Permeable Pavements:
Cold Climate Research

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Toronto and Region Conservation

Toronto and Region Conservation for The Living City

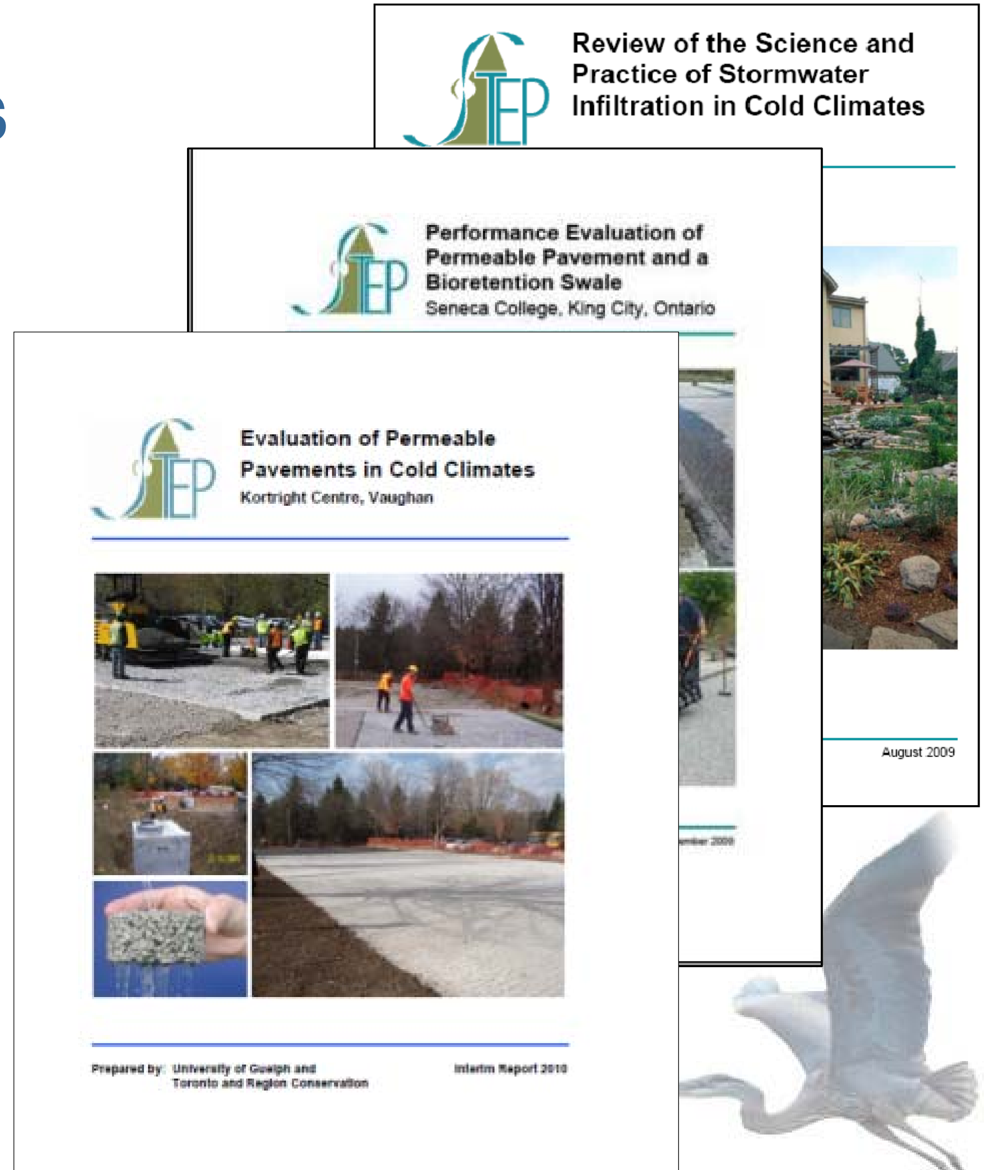
Sustainable Technologies Evaluation Program

Sustainable Technologies Evaluation Program

- Multi-agency program led by TRCA
- Main program objectives:
  - ✓ Evaluate clean water and energy technologies
  - ✓ Assess barriers/opportunities for broader adoption of technologies
  - ✓ Develop tools, guidelines and policies
  - ✓ Education, advocacy, and technology transfer
- Program web address: www.sustainabletechnologies.ca

Research Initiatives

- Performance Evaluation of Permeable Pavement and a Bioretention Swale - Seneca College, King City, Ontario
- Evaluation of Permeable Pavements in Cold Climates - Kortright Centre, Vaughan, Ontario
- Review of the Science and Practice of Stormwater Infiltration in Cold Climates



Study Objectives

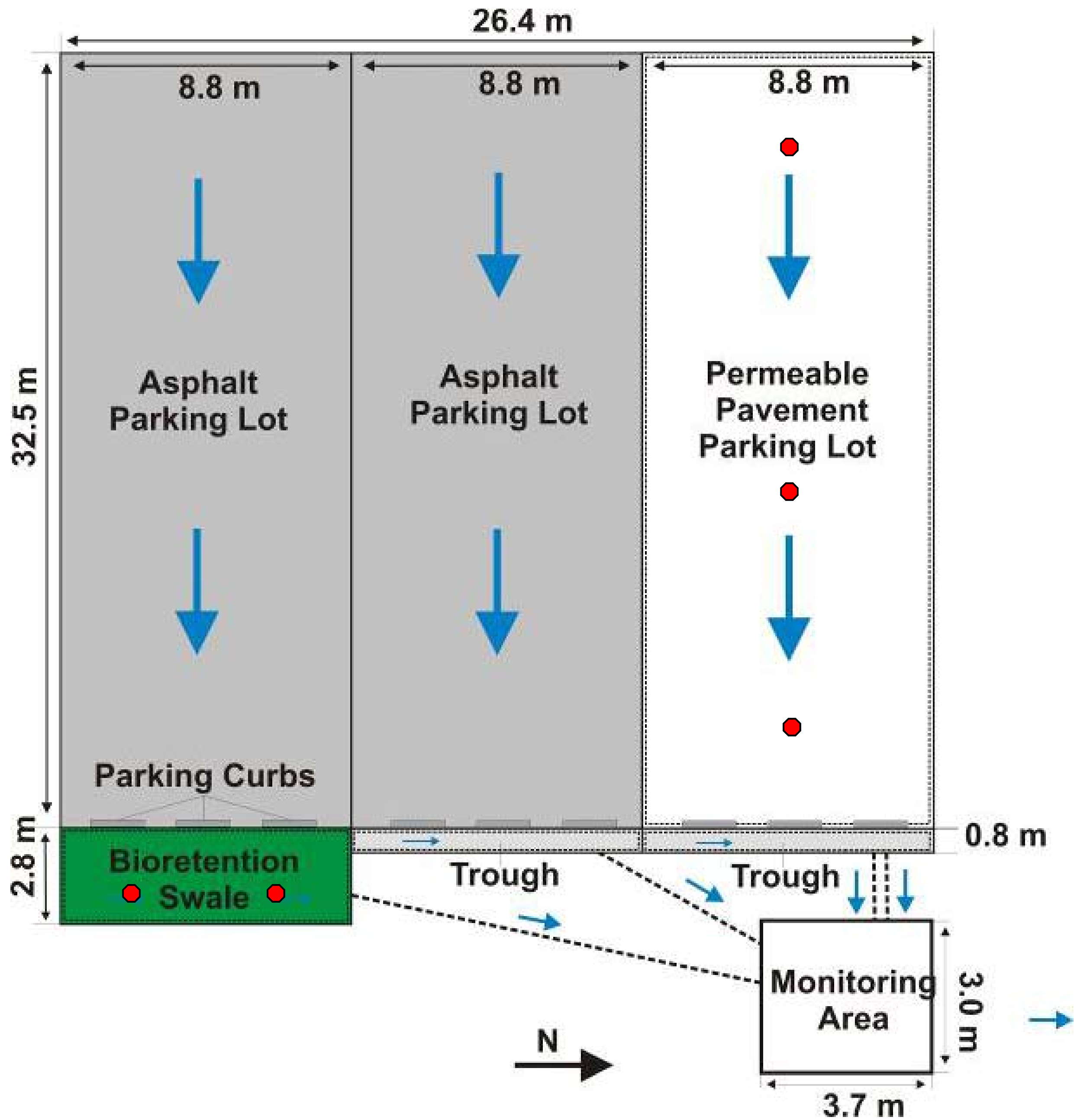
- Studies address issues related to:
  - Surface and groundwater quality
  - soil quality
  - Infiltration and clogging potential
  - Heat island effects
  - Durability
  - Cold climate issues
  - Design optimization
  - Maintenance requirements

