Soil Management Best Practices Guide for Urban Construction

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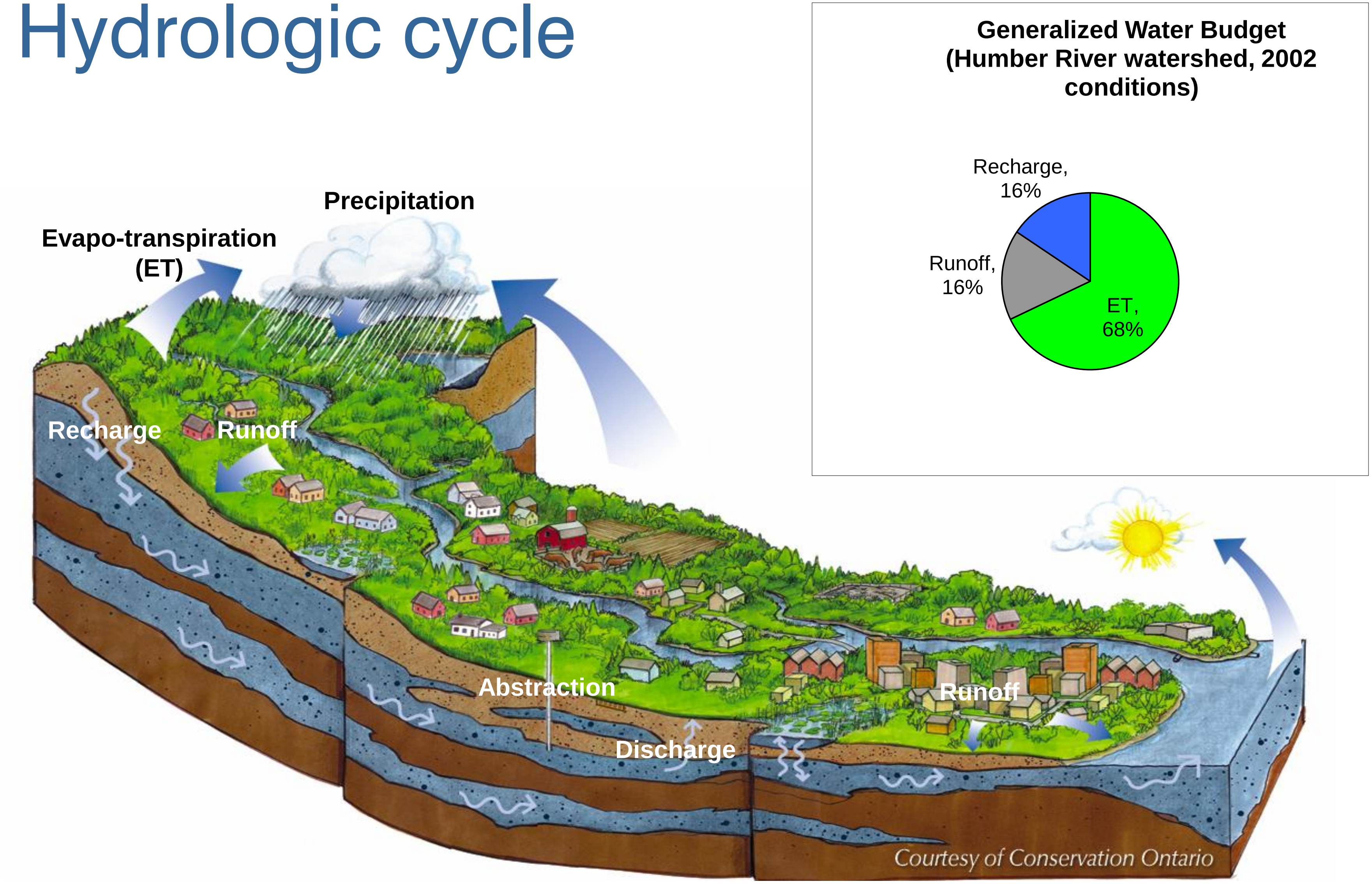
Sustainable Technologies Evaluation Program

- Multi-agency program led by TRCA
- Main program objectives:
  - ✓ Evaluate clean water and energy technologies;
  - ✓ Assess barriers to/opportunities for widespread implementation;
  - ✓ Develop knowledge transfer tools, guidelines and policy alternatives;
  - ✓ Education, advocacy, and technology transfer.
- Program web address: www.sustainabletechnologies.ca

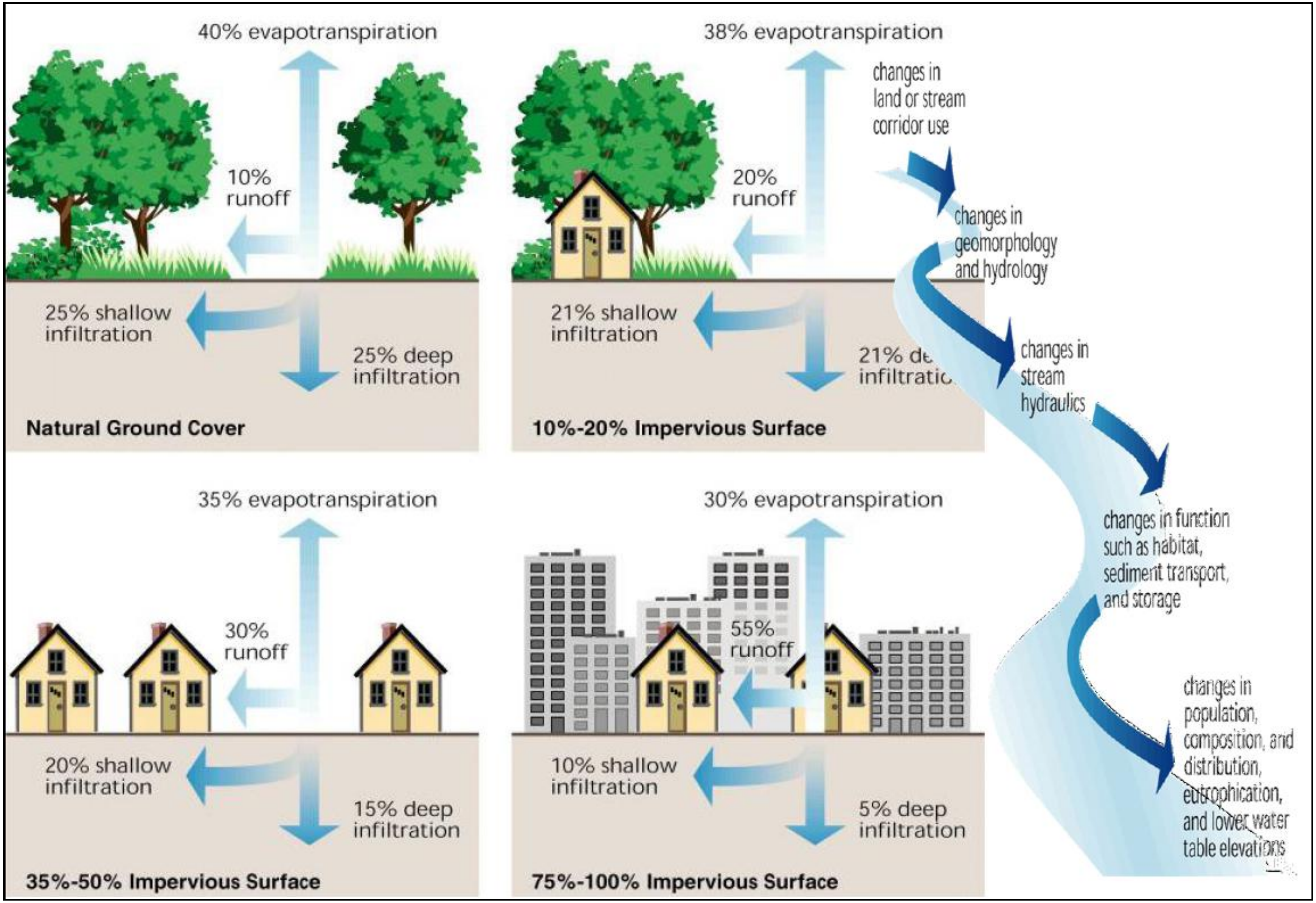
Presentation overview

1. The case for better soil management during urban construction
2. Introduction to the best practices guide
3. Recommended standards and implementation options

