Integrating Green Infrastructure in Constrained Urban Sites

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Waterfront Toronto

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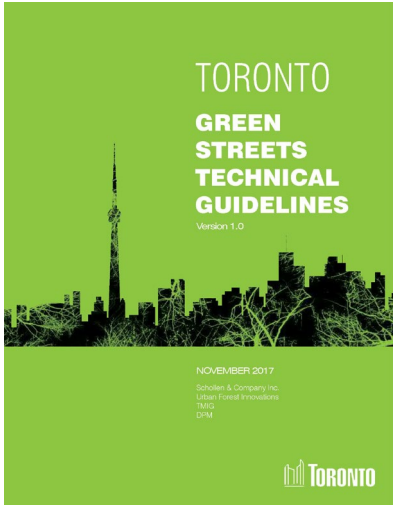
Integrating Green Infrastructure in Constrained Urban Sites

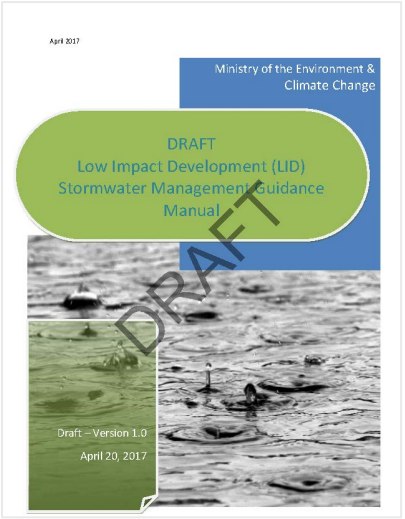
1. Policy Frameworks
2. Opportunities for Green Infrastructure Integration
3. Urban and Waterfront Constraints
4. Waterfront Street Projects:
   - Lake Shore Public Realm Pilot Project - *retrofit*
   - Queens Quay East & Waterfront East LRT Extension – *retrofit & new build*
   - Cherry St. & the Port Lands Roads – *new build*
5. Strategies & Questions for Further Research

Green Infrastructure Policy Frameworks

Managing stormwater through Green Infrastructure and Nature-Based Solutions is becoming increasingly integrated into policy, but difficult to implement in practice.

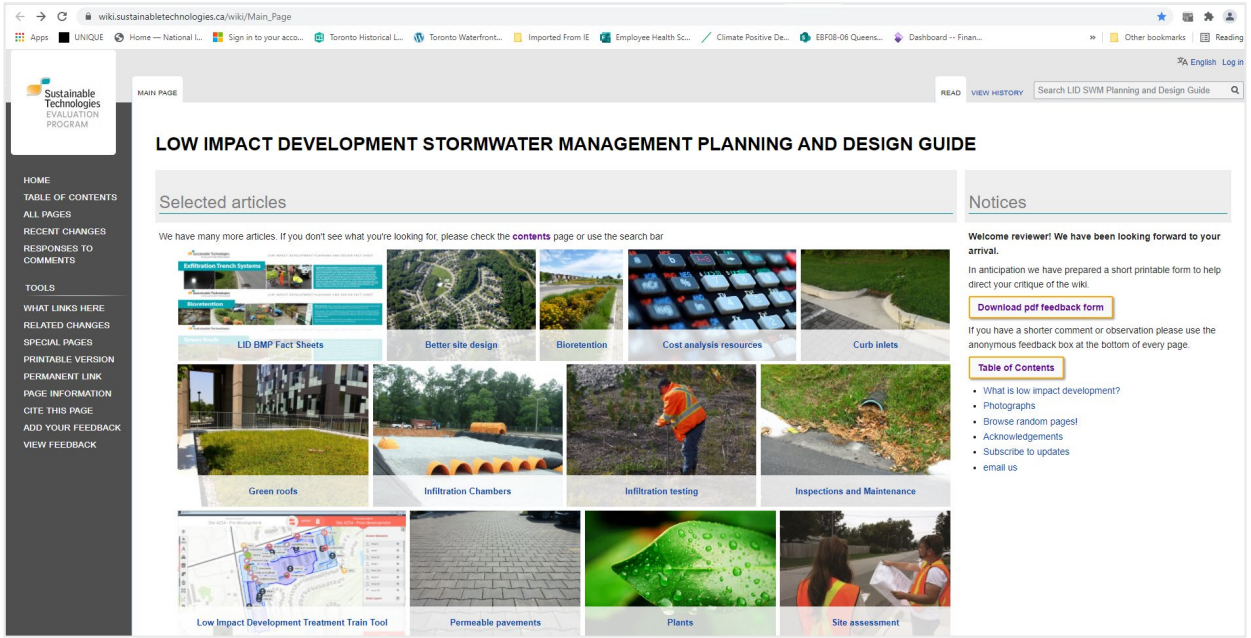
- Green Streets Technical Guidelines & Standards
- Toronto Green Standard v3
- Wet Weather Flow Masterplan
- MOE SWM Guidelines





Green Infrastructure & LID Guidance Resources

There is no shortage of resources and guidance for Green Infrastructure freely available.



Green Infrastructure Standards

We finally even have approved standards in Toronto for GI.

Construction Specifications and Drawings for Green Infrastructure

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Green Infrastructure Field Inspection Forms +

Green Infrastructure Specifications +

Green Infrastructure Drawings −

Individual Drawings

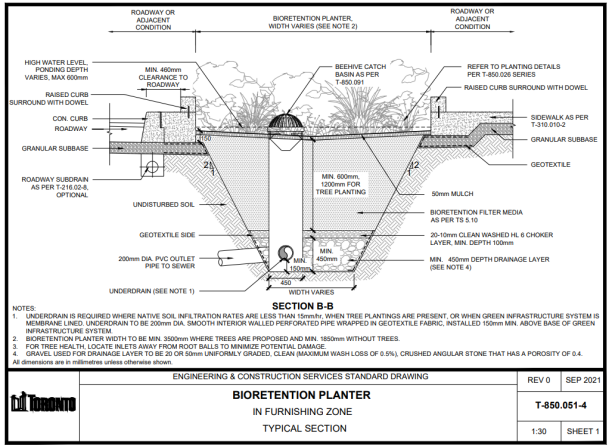
Drawing No.	Drawing Title	Revision Date
T-850.026-1	Planting Details – Tree Planting Details	Sep 2021
T-850.026-2	Planting Details – Shrub and Herbaceous Planting Details	Sep 2021
T-850.026-3	Planting Details – Recommended Plant List – Tree Plant Palette	Sep 2021
T-850.026-4	Planting Details – Recommended Plant List – Dry-Sunny Plant Palette	Sep 2021
T-850.026-5	Planting Details – Recommended Plant List – Shady-Moist Plant Palette	Sep 2021
T-850.026-6	Planting Details – Recommended Plant List – Urban Plant Palette	Sep 2021
T-850.026-7	Planting Details – Recommended Plant List – Suburban Plant Palette	Sep 2021
T-850.026-8	Planting Details – Recommended Plant List – Bioretention Plant Palette	Sep 2021
T-850.026-9	Planting Details – Sample Layout Plans – Typical Planting Height Zones	Sep 2021
T-850.026-10	Planting Details – Sample Layout Plans – Dry-Sunny 1	Sep 2021
T-850.026-11	Planting Details – Sample Layout Plans – Dry-Sunny 2	Sep 2021

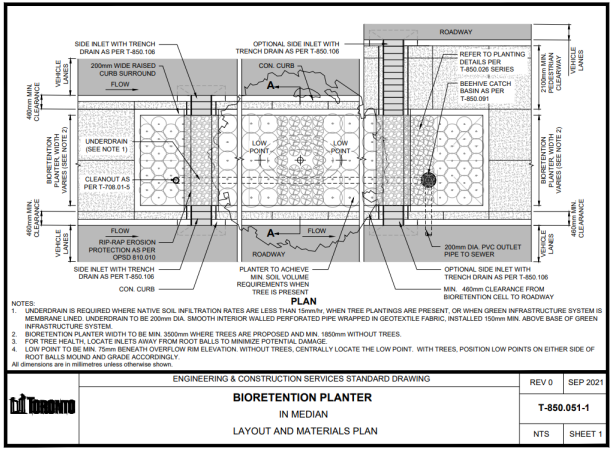
In This Section

- **Standards for Designing and Constructing City Infrastructure** −
  - Archived Construction Specifications
  - Archived Drawings
  - Archived Revision Information Sheets
  - Capital Construction Signage
  - **Construction Specifications and Drawings for Green Infrastructure**
  - Construction Specifications and Drawings for Road Works
  - Construction Specifications and Drawings for Sewers and Watermains
  - Construction Specifications and Drawings for Traffic Control Devices
  - Development Infrastructure Policy & Standards (DIPS)

Contact Information

Robert Klimas, P.Eng., Senior Engineer, Business Improvement & Standards



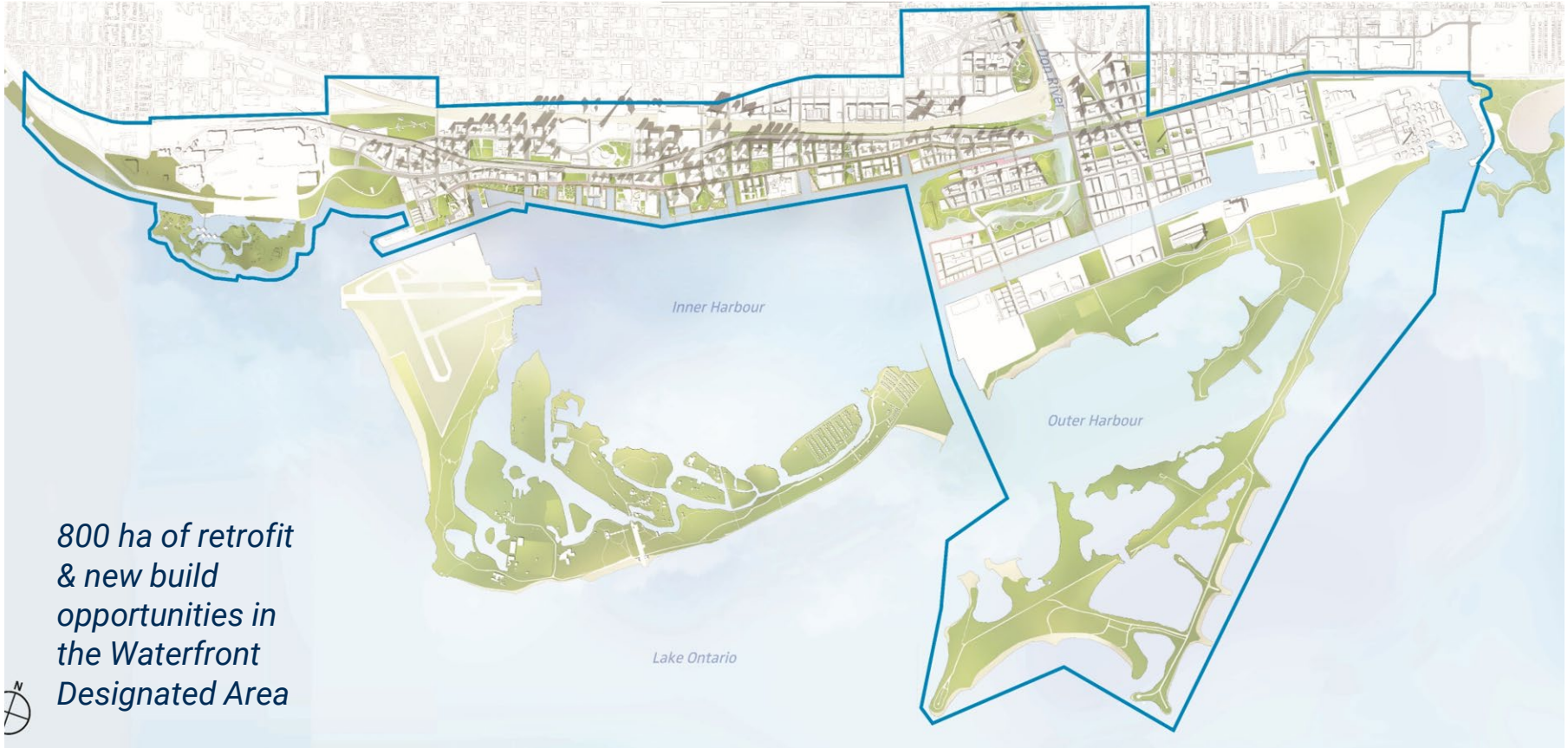


Waterfront Toronto Policy Frameworks

Waterfront Toronto's mandate to build sustainable communities leading with landscape is well aligned with the objective to integrate nature-based solutions in the public realm.