Today's focus…

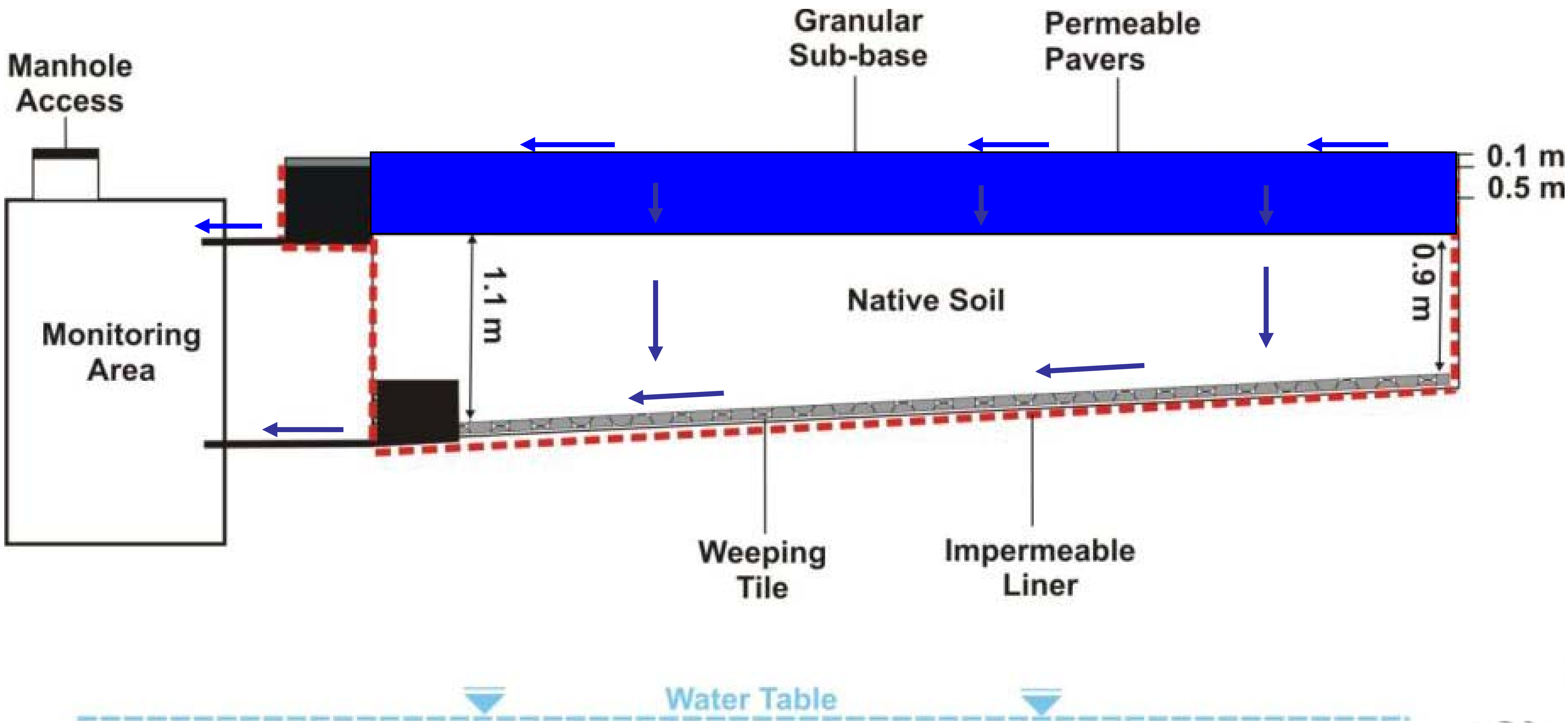
- Effectiveness of stormwater infiltration practices on tight soils
- Potential for groundwater contamination
- Potential for soil contamination

Seneca College: *Study Site*

Study Design:
Plan View

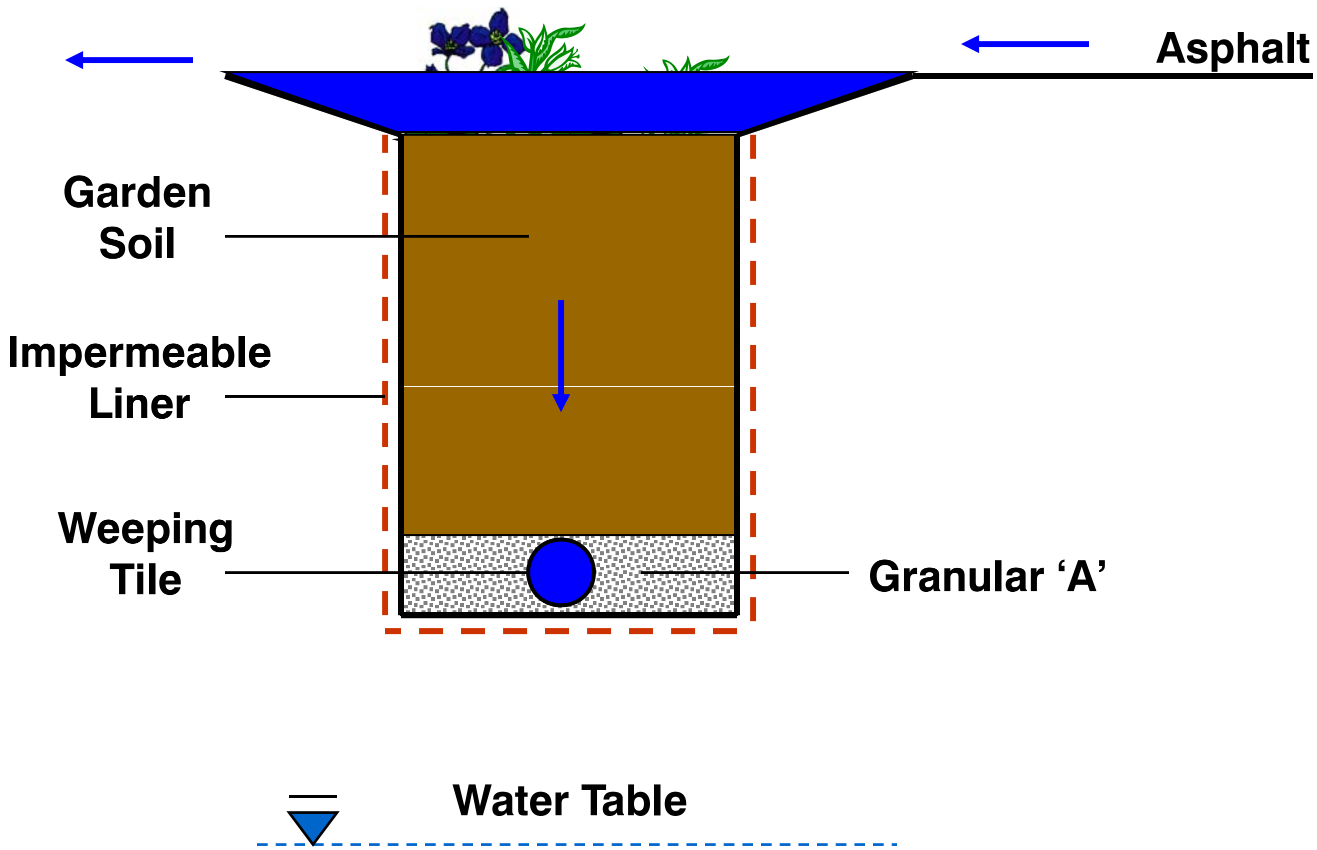


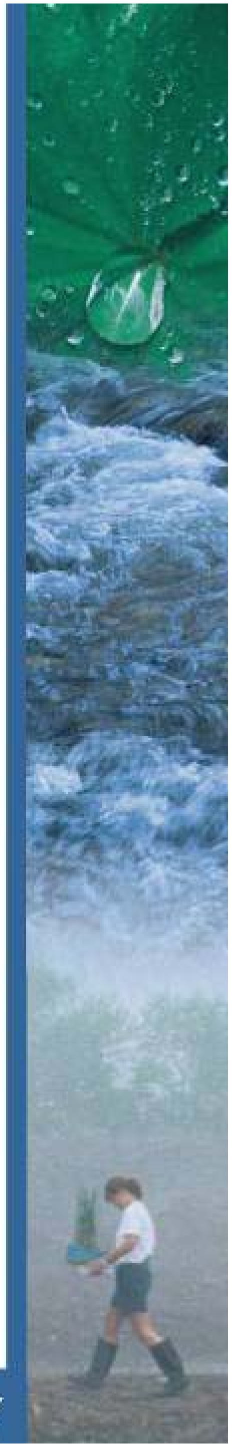
Study Design:
Permeable Pavement Profile