Hydrologic cycle

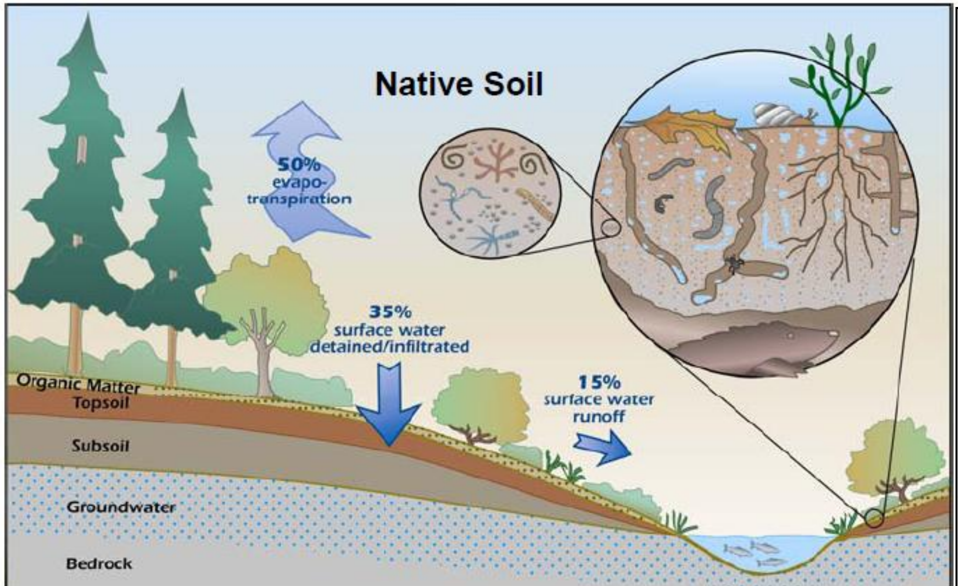


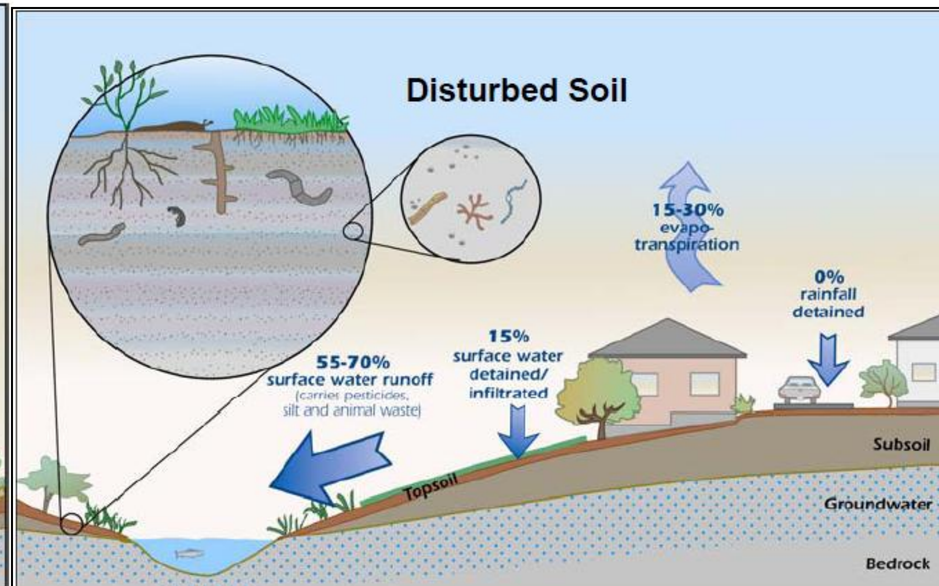
IMPACTS OF URBANIZATION ON THE WATER CYCLE



Conventional soil management practices on Ontario construction sites

- Topsoil stripped, stockpiled in mounds and stored 6 months or more;
- Stockpiled topsoil is reapplied as is on pervious areas at depths of 10 to 15 cm over compacted subsoil;
- Produces landscaped areas that function more like impervious surfaces.





Stormwater management functions of healthy native soil

- Provides high rates of water infiltration and retention;
- Minimizes surface runoff and erosion;
- Traps sediments, metals, excess nutrients and biodegrades chemical contaminants;
- Supports vigorous vegetative cover;
- Supports beneficial soil life that fight pests and disease and supply plant nutrients.

During land development soil functions are often impaired by topsoil loss and compaction:

- Decreases porosity, soil organisms, organic matter, infiltration and water holding capacity;
- Increases runoff, risk of contamination from paved surfaces and yards;
- Increases erosion and risk of flooding;
- Impairs plant growth, pest and disease resistance;
- Increases needs for irrigation, fertilizers and pesticides.

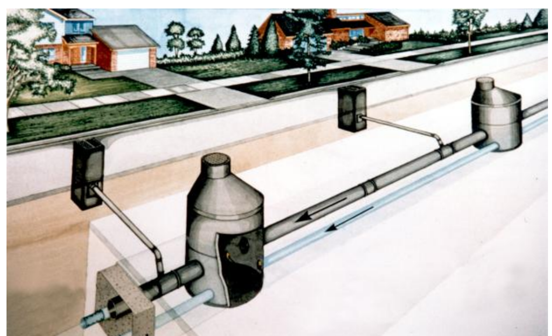
Stormwater Management (SWM)

Potential impacts are mitigated through the implementation of a "treatment train" of stormwater management practices consisting of:

Lot Level Controls

Permeable pavement

Conveyance Controls

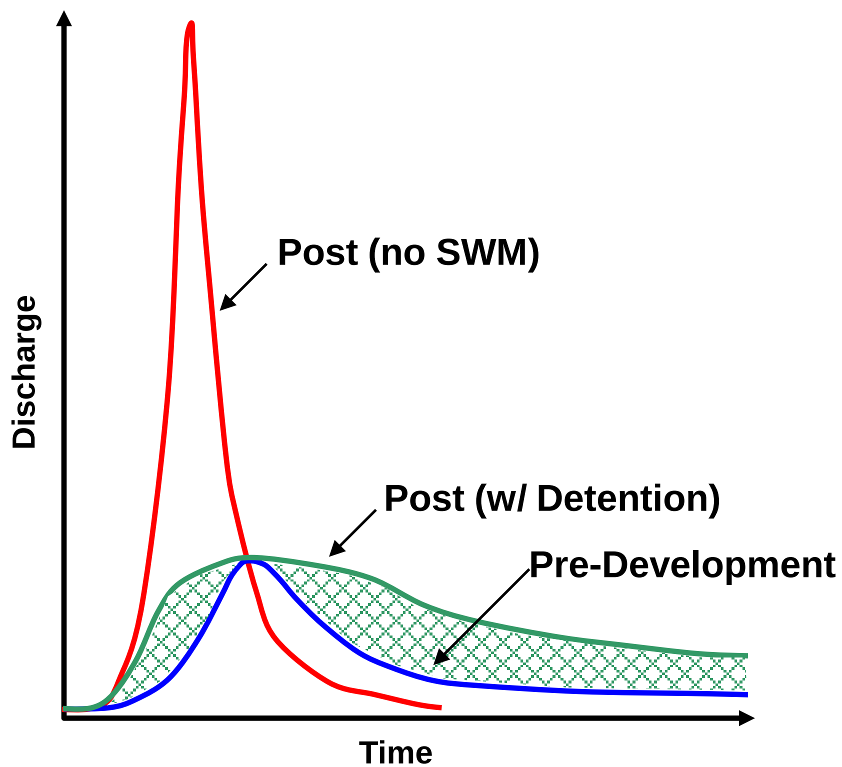


Perforated pipe system

End-of-Pipe Controls

Wet Pond

Flaws in the detention pond approach



- No "safe" way to discharge 2x to 6x more runoff;
- Design assumptions are unrealistic;
- Still alters stream flow regimes;
- Does not mitigate loss of natural flow pathways or temperature impacts;
- Cumulative effects of watershed development are not managed.

