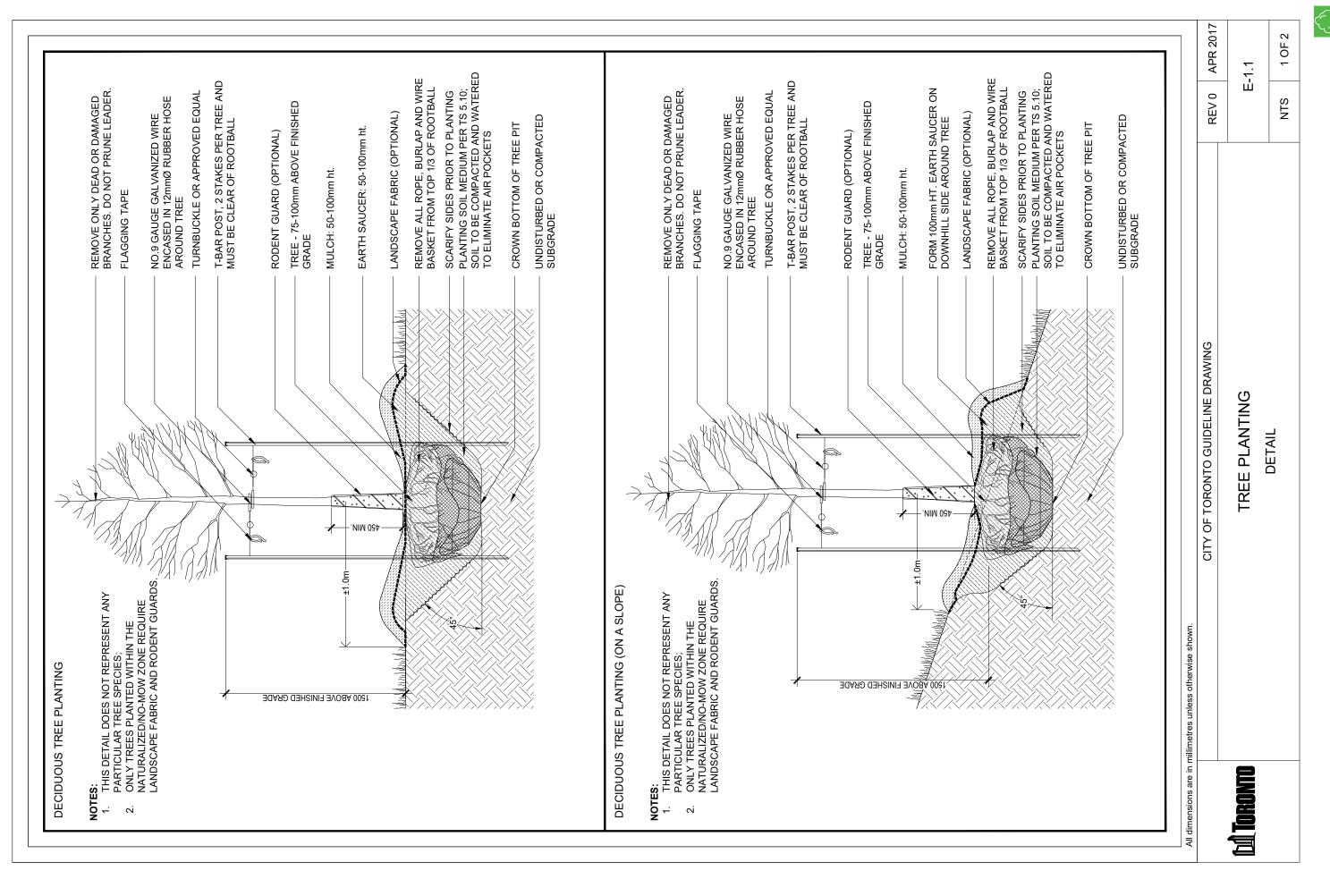




# GREEN INFRASTRUCTURE OPTIONS - TECHNICAL DRAWINGS - INDEX

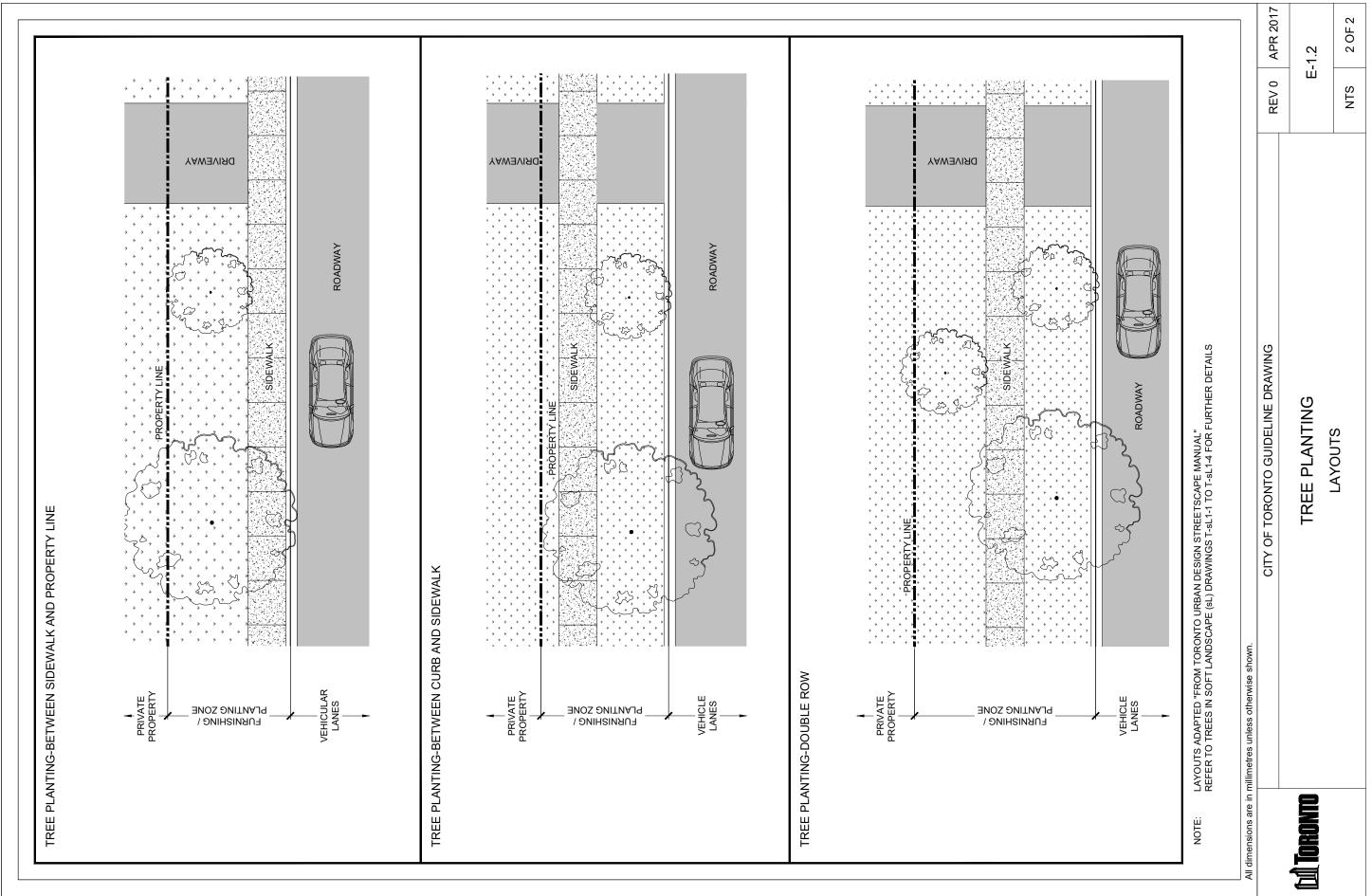
	Number		Name	Applications
J	1		Natural Crant Tran Direting	
\ <b>9</b> 0	E-2		Native Herbaceous Planting	
100	E-3	(TRCA)	Ecopassages	
3	E-4		Light Limitation	
	AQ-1	(MS)	Green Walls	Bridges
L	AQ-2		Street Trees	
LIT∀	AQ-2A			Frontage Zones, Furnishing / Planting Zones/Parking Lay-Bys, Medians
/ <b>n</b> `C	AQ-2B		Trees in Open Tree Planter	Frontage Zones, Furnishing / Planting Zones, Medians
וצ כ	AQ-2C	(MS)	ole Planters	Frontage Zones, Furnishing / Planting Zones, Medians
Ι <b>Α</b>	AQ-2D	(MS)	Precast Tree Planters	Frontage Zones, Furnishing / Planting Zones, Medians
	AQ-3	(MS)	Photocatalytic Paving	On-Street Parking Lanes Lanes / Cycling Infrastrcture / Sidewalks / Decorative Paving
J	GHG-1	(SM)	I ED Lights	Street Lights/Decorative Lighting
3 <b>Θ</b> .	GHG-2	(MS)	ovoltaic Panels	Street Lights/Decorative Lighting / Parking Meters / Vehicle Charging Stations /Decorative Paving
	GHG-3	(SW)		Sidewalks / Ording Infrastrcture / Crosswalks / On-Street Parking Lanes
IEI EN	GHG-4	(MS)	Lights	Steemans) - Comis initiastricas estats / Grosswalks Cycling Infrastricture / Sidewalks / Crosswalks
	GHG-5	(SW)	Road Markings	Vehicle Lanes / Cycling Infrastrcture / Crosswalk
	9-9H9	(MS)		Street Lights
Ð	GHG-7	(MS)	nts	All Paved Surfaces
	WO-1.1		Bioretention - Planters	Furnishing / Planting Zones / Bridges / Medians - Islands - R-A
	WQ-2.1		Stormwater Planters	Frontage Zones / Bridges
	WQ-3.1		Bioretention - Curb Extensions	Intersections / Mid-block / Transit Stops
	7 7 0 7 7			Functional Danger ( Mandian Daired Islands
	WQ-4.1		- Cells	/ Planting Zones /
<b>X</b>	WQ-5.1		Rain Gardens	Furnishing / Planting Zones / Medians - Raised Islands
ON	WQ-6.1		Enhanced Grass Swales	Furnishing / Planting Zones / Bridges / Medians - Raised Islands
310	WO-7.1		Dry Swales/Bioswales	Furnishing / Planting Zones / Furnishing / Planting Zones / Bridges / Medians - Raised Islands
FIC				
43	WQ-7.2		Bioswales with Stone Well	Furnishing / Planting Zones / Medians - Raised Islands /Bridges
ΝD	WQ-8.1		Green Gutters	Edge Zone / Dedicated LRT
IA v	WQ-9.1		Filter Strips / Buffer Strips	Furnishing / Planting Zones
ŒΙ.	WQ-10.1		Drainage Wells	Vehicle Lanes
LNV	WQ-11.1		Perforated Pipe Systems	Vehicle Lanes / Furnishing / Planting Zones
מחע	WQ-12.1		Soakaways	Vehicle Lanes / On-Street Parking Lanes / Parking Lay-Bys / Cycling Infrastrcture / Furnishing / Planting Zanes / Madians - Paiced Islands / Pridges
۲۷,				Haikiig zoites / Medians - Maised Islands / Dinges
ΓΙΊΑι	WQ-13.1		Infiltration Trenches	Vehicle Lanes / On-Street Parking Lanes / Parking Lay-Bys / Cycling Infrastrcture / Furnishing / Planting Zones / Medians - Raised Islands / Bridges
צ סר	WQ-14.1		Infiltration Chambers	Vehicle Lanes / On-Street Parking Lanes / Parking Lay-Bys / Cycling Infrastrcture / Furnishing / Planting Zones / Medians - Raised Islands / Bridges
37				ומונחוק בטוכז / יזיכעומוז יזעוזרע ומומונע זי אינישרע יזימוזען אינישרע יזימוזען אינישרע יזימוזען אינישרע יזימוזען
ΓAΛ	WQ-15.i		Permeable Pavement - Pervious Concrete	On-Street Parking Lanes / Parking Lay-Bys / Cycling Infrastrcture /Sidewalks
N	WQ-15.ii		Permeable Pavement - Porous Asphalt	Vehicle Lanes / On-Street Parking Lanes / Parking Lay-Bys / Cycling Infrastrcture
	WQ-15.iii		Permeable Pavement - Interlocking Precast Concrete Pavers	Vehicle Lanes / On-Street Parking Lanes / Parking Lay-Bys / Cycling Infrastrcture
	WQ-16.1		Stormwater Tree Pits	Furnishing / Planting Zones / Medians - Raised Islands / Bridges
	WO-17 1		Stormwater Tree Trenches	Firnishing / Planting Zones / Medians - Raised Islands / Bridges
	WQ-18.1	Rainwater Cistern	Rainwater Cistern	Frontage Zones

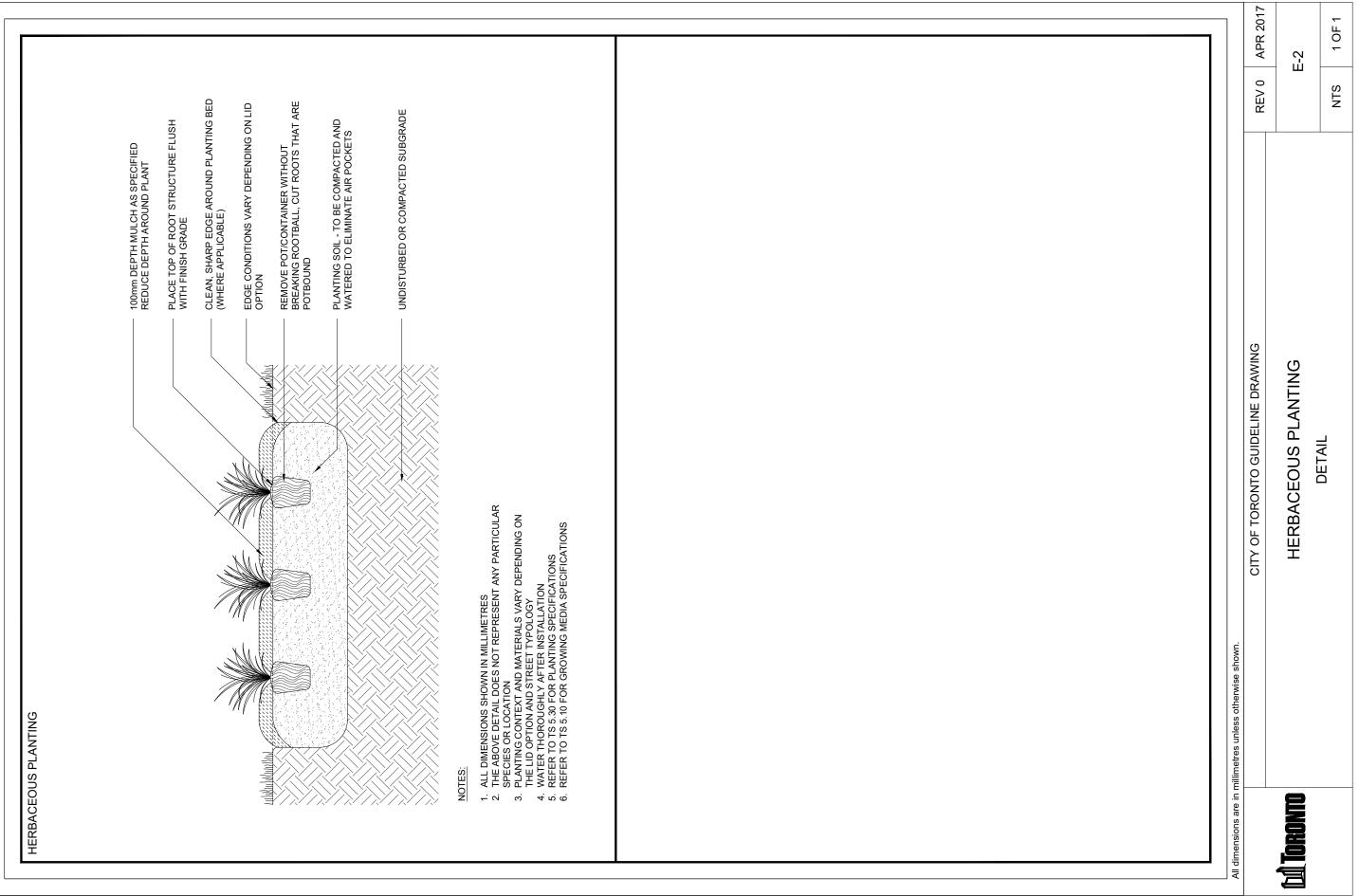
<sup>\*(</sup>MS) - Multiple options - Refer to Manufacturer's Specifications \*(TRCA) - Refer to TRCA Crossing Guideline for Valley and Stream Corridors



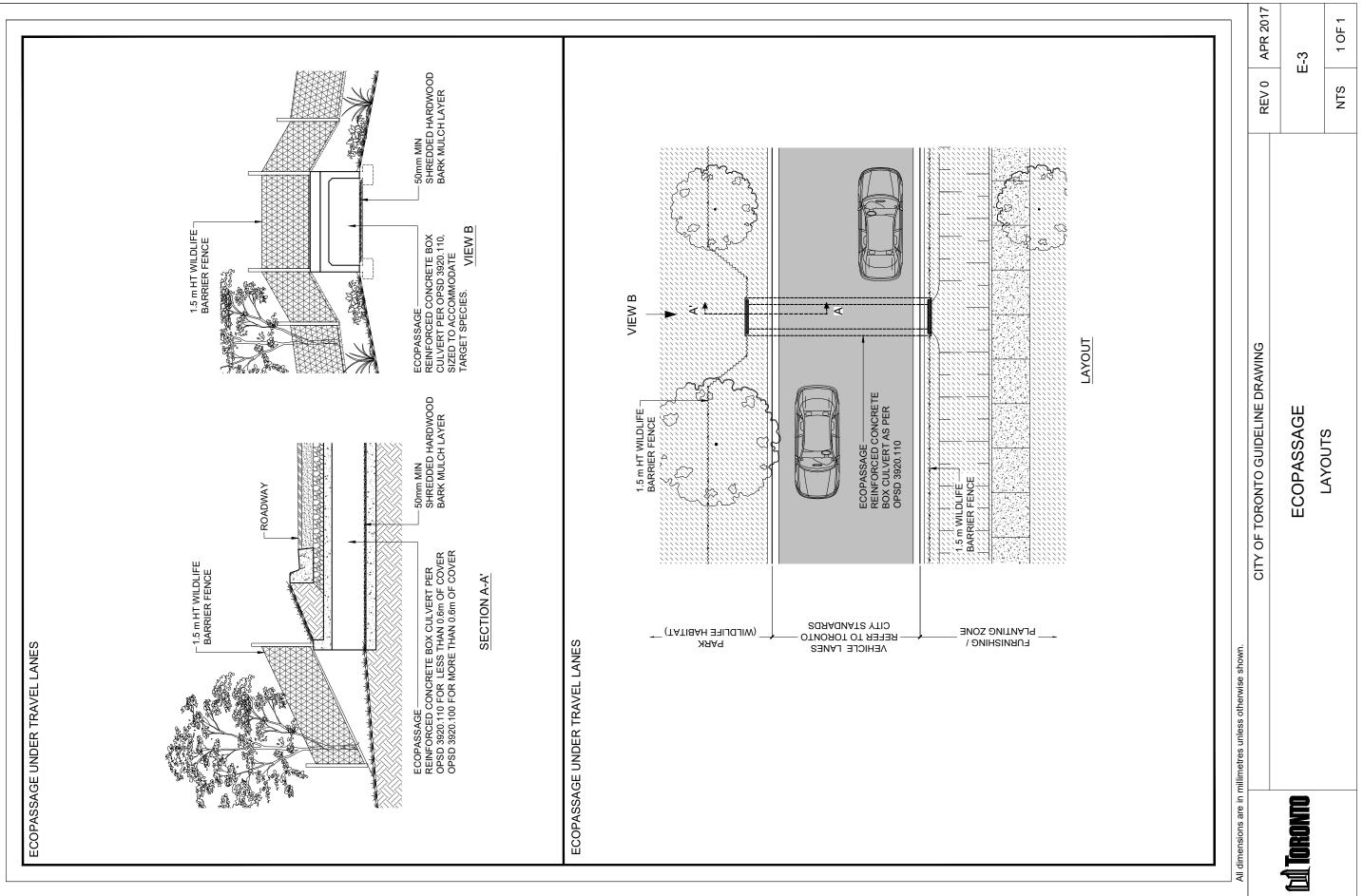
Green Streets Technical Guidelines

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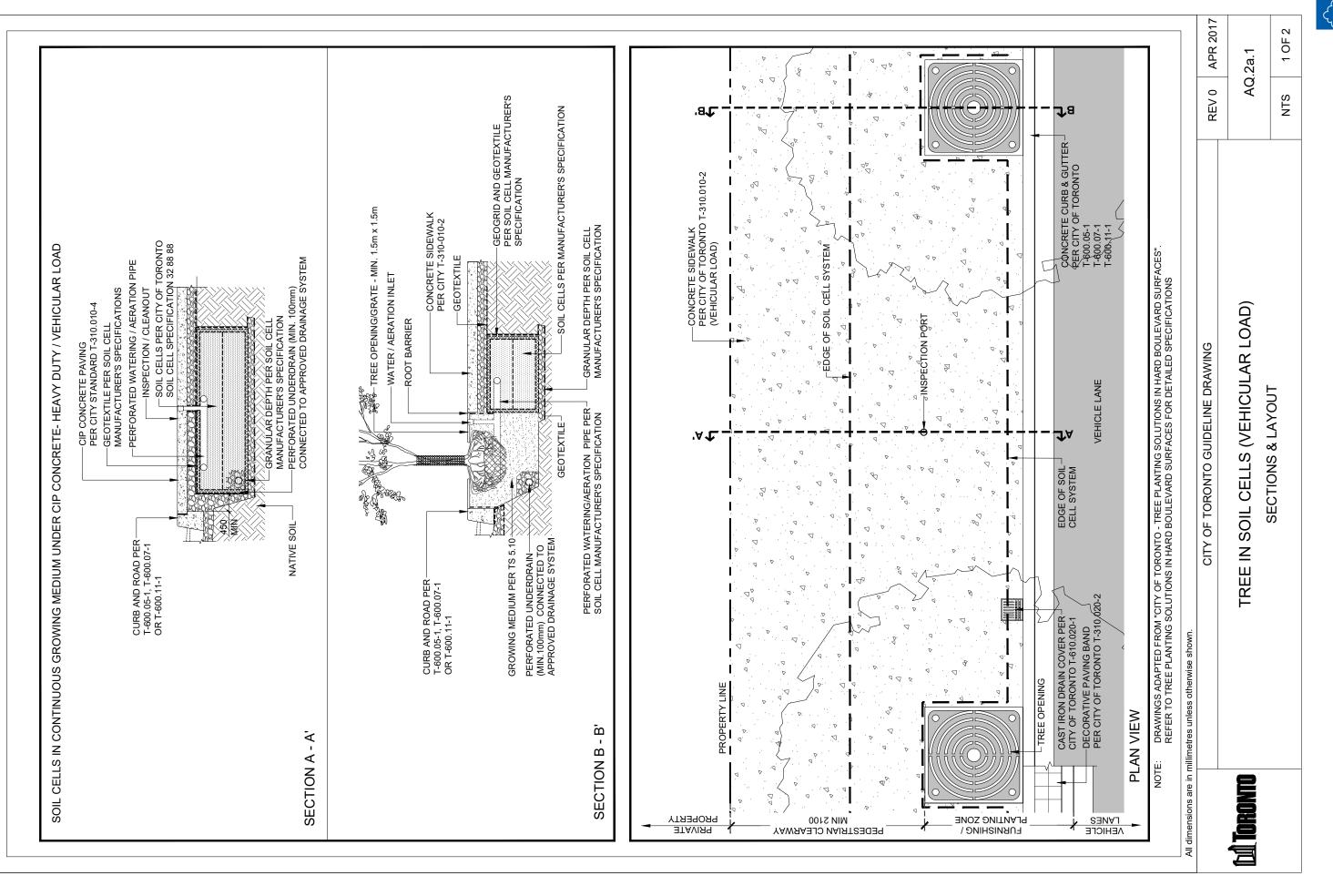


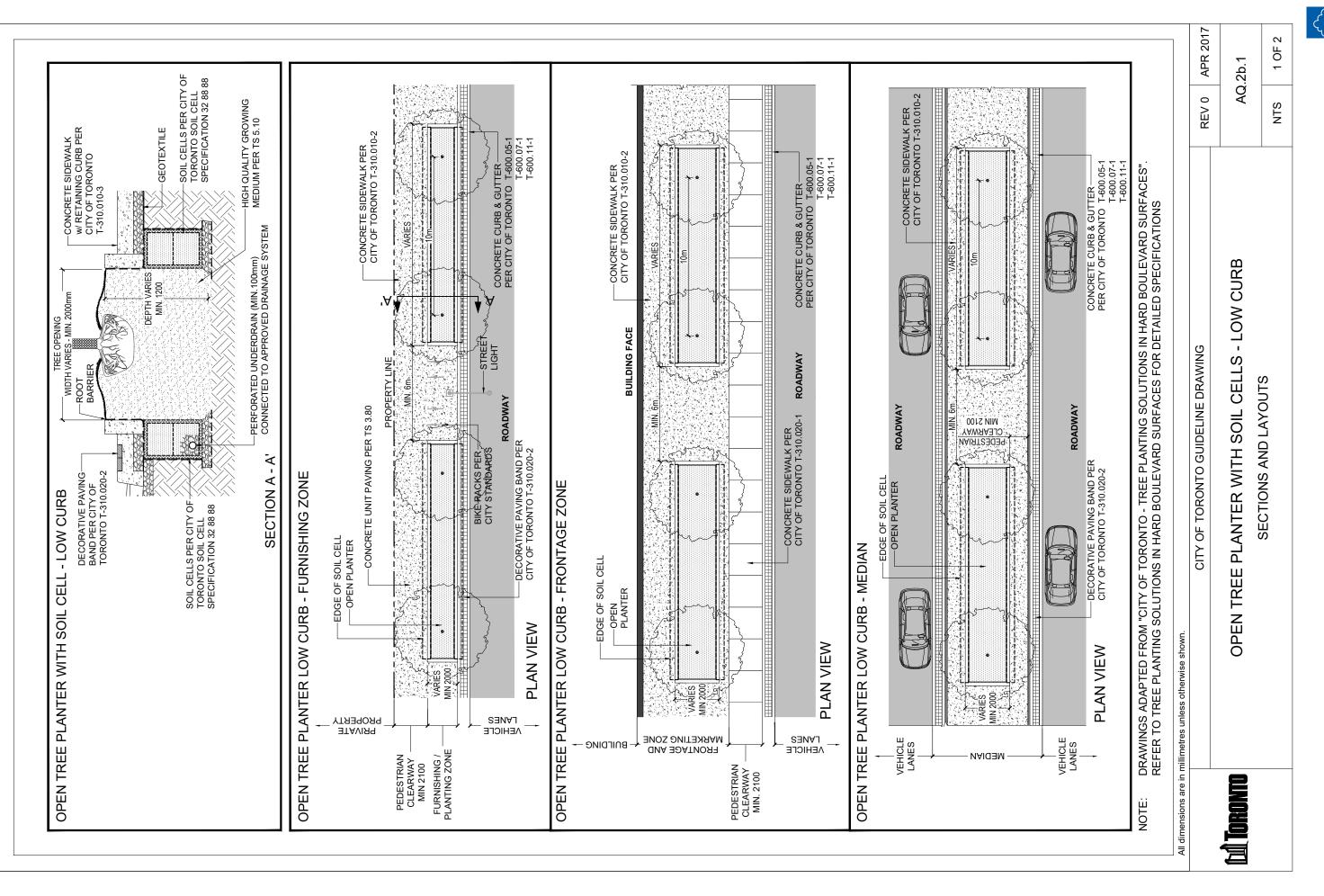
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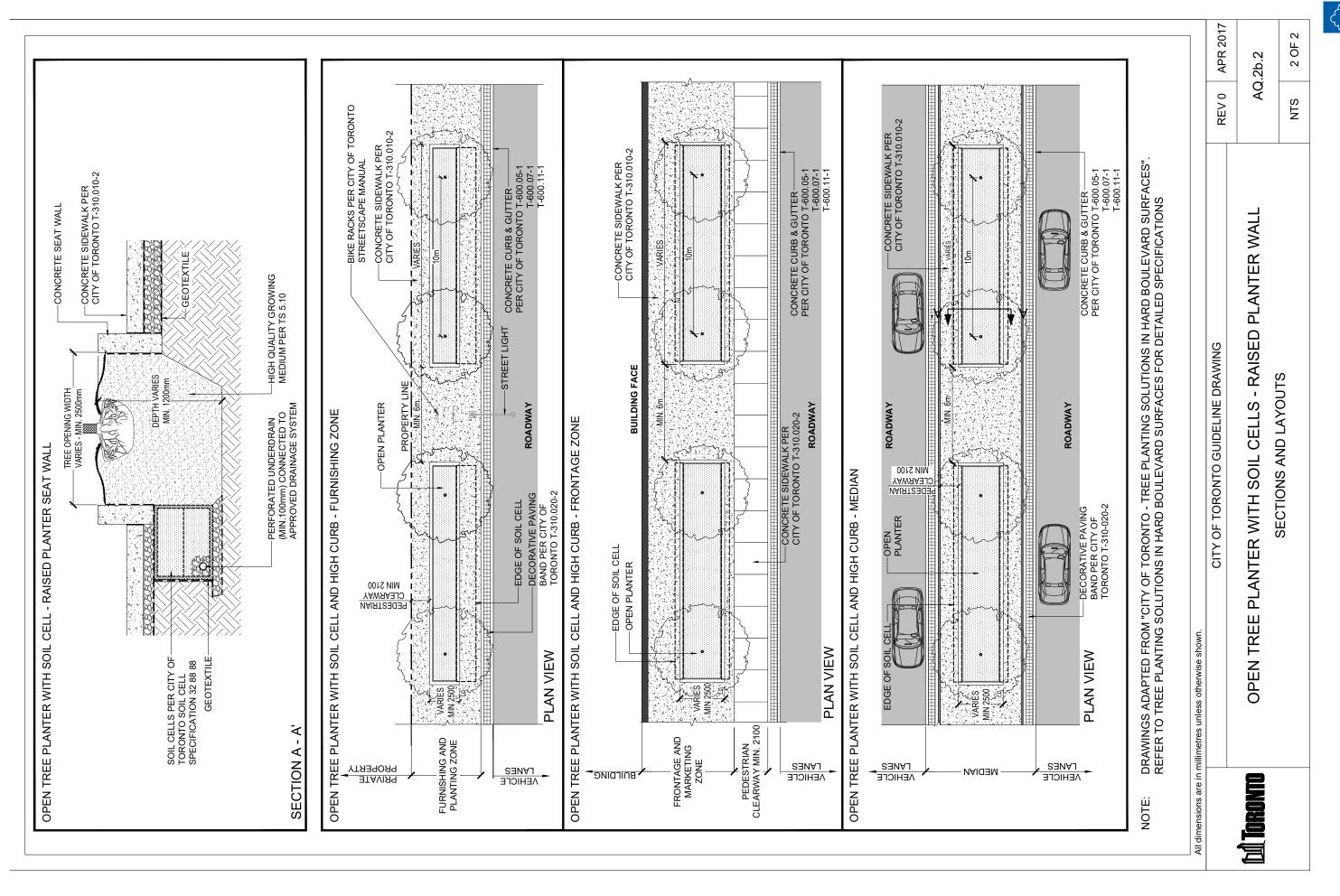




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# GEOMETRY & LAYOUT A.0

- Minimum footprint based on size of drainage area.
   Impervious contributing area to treatment facility area ratio should be 5:1 to 15:1.
   Ensure that the surface of the bioretention facility is level.

# PRETREATMENT A.

Pre-treatment area varies based on site context. include enhanced grass swales, bioswales and mechanical pre-treatment devices.

- FILTER MEDIA A.2

- Pre-mixed from an approved vendor;
  Filter media composition (by weight):
  Sand 75 to 85%
  Fines 2 to 5%
  Organic Matter 8 to 10%
  Pundex value 12 to 30 ppm
  Soluble Salts <2.0mmhos/cm</li>
  Cationic exchange capacity >5 meq/100 g
  pH 5.5 to 7.5
  Infiltration rate > 120 mm/hr, max. 300mm/hr
- Materials testing by an independent testing lab is required to confirm filter media composition. Sample to be collected at supply site by a Geotechnical engineer using standard protocols. If issues arise with the performance of an installation, then samples should be collected from the constructed facility for further testing;
   Depth varies Minimum recommended depth 1.0 1.25m for enhanced pollutant removal;
   Bioretention with trees minimum depth 1.0m. Total volume 30m³/tree or 20m³/tree for trees sharing soil.
   Capacity Volumetric computation should be based on surface and down
- Capacity Volumetric computation should be based on surface area and depth.
   Refer to TS 5.10 Construction Specification for Growing

# GRAVEL STORAGE A.3

- Depth Min. 300 mm; Material 50 mm dia. washed clear stone; Capacity Volumetric computation based on depth; Choker Layer: 100 mm pea gravel layer between filter media and gravel storage layers.

# MULCH A.4

- Depth 75 mm; Material Shredded hardwood bark mulch.
- OVERFLOW

# A.5

- Sized to convey larger storm events;
   PVC Overflow Pipe invert should be set at a maximum 250mm above the filter bed surface;
   Cap metal beehive cap or approved equal.

# MONITORING WELL A.6

- rated stand pipe (100-150mm dia.)

- Vertical PVC perforated stand pipe (100-150mr with lockable cap;
   Extend to the bottom of the bioretention facility.

# UNDERDRAIN (OPTIONAL) A.7

- Required where native soil infiltration rates are <15mm/hr or adjacent to structures;</li>
  Min. 200mm dia. perforated pipe installed 100mm above the bottom of the gravel storage layer;
  Capped at upstream end and connected to storm sewer;
  Connected to monitoring well for clean out;
  Refer to OPSS 405 Construction Specification for Subdrain Pipe.

# GEOTEXTILE A.8

- en monofilament or non-woven needle Material - Woven monofilament or non-woven punched fabrics;
   Refer to OPSS 1860 Material Specification for Geotextiles.

- PLANTING A.9
- Plant material selection and arrangement considerations:

   Plant material selection and arrangement should consider Native plant material should be selected wherever

  - possible;
    Plant materials should be selected for their tolerance of salt and urban conditions. Shade should also be considered for herbaceous material planted under trees
- or in other ultra-urban shaded areas;

   Planting design should provide variety in seasonal colour and winter interest;

   Plant material should be arranged in groupings by relative height texture and aesthetic attributes;

   Refer to the GSTG Vegetation Selection Tool for an
- appropriate parette,

  Refer to Construction Specification for Planting (TS 5.30).

# IDENTIFICATION MEDALLION A.10

 $\bullet$  To be installed on planter wall. Refer to guideline drawing G-1.

APR 2017 WQ-1.1a REV 0 CITY OF TORONTO GUIDELINE DRAWING **BIORETENTION PLANTERS** All dimensions are in millimetres unless otherwise shown **INDROVIO** 

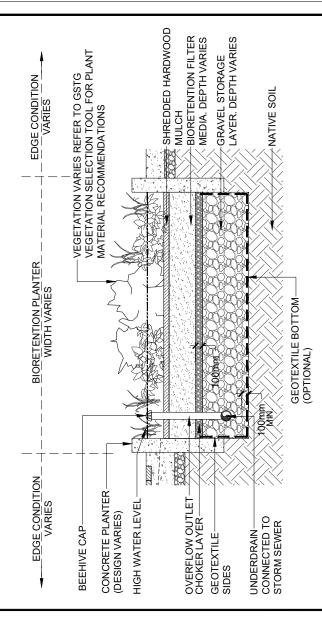
SECTIONS

SHREDDED HARDWOOD
MULCH
BIORETENTION FILTER
MEDIA. DEPTH VARIES GRAVEL STORAGE LAYER. DEPTH VARIES VEGETATION VARIES REFER TO GSTG VEGETATION SELECTION TOOL FOR PLANT MATERIAL RECOMMENDATIONS EDGE CONDITION VARIES NATIVE SOIL BIORETENTION PLANTER WIDTH VARIES BIORETENTION PLANTER WITHOUT UNDERDRAIN For sites with subsoil permeability >15mm/hr, water table depth > 1.0m GEOTEXTILE BOTTOM (OPTIONAL) NOTE: 4.0m MIN SETBACK FROM BUILDING FACE EDGE CONDITION VARIES CONCRETE PLANTER-(DESIGN VARIES) OVERFLOW OUTLET-CONNECTED TO STORM SEWER HIGH WATER LEVEL BEEHIVE CAP

# BIORETENTION PLANTER WITH UNDERDRAIN For sites with subsoil permeability <15mm/hr, water table depth

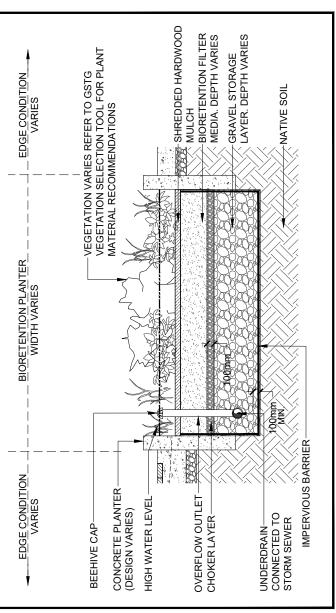
> 1.0m

NOTE: 4.0m MIN SETBACK FROM BUILDING FACE



# BIORETENTION PLANTER WITH UNDERDRAIN AND IMPERVIOUS LINER For sites with contaminated subsoil or high water table within 1.0m

NOTE: NO MINIMUM SETBACK FROM BUILDING FACE REQUIRED



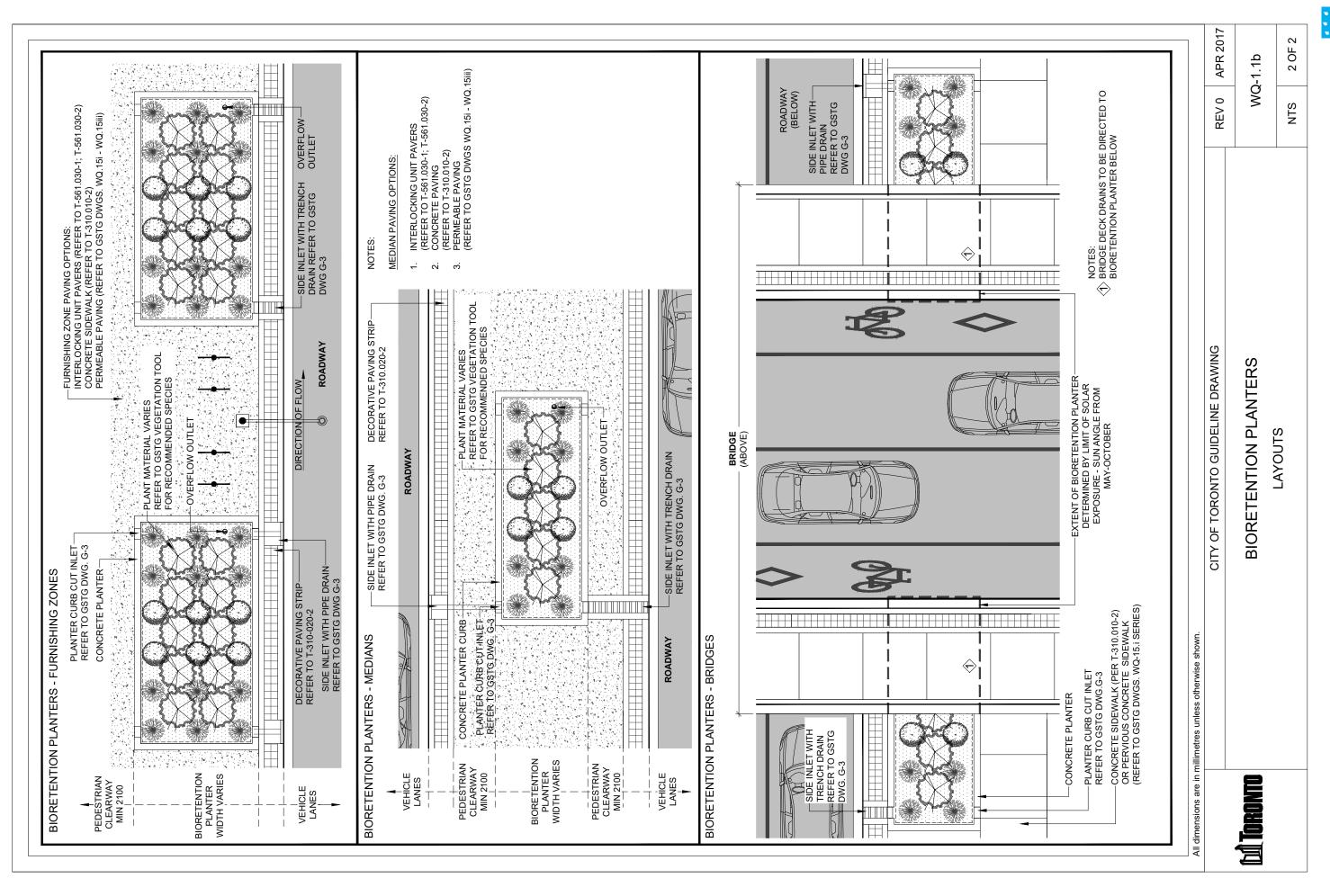
NOTE: SCARIFY BASE OF EXCAVATION

TGS Priority - Water Quantity, Quality & Efficiency

NTS







TGS Priority - Water Quantity, Quality & Efficiency

# GEOMETRY & LAYOUT A.0

Minimum footprint based on size of drainage area.
 Impervious contributing area to treatment facility area ratio should be 5:1 to 15:1.
 Ensure that the surface of the bioretention facility is level.

STORMWATER PLANTER WITHOUT UNDERDRAIN For sites with subsoil permeability >15mm/hr, water table depth > 1.0m

NOTE: 4.0m MIN SETBACK FROM BUILDING FACE

- **PRETREATMENT** A.1

PEDESTRIAN CLEARWAY BUILDING/ VARIES BRIDGE

STORMWATER PLANTER WIDTH VARIES

EDGE CONDITION VARIES

VEGETATION VARIES REFER TO GSTG VEGETATION SELECTION TOOL FOR PLANT MATERIAL RECOMMENDATIONS

BEEHIVE CAP

CONCRETE PLANTER-HEIGHT VARIES

HIGH WATER LEVEL

Pre-treatment area varies based on site context.
 include enhanced grass swales, bioswales and mechanical pre-treatment devices.

- FILTER MEDIA A.2

SHREDDED

HARDWOOD MULCH

-GRAVEL STORAGE LAYER

FILTER MEDIA

GEOTEXTILE SIDES

CHOKER LAYER

-NATIVE SOIL

- Pre-mixed from an approved vendor;
  Filter media composition (by weight):
  Sand 75 to 85%
  Fines 2 to 5%
  Organic Matter 8 to 10%
  Pundex value 12 to 30 ppm
  Soluble Salts <2.0mmhos/cm</li>
  Cationic exchange capacity >5 meq/100 g
  pH 5.5 to 7.5
  Infiltration rate > 120 mm/hr, max. 300mm/hr
- Materials testing by an independent testing lab is required to confirm filter media composition. Sample to be collected at supply site by a Geotechnical engineer using standard protocols. If issues arise with the performance of an installation, then samples should be collected from the constructed facility for further testing;
  Depth varies Minimum recommended depth 1.0 1.25m for enhanced pollutant removal;
  Bioretention with trees minimum depth 1.0m. Total volume 30m³/tree or 20m³/tree for trees sharing soil.
  Capacity Volumetric computation should be based on surface area and depth.
  Refer to TS 5.10 Construction Specification for Growing

STORMWATER PLANTER WITH UNDERDRAIN For sites with subsoil permeability <15mm/hr, water table depth > 1.0m

NOTE: 4.0m MIN SETBACK FROM BUILDING FACE

GEOTEXTILE BOTTOM (OPTIONAL)

OVERFLOW OUTLET— CONNECTED TO STORM SEWER

# GRAVEL STORAGE A.3

PEDESTRIAN CLEARWAY BUILDING/ VARIES BRIDGE

STORMWATER PLANTER WIDTH VARIES

EDGE CONDITION ...

- VEGETATION VARIES REFER TO GSTG VEGETATION SELECTION TOOL FOR PLANT MATERIAL RECOMMENDATIONS

- Depth Min. 300 mm;
  Material 50 mm dia. washed clear stone;
  Capacity Volumetric computation based on depth;
  Choker Layer: 100 mm pea gravel layer between filter media and gravel storage layers.

CONCRETE PLANTER-

HIGH WATER LEVEL

SECTION S

OVERFLOW OUTLET CHOKER LAYER

BEEHIVE CAP

# MULCH A.4

- Depth 75 mm; Material Shredded hardwood bark mulch.
- OVERFLOW A.5
- Sized to convey larger storm events;
   PVC Overflow Pipe invert should be set at a maximum of 250mm above the filter bed surface;

SHREDDED HARDWOOD MULCH

FILTER MEDIA

A dominated

GRAVEL STORAGE LAYER

NATIVE SOIL

• Cap - metal beehive cap or approved equal

# MONITORING WELL A.6

- Vertical PVC perforated stand pipe (100-150mm dia.) with lockable cap;
  - Extend to the bottom of the bioretention facility

GEOTEXTILE BOTTOM (OPTIONAL)

UNDERDRAIN CONNECTED-TO STORM SEWER

GEOTEXTILE—SIDES

UNDERDRAIN (OPTIONAL)

A.7

- Required where native soil infiltration rates are <15mm/hr or adjacent to structures;</li>
  Min. 200mm dia. perforated pipe installed 100mm above the bottom of the gravel storage layer;
  Capped at upstream end and connected to storm sewer;
  Connected to monitoring well for clean out;
  Refer to OPSS 405 Construction Specification for Subdrain Pipe.

STORMWATER PLANTER WITH UNDERDRAIN AND IMPERVIOUS LINER For sites with contaminated subsoil or high water table (within 1.0m)
NOTE: NO MINIMUM SETBACK FROM BUILDING FACE REQUIRED

PEDESTRIAN CLEARWAY BUILDING/ VARIES BRIDGE

BIORETENTION PLANTER WIDTH VARIES

EDGE CONDITION VARIES

# GEOTEXTILE A.8

BEEHIVE CAP

CONCRETE PLANTER

HIGH WATER LEVEL

- Material Woven monofilament or non-woven punched fabrics;
   Refer to OPSS 1860 Material Specification for

# A.9

- PLANTING

- Plant material selection and arrangement considerations:

   Plant material selection and arrangement should consider
- Plant materials should be selected for their tolerance of salt and urban conditions. Shade should also be considered for herbaceous material planted under trees or in other ultra-urban shaded areas;
  Planting design should provide variety in seasonal colour and winter interest;
  Plant material should be arranged in groupings by relative height texture and aesthetic attributes;
  Refer to the GSTG Vegetation Selection Tool for an Native plant material should be selected wherever nossible.