- Resilience and Innovation Framework for Sustainability
- Minimum Green Building Requirements (MGBRs) V3, aligned with TGS Tier 3

Opportunity for Green Infrastructure Integration



800 ha of retrofit & new build opportunities in the Waterfront Designated Area

The Opportunity

300+ hectares of new infrastructure and development will be built on the eastern waterfront and the Port Lands in the next few decades.

Will it continue business as usual or integrate green infrastructure and nature based solutions?

Why isn’t there more GI implemented in the public realm? What are the barriers?

City of Toronto Constraints:

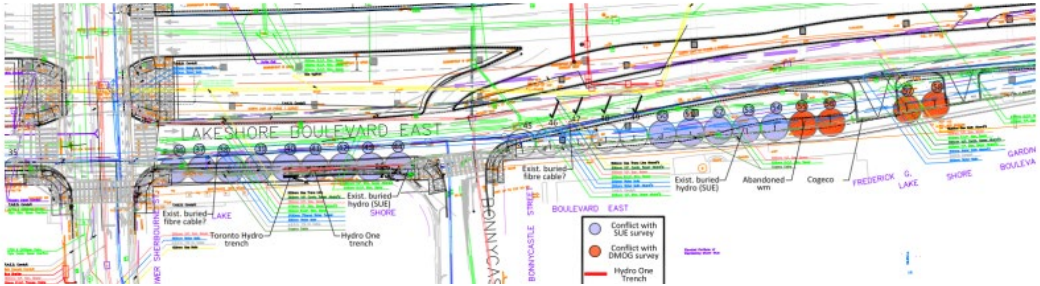
- Densely packed utilities
- Strict Standards for road and transit ROWs
- Heavy Salting in Winter
- Unclear maintenance responsibilities for planting and GI in ROW

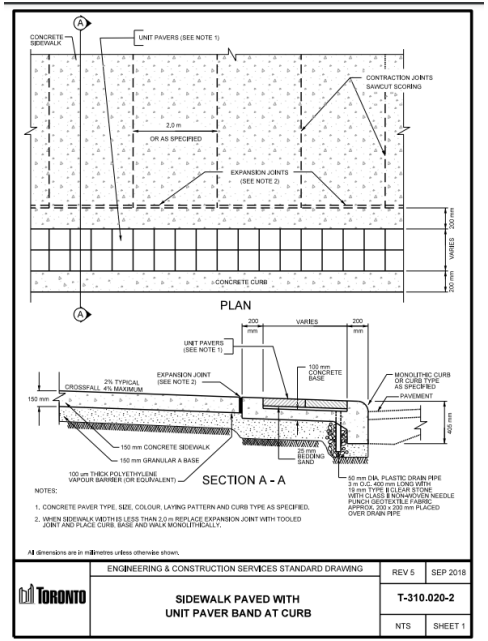
Waterfront Constraints

- High & variable groundwater
- Variable lake levels
- Contaminated soils and groundwater
- Stormwater flooding due to widespread hardscape

Urban Challenges

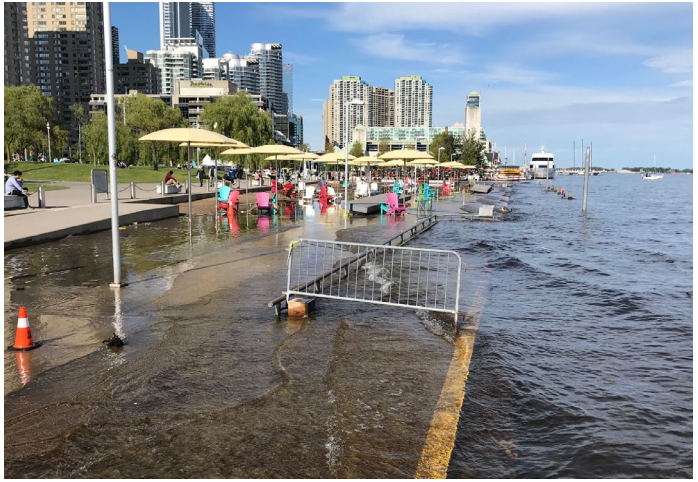
- Densely packed utilities
- Strict Standards for road and transit ROWs
- Heavy Salting in Winter
- Unclear maintenance responsibilities for planting and GI in ROW

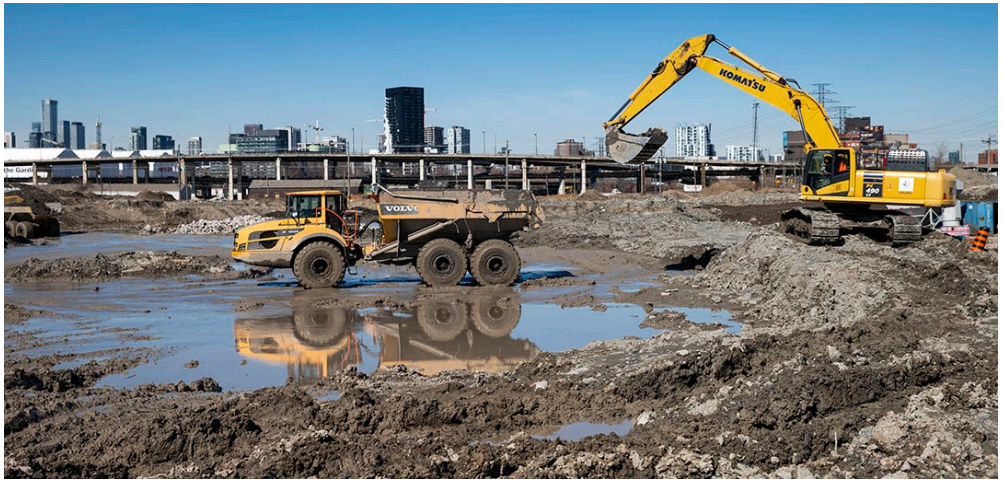




Additional Waterfront Challenges

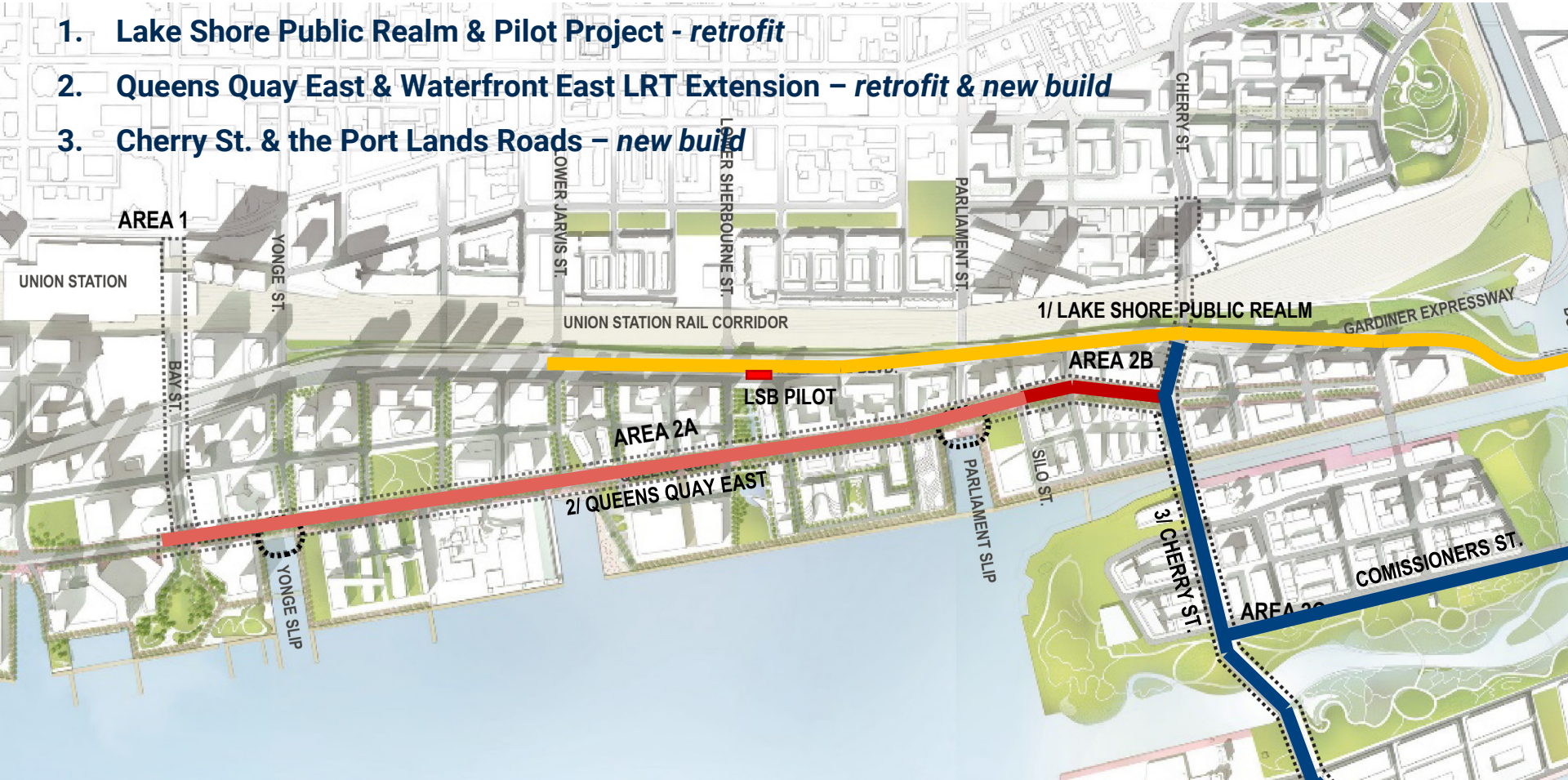
- Variable lake level and flooding
- High and variable groundwater
- Stormwater flooding due to widespread hardscape
- Soil and groundwater contamination due to previous industrial uses