WHY DO WE NEED TO IMPROVE CURRENT PRACTICES?

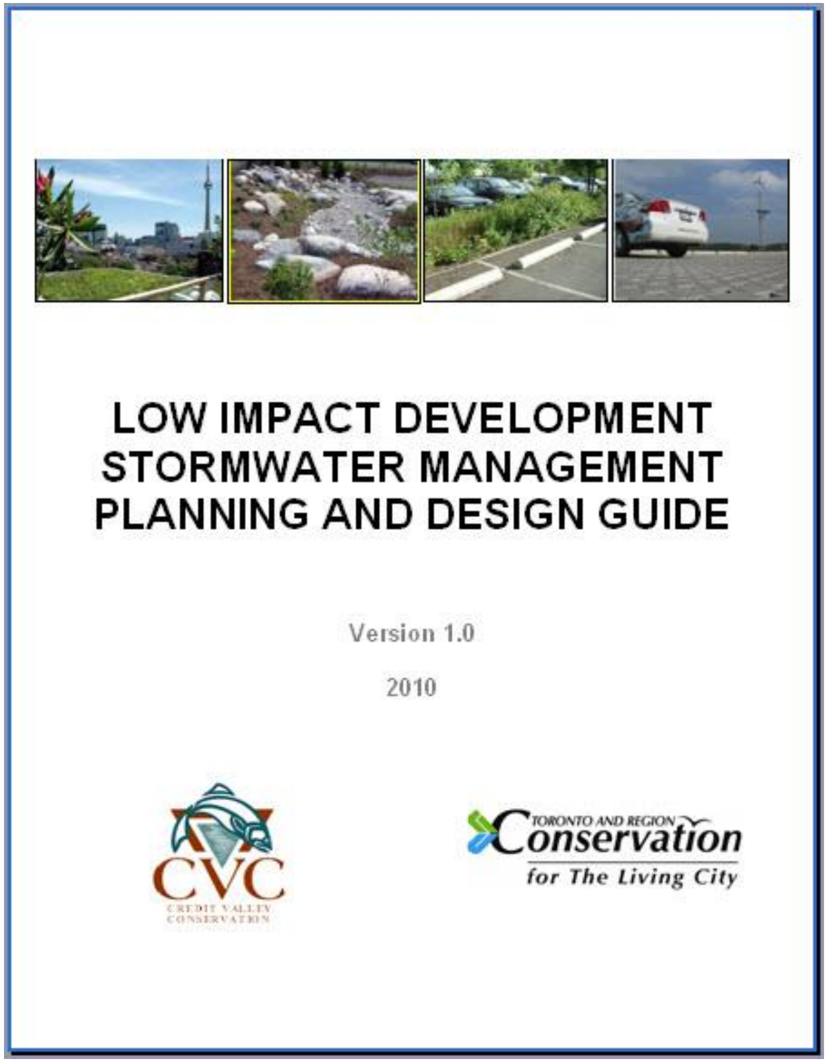
Conventional end-of-pipe SWM strategies don't address all impacts

Changes to water budget (increased runoff & decreased recharge & ET)

- Accelerated stream channel erosion and/or sedimentation;
- Risk of damage to infrastructure & property;
- Degraded water quality (increased temperature and pollutant loads);
- Degraded aquatic and terrestrial habitats;
- Less diverse aquatic communities.

Low Impact Development (LID) is a stormwater management strategy that seeks to mitigate the impacts of increased runoff and stormwater pollution.

LID comprises a set of site design strategies and distributed stormwater management practices that harvest, filter, evapotranspire, detain and infiltrate rainwater.


LOW IMPACT DEVELOPMENT
STORMWATER MANAGEMENT
PLANNING AND DESIGN GUIDE

Version 1.0

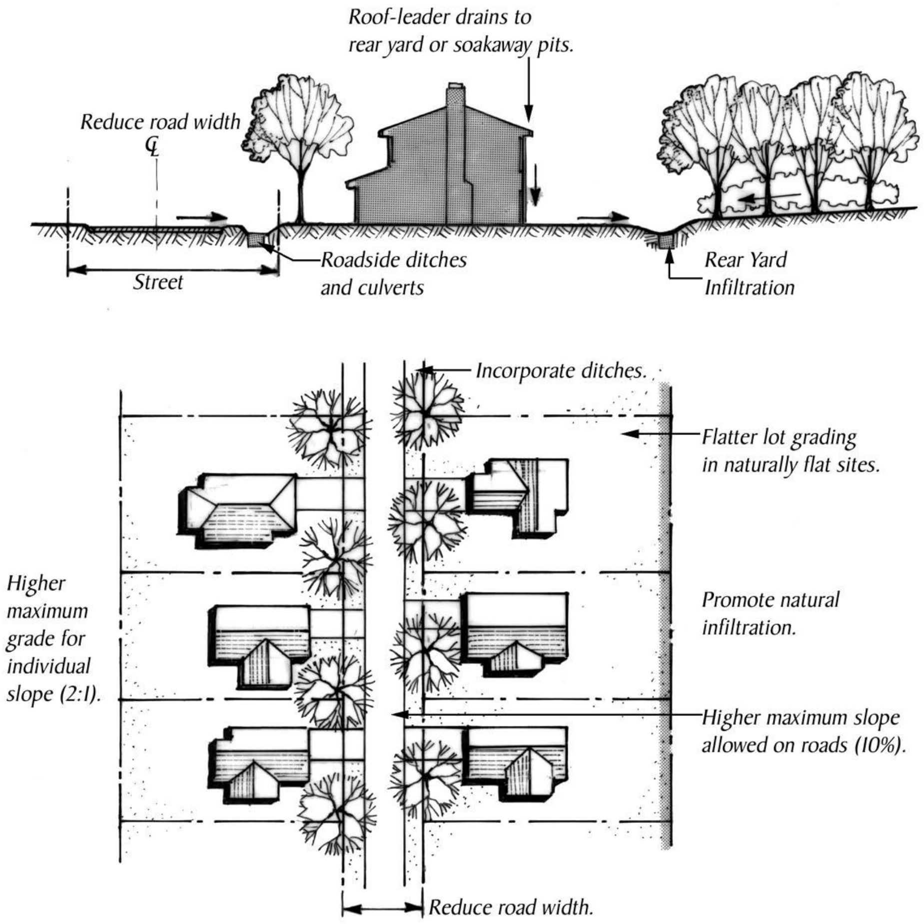
2010

Available at www.sustainabletechnologies.ca

LOW IMPACT DEVELOPMENT PRINCIPLES

2. Focus on runoff prevention

- Minimize impervious cover (e.g., innovative road network design, shared parking areas, permeable pavement, green roofs);
- Create absorbent landscapes through soil restoration
- Infiltrate roof runoff on site
- Rainwater harvesting.