SHREDDED HARDWOOD MULCH FILTER MEDIA

OVERFLOW OUTLET

CHOKER LAYER

00000000

GRAVEL STORAGE

NATIVE SOIL

VEGETATION VARIES REFER TO GSTG
VEGETATION SELECTION TOOL FOR PLANT
MATERIAL RECOMMENDATIONS

IMPERVIOUS LINER

UNDERDRAIN CONNECTED TO STORM SEWER

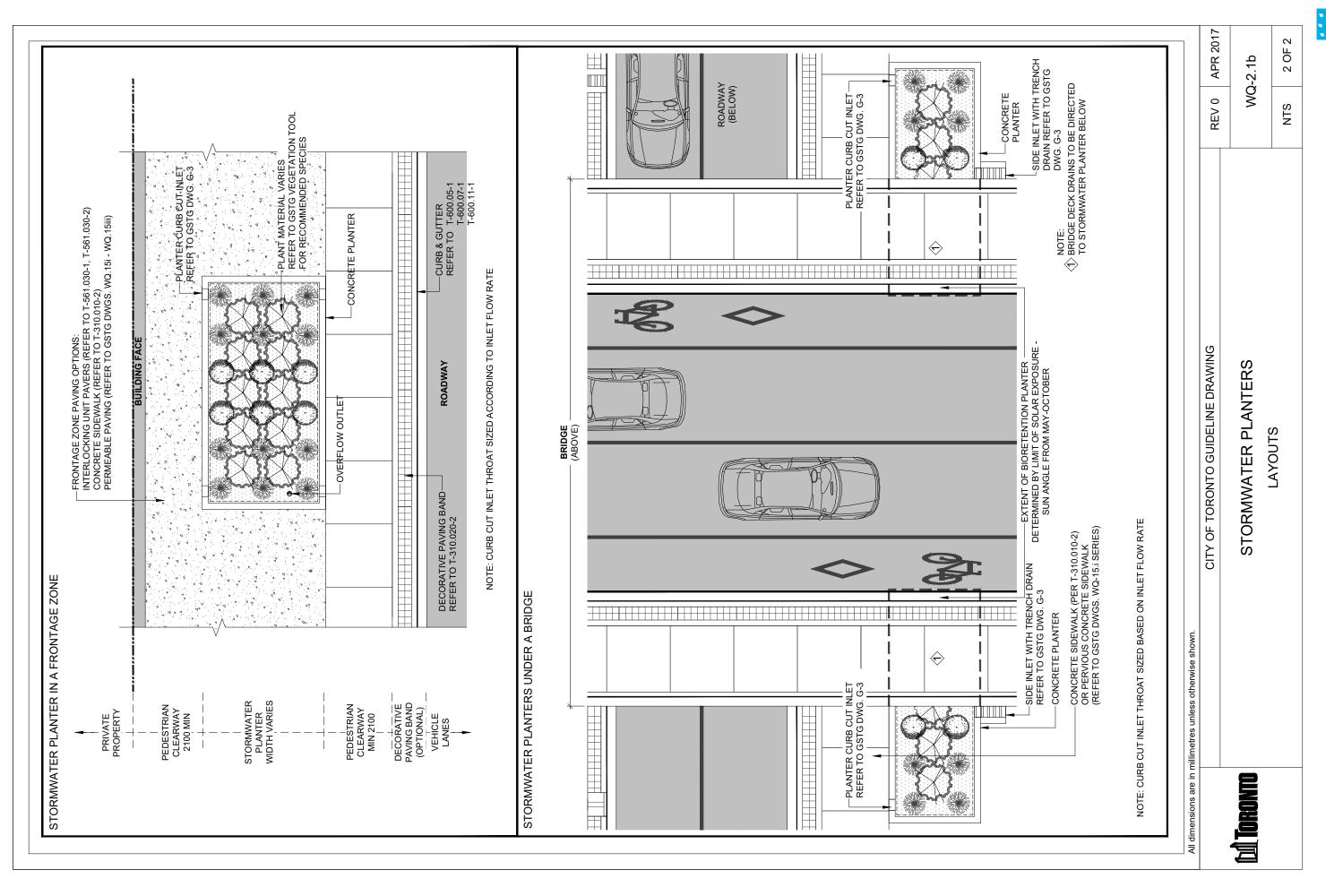
APR 2017 WQ-2.1a REV 0 NTS CITY OF TORONTO GUIDELINE DRAWING STORMWATER PLANTERS NOTE: SCARIFY BASE OF EXCAVATION SECTIONS ification for Planting (TS 5.30).  $\bullet$  To be installed on planter wall. Refer to guideline drawing G-1. All dimensions are in millimetres unless otherwise shown IDENTIFICATION MEDALLION TORONG TORONG A.10





Green Streets Technical Guidelines

[LI] TORONTO



TGS Priority - Water Quantity, Quality & Efficiency

# GEOMETRY & LAYOUT A.0

- Minimum footprint based on size of drainage area.
   Impervious contributing area to treatment facility area ratio should be 5:1 to 15:1.
   Ensure that the surface of the bioretention facility is level.

# PRETREATMENT A.

• Pre-treatment area varies based on site context. Options include enhanced grass swales, bioswales and mechanical pre-treatment devices.

# FILTER MEDIA

- Pre-mixed from an approved vendor;
  Filter media composition (by weight):
  Sand 75 to 85%
  Fines 2 to 5%
  Organic Matter 8 to 10%
  Pundex value 12 to 30 ppm
  Soluble Salts <2.0mmhos/cm</li>

- Cationic exchange capacity >5 meq/100 g pH 5.5 to 7.5 Infiltration rate > 120 mm/hr, max. 300mm/hr
- Materials testing by an independent testing lab is required to confirm filter media composition. Sample to be collected at supply site by a Geotechnical engineer using standard protocols. If issues arise with the performance of an installation, then samples should be collected from the constructed facility for further testing:
   Depth varies Minimum recommended depth 1.0 1.25m for enhanced pollutant removal:

  - for enhanced pollutant removal;

     Bioretention with trees minimum depth 1.0m. Total volume 30m³/tree or 20m³/tree for trees sharing soil.

     Capacity Volumetric computation should be based on surface area and depth.

     Refer to TS 5.10 Construction Specification for Growing

# GRAVEL STORAGE A.3

- Depth Min. 300 mm;
  Material 50 mm dia. washed clear stone;
  Capacity Volumetric computation based on depth;
  Choker Layer: 100 mm pea gravel layer between filter media and gravel storage layers.

# MULCH A.4

- Depth 75 mm;
   Material Shredded hardwood bark mulch.
- OVERFLOW A.5
- Sized to convey larger storm events;
   PVC Overflow Pipe invert should be set at a

  - 250mm above the filter bed surface; Cap metal beehive cap or approved equal.

# MONITORING WELL A.6

- Vertical PVC perforated stand pipe (100-150mm dia.) with lockable cap;
   Extend to the bottom of the bioretention facility.

# UNDERDRAIN (OPTIONAL) A.7

- or adjacent to structures;

   Min. 200mm dia. perforated pipe installed 100mm above the bottom of the gravel storage layer;

   Capped at upstream end and connected to storm sewer;

   Connected to monitoring well for clean out;

   Refer to OPSS 405 Construction Specification for

# GEOTEXTILE A.8

- en monofilament or non-woven needle

- Material Woven monofilament or punched fabrics;
   Refer to OPSS 1860 Material Spec

# PLANTING A.9

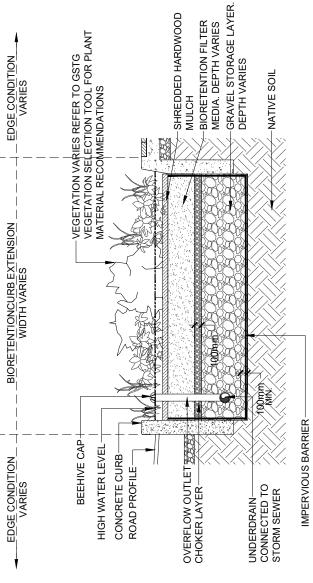
- Plant material selection and arrangement considerations: Plant material selection and arrangement should consider
  - cted wherever the site context;

    Native plant material should be sele
- Plant materials should be selected for their tolerance of salt and urban conditions. Shade should also be considered for herbaceous material planted under trees or in other ultra-urban shaded areas;
  Planting design should provide variety in seasonal colour and winter interest;
  Plant material should be arranged in groupings by relative height texture and aesthetic attributes;
  Refer to the GSTG Vegetation Selection Tool for an
- ction Tool for an
- appropriate palette;
   Refer to Construction Specification for Planting (TS 5.30).

# IDENTIFICATION MEDALLION A.10

ving G-1.

MULCH
BIORETENTION FILTER
MEDIA. DEPTH VARIES
GRAVEL STORAGE LAYER.
DEPTH VARIES -GRAVEL STORAGE LAYER. DEPTH VARIES SHREDDED HARDWOOD MULCH SHORETENTION FILTER MEDIA. DEPTH VARIES -SHREDDED HARDWOOD MULCH VEGETATION VARIES REFER TO GSTG VEGETATION SELECTION TOOL FOR PLANT MATERIAL RECOMMENDATIONS VEGETATION VARIES REFER TO GSTG VEGETATION SELECTION TOOL FOR PLANT MATERIAL RECOMMENDATIONS EDGE CONDITION VARIES EDGE CONDITION VARIES EDGE CONDITION VARIES NATIVE SOIL NATIVE SOI BIORETENTION CURB EXTENSION WITH UNDERDRAIN & IMPERVIOUS LINER For sites with contaminated subsoil or high water table (within 1.0m)
NOTE: NO MINIMUM SETBACK FROM BUILDING FACE REQUIRED BIORETENTIONCURB EXTENSION WIDTH VARIES BIORETENTION CURB EXTENSION WIDTH VARIES BIORETENTION CURB EXTENSION WIDTH VARIES BIORETENTION CURB EXTENSION WITHOUT UNDERDRAIN For sites with subsoil permeability >15mm/hr, water table depth > 1.0m NOTE: 4.0m MIN SETBACK FROM BUILDING FACE BIORETENTION CURB EXTENSION WITH UNDERDRAIN For sites with subsoil permeability <15mm/hr, water table depth > 1.0m NOTE: 4.0m MIN SETBACK FROM BUILDING FACE GEOTEXTILE BOTTOM (OPTIONAL) BEEHIVE CAP BEEHIVE CAP HIGH WATER LEVEL BEEHIVE CAP HIGH WATER LEVEL-CONCRETE CURB-ROAD PROFILE-HIGH WATER LEVEL CONCRETE CURB— EDGE CONDITION VARIES EDGE CONDITION VARIES EDGE CONDITION VARIES CONCRETE CURB-ROAD PROFILE— OVERFLOW OUTLET CONNECTED TO STORM SEWER GEOTEXTILE BOTTOM (OPTIONAL) ROAD PROFILE OVERFLOW——OUTLET
CHOKER LAYER— UNDERDRAIN—CONNECTED TO STORM SEWER CHOKER LAYER GEOTEXTILE-SIDES GEOTEXTILE-SIDES



NOTE: SCARIFY BASE OF EXCAVATION

netres unless otherwise shown.

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**BIORETENTION CURB EXTENSION** CITY OF TORONTO GUIDELINE DRAWING SECTIONS

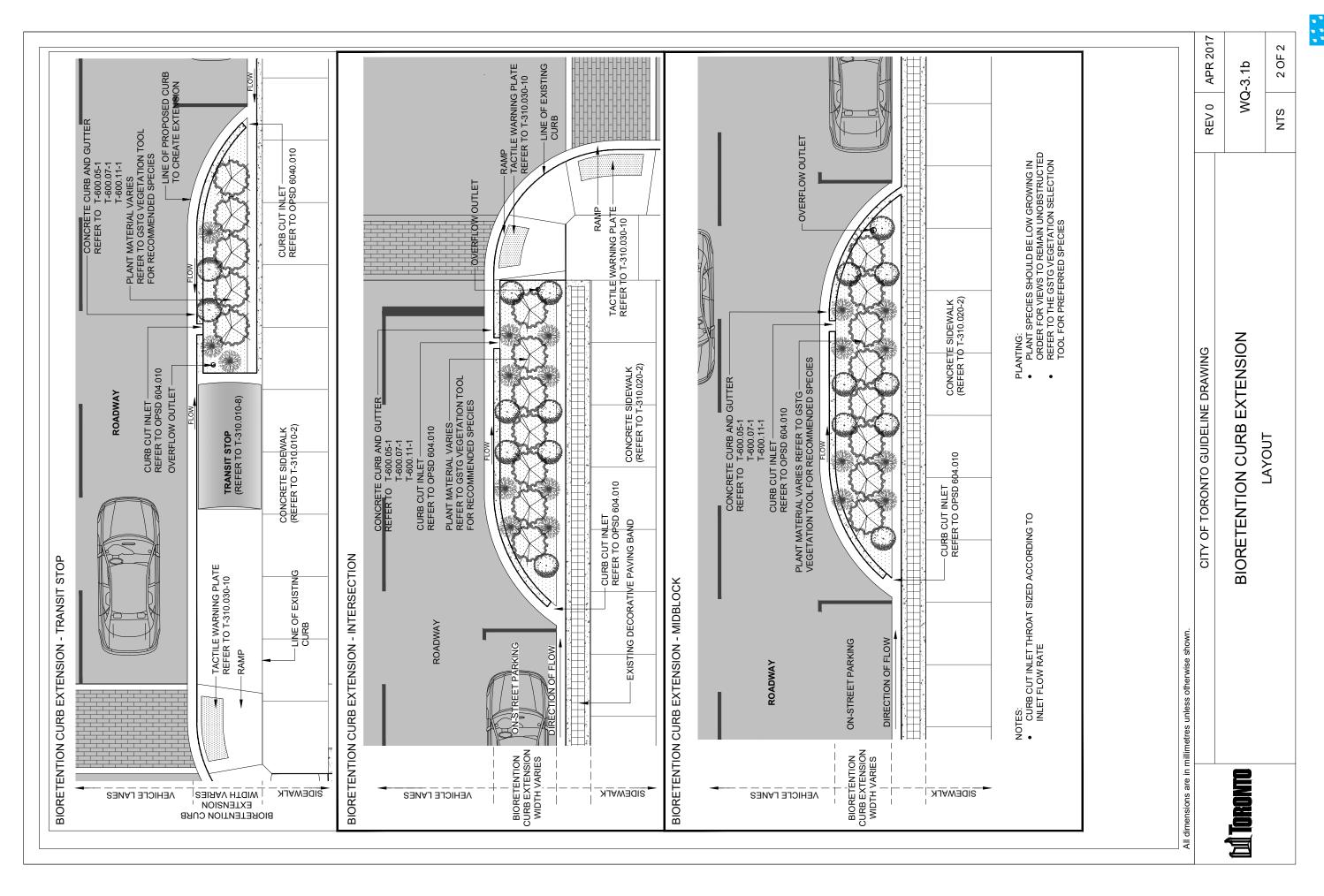
WQ-3.1a

APR 2017

REV 0







- Minimum footprint based on size of drainage area.
   Impervious contributing area to treatment facility area ratio should be 5:1 to 15:1.
   Ensure that the surface of the bioretention facility is

# PRETREATMENT A.

Pre-treatment area varies based on site context. Options include enhanced grass swales, bioswales and mechanical pre-treatment devices.

# FILTER MEDIA A.2

- re-mixed from an approved vendor;
  liter media composition (by weight):
  Sand 75 to 85%
  Fines 2 to 5%
  Organic Matter 8 to 10%
  P-Index value 12 to 30 ppm
  Soluble Salts <2.0mmhos/cm
  Cationic exchange capacity >5 meq/100 g
  pH 5.5 to 7.5
- Materials testing by an independent testing lab is required to confirm filter media composition. Sample to be collected at supply site by a Geotechnical engineer using standard protocols. If issues arise with the performance of an installation, then samples should be collected from the constructed facility for further testing;
   Depth varies Minimum recommended depth 1.0 1.25m for enhanced pollutant removal;
   Bioretention with trees minimum depth 1.0m. Total volume 30m³/tree or 20m³/tree for trees sharing soil.
   Capacity Volumetric computation should be based on page 1.0

# GRAVEL STORAGE A.3

## MULCH A.4

Depth - 75 mm;
 Material - Shredded hardwood bark mulch.

## OVERFLOW A.5

- Sized to convey larger storm events;
  PVC Overflow Pipe invert should be set at a maximum of 250mm above the filter bed surface;
  Cap metal beehive cap or approved equal.

# MONITORING WELL A.6

- dia.) Vertical PVC perforated stand pipe (100-150mi with lockable cap;
   Extend to the bottom of the bioretention facility.

# UNDERDRAIN (OPTIONAL) A.7

- Required where native soil infiltration rates are <15mm/hr or adjacent to structures;

  Min. 200mm dia. perforated pipe installed 100mr above the bottom of the gravel storage layer;

  Capped at upstream end and connected to storm

**NAWAVIA** 

- sewer,

  Connected to monitoring well for clean out;

  Refer to OPSS 405 Construction Specification for Subdrain Pipe.

### GEOTEXTILE A.8

- Material Woven monofilament or non-punched fabrics;
   Refer to OPSS 1860 Material Specifica Geotextiles.

PLANTING

A.9

Plant material selection and arrangement should consider the site context;
 Native plant material should be selected wherever

ction and arrangement consider ection and arrangement should

- Plant materials snow. Shade should and salt and urban conditions. Shade should and considered for herbaceous material planted under trees or in other ultra-urban shaded areas;
   Planting design should provide variety in seasonal and winter interest;
- Plant material should be arranged in groupings by relative height texture and aesthetic attributes;
  Refer to the GSTG Vegetation Selection Tool for an appropriate palette;
  Refer to Construction Specification for Planting (TS 5.30).
  NOTE: Facility to be kept offline until seed establishes.



APR 2017

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SLOPE GRAVEL LAYER CONCRETE CURB WITH CURB CUT INLETS
REFER TO OPSD 604.010 ROADWAY PERFORATED PIPE UNDERDRAIN COMPACTED NATIVE SUBGRADE BIORETENTION FILTER MEDIA OVERFLOW OUTLET PLANT MATERIAL VARIES
REFER TO GSTG VEGETATION SELECTION
TOOL FOR RECOMMENDED SPECIES PROPERTY LINE SECTION A-A' BIORETENTION CELL IN BOULEVARD ability >15mn SLOPE BIORETENTION CELL For site. 93 , K.

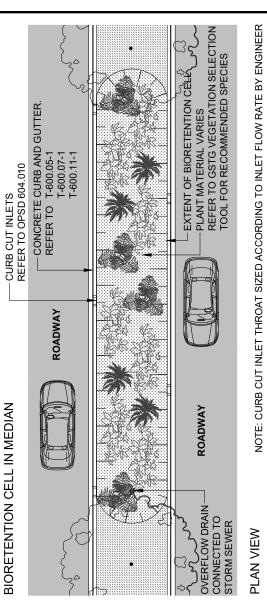
OVERFLOW DRAIN-CONNECTED TO STORM SEWER  $\mathcal{E}$ 

NOTE: CURB CUT INLET THROAT SIZED ACCORDING TO INLET BIORETENTION CELL IN MEDIAN PLAN VIEW

FLOW RATE BY ENGINEER

— PLANT MATERIAL VARIES
REFER TO GSTG VEGETATION SELECTION
TOOL FOR RECOMMENDED SPECIES
CURB CUT INLETS

ORETENTION CELL



PLAN VIEW

SECTION AND LAYOUTS

**[1] TORONTO** 

WQ-4.1 NTS



Green Streets Technical Guidelines

[LI] TORONTO

Size - less than 1000 m²
 Minimum footprint based on size of drainage area Impervious contributing area to treatment facility area ratio should be 5:1 to 15:1.

# PRETREATMENT A.1

Pre-treatment area varies based on site Options include enhanced grass swales bioswales and mechanical pre-treatmen

A.2

300mm recommended content - 8-15% by weight or 30-40% by AMENDED SOIL
 Depth - 300mm r

### MULCH A.3

- Depth 75 mm;
   Material Shredded hardwood bark
   Refer to OPSS MUNI 804 Construs Specification for Seed and Cover.

### OVERFLOW 4.4

- Sized to convey larger storm events;
  PVC Overflow Pipe invert should be set at a maximum of 250mm above the filter bed surf.
  Cap Metal beehive cap or approved equal.

# MONITORING WELL A.5

- Vertical perforated stand pipe (100-150mm dia.) with lockable cap;
   Extend to the bottom of the bioretention facility.

# UNDERDRAIN (OPTIONAL) A.6

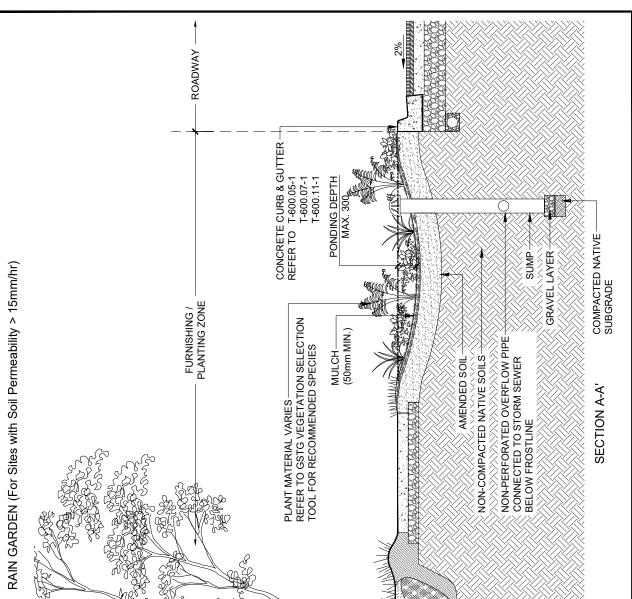
- ired where native soil infiltration rates are
- <15mm/hr;</p>
   Min. 200mm dia. perforated pipe c/w filter sock installed 100mm above the bottom of the gravel
  - storage layer; Capped at upstream end and connected to storm
- Connected to monitoring well for clean out; Refer to OPSS 405 Construction Specification for Subdrain Pipe.

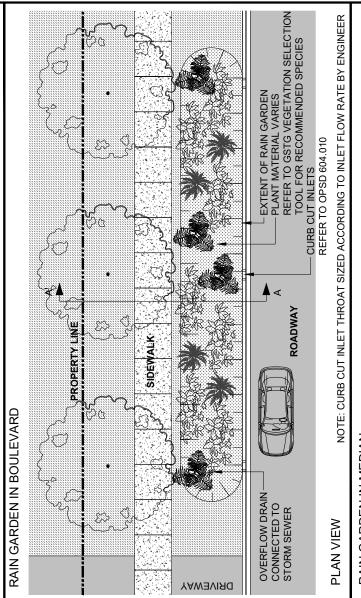
### PLANTING A.7

selection and arrangement

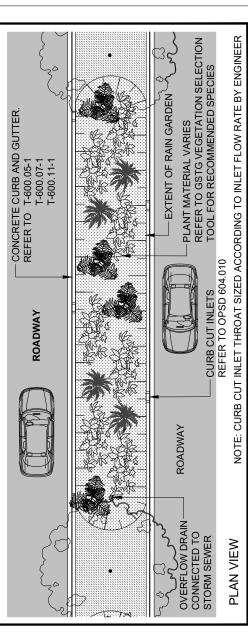
- selection and arrangement should
- nsider the site context; tive plant material should be selected whe
- possible;
   Plant materials should be selected for their tolerance of salt and urban conditions. Shade should also be considered for herbaceous mat planted under trees or in other ultra-urban sha

areas;
• Planting design should provide variety in seasonal colour and winter interest,
• Plant material should be arranged in groupings by relative height texture and aesthetic attributes
• Refer to the GSTG Vegetation Selection Tool for an appropriate palette;
• Refer to Construction Specification for Planting (TS 5.30);
• Refer to Construction Specification for Direct Seeding (TS 5.10).





RAIN GARDEN IN MEDIAN



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CITY OF TORONTO GUIDELINE DRAWING SECTION AND LAYOUTS RAIN GARDEN

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[DI] TORONTO

- 0.5m/s; Min. 5m swale length between culverts; Width Bottom 75mm to 3000mm;
- Longitudinal slopes 0.5% 4%. Install check dams on slopes > 3%;
  Side slopes 4:1 is preferred;
  Area Ratio of enhanced grass swale to contributing road surface should equal 1:1 or greater;
  Flow depth Max. 100mm during a 25mm storm.

# AMENDED SOIL A.1

- Depth 300mm;Organic content 8 to 15%.

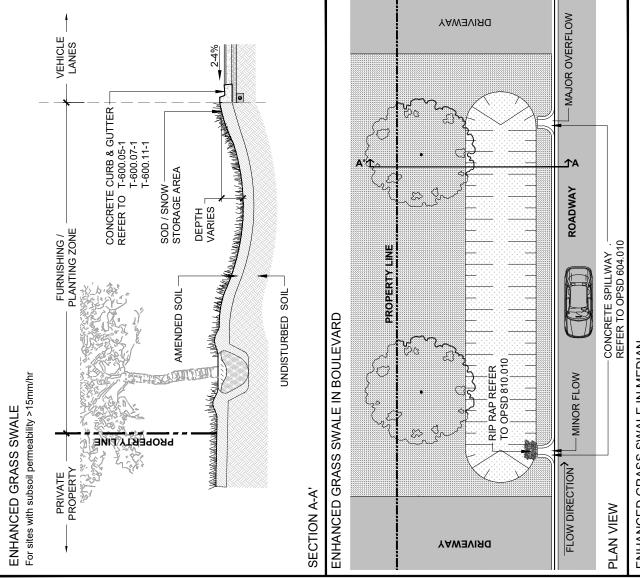
# PLANTING A.2

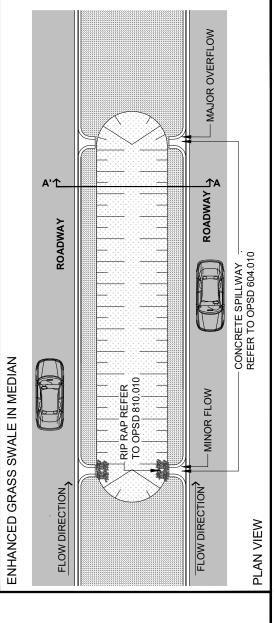
- Planting season spring;
   Maintain plant height of 150mm;
   Refer to Construction Specification for Planting (TS 5.30);
   Refer to Construction Specification for Direct Seeding (TS 5.20);
   Sodded swale: sod to be grown in sand to increase infiltration;
   Seeded swale: facility to be kept offline until see tion for Planting

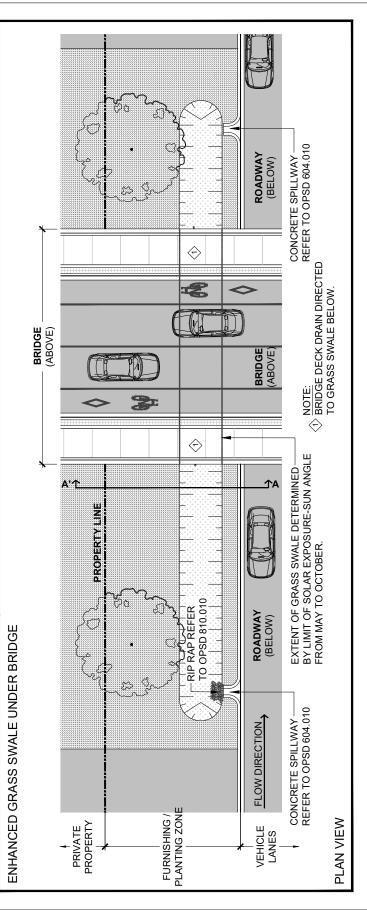
NOTE:

• CONCRETE SPILLWAY THROAT SIZED ACCORDING

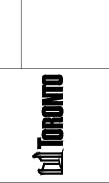
TO INLET FLOW RATE BY ENGINEER







etres unless otherwise shown.



CILY OF LORONIO GOIDELINE DRAWING	ENHANCED GRASS SWALE	SECTION AND LAYOUTS

NTS

APR 2017

REV 0

WQ-6.1

TGS Priority - Water Quantity, Quality & Efficiency



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Green Streets Technical Guidelines

[1] TORONTO

Geometry - Trapezoidal or parabolic cross-section;
Min. 5m swale length between culverts;
Width - Bottom 75mm - 2000mm.
Slopes

Longitudinal - 0.5% - 4%. Install check dams or

OPTION A - BIOSWALE WITHOUT UNDERDRAIN For sites with soil permeability >15mm/hr

- Longitudinal 0.5% 4%. Install check dams on slopes >3%;
   Sides Max. 3:1.

VEHICLE LANES

FURNISHING / PLANTING ZONE

PRIVATE PROPERTY

CONCRETE CURB & GUTTER— REFER TO T-600.05-1 T-600.07-1 T-600.11-1

GRASS EDGE—300mm DEPTH TOPSOIL—PER TS 5.10.05.01

☐ INLET CONTROL

HWL

CULVERT HEADER

# PRETREATMENT A.

Pre-treatment area varies based on site context.
 Options include enhanced grass swales, bioswales and mechanical pre-treatment devices.

# FILTER MEDIA A.2

- Pre-mixed from an approved vendor;
  Filter media composition (by weight):
  Sand 75 to 85%
  Fines 2 to 5%

- Organic Matter 8 to 10%
  P-Index value 12 to 30 ppm
  Soluble Salts <2.0mmhos/cm
  Cationic exchange capacity >5 meq/100 g
  pH 5.5 to 7.5
  Infiltration rate > 120 mm/hr, max. 300mm/hr
- Materials testing by an independent testing lab is required to confirm filter media composition. Sample to be collected at supply site by a Geotechnical engineer using standard protocols. If issues arise with the performance of an installation, then samples should be collected from the constructed facility for further testing;
   Depth varies Minimum recommended depth 1.0 1.25m for enhanced pollutant removal;

NON-WOVEN FILTER FABRIC

FILTER MEDIA

OPTION B - BIOSWALE WITH UNDERDRAIN For sites with soil permeability <15mm/hr

SECTION A-A'

- 1.25m for enhanced pollutant removal;
  Bioretention with trees minimum depth 1.0m. Total volume 30m³/tree or 20m³/tree for trees sharing soil.
  Capacity Volumetric computation should be based on surface area and depth.
  Refer to TS 5.10 Construction Specification for Growing Media

VEHICLE LANES

FURNISHING / PLANTING ZONE

PRIVATE PROPERTY

CONCRETE CURB & GUTTER— REFER TO T-600.05-1 T-600.07-1 S EDGE—\_\_\_\_T-600.11-1

GRASS EDGE—300mm DEPTH TOPSOIL—PER TS 5.10.05.01—VARIES

─INLET CONTROL ── CULVERT

₩.

CULVERT HEADER

# GRAVEL STORAGE A.3

- Depth Min. 300 mm;
  Material 50 mm dia. washed clear stone;
  Capacity Volumetric computation based on depth;
  Choker Layer: 100 mm pea gravel layer between filter media and gravel storage layers.

# OVERFLOW A.4

Sized to convey larger storm events;
 PVC Overflow Pipe invert should be se of 250mm above the filter bed surface;

# UNDERDRAIN (OPTIONAL) A.5

- Required where native soil infiltration rates are <15mm/hr or adjacent to structures;
   Min. 200mm dia. perforated pipe installed 100mm above the bottom of the gravel storage layer;
   Capped at upstream end and connected to storm

MIN. 200mm Ø PERFORATED PIPE

mm001 .NIM

NON-WOVEN FILTER FABRIC GRANULAR FILTER TRENCH -CHOKER LAYER

sewer;

Connected to monitoring well for clean out;

Monitoring well: vertical standpipe connected to the underdrain at downstream;

Undert Headwall - Cast-in-place or precast concrete minimum 150mm thick.

Culvert Header Overflow Inlet Control - Pre-fabricated plastic or metal, sized to correspond to capacity of receiving culvert;

Refer to OPSS 405 - Construction Specification for

SECTION A-A'

BIOSWALE

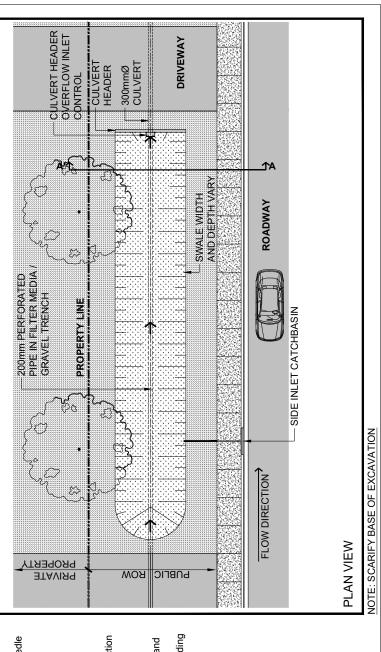
# GEOTEXTILE A.6

- nent or non-woven needle Material - Woven monofilament or non-woven punched fabrics;
   Refer to OPSS 1860 Material Specification for Geotextiles.
- MAINTAINED SWALE

   Bioswale should be sodded per TS 5.00 Construction Specification for Sodding.

### PLANTING A.7

- NATURALIZED SWALE
  Bioswales should be planted with native drought and salt tolerant grasses;
  Refer to Construction Specification for Direct Seeding (TS 5.20);
  Refer to Construction Specification for Growing Medium (TS 5.10).



All dimensions are in millimetres unless otherwise shown.



CITY OF TORONTO GUIDELINE DRAWING	BIOSWALE (SUBURBAN)	SIDEWALK ON STREET SIDE OF BOLLI EVARD

APR 2017

REV 0

WQ-7.1a





1 OF 5

NTS

Green Streets Technical Guidelines

[LI] TORONTO

- Geometry Trapezoidal or parabolic cross-section;
   Min. 5m swale length between culverts;
   Width Bottom 75mm 2000mm.
   Slopes
   Longitudinal 0.5% 4%. Install check dams or
- Longitudinal 0.5% 4%. Install check dams on slopes > 3%; Sides Max. 3:1.

# PRETREATMENT A.

Pre-treatment area varies based on site context. Options include enhanced grass swales, bioswales and mechanical pre-treatment devices.

# FILTER MEDIA A.2

- re-mixed from an approved vendor;
  ilter media composition (by weight):
  Sand 75 to 85%
  Fines 2 to 5%
  Organic Matter 8 to 10%
  P-Index value 12 to 30 ppm
  Soluble Salts <2.0mmhos/cm
  Cationic exchange capacity >5 meq/100 g
  pH 5.5 to 7.5
  Infiltration rate > 120 mm/hr, max. 300mm/hr
- Materials testing by an independent testing lab is required to confirm filter media composition. Sample to be collected at supply site by a Geotechnical engineer using standard protocols. If issues arise with the performance of an installation, then samples should be collected from the constructed facility for further testing.
   Depth varies -Minimum recommended depth 1.0 1.25m for enhanced pollutant removal;
   Bioretention with trees minimum depth 1.0m. Total volume 30m³/tree or 20m³/tree for trees sharing soil.
   Capacity Volumetric computation should be based on surface area and death.
- - Capacity Volumetric cousurface area and depth.
     Refer to TS 5.10 Construction of Media

# GRAVEL STORAGE A.3

- Depth Min. 300 mm;

   Material 50 mm dia. washed clear stone;

   Capacity Volumetric computation based on depth;

   Choker Layer: 100 mm pea gravel layer between filter media and gravel storage layers.

# OVERFLOW A.4

Sized to convey larger storm events;
 PVC Overflow Pipe invert should be se of 250mm above the filter bed surface;

# UNDERDRAIN (OPTIONAL) A.5

- Required where native soil infiltration rates are <15mm/hr or adjacent to structures;

  Min. 200mm dia. perforated pipe installed 100mm above the bottom of the gravel storage layer;

  Capped at upstream end and connected to storm

- sewer;

   Connected to monitoring well for clean out;

   Monitoring well: vertical standpipe connected to the underdrain at downstream;

   Culvert Headwall Cast-in-place or precast concrete minimum 150mm thick;

   Culvert Header Overflow Inlet Control Pre-fabricated plastic or metal, sized to correspond to capacity of receiving culvert;

   Refer to OPSS 405 Construction Specification for

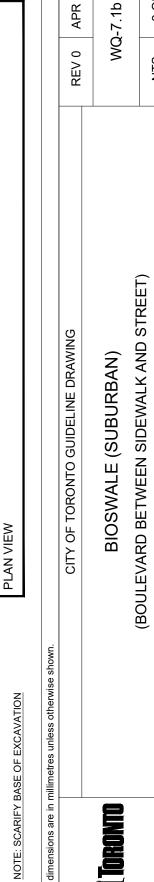
## GEOTEXTILE A.6

- Material Woven monofilament or non-woven punched fabrics;
   Refer to OPSS 1860 Material Specification for Geotextiles.
- PLANTING

# A.7

# dded per TS 5.00 Construction MAINTAINED SWALE • Bioswale should be sodde Specification for Sodding.

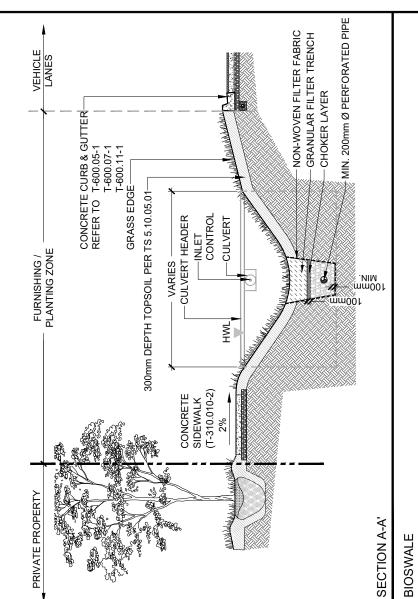
- NATURALIZED SWALE
  Bioswales should be planted with native drought and salt tolerant grasses;
  Refer to Construction Specification for Direct Seeding (TS 5.20);
  Refer to Construction Specification for Growing Medium (TS 5.10).

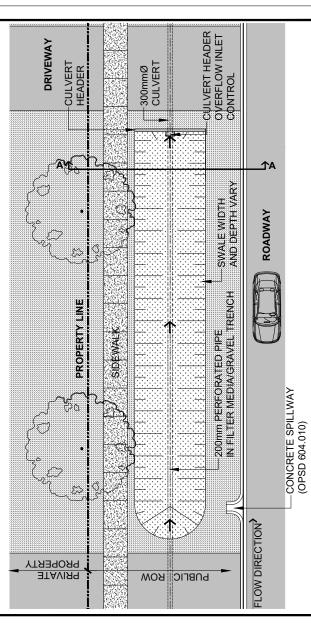


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FILTER MEDIA NON-WOVEN FILTER FABRIC VEHICLE LANES CONCRETE CURB & GUTTER+ REFER TO T-600.05-1 T-600.07-1 T-600.11-1 GRASS EDGE 300mm DEPTH TOPSOIL PER TS 5.10.05.01--CULVERT FURNISHING / PLANTING ZONE OPTION A - BIOSWALE WITHOUT UNDERDRAIN For sites with soil permeability >15mm/hr CONCRETE SIDEWALK (T-310.010-2) PRIVATE PROPERTY SECTION A-A'

OPTION B - BIOSWALE WITH UNDERDRAIN For sites with soil permeability <15mm/hr









A.0

BIOSWALE WITH UNDERDRAIN (no sidewalks)

- Jmnı. 4%. Install check dams Geometry - Trapezoidal or par
   Min. 5m swale length betweer
   Width - Bottom 75mm - 2000n
   Longitudinal slopes - 0.5% - 4" Longitudinal slopes - 0.5 slopes > 3%;Side slopes - Max. 3:1.

# FILTER MEDIA A.

- re-mixed from an approved vendor;
  liter media composition (by weight):
  Sand 75 to 85%
  Fines 2 to 5%
  Organic Matter 8 to 10%
  P-Index value 12 to 30 ppm
  Soluble Salts <2.0mmhos/cm
  Cationic exchange capacity >5 meq/100 g
  pH 5.5 to 7.5
  Infiltration rate > 120 mm/hr, max. 300mm/hr
- at supply site by a Geotechnical engineer using standard protocols. If issues arise with the performance of an installation, then samples should be collected from the constructed facility for further testing;

   Depth varies Minimum recommended depth 1.0 1.25m for enhanced pollurant removal;

   Capacity Volumetric computation should be based on surface area and depth.

   Refer to TS 5.10 Construction Specification for Growing Media s testing by an ind n filter media cor

# GRAVEL STORAGE A.2

- Depth Min. 300 mm; Material 50 mm dia. w Capacity Volumetric c
- ... washed clear stone; ic computation based on depth nm pea gravel layer between fil orage layers.

# A.3

- Sized to convey larger storm events;
   PVC Overflow Pipe invert should be s 250mm above the filter bed surface;
   Cap Metal beehive cap or approved

# UNDERDRAIN (OPTIONAL) A.4

- adjacent to structures;
  in. 200mm dia. perforated pipe installed 100mm above e bottom of the gravel storage layer;

- uncontrol of the grade standard rayer,

  Capped at upstream end and connected to storm sewe

  Connected to monitoring well for clean out;

  Monitoring well: vertical standpipe connected to the underdrain at downstream;

  Culvert Headwall Cast-in-place or precast concrete minimum 150mm thick;

  Culvert Header Overflow Inlet Control Pre-fabricated plastic or metal, sized to correspond to capacity of receiving culvert;

  Refer to OPSS 405 Construction Specification for Subdrain Pipe.

# GEOTEXTILE A.5

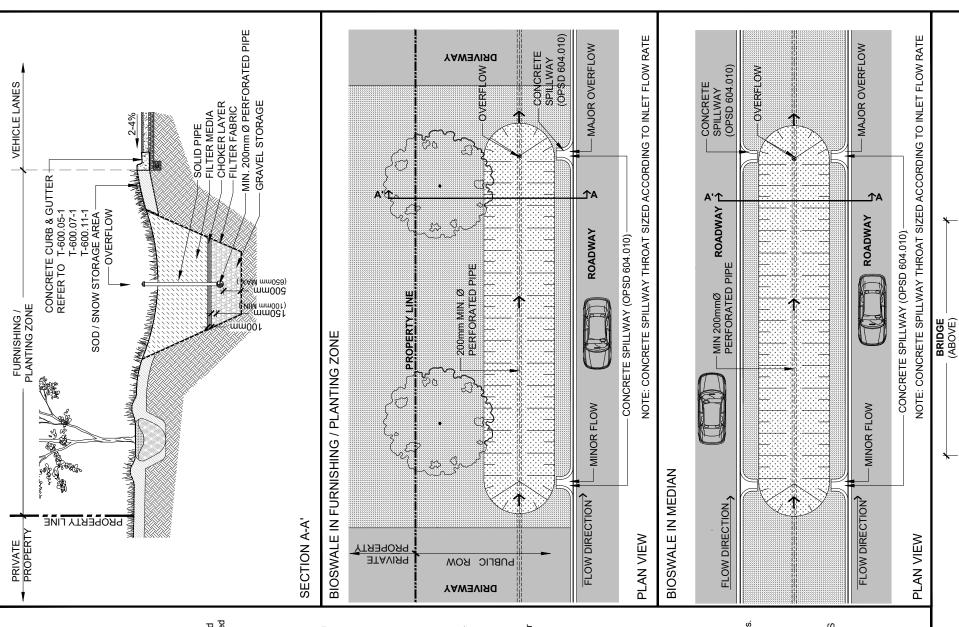
- monofilament or non-woven needle

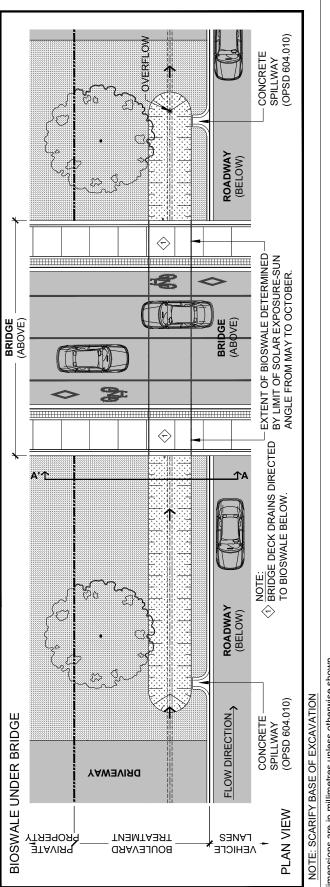
- punched fabrics;

  Refer to OPSS 1860 Material Specification for Geotextiles.

# PLANTING A.6

- ould be sodded per TS 5.00 for Sodding.
- ding (TS olerant grasses; tion Specification for Direct Se







CITY OF TORONTO GUIDELINE DRAWING	BIOSWALE (SUBURBAN)	(BOULEVARD WITH NO SIDEWALK)

APR 2017

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# FILTER MEDIA A.0

- m an approved vendor; omposition (by weight): 5 to 85% to 5%

- Iter media composition (by weight):
  Sand 75 to 85%
  Fines 2 to 5%
  Organic Matter 8 to 10%
  P-Index value 12 to 30 ppm
  Soluble Salts <2.0mmhos/cm
  Cationic exchange capacity >5 meq/100 g
  pH 5.5 to 7.5
  Infiltration rate > 120 mm/hr, max. 300mm/hr
- Materials testing by an independent testing lab is required to confirm filter media composition. Sample to be collected at supply site by a Geotechnical engineer using standard protocols. If issues arise with the performance of an installation, then samples should be collected from the constructed facility for further testing:
   Depth varies -Minimum recommended depth 1.0 1.25m

  - Depth varies Minimum recommended depth 1.0 1.25n for enhanced pollutant removal;
     Bioretention with trees minimum depth 1.0m. Total volume 30m²/tree or 20m²/tree for trees sharing soil.
     Capacity Volumetric computation should be based on
    - struction Specification for

# GRAVEL STORAGE

- Depth Min. 300 mm;
   Material 50 mm dia. washed clear stone;
   Capacity Volumetric computation based on depth;
   Choker Layer: 100 mm pea gravel layer between filter media and gravel storage layers.

### MULCH A.2

- Depth 75 mm;
   Material Shredded hardwood bark mulch

# UNDERDRAIN (OPTIONAL) A.3

- Required where native soll inniluaturi reconstruction of 15mm/hr or adjacent to structures;
   Min. 200mm dia. perforated pipe installed 100mm above the bottom of the gravel storage layer;
   Capped at upstream end and connected to storm sewer;
   Connected to monitoring well for dean out;
   Refer to OPSS 405 Construction Specification for Subdrain Pipe.