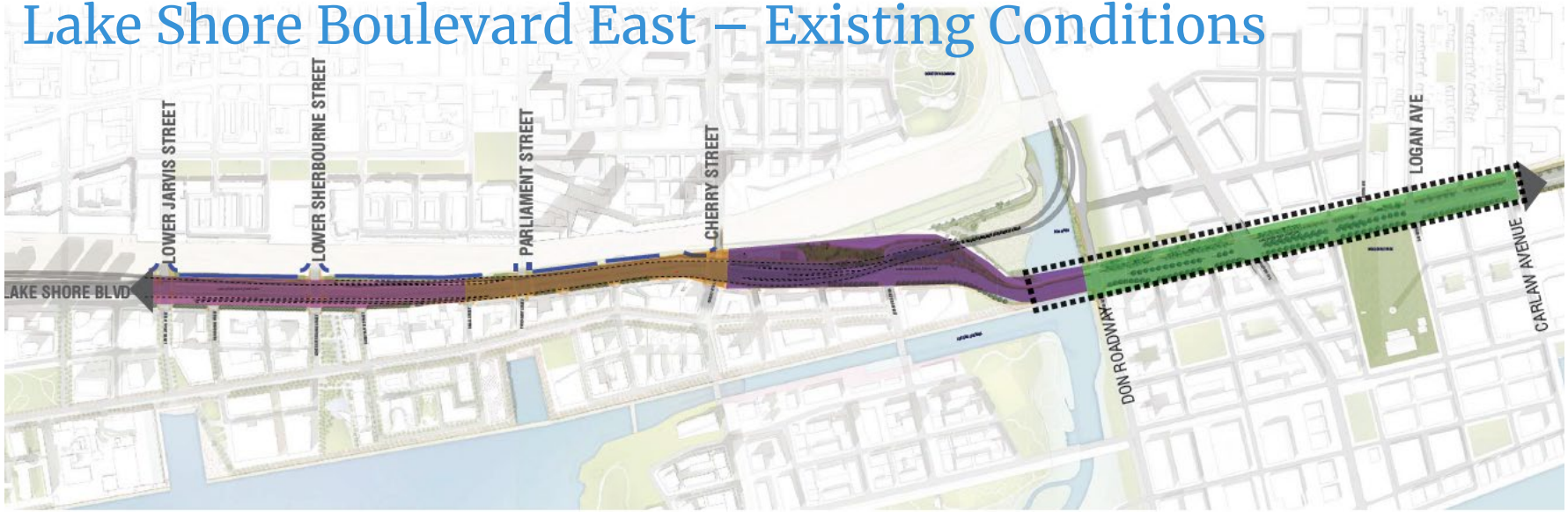


Waterfront Streetscape & Transit Projects

1. **Lake Shore Public Realm & Pilot Project - *retrofit***
2. **Queens Quay East & Waterfront East LRT Extension – *retrofit & new build***
3. **Cherry St. & the Port Lands Roads – *new build***



Lake Shore Boulevard East – Existing Conditions



ZONE 1 - GRITTY
JARVIS STREET TO BONNYCASTLE

ZONE 2 - NARROW
BONNYCASTLE TO CHERRY

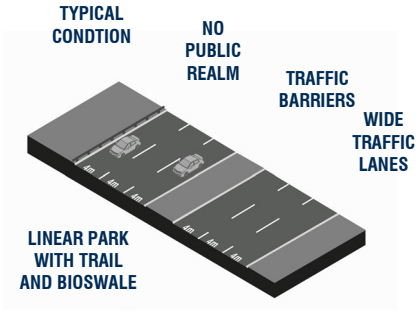
ZONE 3 - INFRASTRUCTURAL/NATURAL
CHERRY TO DON ROADWAY

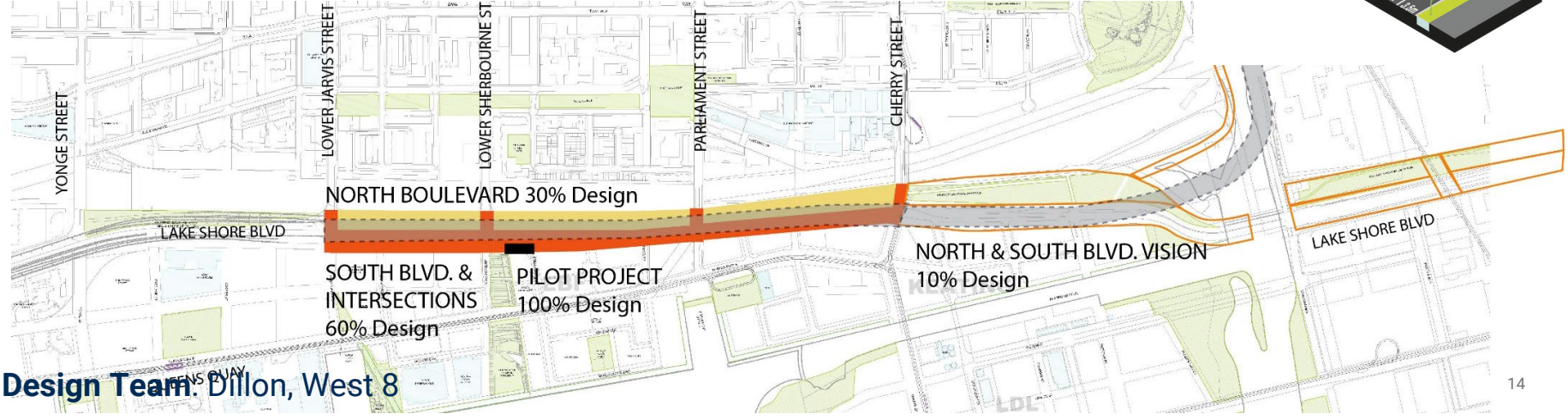
ZONE 4 - URBAN
DON ROADWAY TO CARLAW AVENUE

Gardiner & Lake Shore Blvd. East Public Realm

SOUTH SIDEWALK & BIORETENTION PLANTER

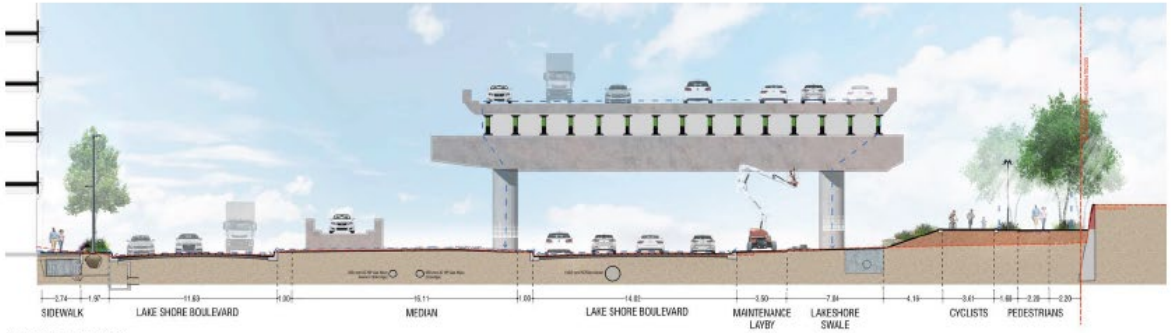
NORTH LANDSCAPED TRAILS & BIOSWALE



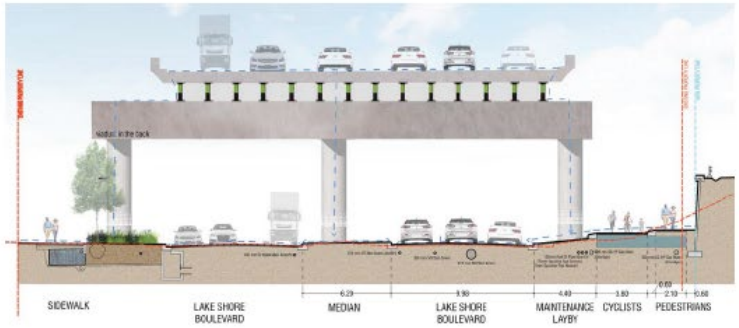


Design Team: Dillon, West 8

Gardiner & Lake Shore Public Realm – Typical Sections



ZONE 1 - GRITTY
JARVIS STREET TO BONNYCASTLE



ZONE 2 - NARROW
BONNYCASTLE TO CHERRY

ZONE 3 - INFRASTRUCTURAL/NATURAL
CHERRY TO DON ROADWAY

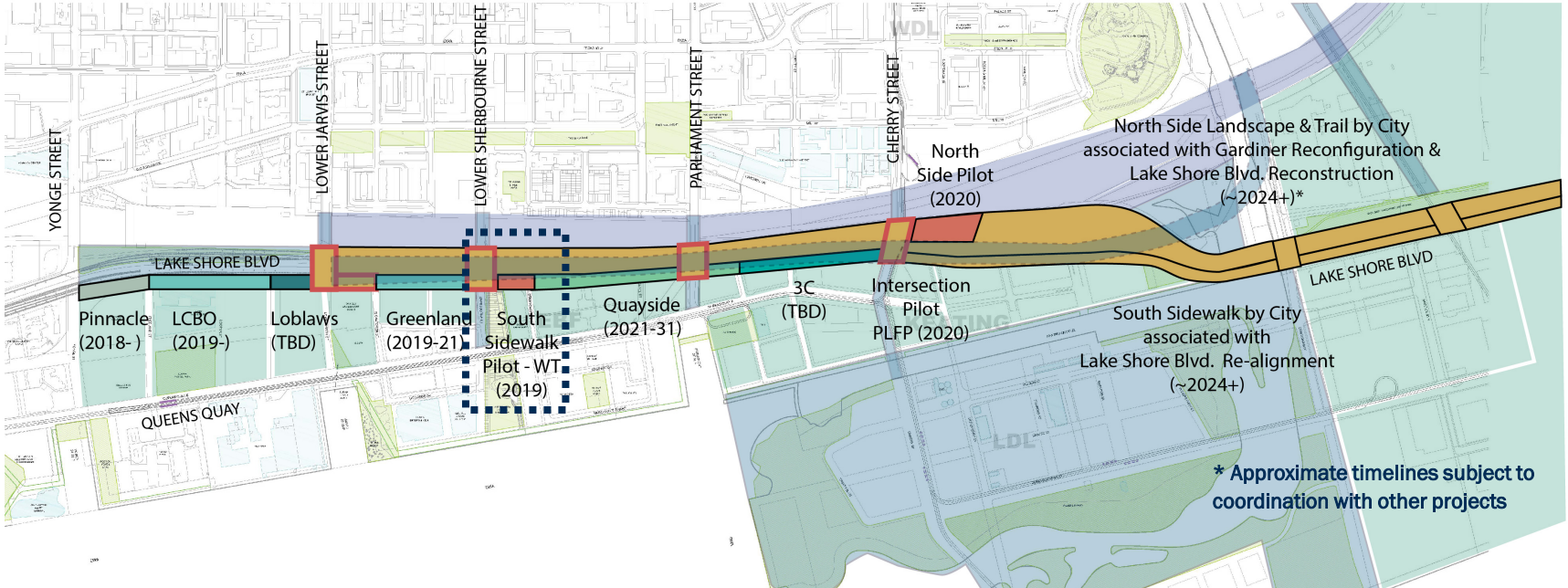
5

Design Team: Dillon, West 8

Phasing & Implementation Strategy

LEGEND

- Design Deliverable (DELIVERY AGENT)
- Linear Park & Streetscape Master Plan (BY CITY)
- Quick Start Intersection Guidelines & Ultimate Intersections Design (BY CITY)
- Pilot Projects 100% Design (BY CITY / WT)
- Design Guidelines (BY VARIOUS DEVELOPERS)
- Metrolinx Projects
- City / WT Infrastructure Projects
- Private Development