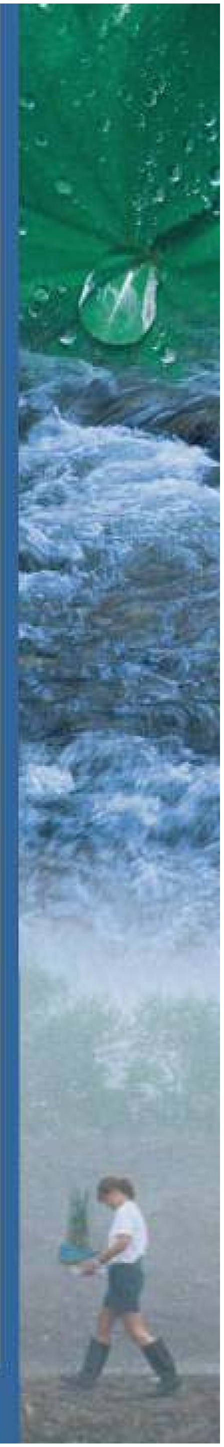
Study Design:

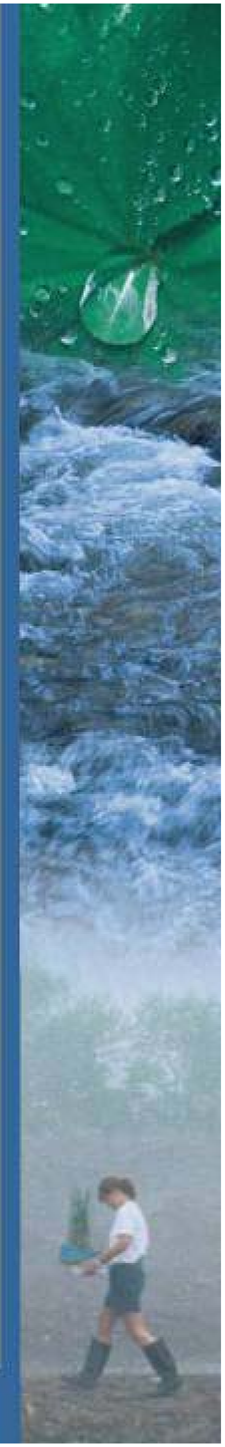
Bioswale Profile





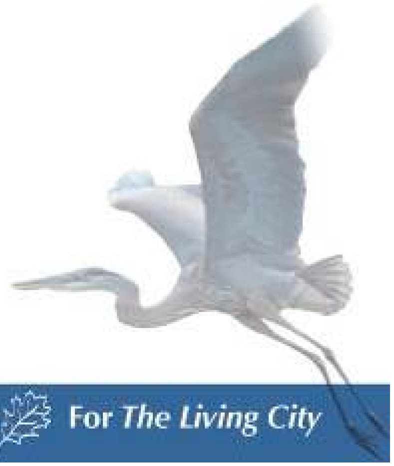

Hanson





Issues

- **Effectiveness of Stormwater Infiltration Practices on tight soils**
- Potential for groundwater contamination
- Potential for soil contamination



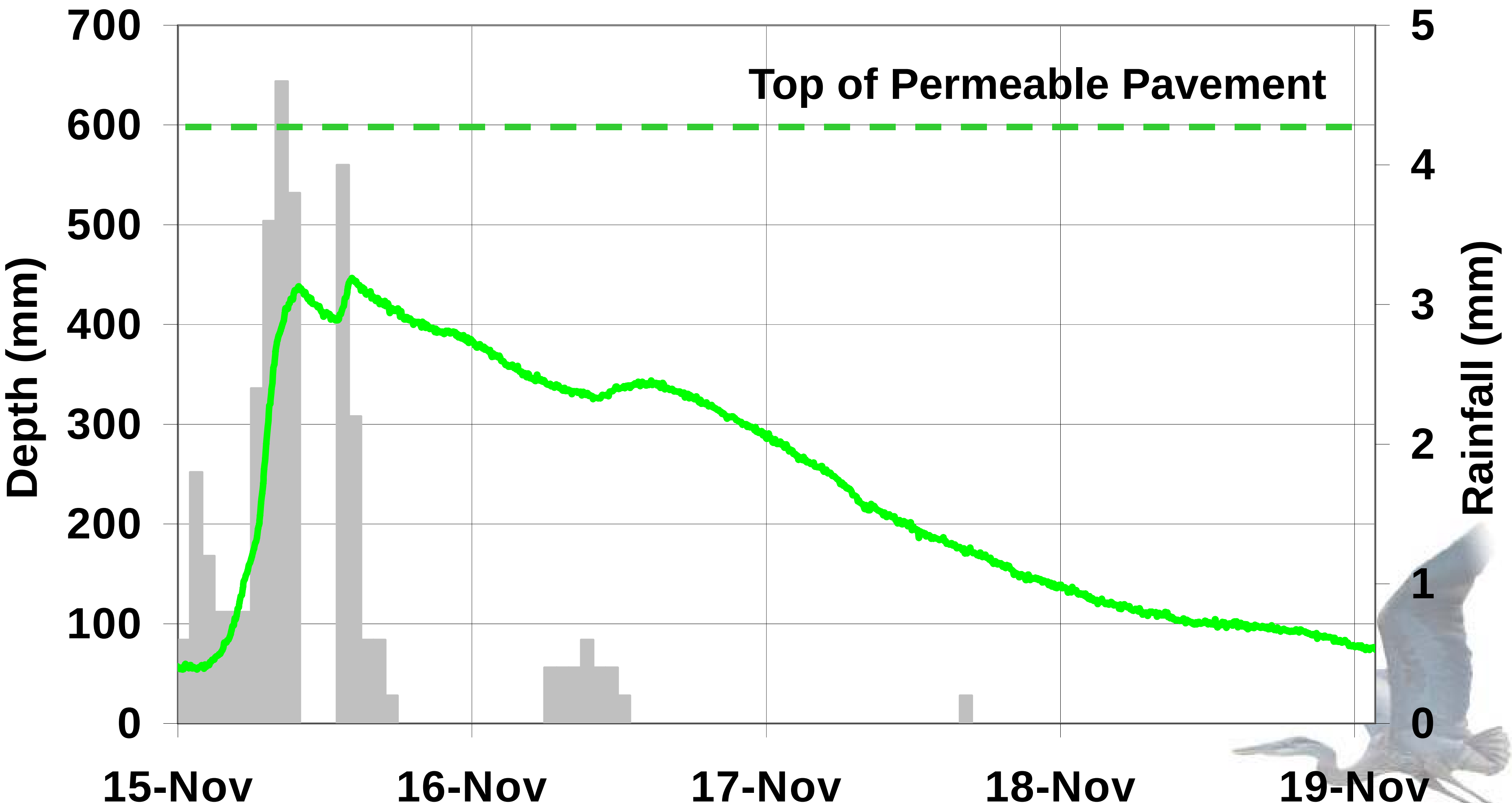
Guidelines for Minimum Soil Percolation Rate

Reviewed manuals from 11 jurisdictions in Canada (4), Northeastern U.S. (6) and the UK (1)

Jurisdiction	Recommendations
Ontario (2003), Halifax (2006)	**15 mm/h** (60 mm/h for Infil. Basins)
British Columbia (2002)	**No restrictions**; underdrain recommended where infiltration is slow
Maine (2006)	**13 mm/h** (not > 61 mm/h)
Pennsylvania (2006)	**2.5 mm/h** (not > 254 mm/h)
Minnesota (2008)	**No restrictions**; underdrain recommended where < 25 mm/h
New York (2003); Maryland (2000)	**13 mm/h** (clay content < 20%; silt + clay content < 40%)
United Kingdom (2007)	**No restrictions**