# GEOTEXTILE A.4

- Material Woven monofilament or non-woven needle punched fabrics;
   Refer to OPSS 1860 Material Specification for Geotextiles.

### PLANTING A.5

- Plant material selection and arrangement considerations:

   Plant material selection and arrangement should consider the site context;

   Native plant material should be selected wherever possible;

   Plant materials should be selected for their tolerance of salt and urban conditions. Shade should also be considered for herbaceous material planted under trees or in other ultra-urban shaded areas;

   Planting design should provide variety in seasonal colour and winter interest;

   Plant material should be arranged in groupings by relative height texture and aesthetic attributes;

   Refer to the GSTG Vegetation Selection Tool for an appropriate paletie.

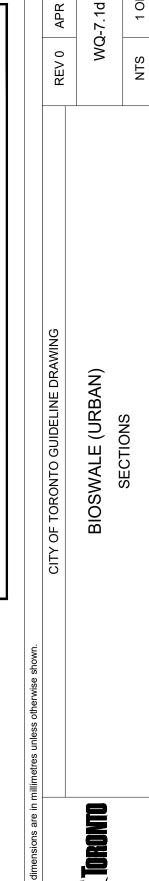
- ion Specification for Planting (TS

# IDENTIFICATION MEDALLION A.6

to guideline drawing G-1.

# NOTE: SCARIFY BASE OF EXCAVATION

### - GRAVEL STORAGE - UNDERDRAIN GEOTEXTILE LINER CHOKER LAYER **MULCH LAYER** METAL TREE PROTECTION FENCE METAL TREE PROTECTION FENCE **FILTER MEDIA** FILTER MEDIA NATIVE SOIL GEOTEXTILE LINER (SIDE) GRAVEL STORAGE CHOKER LAYER RICTER MEDIA NATIVE SOIL 300 BIOSWALE WITH UNDERDRAIN AND IMPERVIOUS LINER BIOSWALE MIN. 1500 աա001 աա001 BIOSWALE WITHOUT UNDERDRAIN For sites with subsoil permeability >15mm/hr BIOSWALE WITH UNDERDRAIN For sites with subsoil permeability <15mm/hr NIM mm02 EDGE TREATMENT VARIES METAL TREE PROTECTION FENCE SIDE INLET REFER TO GSTG DRAWING G-3 SIDE INLET ———REFER TO GSTG DRAWING G-3 HILTI FASTENER HILTI FASTENER SIDE INLET REFER TO GSTG DRAWING G-3 SECTION



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-GRAVEL STORAGE -UNDERDRAIN

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NATIVE SOIL

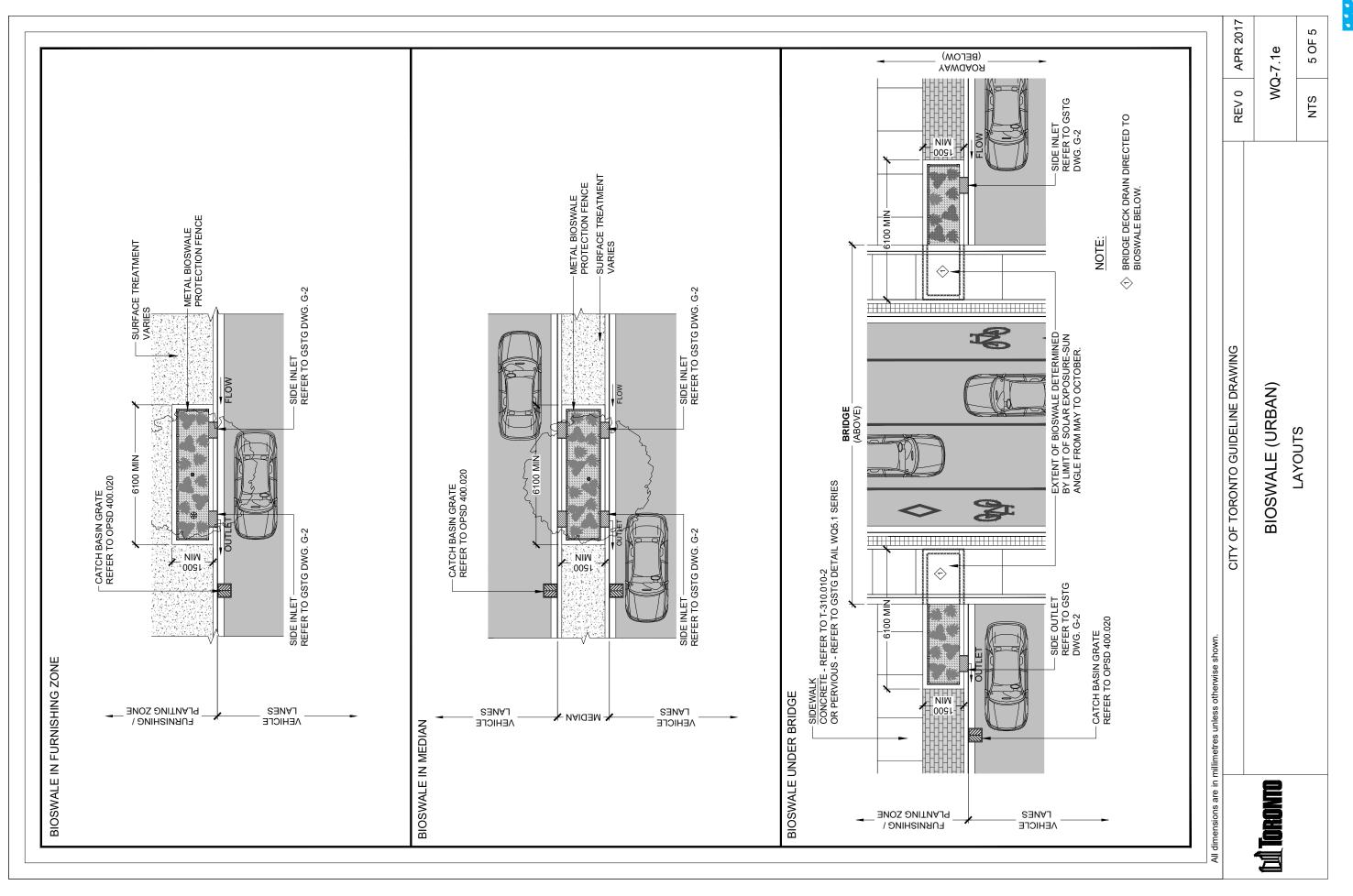
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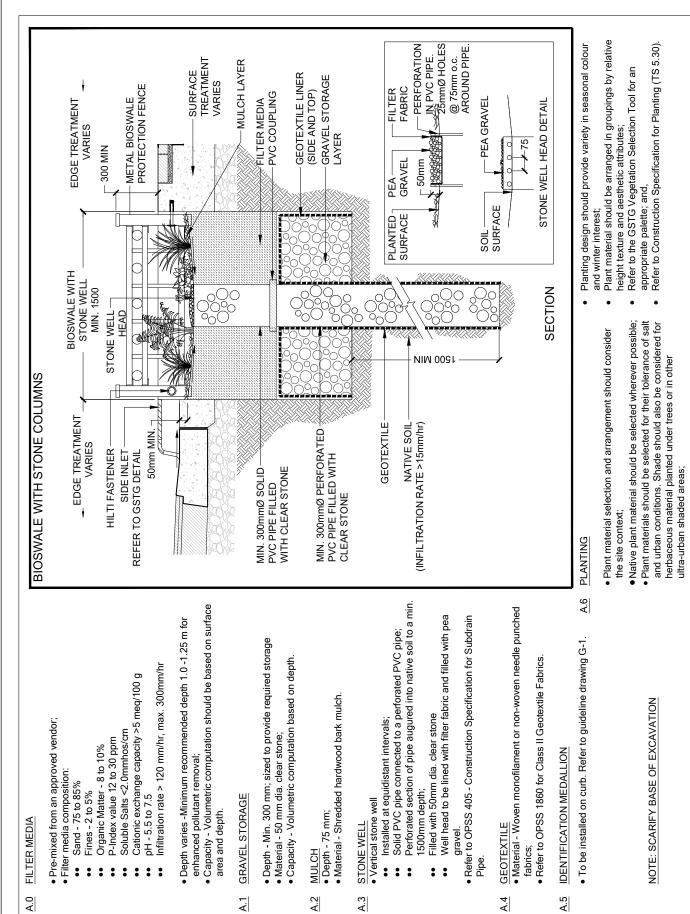
IMPERVIOUS LINER

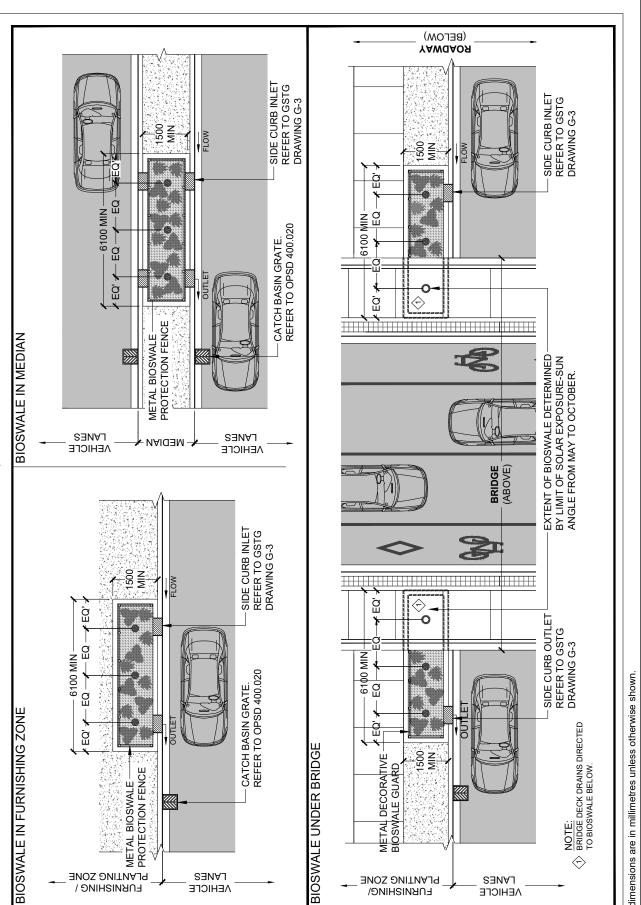
CHOKER LAYER











APR 2017

REV 0

WQ-7.2

**BIOSWALE WITH STONE WELL** 

**EM**TORONTO

SECTION & LAYOUT

CITY OF TORONTO GUIDELINE DRAWING

NTS

Width varies based on context. Max 1.0m; Green Gutter extends the length of street or transit line, with crossings at intersections and transit stops.

# ENGINEERED SOIL P.1

- eq/100 g Pre-mixed from an approved vendor;
  Filter media composition (by weight):
  Sand - 75 to 85%
  Fines - 2 to 5%
  Organic Matter - 8 to 10%
  P-Index value 12 to 30 ppm
  Soluble Salts <2.0mmhos/cm
  Cationic exchange capacity >5 meq
  - 300mm/hr
- Materials testing by an independent testing lab is required to confirm soil composition. Sample to be collected at supply site by a Geotechnical engineer using standard protocols. If issues arise with the performance of an installation, then samples should be collected from the constructed facility for further testing;
- ended depth Depth varies - Minimum recor 450mm;

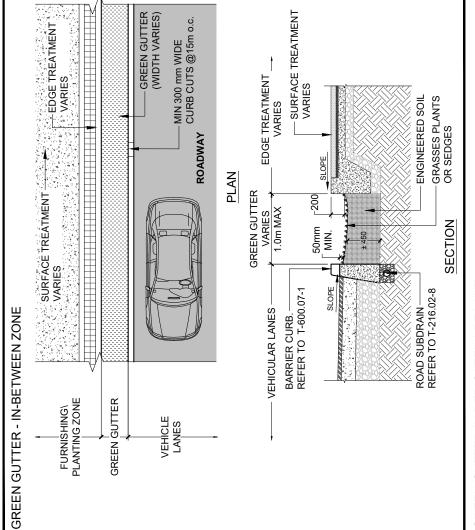
# PLANTING A.2

- Should be planted with salt tolerant grasses or
- sedges

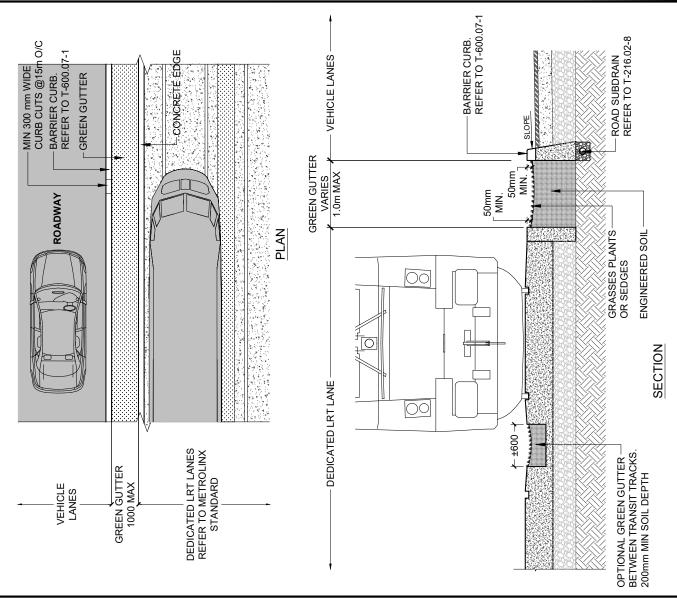
   Refer to the GSTG Vegetation Selection Tool for an appropriate palette.

   Refer to Construction Specification for Planting (TS 5.30)

CURB CUT INLET THROAT SIZED BY ENGINEER ACCORDING TO INLET FLOW RATE.



# GREEN GUTTER IN DEDICATED LRT LANE



All dimensions are in millimetres unless otherwise shown.

**EM TORONTO** 

JRAWING		JTS	
II Y OF LORON O GOIDELINE DRAWING	GREEN GUTTER	SECTIONS AND LAYOUTS	
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WQ-8.1

NTS





[1] TORONTO

- Contributing area:Max slope 3%;Flow path length 5-25m.

# A.1

 Pea gravel diaphragm;
 Level spreaders - Used on slopes greater than 5%. PRETREATMENT

- AMENDED TOPSOIL A.2

- Organic content 5 to 15% by ww
  pH 6.0-7.8
  P-index value 12-40 ppm
  Soluble Salts < 2.0 mmhos/cm</li>
  Bulk density ≤ 1.42 g/cm³
  Infiltration rate ≥ 120mm/h

# GRAVEL / EARTHEN BERM A.3

- Material 15-25mm dia. graveSand 35 60%;Silt 30 55%;Gravel 10 25%.

# PLANTING A.4

- considerations:

   Plant material selection and arrangement should consider the site context;

   Native plant material should be selected wherever possible;

   Plant materials should be selected for their selected for their
- wherever possible;

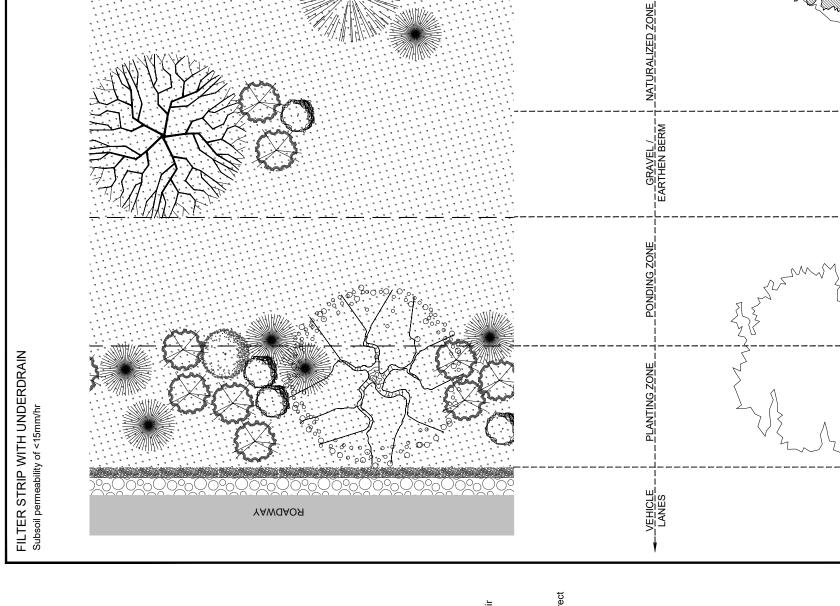
   Plant materials should be selected for their tolerance of salt and urban conditions;

   Refer to the GSTG Vegetation Selection
  Tool for an appropriate palette;

   Refer to Construction Specification for Planting (TS 5.30);

   Refer to Construction Specification for Direct Seeding (TS 5.20);

   Refer to Construction Specification for Growing Medium (TS 5.10).



CONNECTION TO STORM SEWER / OUTLET

-PEA GRAVEL DIAPHRAGM

-PERFORATED UNDERDRAIN

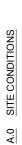
-GRAVEL LAYER -AMENDED TOPS

PONDING DEPTH VARIES (150mm - 300mm)

BERM VARIES (150-300mm)

APR 2017 WQ-9.1 REV 0 NTS CITY OF TORONTO GUIDELINE DRAWING VEGETATED FILTER STRIP SECTION AND LAYOUT **IN TORONTO** 





For sites with subsoil

# PRETREATMENT

Pre-treatment area varies bas include enhanced grass swalr mechanical pre-treatment dev

# GRAVEL STORAGE A.2

- Depth Min. 1800mm;
   Material 50 mm dia. clear stone;
   Capacity Volumetric computation based on depth;

## OVERFLOW A.3

# A.4 INLET PIPE

Material - Solid PVC pipe or approve equal;
Size - Volume dependent - min. 200mm dia.

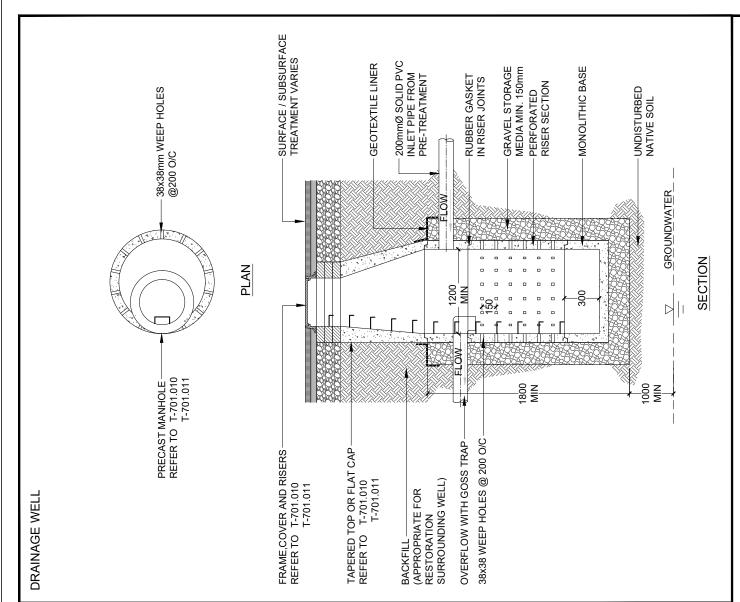
# A.5

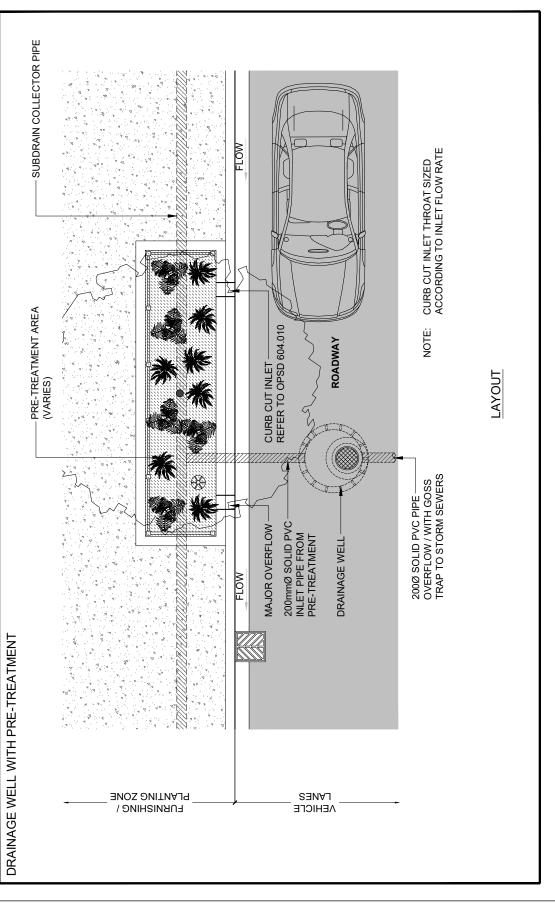
GEOTEXTILE

- Material Woven monofilament or non-woven punched fabric;
   Refer to OPSS 1860 Material Specification for Geotextiles.

# IDENTIFICATION MEDALLION A.6

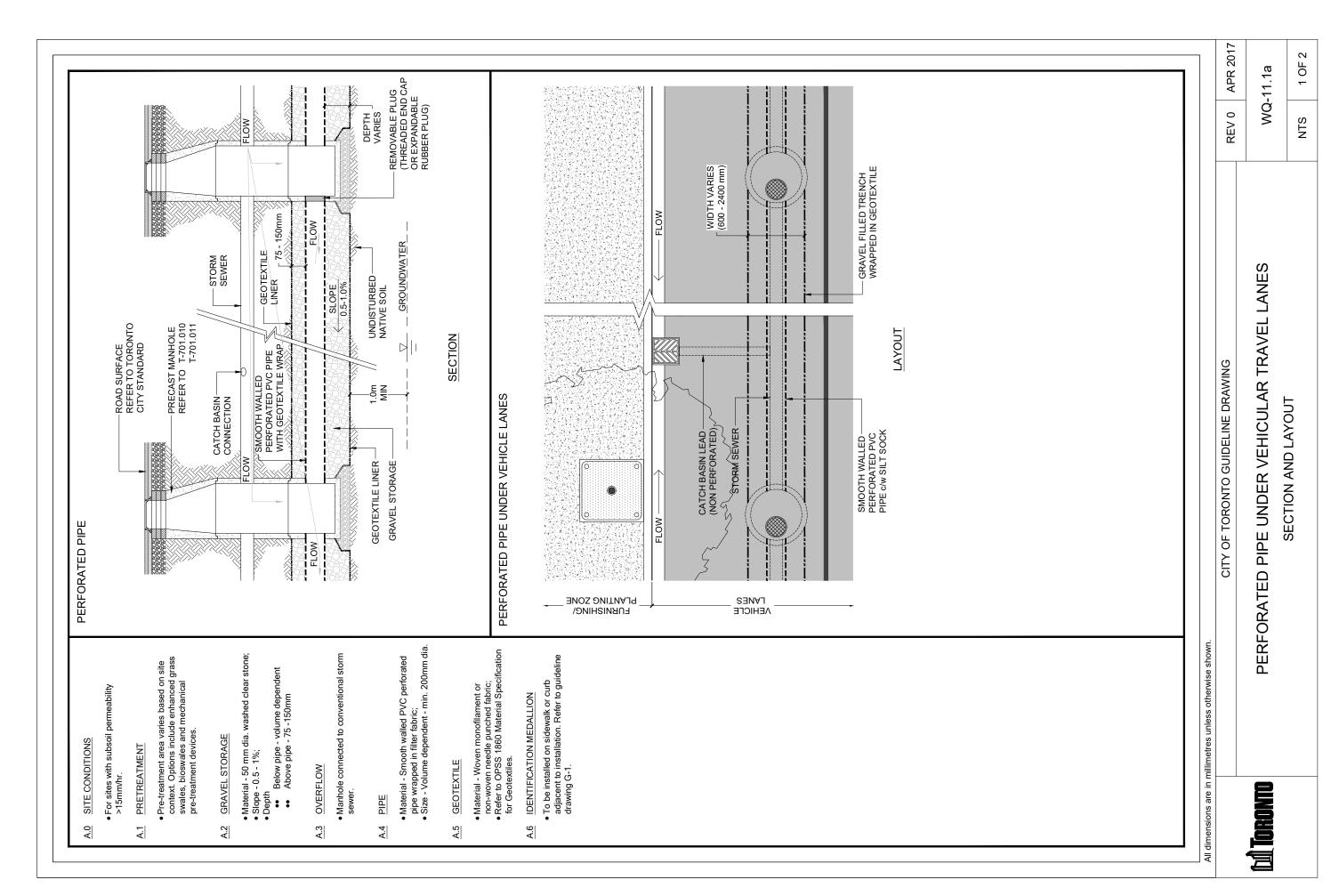
drawing G-1. To be installed on curb. Refer to

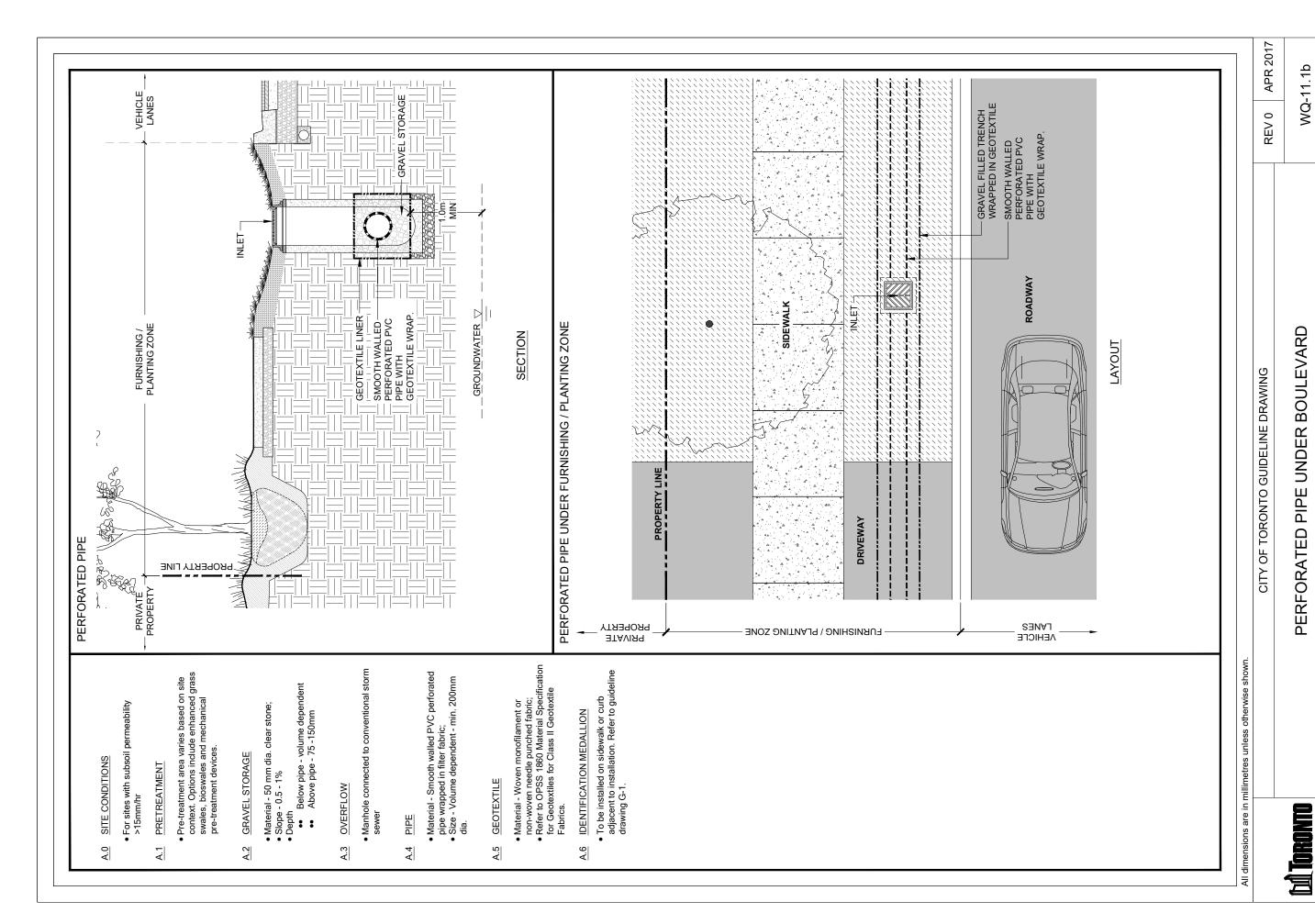




APR 2017 WQ-10.1 REV 0 NTS CITY OF TORONTO GUIDELINE DRAWING SECTIONS AND LAYOUTS DRAINAGE WELL **E**TORONTO







NTS

SECTION AND LAYOUT

# SAND LAYER A.

- Should contain minimal fines and organic
- ies 150-300mm

# GRAVEL STORAGE

- Uniformly graded 50m30-40% void spaceDepth varies

SUBDRAINS

- Inlet pipe (if applicable)
   Perforated PVC or equivalent (200mm ¢) connected to non-perforated pipe from
  - source Installed below frost level
- Overl
- flow pipe (if required) Overflow not required if permeability of
- native soils is >15mm/hr
  Overflow pipe at the top of gravel layer to
  be connected to the storm sewer. Pipes
  must be sized appropriately by engineer.

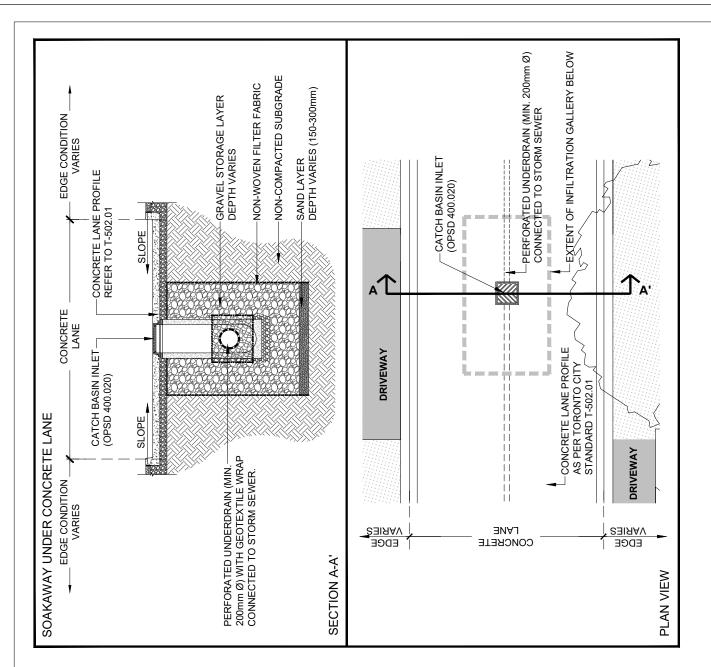
Refer to OPSS 405 - Construction Specific for Pipe Subdrains.

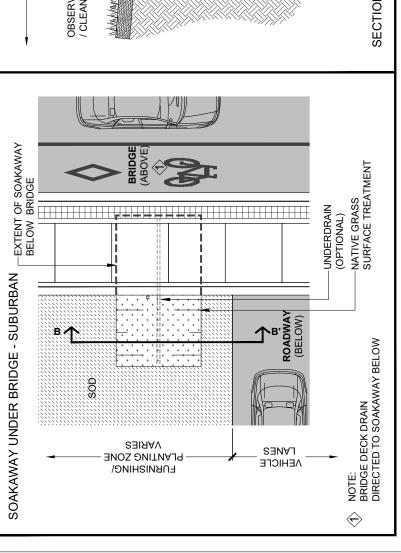
# GEOTEXTILE **A**.4

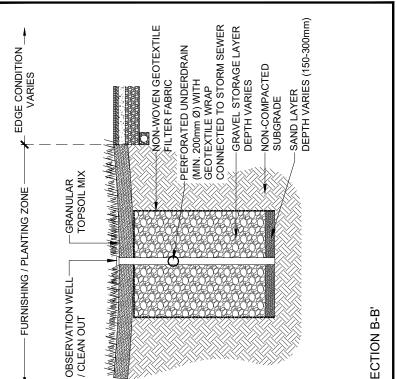
- Non-woven needle punched fabric or approved
- equal;
   Refer to OPSS 1860 Material Specification for Geotextiles;
   Line sidewalls and overlap 300mm at top if

# IDENTIFICATION MEDALLION A.5

To be installed on sidewalk or curb adjacent to installation. Refer to guideline drawing G-1.







CITY OF TORONTO GUIDELINE DRAWING SECTIONS AND LAYOUTS SOAKAWAYS TORONTO

SECTION B-B'

APR 2017

REV 0

WQ-12.1

NTS



Green Streets Technical Guidelines

- tangular excavations Length varies based on desired capacity Bottom width varies (600mm-2400 mm) Bottom surface should be level

# SAND LAYER A.1

Should contain minimal fines
Depth varies - 150 - 300mm

# GRAVEL STORAGE A.2

- Uniformly graded 50m30-40% void spaceDepth varies

## SUBDRAINS A.3

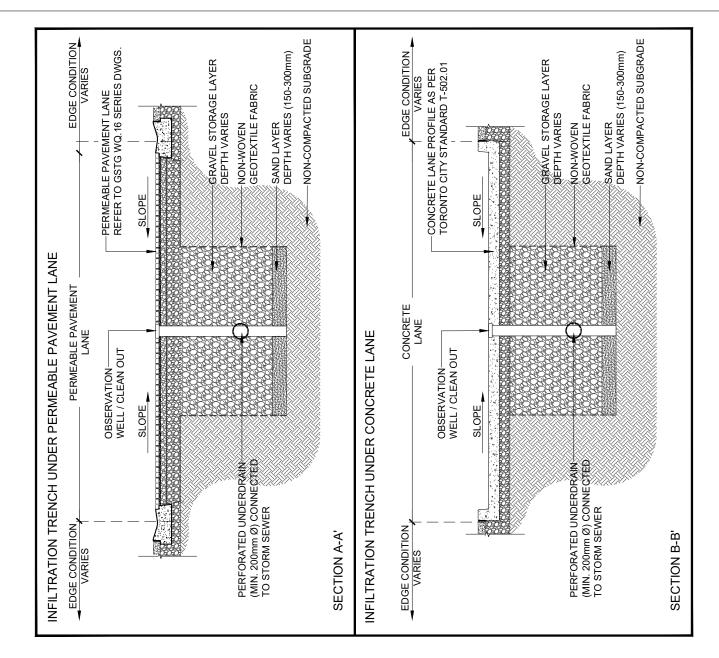
- Inlet pipe (if applicable)
   Perforated PVC or equivalent (200mm connected to non-perforated pipe from source
   Installed below frost level
- Ove
- verflow pipe (if required)

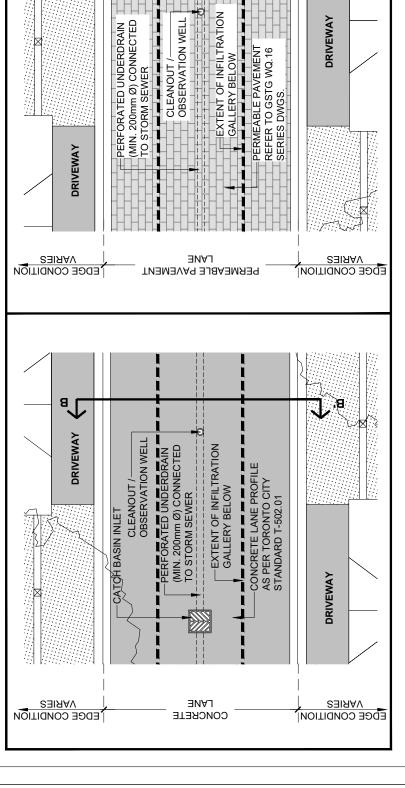
  Overflow not required if permeability of native soils is >15mm/hr

  Overflow pipe at the top of gravel layer to be connected to the storm sewer. Pipes must be sized appropriately by engineer.
- itoring well / Cleanout
  Capped non-perforated standpipe
  connected to the underdrain (if required) at
  the furthest downstream end.
- Refer to OPSS 405 Corfor For Pipe Subdrains.

# GEOTEXTILE A.4

- Non-woven needle punched fabric or equal;
  Refer to OPSS 1860 Material Specif Geotextiles;
  Line sidewalls and overlap 300mm at required.
  - IDENTIFICATION MEDALLION A.5



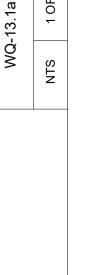


PLAN VIEW

unless otherwise shown All dimensions are in

M TORONTO	

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IFILTRATION TRENCH UNDER LANE	SECTIONS AND LAYOUTS
	INFILTRATION TRENCH UNDER LANE



APR 2107

REV 0

DRIVEWAY



Green Streets Technical Guidelines

[1] TORONTO

### SAND LAYER A.

- Should contain minimal fines and organic
- Depth varies 150 300mm

# GRAVEL STORAGE A.2

- Uniformly graded 50mm clear stone
   30-40% void space
   Depth varies

- SUBDRAINS

# A.3

- Inlet pipe (if applicable)
   Perforated HDPE or equivalent (200mm \$\phi\$)
   connected to non-perforated pipe from source
   Installed below frost level
- Ove
- verflow pipe (if required)

  Overflow not required if permeability of native soils is >15mm/hr

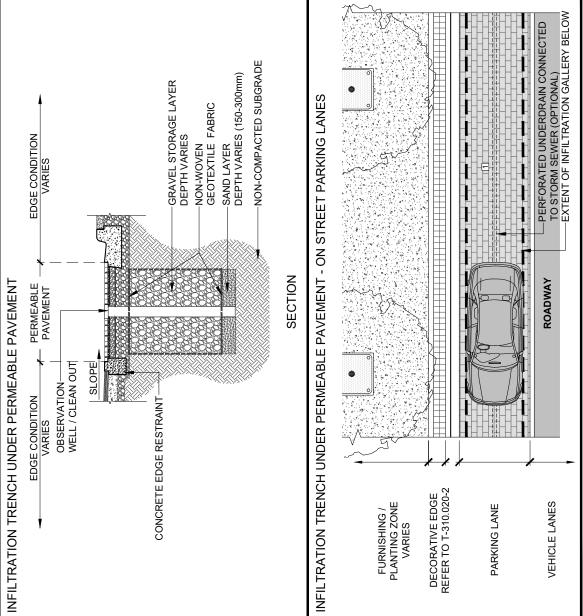
  Overflow pipe at the top of gravel layer to be connected to the storm sewer. Pipes must be sized appropriately by engineer.
- Monitoring well / Cleanout
   Capped non-perforated standpipe connected to the underdrain (if required) at the furthest downstream end.
  - Refer to OPSS 405 Construction Specification for Pipe Subdrains.

# GEOTEXTILE **A**.4

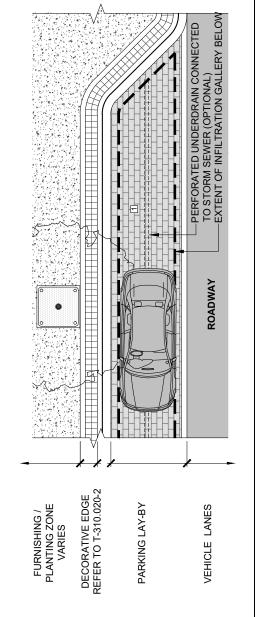
- Non-woven needle punched fabric or approved equal;
   Refer to OPSS 1860 Material Specification for

# IDENTIFICATION MEDALLION A.5

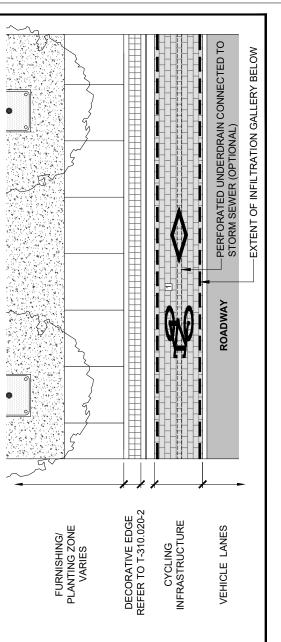
• To be installed on sidewalk or curb adjacent installation. Refer to guideline drawing G-1.



# INFILTRATION TRENCH UNDER PERMEABLE PAVEMENT - PARKING LAY-BYS



# INFILTRATION TRENCH UNDER PERMEABLE PAVEMENT - CYCLING INFRASTRUCTURE



NOTE FOR PERMEABLE PAVEMENT OPTIONS REFER TO GSTG WQ.16 SERIES DRAWINGS.

CROSS SLOPE VARIES CONTINGENT ON OVERALL ROAD CROSS-SECTION AND PROFILE. PREFERRED MAXIMUM CROSS SLOPE GRADIENT FOR PERMEABLE PAVING SURFACE NOT TO EXCEED 2%

E TORONTO

INFILTRATION TRENCH UNDER PERMEABLE PAVEMENT **SECTION & LAYOUTS** 

CITY OF TORONTO GUIDELINE DRAWING

WQ-13.1b NTS

APR 2017

REV 0







- Rectangular excavations

   Length varies based on desired capacity

   Bottom width varies (600mm-2400 mm)

   Bottom surface should be level

# A.1

Pre-treatment area v context. Options incl swales, bioswales a pre-treatment device

# A.2

- SAND LAYER
- Depth varies 150 300r Should contain min matter

GRAVEL STORAGE

A.3

Uniformly graded 50m30-40% void spaceDepth varies

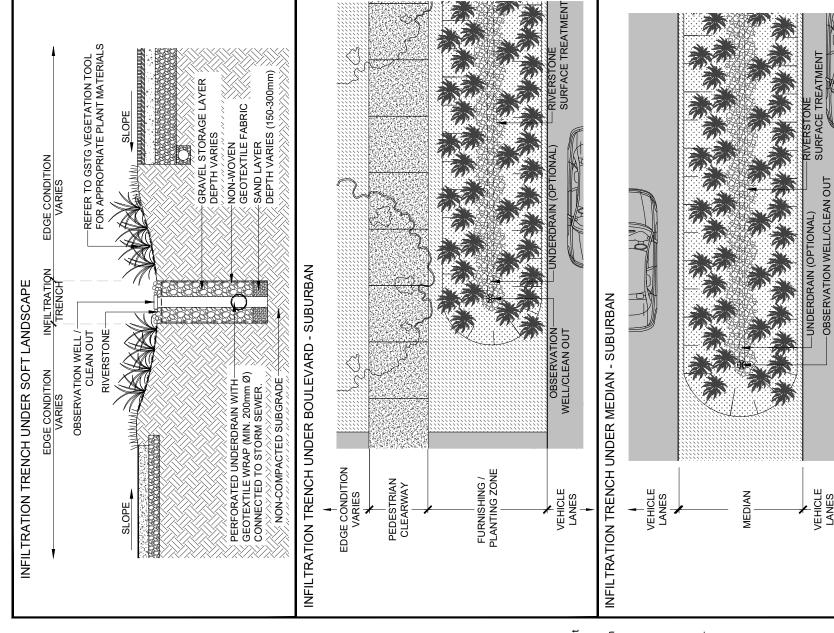
## SUBDRAINS A.4

- Inlet pipe (if applicable)Perforated PVC or
- ated PVC or equivalent (200mm cted to non-perforated pipe from
- quired if permeability of ŏ :

- nitoring well / Cleanout Capped non-perforated standpipe connected to the underdrain (if required) at the furthest downstream end. Refer to OPSS 405 - Construction Spefor Pipe Subdrains.

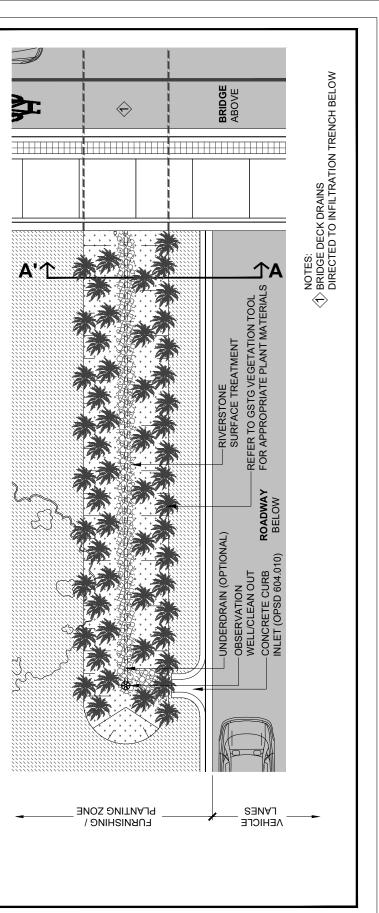
# GEOTEXTILE A.5

- Non-woven needle punched fabric or approved equal;
  Refer to OPSS 1860 Material Specification for Geotextiles;
  Line sidewalls and overlap 300mm at top if required.





ROADWAY



All dimensions are in millimetres unless otherwise shown



INFILTRATION TRENCH UNDER SOFT LANDSCAPES SECTION & LAYOUTS

CITY OF TORONTO GUIDELINE DRAWING

WQ-13.1c NTS

APR 2017

REV 0





- based on desired capacity varies (600mm-2400 mm) s should be level

# SAND LAYER A.1

- Should contain minimal fines and organic matter
   Depth varies 150 300mm

# GRAVEL STORAGE A.2

- Uniformly graded 50m30-40% void spaceDepth varies

## SUBDRAINS A.3

- Inlet pipe (if applicable)
  Perforated PVC or equivalent (200mm ¢) connected to non-perforated pipe from source
  Installed below frost level
- itoring well / Cleanout Capped non-perforated standpipe connected to the underdrain (if required) at the furthest downstream end. Mo.
- Refer to OPSS 405 Construction Specification for Pipe Subdrains.