South Sidewalk Design Guidelines

SPECIES DIVERSITY AND SALT TOLERANCE

Mid-block Trees
Shade and disease tolerant Elm varieties

Ulmus americana “Homestead”
Ulmus japonica x Wilsoniana “Morton”
Ulmus americana “Princeton”
Ulmus americana “Valley Forge”

Diversity at Intersections
Tulip Trees and Oaks

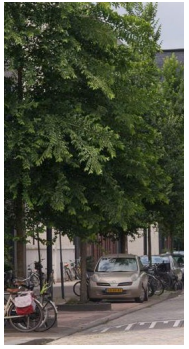
Liriodendron tulipfera
Quercus bicolor
Acer rubrum

Groundcover planting
Salt and shade tolerant perennial species

Astilbe chinensis “Visions in White” (Chinese astilbe)
Astilbe “Delft Lace” (Delft Lace astilbe)
Euribia macrophyllus (native aster)
Solidago flexicaulis (goldenrod)
Deschapsia cespitosa (tufted hair grass)

Permeable concrete unit pavers

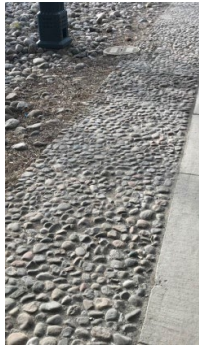
Climate resilient planting



Granite curbs along south side developments

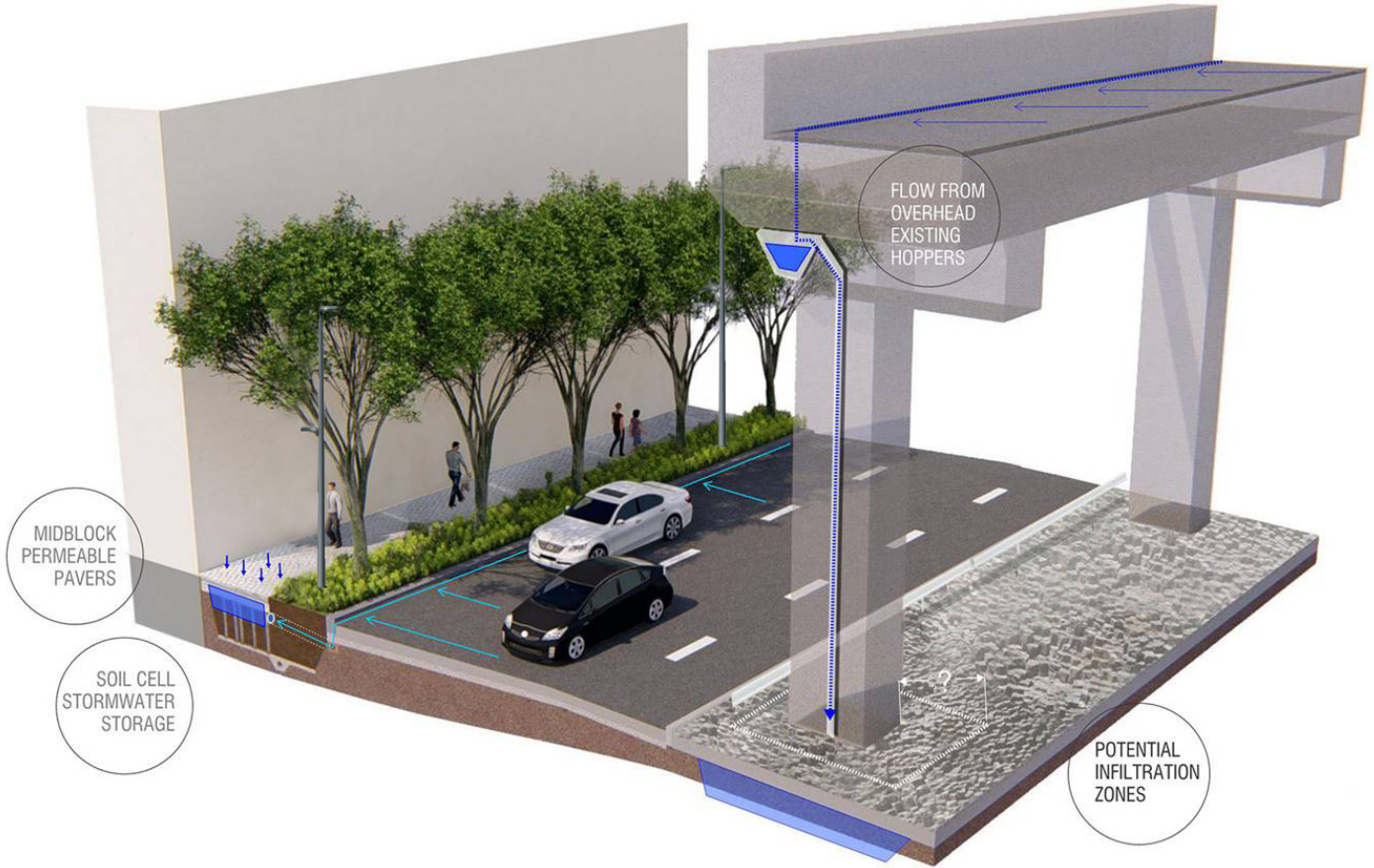
Typical concrete curbs on medians

Stabilized stone as median edge



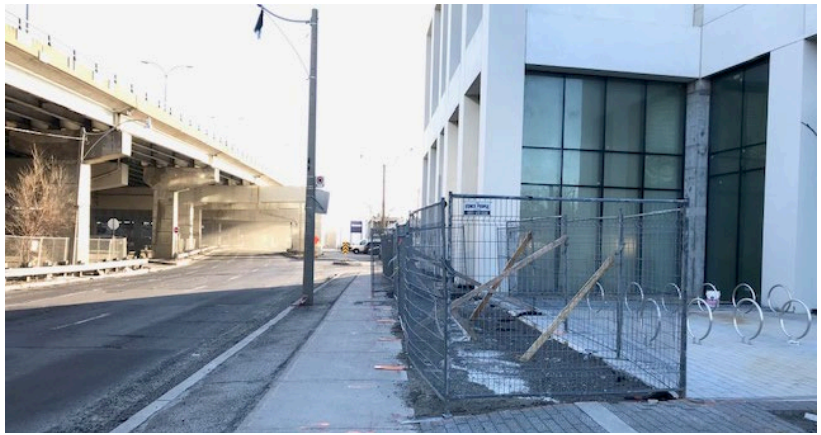
Rough Natural Stone Aggregate 2-4cm Dia. and 10-20cm Dia

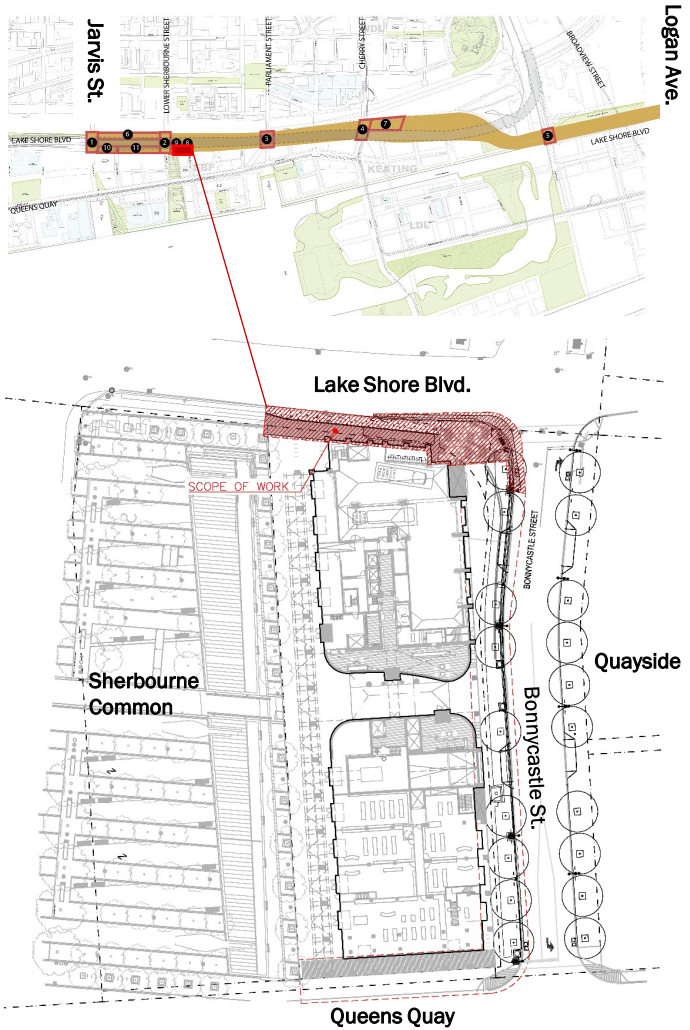
Stormwater Management through Green Infrastructure



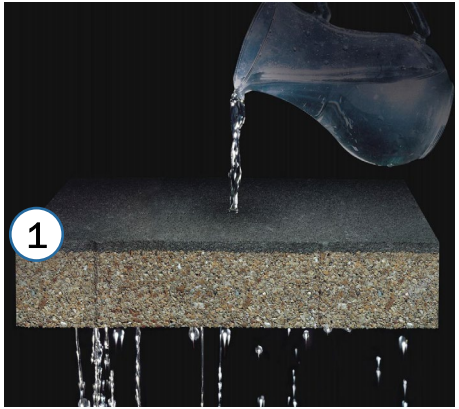
Lake Shore Public Realm Pilot Project

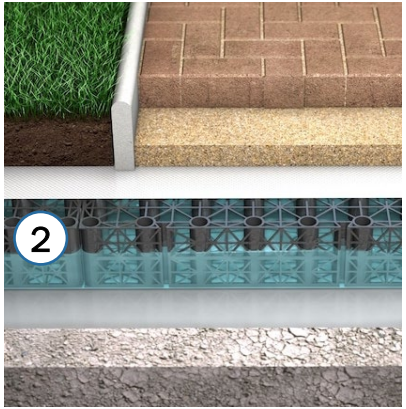
- In partnership with City of Toronto Green Streets, we are **conducting a pilot project** to **test innovative materials** that can achieve low-impact development (LID) design standards.
- The goal of this pilot project is to evaluate how well these materials improve the **sustainability of our street plantings** and **management of stormwater.**
- The results will inform the detailed design of Lake Shore Boulevard East corridor and the City's Green Street standards.