LOW IMPACT DEVELOPMENT PRINCIPLES

4. Emphasize simple, low-tech, low-cost practices

- Soil restoration on all pervious (landscaped) areas
- Rain barrels
- Rain gardens
- Soakaways
- Grass swales

Key benefits of preserving and restoring healthy soils

- Restores porosity and organic matter which increases infiltration and water holding capacity;
- Improves filtration & trapping of contaminants in runoff;
- Restores conditions needed by beneficial soil organisms;
- Promotes vigorous growth of plantings;
- Minimizes maintenance;
- Creates more attractive & marketable properties.

Effectiveness of soil restoration practices

Parameter	Malone et al., 1996	Chow et al., 2002	Balousek, 2003	Faucette et al., 2005	Reinsch et al., 2007
Native soil type	Silty loam	Gravelly loam	Silty clay loam	Sandy clay loam	Clay
Treatment	Yard waste compost (YWC) incorporation (15 cm depth)	Pulp fibre incorporation (20 – 25 cm depth)	Deep tilling, chisel plowing and YWC incorp. (15 cm depth)	Compost blankets (37.5 mm depth & 4 diff. compost sources) plus filter berms	YWC blanket; YWC incorp.; YWC incorp. plus filter berm
Runoff volume reduction*	67%	23%	88%	30 to 55%	96% (blanket) 69% (incorp.) 74% (incorp. & filter berm)
Sediment load reduction*	77%	71%	n/a	97 to 99%	>99%
Nutrient load reduction**	n/a	n/a	n/a	29 to 62%	>99%

* Values are % reductions over all events monitored relative to a bare soil control.
** Value is % reduction of dissolved reactive phosphorus load after vegetation was re-established.

Soil Management Best Practices:
An Urban Forest Perspective

- Trees are a major component of the hydrologic cycle
- Trees reduce runoff through processes of
  - Interception
  - Transpiration
  - Infiltration

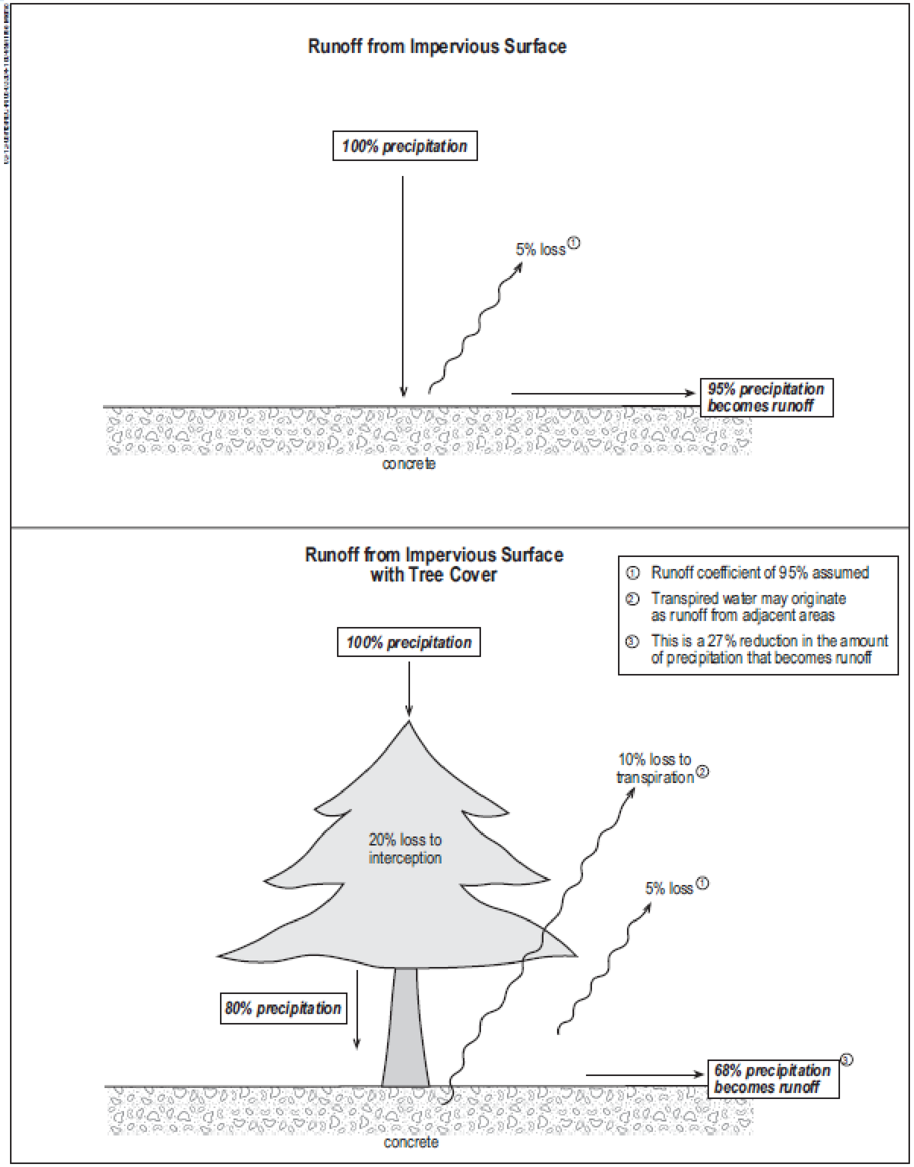


Figure 4. Conifer over an impervious surface.

Quantifying the benefits of trees

- cityGREEN Software™
  - GIS software which is used to analyze:
    - Stormwater runoff
    - Air pollution removal
    - Carbon storage and sequestration
    - Land cover breakdown
    - Alternate scenario modeling

Urban Watershed Forestry
(Stormwater Forestry)

- Def'n: The integration of the fields of Urban Forestry and Watershed Planning
- Field Study Research by the EPA, USDA Forestry Service and others have demonstrated and quantified the value of trees in stormwater management

City of Ottawa example

- Analysis based on existing urban forest cover of 27%
  - *Removed 630,000 kg of air pollutants/year at a dollar value of $3.95 million*
  - *Stored 1.01 million tonnes of carbon and sequestered 7,900 kg/year*
  - *Provided the equivalent of 3.84 million m^3 of stormwater storage representing a savings of $219 million if this was captured in built SWM facilities*