# INFILTRATION CHAMBERS A.4

Refer to manufacturer's specifications

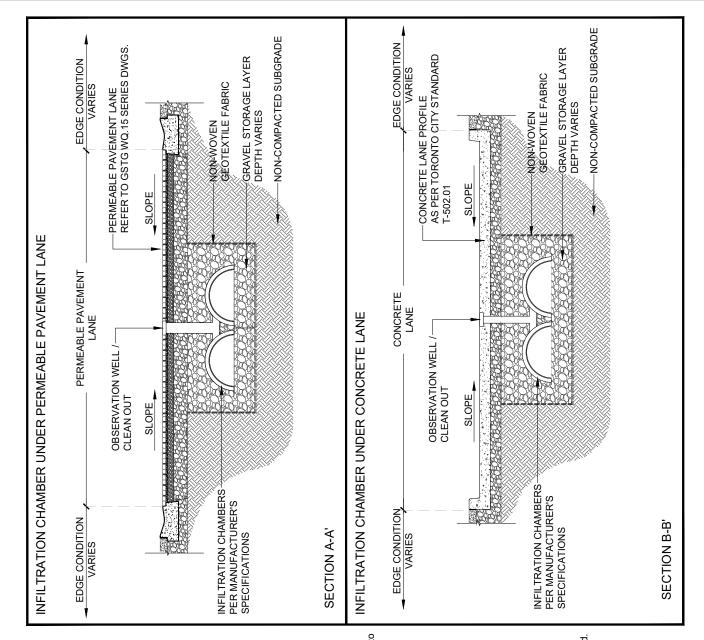
## GEOTEXTILE A.6

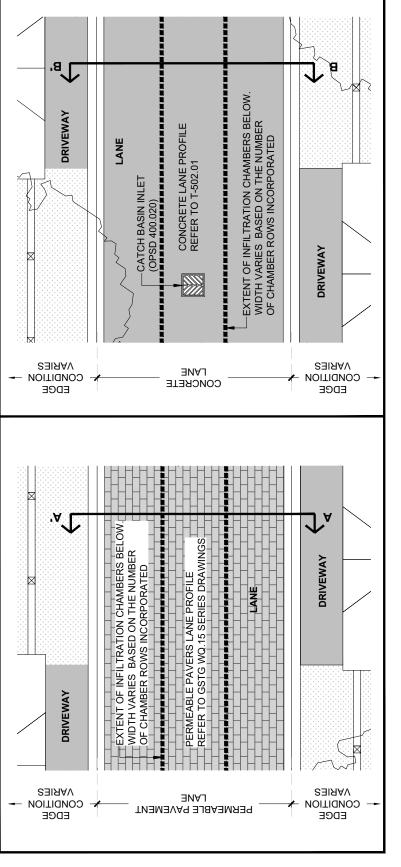
- Non-woven needle punched fabric or approved equal. Refer to OPSS 1860 Material Specification for Geotextiles;
   Line sidewalls and overlap 300mm at top if required.

IDENTIFICATION MEDALLION

A.7

To be installed on paving or curb adjacent installation. Refer to guideline drawing G-1.





PLAN VIEW

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**TORONTO** 

CITY OF TORONTO GUIDELINE DRAWING	NFILTRATION CHAMBER UNDER LANE	SECTIONS AND LAYOUTS
CITY OF TORONTO GUIL	INFILTRATION CHAME	SECTIONS AND

APR 2017

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WQ-14.1.a

NTS





[1] TORONTO

- Rectangular excavations
   Length varies based on desired capacity
   Bottom width varies (600mm-2400 mm)
   Bottom surface should be level

# SAND LAYER A.

- Should contain minimal fines and organic matter
   Depth varies 150 300mm

# GRAVEL STORAGE A.2

Uniformly graded 50mn30-40% void spaceDepth varies

## SUBDRAINS A.3

- Inlet pipe (if applicable)
   Perforated PVC or equivalent (200mmø) connected to non-pe pipe from source; Installed below frost level.
- Monitoring well / Cleanout
   Capped non-perforated standpipe connected to the underdrain (if required) at the furthest downstream end.
- Refer to OPSS 405 Construction Specification for Pipe Subdrains.

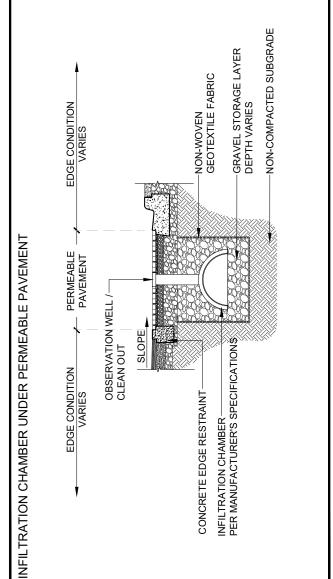
# INFILTRATION CHAMBER A.4

- GEOTEXTILE A.5
- Non-woven needle punched fabric or approved equal. Refer to OPSS 1860 Material Specification for Geotextiles;
  Line sidewalls and over lap 300mm at top if

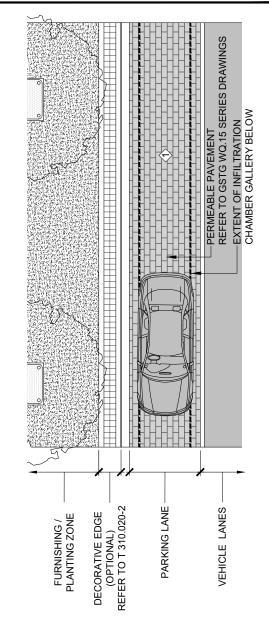
# IDENTIFICATION MEDALLION

Ä

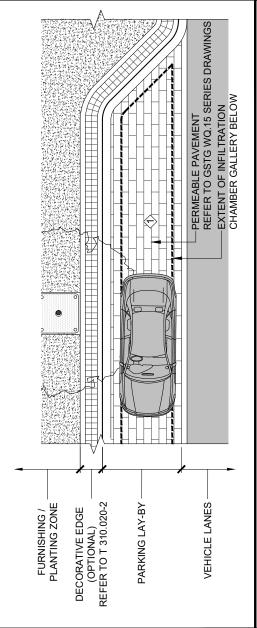
To be installed on sidewalk or curb adjacent installation. Refer to guideline drawing G-1.



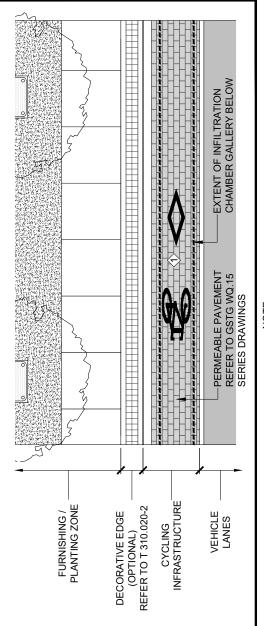
# INFILTRATION CHAMBER UNDER PERMEABLE PAVEMENT - ON STREET PARKING LANES



# INFILTRATION CHAMBER UNDER PERMEABLE PAVEMENT - PARKING LAY-BYS



# INFILTRATION CHAMBER UNDER PERMEABLE PAVEMENT - CYCLING INFRASTRUCTURE



NOTE FOR PERMEABLE PAVEMENT OPTIONS REFER TO GSTG WQ.16 SERIES DRAWINGS.

CROSS SLOPE VARIES CONTINGENT ON OVERALL ROAD CROSS-SECTION AND PROFILE. PREFERRED MAXIMUM CROSS SLOPE GRADIENT FOR PERMEABLE PAVING SURFACE NOT TO EXCEED 2%

**E**TORONTO

INFILTRATION CHAMBER UNDER PERMEABLE PAVEMENT SECTION & LAYOUTS

CITY OF TORONTO GUIDELINE DRAWING

WQ-14.1b NTS TGS Priority - Water Quantity, Quality & Efficiency

APR 2017

REV 0

[DI] TORONTO

# PRETREATMENT A.1

# SAND LAYER A.2

Should contain minimal fines

# GRAVEL STORAGE A.3

- matter
   Depth varies 150-300mm
- Uniformly graded 50mm clear stone
   30-40% void space
   Depth varies

### SUBDRAINS A.4

- Inlet pipe (if applicable)
   Perforated PVC or equivalent (200mm connected to non-perforated pipe from
  - source Installed below frost level
- itoring well / Cleanout
  Capped non-perforated standpipe
  connected to the underdrain (if required)
  at the furthest downstream end. itoring well / Clear Capped non-perf § :
- Refer to OPSS 405 Constru Specification for Pipe Subdra

# INFILTRATION CHAMBER A.5

Refer to m

## GEOTEXTILE A.6

- Non-woven needle punched fabric or approved equal. Refer to OPSS 1860 -Material Specification for Geotextiles;
   Line sidewalls and over lap 300mm at top

# PLANTING A.7

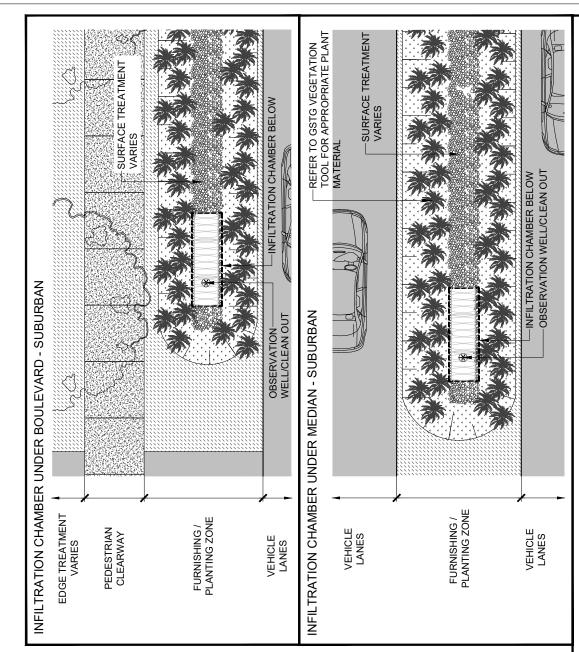
Plant material should tolerant of salt and urban conditions. Refer to the GSTG Vegetation Selection Tool for an appropriate palette.

# IDENTIFICATION MEDALLION A.8

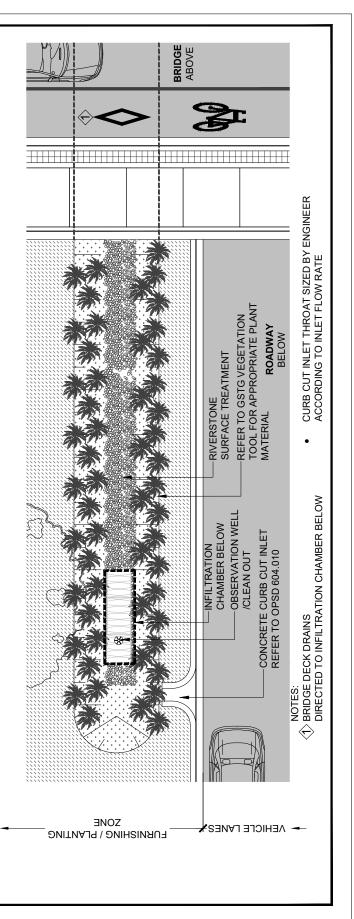
To be installed on sidewalk or curb adjacent installation. Refer to guideline drawing G-1.

### GRAVEL STORAGE DEPTH VARIES EDGE CONDITION VARIES EDGE CONDITION JNFILTRATION VARIES CHAMBER INFILTRATION CHAMBER RECIPICATIONS SPECIFICATIONS NON-COMPACTED SUBGRADE OBSERVATION—WELL / CLEAN OUT RIVERSTONE SLOPE INFILTRATION CHAMBER UNDER SOFT LANDSCAPE SLOPE GRAVEL STORAGE DEPTH VARIES EDGE CONDITION VARIES EDGE CONDITION JNFILTRATION VARIES CHAMBER NON-COMPACTED SUBGRADE INFILTRATION CHAMBER PER MANUFACTURER'S SPECIFICATIONS OBSERVATION—WELL / CLEAN OUT SLOPE RIVERSTONE

SLOPE







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INFILTRATION CHAMBER UNDER SOFT LANDSCAPES SECTION & LAYOUTS

CITY OF TORONTO GUIDELINE DRAWING

APR 2017

REV 0

WQ-14.1c



# A.0 PERVIOUS CONCRETE PAVING

A.0.1 Material: NO4-RG-S7 mix;

A.0.2 Thickness varies: 100mm-150mm;

npressive strength = 15MPa; A.0.3 28 day

A.0.4 Void ratio = 15% to 25%;

ability = 900 to 21,500 mm/hr; A.0.5 Pern Refer to OPSS 356 - Construction Specification for Previor Concrete Pavement for Low Volume Traffic Applications

# STONE RESERVOIR

A.1.1 ALL AGGREGATES:

• Max. wash loss - 0.5%

• Min. durability index - 35

• Max. abrasion - 10% for 100 and

- 50% for 500 revolutions

### BEDDING: A.1.2

5 mm diameter stone or as per the Design Engineer

Depth varies

75mm heavy duty; 40mm light duty;

Max allowable depth of the filter bed determined by the following: dmax = i x ts / Vr

# Wher

dmax = Maximum stone bed depth (m);
i = Infiltration rate for native soils (m/hr);
Vr = Void ratio for stone bed (typically 0.3-0.4);
ts = Time to drain stone bed (typically 24 hours;
72 hours max) (hr).

# **GRANULAR BASE** A.1.3

- 0-5% smaller than 2.36mm 0-10% smaller than 4.75mm 25-60% smaller than 12.5mm 95-100% smaller than 37.5mm

Stone storage bed design calculated based on the following:

# dp=[Qc\*R+P-i\*T]/Vr Whe

용 8 \* • •

 p = Stone bed depth (m)
 c = Depth of contributing runoff area (not including permeable surface (m)
 c = Contributing drainage area (Ac) / <u>د</u>

Permeable paving area (Ap)
= Rainfall depth (m)
= Infiltration rate for native soils (m/day)
= Time to fill stone bed (typically 2 hr)
r = Void ratio for stone bed (0.3-0.4) **⊢** >

Note - Ac - should not contain pervious areas

# A.1.4

GRANULAR SUB-BASE:

• Material: 50mm dia. clear crushed gravel;

• Refer to Material Specification for Aggregates (TS 1010).

Material: Woven monofilament or non-woven needle punched fabrics;
 Refer to OPSS 1860 Material Specification for Geotextiles.

# GEOTEXTILE A.2

# A.3

- UNDERDRAIN (Optional)
  Required where native soil infiltration rates are <15mm/hr;</li>
  Min. 200mm dia. perforated pipe installed 100mm above the bottom of the gravel storage layer;
  Capped at upstream end and connected to storm sewer;
  Connected to monitoring well for clean out;
  Refer to OPSS 405 Construction Specification for Subdrain Pipe.

### TESTING **A**.4

ASTM 1688 - Standard testing method for density and void content;

ASTM 1701 - Standard testing method for infiltration rate of in-place pervious concrete;
 ASTM 1754 - Standard testing method for density & void content of hardened pervious concrete.

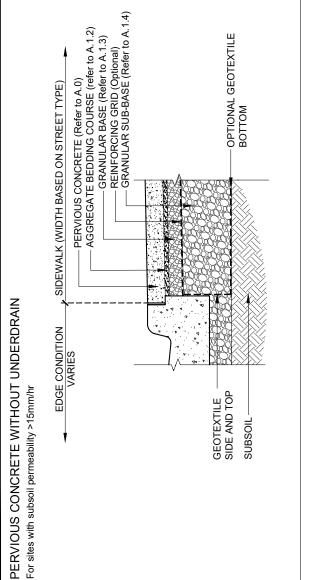
# IDENTIFICATION MEDALLION A.5

To be installed on curb. Refer to guideline drawing G-1.

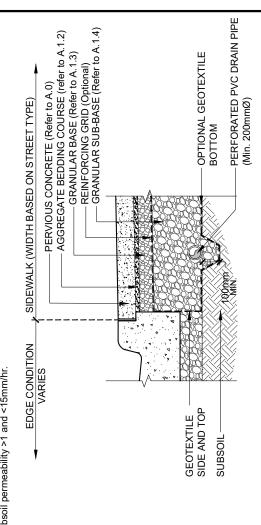
All dimensions are in millimetres unless otherwise shown

**Interpretation** 

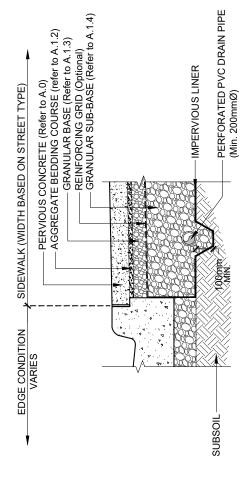
# PERMEABLE PAVEMENT - PERVIOUS CONCRETE CITY OF TORONTO GUIDELINE DRAWING SECTIONS



PERVIOUS CONCRETE WITH UNDERDRAIN For sites with subsoil permeability >1 and <15mm/hr.



# PERVIOUS CONCRETE WITH UNDERDRAIN & IMPERVIOUS LINER For sites with contaminated soils



### NOTES:

- DESIGN DETAILS TO BE ADAPTED FOR THE SPECIFIC LOCATION AND INSTALLATION.
- ANY PRE-EXISTING IMPERVIOUS BASE COURSE MATERIAL MUST BE REMOVED PRIOR TO PERMEABLE PAVER INSTALLATION.

1 OF

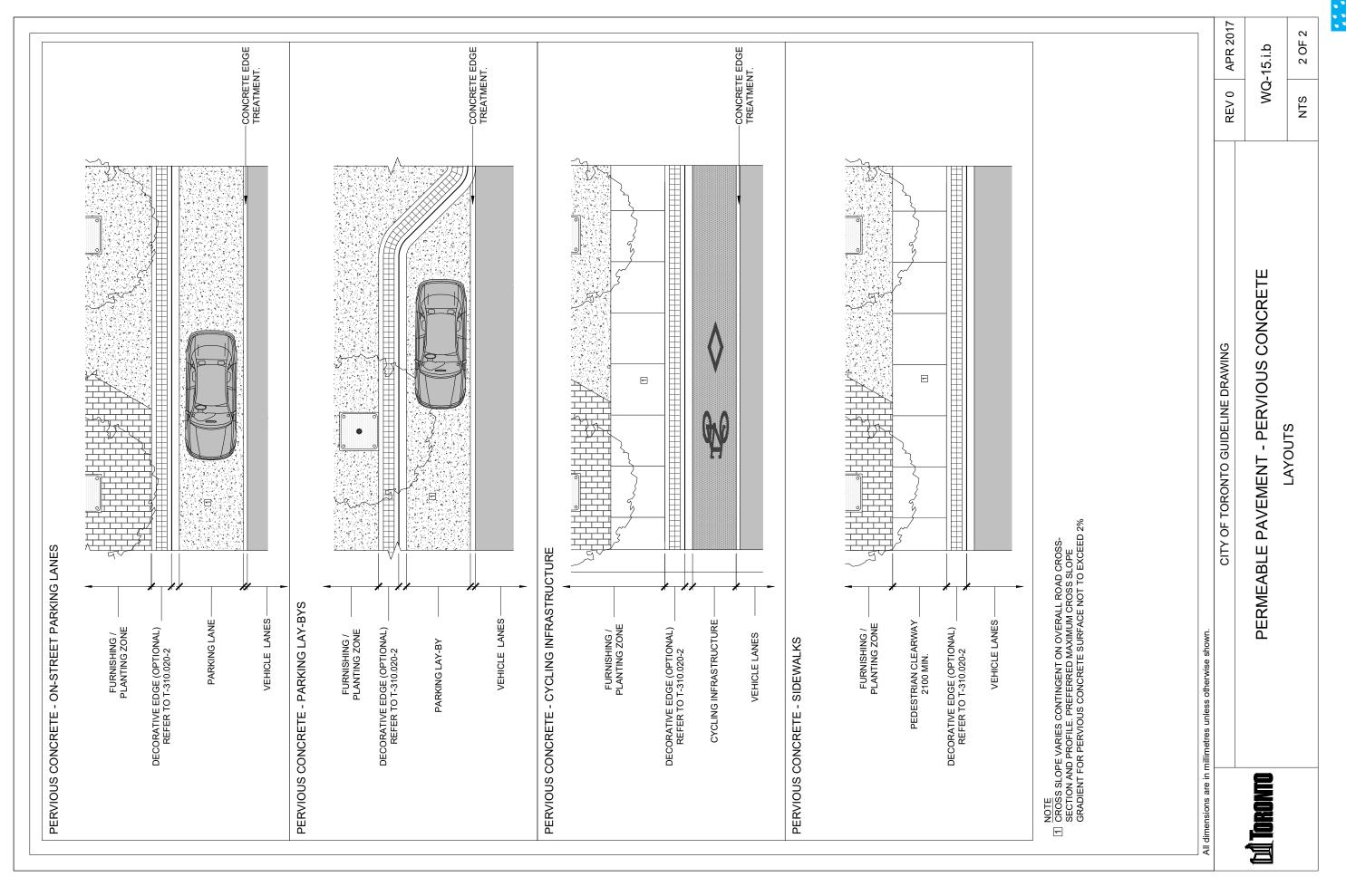
APR 2017

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Green Streets Technical Guidelines



Green Streets Technical Guidelines

[1] TORONTO

# A.0 POROUS ASPHALT PAVING

- nd guipu ies from 50-100mm depe A.0.1 Thickness varie expected load.
- A.0.2 Open-graded asphalt mix 16% min. void space.
- A.0.3 Add polymer to strengthen for heavy loads.
- STONE RESERVOIR
- A.1.1 ALL AGGREGATES:
- Max. wash loss 0.5%
  Min. durability index 35
  Max. abrasion 10% for 100 and 50% for 500 revolutions

# BEDDING:

- as per the Design eter stone or

# A.1.2

- - Depth varies:75mm heavy duty;40mm light duty;
- Max allowable depth of the filter bed determined by the following:

  - $dmax = i \times ts / Vr$

# Where:

- dmax = Maximum stone bed depth (m)
  i = Infiltration rate for native soils (m/hr)
  Vr = Void ratio for stone bed (typically 0.3-0.4)
  ts = Time to drain stone bed (typically 24 hours; 72 hours max) (hr)

- GRANULAR BASE

  Material: A.1.3

- 0-5% smaller than 2.36mm 0-10% smaller than 4.75mm 25-60% smaller than 12.5mm 95-100% smaller than 25.0mm 100% smaller than 37.5mm
- Stone storage bed design calculated based on the following: dp= [Qc \* R + P - i \* T] / Vr

# Where:

- dp = Stone bed depth (m)
   Qc = Depth of contributing runoff area (not including permeable surface (m)
   R = Contributing drainage area (Ac) / Permeable paving area (Ap)
   P = Rainfall depth (m)
   i = Infiltration rate for native soils (m/day)
   T = Time to fill stone bed (typically 2 hr)
   Vr = Void ratio for stone bed (0.3-0.4)

# Note - Ac - should not contain pervious areas.

- A. 1.4 GRANULAR SUB-BASE:

   Material: 50mm dia. clear crushed gravel

   Refer to Material Specification for Aggregates (TS 1010)

- A.2
- GEOTEXTILE

   Material: Woven monofilament or non-woven needle punched fabrics;

   Refer to OPSS 1860 Material Specification for Geotextiles.

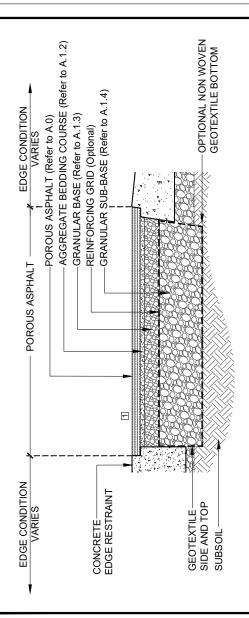
# UNDERDRAIN (Optional) A.3

- Required where native soil infiltration rates are <15mm/hr;</li>
- Min. 200mm dia. PVC perforated pipe installed 100mm above the bottom of the gravel storage
- Capped at upstream end and connected to storm sewer;
- PSS 405 Construction Specification for Refer to OPSS Subdrain Pipe.

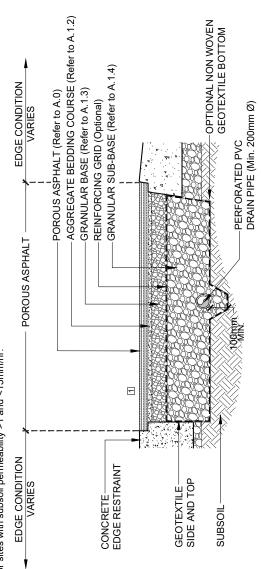
# IDENTIFICATION MEDALLION A.4

To be installed on curb. Refer to guideline drawing G-1.

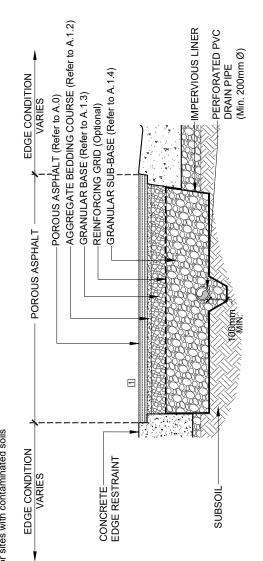
# POROUS ASPHALT WITHOUT UNDERDRAIN For sites with subsoil permeability >15mm/hr



POROUS ASPHALT WITH UNDERDRAIN For sites with subsoil permeability >1 and <15mm/hr.



# POROUS ASPHALT WITH UNDERDRAIN & IMPERVIOUS LINER For sites with contaminated soils



### NOTE

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- CROSS SLOPE VARIES CONTINGENT ON OVERALL ROAD CROSS-SECTION AND PROFILE. PREFERRED MAXIMUM CROSS SLOPE GRADIENT FOR POROUS ASPHALT SURFACE NOT TO EXCEED 2%
  - NOTES:
- DESIGN DETAILS TO BE ADAPTED FOR THE SPECIFIC LOCATION AND INSTALLATION.
- ANY PRE-EXISTING IMPERVIOUS BASE COURSE MATERIAL MUST BE REMOVED PRIOR TO PERMEABLE PAVER INSTALLATION.

netres unless otherwise shown.

# **In Toron**

# PERMEABLE PAVEMENT - POROUS ASPHALT CITY OF TORONTO GUIDELINE DRAWING SECTIONS

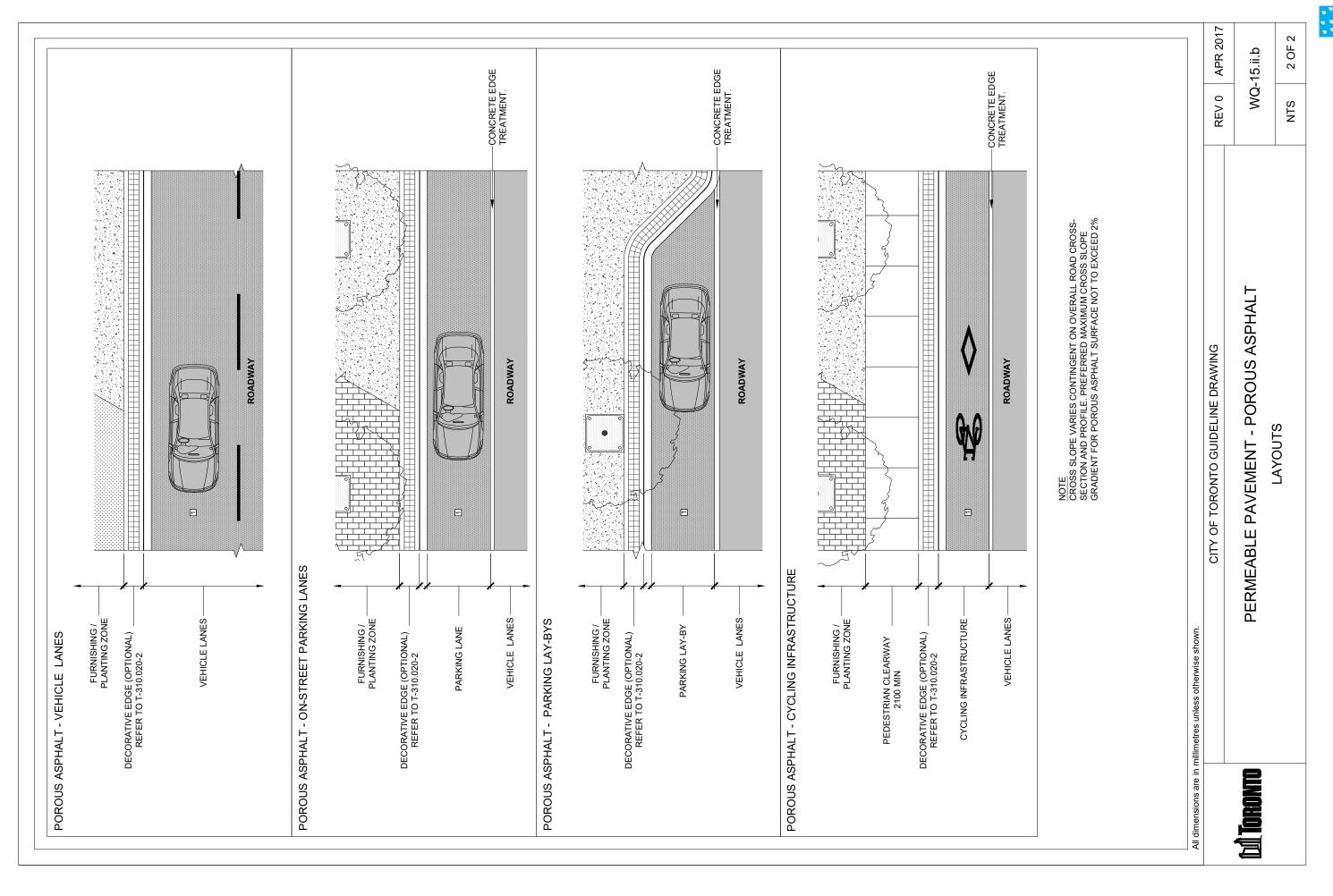


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INTERLOCKING PRECAST CONCRETE PAVERS WITHOUT UNDERDRAIN For sites with subsoil permeability >15mm/hr

Refer to OPSS PROV 355 - Construction Specification for Installation of Interlocking Concrete Pavers and CAN-3-A231.2, Standard Specification for Precast Concrete Pavers;

- A.0.1 Paver thickness:
   Heavy duty 100mm;
   Light duty 80mm;

PERMEABLE PAVERS (Refer to A.0)

— AGGREGATE BEDDING COURSE (refer to A.1.2)

— GRANULAR BASE (Refer to A.1.3)

— REINFORCING GRID (Optional)

— GRANULAR SUB-BASE (Refer to A.1.4)

EDGE CONDITION VARIES

PERMEABLE CONCRETE PAVERS

EDGE CONDITION VARIES

OPTIONAL NON WOVWN GEOTEXTILE BOTTOM

<sup>8</sup>. △ 4. 4. .

A.0.2 Pigment: Refer to ASTM C 979;

CONCRETE ——— EDGE RESTRAINT

- A.0.4 Joints: Width:
- A.0.3 Maximum breakage = 5%;
- crushed aggregate. Width: 6mm - 10mm; Joint fill material - 5 mm dia.

GEOTEXTILE -SIDE AND TOP SUBSOIL -----

- A.1.1 ALL AGGREGATES:

   Max. wash loss 0.5%

   Min. durability index 35

   Max. abrasion 10% for 100

   50% for 500 revolutions
- 100 and

INTERLOCKING PRECAST CONCRETE PAVERS WITH UNDERDRAIN For sites with subsoil permeability > 1 and <15mm/hr.

- A.1.2 BEDDING:
- the Design Engineer 5 mm diameter stone or as per
- 75mm heavy duty;40mm light duty;
- Max allowable depth of the filter bed determined by the following:

AGGREGATE BEDDING COURSE (refer to A.1.2)

GRANULAR BASE (Refer to A.1.3)

REINFORCING GRID (Optional)

GRANULAR SUB-BASE (Refer to A.1.4)

CONCRETE ——— EDGE RESTRAINT

RETE EDGE CONDITION VARIES

PERMEABLE PAVERS (Refer to A.0)

PERMEABLE CONCRETE PAVERS

EDGE CONDITION VARIES

dmax = i x ts / Vr

- Where:
- dmax = Maximum stone bed depth (m)
  i = Infiltration rate for native soils (m/hr)
  Vr = Void ratio for stone bed (typically 0.3-0.4)
  ts = Time to drain stone bed (typically 24 hours; 72 hours max) (hr)

GEOTEXTILE - SIDE AND TOP

A.1.3 GRANULAR BASE

— OPTIONAL NON WOVEN GEOTEXTILE BOTTOM — PERFORATED PVC DRAIN PIPE (Min. 200mm Ø)

INTERLOCKING PRECAST CONCRETE PAVERS WITH UNDERDRAIN & IMPERVIOUS LINER For sites with contaminated soils

- 0-5% smaller than 2.36mm 0-10% smaller than 4.75mm
- 25-60% smaller than 12.5mm 95-100% smaller than 25.0mm 100% smaller than 37.5mm

- sed on the Stone storage bed design calculated bas following:

dp= [Qc \* R + P - i \* T] / Vr

EDGE CONDITION VARIES

PERMEABLE CONCRETE PAVERS

EDGE CONDITION VARIES

PERMEABLE PAVERS (Refer to A.0)

- Qc = Depth of contributing runoff area (not including permeable surface (m)
   R = Contributing drainage area (Ac) / Permeable paving area (Ap)
   P = Rainfall depth (m)
   i = Infiltration rate for native soils (m/day)
   T = Time to fill stone bed (typically 2 hr)
   Vr = Void ratio for stone bed (0.3-0.4) Where:

  • dp = Stone bed depth (m)

  • Qc = Depth of contributing ru

CONCRETE———EDGE RESTRAINT

- Note Ac should not contain pervious areas

MPERVIOUS LINER PERFORATED PVC DRAIN PIPE (Min. 200mm Ø)

# A.1.4

NOTE

SUBSOIL

GRANULAR SUB-BASE:

• Material: 50mm dia. crushed gravel;

• Refer to Material Specification for Aggregates (TS 1010).

☼ CROSS SLOPE VARIES CONTINGENT ON OVERALL ROAD CROSS-SECTION AND PROFILE. PREFERRED MAXIMUM CROSS SLOPE GRADIENT FOR PERMEABLE PAVING SURFACE NOT TO EXCEED 2%

# GEOTEXTILE A.2

- Material: Woven monofilament or non-woven repunched fabrics;
   Refer to OPSS 1860 Material Specification for Geotextiles.

# A.3

UNDERDRAIN (Optional)
• Required where native soil infiltration rates are <15mm/hr,

ANY PRE-EXISTING IMPERVIOUS BASE COURSE MATERIAL MUST BE REMOVED PRIOR TO PERMEABLE PAVER INSTALLATION.

DESIGN DETAILS TO BE ADAPTED FOR THE SPECIFIC LOCATION AND INSTALLATION.

NOTES:

- Min. 200mm dia. perforated pipe installed 100mm above the bottom of the gravel storage layer,
  Capped at upstream end and connected to storm sewer,
- SS 405 Construction Spec Refer to OPSS A
   Subdrain Pipe.

# IDENTIFICATION MEDALLION A.4

- To be installed on curb. Refer to guideline drawing G-1.
- erwise shown ons are in

**INTORONTO** 

# CITY OF TORONTO GUIDELINE DRAWING

APR 2017

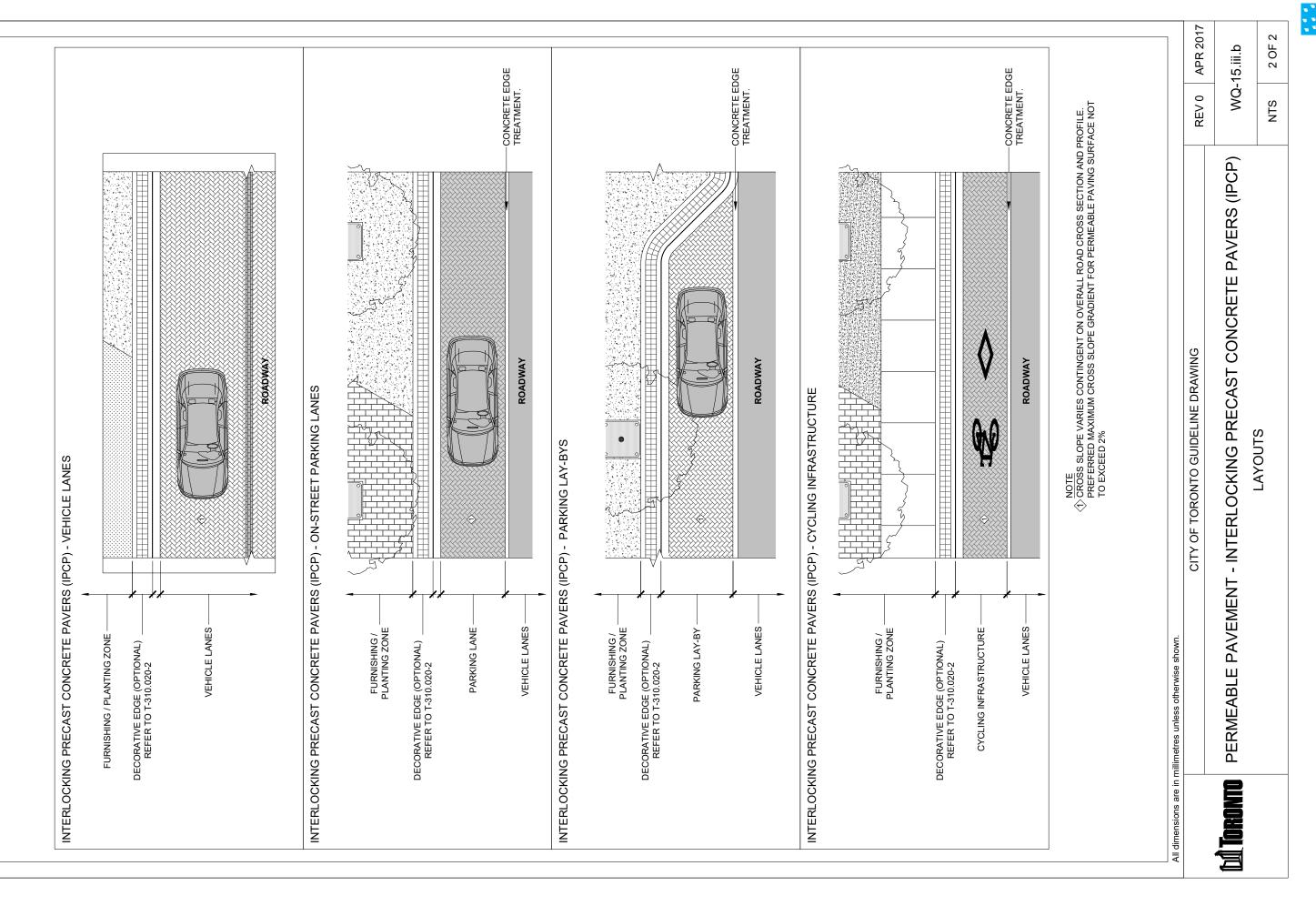
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PERMEABLE PAVEMENT - INTERLOCKING PRECAST CONCRETE PAVERS (IPCP) SECTIONS