Testing New Non-Standard Materials & Innovations in SWM





1. **HydroPavers – Permeable unit pavers** made of recycled ceramics

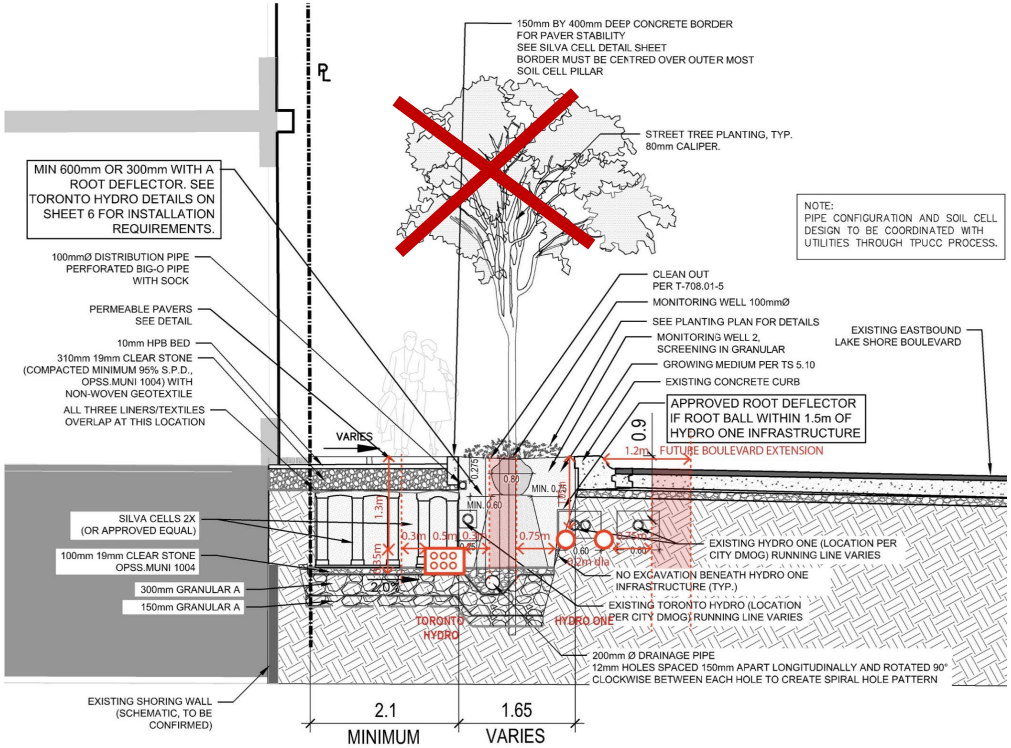
2. **Permavoid sub-base** to store stormwater for passive irrigation of planting

3. **Sandblasted and sawcut concrete** with exposed granite aggregate

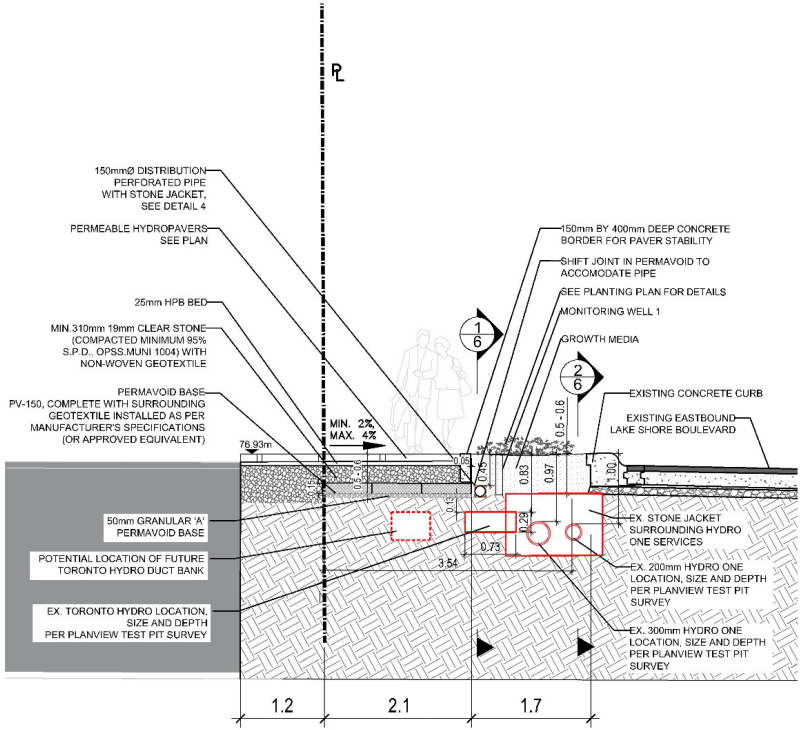
4. **Salt-remediating plants** – *Armeria maritima* (sea thrift) to take up winter salt out of the soil

*The project will be **monitored by TRCA Sustainable Technologies Evaluation Program** to evaluate:*
- *stormwater retention and quality improvements*
- *health and reduced maintenance of roadside plantings irrigated with stormwater*
- *performance of non-standard permeable pavers and base*

Utility Constraints & Required Offsets



Original South Sidewalk Design



Adapted South Sidewalk Pilot Design

Lake Shore Public Realm Pilot Project

LAKE SHORE BOULEVARD EAST
SOUTH SIDE PILOT
Existing Planting Palette

Zig-Zag Goldenrod
Salt tolerance : Tolerant
Light : Sun and part-shade

Big Leafed Aster
Salt tolerance : Tolerant
Light : Sun and part-shade

Tufted Hair Grass
Salt tolerance : Tolerant
Light : Sun and part-shade and shade

Lindley's aster
Salt tolerance : ?
Light : Sun and part-shade

Delft Lace Astilbe
Salt tolerance : Intolerant
Light : Small sun, shade and heavy shade

Chinese Astilbe (White)
Salt tolerance : Intolerant
Light : Small sun, shade and heavy shade

Liriope muscari
Salt tolerance : Tolerant
Light : Sun and part-shade

+

Salt Remediation Plants
Halophytes

Sea Lavender
Limonium vulgare

X

NOT AVAILABLE IN ONTARIO

Sea Thrift
Armeria maritima

Site Photos – Construction




Summer to Fall 2020

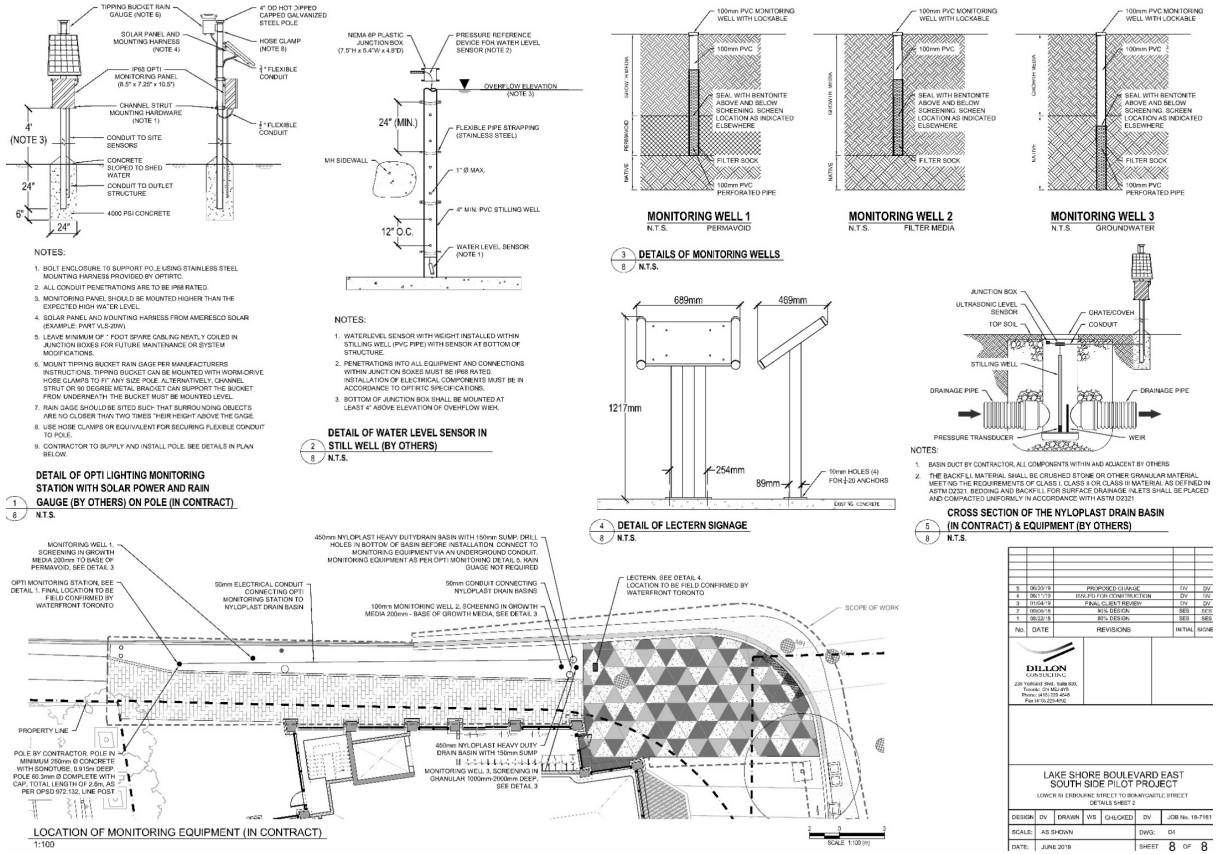
Lake Shore Boulevard Public Realm Pilot Project

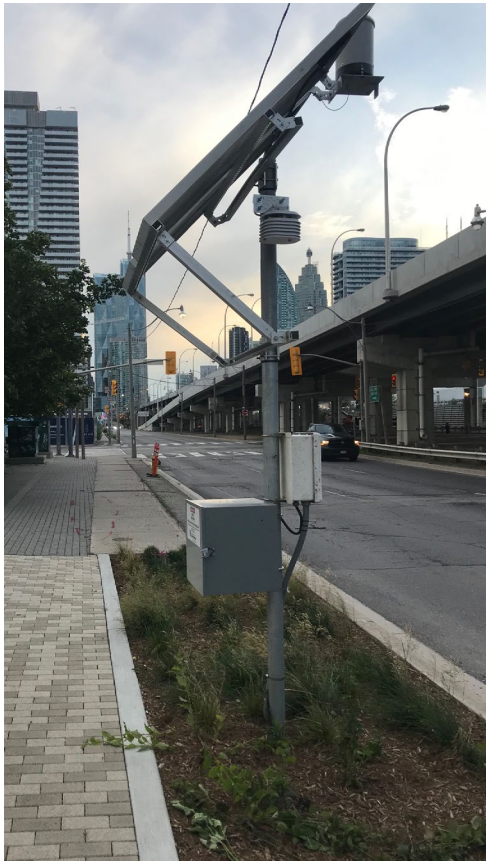
Lake Shore Pilot Project at 12 Bonnycastle St. was completed in Sep. 2020.