Surface Water Storage and Infiltration:

31 mm Rain Event



Surface Water Storage and Infiltration:

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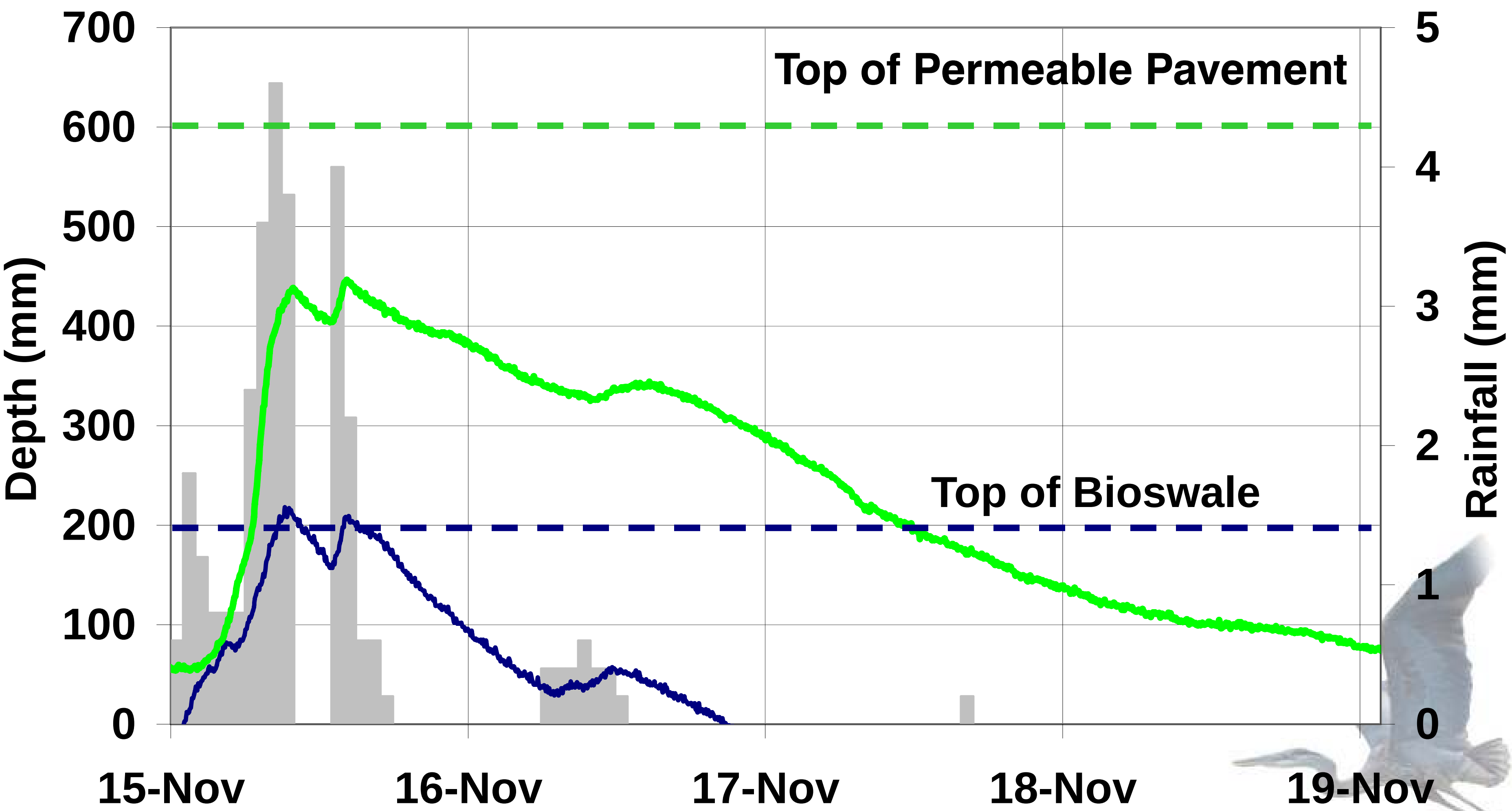