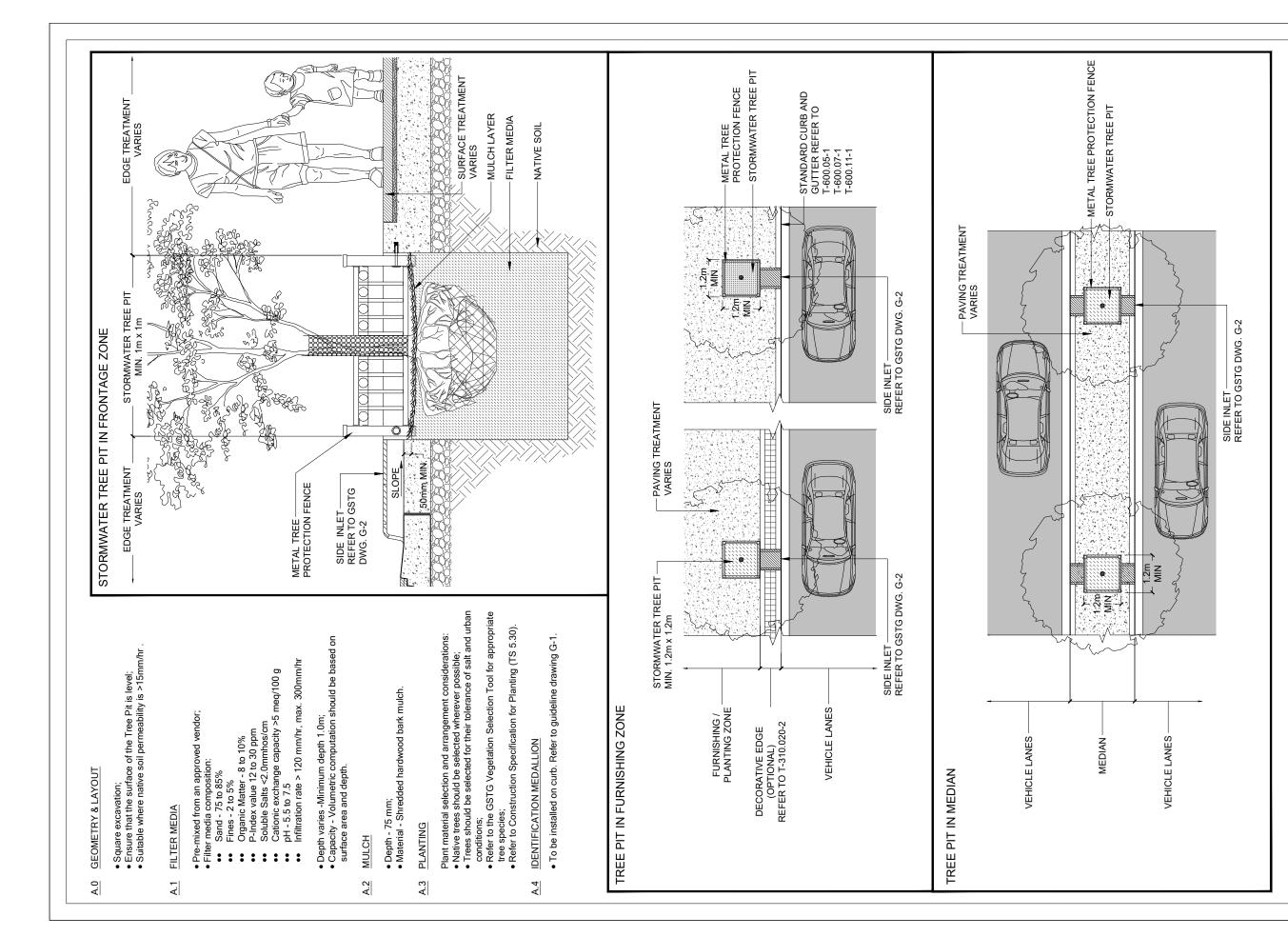


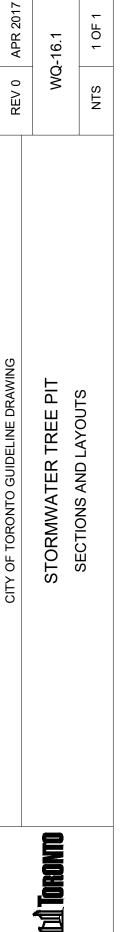






Green Streets Technical Guidelines



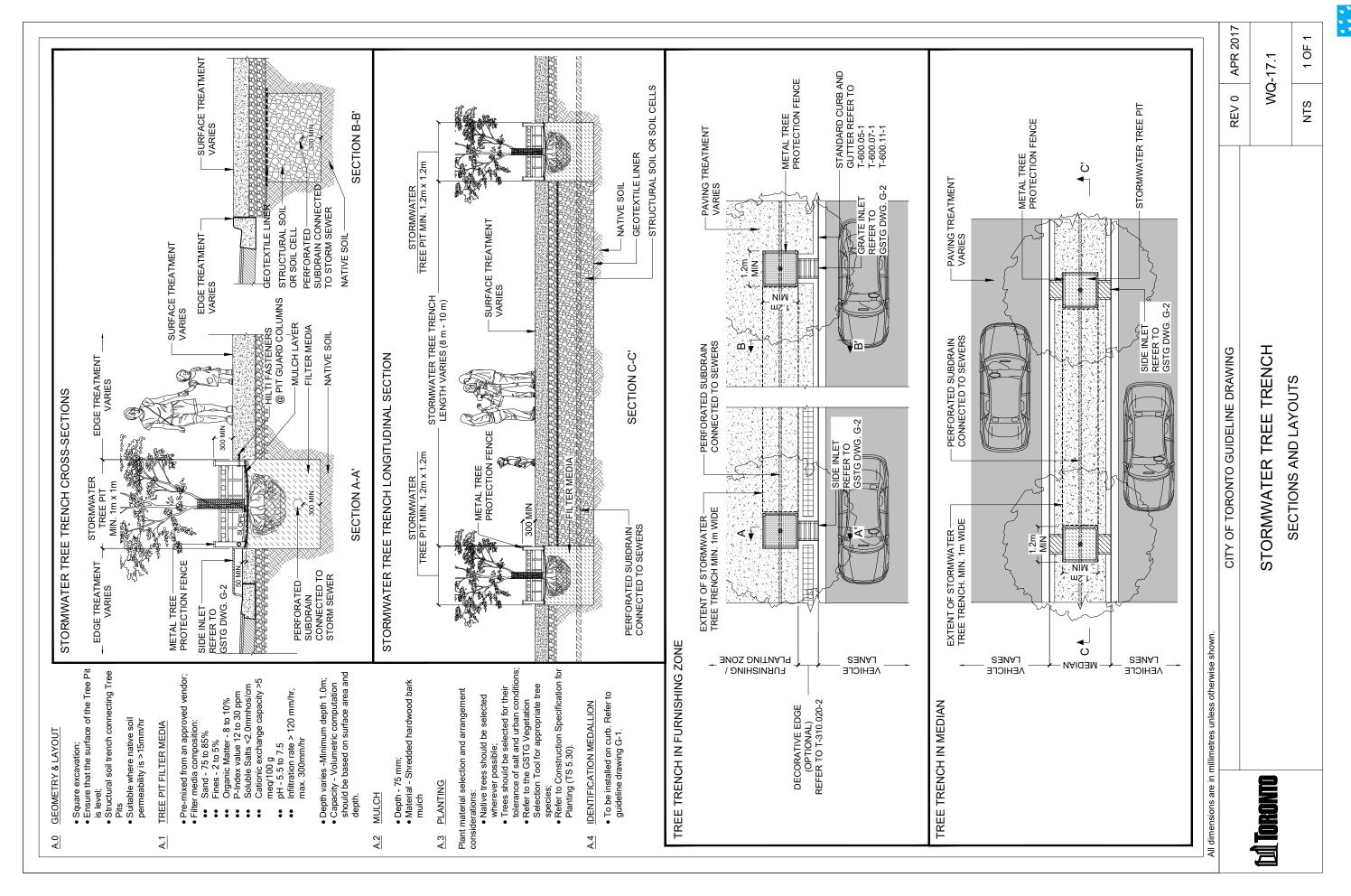


All dimensions are in millimetres unless otherwise shown

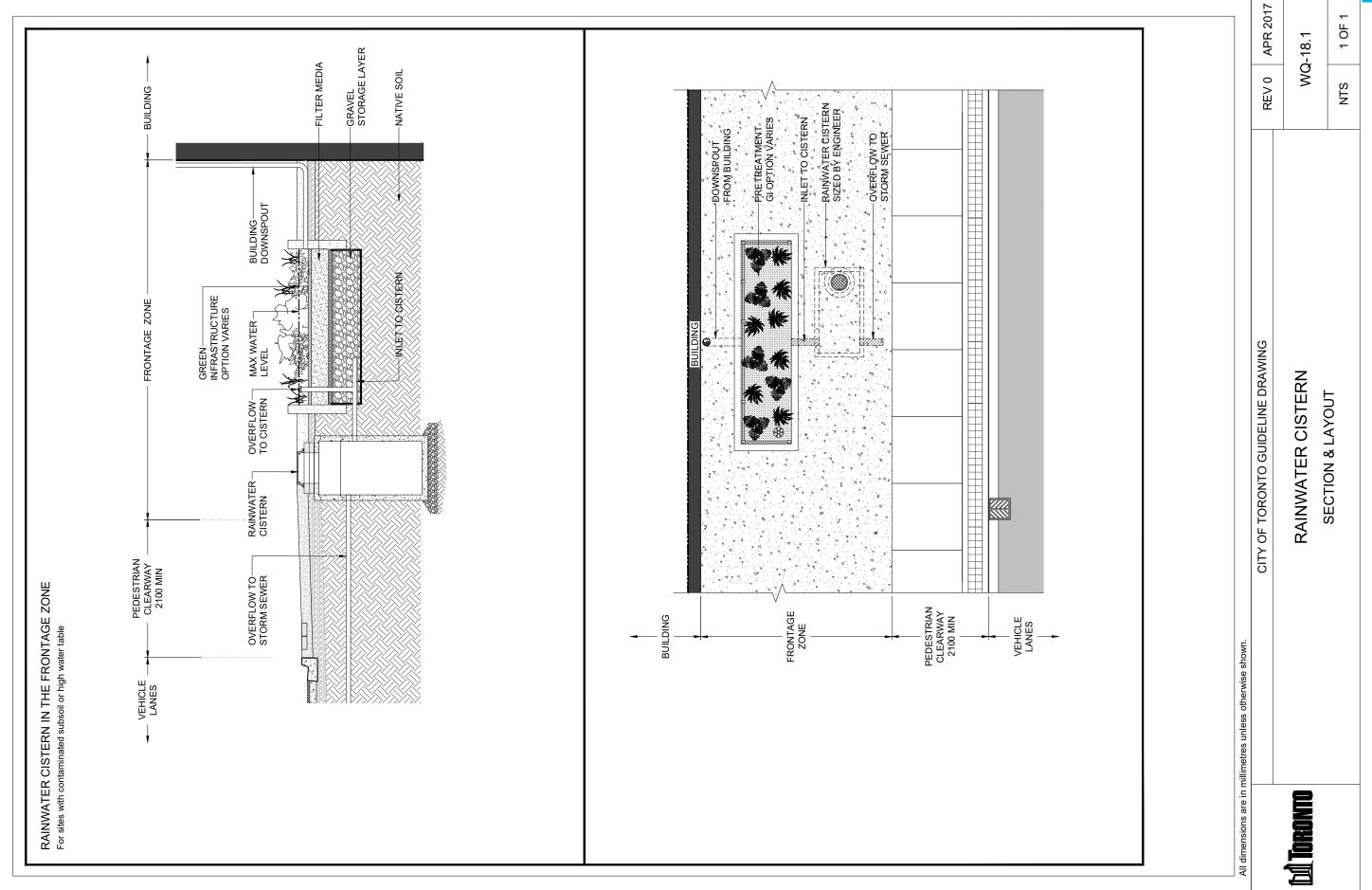


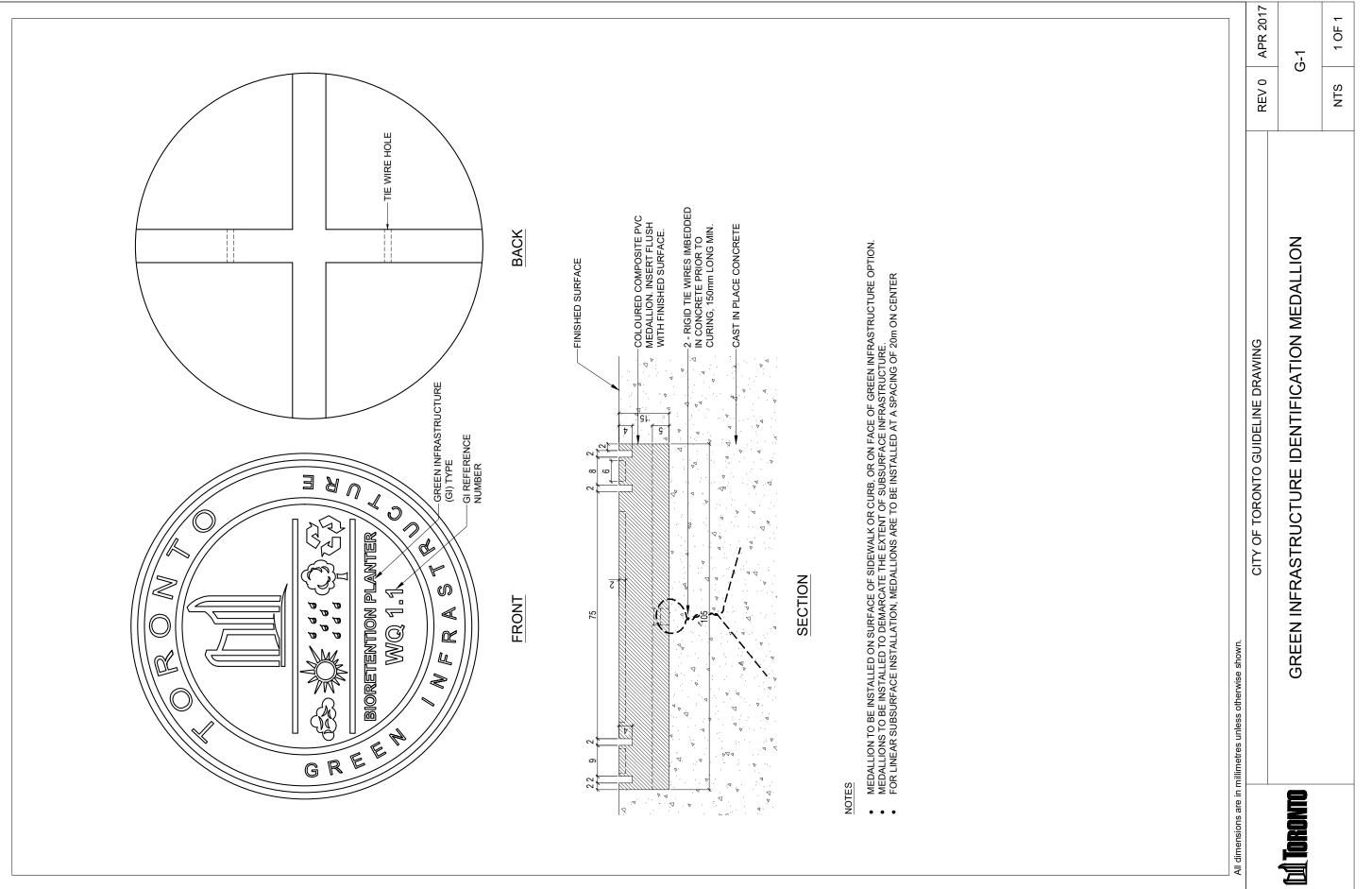
Green Streets Technical Guidelines

[1] TORONTO



Green Streets Technical Guidelines

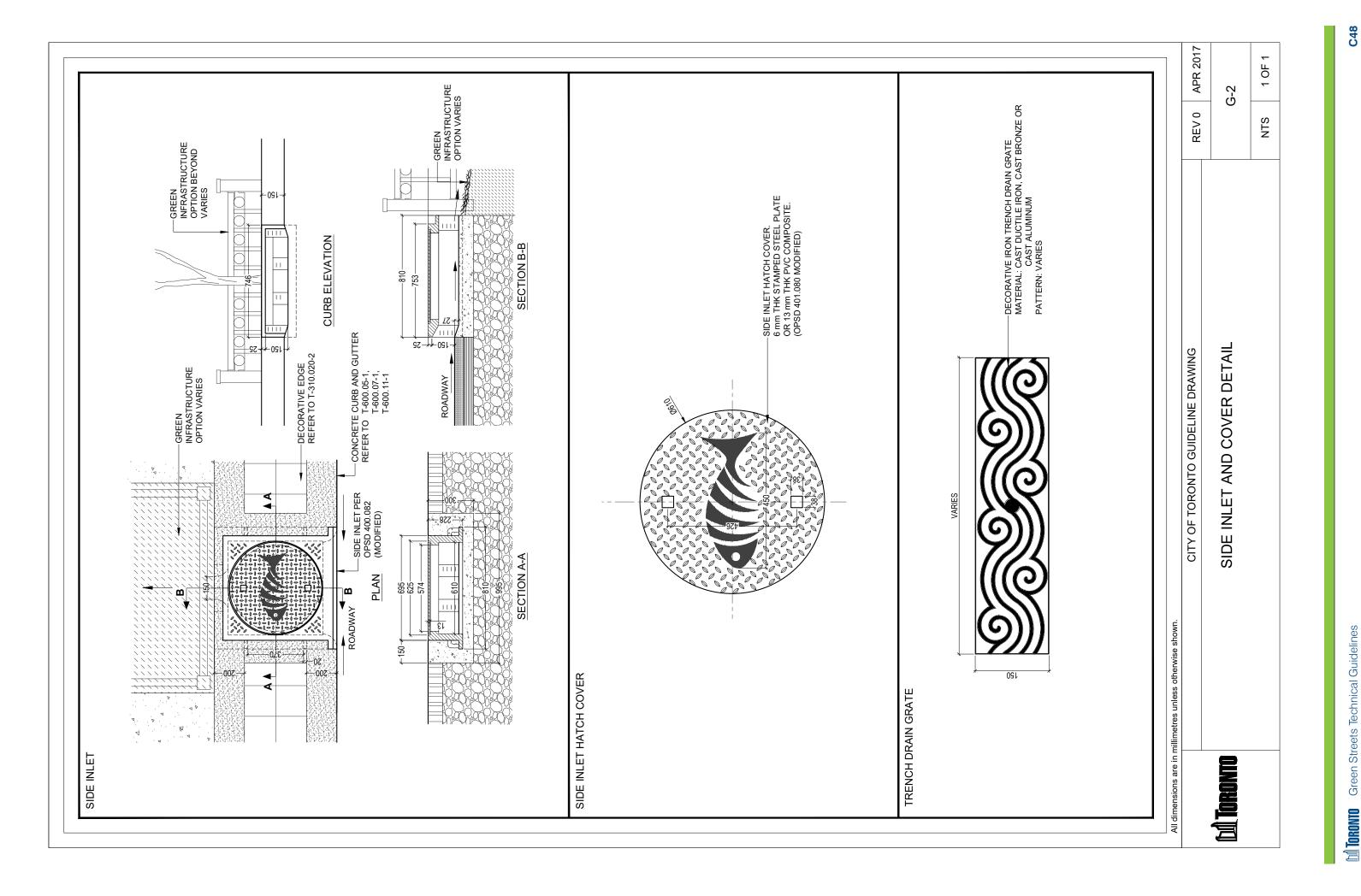


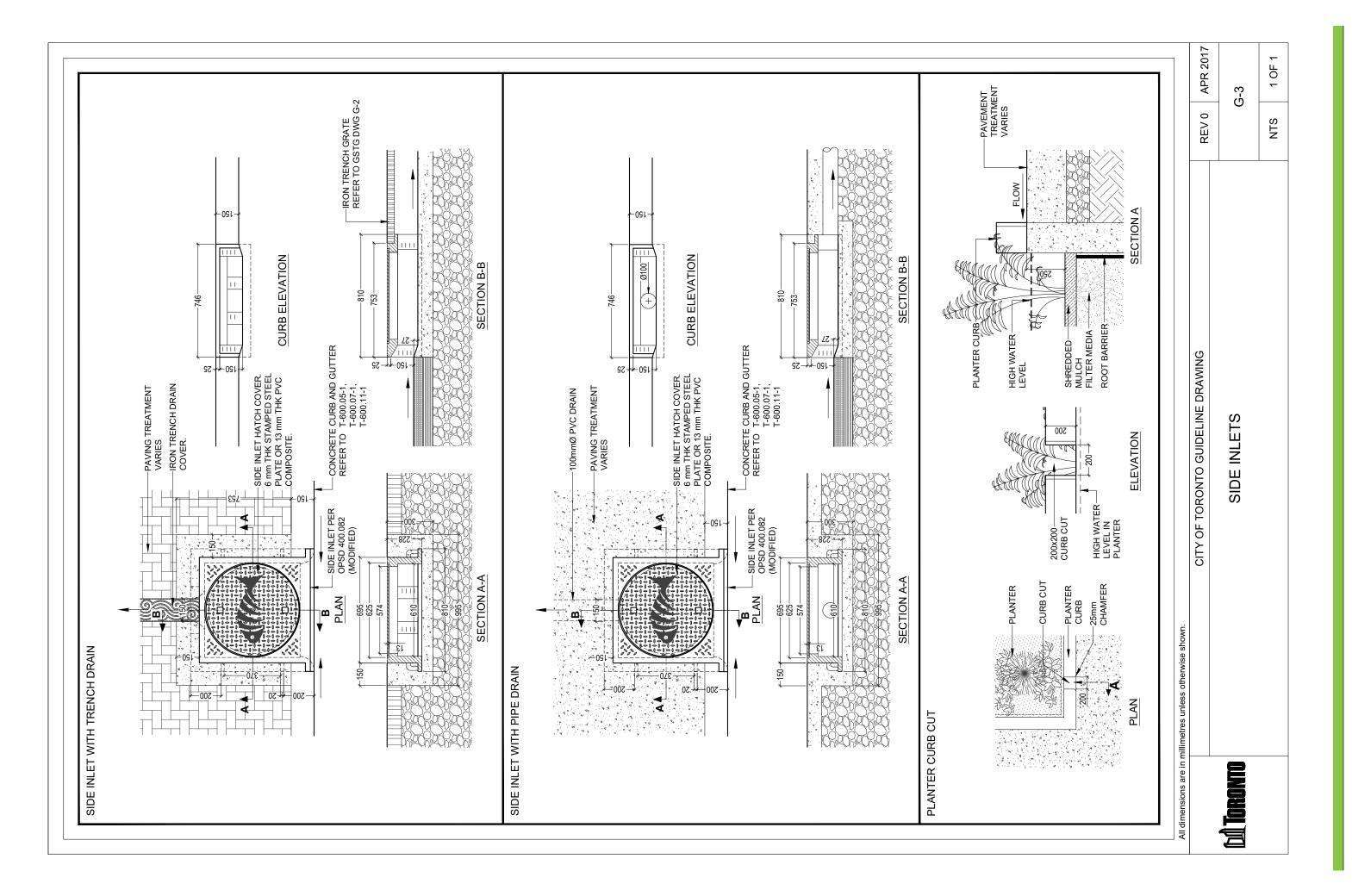


Green Streets Technical Guidelines

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APPENDIX D - METHOD FOR UTILIZING THE GREEN INFRASTRUCTURE SELECTION TOOL



### METHOD FOR UTILIZING THE GREEN INFRASTRUCTURE SELECTION TOOL

### **Direction**

The Green Infrastructure (GI) Selection Tool is designed to be used by addressing the 'Type of Work', 'Street Type' and/or 'Application' first and then working from left to right through the parameters in the database to further refine the search. If however, there is a specific parameter criterion that is critical to the search, then that parameter should be considered first.

The Selection Tool is operated through the filter function of Microsoft Excel. When a parameter applies to a GI option an 'X' is placed in the intersecting cell, when it applies with conditions an asterisk is used followed by an acronym identifying the consideration, and when it does not apply then the cell is left blank.

### **Example**

The following example provides step-by-step instructions to direct the use of the GI Selection Tool to identify a palette of GI options based on known site characteristics and required tolerances. In this example, the site has the following characteristics:

- Type of Construction |
- **New Street Construction**
- Street Type |
  - Mixed-Use Accent Street
- **Application** All except Bridges
- Soil Permeability
  - <15mm/hr
- Topography |
- Depth to Water Table 1-2m
- Depth to bedrock | >2m
- Known Soil Contamination
- Open Space Context | Adiacent a Park
- Storm Sewer Infrastructure
- Urban Separated Transit Infrastructure |
- No Subway, No LRT Utilities Infrastructure |
- **Underground Only** Known Flooding
- Contributing to Flood Areas Urban Forest |
- Low
- Watershed Context |
  - Operations and Maintenance |

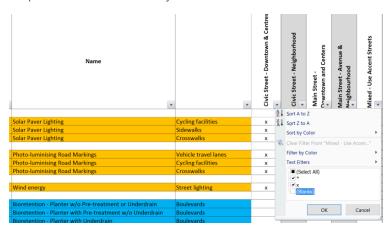
Curbside Waste Removal and Sand Application

### Step 1

Select Tab 3.0 to begin screening for a 'New Street' construction project

### Step 2

Start the process by screening for the 'Type' of street, in this case a Mixed-Use Accent Street. Refer to the Complete Streets Guidelines for a comprehensive description of each street type. To select for Mixed Use Accent Streets, click the drop down arrow in the Mixed-Use Accent Streets cell and deselect the 'blank' filter and then click OK. This will reduce the number of options available to only those that would be viable.



### Step 3 | Applications:

All Applications are considered except bridges, therefore, select the drop-down in the Bridges cell, deselect 'X' and click OK. This will remove any options that apply to Bridges specifically.

Step 4 | Soil Permeability: Deselect the 'blank' option in the drop-down for SP-1 (<15mm/hr). This will remove options that are only suitable in highly permeable soils.

Step 5 | Topography: There are no 'blanks' in the drop down for 1%-5%. Therefore there are no changes to be made to the drop-down menu.

Step 6 | Depth to Water Table: Deselect the 'blank' option in the drop-down for WT-2 (1-2m). This will remove options that are not suitable in areas with water table depth less than 1m or greater than 2m.

Step 7 | Depth to Bedrock: There are no 'blanks' in the drop-down for BE-3 (>2m). Therefore there are no changes to be made.

### **Step 8 | Known Soil Contamination:**

Deselect the 'blank' option in the drop-down menu for 'NO'. This will restrict options to those suitable in areas with no soil contamination.

Step 9 | Open Space Context: All remaining options are suitable adjacent a park, therefore no changes are necessary as there are no 'blank' options to deselect.

### Step 10 | Storm Sewer

Infrastructure: Deselect the 'blank' option in the drop-down for Urban Separated Sewers. This will restrict options to those suitable for urban separated sewers.

Step 11 | Transit Infrastructure: There is no transit infrastructure to contend with in this scenario, therefore there are no changes required in this section.

### Step 12 | Utilities Infrastructure:

All remaining options are suitable in coordination with underground utilities. As this is a new street construction, every effort should be made to place utilities such that they do not interfere with GI options.

Step 13 | Known Flooding: All remaining options are suitable in contributing to flood prone areas, therefore no changes are necessary as there are no 'blank' options to deselect.

Step 14 Urban Forest: All remaining options are suitable in areas of low urban canopy, therefore no changes are necessary as there are no 'blank' options to deselect.

Step 15 Watershed Context: All remaining options are suitable in areas of moderate erosion vulnerability, therefore no changes are required as there are no 'blank' options to deselect.

Step 16 Operations and

Maintenance: Deselect the 'blank' option in the drop-down menus for "curb-side waste removal" and "sand application". This will restrict options to those suitable given these maintenance and operation parameters.

The resulting list below provides a palette of GI options that are viable within the right-of-way of this sample street

Number	Name	
E-1	Natural Canopy	
AQ-1	Green Roof	
AQ-2	Street Trees	
GHG-1a		Street lighting
GHG-2a		Street lighting
GHG-2c	Solar Photovoltaic Panels	Parking meters
GHG-2d	Solar Photovoltaic Panels	Vehicle charging stations
GHG-2e	Solar Photovoltaic Panels	Feature paving
GHG-3a	Solar Roadways	Sidewalks
GHG-3b	Solar Roadways	Cycling facilities
GHG-3c	Solar Roadways	Crosswalks
GHG-3d	Solar Roadways	On-street parking lanes
GHG-4a	Solar Paver Lighting	Cycling facilities
GHG-4b	Solar Paver Lighting	Sidewalks
GHG-4c	Solar Paver Lighting	Crosswalks
GHG-5a	Photo-luminising Road Markings	Vehicle travel lanes
GHG-5b	Photo-luminising Road Markings	Cycling facilities
GHG-5c	Photo-luminising Road Markings	Crosswalks
WQ-2.1d	Bioretention - Curb Extension/Bump-out with Pre-treatment &	Intersections
WQ-13.3b	Soakaway/infiltration Gallery/Dry Well/Soakaway Pit with pre-	Furnishing zones
WQ-14.1b	Perforated Pipe System - with pre-treatment	Vehicle travel lanes
WQ-16.2	Planter Boxes/Movable Planters	Furnishing zones
WQ-17.2	Precast Tree Planters	Furnishing zones
WQ-23.2	Structural Soil	Furnishing zones
WQ-24.1c	CIP Structural Concrete Panels Over Continuous Growing Medi	Furnishing zones
WQ-24.1d	CIP Structural Concrete Panels Over Continuous Growing Medi	Furnishing zones
WQ-24.2c	Precast Structural Concrete Panels & Unit Paving Over Continu	Furnishing zones
WQ-24.2d	Precast Structural Concrete Panels & Unit Paving Over Continu	Furnishing zones
WQ-25.2	Soil Cell in Continuous Growing Medium Trench	Furnishing zones
WQ-26.1c	Open Tree Planters	Furnishing zones
WQ-26.1d	Open Tree Planters with Soil Cells	Furnishing zones

### **Reset the Selection Tool**

To reset the Tool click 'clear' under Sort & Filter in the Data menu. Green infrastructure options resulting from this example relate to four of five TGS priorities including: Ecology, Air quality, GHG / Energy Efficiency & Water Quality, Quantity and Efficiency. Once a palette of options are identified, then the GI selection, design and implement processes can begin.

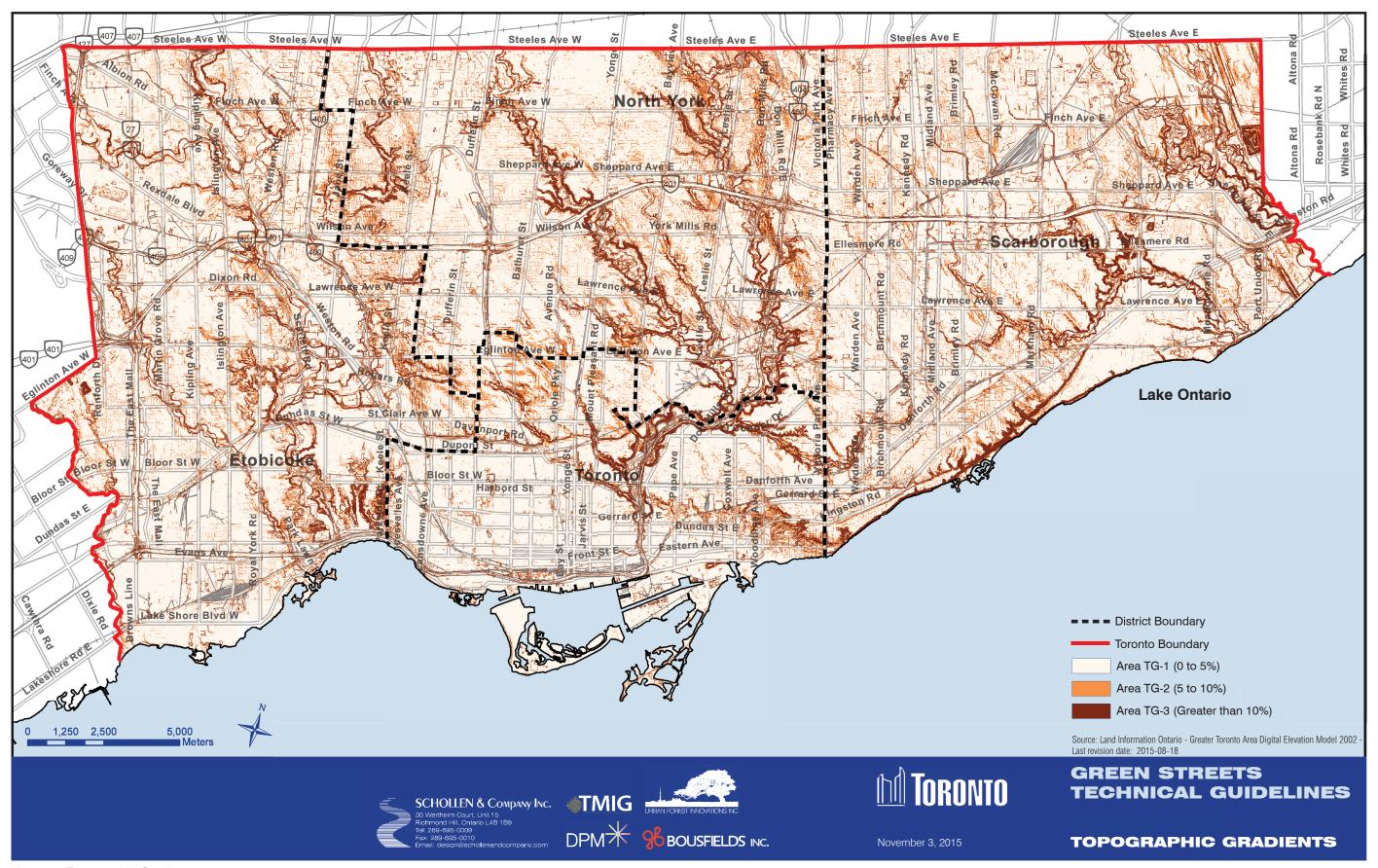
Each GI option has an associated reference number. These numbers correlate to Guideline Drawings for each GI option (and permutation thereof) within the Selection Tool.