Improvements include:

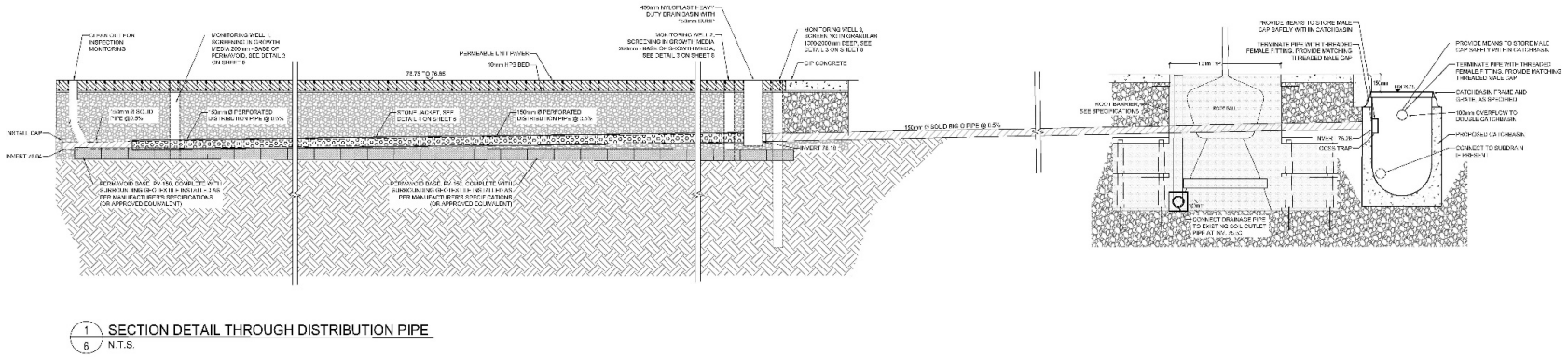
- Bioretention planting with stormwater passive irrigation
- Permeable paver and base sidewalk
- Exposed aggregate concrete with sawcut pattern at intersection corner

TRCA STEP Monitoring & Problem-Solving

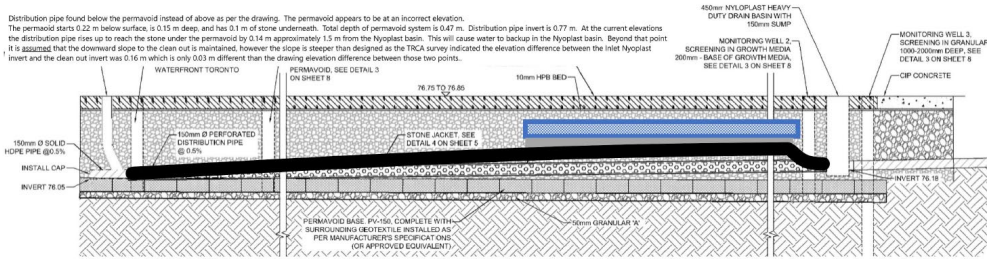




TRCA STEP Monitoring & Problem-Solving



1 SECTION DETAIL THROUGH DISTRIBUTION PIPE
6 N.T.S.



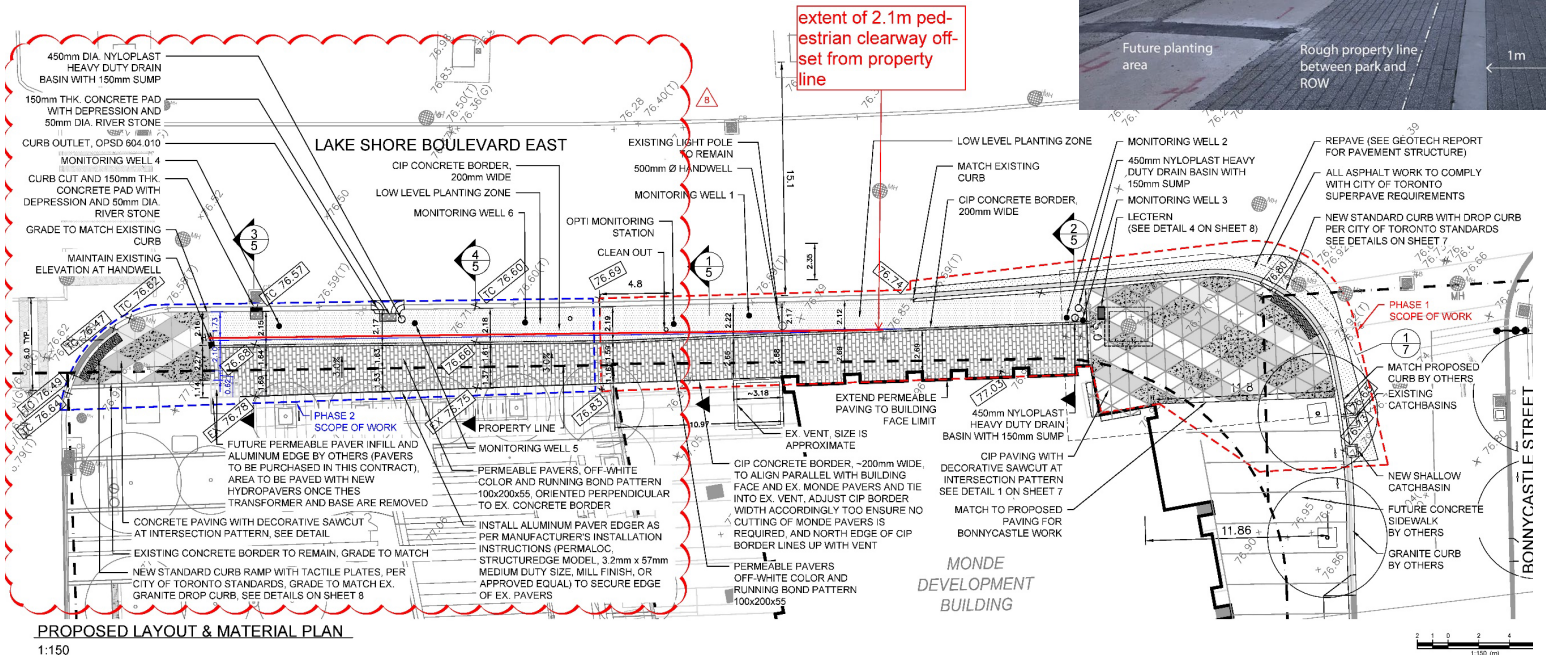
Pipes were not installed per the design slopes due to utility obstructions, so the system was not functioning properly to distribute water to the biorentention planter.

TRCA STEP Monitoring & Problem-Solving

Next Steps

Lake Shore Public Realm Pilot **Phase 2** will test:

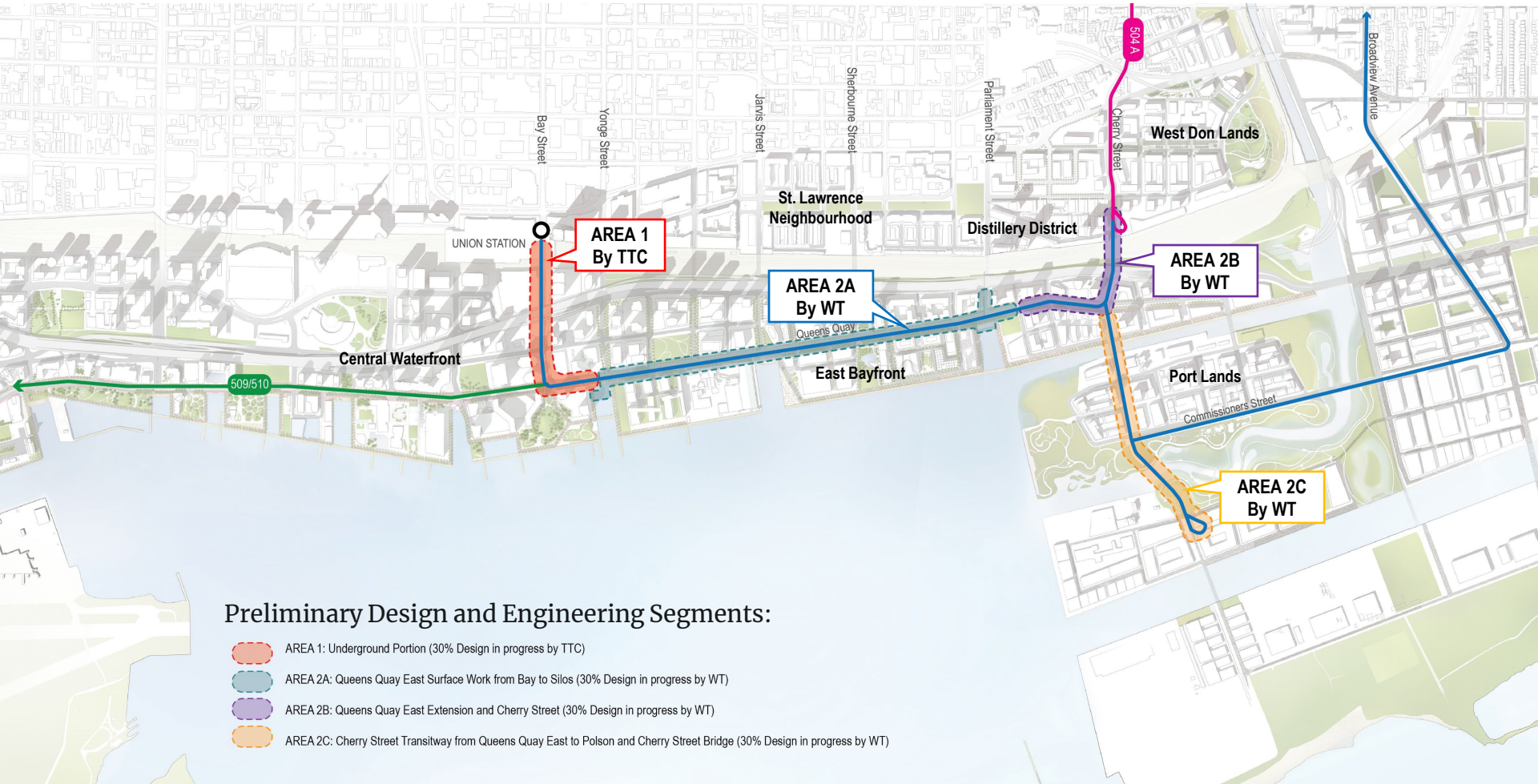
- Hydropavers on granular base
- Surface curb cut inlets instead of
- Different soil spec. and revised planting



Lake Shore East of River – Under Construction

Design Team: Entuitive, West 8, Planning Partnership, Planmac

2/ Waterfront East LRT : Queens Quay East and Cherry St.