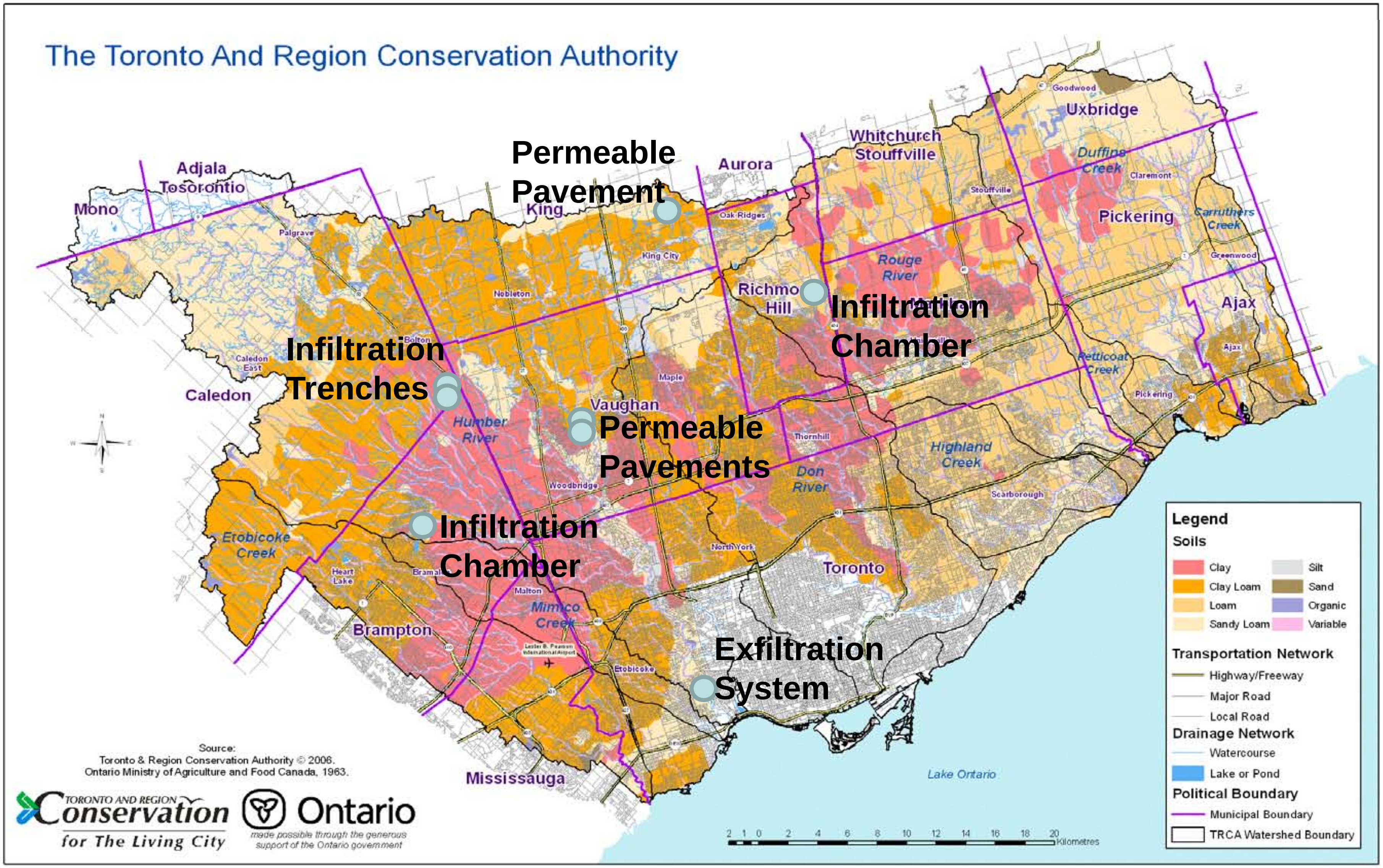
The Toronto And Region Conservation Authority
Permeable Pavement
Infiltration Chamber
Infiltration Trenches
Permeable Pavements
Infiltration Chamber
Exfiltration System
Mono
Adjala Tosorontio
King
Aurora
Whitchurch Stouffville
Uxbridge
Duffins Creek
Pickering
Carruthers Creek
Ajax
Rouge River
Richmond Hill
Caledon
Humber River
Vaughan
Don River
Highland Creek
Petticoat Creek
Etobicoke Creek
Mimico Creek
Brampton
Toronto
Mississauga
Lake Ontario
Legend
Soils
Clay
Clay Loam
Loam
Sandy Loam
Silt
Sand
Organic
Variable
Transportation Network
Highway/Freeway
Major Road
Local Road
Drainage Network
Watercourse
Lake or Pond
Political Boundary
Municipal Boundary
TRCA Watershed Boundary
Source:
Toronto & Region Conservation Authority © 2006.
Ontario Ministry of Agriculture and Food Canada, 1963.
Toronto and Region Conservation for The Living City
Ontario
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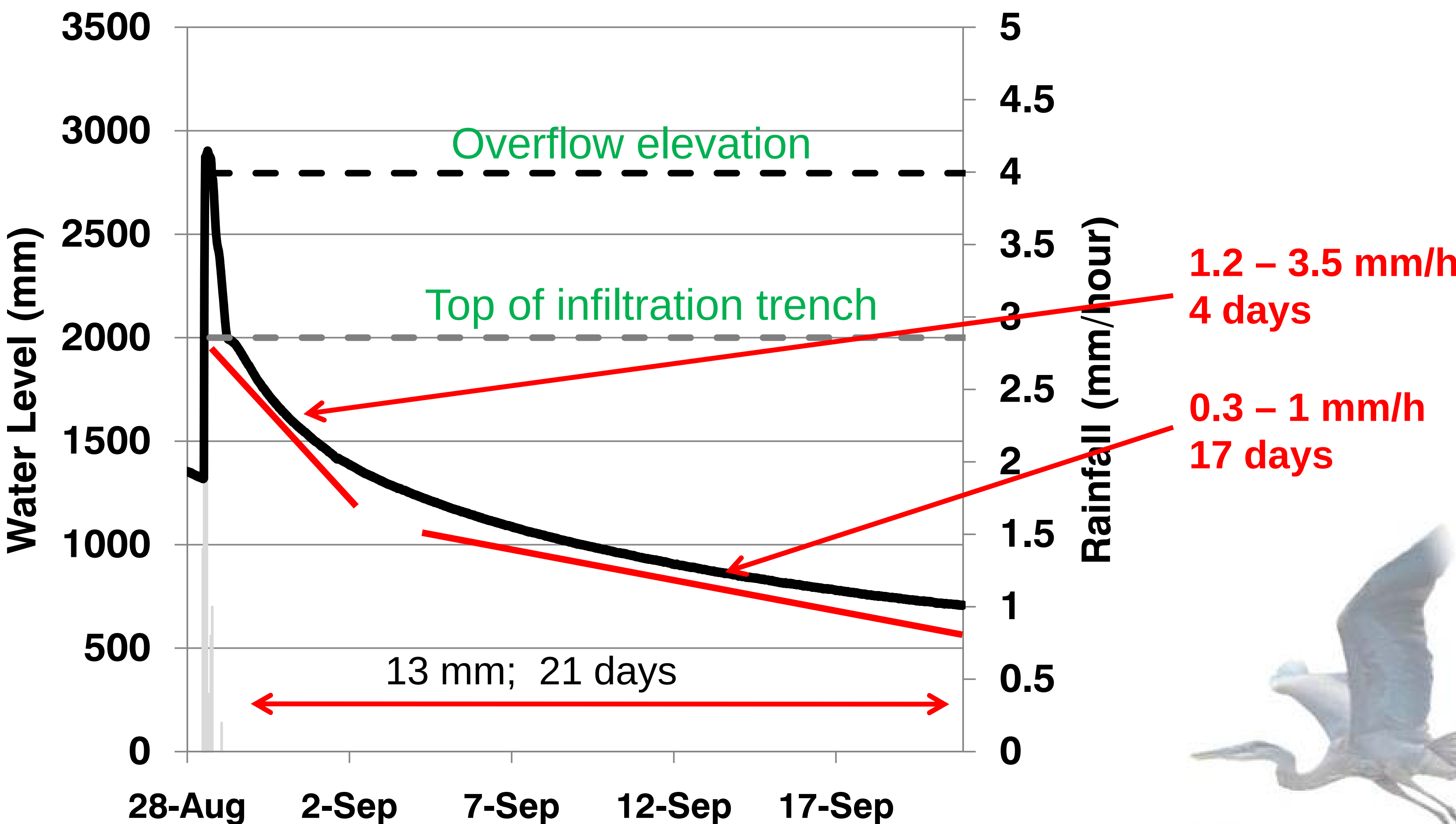
Kilometres

Performance on fine-textured soils: Runoff reduction

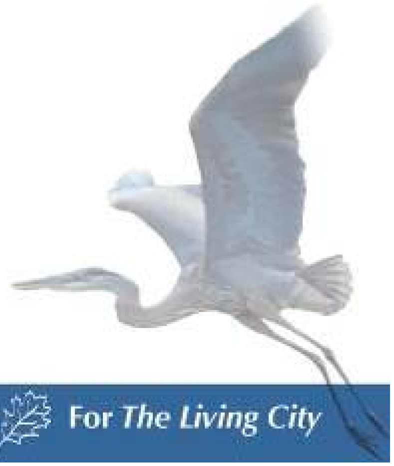
Study	Practice	Location	Soil Type	Runoff reduction	Underdrain
U of Guelph & TRCA, 2011	Permeable Pavements	Kortright Parking Lot	Silty Clay Till	**53% (interim result)**	Yes
TRCA, 2008	Permeable Pavement	Seneca College Parking Lot	Silty Clay Till	**99%**	No
SWAMP, 2002	Perforated Pipe	Toronto Resid. road	Clay to Clay Silt Till	**47 to 86%**	No
TRCA, 2011	Infiltration Chamber	Richmond Hill Roof Runoff	Sandy Silt Till	**85%**	No
TRCA, 2011	Detention Chamber	Brampton Parking Lot	Silty Clay Till	negligible	No
TRCA, 2011	Bioretention	Kortright Parking Lot	Silty Clay Till	**Approx. 90% (interim result)**	Yes
Dreelin *et al*., 2006	Grassed grid pavement	Georgia	35 – 60% Clay	**93%** (events < 20 mm)	Yes
Kwiatkowski *et al*, 2007	Pervious Concrete	Pennsylvania	Silty Sand	100% (events < 50 mm)	No