**D2** 

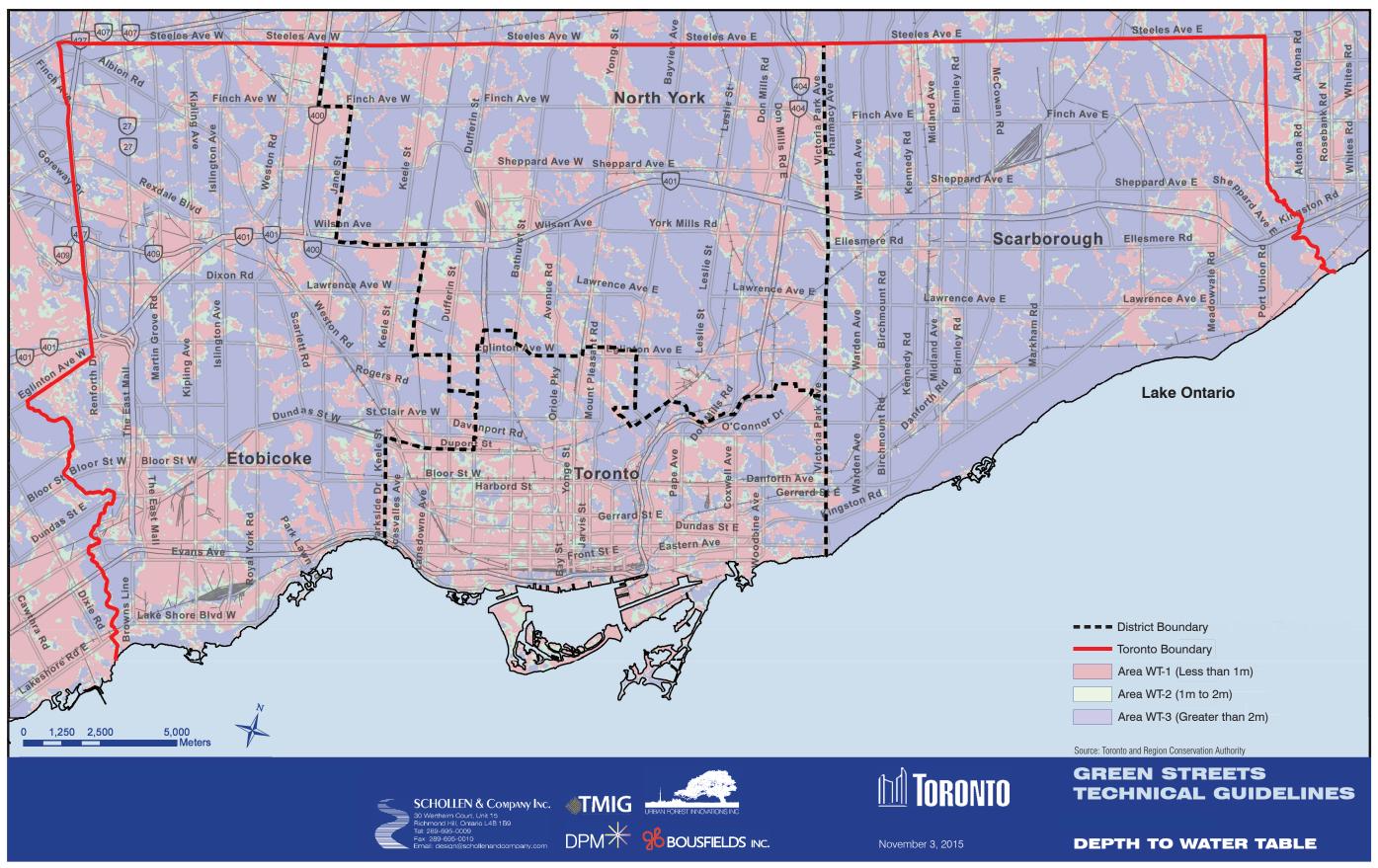
Green Streets Technical Guidelines



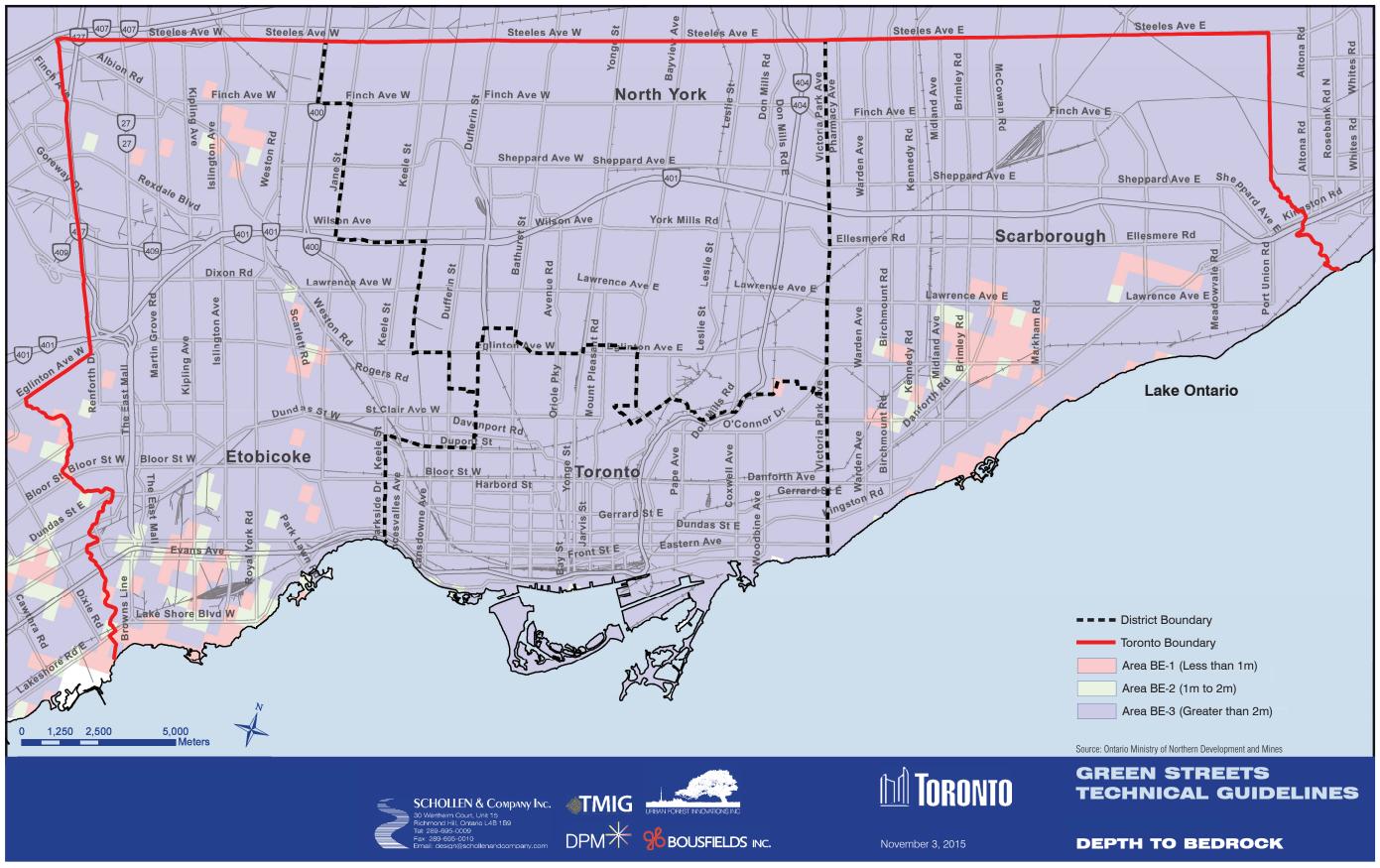
APPENDIX E - CITY-WIDE REFERENCE MAPS



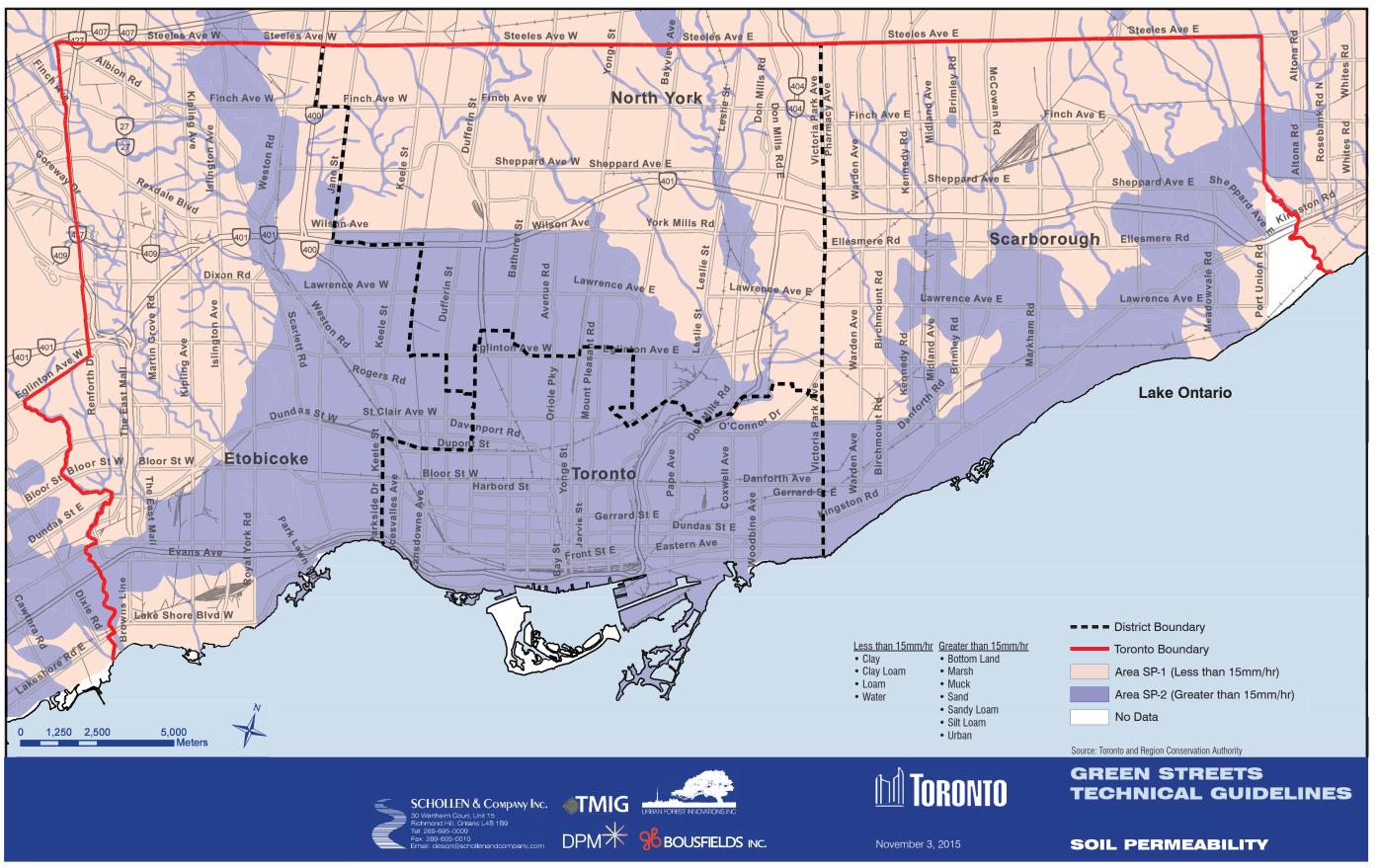
Map 1.0 - Topographic Gradients



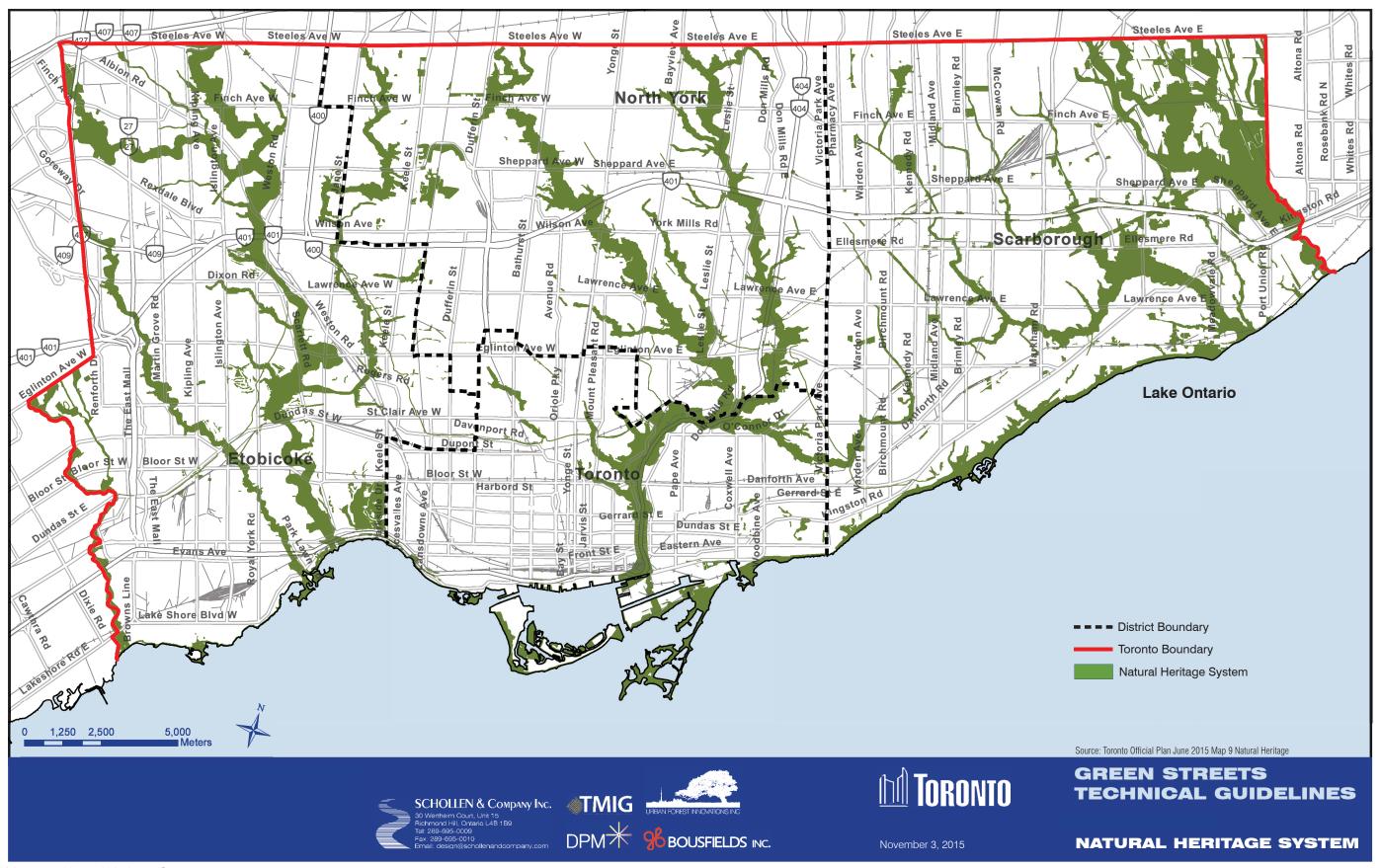
Map 2.0 - Depth to Water Table



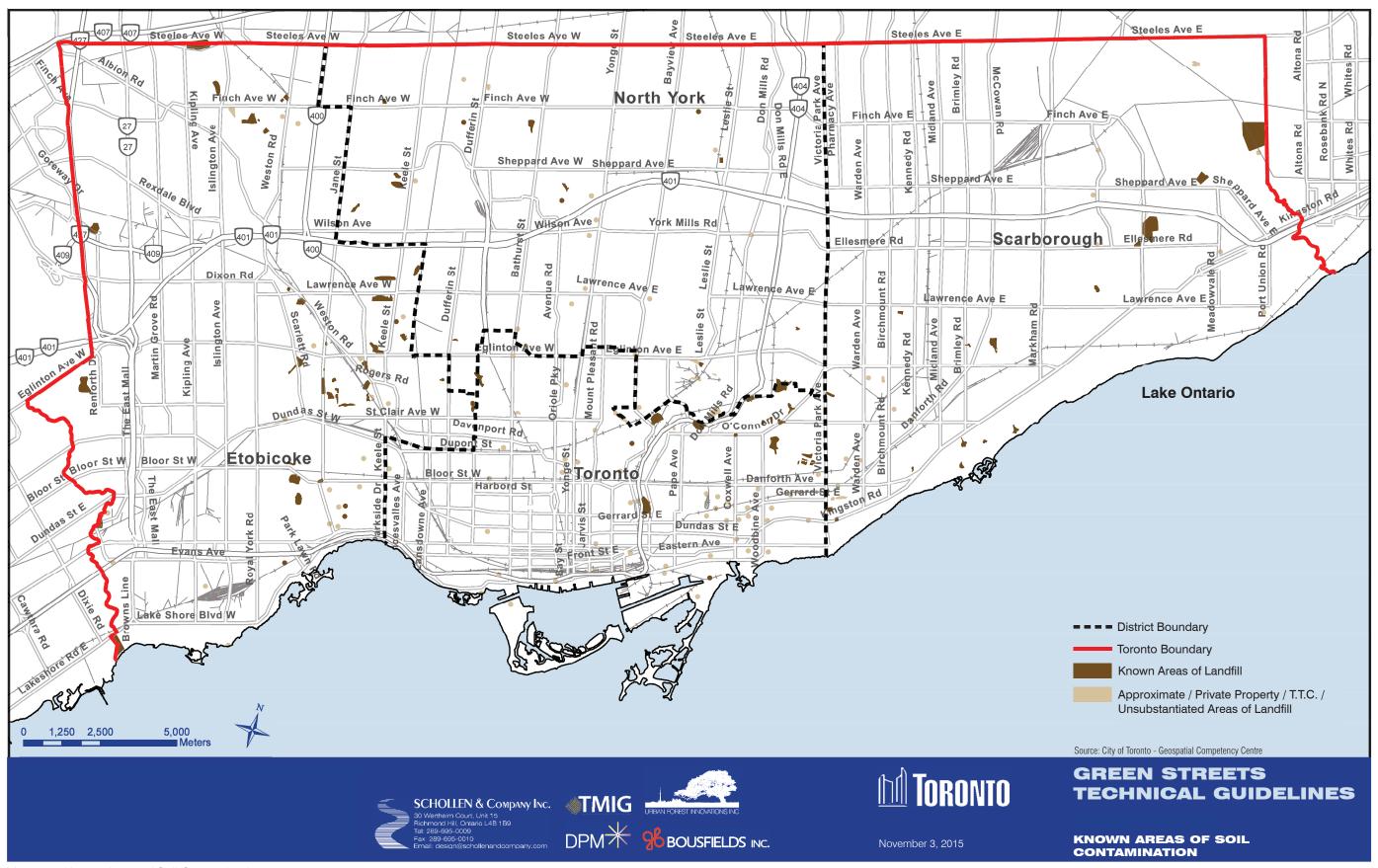
Map 3.0 - Depth to Bedrock



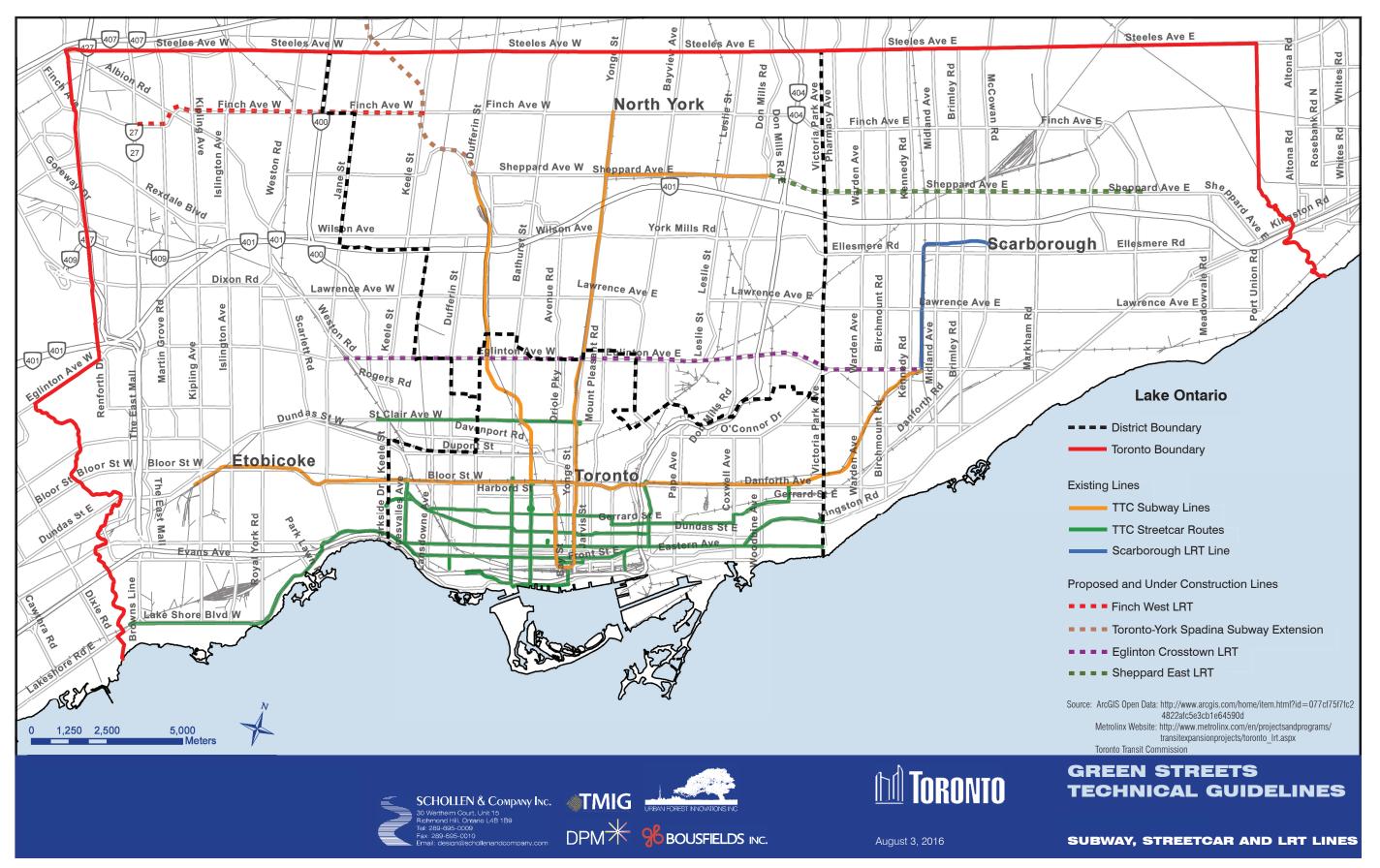
Map 4.0 - Soil Permeability



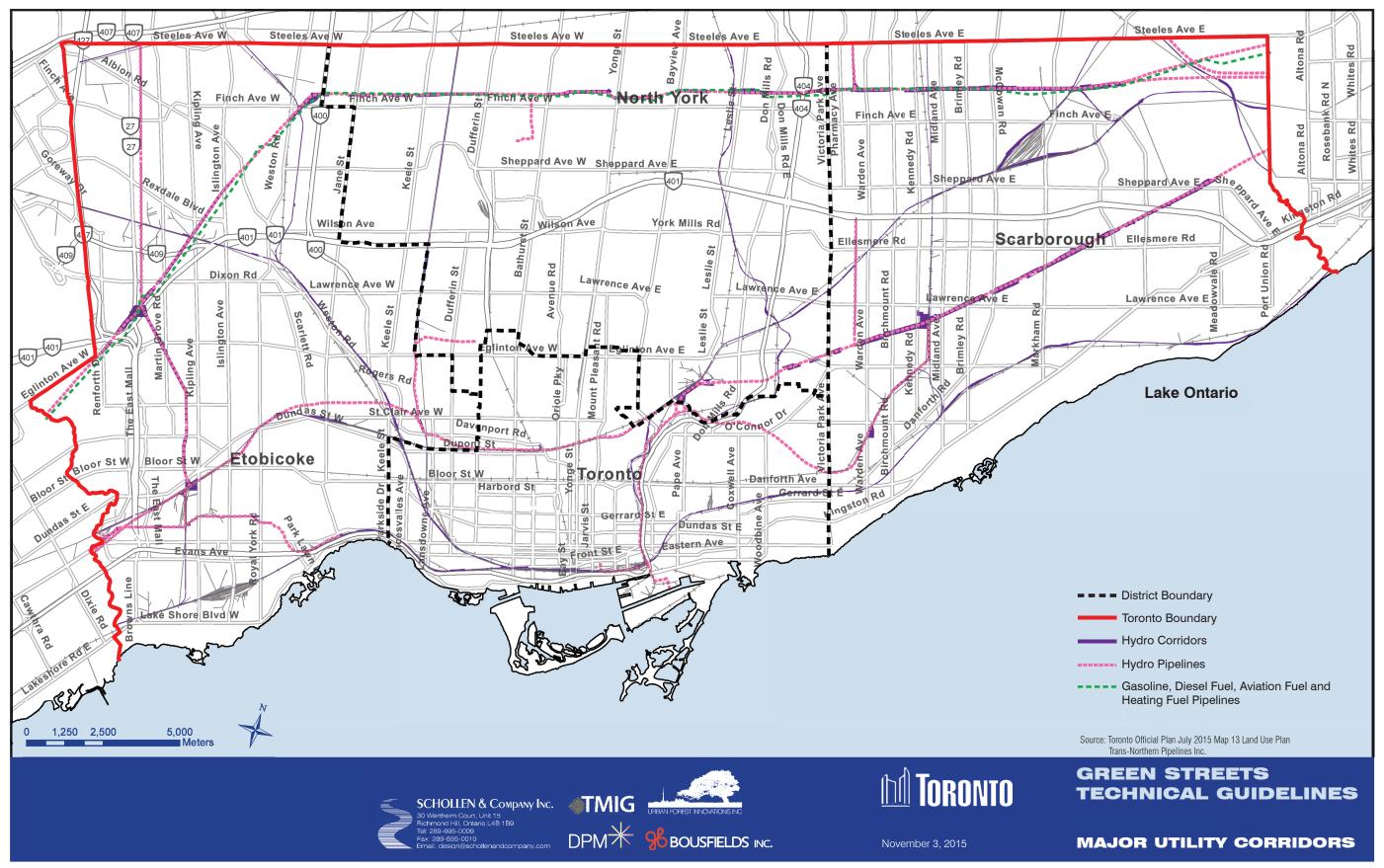
Map 5.0 - Natural Heritage System



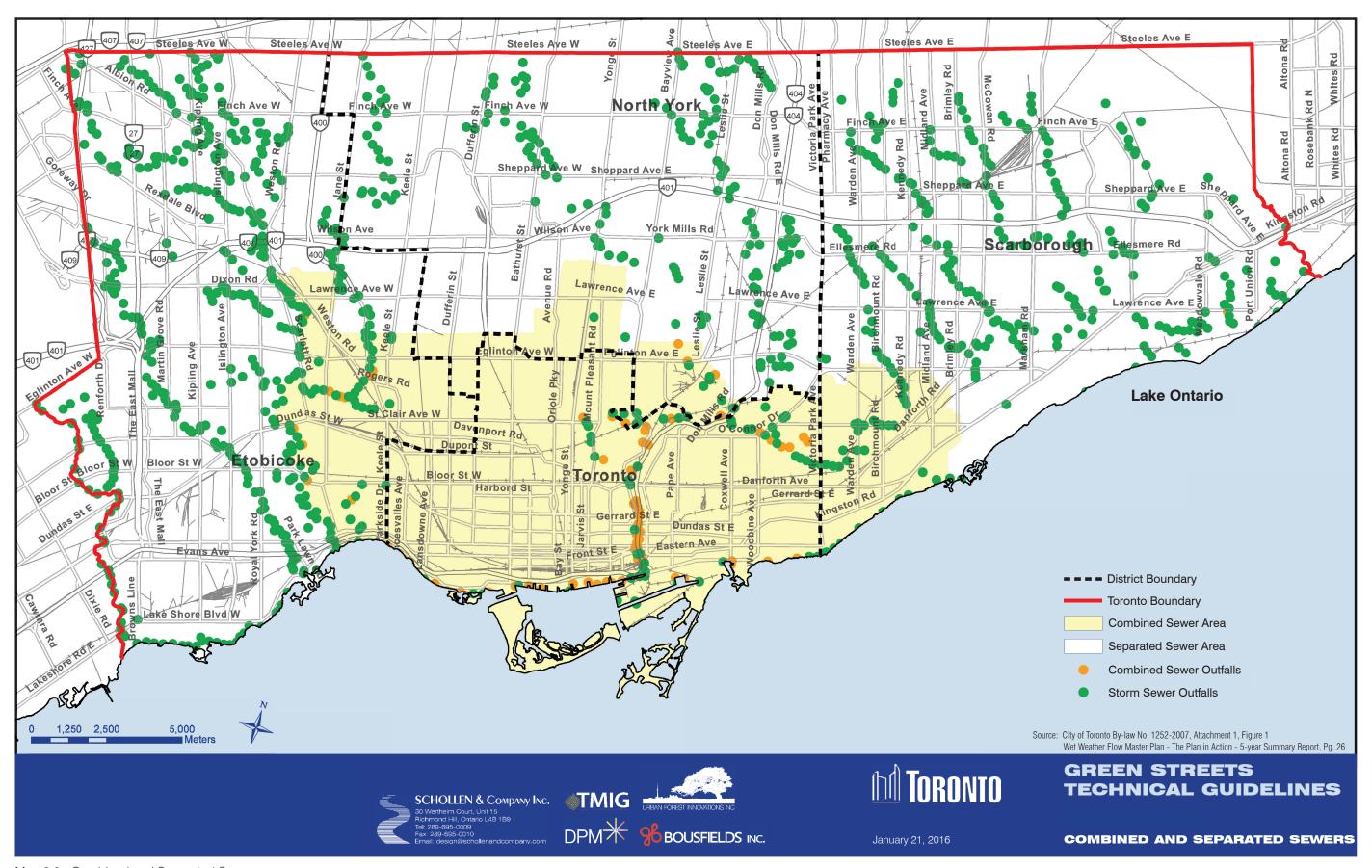
Map 6.0 - Known Areas of Soil Contamination



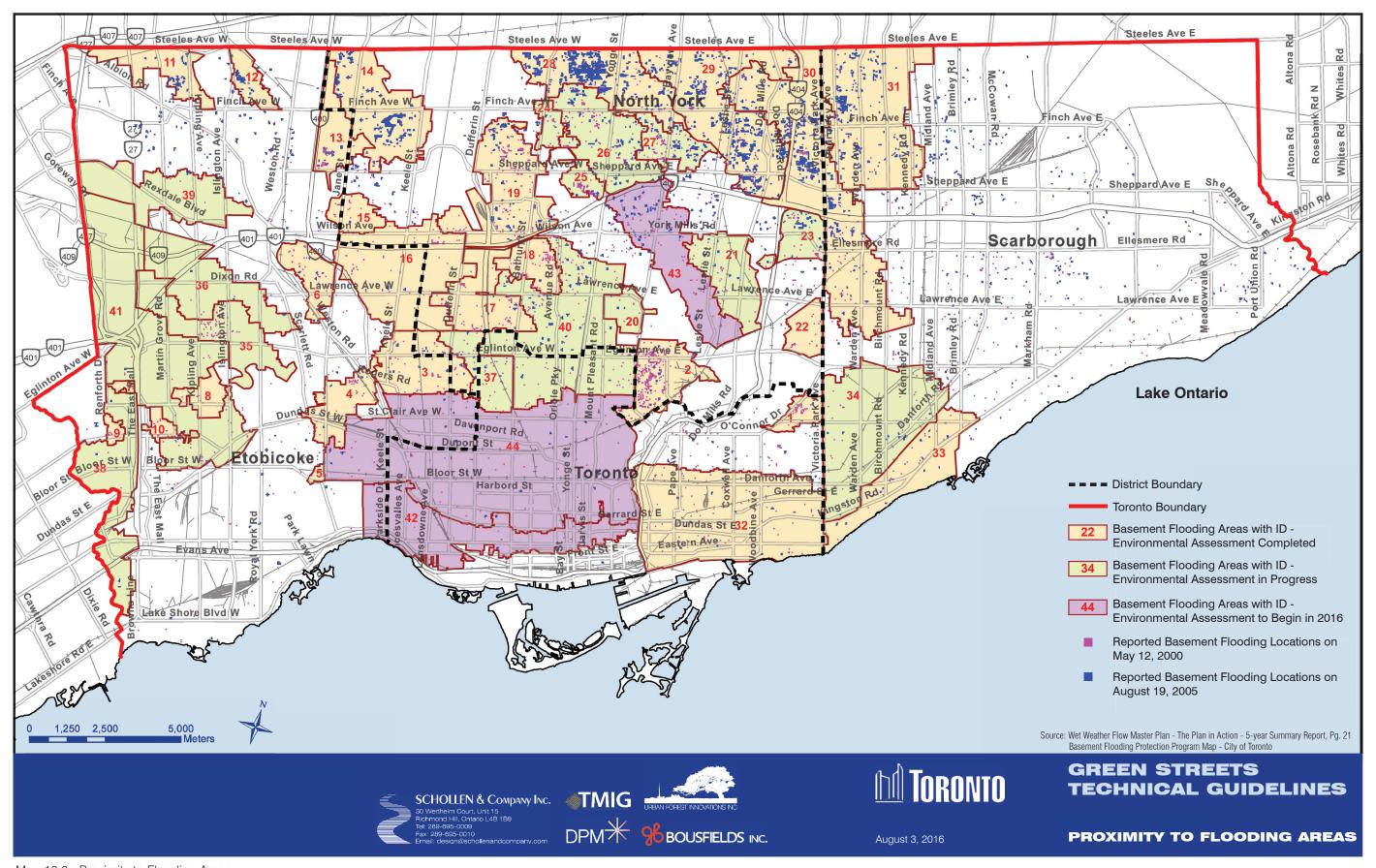
Map 7.0 - Subways, Streetcars and LRT Lines



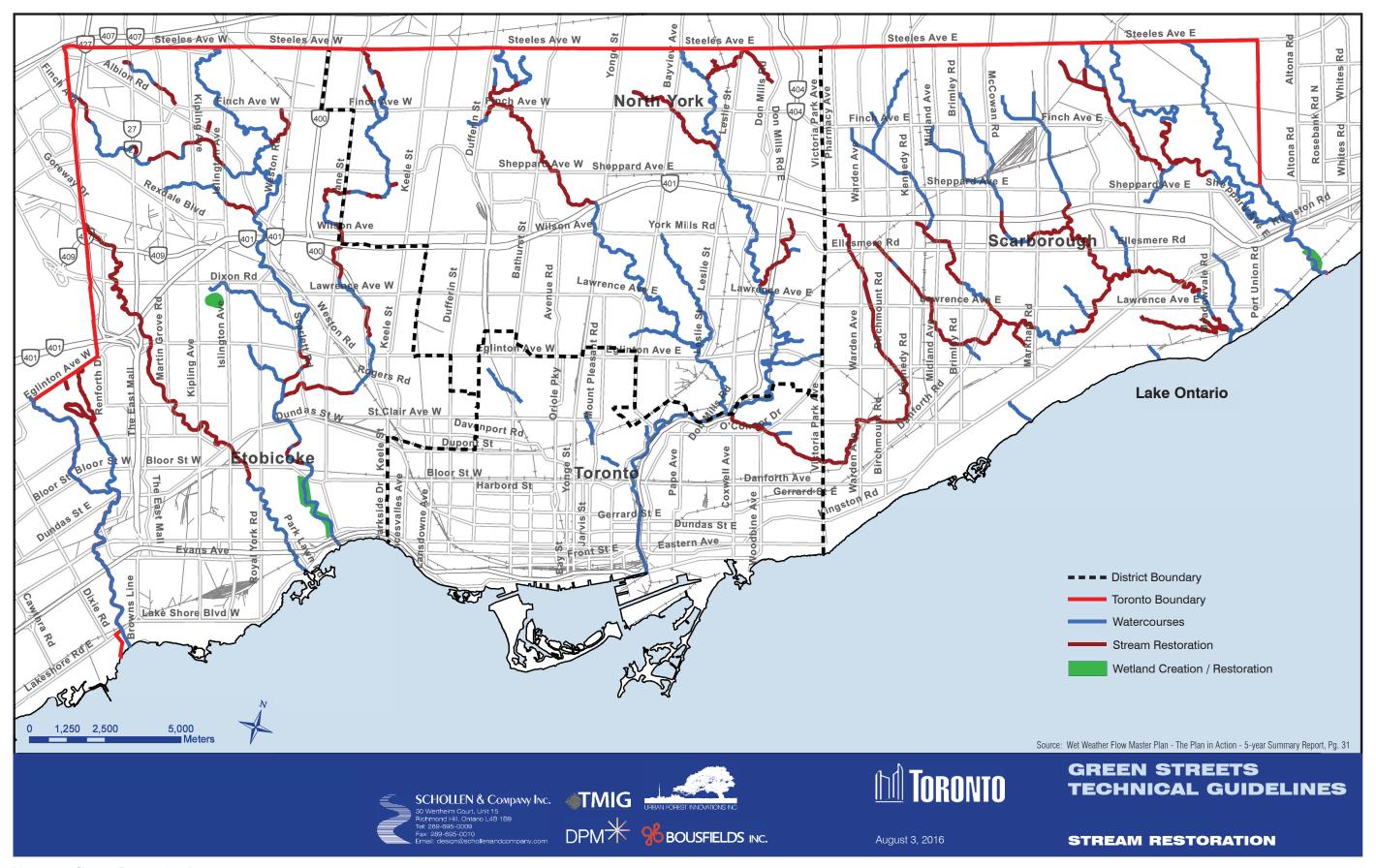
Map 8.0 - Major Utility Corridors



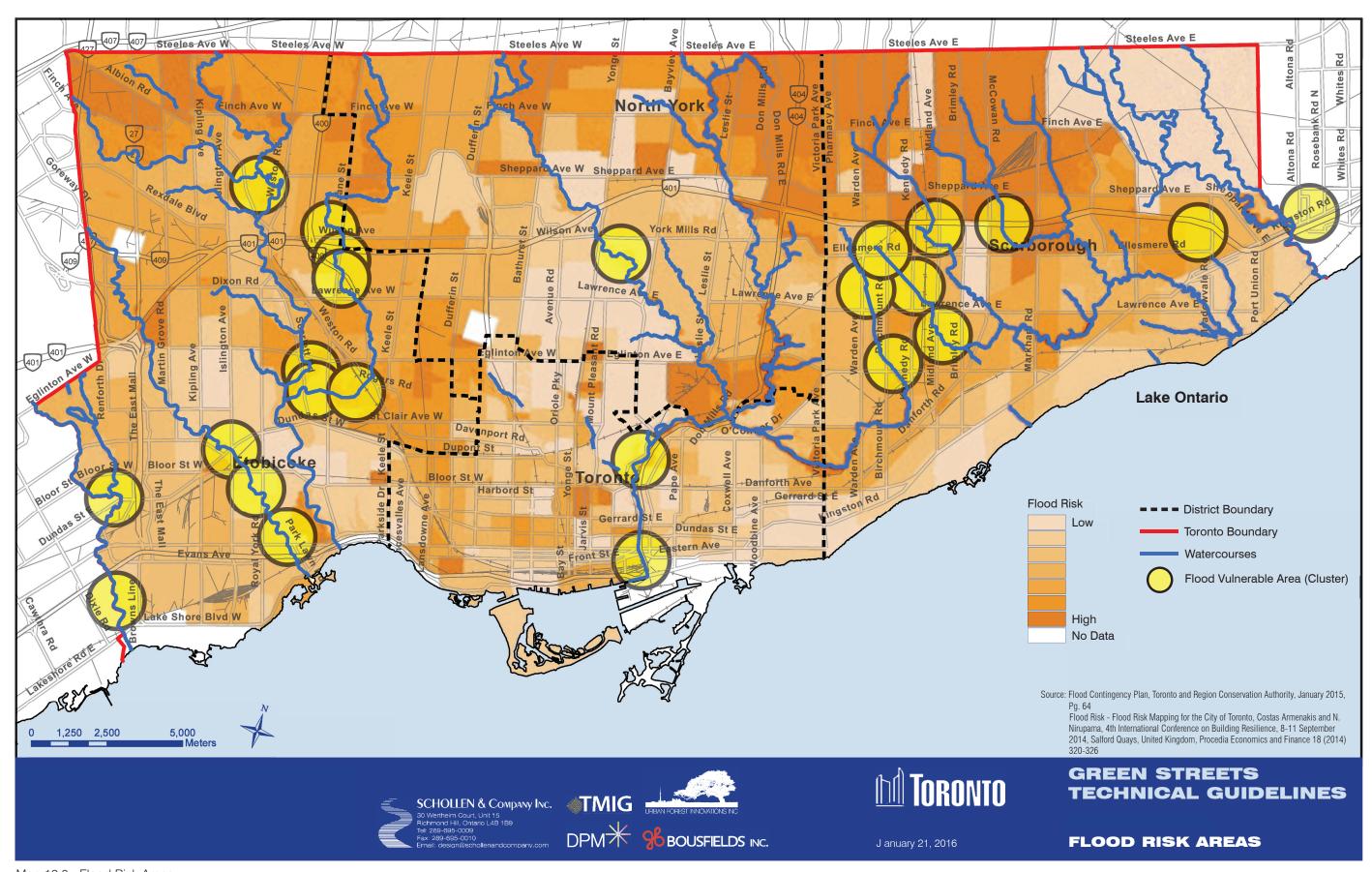
Map 9.0 - Combined and Separated Sewers



Map 10.0 - Proximity to Flooding Areas



Map 11.0 - Stream Restoration Areas



Map 12.0 - Flood Risk Areas



APPENDIX F - OPERATIONS & MAINTENANCE PROTOCOLS

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Green Infrastructure / LID Option	Operations & Maintenance Protocols (OMP)	Inspections/Monitoring	Repairs / Replacement
E-1 NATURAL TREE CANOPY	E1_OMP #1  Description: Removal of garbage and natural debris on or around tree base Timing: Once in spring and after major wind storm events as required Equipment: Handwork Personnel: One individual Hours: Area dependent  AQ3_OMP #2  Description: Watering Timing: New trees - weekly, mature trees as required Equipment: Irrigation system (if available) / water truck Personnel: One individual Hours: Area dependent  AQ3_OMP #3  Description: Weeding & pest control Frequency: Weeding & pest control Frequency: Weeding & pest control Sequence of the personnel: One individual Hours: Area dependent  AQ3_OMP #3  Description: One individual Hours: Area dependent	INSPECTION / MONITORING  KEY AREAS OF CONCERN / INSPECTION FREQUENCY:  • Structural integrity inspection (Annually)  • Tree health inspection (Bi-annually)  • Girdling at tree grate (Bi-annually)  • Pest and disease inspection (Bi-annually)  • Inspection and maintenance log  SPECIALIZED EQUIPMENT / TRAINING  SPECIALIZED TRAINING:  • Irrigation systems training  • Arborist certification for tree pruning/care	TRUNK AND CROWN INJURY REPAIRS  Pruning  Cabling/bracing Remove bark  ROOTZONE AERATION  Vertical mulching or radial aeration  NOTES: Irrigation to occur at night or in early morning
GY CALL	AQ3_OMP #4 Description: Pruning Frequency: Pruning annually (by Certified Arborist) Equipment: Handwork Personnel: One individual Hours: Area dependent  AQ3_OMP #4 Description: Mulch placement over root system Frequency: As required - maintain 50mm-100mm depth Equipment: Handwork - shredded bark, wood chip or pine needles Personnel: One individual Hours: Area dependent		
E-2 NATIVE HERBACEOUS PLANTING	E2_OMP #1 Description: Watering Timing: As required (seasonal/temperature dependent) Equipment: Irrigation system / water truck Personnel: One individual Hours: Area dependent  E2_OMP #2 Description: Weeding Frequency: As necessary Equipment: Handwork	INSPECTION / MONITORING  KEY AREAS OF CONCERN / INSPECTION FREQUENCY:  Irrigation and drainage systems - if applicable (As required)  Vegetation density/health/composition (As required)  Plant fertility - Soil testing (As required)  Pest and disease inspection (Bi-annually)  Inspection and maintenance log	PLANT REPLACEMENT  • As required  NOTES:  • Irrigation to occur at night or in early morning
	Personnel: One individual Hours: Area dependent  E2_OMP #3  Description: Fertilizing Frequency: Once in spring Equipment: Through irrigation system Personnel: One individual Hours: Area dependent	SPECIALIZED EQUIPMENT / TRAINING  SPECIALIZED EQUIPMENT:  • Water truck  SPECIALIZED TRAINING:  • Irrigation Systems Training	
E-3 ECOPASSAGES	E3_OMP #1  Description: Clear ecopassage of vegetation, silt and refuse Timing: Bi-annually - Annually Equipment: irrigation system/water truck Personnel: Two Hours: Area dependent  E3_OMP #2  Description: Re-establish internal environment Frequency: As necessary Equipment: Visual / handwork Personnel: Two Hours: Area dependent	INSPECTION / MONITORING  KEY AREAS OF CONCERN / INSPECTION FREQUENCY:  - Unobstructed passageway  - Condition of crossing structures  - Internal environment of the passageway  - Wildlife crossing signage  - Inspection and maintenance log  SPECIALIZED EQUIPMENT / TRAINING SPECIALIZED TRAINING:  - None	WILDLIFE FENCE  • Repair or replace as required
E-4 LIGHT LIMITATION		INSPECTION / MONITORING  KEY AREAS OF CONCERN / INSPECTION FREQUENCY:  Light pass into natural heritage areas (Bi-Annually)	Reorient lighting as required



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	Green Infrastructure / LID Option	Operations & Maintenance Protocols (OMP)	Inspections Method / Frequency	Repairs / Replacement
LITY	GREEN WALL (AQ-1)	AQ1_OMP #1 Description: Watering Frequency: As required (seasonal / temperature dependent) Note: Irrigation to occur at night or in early morning Equipment: Irrigation system Personnel: One individual Hours: Area dependent  AQ1_OMP #2 Description: Weeding Frequency: As necessary Equipment: Handwork Personnel: One individual Hours: Area dependent  AQ1_OMP #3 Description: Fertilizing (injection through irrigation system) Frequency: Once in spring Equipment: Irrigation system Personnel: One individual Hours: 1hr/system  AQ1_OMP #4 Description: Irrigation start-up and winterization Frequency: Spring and fall Equipment: Air compressor Personnel: One individual Hours: 1hr/system	INSPECTION / MONITORING  KEY AREAS OF CONCERN / INSPECTION FREQUENCY:  Structural integrity inspection (Annually)  Irrigation system inspection (Annually or after every rain event >60mm)  Vegetation density / health / composition (Bi-Annually)  Irrigation system testing (Annually)  Plant fertility - Soil testing (Annually)  Inspection and maintenance log  SPECIALIZED EQUIPMENT / TRAINING  SPECIALIZED EQUIPMENT:  Air compressor (OMP #4)  SPECIALIZED TRAINING:  Green Wall Maintenance Training  Irrigation Systems Training  Drainage System Training	PLANT REPLACEMENT  • To occur under supervision of Green Wall maintenance specialist  IRRIGATION SYSTEM REPAIR AND REPLACEMENT  • By irrigation specialist familiar with green walls
AIR QUAI	STREET TREES (AQ-2)	AQ2_OMP #1 Description: Removal of garbage and natural debris on or around tree base Timing: Bi-annually (spring / late fall) Equipment: Handwork Personnel: One individual Hours: Dependent on number of trees  AQ2_OMP #2 Description: Watering Timing: New trees - weekly, mature trees as required Equipment: Irrigation system (if available) / water truck Personnel: One individual Hours: Dependent on number of trees  AQ2_OMP #3 Description: Weeding Frequency: As necessary Equipment: Handwork Personnel: One individual Hours: Dependent on number of trees  AQ2_OMP #4 Description: Pruning, pest control & rootzone aeration Frequency: Pruning, pest control & rootzone aeration annually (by Certified Arborist) Equipment: Handwork Personnel: One individual Hours: Dependent on number of trees  AQ2_OMP #4 Description: Mulch placement over root system Frequency: As required - maintain 50mm-100mm depth Equipment: Handwork - shredded bark, wood chip or pine needles Personnel: One individual Hours: Dependent on number of trees	INSPECTION / MONITORING  KEY AREAS OF CONCERN / INSPECTION FREQUENCY:  Structural integrity inspection (Annually)  Tree health inspection (Bi-annually)  Girdling at tree grate (Bi-annually)  Pest and disease inspection (Bi-annually)  Inspection and maintenance log  SPECIALIZED EQUIPMENT / TRAINING  SPECIALIZED TRAINING:  Arborist certification for pruning / rootzone aeration	TRUNK AND CROWN INJURIES Pruning Cabling/bracing Remove bark  IMPROVE ROOTZONE AERATION Vertical mulching or radial aeration

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	Green Infrastructure /	O ( O M · . ( D · ( l · (OMD)	Inspections	Description (Description)
	LID Option	Operations & Maintenance Protocols (OMP)	Method / Frequency	Repairs / Replacement
		1400A OND #4	INSPECTION / MONITORING	OTRUGTURAL COUL OL COCINO
	PLANTING IN HARD SPACES (AQ-2)	AQ2A_OMP #1 Description: Removal of litter and debris from tree opening	INSPECTION / MIONITURING	STRUCTURAL SOIL CLOGGING  • Remove and replace top 15cm of soil to alleviate fine texture clogging: as necessary
		Frequency: Bi-annually	KEY AREAS OF CONCERN / INSPECTION FREQUENCY:	Tomoro and replace top recent of control and take into toxical congging, ac necessary
	AQ-2A (Tree in) Soil Cells	Equipment: Handwork	Structural integrity of surface treatment (Annually)	POOR PLANT GROWTH
		Personnel: One individual	Tree opening - Soil settlement (Annually)	Replace top 5cm of soil with compost: as necessary
	AQ-2B (Tree in) Open Planters	Hours: Area dependent	• Tree opening - Clogging (Spring and fall or after every rain event >60mm)	
	, , ,	AQ2A OMP #2	Sediment accumulation inspection (Bi-annually)     Standing water (Monthly or after every rain event >60mm)	<ul> <li>Amend soil with limestone or compost/sulphur to raise or lower pH of soil as required. Soil should have a pH of 6.0-7.8</li> </ul>
	AQ-2C Planter Boxes / Movable Planters	Description: Sediment removal from tree opening (if required)	Garbage (Weekly)	11ave a pri 01 0.0-7.0
	714 20 Tidillo Boxoo / movable Tidillo	Frequency: As necessary (>5cm depth)	• Tree	Replace dead/ diseased trees: as required
	AQ-2D Precast Tree Planters	Equipment: Handwork	Safety (Spring or after every rain event >60mm)	
	AQ-2D Precast Tree Planters	Personnel: One individual Hours: 0.25hrs/tree	Health (Spring / fall)	SALT ACCUMULATION
		Hours: 0.25hrs/tree	Root girdling (Every 4-5 years)	<ul> <li>Flush with fresh water to alleviate excess salt in the soil: as necessary</li> </ul>
		AQ2A_OMP #3	Mulch on root collar (Annually)     Damage from pests and animals (Bi-annually)	ACCESS TO UTILITIES
		Description: Pruning	- Daniage from pests and animals (bi-animality)	Remove and reuse panels or remove and replace as necessary in accordance with
		Frequency: Annually (by Certified Arborist)	SOIL CELLS	manufacturers recommendations
		Equipment: Handwork/chainsaw Personnel: One individual	Soil cell structure (only required if facility shown sign of damage due to excessive load)	
		Hours: 0.25hrs/tree	Air / water Inlet - clogging / proper operation (Annually / after major storms)	
			Energy dissipation component - proper operation (Annually / after major storms)	
		AQ2A_OMP #4	Flow restrictor - proper operation (Annually / after major storm)     Distribution pipe - proper operation (Annually)	
		Description: Watering Frequency: Under 2yrs - Weekly, Over 2yrs - as required	Underdrain pipe - proper operation (Annually)     Underdrain pipe - proper operation (Annually)	
ALI		Equipment: Gatorbags / Water truck	Ondordrain pipo propor oporation ( annually)	
		Personnel: One individual	Inspection and maintenance log	
QU,		Hours: 0.25hrs/tree		
AIR		AQ2A OMP #5	SPECIALIZED EQUIPMENT / TRAINING	
⋖		Description: Flush sub-drain (if applicable)	OF EGIALIZED EQUIT MENT / TRAINING	
		Frequency: Annually	SPECIALIZED EQUIPMENT:	
		Equipment: Water Truck	Chainsaw (OMP #3)	
		Personnel: One individual	Gatorbags (OMP #4)	
		Hours: System dependent	Water truck & hose (OMP #4)	
		AQ2A_OMP #6	SPECIALIZED TRAINING:	
		Description: Pest Management	Inspection and cleanout procedures	
		Frequency: As required Equipment: Case dependent	Sediment removal procedure	
		Personnel: Case dependent	Sub-drain flushing procedure	
		Hours: Case dependent	Identification of monuments and extent of facility     Soil cell repair training	
	AQ-3 PHOTOCATALYTIC PAVING	AQ3 OMP#1	INSPECTION / MONITORING	RESURFACING (As necessary)
	AU-3 FRUTUCATALTTIC PAVING	Description: Sweep	ING. EQUARY MORITORING	INCOUNT AVINO (AS HECESSALY)
		Frequency: Annually (Spring)	KEY AREAS OF CONCERN / INSPECTION FREQUENCY:	
		Equipment: Mechanical Sweeper	Structural integrity inspection (Annually)	
		Personnel: One Individual	Inspection and maintenance log	
		Hours: Area dependent	SPECIALIZED EQUIPMENT / TRAINING	
			SPECIALIZED EQUIPMENT:	
			Mechanical sweeper	
			SPECIALIZED TRAINING:	
			Training on mechanical sweeper	



	Green Infrastructure / LID Option	Operations & Maintenance Protocols (OMP)	Inspections/Monitoring	Repairs / Replacement
G	HG-1 LED Lights	GHG1_OMP #1 Maintenance agreement with utility owner	INSPECTION / MONITORING  KEY AREAS OF CONCERN / INSPECTION FREQUENCY:  • Proper functioning of lights (Annually)	Replace as necessary
	HG-2 Solar Photovoltaic Panels	GHG2_OMP #1 Maintenance agreement with utility owner	INSPECTION / MONITORING  KEY AREAS OF CONCERN / INSPECTION FREQUENCY:  • Proper functioning of solar photovoltaic panels (Annually)	Repair or replace as necessary
EFFICIEN	HG-3 Solar Roads	GHG3_OMP #1 Maintenance agreement with utility owner	INSPECTION / MONITORING  KEY AREAS OF CONCERN / INSPECTION FREQUENCY:  • Proper functioning of solar roads (Annually)	Repair and replace as necessary
SSIONS / ENER	HG-4 Solar Paving Lights	GHG4_OMP #1 Maintenance agreement with utility owner	INSPECTION / MONITORING  KEY AREAS OF CONCERN / INSPECTION FREQUENCY:  • Proper functioning of paver lights (Annually)	Repair or replace as necessary
GREENHOUSE GAS EMMISSIONS / ENERGY 空 空	HG-5 Photoluminescent Road Markings	GHG5_OMP #1	INSPECTION / MONITORING  KEY AREAS OF CONCERN / INSPECTION FREQUENCY:  • Visibility of photoluminising properties	Repaint as necessary
GREENHO	HG-6 Wind Energy	GHG6_OMP #1 Maintenance agreement with utility owner	INSPECTION / MONITORING  KEY AREAS OF CONCERN / INSPECTION FREQUENCY:  • Proper functioning of wind mill	Repair or replace as necessary
GH	HG-7 Cool Pavements	GHG7_OMP #1 Description: Sweep Frequency: Annually (Spring) Equipment: Mechanical Sweeper Personnel: One Individual Hours: Area dependent	INSPECTION / MONITORING  KEY AREAS OF CONCERN / INSPECTION FREQUENCY:  • Structural integrity inspection (Annually)  • Inspection and maintenance log  SPECIALIZED EQUIPMENT / TRAINING  SPECIALIZED EQUIPMENT:  •Mechanical sweeper  SPECIALIZED TRAINING:  • Training on mechanical sweeper	RESURFACING (As necessary)



	Green Infrastructure / LID Option	Operations & Maintenance Protocols (OMP)	Inspections/Monitoring	Repairs / Replacement
	BIORETENTION (WQ-A)	WQA_OMP #1 Description: Inspect & clean inlets	INSPECTION / MONITORING	MULCH REPLACEMENT  - Add mulch to maintain 5-10 cm depth: Every two years
	WQ-1 Bioretention Planters	Timing: Bi-annually (spring / late fall)  Equipment: Handwork  Personnel: One individual	KEY AREAS OF CONCERN / INSPECTION FREQUENCY:  • Contributing drainage area condition (Bi-annually)  • Inlet structural integrity / obstruction / erosion (Annually)	SURFACE PONDING  • Remove accumulated sediment and till filter media to 20 cm. If unsuccessful remove and replace
	WQ-2 Stormwater Planters	Hours: 0.25hrs/inlet  WQA_OMP#2	- Inlet saduction integrity / outside the residency and all your limitarity) - Inlet sediment accumulation (Bi-annually) - Pretreatment sediment accumulation inspection (Bi-annually)	plant material along with top 15cm of filter media.
	WQ-3 Bioretention Curb Extensions / Bump-Outs	Description: Cultivate surface and weed planting bed Timing: Once in spring	Side slope erosion (Annually)     Surface ponding - Perimeter / Filter bed (Annually)     Standing water - Filter bed (Monthly through warranty period, Bi-annually beyond warranty)	CONCENTRATION OF FLOWS  • Add flow spreading device or regrade existing to level: as required
	WQ-4 Bioretention Cells	Equipment: Handwork Personnel: One individual Hours: 0.25hrs/linear metre	Sarbage (Bi-annually)     Filter bed erosion/sediment accumulation/surface sinking (Monthly through warranty period, Bi-annually beyond warranty)	FILTER MEDIA CLOGGING  Remove mulch and plantings. Core aerate to 30 cm and replace with non-compacted filter media: as necessary
WATER - QUALITY, QUANTITY AND EFFICIENCY	WQ-5 Rain Gardens	WQA_OMP #3  Description: Removal of litter and debris Frequency: Bi-annually (to coincide with routine plant maintenance) Equipment: Handwork Personnel: One individual Hours: 0.10hrs/linear metre  WQA_OMP #4  Description: Sweep contributing areas and remove sediment from pretreatment (if applicable) Frequency: Bi-annually to Annually Equipment: Mechanical sweeper / handwork Personnel: One individual Hours: Area dependent	Mulch depth (Annually)     Vegetation density / health / composition (Bi-annually)     Monitoring well condition (Annually)     Overflow outlet obstruction (Monthly through warranty period, Bi-annually beyond warranty)     Sub-drain obstruction (Monthly through warranty period, Bi-annually beyond warranty)     Sediment accumulation testing (Bi-annually)  Inspection and maintenance log     Quantitative flow monitoring     Water quality monitoring  SPECIALIZED EQUIPMENT / TRAINING	POOR PLANT GROWTH  Remove mulch, replace top 5 cm of filter media with compost and restore 5 to 10 cm of mulch, as necessary  Amend soil with limestone or compost/sulphur to raise or lower pH of soil as required. Soil should have a pH of 6.0-7.8  Replace dead/diseased plant material: Bi-annually-Annually  SALT ACCUMULATION  Flush with fresh dechlorinated water to alleviate excess salt in the soil: as necessary
		WQA_OMP #5 Description: Pruning Frequency: Prune annually (by Certified Arborist) Equipment: Handwork Personnel: One individual Hours: 0.25hrs/linear metre  WQA_OMP #6 Description: Watering Frequency: Bi-weekly through establishment only (modify schedule in periods of wet) Equipment: Water truck Personnel: One individual Hours: 0.25hrs/linear metre  WQA_OMP #7	SPECIALIZED EQUIPMENT:  • Mechanical sweeper (OMP #4)  • Water truck & hose (OMP #6)  • Vacuum truck  SPECIALIZED TRAINING:  • Inspection and cleanout procedures  • Drainage system training  • Sediment removal procedure  • Sub-drain flushing procedure  • Arborist certification for tree pruning/care	SEDIMENT ACCUMULATION  Remove accumulated sediment with vacuum truck. In extreme cases remove plant material and top cm of contaminated filter media. Replace with 5 cm of new filter media and plant material, if necessar OBSTRUCTED SUB-DRAIN (if applicable)  Snake or vacuum truck to remove obstruction: as required.
		Description: Redistribute mulch to maintain >5 cm depth throughout Frequency: Quarterly Equipment: Handwork / rake Personnel: One individual Hours: 0.25hrs/linear metre  WQA_OMP #8 Description: Flush sub-drain (if applicable) Frequency: Annually Equipment: Water truck & hose Personnel: One individual Hours: 0.25hrs /sub-drain segment		



	Green Infrastructure /	Operations & Maintenance Protocols (OMP)	Inspections/Monitoring	Repairs / Replacement
	LID Option	Comment of the control of the contro		
	SWALES (WQ-B)	WQB_OMP #1 Description: Inspect & clean inlets	INSPECTION / MONITORING	BARE SOIL AREAS • Reseed bare soil areas: Bi-annually-Annually
	WQ-6 Enhanced Grass Swale	Timing: Bi-annually (Spring & Fall) Equipment: Handwork Personnel: One individual	KEY AREAS OF CONCERN / INSPECTION FREQUENCY:  Contributing drainage area condition (Bi-annually)  Inlet structural integrity / obstruction / erosion (Annually)	Add mulch (maintain 5-10 cm depth) planted bioswales: Every two years
	WQ-7 Bioswale / Dry Swale	Hours: 0.10hrs/inlet  WQB_OMP #2	Inlet sediment accumulation (Bi-annually)     Pretreatment sediment accumulation inspection (Bi-annually)	POOR PLANT GROWTH  • Replace top 5 cm of topsoil with compost: as necessary
		Description: Removal of litter and debris Frequency: Bi-annually Equipment: Handwork	Side slope erosion (Annually) Surface ponding - Perimeter / Filter bed (Annually) Standing water - Filter bed (Monthly through warranty period, Bi-annually beyond warranty) Garbage (Bi-annually)	<ul> <li>Amend soil with limestone or compost/sulphur to raise or lower pH of soil as required. Soil should have a pH of 6.0-7.8</li> </ul>
		Personnel: One individual Hours: 0.10hrs/linear metre  WQB_OMP #3	Filter bed erosion/sediment accumulation/surface sinking (Monthly through warranty period, Biannually beyond warranty)	Replace dead/ diseased plant material (if applicable): Bi-annually-Annually
		Description: Sweep contributing areas and remove sediment from pretreatment Frequency: Bi-annually	Check dam condition and function (Annually)     Mulch depth (Annually)     Vegetation density / health / composition (Bi-annually)	Regrade & replant eroded areas: As necessary
ENCY		Equipment: Mechanical sweeper / handwork Personnel: One individual Hours: Area dependent	Monitoring well condition (Annually)     Overflow outlet obstruction (Monthly through warranty period, Bi-annually beyond warranty)	Add flow spreading or turf reinforcing device: if required
FFICI		WQB_OMP #4 Description: Mowing (if applicable)	Sub-drain obstruction (Monthly through warranty period, Bi-annually beyond warranty)     Sediment accumulation testing (Bi-annually)	• Remove sediment accumulation >5 cm depth with rake and shovel where feasible: as necessary
AND E		Frequency: Bi-monthly or as required (do not mow in wet conditions)  Equipment: Light weight riding mower  Personnel: One individual	Inspection and maintenance log     Quantitative flow monitoring	COMPACTED SOILS  Core aerate; or remove stone and vegetation cover and till topsoil to a depth of 20 cm; or remove
NTITY		Hours:1hr/hectare WQB_OMP #5	Water quality monitoring     SPECIALIZED EQUIPMENT / TRAINING	and replace with non-compacted filter media or topsoil that meets design specifications - once every 3-5 years
WATER - QUALITY, QUANTITY AND EFFICIENCY		Description: Weeding Frequency: Weed bi-annually	SPECIALIZED EQUIPMENT:	SALT ACCUMULATION • Flush with fresh water to alleviate excess salt in the soil: as necessary
ALITY		Equipment: Handwork Personnel: One individual Hours: Area dependent	<ul> <li>Aerator</li> <li>Mechanical sweeper (OMP #3)</li> <li>Light weight riding mower or mulching mower (OMP #4)</li> </ul>	SURFACE PONDING • Remove accumulated sediment. Till filter media to 20 cm or remove and replace top 15 cm of filter
R - QU		WQB_OMP #6 Description: Pruning (if applicable)	Water truck & hose (OMP #7 & #9)	media: as necessary
WATE		Frequency: Prune annually (by Certified Arborist)  Equipment: Handwork  Personnel: One individual	SPECIALIZED TRAINING:  Inspection and cleanout procedures  Aerator operation	
		Hours: Area dependent  WQB_OMP #7	Mower operation     Flushing of subdrain procedures	
		Description: Watering Frequency: Bi-weekly through establishment only (modify schedule in periods of wet) Equipment: Water truck Personnel: One individual	Arborist certification for tree pruning/care	
		Hours:1hr/hectare  WQB_OMP #8  Description Politicity to study to project a 25 are death throughout (if applicable)		
		Description: Redistribute mulch to maintain >5 cm depth throughout (if applicable) Frequency: Bi-annually Equipment: Handwork / rake		
		Personnel: One individual Hours: 0.25hrs /linear metre  WQB OMP #9		
		WQB_OMP #9  Description: Flush sub-drain (if applicable)  Frequency: Annually		
		Equipment: Water truck & hose Personnel: One individual Hours: 0.25hrs /subdrain		