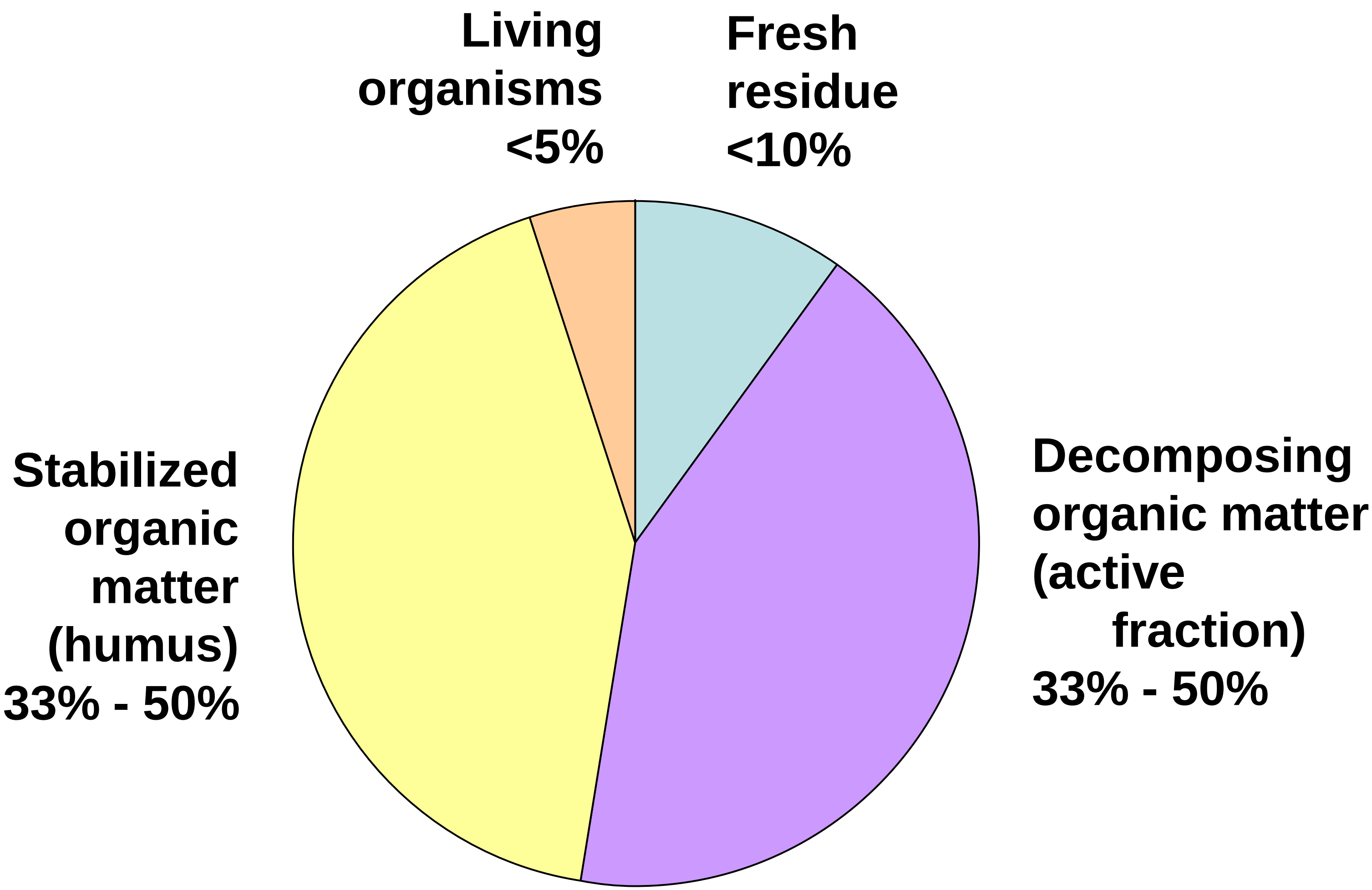
For trees to provide these benefits, they require

- Sufficient soil volume and soil quality to allow them to reach maturity

- The same benefits and requirements apply to turf and all other plants also

- **Organic matter** is the key to a fully functional soil

Components of soil organic matter (SOM)