Preliminary Design and Engineering Segments:

- AREA 1: Underground Portion (30% Design in progress by TTC)
- AREA 2A: Queens Quay East Surface Work from Bay to Silos (30% Design in progress by WT)
- AREA 2B: Queens Quay East Extension and Cherry Street (30% Design in progress by WT)
- AREA 2C: Cherry Street Transitway from Queens Quay East to Polson and Cherry Street Bridge (30% Design in progress by WT)

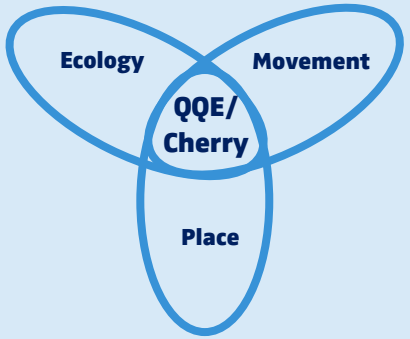
Design Brief for Queens Quay East

Vision

Queens Quay is Toronto's **primary lakefront boulevard** connecting its existing and emerging precincts, parks and public spaces and **establishing a strong cohesive character across the waterfront**. Building on the successful revitalization of the western section, Queens Quay East will further integrate **urban ecology, active transportation, and place-making** to create a street that is resilient to future change.

Core Objectives:

1. Integrating with Urban Ecology
2. Moving People
3. Building a Destination



Design Brief for Queens Quay East

1/ Integrating with Urban Ecology: Design for **ecological performance**

- Expanded tree canopy and planting
- Integrated green infrastructure
- More permeable ground surface
- Enhanced user comfort
- Habitat and eco-corridors for biodiversity
- Resilient species selection for waterfront
- Customized details for variable lake levels
- Low-maintenance landscape
- Monitoring and adaptive maintenance

2/ Moving People: Design for **safety, convenience and flexibility**

- Improve clarity at intersections
- Improve pedestrian crossings
- Safe intermodal interactions
- More convenient cycling environment
- Accommodate new micro-mobility
- Flexibility to accommodate new trends
- Performance review & adaptive management

3/ Building a Destination: Design for **character and experience**

- Continuity of design language with QQW
- Greater coherence of paving materials
- Durable materials and craftsmanship
- Slips and intersections as destinations
- Flexibility for closures & programming
- Consistent palette of furniture, lighting, etc.
- Integrated infrastructure for programming
- Encourage social interaction

Queens Quay West

Design Team: West 8/DTAH JV, Arup, WSP

Queens Quay East at East Bayfront

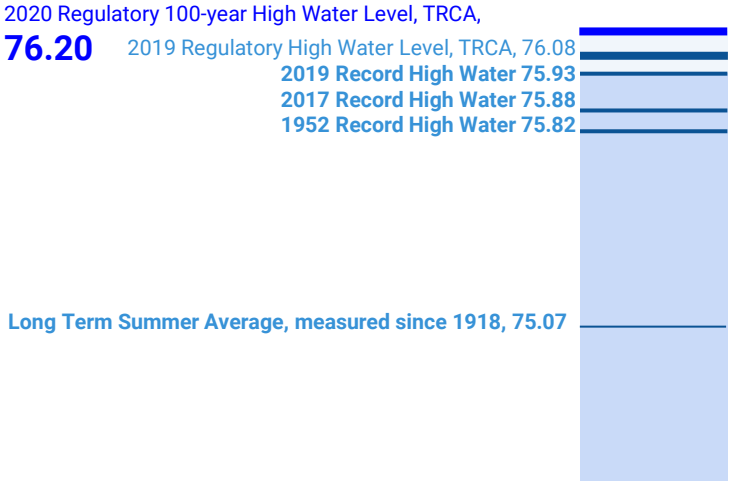
Design Team: West 8/DTAH JV, Arup, WSP

Waterfront East LRT **Area 2A** – Queens Quay East and Cherry St.

Waterfront Challenges: High Lake Level

Challenges

- Low grades in relation to High Lake level and susceptibility to high groundwater
- Utilities
- Transit standards
- Public Realm Standards



Lake Ontario: Two record high water events in last four years

Growing Healthy Trees vs. Stormwater Management

Growing Healthy Trees – Diversity

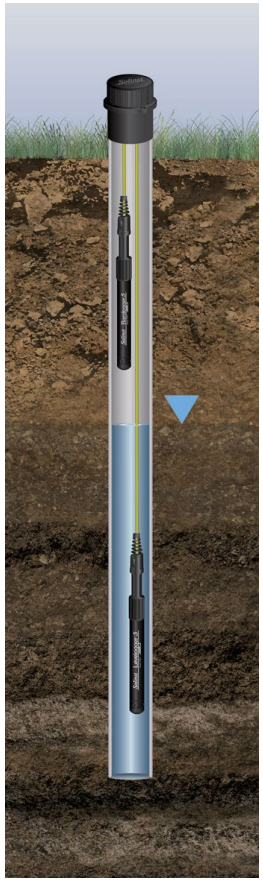
BROADLEAF TYPOLOGY

FINELY TEXTURED TYPOLOGY

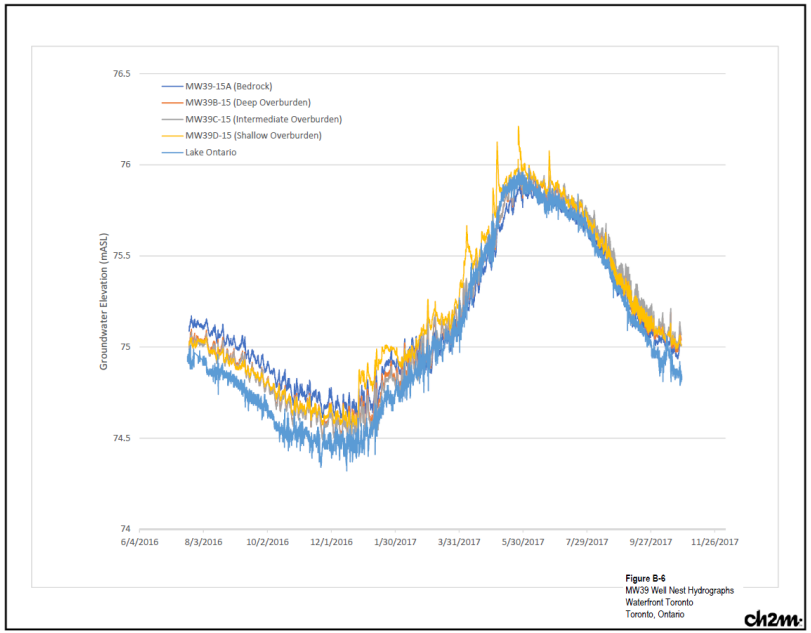
YONGE SLIP

Sample Planting Plan - Bay to Yonge

Active Groundwater Monitoring & Adaptive Management

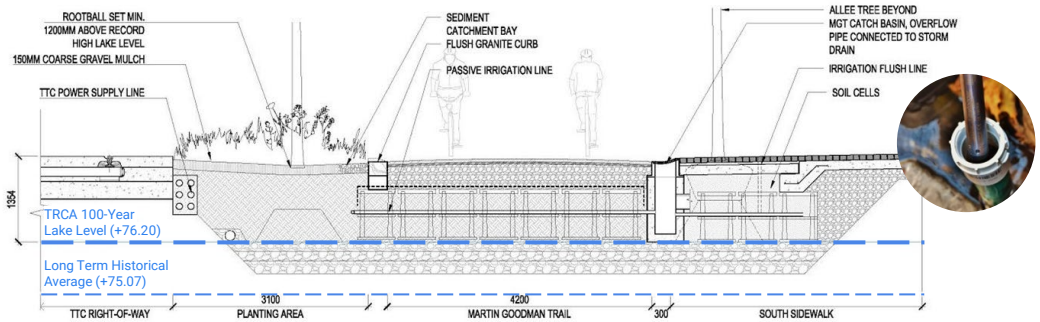


WT will install six shallow groundwater monitoring wells with groundwater dataloggers to monitor correlation of groundwater to fluctuating lake levels, and to inform groundwater benchmarks for green infrastructure and grading design.



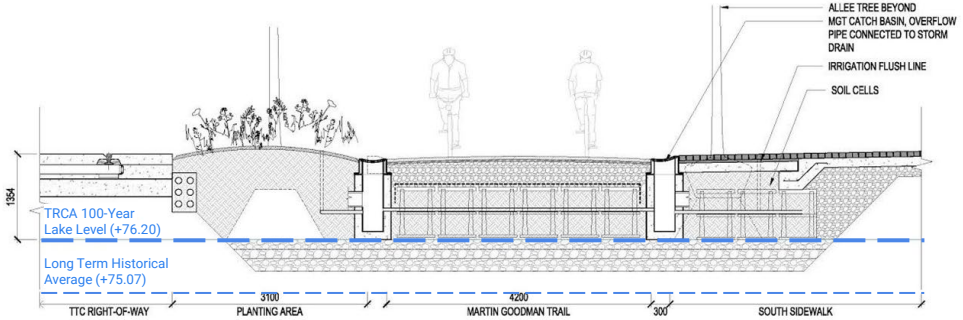
Green Infrastructure Design to be Informed by Monitoring

Stormwater management and planting concepts to be revisited at Detailed Design with outcome of groundwater monitoring program



Option 1: Bioswale, Perennial and Stormwater Focused

Green to Grey, Sheffield



Option 2: Raised Beds, Tree focused

Buffalo Niagara Campus

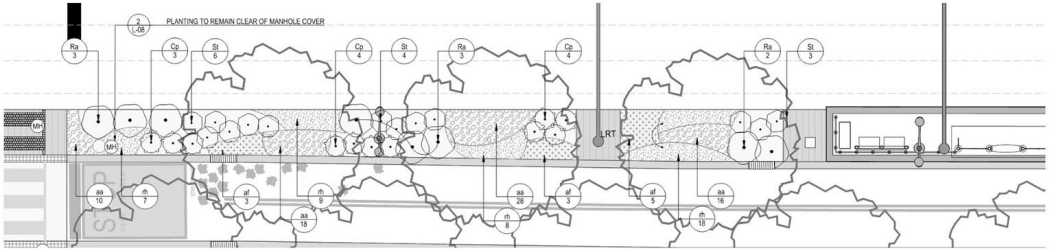
Planting Pilot in Queens Quay West

to be Constructed next year

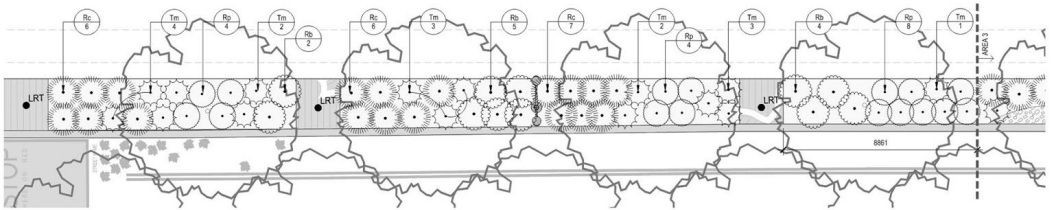
PLANT LIST

SHRUBS	CODE	BOTANICAL NAME	COMMON NAME
	Cp	Ceanothus x pallidus `Marie Simon`	Marie Simon New Jersey Tea
	Ra	Rhus aromatica `Gro-Lo`	Fragrant Sumac
	Rb	Rosa blanda	Smooth Rose
	Rc	Rosa carolina	Carolina Rose
	Rp	Rosa palustris	Swamp Rose
	St	Spiraea tomentosa	Steeplebush
	Tm	Taxus x media `Wardii`	Ward Yew