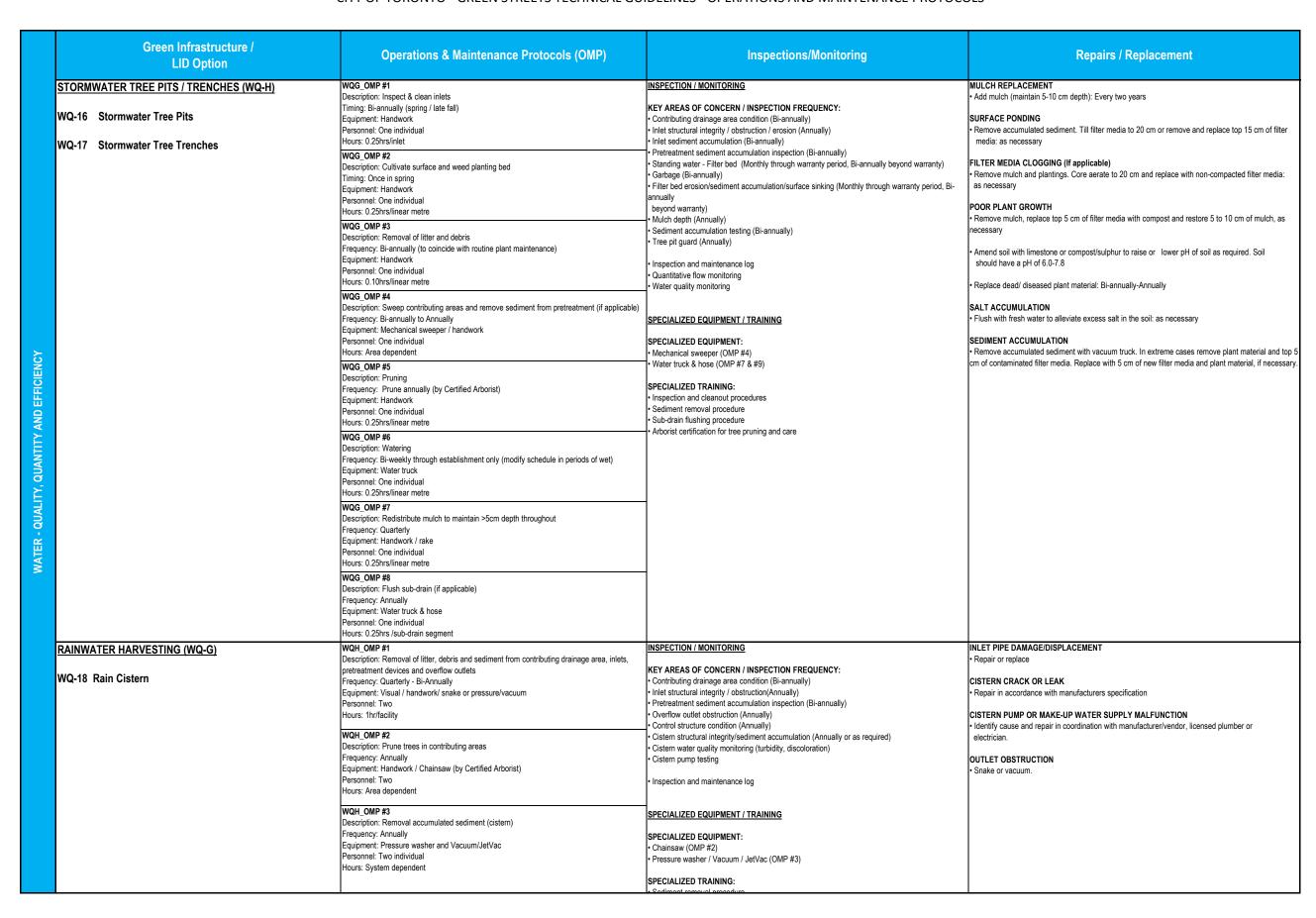


		Operations & Maintenance Protocols (OMP)	Inspections/Monitoring	Repairs / Replacement
	GUTTERS (WQ-C)	WQC_OMP #1 Description: Inspect & Clean Inlets	INSPECTION / MONITORING KEY AREAS OF CONCERN / INSPECTION FREQUENCY:	BARE SOIL AREAS  • Reseed bare soil areas: Bi-annually-Annually
	WQ-8 Green Gutter	Frequency: Bi-annually (spring / late fall) Equipment: Handwork Personnel: One individual Hours: 0.10hrs/inlet	Contributing drainage area condition (Bi-annually) Inlet structural integrity/obstruction/erosion (Annually) Pretreatment sediment accumulation inspection (Bi-annually) Standing water (Monthly through warranty period, Bi-annually beyond warranty)	EROSION AREAS • Regrade & replant eroded areas: As necessary
		WQC_OMP #2 Description: Removal of litter and debris	Garbage (Bi-annually)     Engineered soil erosion/sediment accumulation/surface sinking(Monthly through warranty period, Bi-annually beyond warranty)	Add flow spreading or turf reinforcing device as required  SEDIMENT ACCUMULATION
		Frequency: Twice per year (min.) Equipment: Handwork Personnel: One individual	Vegetation density/health/composition (Bi-annually)     Overflow outlet structure (Monthly through warranty period, Bi-annually beyond warranty)	Remove sediment accumulation >5 cm depth with rake and shovel where feasible: as necessary
		Hours: 0.10hrs/linear metre	Sediment accumulation testing (Bi-annually)     Inspection and maintenance log	SALT ACCUMULATION  • Flush with fresh water to alleviate excess salt in the soil: as necessary
		WQC_OMP #3  Description: Sediment removal (pretreatment)  Frequency: Annually  Equipment: Handwork	Quantitative flow monitoring     SPECIALIZED EQUIPMENT / TRAINING	SURFACE PONDING  Remove accumulated sediment. Till filter media to 30 cm or remove and replace top 15 cm of filter media, as necessary.
		Personnel: One individual Hours: 0.25hrs/linear metre	SPECIALIZED EQUIPMENT:  • Vacuum / JetVac	
NCY			SPECIALIZED TRAINING:  Inspection and cleanout procedure Sediment removal procedure	
FFICE	BUFFER STRIP (WQ-D)	WQD_OMP #1  Description: Inspect & clean inlets  Timing: Bi-annually	INSPECTION / MONITORING KEY AREAS OF CONCERN / INSPECTION FREQUENCY:  • Contributing drainage area condition (Bi-annually)	BARE SOIL AREAS  Reseed bare soil areas: Bi-annually-Annually
- QUALITY, QUANTITY AND EFFICIENCY	WQ-9 Filter Strip / Buffer Strip	Equipment: Handwork Personnel: One individual Hours: 0.5hrs/facility	Inlet structural integrity/obstruction/erosion (Annually)     Standing water (Monthly through warranty period, Bi-annually beyond warranty)     Garbage (Bi-annually)	CONCENTRATION OF FLOWS  Realign pretreatment stones (if applicable):Quarterly - Bi-annually
ANTITY		WQD_OMP #2 Description: Watering	Filter bed erosion/sediment accumulation/surface sinking (Monthly through warranty period, Biannually beyond warranty)     Vegetation density/health/composition (Annually)	Replenish stone cover (if applicable) to maintain 5-10cm cover in non vegetated areas.      Add flow spreading device or regrade existing to level: as required
IY, QU		Frequency: As required (May-September) Equipment: Water truck Personnel: One individual	Overflow outlet obstruction (Annually)	FILTER MEDIA CLOGGING  • Core aerate and replace with non-compacted topsoil: every 3-5 years
QUALI'		Hours: 0.25hrs /facility  WQD_OMP #3  Description: Mowing (5-10cm ht)	Inspection and maintenance log     Water quality monitoring	Remove and replace top 15cm of topsoil to alleviate fine texture clogging: as necessary
WATER -		Frequency: Monthly - Bi-monthly Equipment: Lightest mower or mulching mower available (do not mow in wet conditions)	SPECIALIZED EQUIPMENT / TRAINING	POOR PLANT GROWTH  • Amend top 5cm of topsoil with compost: as necessary
<b>/</b> /		Personnel: One individual Hours: 0.25hrs/facility  WQD_OMP #4	SPECIALIZED EQUIPMENT:  • Water truck (OMP #2)  • Lightweight mower or mulching mower (OMP #3)	Amend soil with limestone or compost/sulphur to raise or lower pH of soil as required. Soil should have a pH of 6.0-7.8
		Description: Removal of litter and debris Frequency: Quarterly - Semi-annually Equipment: Handwork	SPECIALIZED TRAINING:  • Inspection and cleanout procedure	Replace dead/ diseased plant material: Bi-annually-Annually
		Personnel: One individual Hours: 0.25hrs/facility	Sediment removal procedure	SALT ACCUMULATION  • Flush with fresh water to alleviate excess salt in the soil: as necessary
		WQD_OMP #5  Description: Sediment removal (pretreatment)  Frequency: Bi-annually - Annually  Equipment: Handwork  Personnel: One individual		SEDIMENT ACCUMULATION  • Remove plant material and top 15cm of contaminated topsoil. Replace with 15cm of new topsoil and plant material: as necessary
		Hours: 0.25hrs/facility  WQD_OMP #6  Description: Remove undesirable species		
		Frequency: Quarterly - Bi-annually Equipment: Handwork Personnel: One individual Hours: 0.5hrs/facility		
		WQD_OMP #7 Description: Tree/shrub pruning Frequency: Annually		
		Equipment: Handwork (by Certified Arborist) Personnel: One individual Hours: 0.5hrs/facility		
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	Green Infrastructure / LID Option	Operations & Maintenance Protocols (OMP)	Inspections/Monitoring	Repairs / Replacement
	UNDERGROUND INFILTRATION SYSTEMS (WQ-E) WQ-10 Drainage Well	WQE_OMP #1 Description: Removal of litter and debris from contributing drainage area, inlets, pretreatment devices and overflow outlets Frequency: Quarterly - Bi-annually Equipment: Handwork	INSPECTION KEY AREAS OF CONCERN / INSPECTION FREQUENCY:  Contributing drainage area condition (Bi-annually)  Inlet structural integrity / obstruction (Annually)  Pretreatment sediment accumulation (Bi-annually)	CLOGGING Remove accumulated sediment from when >5 cm depth or obstructing inflow into the system with hydrovac truck Add pretreatment device to prevent debris from entering the facility
	WQ-11 Perforated Pipe WQ-12 Soakaway	Personnel: Two Hours: 1hr/facility WQE_OMP #2 Description: Reseed bare soil in contributing areas (if applicable) Frequency: Bi-annually - Annually	Filter bed erosion/sediment accumulation (Annually)  Control structure condition and sediment accumulation (Annually)  Monitoring well condition (Annually)  Overflow outlet obstruction (Monthly through warranty period, Annually beyond warranty)  Sub-drain obstruction (Monthly through warranty period, Annually beyond warranty)	Snake or pressure vacuum to remove sub-drain obstructions.      Replace missing or damaged sub-drain caps
	WQ-13 Infiltration Trench	Equipment: Handwork Personnel: One individual Hours: Area dependent  WQE_OMP #3	MONITORING  • Monitoring well condition (Annually)  • Monitor flows - Flow meters - inlet/outlet (if applicable)	CONTROL STRUCTURE/PIPE CONNECTION LEAK  • Drain facility and repair/seal leak  NOTES:
QUANTITY AND EFFICIENCY	WQ-14 Infiltration Chamber	Description: Removal accumulated sediment (Inlets/outlets/control structure) Frequency: Bi-annually - Annually Equipment: Handwork Personnel: One individual Hours: 1hr/facility  WQE_OMP #4 Description: Removal accumulated sediment (sub-drain) Frequency: Annually Equipment: Vacuum/JetVac Personnel: Two Hours: System dependent  WQE_OMP #5 Description: Removal of oil and grease from pretreatment device (if applicable) Frequency: As needed Equipment: Vacuum Truck	Inspection and maintenance log  SPECIALIZED EQUIPMENT / TRAINING  SPECIALIZED EQUIPMENT:     Vacuum / JetVac (OMP #4)  SPECIALIZED TRAINING:     Inspection and cleanout procedure     Sediment removal procedure     Oil and grease removal and disposal training     Confined space entry training	Prohibit storage of soil, compost, sand, salt or unwashed granular in contributing drainage area and inlets
ANTITY	PERMEABLE PAVEMENT (WQ-F)	Personnel: One Individual Hours: 0.5hrs/facility  WQF OMP #1	INSPECTION / MONITORING	CRACKED / MISSING PAVEMENT
- QUALITY, QUA	WQ-15i Pervious Concrete	Description: Removal of litter and debris Frequency: Quarterly - Bi-annually Equipment: Handwork Personnel: One individual	KEY AREAS OF CONCERN / INSPECTION FREQUENCY:  Contributing drainage area condition (Bi-annually)  Standing water (Bi-annually)  Garbage (Quarterly)	Fill with materials consistent with original (if applicable)  For large potholes, cut and replace surface layer (if applicable)
WATER - QUA	WQ-15iii Permeable Interlocking Concrete Pavers	Hours: 0.25hrs/Area dependent  WQF_OMP #2  Description: Remove accumulated surface sediment (sweep or vacuum) Frequency: Bi-annually - Annually Equipment: High efficiency regenerative air or pure vacuum sweeper Personnel: One individual Hours: Area dependent  WQF_OMP #3  Description: Replace / top up joint material (if applicable) Frequency: Bi-annually Equipment: Handwork Personnel: One individual Hours: Area dependent  WQF_OMP #4  Description: Repaint parking space divisions (if applicable) Frequency: Every three years Equipment: Road marking machine Personnel: Two Hours: Area dependent  WQF_OMP #5  Description: Flush sub-drain (if applicable) Frequency: Annually Equipment: Handwork Personnel: One individual Hours: 0.25hrs/facility  WQF_OMP #6  Description: Snow removal Frequency: As required Equipment: Snow plow (to be raised 0.6 cm above surface) Personnel: As required Hours: Area dependent	Pavement surface condition/sediment accumulation (Annually) Monitoring well condition (Annually) Control structure condition / sediment accumulation (Annually) Inspection and maintenance log Quantitative flow monitoring  SPECIALIZED EQUIPMENT / TRAINING  SPECIALIZED EQUIPMENT: Mobile sweeper / Vacuum / JetVac (OMP #2) Road marking machine (OMP #4) Snow plow (OMP #6)  SPECIALIZED TRAINING: Sediment removal procedure Road marking procedure Road marking procedure for Permeable Paving	Replace or reset unit pavers (if applicable)  SURFACE PONDING Sweep/vacuum thoroughly Pressure wash or wire brush may also be required for heavily clogged areas  SUBDRAIN OBSTRUCTION Snake or pressure vacuum for removal: as required  NOTE: Prohibit access by construction vehicles Prohibit storage of snow, soil, compost, sand, salt or unwashed granular Adjacent landscape areas must be covered with vegetation with no soil runoff possibility Minimize application of deicers

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Green Streets Technical Guidelines







#### Part I | Foundation and Framework (April to November 2015)

- 1. Work session with Complete Streets team
- 2. City staff & stakeholder interviews
  - 31 interviews
  - 10 departments
    - Engineering and Construction Services
    - Business Improvement Standards Engineering Support Services
    - Toronto Water
    - City Planning
    - Transportation Services
    - Parks, Forestry and Recreation
    - Toronto Parking Authority
    - Economic Development and Culture BIA
    - Forestry Operations
- 3. Product supplier interviews
- 4. Precedent research

# Part II | Exploration and Evaluation of Opportunities (May 2015 to

January 2016)

- 1. Review meetings with project team and Advisory Group
- 2. Working group presentations

### Part III | Green Streets Technical Guidelines (January 2016 to August 2017)

- 1. Complete Streets integration
- 2. Generation of a long list of green infrastructure options, refinement to a shortlist of options
- 3. Development of an green infrastructure Selection Tool and a Vegetation Selection Tool
- 4. Preparation of Technical Drawings
- 5. Preparation of the Technical Guideline Document including Operations and Maintenance Manual
- 6. Working and Advisory Group review sessions
- 7. Senior Staff review

Green Streets Technical Guidelines

### **City of Toronto Green Streets Technical Guidelines**

# SCHOLLEN & Company Inc. 30 Wertheim Court, Unit 15 Richmond Hill, Ontario L4B 1B9 Tel: 289-695-0009 Fax: 289-695-0010 Email: design@schollenandcompany.com

### INTERVIEW SESSIONS SUMMARY MATRIX

Schollen & Company Inc. / TMIG / UFA / Bousfields Inc. / DPM October 2015

Document Format / Contents	<ul> <li>Document should be concise and simple</li> <li>Provide index for ease of use</li> <li>Provide table of contents (not necessarily numbered)</li> <li>Provide matrix for plant species selection</li> <li>Post document on the internet – City has requirements</li> <li>Format should integrate with City's standard specification format</li> <li>Guidelines should be structured like specifications</li> <li>Maintenance recommendations</li> <li>Recommendations related to requirements for up front testing should be provided</li> </ul>	<ul> <li>Material testing and specifications should be provided</li> <li>Specify standard bioretention soil mix</li> <li>Guidance for developers – LID applications</li> <li>Cost/benefit summary should be provided</li> <li>Existing conditions graphic versus targeted system</li> <li>Screening tool should address: <ul> <li>proximity to building</li> <li>depth to subsurface structures</li> </ul> </li> <li>"Pull-out" sheets for maintenance</li> </ul>	<ul> <li>Map out implementation process</li> <li>Provide realistic cost estimate (per linear metre)</li> <li>Provide funding recommendations</li> <li>PPT showing what has already been done "Green Street" examples</li> <li>Standards for planting specifications should be provided</li> </ul>
Integration	Guidelines will need to integrate with:         Urban Design Streetscape Guideline         Healthy Street Guideline – Active Living Design Guideline         Bikeway Guideline         By-laws for boulevard treatments         Specification format         City standard drawings         Utility standards and specifications         Toronto Green Standard         Urban forest details         Streetscape details         Beautiful Streets         Toronto Draft BMP Guideline	<ul> <li>Fully integrated with capital planning process</li> <li>Integration with NHS</li> <li>Integration with BIA initiatives</li> <li>Other publications:         <ul> <li>TAC Manual for Greener Roads</li> <li>(TAC Manual Addresses Climate Change)</li> </ul> </li> </ul>	
Street Typologies	<ul> <li>Street Typologies - There is a need to sub-classify to address driveway and on-street parking configurations.</li> <li>Suburban streets verses urban streets present different opportunities</li> <li>Rural cross-sections – Definitely a City policy (or practice), they exist in the City.</li> </ul>	<ul> <li>Rolled curbs – Toronto does not have this as a standard detail.</li> <li>Standard sub-drain below curb – could be a SWM initiative.</li> <li>Permeable pavers in laneways are good candidates for Green Streets.</li> </ul>	The design standards for roads will need to be changed to accommodate 'Green Streets' initiatives. There is more opportunity in the suburbs compared to the downtown area. The standard location of utilities may require changes.

#### **Comments**

#### Challenges

- There is need for integration with by-laws for boulevard treatments
- 'Silva Cells' have been installed but they are laboursome to install correctly and are expensive. There is a need for a better 'Silva Cell' solution
- Use of unshriklable fill (City's standard requirement) increases extent of impervious area but does provide benefits in terms of quality of repair of road cuts for utilities
- Underground utilities surveys are lacking and the accuracy of utility locations as shown on drawings is suspect
- Geotechnical investigations need to be done upfront and early in the design process
- Soil compaction is an issue
- Planting trees over infrastructure is problematic sanitary sewers in particular pose a problem
- Challenge: Lack of expertise is specifying materials
- Key Challenges
  - Delivery system
  - Contractor lack of training
- Flexibility is required to accommodate a suite of options
- Problems with Stormceptors City only credits 50% TSS instead of manufacturer's claim of 80%.
- Resistance factors Affordability, life cycle, operation and maintenance (keep is simple) (road operations people prefer simple solutions) – Needs to be safe – Can't sacrifice on safety.
- City is standardizing lighting New Cobrahead example Yonge/Dundas.
- Silva cell installations Costly and complex.
- Streetscape details Issue: What is structural capacity of concrete slab? City to retain structural engineer to verify detail. H20 loading.
- Materials need to be available for a long duration (many years).
- Who is taking care of streetscape? Neighbouring commercial owners take responsibility but condos / residential can be problematic.
- Issue Limited space and lack of accuracy in locating underground utility infrastructure.
- Major conflict Trees and pedestrian clearway.
- Bioretention cell Specified soil mixture could not be delivered in timely manner.
- Specification is overly complicated Contractor can't deliver bioretention mix. Provide simple specification –review bioretention soil specification. Mario to send specification for review.
- Testing turn-around time is an issue.

- Need to do more up front testing / investigation prior to final design to locate utilities, characterize soils.
- Permeable pavement Transportation does not want to maintain pavement that is installed on granular base.
- Street lighting Toronto Hydro does in-house design and wants to do construction but this is problematic.
- Interlock surface Bedding is the key issue.
- Requirement to install curbs Key issue with rolled curbs relates to people driving/parking on grass but this is not problematic. Rolled curbs are presently discouraged.
- Minimum planting distance of trees to signs and signage is an issue
- Disagreements on standards and details Varies between CA staff
- Certain infrastructure is not appropriate, for example, idealistic street tree details.
- Different definition of "boulevard" for different districts is a problem.
- Risk adversity is an issue.
- Develop contractor expertise.
- Prequalifications for contractor Provide an outline in the quideline.
- Challenges Operations.
  - Fitting things into the street
- Many users within road R.O.W..
  - Surface of roads/sidewalks Transportation
  - Replanting trees / storm / sanitary Respective areas
  - Bioretention systems Frequency/cost
- Majority of SWM is now on private property with be exception of super pipes / OGS, which are occasionally allowed within the public ROW.
- Utilities are an issue
  - Gas lines too shallow
  - Inaccurate as-builts for gas mains
- Snow storage is an issue.
- Need to build properly Frost heave/sub-base can be saturated causing long-term problems.
- Mature trees can limit options for ditches.
- Complexity Everything in the ground requires approvals –
   11-12 utilities design is complicated.
- Utilities place restrictions on streetscape design.
- Challenges:
  - o Reduction in walkable space
  - Maintenance
  - Public realm implements project and expects BIA to maintain them

- · Utilities cuts are a challenge.
- Cost is a problem \$10000 for a tree pit is too expensive and is a dis-incentive to BIAs planting trees.
- Should be a balance between cost and requirements:
  - Cost can be too prohibitive
  - Rather see more trees than one costly tree
- No department has budget for trees.
- Audience Utility providers need to be educated.
- Challenges:
  - Not sure what LID entails.
  - Prework not done to support LID design i.e. survey/geotechnical investigations.
  - o Utility company coordination.
- SWM/Bioswales Difficulties stem from:
  - Concern with lack of education for the public.
  - Lack of information circulated to homeowners/developers
  - Problems fall back to Operations.
- Liability issue in the event of failure of LID system:
  - o Who is liable?
  - By-law policy needs to be tightened up to address homeowner obligations.
  - Worst case scenario needs to be considered during the design process.
- Water table is an issue Needs to be considered.
- Challenges occur mostly in winter plowing scenario is the biggest challenge.
- Leaf litter can be problematic.
- Adequate drainage is necessary Sub-drainage/swales.
- Private impervious areas are a problem. Capacity exceedances are an issue due to runoff from private lands.
- How trees get placed in relation to street lighting is an issue.
- Existing neighbourhoods increase in % impervious area due to infill/tear-down and rebuild.
- Sidewalk width is an issue:
  - Cabbagetown Pavers raised due to tree growth present trip hazards.
  - Walkable space is an issue Risk and liability are issues with the grates, pavers, pits, etc.

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- Soil mix is specified but is not correct, causing mortality.
- Critical to select planting priorities. Why plant trees when they have little chance of survival?
- Need to screen properly for street trees in terms of soils, microclimate and other criteria.

Green Streets Technical Guidelines

Comments			
Implementation	<ul> <li>There is a need to address implementation to find out what works and what doesn't work</li> <li>Silva Cells – Contractor oversight is essential since the installation is complex</li> <li>Focus on road reconstruction projects</li> <li>It is important that the designer is involved in construction review</li> <li>Placement of Biofiltration Soils – How to handle the soils so there is no segregation?</li> </ul>	<ul> <li>Sequencing of the work is an issue as is protection of LIDs during construction. CVC document provides some guidance</li> <li>Concerns about inspection and certification requirements</li> <li>Having a Landscape Architect as ESC would be beneficial</li> <li>A prequalification list of contractors would be beneficial to ensuring quality of installation.</li> <li>Good to have supplier involved in installation (i.e. Silva cells).</li> <li>Technical issues – Had to pave with asphalt during construction to protect sub-base.</li> </ul>	<ul> <li>Requirement for more training – Use Nashdene as training site         <ul> <li>Specialized repair crew would be an asset.</li> </ul> </li> <li>Treat as a utility – One call system for locates is one method of identifying when Silva cells exist.</li> <li>Icons in sidewalk to delineate location of soils cells:         <ul> <li>1 icon for SWM</li> <li>1 icon for tree related installation</li> </ul> </li> </ul>
Project Examples	<ul> <li>There is a good example of where street trees are thriving with a simple detail (Adderley and John Streets). This may be worth considering.</li> <li>The Scarborbough stormwater project (Danforth) designed by Aquafor Beech is a good prototype</li> <li>Keele Street Project – There was information lacking and a need for coordination with Urban Forestry and other departments</li> <li>Coxwell Project – There were issues with soil mix/compaction and soil underdrain issues. Details need to be provided</li> <li>Fairport Project – Problem with the skills of the contractor</li> <li>The 'Six Points' project (Dufferin Street/Kipling Avenue) is an example of integrating 'Green' initiatives into the streetscape.</li> <li>2828 Danforth project will include a tree protection fence detail that should assist in protecting trees from damage. These can be customized to include different graphics/logos</li> <li>Queen's Quay – Irrigation system – Not intended to maintain the system so MOECC approval was not requiring.</li> <li>Pilot projects – "Over analysis" is a problem: <ul> <li>Maintenance aspects need to be considered</li> <li>Repair methods must be spelled out</li> <li>Just do it – Compare products and learn</li> <li>Need to allocate operating budget</li> </ul> </li> <li>Bioswales on Bay Street south of Davenport.</li> <li>Permeable pavement in boulevard areas.</li> <li>Eastwood – Gerrard/Coxwell – Reconstruction with permeable asphalt – Issues with installation.</li> <li>Fairfort (Coxwell) &amp; Danforth projects: <ul> <li>Challenges – contractor issue on Fairfort</li> <li>unable to produce shop drawings, materials</li> <li>contractor knowledge was deficient</li> <li>specialized expertise was required</li> </ul> </li> <li>Danforth – Soil cells and bioretention.</li> <li>Porous pavement – Canadian Tire Leslie/Sheppard – Good performance and longevity.</li> </ul>	<ul> <li>Kilgour Estates / CNIB – Unit stone pavement system functioning well.</li> <li>Riverview Street (Bloor and south Kingsway) has potential for swales. Park-like area that could be used for bioretention – Bands of interlocking paving.</li> <li>Yorkville – Bay and Avenue Road – Concrete base with unit stone paver.</li> <li>Has implemented bump-outs (Lower Sherbourne).</li> <li>New parking lot for Eastvalle Training Centre is an example.</li> <li>Lawrence Park EA as an example – One size fits all is a non-starter.</li> <li>Toronto East York District – bioswales have been implemented and LIDS are being incorporated into Toronto Community Housing developments.</li> <li>Lawrence Heights – Bioswales.</li> <li>Stanley Green – Bioswales.</li> <li>Bayview Avenue <ul> <li>Ditch in existing road, but only because it was not possible to connect to the trunk storm sewer</li> <li>Homes have sumps.</li> </ul> </li> <li>Cedarview project <ul> <li>Exfiltration drain, gallery below, clean outs</li> <li>Retrofit of ditches</li> <li>Flooding under high flow events is a problem</li> <li>Never implemented, as City could not agree on who would maintain them</li> </ul> </li> <li>Prince Edward Drive, north of Berry Road: <ul> <li>Moduloc pup CB south of Bloor</li> <li>Leaky catchbasins</li> </ul> </li> <li>Steven Road Etobicoke – MOE.</li> </ul> <li>Queensway projects – Silva cells – Good for new builds. Silva cells also incorporated into Six Points redevelopment (under construction).</li> <li>201 Claremont – Living wall.</li>	<ul> <li>BIAs have implemented green streets – Lots of trees, parkettes.</li> <li>Permeable Pavers – Yonge Street Granby/McGill.</li> <li>Danforth Village - Large planters were too large for BIA to maintain.</li> <li>Yorkville project/'Greening of Yorkville' is underway.</li> <li>Green Streets Project – South Station is an example.</li> <li>Problems – Encroachment on private property (underground garage).</li> <li>Roncesvalles: <ul> <li>Issue with technical specifications - collapsed planters were a problem.</li> <li>Support design and structure of slabs may have been the problem.</li> <li>Something new – Not sure if detail on construction was the issue.</li> </ul> </li> <li>Permeable concrete – East side of Bayview, south side of Eglinton – 3 years in streetscape.</li> <li>Balmoral subdivision – SE corner Wilson Heights and Sheppard – Cul-de-Sac replacement – 200mm concrete base, subdrains to catchbasins.</li> <li>Skymark – 40 years ago – Interlocking pavers on roadway. Street is a bus loop – Set for repair in 2017. Could be great opportunity for permeable pavement.</li> <li>Bloor Yorkville BIA – Soil augmentation not well done – All clay. Once soil was replaced, trees are thriving.</li> <li>City Projects: <ul> <li>Moore Avenue, August 31, 2010.</li> <li>Chine Drive, January 31, 2014.</li> <li>Redlea Avenue Phase I, May 20, 2014.</li> <li>Meadowvale Road, January 13, 2015.</li> <li>Redlea Avenue Phase II, ECA approval pending.</li> </ul> </li> <li>Development Projects: <ul> <li>Queen's Wharf, October 8, 2010.</li> <li>Bridgepoint Hospital, December 24, 2009.</li> </ul> </li> </ul>

Comments				
Policy Considerations	<ul> <li>Streetscape Manual is a Tool – It is flexible to accommodate 'Green Street' options</li> <li>Not all projects require MOECC approval only those with the intent of operating in perpetuity need MOECC approval</li> <li>Ontario Regulation 5258 – Requires that facility be located within only 1 lot or parcel of land</li> <li>Testing procedures are different for different manufacturer's products. Standardized testing is required.</li> <li>Maintenance requirements from MOECC can be too stringent.</li> <li>MOECC has the right to inspect at any time and review log books to ensure compliance.</li> <li>Target – 5mm is standard.</li> <li>Hybrid systems – Building Code vs Water Resources Act</li> </ul>	<ul> <li>Permeable pavement – No approvals are required.</li> <li>Mechanisms to support permeable pavement: Municipal consent agreements</li> <li>Input into municipal code and property standards – Could require for driveways – Big difference in flood mitigation of permeable pavement driveways are wide spread.</li> <li>Trees – Boulevards – Silva Cells with trees – if trees fail in Silva Cell, this is a costly problem – Can tree by-law be amended to allow for "tree harvesting"?</li> <li>Recommendation to have MOECC guideline to coordinate with City policies/guidelines.</li> <li>Standard Operating Procedures exist for all departments Citywide.</li> </ul>	<ul> <li>Standard Operating Procedures – May need to change with respect to Operations – Snow plow damage for example might necessitate different equipment.</li> <li>Mandated maintenance requirements for MOECC approval.</li> <li>Some outcomes are mandated by MOECC (sewer overflows) are others. Water balance is not mandated.</li> <li>Sole source is an issue therefore 'performance' specifications are necessary to ensure products are effective, resilient and maintainable. Typically requires 3 quotes for replacement parts, this is an issue if you do not have specifications for component parts from original supplier.</li> </ul>	
Techniques	<ul> <li>Jelly Fish – Operations does not like to maintain – Difficult to access and weighs much more when full.</li> <li>Mitigation vs adaptation – Example: warm asphalt – less GG emissions.</li> <li>Using recycled products is a "Green" initiative.</li> <li>Provide plants that support insect / wildlife populations.</li> <li>Reduce light level when it snows – Central control would be useful.</li> <li>Stormwater planters – Not an issue with loading. If sidewalk is hard surfaced it should be able to take a load.</li> <li>Mapping the location of Silva cells, etc is not done and should be implemented.</li> </ul>	<ul> <li>Trench drain – Need to standardize detail. Curb inlet detail is custom.</li> <li>Porous asphalt – Not favoured due to performance issues.</li> <li>How much transpiration per tree? Brian will send numbers for consideration.</li> <li>Green initiatives – Push towards LID vs OGS devices. OGS devices only remove larger particles instead of fine particles with pollutants attached.</li> <li>Silva cell – Promoted as full maturity growth system may be not realistic.</li> <li>Porous CBs – MOE required analysis for each CB – to onerous.</li> </ul>	<ul> <li>Planter boxes – Snow clearing is not a problematic.</li> <li>Have Used P.C. permeable pavement on laneways.</li> <li>Pourous Asphalt has been used.</li> <li>Maintaining ditches is a 'Green Streets' initiative.</li> <li>Permeable pavement in laneways – What are safeguards re: extreme low temperatures and potential for malfunction.</li> <li>Need to specify a 'Performance Standard' – 'Soil Cell' is the generic name.         <ul> <li>Add to Performance Standard – 'Require detailed O+M Manual'.</li> <li>Manual needs to address 'LID' complexities.</li> </ul> </li> <li>Soil volume standards have changed the way of thinking with respect to design process.</li> </ul>	
Green Street Objectives	<ul> <li>Social objectives – These should be considered as well. Good street design has the potential to uplift socially challenged communities. We need to have regard for social needs. There is also an opportunity for social/beautification funding.</li> <li>Green Streets – Adopt a 'Best Efforts' approach rather than 'Hard Targets'.</li> <li>Priority – Bring nature back to the City and strengthen connections to the natural environment. Enhance placemaking and make the City more habitable.</li> <li>Bring parks to the streets.</li> <li>Climate change – What are the targets (affordability vs "making things better").</li> <li>Urban biodiversity is an objective.</li> <li>Cultivating stewardship – Drawing attention to non-human occupants of the city.</li> </ul>	<ul> <li>SWM – Enhance biodiversity.</li> <li>Trees are foundations of habitat.</li> <li>Needs: <ul> <li>A variety of species</li> <li>A variety of structural habitat</li> <li>Connectivity</li> <li>Green streets intersection with NHS – Opportunities for crossings for heptiles</li> </ul> </li> <li>CSO areas – Lower target would be 10mm.</li> <li>Climate change/building in resilience is important.</li> <li>Shade canopy – need to have effective shade. <ul> <li>Provision of shade is a common public concern</li> <li>Partnering with Public Health to promote shade</li> </ul> </li> <li>Water quality is the hook to bring Toronto Water in (WWFMMP objectives).</li> </ul>	<ul> <li>Need to tie into principles – WWFMMP as well as:         <ul> <li>Well being</li> <li>Nature attention deficit disorder</li> <li>Health and mental health</li> <li>Air quality</li> <li>Social improvements</li> </ul> </li> <li>Operation and Maintenance are key issues.</li> <li>Operational Challenges:         <ul> <li>Winter maintenance – Major Issues.</li> <li>Spring/summer/fall – No real issues – Maintenance is routine.</li> </ul> </li> <li>Snow storage capacity is a key consideration.</li> <li>Narrow roads/pedestrian areas limit space between curb and sidewalk.</li> <li>Training and information – Responsibilities are unclear.</li> <li>40 year life cycle for trees would be great/5 year is typical today.</li> </ul>	

#### Comments **Potential Opportunities** • There is lots of room in boulevards for 'Green' initiatives Permaculture has potential. Projects have been done for decades. Incorporating different • There is the potential for redistribution of gas mains/hydro Email Kelly to request information on animal crossing types of treatments including: Ditches • The space in the boulevard, next to the curb, is an ideal spot protocols. for permeable pavement as are medians. There is an example • Laneways are a candidate for permeable pavement. More trees of a solar P.V. installation in a median. • High reflectivity pavement – Is problematic for some people Narrowing roads Infiltration • Permeable Pavement – Not for use on travelled lanes but is with eye disabilities. appropriate for low use areas, for example culs-de-sac islands • Green Streets – Reducing lane with cars provides benefits re: Exfiltration Permeable Pavement CB locations conflicts and provides street tree opportunities. • Bikes Lanes – Is there an opportunity for LID in bike lanes? Laneways Photovoltaics – Could be used as shade structures or street • Green Street – Technical detail re: bump outs / curb relocation Parking Lay-bys furniture is required. • 'Tree – cycling' might only be suitable for downtown core Private driveways present an opportunity • There may be the potential for a project in East York where sites are constrained for long term sustainable tree • Solar Panels – There is an example in Korea Town done by the East York – Janet Davis's Ward growth. Wants Green Streets to move forward BIA. Solar panels may be appropriate for use in the • Opportunities on private property should be explored. Climate change adaption streetscape. • Generally opposed to 'Tree Cycling' concept: o Scarborough Southwest EA Study established a • Educational value of initiatives should be capitalized upon. Need to be aware of timeframes for maintenance of • Promote Green Streets - LID initiatives can reduce reliance on precedent for public acceptance of Green initiatives infrastructure but ambition should be to grow the urban Healthy benefits. big pipes. Joint utility trenches. • Potential for incentives for permeable pavement. • Applying 'Forestry' principles (Phil) to urban forestry: • Pilot projects are low risk – Great way to learn quickly. Over 500 environmental requirements are set out in contract. • Tree canopy can be timed to correspond with service life Energy efficient lighting • Crossings at hydro corridor / open space provide animal of underground infrastructure. o Green roofs on transit shelters have been done movement / biodiversity opportunities. • Construction techniques change over time for example • Urban farming – is an overlay (i.e. need to discourage people • Cycling of trees – Valid concept. torpedoing/lining. from gardening in bioswales due to risk of contamination). • Potential for living structures in Streetscapes? • Tree Planting – potential to add to private realm to offset lost opportunities in streets.

**International Toronto** 

Green Streets Technical Guidelines

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#### **Comments**

#### **Maintenance Considerations**

- There is a need for an LID maintenance manual
- Maintenance There is a need to spell out on-going maintenance requirements during the period prior to assumption by the City
- Permeable Pavers R.C.M. is something Mr. Cheung would like to do. Larger areas are better than smaller installations with regard to maintenance.
- Who maintains is a question Toronto Water or Transportation Services
- Maintenance is a concern MOECC has the right to request reports.
- Need to find out criteria for who maintains what. Toronto Water vs Transportation Services.
- What is cheaper to maintain Vegetated swale or super pipes?
   Practical solutions need to be affordable to maintain
- Road cuts are an issue Will repairs be done correctly by utility contractors?
- Snow removal is a concern with respect to potential damage to LIDs.
- City delivery vs Contractor delivery:
  - Street sweeping is internal
  - Winter operations Contracted out
  - CB clearing: Toronto Water First foot below grade Transportation Services beyond 1 foot below ground
- Utility Cuts Repairs are contracted out.
- Maintenance of "new" installations / technologies is more costly.
- Need to define one consolidated operations protocol Green Streets operations / maintenance by a dedicated body.
- BIAs also maintain but require proper direction, BIAs have maintenance agreements.
- Maintenance Can maintenance requirements be defined/quantified is Green Streets Guidelines.
- Use life cycle cost as a lens.
- · Maintenance must be realistic.
- Standardized maintenance is important.
- Biggest component Maintenance:
  - o Book 7 Need to close a lane must be considered
  - Takes over Orphan Spaces where feasible (some are not maintainable)
- Transportation rights-of-way outside of public realm would be maintained by transportation or someone else.
- Maintenance is done internally.
- Importance in implementing LID/SWM Requires funding for training.

- Maintenance Corktown Common Maintenance manual with pull out sheets for maintenance schedule is very effective.
- Operation and Capital programming need to be convinced.
- Need a budget item for maintenance.
- Maintenance
  - o Who does it?
  - Is adjacent landowner accountable for maintenance within public right-of-way.
- Temporary patch is done by utility providers.
- Realistic costing for implementation and maintenance should be provided:
  - o Factors of multiplication in comparison to base treatment
- Maintaining bioswales As a homeowner responsibility can't tie that responsibility to homeowner.
- Bring LID options up sooner than later Maintenance is a big issue.
- Councillors need to be aware of maintenance. Silva cells repair is an issue. Cost implications on repair.
- Watering trees is a good example "if you can't water the trees don't plant trees".
- · Repair of utility cuts is an issue.
- Build things that we can maintain.
- Littering issues, needles collect in bioswales in more concealed areas / susceptible to drug use.
- Inspect once a month (probably not enough).
- Winter maintenance requirements Salt is used No salt / sand mix calibration rates with salt.
- Looking to incorporate application rates / limits into future winter maintenance contracts.
- Smart About Salt Council.
- Maintenance Push back is a problem.
- We need to define responsibilities for 'Green' drainage systems:
  - o Who looks after what?
  - Once water reaches below surface it should be Toronto Water's responsibility.
- Optimal dimension for snow storage 3 5m Absolutely minimum should be at least 1-1.5m.
- Snow removal is costly \$5 million/day City-wide.
- Levels of service Maintenance is based on road classifications.
  - High pedestrian load 2cm threshold for snow removal.
  - Local Streets 8cm threshold for snow removal.

- Silva Cell O+M Manual is provided Warranty is void if product is cut.
- Need to provide minimum maintenance standards to overcome long term council/budget changes.
- Maintenance indications Nuisance failure should be evident prior to catastrophic performance failure.
- 0+M is a concern Budget constraints are in issue.
- Snow removal is an issue Design should consider that everything is under 2' of snow.
- Utility cuts Integration with green infrastructure is an issue.
- Sometimes Forestry is required to fix problematic designs but they are not designers.
- Operations manual is required for all installations.
- Hardware is not always readily available.
- Type of soil determines irrigation requirements irrigation systems are problematic.
- Pilot project with LEAF Store owners water trees and this has been successful Needs to be promoted as a program.
- Soil augmentation/watering should be done simultaneously.
   High volume of commercial trees throughout the City require watering.
- Present watering proposed places an onus on trees that are stressed/newly planted.
- Forestry splits City in half (southwest/northwest). Focus is on commercial trees in hard spaces.
- Issue with existing trees pits What do we do? How do you
  deal with retrofit situations due to tree growth? Rubber
  curbs/plow damage? Artificial turf is a problem.
- Transportation services do not clean tree pits. This is an issue. Cigarettes butts are a big issue.
- Silva cell maintenance is still being discussed Forestry is not well suited to do this.
- Working with Hydro on response to 2013 ice storm Hydro has asked that there be no branches over primary wires.
- Infiltration facilities should be designed so that they can
  operate and be maintained in all seasons. The access to the
  infiltration system and the pipe size used need to be
  considered.
- The facility design should provide for the possibility that its
  function may be disrupted if an existing utility needs to be
  repaired that is in conflict with or in close proximity to the
  infiltration trench. Should this occur, the reinstatement of the
  infiltration facility will be required by the utility company. This
  may require changes to municipal consent process when work
  is proposed within a City road allowance.

G8

Green Streets Technical Guidelines

<i>N</i> onitoring	<ul> <li>Initial installations could be subject to more intense monitoring.</li> <li>Accurate mapping of utilities is critical.</li> </ul>
Design Process	<ul> <li>Development Application Review — City should ask for LIDs upfront. Presently the request comes too late in the process. There should be a pre-screening exercise</li> <li>Geotehcnical investigations are done too late in the design process</li> <li>Collaboration throughout the design process is important</li> <li>Sustainability office has a role to play.</li> <li>Public realm department has been established.</li> <li>Procedural recommendations to be provided PINS (Project Information Notices) — Biodiversity would like to be included is circulation.</li> <li>Relationship between Toronto Water / Transportation Services needs to be defined.</li> <li>DIPS (Development Infrastructure Planning Manual) standards — Standard cross-sections.</li> <li>Confirm if MOEEC approval is required up front in the process.</li> <li>ECS is responsible to design / contract admin for Transportation Services / Toronto Water.</li> <li>Process — Can be an uncooperative relationship with ECS.</li> <li>Issue: lack of notification of opportunities — Existing system is not working.</li> <li>There is no vehicle for construction outside of ECS process, except BIA office (BIA is client) — This is problematic.</li> <li>Community and councillor driven initiatives do not fit in typical process.</li> <li>Obstacles in process:         <ul> <li>Cooperation during design</li> <li>Difficulty is at implementation/operational stages</li> <li>Implementation — "curb to curb" asphalt and pipes — No expertise in curb to building face street line.</li> <li>Implementation is a challenge due to lack to education/understanding</li> <li>Maintenance</li> </ul> </li> <li>Areas for improvement:         <ul> <li>Roster of specs and details is lacking</li> <li>Tendering practises — No prequalification for streetscape / landscape contractors</li> <li>City inspectors need more education regardi</li></ul></li></ul>

- "Orphan Space Program" PFR or contractor Spaces with no defined owner – Horticultural maintenance is undertaken.
- Process: how are projects identified?
  - Review / assessment should be done with a team rather than through as a list of capital projects as is the present protocol
- Catalyst is repair/resurfacing for getting a street on the list –
   There is a need to have an assessment once the street is identified to identify Green Streets opportunities.
- Funding is not adequate to accommodate Green Streets initiatives as part of road reconstruction at the present time.
- Allocation of funding Offsets for Green Streets should be considered.
- Communication
  - Poster idea might be helpful
  - Training sessions
  - Design checklist
- o Who needs to be trained on what and when?
- Notification timing is 2 years prior to project.
- PIN Project Information Notification Need to re-instate.
- More information required upfront "Complete Streets" will address this.
- Need to discuss with MCIC Focus is on "curb to curb".
- Funding opportunities open up if there is a tangible SWM benefit.
- WWFMMP changes More advocacy, unit flow rates, rectification of deficiencies.
- Toronto Water is open to pilot projects.
- Funding is a big issue Constraint to implementation of Green Streets. Parks branch is not feasible to fund implementation.
- ECS is focussed on implementation Internal conflicts between Water and Transportation are a barrier.
- Issue is who pays? Cost sharing is a problem.
- Capital planning exercise needs to account for Green Streets.
- Need to simplify process.
- Strong suggestion 12 years have past since pilot projects have been implemented. It is time to move forward.
- Division heads need to be involved. Budget should be established for green initiatives.
- Utility permitting Road Operations Group manages this.
- Municipal Consent Requirements Access Agreement set of rules and permit requirements.

- LID requests from clients Requires expertise/complexity.
  - Less than a year to design projects.
  - Expertise is not available in-house.
- LIDs can delay / put project at risk.
- Budget schedule and biggest impact.
- Capital Delivery Managers in ECS need to be consulted.
- ECS works on functional not district basis:
  - Linear
  - Underground
  - Major infrastructure
- · More lead time required for LID.
- Projects come from MCIC. 5 year delivery model:
  - Based on asset management protocol for Toronto Water
  - List is sent to MCIC
  - Based on assets approval Life cycle management for Transportation Services
- There is not a fulsome circulation for review, particularly for transportation projects – This is problematic.
- Delays and cost over-runs are a problem for ECS They take the blame.
- Horizon is five years Project start to completion.
- Budgets get set by asset owners They establish budget.
- Fulsome site assessment with a wide lens.
- Additional of LIDs should be at project concept stage.
- MCIC circulates project list (FROST) How many people read it?
- Need to identify at the stage of asset review.
- Need to ensure there is a mechanism to easily allow future new ideas for SWM/LID to get incorporated into City standards.
- Kev issue Cost allocation.
- Public buy-in is very important.
- Public information meeting is usually held at 60% detailed design.
- Cost sharing is an issue.
- Public meetings Courtesy thing Changing the street is a big issue can influence design.
- When do public meetings happen 6-5 months before design (drop in centres).
- Data Base Pavement management system data base informs capital programs 5 year timeframe with 10 year horizon.
  - Certain Streets Green Streets initiatives have been flagged as part of capital planning process.