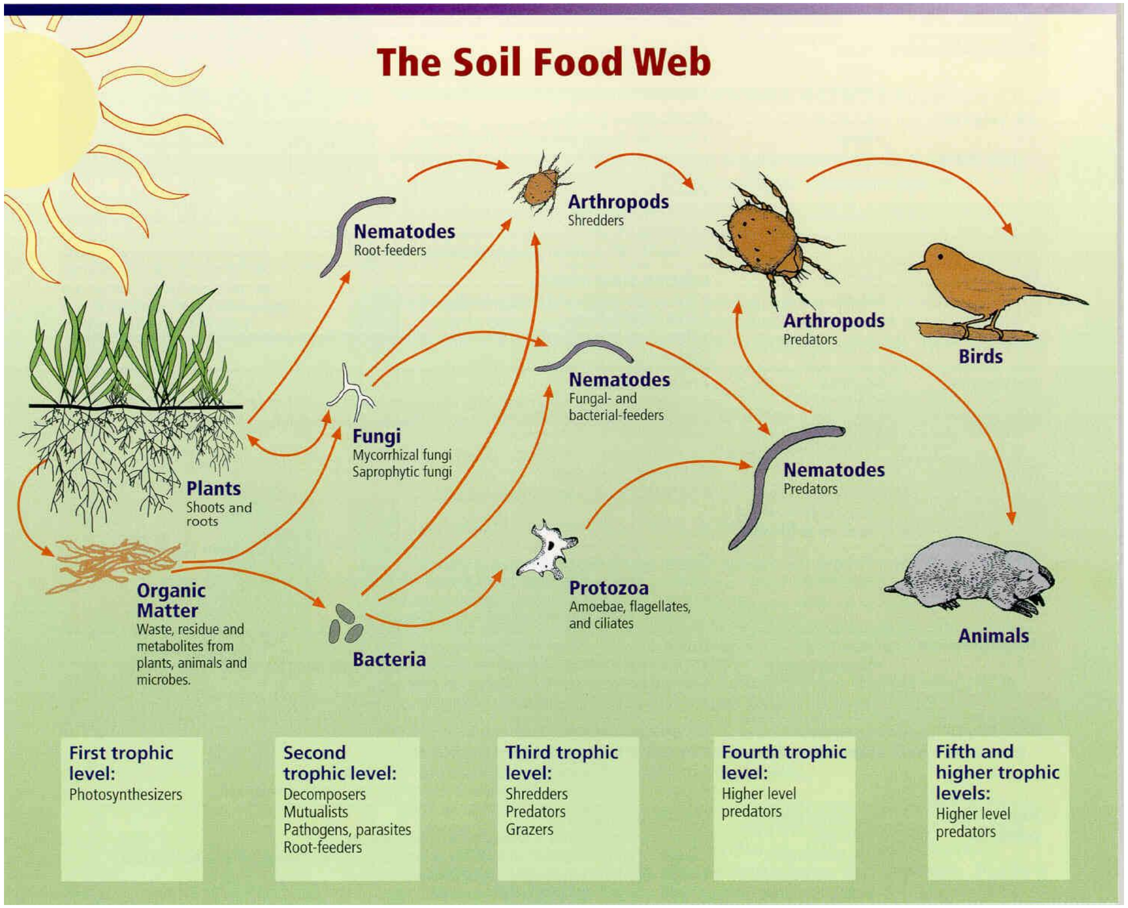
The Soil Food Web

Physical and chemical soil properties depend on micro-organisms

And other soil dwellers

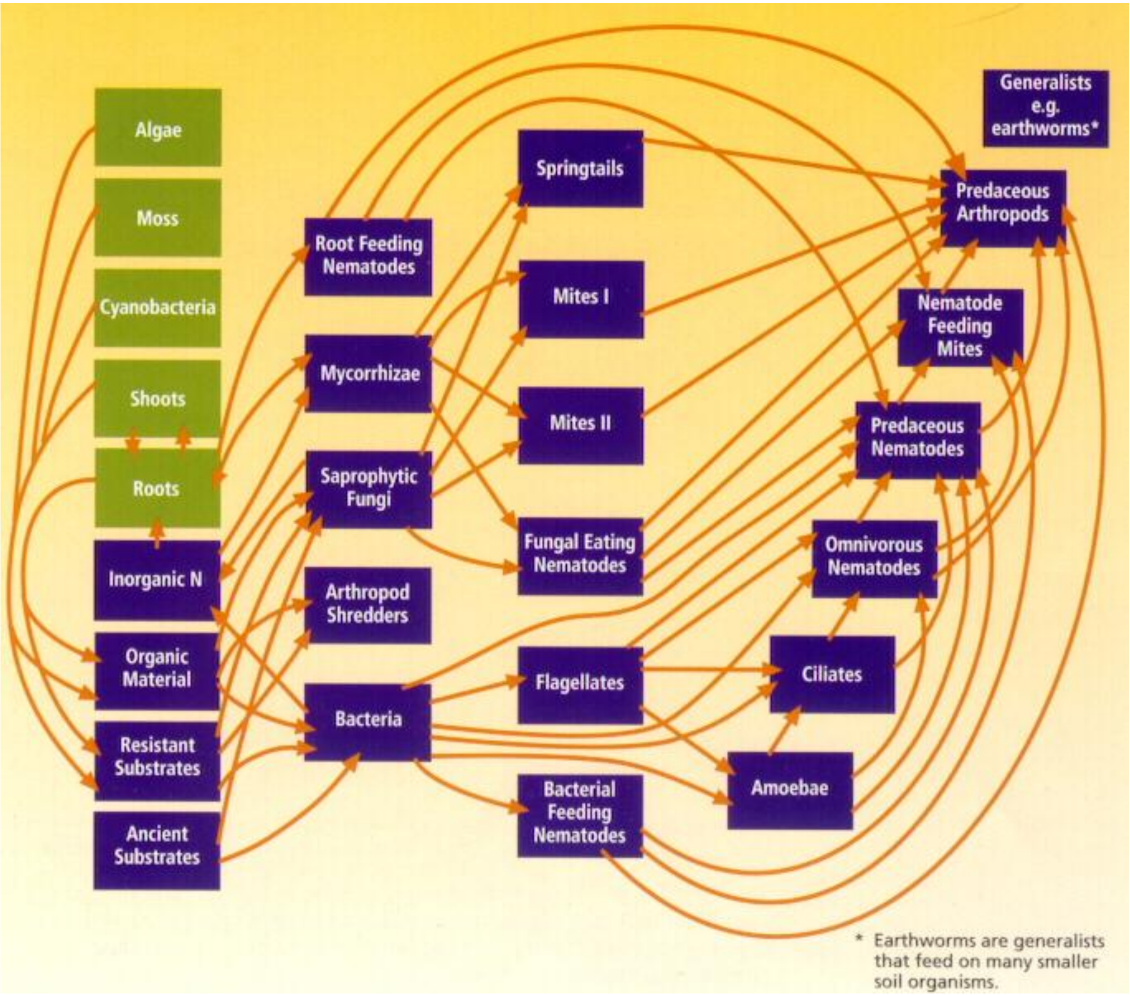
found abundantly in healthy soils

- Structure
- Water holding capacity
- Infiltration
- Cation exchange capacity

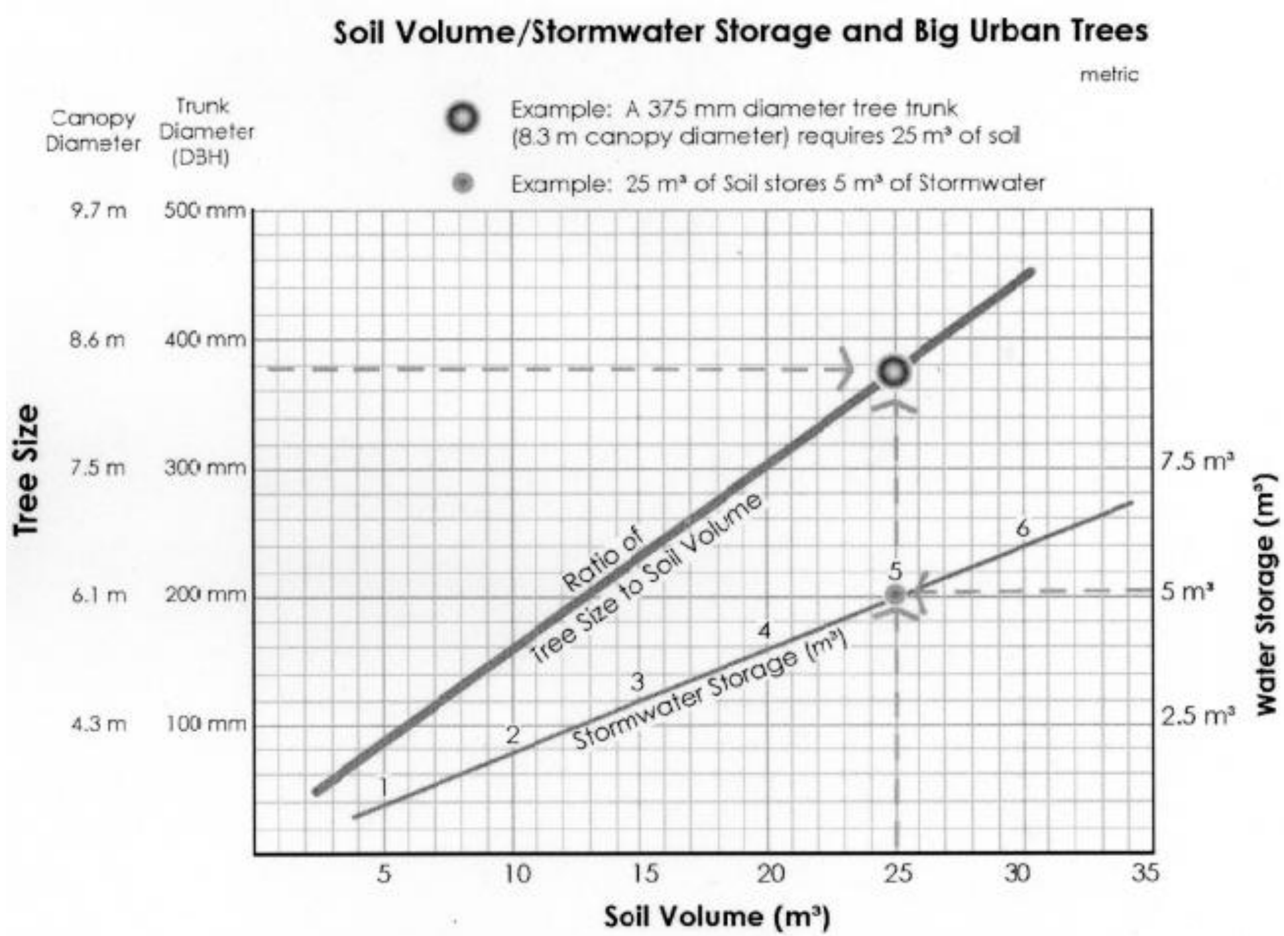


Another world underground which creates low maintenance landscapes

Healthy soils have constant cycling of water, oxygen and nutrients which meets the requirements of plants and trees. This reduces or eliminates the need for irrigation, fertilizers and pesticides



How much soil does a tree require?



James Urban

Target tree canopy covers for increased benefits from trees

Municipality	Present Canopy Cover	Target Canopy Cover
City of Toronto	17%	30 to 40%
Town of Oakville	29%	40%
City of Guelph	30%	40%

Questions:

- Are these targets attainable?
- Are some present canopy covers decreasing?

Challenges to maximizing the benefits of trees in the urban watershed

- Poor soil quality
- Limited volume
- Construction activities
- Intensification and infill development
- Conflicts with infrastructure
- **Construction practices since 1950**

What is the difference between then and now?

- Mass grading and master planned communities

Modern development processes

- Vastly alter large blocks of land
- Compact subsoil to levels not possible prior to 1950

- Degrade topsoil resources through handling and storage practices
- This is actually no longer topsoil

What is expected of this site?

This site will be graded, topsoil added and the finished landscape expected to perform as a natural and pervious site

This planting site contains…………

- Compacted fill
- "A" gravel
- Screenings
- Concrete washout
- Anaerobic topsoil
- 1% – 2% organic matter
- Compaction levels approaching 2 g/cm^3

Planting

- Correct tree for the site?
- Correct planting procedure?
- The truth?

  Often no tree is suitable for many sites

- What will be the contribution of these trees in 40 years?