Infiltration Trench - Caledon



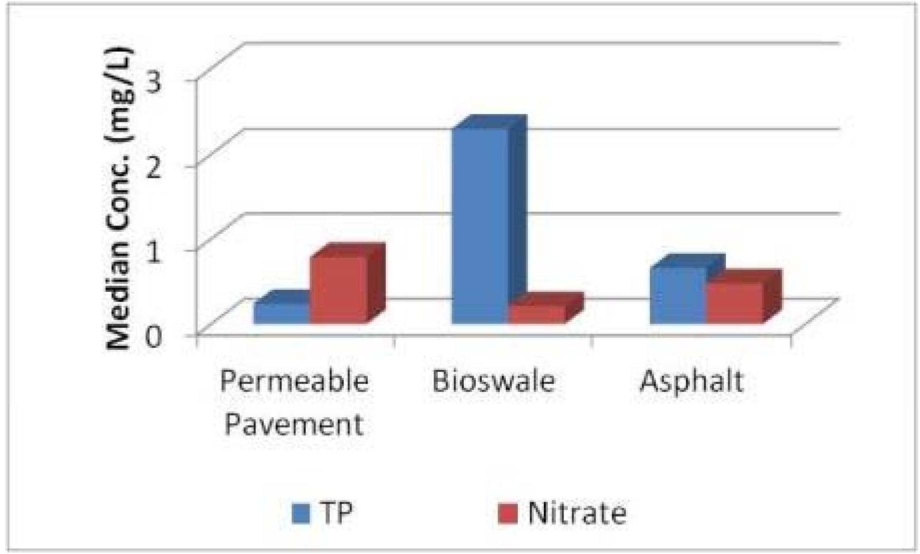
Issues

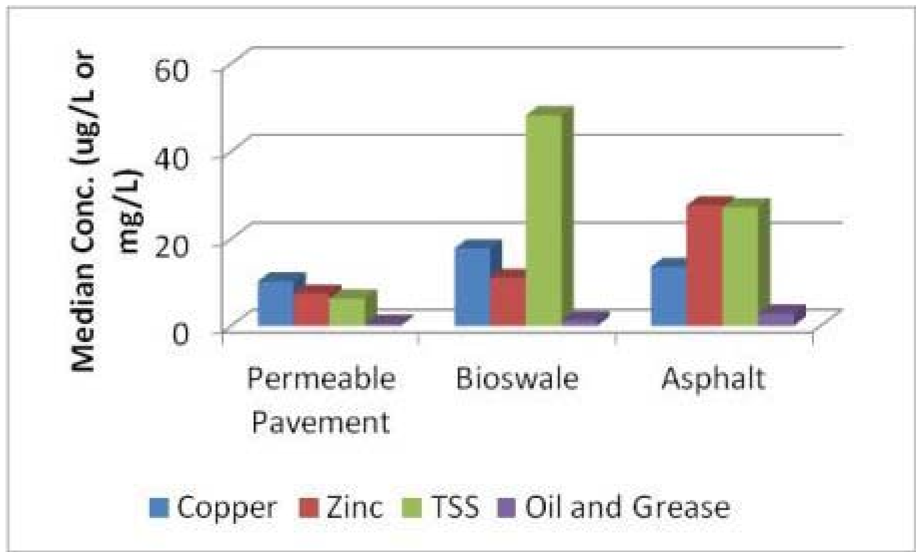
- Effectiveness of Stormwater Infiltration Practices on tight soils
- **Potential for groundwater contamination**
- Potential for soil contamination



Water Quality:

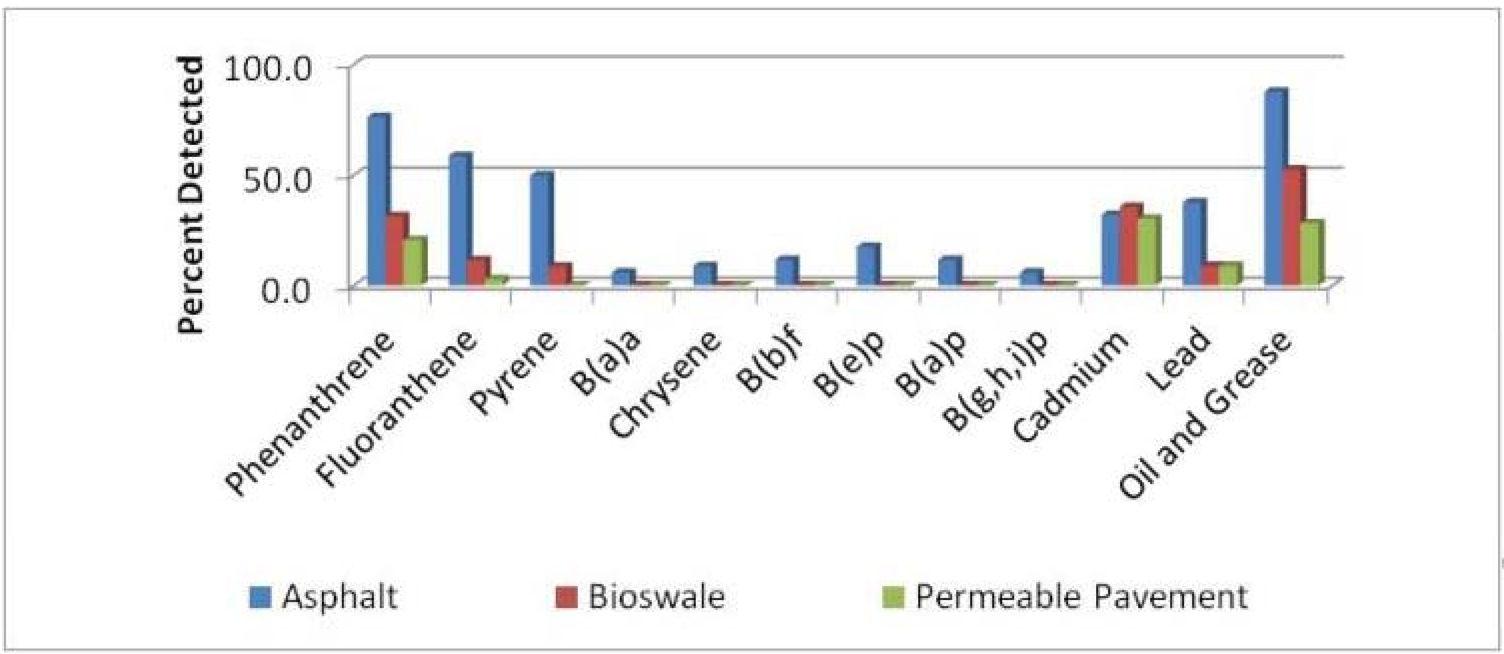
- PICP infiltrate concentrations low
- Phosphorus and TSS high in bioswale infiltrate





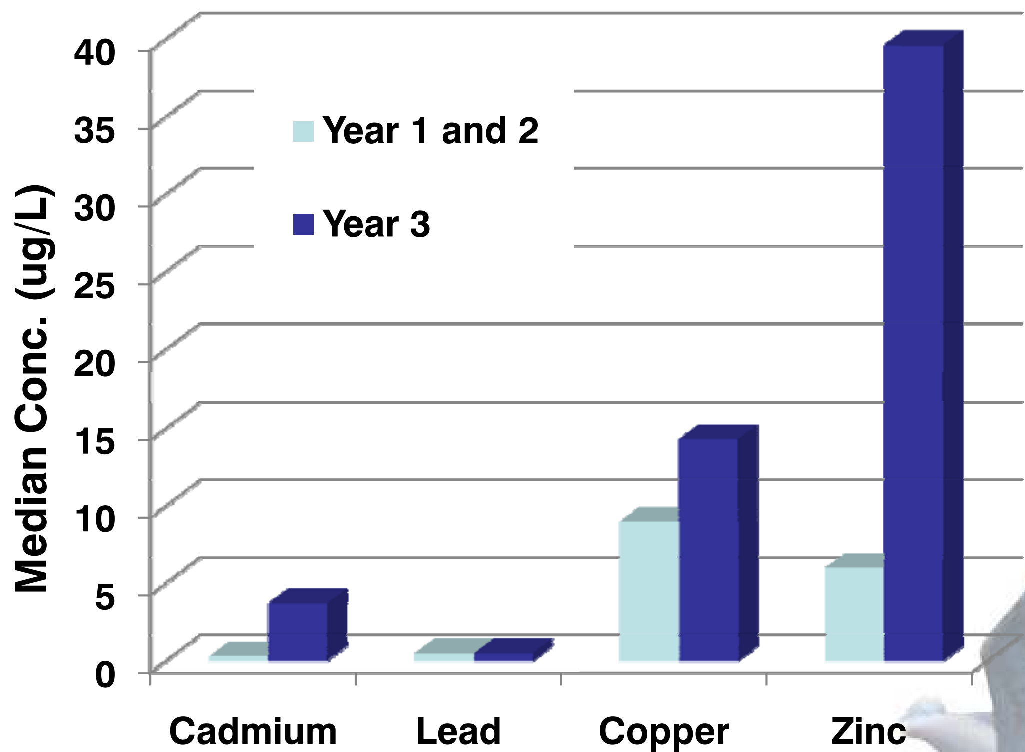
Water Quality:

- Most potential groundwater contaminants were detected more frequently in asphalt runoff



Changes over time

- Metal mobility affected by salts:
  - Ion exchange
  - Complexation
  - Colloid dispersion



But what about salts?