**TORONTO** 

Green Streets Technical Guidelines

Comments			
esign Process (con'd)	<ul> <li>Categories of types of projects.         <ul> <li>RE/Re Pave – Limited opportunities.</li> <li>Reconstruction – Much more opportunity – Depends on Street type.</li> </ul> </li> <li>Toronto Water – Indentifies needs in conjunction with transportation (closely coordinated).</li> <li>ECS process – If transportation/Toronto Water identifies project BIA will 'Piggy Back' on these projects.</li> <li>EDC flags projects from MCIC that are located in BIAs.</li> <li>Scope decided by the City 1-2 years in advance of construction – Not a lot of time given the complexity of BIA projects.</li> <li>Good ideas come in too late.Process from conceptual design to detailed design to quickly to accommodate integration of Green Streets ideas.</li> <li>Scope Expansion – New technical requirements, i.e. survey, are problematic.</li> <li>Need to ensure ideas are workable:         <ul> <li>If it does not work – ECS has a problem.</li> <li>Deal with urban planning for LID initiation/integration.</li> <li>Hesitant to try new things due to:</li></ul></li></ul>	<ul> <li>Right now ECS does the assessment and they are not experts.</li> <li>All planning decisions should be made before project gets to ECS.</li> <li>Time is a big constraint.</li> <li>Time delays: <ul> <li>Research.</li> <li>Conceptual Design.</li> <li>Utility complications.</li> </ul> </li> <li>Need to know – Technical checklist: <ul> <li>What needs to be done?</li> <li>How it should be done?</li> <li>When it needs to be done in order to facilitate schedule adjustments and plug Green Streets modules into schedule.</li> </ul> </li> <li>Time needs to be allocated for: <ul> <li>Technical investigations.</li> </ul> </li> <li>Not all projects necessarily require public consultation – address in checklist to define which projects should be subject to public consultation.</li> <li>Hard surface vs. soft surface solutions tend to be the decision point for public consultation.</li> <li>Feed back – ECS only hears about problems, not successes.</li> <li>Not yet circulated with ECS planning (5 years). Would like to be part of project scoping.</li> <li>Public education – needs to be bolstered.</li> <li>Managing expectations is necessary.</li> </ul>	<ul> <li>Transportation has initiation 2 new positions that will be the decisions markers with respect to what components are included in street projects.         <ul> <li>Financial scope to be confirmed early on.</li> <li>Need for review 30% (funding confirmed), 60%, 90% review.</li> </ul> </li> <li>Telegraphing multiple years in advance (3 years is optimal).</li> <li>Green Streets team needs to be implemented to assist ECS another to coordinate initiatives.</li> <li>MCIC – Process will be assisted by bringing Green Streets decisions forward early.</li> <li>3 year look ahead is the target for transportation/water.         <ul> <li>To provide opportunities to secure funding.</li> </ul> </li> <li>Lost opportunity to do infrastructure/appearances presented reconstruction when Forestry is not consulted in the process</li> <li>Standardization is essential.</li> <li>Forestry does not oversee construction – Transportation inspector may not be paying attention to planting techniques.</li> <li>Lack of communication amongst departments is an issue. Plare not always provided information on when/where trees habeen planted (i.e. on road reconstruction projects).</li> <li>Forestry operations should be involved in all projects that invitree plantings. Involvement needs to be up-front in the process.</li> </ul>
Consultation Process			

Comments			
Design Considerations	<ul> <li>There is a need to ensure that bioretention cells have a minimum width/depth/slope so that they are recognizable to pedestrians.</li> <li>Trench Drains – There is a concern about maintenance, litter and blockage, grates being covered by leaves, grates being damaged.</li> <li>Side Inlet Catch Basins – Small opening does not work with City's equipment and litter is a concern.</li> <li>Design – Provide a 'Factor of Safety'. Drawdown time 24-48 hours.</li> <li>Street tree plantings should be designed for a life span of 30 years. Wood could then be salvaged for alternate uses. This would allow for maintenance of LIDs. Concept of 'cycling' the urban forest was discussed.</li> <li>Avoid conflicts between trees and utilities.</li> <li>What can be done to increase storage in LIDs?</li> <li>Fact sheet would be helpful regarding 'Green Streets'.</li> <li>Details need to be simple/not too expensive.</li> <li>Porous Concrete – Testing?  <ul> <li>Laneway drainage is an issue.</li> </ul> </li> <li>Validity of examining solar orientation – Solar exposure related to tree growth.</li> <li>Patrick Cheung – CBs that pump water back into tree (irrigation system).</li> <li>Loading is an issue on slabs.</li> <li>Trees need access for root systems and area calculations should not be divided by property lines.</li> </ul>	<ul> <li>1.5m clearance width required for sidewalk snow removal:         <ul> <li>Free of obstructions.</li> <li>Must be continuous sidewalk.</li> <li>On-street parking complicates clearing.</li> <li>Etobicoke 90% of sidewalks are cleared.</li> <li>Scarborough 95% of sidewalks are cleared.</li> <li>North York 95% of sidewalks are cleared.</li> </ul> </li> <li>Sand is not predominant in mix 20% sand/80% salt.</li> <li>Pre-treatment is required to mitigate icing.</li> <li>Brine is used on roadways only – Effective to minus 9 degrees Celsius.</li> <li>Beet juice is good to minus 30 degrees Celsius.</li> <li>Long term availability of replacement materials is an issue (i.e. colours and styles of unit stone pavers change over time).</li> <li>Need tangible numbers for maintenance on a per linear meter basis.</li> <li>Service laterals pose an issue – utility cuts, access, frequency of interference.</li> <li>Identify priorities based on extent of lateral series connections required (parks, schools have fewer laterals to deal with in the streetscape).</li> <li>Tree pits could be enhanced as part of utility cut repair (sidewalk repair).</li> <li>Planters – Removed and replant at grade is preferred.</li> <li>Containers – Not precast – Cast-in-place planters at grade are good – University Avenue for example. Planters provide salt protection and aid in protecting trees.</li> </ul>	<ul> <li>Biodiversity improved in planters (raised) due to ability to utilize less salt-tolerant species.</li> <li>Trip Hazards – Tree pits can pose a trip hazard.</li> <li>Metal grate over pits can be too slippery. This required Forestry to undertake remedial action.</li> <li>Trip hazard mitigation/slip free surface is essential.</li> <li>More complex planting techniques = Increase maintenance costs.</li> <li>Concerns – Quality of soil itself and not necessarily soil volume is the issue: <ul> <li>Quality of soil is more important.</li> <li>Soil augmentation is important</li> </ul> </li> <li>Tree rails work well with sedum to protect from trampling.</li> <li>Perennials work better for deterring cigarettes butts – But how do you maintain?</li> <li>Collar girdling – Expandable rings/maintenance solutions need to be explored so that trees in tree pits can grow large.</li> <li>Minimize garbage accumulation - Weeding is also an issue.</li> <li>BIAs – Some want custom tree grates – Need a standard for selection with options for customization.</li> <li>Small fences with BIA logo could work.</li> <li>Tree grates are important - Tree rails are excellent. Tree guards are also effective.</li> <li>Species limitations – What will survive in which locations?</li> </ul>
Funding	<ul> <li>Established pot of funding for 'Green Streets' initiatives would be good.</li> <li>Transportation funding is based on is 'State of good Repair' criterion.</li> <li>Funding of tree plantings in road reconstruction projects – should it be ECS or Forestry?</li> <li>Friction related to who pays for what is a problem.</li> </ul>	<ul> <li>New budget is required to address Green Streets initiatives but Operations does not get new funding – Need to flag in the report.</li> <li>Need to make an economic case to justify Green Streets.</li> <li>Green infrastructure to 'cost avoid' grey infrastructure.</li> <li>Cost avoidance – with added benefits in terms of objectives.</li> </ul>	<ul> <li>Order of magnitude increase in cost over conventional servicing is an issue</li> <li>Utilities costs are in issue.</li> <li>Money is an issue – Funding needs to be prescribed based on a certain standard. Capital funding runs short.</li> </ul>



### PRECEDENT RESEARCH

A number of government agencies throughout North America have prepared manuals and guideline documents that are aimed at directing the implementation of "Green Street" initiatives. The foci of these various documents differ; some are aimed primarily at promoting the implementation of initiatives to manage stormwater runoff while others address a broader range of 'green' initiatives including reduced urban heat island effect, multi-modal transportation or urban forest enhancement. In addition, each of the precedent documents that were reviewed adopted a different level of detail with some focussing on 'the big picture' and others delving into more technical detail. Documents reviewed were sourced from different geographic locations throughout North America. Some share a similar climatic context with Toronto and others do not. This broad spectrum of documents was selected in order to examine a diverse range of Green Street possibilities that could be adapted to the Toronto context. The following documents were reviewed:

- New York City, Green Infrastructure Plan, 2010
- New York City, Environmentally Protection Standards for Green Infrastructure, 2014
- City of Cleveland, Complete and Green Streets, 2012
- City of Milwaukee, Green Streets Stormwater Management Plan, 2013
- United States Environmental Protection Agency (US EPA), Managing Wet Weather Flow with Green Infrastructure Municipal Handbook Green Streets, 2008
- City of Los Angeles, Low Impact Development Manual (LID), 2011
- City of Boston, Boston Complete Streets Design Guidelines, 2013
- City of Philadelphia, Green Streets Design Manual, 2014
- City of Edmonton, LID Best Management Practices Design Guide Edition 1.0, 2011
- City of Portland, NE Holladay Green Street Corridor Plan Achieving EcoDistrict Goals, 2012
- City of Portland, 2012 Revisions for the Public Works Details, 2012
- City of Chicago, The Chicago Green Alley Handbook, 2010
- Streetscape Guidelines for the City of Chicago Streetscape and Urban Design Program, 2003
- District of Columbia, A Guide to Green Infrastructure in the District of Columbia, 2014,
- City of Omaha, Green Streets for Omaha, 2003
- City of Omaha, Omaha Streetscape Handbook, 2008

Each of the documents listed above was reviewed on the basis of the following:

- **1. Level of Guidance** | The level of detail at which the document addressed the design of Green Street initiative ranging from general to technical.
- **2. Range of Green Street Objectives Addressed |** The focus of the document ranging from one-dimensional, stormwater management based options to multi-dimensional environmental, social and ecological solutions.
- 3. Types of Green Infrastructure / Green Street Alternatives
  Recommended and Rationale | Recommendations related to green infrastructure applicability and performance.
- **4. Document Status** | Status of approval and relationship between the document and other related guidance documents / policies.
- **5. Organization by Street Typologies**
- **6. Implementation Strategies and Recommendations** | Has the document been implemented and what are the results?
- **7. Operations and Maintenance** | Degree of guidance that the document provides related to the operations and maintenance of Green Streets initiatives.
- **8. Cold Climate Guidance** | Does the document provide specific recommendations to address implementation and operation in cold climate conditions?
- **9. Lessons Learned** | A Summary of the key lessons learned as a result of the implementation of the recommendation set out in the document.
- **10. Other Comments** | A list of comments related to components of the document that were particularly relevant for consideration in the process of generating the City of Toronto Green Streets Technical Guidelines.

A precedent summary outlining drivers that have influenced creation of the City of Toronto Green Streets Technical Guidelines document has been provided on page G13 and the findings from each precedent document are described on pages G14 - G29.

**G12** 



Green Streets Technical Guidelines

#### PRECEDENT RESEARCH - IMPLICATIONS AND INFLUENCES

#### 1. Level of Guidance / Components

- Provide limited "overview" section
- Provide rational / targets related to each Green Street objective
- List green infrastructure opportunities
- Describe precedent projects throughout city
- Provide examples of typical installations, locations, benefits
- Provide Green Street selection tool / flowchart
- Provide tree selection tool / matrices
- · Provide catalogue of schematic construction details
- Include sizing calculations
- Provide illustrative sections / details
- Provide "fact sheets" for easy reference
- Provide retrofit versus new construction options

#### 2. Range of Green Street Objectives to be Addressed

- Stormwater management
- Rain gardens
- Street trees / urban forest
- Electric vehicle charging stations
   Increased cycle access
- Permeable surfaces
- Impervious area reduction
- Reduced urban heat island effect
- Dark sky compliance
- Walkability
- Energy conservation / generation
- Sustainable materials

#### 3. Types of LID / Green Street Alternatives Recommended and Rationale

- Perforated pipe systems
- Bioswales
- Stormwater inlets
- Bioswales with stone columns
- Sediment pad
- Steel guards for planted areas
- Bioretention systems
- Tree trenches
- Street trees / tree boxes
- Planter boxes
- Drv wells
- Infiltration systems
- Filter strips
- Bioinfiltration systems
- Vegetated swales
- Raised tree beds
- Stormwater planters

- Community gardens with rainwater harvesting
- Green roofs
- Blue roofs
- Permeable pavements
- Swales
- Tree pits
- Storage chambers
- Green walls
- Vegetated stormwater management systems
- Street lights (state-of-the-art)
- Clean energy / renewable energy
- Stormwater "bump-out"
- Green gutters
- Stormwater drainage wells

#### 4. Organization by Street Typologies

- Organize Green Street recommendations based on "Complete Streets"
- Provide "typology-based" selection tool

#### **5. Document Status**

- Standalone but integrated with "Complete Streets"
- Coordinated and formatted to correspond with City standard, specifications
- Coordinated with Streetscape Design Manual and other urban design guideline documents
- Consider annual reports / updates

#### 6. Implementation Strategies and Recommendations

- Identify priority areas based on CSO, flood mitigation, etc.
- Recommend project tracking database and mapping program
- Provide recommendations for post-construction monitoring and data management
- Provide standardized details
- Provide examples of successful implementation
- Discuss barriers to implementation and remedies
- Provide implementation principles
- Recommend project development and review process
- Identify funding opportunities / needs
- Identify regulations / approval requirements
- Provide guidance on selection and application
- Set out range of costs

#### 7. Operations and Maintenance

- Provide recommendations for:
  - Maintenance
  - Maintenance equipment
  - Winter maintenance
- Landscape maintenance
- Catchbasin cleaning
- Maintenance agreements
- Life-cycle maintenance
- Recommendations should be specific to each LID type
- Provide matrix with general operation and maintenance requirements
- Identify security and safety consideration

- Utility coordination and repair

Provide recommendations to coordinate maintenance with design

#### 8. Cold Climate Guidance

- Snow storage and clearance
- Provide winter maintenance recommendations for each LID type

#### 9. Lessons Learned

- Incorporate stone gabion in bioswales to enhance performance
- Avoid groundwater influx
- Avoid introduction of surface flow from adjacent vegetated areas
- Use correct materials / construction techniques
- Avoid soil compaction
- Complete infiltration tests prior to design
- Introduce a new process that is aimed at:
  - Assessing necessary function of the road with the objective of reduction in lane widths and impervious cover
  - Enhancing streetscape elements to manage stormwater
  - Integrating transportation and environmental planning

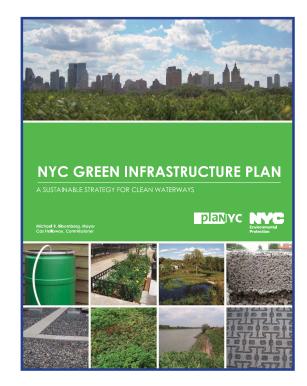
#### **10. Other Comments**

- New York Standards for Green Infrastructure provides a comprehensive compendium of details. These should be reviewed in detial for applicability
- Los Angeles document sets out a broad range of LID options for
- · Provide an index of acronyms at beginning of document
- Provide a detailed, searchable index
- Provide a matrix that illustrates the suitability of each "Green Street" option to each street typology
- Provide a glossary of terms
- Edmonton document is the best source for cold climate operation, design and maintenance recommendations
- · Portland Public Works details provides a comprehensive catalogue of details that should be reviewed for applicability
- Provide general land area / impervious area calculations for road rightsof-way to demonstrate potential positive implications of "Green Streets"
- Provide performance standards for each "Green Streets" option



New York City Infrastructure Program 2010 PlaNYC

**NYC Environmental Protection** 







#### 1. Level of Guidance

- Urban ROW LIDs: includes standard details for bioswales, planting and guard details, rain gardens
- Lists green infrastructure opportunities, estimated performance and costs for priority Combined Sewer Overflow (CSO) watersheds in new development, existing development, in ROWs, in parks
- Describes LID test projects throughout the city

## 2. Range of Green Street Objectives Addressed

Stormwater management

## 3. Types of LID / Green Street Alternatives Recommended and Rationale

- Community gardens with rainwater harvesting
  - Rain barrels
  - Green roofs
  - Blue roofs (retaining water on roofs)
  - Permeable pavements
  - ROW swales and tree pits
  - Storage chambers
  - Perforated pipe
- Aim is to minimize stormwater runoff from entering the combined sewer system
- Goal is to manage stormwater from 10% of the impervious surfaces in the combined sewer contributory area

## 4. Organization by Street Typologies

• Addresses varying right-of-way (R.O.W.) widths

#### **5. Document Status**

- Approved
- Standalone document with yearly annual reports

## 6. Implementation Strategies and Recommendations

- Implemented area-wide green infrastructure in priority CSO tributary areas: 42 design and construction contracts
- Growth of green infrastructure schoolyards partnership with Trust for Public Land
- Development of project-tracking and asset management system
- Report for Post-Construction Monitoring Green Infrastructure
  - Green Infrastructure met or exceeded runoff management expectations
  - Green Infrastructure managed 1-inch runoff across 10% of impervious surfaces

#### 7. Operations and Maintenance

Not addressed

#### 8. Cold Climate Guidance

Not discussed

#### 9. Lessons Learned

- Incorporation of the stone gabions in the ROW bioswales improved performance
  - allows water to get from the surface ponding area to the subsurface storage and infiltration zones more rapidly
- ROW bioswales negatively affected by surface flow infiltrating from nearby vegetated areas or groundwater seeping from high bedrock areas

#### **10. Other Comments**

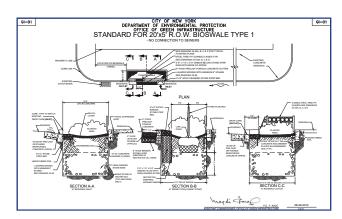
N/A

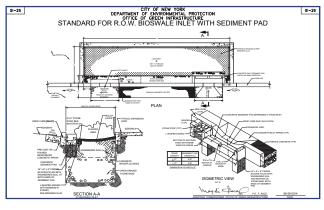


New York City Environmentally Protection Standards for Green Infrastructure 2014

City of New York, Department of Environmental Protection Office of Green Infrastructure







#### 1. Level of Guidance

Specific construction details

## 2. Range of Green Street Objectives Addressed

- Stormwater management
- Urban forest

## 3. Types of LID / Green Street Alternatives Recommended and Rationale

- Bioswale
- Stormwater inlet
- Stormwater chamber
- Bioswale with stone columns
- Rain garden
- Perforated pipe
- Sediment pad
- Planting plans for bioswales and rain gardens
- Steel guard for planted areas

## 4. Organization by Street Typologies

• No

#### 5. Document Status

Approved

## 6. Implementation Strategies and Recommendations

• Standard details for implementation

## 7. Operations and Maintenance

Not addressed

## 8. Cold Climate Guidance

Not discussed

#### 9. Lessons Learned

Not discussed

#### **10. Other Comments**

• Excellent compendium of technical details

G15

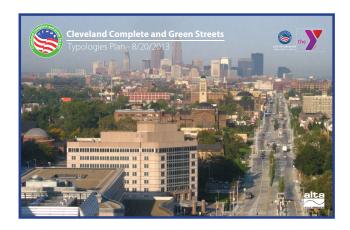


City of Cleveland Completed and Green Streets

2012

City of Cleveland

**YMCA** 









## 1. Level of Guidance

- Includes 3 pages on Green Infrastructure for the Right of Way General recommendations
- Discusses the importance of healthy soils, street trees, and sheet flow dispersion
- Includes recommended cross-sections of ROWs

## 2. Range of Green Street Objectives Addressed

- Stormwater management with a focus on minimizing of runoff entering the combined sewer system
  - Roadway widths
  - Transportation nodes
  - Roadway features (vegetation, parking)
  - Traffic management
  - Connectivity
  - Design speeds

## 3. Types of LID / Green Street Alternatives Recommended and Rationale

- Bioretention
- Pervious paving

## 4. Organization by Street Typologies

Addresses varying right-of-way widths

#### 5. Document Status

• Standalone planning level right-of-way guidance document

## **6. Implementation Strategies and Recommendations**

No information provided

## 7. Operations and Maintenance

Not addressed

## 8. Cold Climate Guidance

Not discussed

#### 9. Lessons Learned

Not discussed

## 10. Other Comments

N/A

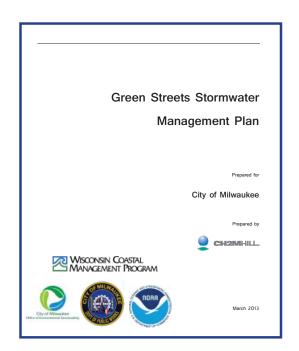


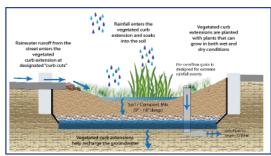
City of Milwaukee – Green Streets Stormwater Management Plan

2013

Wisconsin Coastal Management Program
City of Milwaukee Office of Environmental
Sustainability

City of Milwaukee Department of Public Works
National Oceanic and Atmospheric
Administration







#### 1. Level of Guidance

- Provides green street stormwater strategies to reduce stormwater quantity and improve quality through implementation on streets and alleys recommendations
- Provides examples of typical installation locations, benefits, and maintenance considerations
- Provides cross-sectional renderings of example applications
- Provides flow charts for LID technique evaluation

## 2. Range of Green Street Objectives Addressed

• Stormwater management

#### 3. Types of LID / Green Street Alternatives Recommended and Rationale

- Bioretention
- Pervious paving
- Tree trench

Aim is to minimize stormwater runoff from entering the combined sewer system

## 4. Organization by Street Typologies

• Defines best LID solution for a specific right-of-way location

#### 5. Document Status

- Approved
- Standalone document

#### 6. Implementation Strategies and Recommendations

- Provides examples of successful implementations
- No quantitative results

#### 7. Operations and Maintenance

- Provides recommendations for
  - Maintenance
  - Maintenance equipment
  - Winter maintenance
  - Landscape maintenance by Forestry Services
  - Catchbasin cleaning

#### 8. Cold Climate Guidance

• Winter maintenance recommendations provided

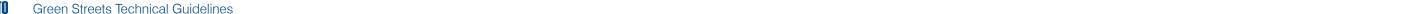
#### 9. Lessons Learned

- Benefits of LID are contingent on use of correct materials, proper construction techniques
- Compaction of native soils, improper soil mixes and the use of heavy equipment in areas designed for infiltration can cause problems that may be difficult to observe visually but will have detrimental impacts on performance
- Recommended that Green Street strategies receive an infiltration test to confirm that they were constructed properly and are achieving the design goals before maintenance of the devices is handed over to the City. Ideally this test would be conducted after new plantings had a chance to become established
- Infiltration testing could include double ring infiltration tests, filling of devices to capacity with water trucks, or monitoring during a specified storm

**G17** 

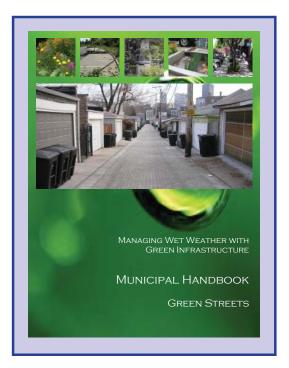
#### 10. Other Comments

• N/A





United States Environmental Protection Agency (US EPA) – Managing Wet Weather Flow with Green Infrastructure Municipal Handbook – Green Streets 2008







#### 1. Level of Guidance

- General guide
- Details the opportunities and benefits of treating stormwater within the ROW
- Establishes the green streets goal to provide source control of stormwater, limit its transport and pollutant conveyance to the collection system, restore predevelopment hydrology to the extent possible, and provide environmentally enhanced roads
- Lists municipalities with specifications and standard details for swales, permeable pavements, healthy tree volume

## 2. Range of Green Street Objectives Addressed

• Stormwater management

#### 3. Types of LID / Green Street Alternatives Recommended and Rationale

- Street trees/tree boxes
- Permeable pavements
- Bioretention
- Swales

#### 4. Organization by Street Typologies

N/A

#### 5. Document Status

- Approved
- Part of a set of street guidance documents: Funding Options Handbook, Green Infrastructure Retrofit Policies Handbook, Rainwater Harvesting Policies Handbook, Incentive Mechanisms Handbook, and more policy guides and tools
- USEPA 'Regular Inspection and Maintenance Guidance' sheets for various LID types

## 6. Implementation Strategies and Recommendations

- Discusses implementation hurdles
- Portland, OR list of green street pilot projects
  - Stormwater curb extensions captured 85% runoff volume in a simulated 25-year storm event flow test, reduced peak flow by 88%
  - Each of the pilot projects have been well documented by the Portland Bureau of Environmental Services using a consistent format to describe pilot background, features, engineering design, landscaping, project costs, maintenance, monitoring, and lessons learned http://www.portlandonline.com/BES/index.cfm?c=34598
- Chicago, IL Green Alleys Program
  - Repaving the alleys with impermeable pavement ranged in cost from \$120,000 to \$150,000, whereas a total Green Alley reconstruction was more along the lines of \$200,000 to \$250,000
  - Additional benefits of the Green Alley Program include not only urban heat island effect reduction, material recycling, energy conservation, and light pollution reduction, but also the creation of a new market

#### 7. Operations and Maintenance

Not addressed

#### 8. Cold Climate Guidance

Not discussed

#### 9. Lessons Learned

- Elements necessary for a successful green streets program:
  - Pilot projects are critical
  - Leadership in sustainability from the top
  - Buy-in from all municipal infrastructure departments
  - Documentation
  - Public outreach
- The green options available demonstrate the flexibility of green infrastructure to satisfy road function and environmental objectives and highlight why transportation corridors are well suited for green infrastructure
- developing a green streets program requires an institutional re-evaluation of how right-of-ways are most effectively managed. This process typically includes:
  - Assessing the necessary function of the road and selecting the minimum required street width to reduce impervious cover
- Enhancing streetscaping elements to manage stormwater and exploring opportunities to integrate stormwater management into roadway design
- Integrating transportation and environmental planning to capitalize on economic benefits

#### 10. Other Comments

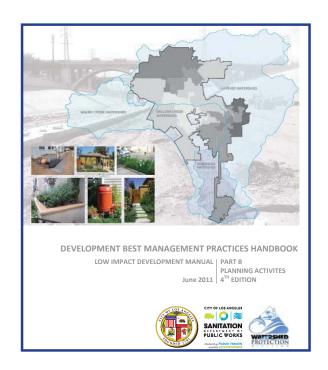
N/A

**City of Los Angeles – Low Impact Development** Manual

2011

City of Los Angeles Department of Public Works

Watershed Protection Division









#### 1. Level of Guidance

- · Provides guidance for individuals involved in new development and redevelopment projects, a result of a city ordinance requiring all dev./redev. to capture and manage 100% of the first 3/4" (19mm) storm event onsite
- Includes details, cross-sections, sample calculations of LID types
- Includes infiltration sizing calculations

## 2. Range of Green Street Objectives Addressed

Stormwater management

## 3. Types of LID / Green Street Alternatives Recommended and Rationale

- Residential LIDS:
- Rain barrels
- Permeable pavements
- Planter boxes
- Rain gardens
- Dry wells
- Other LID types
  - Infiltration basins
  - Infiltration trenches
  - Infiltration galleries
  - Bioretention
  - Permeable pavements
  - Dry wells
  - Hybrid bioretention/Dry wells
  - Bioretention with underdrain
  - Planter boxes
  - Bioinfiltration
  - High-flow biotreatment with raised underdrain
  - Vegetated swales
  - Filter strips

## 4. Organization by Street Typologies

• N/A

#### **5. Document Status**

- Approved
- Standalone document, with yearly annual reports

## 6. Implementation Strategies and Recommendations

Not information provided

#### 7. Operations and Maintenance

Not addressed

## 8. Cold Climate Guidance

Not discussed

#### 9. Lessons Learned

Not discussed

#### **10. Other Comments**

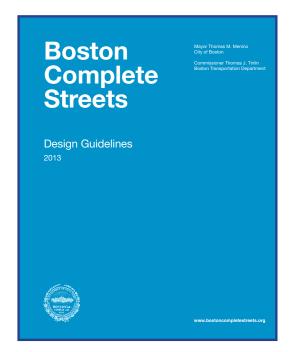
Broad range of LID examples provided

G19



Boston Complete Streets Design Guidelines, Boston Transportation Department 2013

City of Boston





#### 1. Level of Guidance

- General with schematic sketches and some dimensions provided
- Specific direction provided relating to tree specification

## 2. Range of Green Street Objectives Addressed

- Bus lanes and transit prioritization
- Intelligent signals and traffic cameras
- Bicycle and car share stations
- Minimum lane widths
- Rain gardens
- Street trees
- Electric vehicle charging stations
- Ease of maintenance
- Accessible surfaces
- Permeable surfaces
- Smart parking meters
- Bicycle lanes and cycle tracks
- Digital tags and information panels
- Wide sidewalks / pedestrian zones

#### 3. Types of LID / Green Street Alternatives Recommended and Rationale

- Green walls:
  - Stormwater management
  - Energy efficiency
  - Air quality
- Sidewalk materials Provides list of perforated materials for sidewalk zones
- Permeable paving materials
- Greenscape
  - Street trees
  - Vegetated stormwater management
  - Soils selection and management
- Urban forest
  - Tree selection
  - Root environment
  - Open tree trenches
  - Covered tree trenches
- 0010104 1100 1101101
- Raised tree beds
- Tree pits
- Stormwater management
  - Stormwater planters
  - Rain gardens
- Street lights State-of-the-art
- Clean energy Vehicle charging linked to renewable energy

#### 4. Organization by Street Typologies

- Downtown commercial
- Downtown mixed-use
- Neighbourhood main street
- Neighbourhood connector
- Neighbourhood residential
- Industrial
- Shared street
- Parkway
- Boulevard

#### 5. Document Status

- Approved
- Standalone document with yearly annual reports

## 6. Implementation Strategies and Recommendations

- Being implemented
  - Implementation principles provided
  - Project development and review process recommended
  - Public involvement process recommended

#### 7. Operations and Maintenance

- General maintenance guidance provided
  - Maintenance agreement
  - Life cycle maintenance for roadways
- Utility coordination
- Snow storage and clearance

## 8. Cold Climate Guidance

- Specific to each type of LID / green street option
- General guidelines for snow storage and clearance provided

#### 9. Lessons Learned

Not discussed

#### 10. Other Comments

· Provides an index of acronyms includes a detailed index

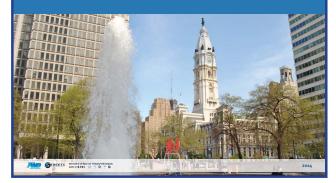


City of Philadelphia Green Streets Design Manual

2014

Philadelphia Water Department
Streets Philadelphia
Mayor's Office of Transportation and Utilities

## City of Philadelphia Green Streets Design Manual







#### 1. Level of Guidance

- General with schematic details and photo illustrations as well as design details and specifications
- Fact sheets provided with general guidance and 30 illustrative details
- Provide guidance for location of green stormwater infrastructure (GSI) systems within road right-of-way
- Provides technical design considerations
- Provides list of design requirements

## 2. Range of Green Street Objectives Addressed

• Stormwater management

## 3. Types of LID / Green Street Alternatives Recommended and Rationale

- Stormwater management
  - Stormwater trees
  - Stormwater tree trenches
  - Stormwater planters
  - Permeable pavements
  - Stormwater bump-out
  - Permeable pavement (asphalt, concrete, pavers)
  - \* Green gutters
  - \* Stormwater drainage wells

\* under development

## 4. Organization by Street Typologies

- High volume pedestrian
- Civic / Ceremonial street
- Walkable commercial corridor
- Urban arterial
- Auto-oriented commercial / industrial
- Park road
- Scenic drive
- City neighbourhood
- Low-density residential
- Shared narrow
- Local

#### 5. Document Status

- Approved
- Generally standalone but to be used in conjunction with "GSI Design Requirements and Guidelines Packet" and "GSI Design Manual"
- Supporting detailed document include "Water Department Design Details and Specifications" and "PWD Green Infrastructure Standard Details"

## 6. Implementation Strategies and Recommendations

- Being implemented
  - Sets out design review and approval process (not relevant to Toronto Philadelphia specific)
  - Identifies funding opportunities (not specific)

#### 7. Operations and Maintenance

- Provides an outline of requirement for construction and inspection
- Outlines maintenance responsibilities

#### 8. Cold Climate Guidance

Not discussed

#### 9. Lessons Learned

Not discussed

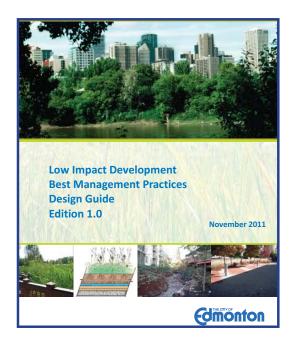
#### 10. Other Comments

Matrix provided to illustrated SMP suitability for each street typology

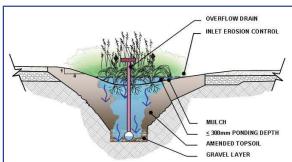


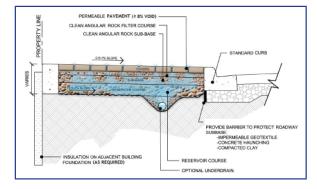
Low Impact Development Best Management Practices Design Guide - Edition 1.0 2011

City of Edmonton









#### 1. Level of Guidance

- Guideline document with specific schematic details for various LID options
- Provides exceptional detail on design, construction and maintenance requirements for each LID type
- Provides plant lists
- Provides facility sizing calculations

## 2. Range of Green Street Objectives Addressed

- Stormwater management
- Urban forest

## 3. Types of LID / Green Street Alternatives Recommended and Rationale

- Bioretention / rain gardens
- Bioswales
- Green roofs
- Permeable pavement
- Box planters
- Naturalized drainageways
- Rainwater harvesting for reuse
- Soil amendments

## 4. Organization by Street Typologies

• No

#### **5. Document Status**

Approved

## 6. Implementation Strategies and Recommendations

- Addresses regulatory context
- Provides guidance on selection and application

## 7. Operations and Maintenance

- Provides operation and maintenance recommendations for each LID option
- Provides maintenance program requirements and schedule

#### 8. Cold Climate Guidance

- Addresses winter maintenance
  - Policy
  - Practical recommendations

#### 9. Lessons Learned

Not discussed

## **10. Other Comments**

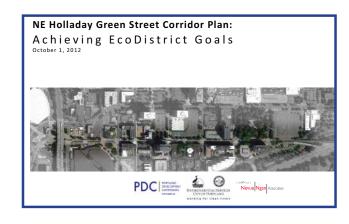
- Provides a glossary of terms
- Best resource for cold climate operation, facility sizing and maintenance information

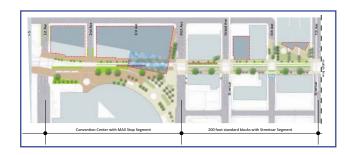


NE Holladay Green Street Corridor Plan -Achieving EcoDistrict Goals 2012

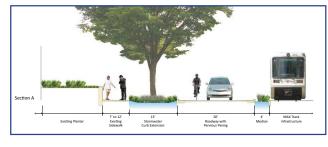
Portland Development Corporation

Environmental Services - City of Portland









## 1. Level of Guidance

- Plan for a specific street corridor
- Provides design toolbox and schematic details / illustrations

## 2. Range of Green Street Objectives Addressed

- Impervious area reduction
- Stormwater management
- Urban forest enhancement

## 3. Types of LID / Green Street Alternatives Recommended and Rationale

- Pervious planters
- Boardwalks
- Green roof at grade
- Pervious paving
- Stormwater curb extension
- Stormwater planters
- Green gutter
- Stormwater canopies, green roofs on transit stops
- Street tree canopy
- Subsurface infiltration and storage
- Movable planters

## 4. Organization by Street Typologies

• No - Examples provided for one specific street only

#### **5. Document Status**

Unknown

## 6. Implementation Strategies and Recommendations

Not addressed

## 7. Operations and Maintenance

Not addressed

## 8. Cold Climate Guidance

Not discussed

#### 9. Lessons Learned

Not discussed

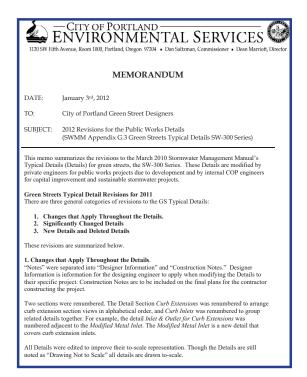
## **10. Other Comments**

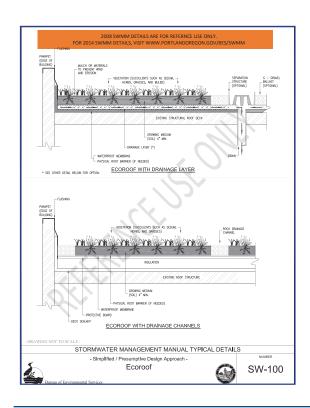
• N/A



# City of Portland - Revisions to 2012 Public Works Details 2012

## City of Portland Environmental Services





#### 1. Level of Guidance

Specific construction details

## 2. Range of Green Street Objectives Addressed

- Stormwater management
- Urban forest
- Reduced urban heat island effect

#### 3. Types of LID / Green Street Alternatives Recommended and Rationale

- Ecoroof
- Permeable pavement
- Swale
- Stormwater planter
- Basin
- Overflow configuration
- Filter strip
- Dry well
- Soakage trench
- Sand filter
- Subsurface sand filter
- Street tree
- Curb extensions
- Curb inlets
- Metal inlets
- Channel and grate
- Rock check dam
- Wood check dam
- Concrete check dam
- Overflow drain
- Oil water separators

## 4. Organization by Street Typologies

• No

#### **5. Document Status**

Approved for reference only

## 6. Implementation Strategies and Recommendations

Reference use only

## 7. Operations and Maintenance

Not addressed

#### 8. Cold Climate Guidance

Not discussed

#### 9. Lessons Learned

Not discussed

#### 10. Other Comments

• Excellent compendium of technical details



## The Chicago Green Alley Handbook 2010

City of Chicago Department of Transportation



Technique I:
Alley Drainage Improvement through Proper Alley
Pitching and Grading

Miley surface is properly
pichods and graded to direct
substitute the coult of the substitute of the substitu



## 1. Level of Guidance

- High level guideline document that is focussed on alley and laneway retrofits
- Provides illustrative examples of various application

## 2. Range of Green Street Objectives Addressed

- Stormwater management
- Reduced urban heat island effect
- Dark sky compliant lighting

## 3. Types of LID / Green Street Alternatives Recommended and Rationale

- Permeable pavement
- High reflectivity surfaces
- Tree planting
- Green roofs on garages

## 4. Organization by Street Typologies

Laneways only

## 5. Document Status

- Approved
- Communication tool for property owners

## 6. Implementation Strategies and Recommendations

- Provides implementaion
- Sets out range of costs

## 7. Operations and Maintenance

Not addressed

## 8. Cold Climate Guidance

Not discussed

#### 9. Lessons Learned

Not discussed

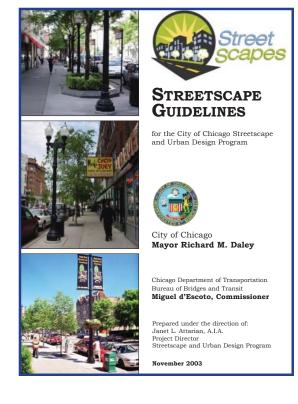
#### 10. Other Comments

• N/A



Streetscape Guidelines for the City of Chicago Streetscape and Urban Design Program 2003

City of Chicago Department of Transportation
Bureau of Bridges and Transit





#### 1. Level of Guidance

- "Streetscape" oriented guide with an emphasis on sidewalks, beautification
- Provides "Tool for Community Involvement"
- High level of detail related to curbs, tree grates, etc

## 2. Range of Green Street Objectives Addressed

- Walkability
- Urban forest

## 3. Types of LID / Green Street Alternatives Recommended and Rationale

- Sidewalks
- Bikeways
- Urban forest

## 4. Organization by Street Typologies

- Dissects streetscape into components
- Defines and describes streetscape elements
- Defines pedestrian "Level of Service" (LOS)

## **5. Document Status**

- Approved
- Companion document: Green Alley Handbook

## 6. Implementation Strategies and Recommendations

- Sets out guidelines for implementation and review process
- Sets out recommended design process
- Identifies funding sources

## 7. Operations and Maintenance

• Recognizes the need for "post construction" maintenance

**G26** 

## 8. Cold Climate Guidance

Not discussed

#### 9. Lessons Learned

Not discussed

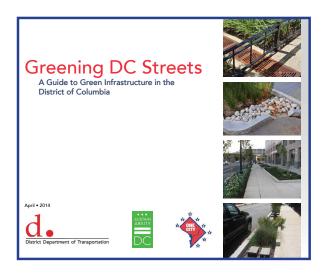
#### **10. Other Comments**

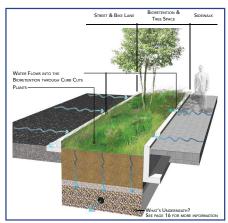
N/A

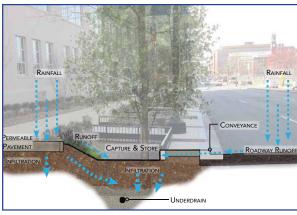
Greening DC Streets - A Guide to Green Infrastructure in the District of Columbia April 2014

District Department of Transportation Sustainability D.C.

One City







#### 1. Level of Guidance

- General principles and objectives
- Examples of LID types discussed / illustrated
- Schematic / illustrative details provided
- · Fact sheets included
- Provides design examples

## 2. Range of Green Street Objectives Addressed

- Stormwater management
- Urban forest

## 3. Types of LID / Green Street Alternatives Recommended and Rationale

- Bioretention (rain gardens)
- Street trees
- Landscape areas
- Permeable pavement
- Removing unnecessary pavement
- Bioretention:
  - Planters
  - Curb extensions
  - Bioswales
- Tree planting:
  - Structural soils
  - Soil cells
  - Suspended sidewalk

## 4. Organization by Street Typologies

• No

#### 5. Document Status

- Approved
- To be used in conjunction with:
  - DDOT Design and Engineering Manuals
  - DDOT: Standard drawings
  - DDOT: Standard specifications for highways and structures
- Green infrastructure plant list
- Green infrastructure maintenance schedule

## **6. Implementation Strategies and Recommendations**

• Sets out regulatory approval requirements

## 7. Operations and Maintenance

- General recommendations provided
- Matrix with basic maintenance requirement provided

#### 8. Cold Climate Guidance

Not discussed

#### 9. Lessons Learned

Not discussed

#### **10. Other Comments**

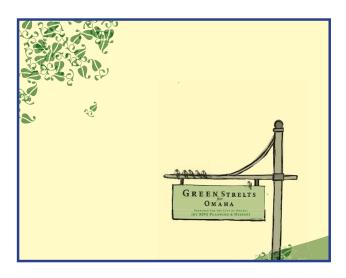
 Provides calculation of land area encompassed by road rights-of-way (26% of total land area)

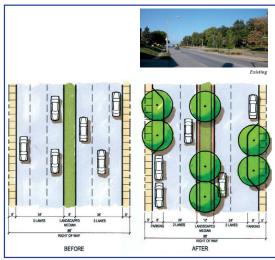


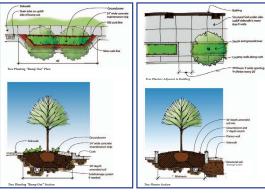
Green Streets for Omaha 2007

Green Streets for Omaha Project Sponsor City of Omaha Parks, Recreation, and Public Property

Green Streets for Omaha Task Force







#### 1. Level of Guidance

- General
- A compendium of examples of "Green" streets in the city with a description of their characteristics
- Provides a catalogue of "Green Street" prototypes
- Includes "retrofit" concept
- Provides retrofit case studies
- Document is more focussed on urban design than function
- · Provides schematic details

## 2. Range of Green Street Objectives Addressed

- Improve traffic safety
- Increased property values
- Increased pedestrian and bicycle access
- Better stormwater management
- Upgrade development
- Better image and community marketing

#### 3. Types of LID / Green Street Alternatives Recommended and Rationale

- Trails
- Medians
- Sidewalks
- Drainage swales
- Ornamental plantings
- Bike lanes
- Planting details (schematic for):
  - Standard boulevard planting
  - Root path
  - Structural soil
  - Tree planters
  - Trees in medians
- Provides tree species list

## 4. Organization by Street Typologies

- Defines a set of street typologies
- Major arterial
- Minor arterial
- Special arterial
- Collector
  - Conveyance
- Street car avenue
- Neighbourhood
- Main street
- Boulevards and parkways
- Local streets
- Provides classification for "Green Streets"

#### **5. Document Status**

- Approved
- To be used in conjunction with:
- Omaha Streetscape Handbook
- Urban Design Handbook for Omaha

#### 6. Implementation Strategies and Recommendations

- Unknown
- Sets out implementation priorities by street name based on a ranking system
- Provides recommendations for funding for capital and maintenance
- Provides cost estimates on a "per mile" basis for new and retrofit projects

**G28** 

#### 7. Operations and Maintenance

• Short section on maintenance aimed primarily at tree plantings

## 8. Cold Climate Guidance

Not discussed

#### 9. Lessons Learned

Not discussed

#### 10. Other Comments

N/A



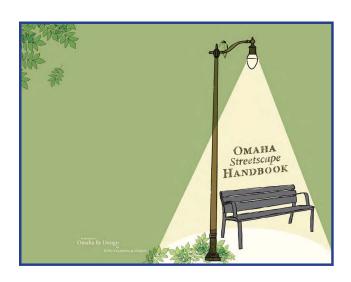


Omaha Streetscape Handbook 2008

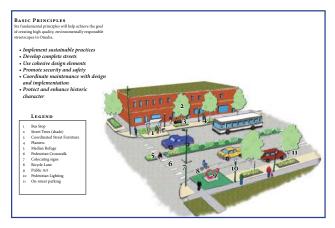
City of Omaha

American Society of Landscape Architects American Institute of Architects American Society of Civil Engineers

American Planning Association Omaha Public Power District Nebraska Department of Roads







#### 1. Level of Guidance

- Establishes principles of streetscape design
- Presents examples in various contexts
- Establishes performance guidelines

## 2. Range of Green Street Objectives Addressed

- Stormwater management
- Sustainable materials
- Lighting and dark skies
- Landscaping and urban heat island

## 3. Types of LID / Green Street Alternatives Recommended and Rationale

- Bioswales
- Pervious paving
- Rain gardens
- Rain barrels
- Renewable materials sources
- Local materials
- Recycled content
- Dark sky compliant lighting
- Tree planting
- Reflective paving and roofing materials

## 4. Organization by Street Typologies

Provides specific street type examples

#### 5. Document Status

- Approved
- To be used in conjunction with:
  - Green Street Master Plan
  - Suburban Parks Master Plan
  - City of Omaha Public Works Standard Plates
  - Downtown Wayfinding Plan
  - Public Art Commission Guidelines
  - Urban Design Element of the Comprehensive Plan

## 6. Implementation Strategies and Recommendations

- Unknown
- No implementation recommendations provided

## 7. Operations and Maintenance

- · Addresses security and safety
- · Coordinates maintenance with design

#### 8. Cold Climate Guidance

Not discussed

#### 9. Lessons Learned

Not discussed

#### **10. Other Comments**

Sets out performance standards for each streetscape component





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