Are we counting on these trees for future benefits such as SWM?

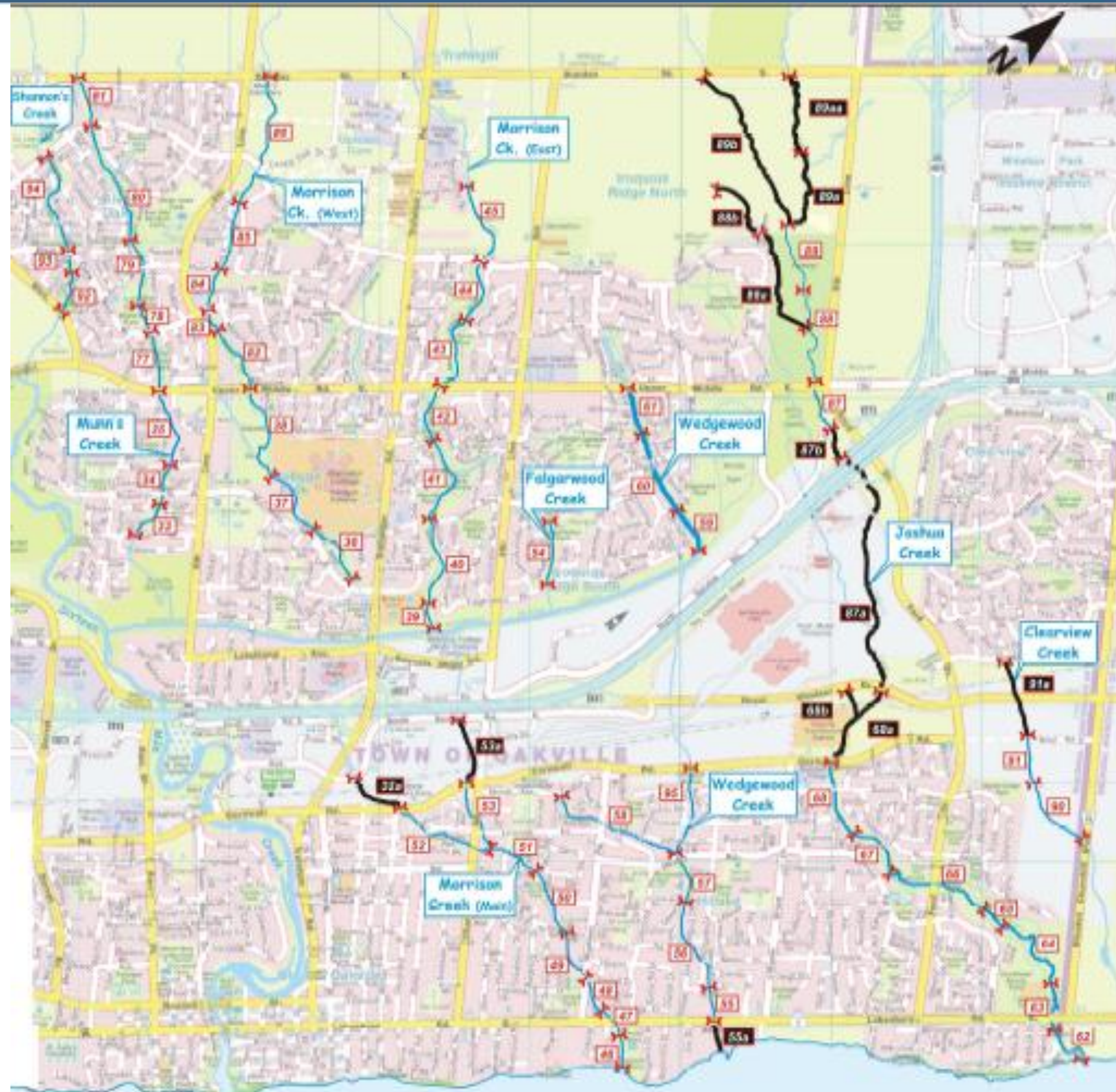
- These trees are 40 years old
- Have caused extensive infrastructure damage
- Received significant injury
- Will decline and be removed

Sidewalk replacement due to damage from tree roots

Time for change

Soil management best practices can help restore the natural functions of soils and vegetation in future developments

Ensuring healthy soils, tree and vegetation cover can reduce stormwater impact on natural channels and other infrastructure



Expenses which are a direct result of past development practices can be significantly reduced in future developments by applying soil BMP's

APPENDIX F
RECOMMENDED CREEK EROSION CAPITAL IMPROVEMENT PROJECTS
and
IMPLEMENTATION SCHEDULE

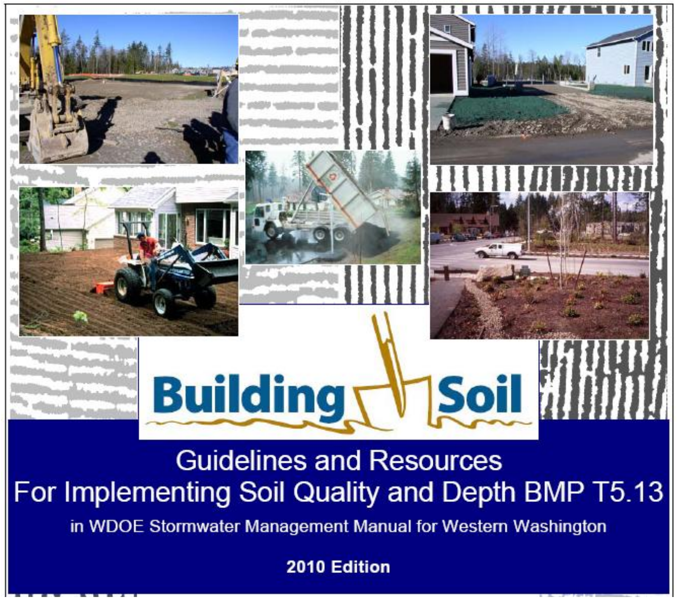
Year	*Priority Creek/Reach*	*Range of Cost of Remedial Works*	*Proposed Capital Forecast Budget*
2007	Wedgewood Creek East Reaches 59-61 Falgarwood (Wedgewood West) Reach 54	$578,400 $198,300	$578,400 (1) $198,300
2008	Wedgewood Creek East Reaches 59-61 Falgarwood (Wedgewood West) Reach 54 Joshua Creek Reach 87a Outfall Major Maintenance	$500,000 $650,000 $100,000 $35,000	$1,285,000
2009	Joshua Creek Reach 87a Fourteen Mile Creek Reach 2 Outfall Major Maintenance	$100,000 $1,000,000 $35,000	$1,135,000
2010	Fourteen Mile Creek Reach 2 Morrison Creek West Reach 37 Sheldon Creek Reach 71 Outfall Major Maintenance	$1,000,000 $150,000 $100,000 $35,000	$1,285,000
2011	Fourteen Mile Creek Reach Reach 5a Clearview Creek Reach 91a Fourteen Mile Reach 75a Morrison Creek Main Reach 49	$150,000 $100,000 $150,000 $100,000 $41,500	$500,000
	TOTAL NEEDS (5 YEARS)	**$4,796,500**	**$4,796,500**