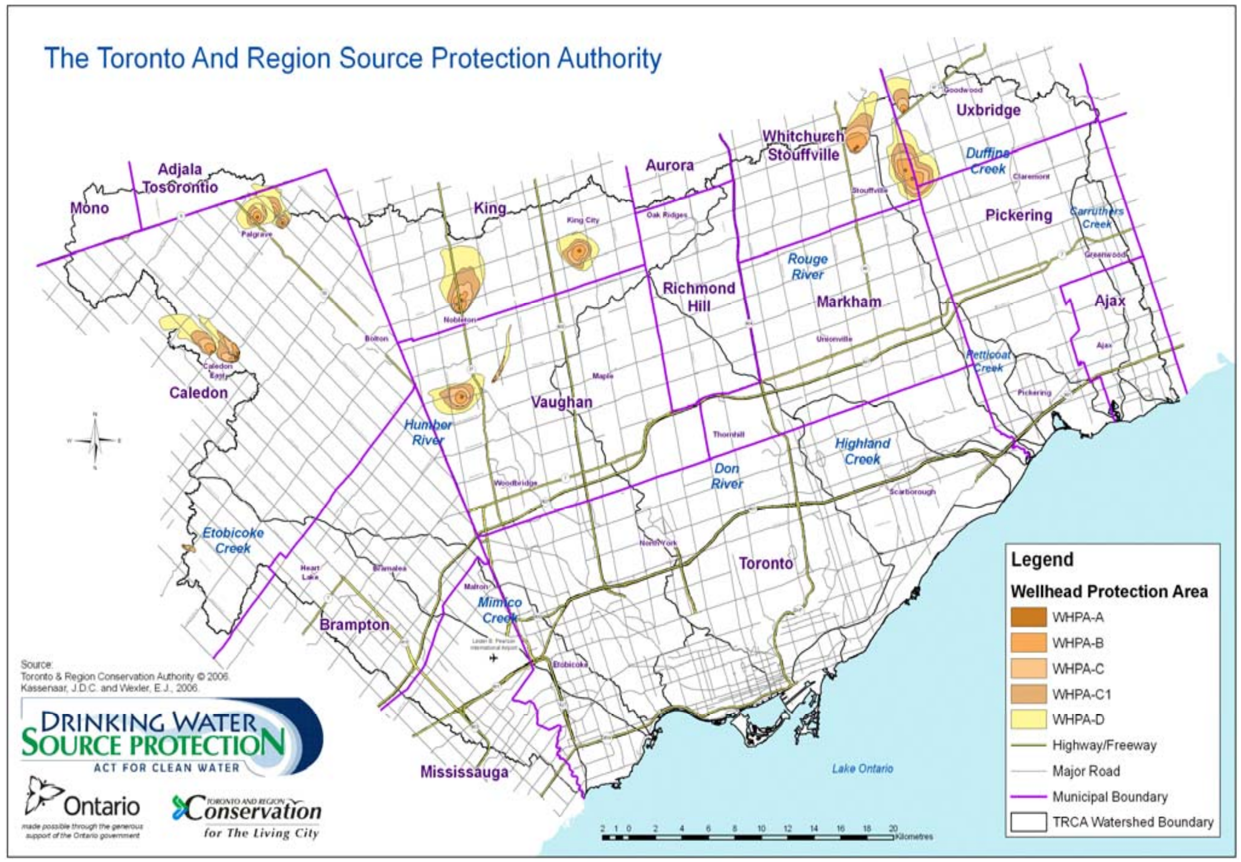
- Toxic to freshwater ecosystems
- Contaminate aquifers
- Adversely affect soil structure
- Increase contaminant mobility
- Hastens corrosion, etc.

- …but they are an inseparable part of our car culture!!

Groundwater Risk Assessment Framework

For designated threats

- Proximity to wells
- Vulnerability of aquifer to contamination
- Contaminant type and quantity



Issues

- Effectiveness of Stormwater Infiltration Practices on tight soils
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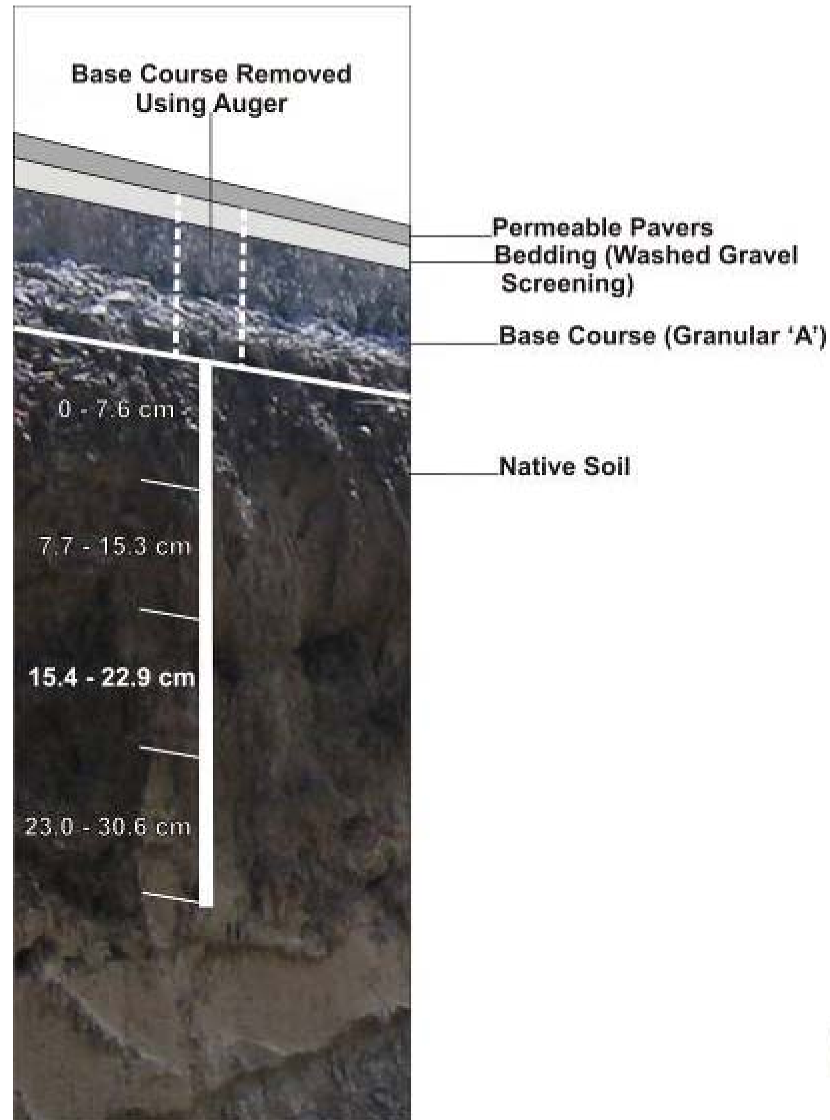
- **Potential for soil contamination**

Soil Quality

- Depth profile of native soil beneath PICPs
- Soil sample taken at nearby reference site for comparison



Surveys of Older PICP Sites

Belfountain Conservation Area (17 years)

Kortright Conservation Area (4 years)

Jerrett's Funeral Home (10 years)

Guelph University (13 years)

Sunset Beach (8 years)

Humberwood (12 years)

Humber College (4 years)

Surveys of Older Bioretention Sites

York University (6 years)

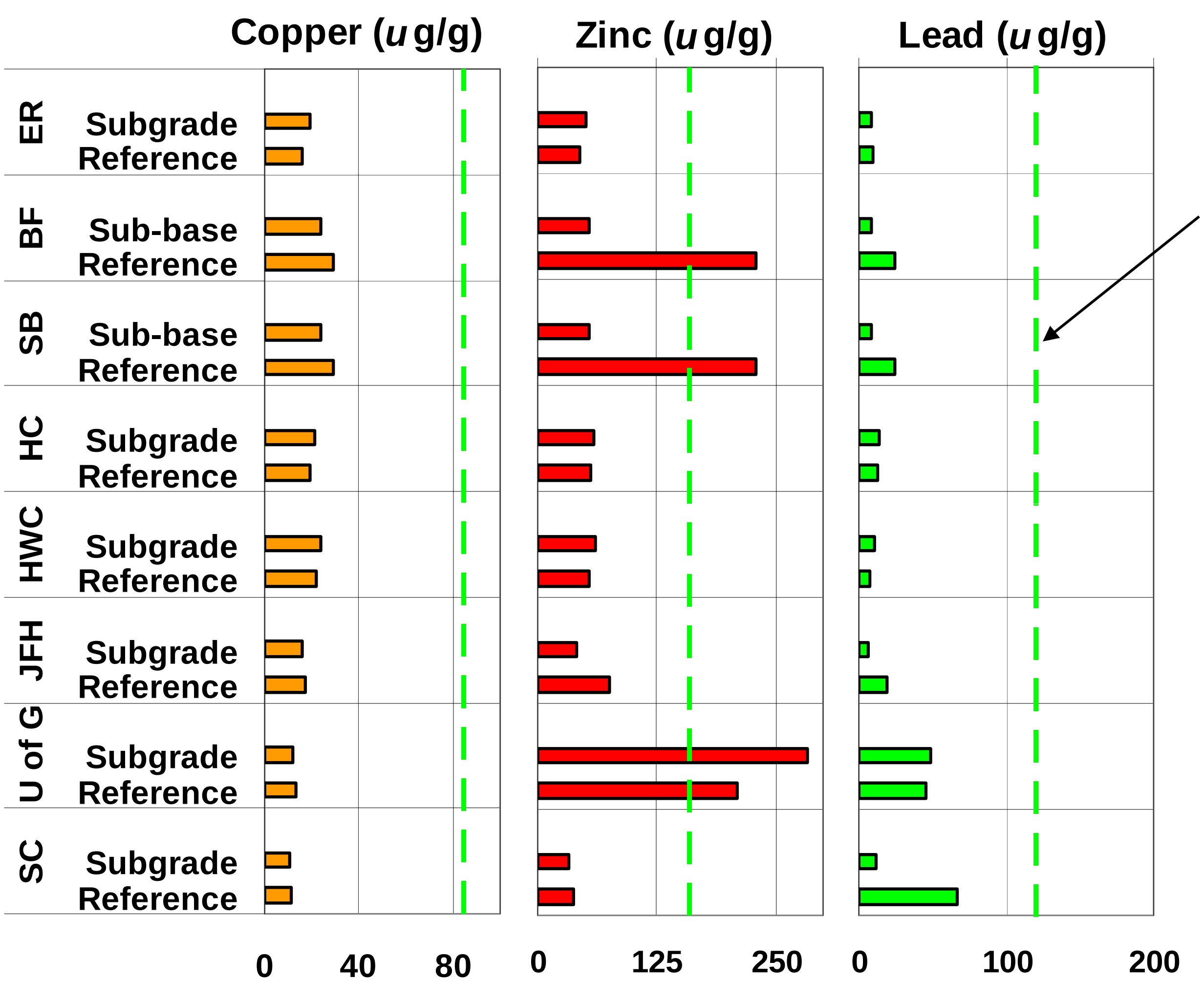
University of Toronto (2 years)