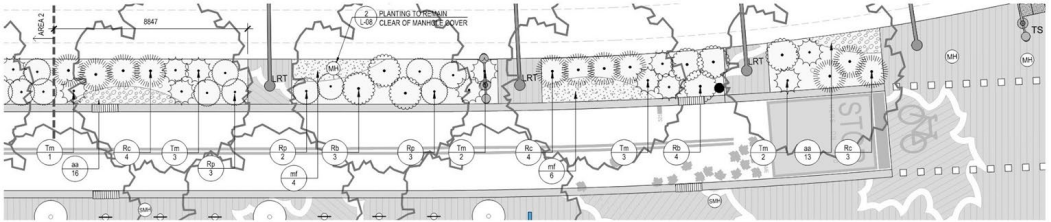
PERENNIALS	CODE	BOTANICAL NAME	COMMON NAME
	af	Agastache foeniculum `Blue Fortune`	Anise Hyssop
	aa	Aruncus aethusifolius	Dwarf Goat`s Bean
	mf	Monarda fistulosa	Bergamot
	rh	Rudbeckia hirta `Cherry Brandy`	Cherry Brandy Gloriosa Daisy



1 AREA 1 PLANTING PILOT - POLLINATOR PALETTE



2 AREA 2 PLANTING PILOT - BIRD BIOTOPE PALETTE



3 AREA 3 PLANTING PILOT - HYBRID PALETTE

Waterfront East LRT **Area 2B – Queens Quay East**

The Fight for Space: Emergency, fire, car lanes, laybys, bus replacement service, BRT phasing scenarios

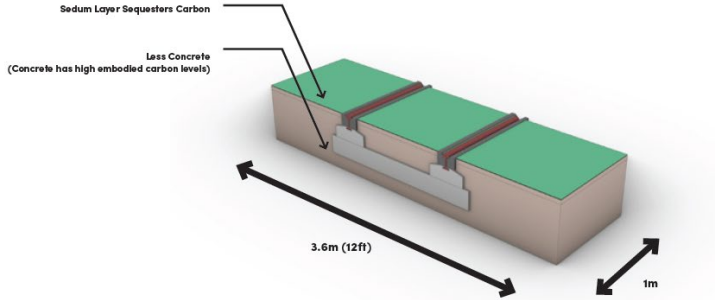
Design Team: Stantec & Public Work

Greening the Transitway: green track

Water Capture and Drainage

Extensive vegetation systems: retain 50% of precipitation

Green Track Embodied Carbon



Approximately 2,200 tonnes less embedded carbon than traditional concrete track

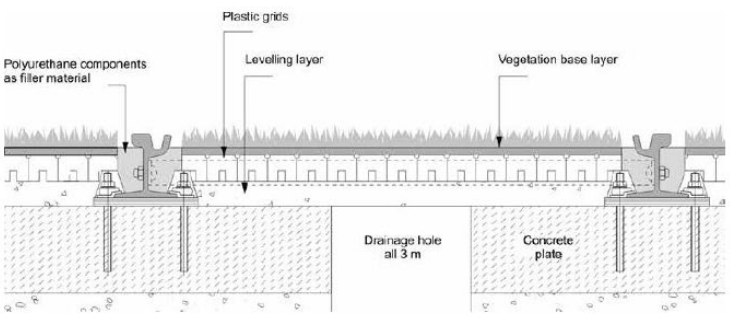


Image: Cross section of an accessible Grass Track using a plastic grass grid system

Research by Public Work

Waterfront East LRT **Area 2B/C** – Cherry St.

Port Lands Flood Protection Roads Team: WSP & DTAH

Waterfront LRT Team: Stantec & Public Work

Port Lands Roads

Team: WSP, DTAH

Port Lands Roads

Green Infrastructure Types

Challenges & Adaptations :

- High variable groundwater at low points – resilient tree species, no soil cells etc.
- Phasing with BRT, then no BRT, then no GI on east side – deferred to future phase

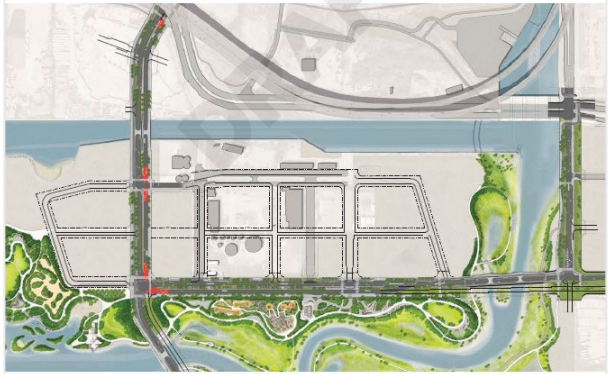
LANDSCAPE TYPES	
Enhanced Grass Swale	• Vegetated open channels with trees, shrubs and herbaceous planting • Located in narrow medians ranging from 2.0m to 2.7m wide
Bioswale	• Vegetated open channels with trees, shrubs and herbaceous planting • Located in medians and boulevards that exceeds 3.0m in width
Open Planter	• Open planter with trees, shrubs and herbaceous planting • Soil cell system under pavement to: - provide adequate planting soil volume - support planter structure - support pavement above planting soil volume
Open Planter with Subsurface Passive Irrigation	• Similar to Open Planter noted above • Additional rainwater catchment into a catchbasin and distributed to planting soil under pavement
Treed Boulevard	• Typical City standard boulevard with short-medium native grass & forbs planting.
Temporary Landscape	• Planted with tall shrubs and herbaceous planting where future development is anticipated

Maintenance Manual– Cherry St. & PLFP Roads

PORT LANDS FLOOD PROTECTION AND ENABLING INFRASTRUCTURE (PLFPEI)

GREEN INFRASTRUCTURE
OPERATION + MAINTENANCE MANUAL FOR:

NEW CHERRY STREET
COMMISSIONERS STREET
DON ROADWAY



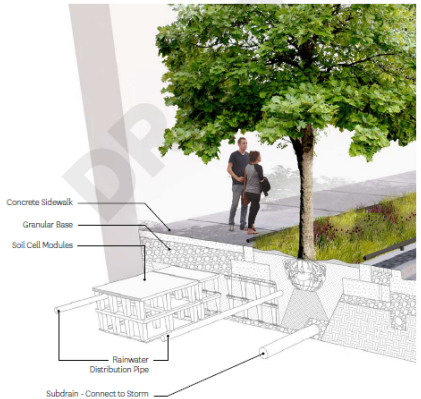
3.4 Open Planter with Soil Cells and Subsurface Passive Irrigation

Overview/Description

These open planters are similar to the previously described facility in Section 3.3 - Open Planter with Soil Cells. The difference lie in the site grading and subsurface components:

a. The facilities receive surface runoff from adjacent sidewalk and Martin Goodman Trail,
b. Surface runoff from Martin Goodman Trail is channeled and collected in a nearby catchbasin. The catchbasin is connected to a 100mmØ perforated irrigation pipe where rainwater is distributed to soils in the soil cell system,
c. They are only present on the west side of New Cherry Street between Villiers Street North and South.

Key components of open planters are: curb planter walls flush with adjacent pavements, soil cells system, filter media beds, vegetation, perforated irrigation pipe and perforated pipe subdrains.



Illustrative diagram of open planter with soil cells and subsurface passive irrigation

DRAFT

Operations and Maintenance Protocols

Perform routine maintenance tasks as outlined below.

OPEN PLANTER WITH SOIL CELLS AND SUBSURFACE PASSIVE IRRIGATION

Components	Maintenance Task	Frequency				Notes
		Bi-weekly	2x/year	1x/year	Others	
1 Filter Bed	Remove trash		X			
	Remove accumulated sediment when ≈ 50mm depth				As needed	
	Re-grade and restore cover over any animal burrows, sunken areas when ≈ 100mm depth and erosion rills when ≈ 300mm in length				As needed	
	Add wood mulch to maintain 100mm depth cover, as indicated in the detail drawings and specifications				Every 2 years	
2 Vegetation	Watering during first two months after planting	X				Modify schedule in periods of wet
	Watering for the remainder of the first two (2) growing seasons (ie. May to September) after planting or until vegetations is established				As needed	
	Watering for the remainder of the facility's lifespan				During drought conditions	Drought conditions classified by Agriculture and Agri-Food Canada's Canadian Drought Monitor as severe (D2) or higher
	Remove undesirable vegetation (eg. tree seedlings, invasives/weeds)		X			
	Replace dead/diseased plants to maintain a minimum of 80% vegetation cover			X		
	Prune shrubs and trees			X		
	Cut back spent plants			X		
	Divide or thin out overcrowded plants			X		
	Soil flushing to remove road salts			X		Perform soil flushing in early spring before buds begin to open into leaves. See the following page for additional information on soil flushing.
3 Soil Cell System					As needed	Refer to Appendix 4.3
4 Subdrain	Flush out accumulated sediment with hose or pressure washer			X		

Team: WSP, DTAH

PLFP Construction

How can we maximize ecological performance while balancing infrastructure requirements and site constraints?

Challenges:

- Densely packed utilities
- Strict Standards for road and transit ROWs
- Heavy Salting in Winter
- Unclear maintenance responsibilities for planting and GI in ROW
- High & variable groundwater
- Variable lake levels
- Contaminated soils and groundwater
- Phasing scenarios and implementation strategies

Strategies for integrating GI in constrained urban sites

- Develop shallow GI systems, maximize areas of permeable surfaces
- Select resilient, robust, and diverse tree and planting species
- Pilot new ideas and technologies to solve problems
- Monitoring & Adaptive Management
- Develop additional standards for GI - Permeability & Low Carbon
  - Permeable base & pavers
  - Permeable road bed
  - Reinforced green track
  - Low carbon, permeable concrete
  - Shallow SWM storage
  - Rules and reasonable offsets for planting around utilities
- Streamlined Process for approvals to incentivize adoption of Green Infrastructure
- Find allies and collaborate across disciplines and sectors

Questions for Further Research

- Is it worthwhile to integrate green infrastructure into difficult constrained sites despite the many obstacles?
- How do you design for resilience to the worst case scenario while not losing the opportunities of everyday conditions? – i.e. variable lake levels
- How can we maximize ecological performance while balancing all the technical requirements and standards regulating urban infrastructure and the public realm?

Questions?

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