De Vere Gardens
(> 18 years)

TRCA head office
(11 years)

Royal York
(> 18 years)

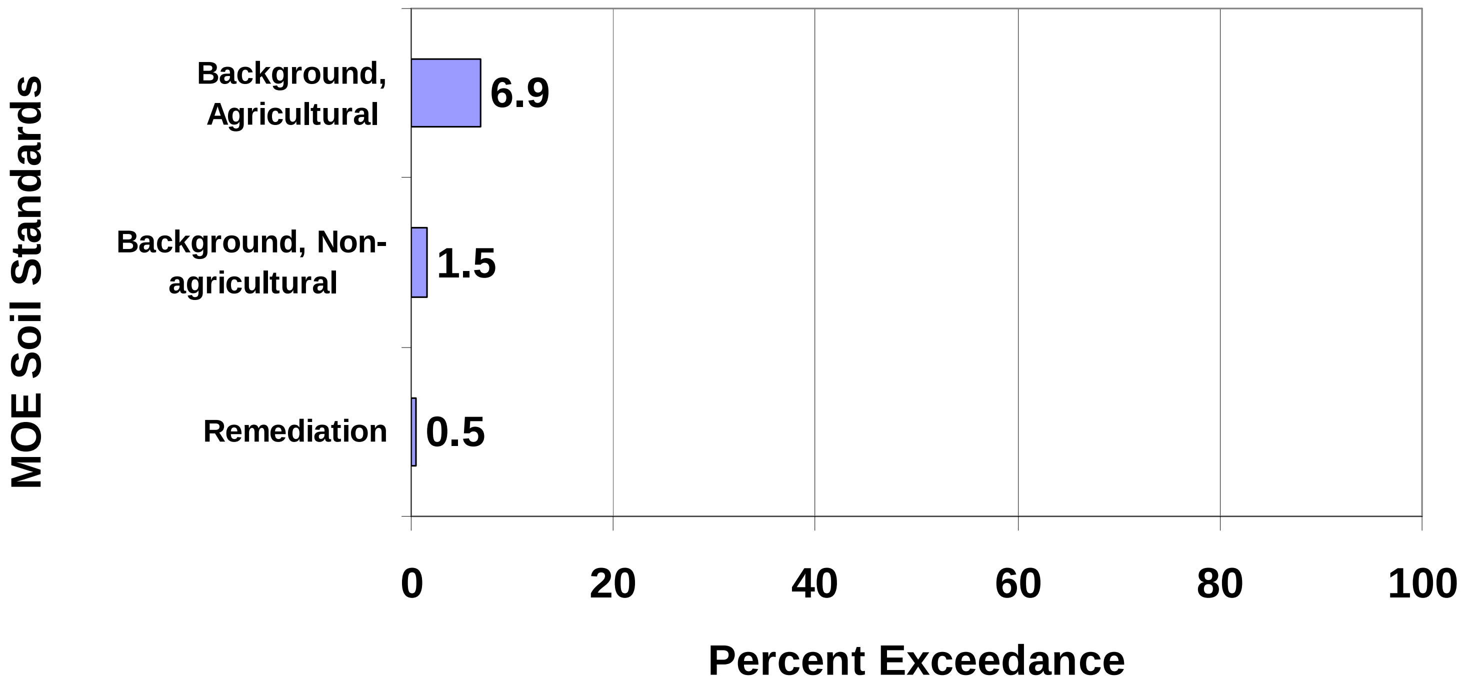
Soil Quality



Background soil concentration for non-agricultural land uses (MOE, 1998)

Soil Quality

- 14 sites (8 permeable pavement, 6 bioswales/ditches)
- 28 pollutants (12 metals, 16 PAHs)
- Age between 2 and > 20 years



Soil Quality – other studies

Study	Sites	Age of Sites	Soil depth at which metal concentrations exceeded Ontario standards
Dierkes and Geiger, 1999	3 Highway Vegetated Filter Strips, Germany	11 – 24 years	0 – 10 cm
Dechesne *et al*, 2005	4 infiltration basins, France	10 - 21 years	0 – 5 cm
Barraud *et al*, 1999	Soakaway, France	> 30 years	No exceedance at 0 – 65 cm
J.F. Sabourin & Assoc., 2008	3 Grassed swales, Residential roads, Ottawa	13 years	No exceedance at 0 – 15 cm

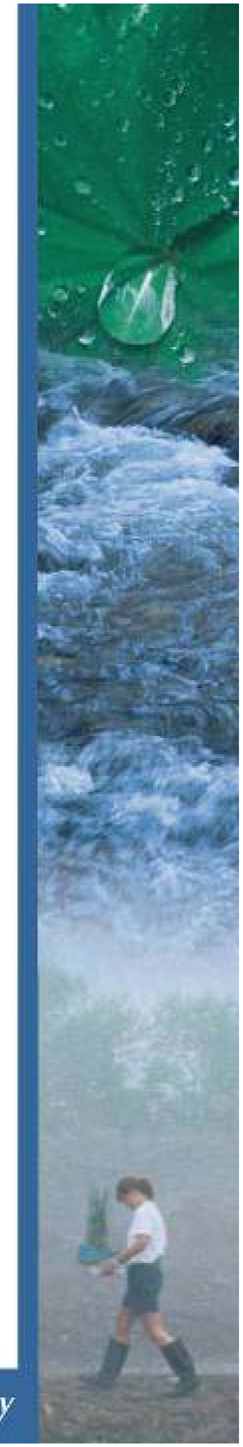
Conclusions

- Need improved guidance in Ontario on:
  - minimum percolation rates for infiltration practices
  - design of infiltration practices on tight soils
- Where there are road salts there will be contamination – need to carefully weigh costs and benefits in each case
- In some contexts, a greater separation distance between the base and water table should be considered
- Decentralized micro-controls do not appear to have significant impacts on soil quality

Project Partners

Sustainable Technologies Evaluation Program

- Peel, York, Toronto
- Toronto and Region Remedial Action Plan
- Ontario Ministry of the Environment
- Gov't of Canada's Great Lakes Sustainability Fund
- Fisheries Canada
- Ontario Ministry of Transportation
- Oak Ridges Moraine Foundation
- John and Pat McCutcheon Foundation
- Interlocking Concrete Pavement Institute
- Cement Association of Canada
- University of Guelph
- Morgaurd Investments
- Urban Ecosystems
- Unilock
- Brown's Concrete
- Hanson
- Lafarge
- Dufferin Aggregates
- Armtech
- Condrain
- Layfield
- Seneca College
- Wal-Mart
- Aecon



Thank You

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TRCA website:

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