1. Capital Works in Progress (CWIP) funding allocated to 2007 Program.

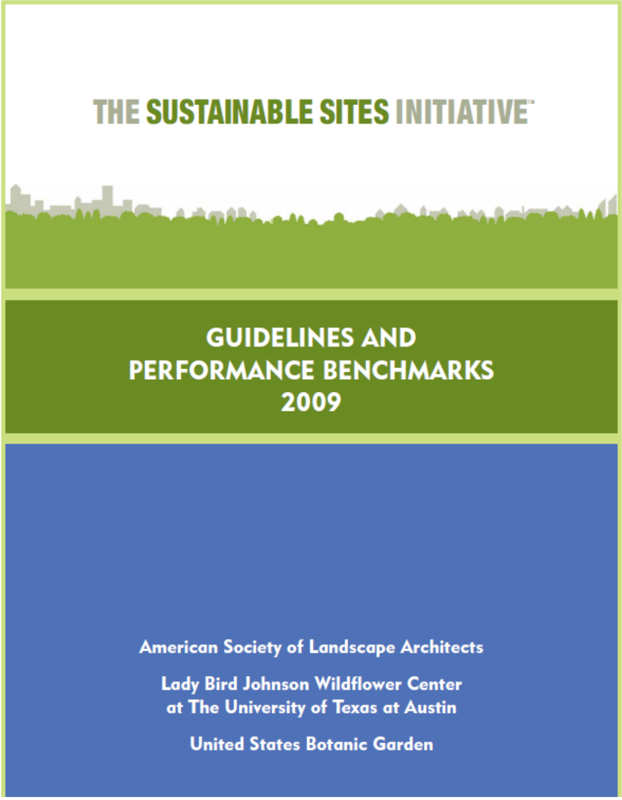
Soil Management Best Practices Guide for Urban Construction

- Recommended minimum standards for post-construction soil quality and depth, BMPs to achieve them and inspection and testing;
- Toronto Remedial Action Plan funding in 2011/12;
- Review of standards and guidelines from several U.S. jurisdictions.

Key resources



Soils for Salmon, 2010,
Western Washington
www.soilsforsalmon.org



Natural Drainage Practice Guidelines for Single Family Residential Development

Amended Soil and
Post Construction Soil Quality and Depth

CITY OF BELLEVUE WASHINGTON

Applies to permits issued through December 31, 2011. Revised June 23, 2011

This guideline is designed to help owners of single family homes meet the City of Bellevue requirements for on-site stormwater management (Minimum Requirement #5) using amended soil. This guideline provides design, construction, inspection, and maintenance guidelines for all projects on single family residential property where Minimum Requirements 1 through 5 only apply. Projects that are also subject to Minimum Requirements 6 and/or 7 must be designed by a licensed civil engineer.

Table of contents

Soil management best practices for preserving and restoring healthy soils

- Leaving native trees, vegetation and soil undisturbed;
- Stripping, stockpiling and <u>preserving</u> existing topsoil on-site for reapplication;
- Restoring post-construction soils in areas to be landscaped to meet minimum soil quality and depth standards.

Recommended soil quality and depth standards

Type of area	Organic Matter (% by dry wt.)	pH	Topsoil depth	Subsoil scarifying	Total uncompacted soil depth
Turf area	5 to 10%	6.0 to 8.0	20 cm	10 cm	30 cm
Planting bed	10 to 15%	6.0 to 8.0	20 cm	10 cm	30 cm
Tree pit	10 to 15%	6.0 to 8.0	60 cm	30 cm	90 cm

Application of the recommended standards

- Should apply to all soils disturbed during construction within a site that will not be covered by impervious surfaces, incorporated into a drainage facility, nor engineered as structural fill or slope and will be maintained in a vegetated state (i.e. landscaped areas), <u>esp. those receiving roof runoff</u>.

Limitations to soil restoration practices

- Should not be implemented on slopes greater than 3:1;
- On slopes between 4:1 and 3:1, slope stabilization practices such as turf reinforcement grids or erosion control matting recommended;
- Should not be undertaken on wet or frozen soils nor in late fall;
- Consideration of shallow underground utilities (e.g. natural gas, hydro, cable lines) and roots of adjacent trees and shrubs – shallower uncompacted soil depths may be warranted.

Soil management best practice options

1. Leave native veg. and soil undisturbed and protect during construction.
2. Strip, stockpile and preserve site topsoil during construction and replace and amend before planting to meet the standard.
3. Amend site subsoil in place to meet the standard.
4. Import a topsoil mixture that meets the standards.

Implementing soil quality and depth standards

- In Ontario there are no requirements to restore healthy functioning soils post-construction;
- Could become part of municipal engineering or urban design standards and CA policies;
- Soil management plans could be required through clearing/grading/fill/site alteration permitting;
- Could take voluntary approach, promote through professional associations, training programs, demonstration and evaluation.

Soil management plans

- Scale drawing of the construction site identifying BMPs;
- Detailing of treatments/products to be used for each disturbed area;
- Volume calculations of compost and stockpiled topsoil or imported topsoil, and mulch to be applied;
- Copies of laboratory analyses of compost and imported topsoil products to be used (required) and pre-construction topsoil quality over the site (optional) documenting at a minimum:
  - Particle size distribution (% sand, silt and clay sized particles);
  - Bulk density;
  - Organic matter content (% by dry weight);
  - pH;
  - Proof the compost meets Ontario guidelines for the production and use as a soil conditioner.

Preparing soil management plans

Step 1: Review site grading and landscaping plans

Step 2: Visit site to determine pre-construction soil conditions

Step 3: Select soil management best practice options

Step 4: Identify amendment materials

Step 5: Calculate amendment, topsoil and mulch volumes

Model SOIL MANAGEMENT PLAN for BMP T5.13
(available as MS Word file at www.SoilsforSalmon.org)

PROJECT INFORMATION Page # ____ of ____ pages
Complete all information on page 1; only site address and permit number on additional pages.

Site Address / Lot No.: ______	
Permit Type:	**Permit Number:**
Permit Holder:	**Phone:**
Mailing Address: ______	
Contact Person:	**Phone:**
Plan Prepared By:	

ATTACHMENTS REQUIRED *(Check off required items that are attached to this plan)*

___ **Site Plan showing, to scale:**
___ Areas of undisturbed native vegetation (no amendment required)
___ New planting beds and turf areas (amendment required)
___ Type of soil improvement proposed for each area
___ **Soil test results (required if proposing custom amendment rates)**
___ **Product test results for proposed amendments**

AREA #______ *(should match Area # on Site Plan)*

PLANTING TYPE ___ Turf ___ Planting Beds ___ Undisturbed native vegetation ___ Other: ______		
SQUARE FOOTAGE OF THIS AREA: ______ square feet		
SCARIFICATION ___ Subsoil will be scarified	___ inches (depth) of scarification needed to achieve finished total 12" loosened depth.	
PRE-APPROVED AMENDMENT METHOD: ___ Topsoil import ___ Amend with compost ___ Stockpile and amend (_____ cu. yds. stockpiled)	____inches of compost or imported topsoil applied X 3.1 *(conversion factor, inches to cubic yards)* _____ = cu. yards per 1,000 sq. ft. X ___ ,000s sq.ft. in this area ____ = cubic yards of amendment → → → → → *(needed to cover this area to designated depth)*	PRODUCT: ______ QUANTITY: ______ CU. YDS.
CUSTOM AMENDMENT ___ Topsoil import ___ Topsoil & compost lift ___ Amend ___ Stockpile and amend (____ cu. yds. stockpiled)	**Attach test results and calculations.** ____ inches organic matter or topsoil import X 3.1 _____ = cu. yards / 1,000 sq. ft. X ___ ,000s sq.ft. in this area ____ = cubic yards of amendment → → → → →	PRODUCT: ______ QUANTITY: ______ CU. YDS.
MULCH	___ ,000 sq.ft. X 6.2 *(conversion, to give 2 inch mulch depth)* ____ = cubic yards of mulch → → → → → →	PRODUCT: ______ QUANTITY: ______ CU. YDS.

TOTAL AMENDMENT/TOPSOIL/MULCH FOR ALL AREAS *(complete on page 1 only, totaling all areas/pages in this Plan)*

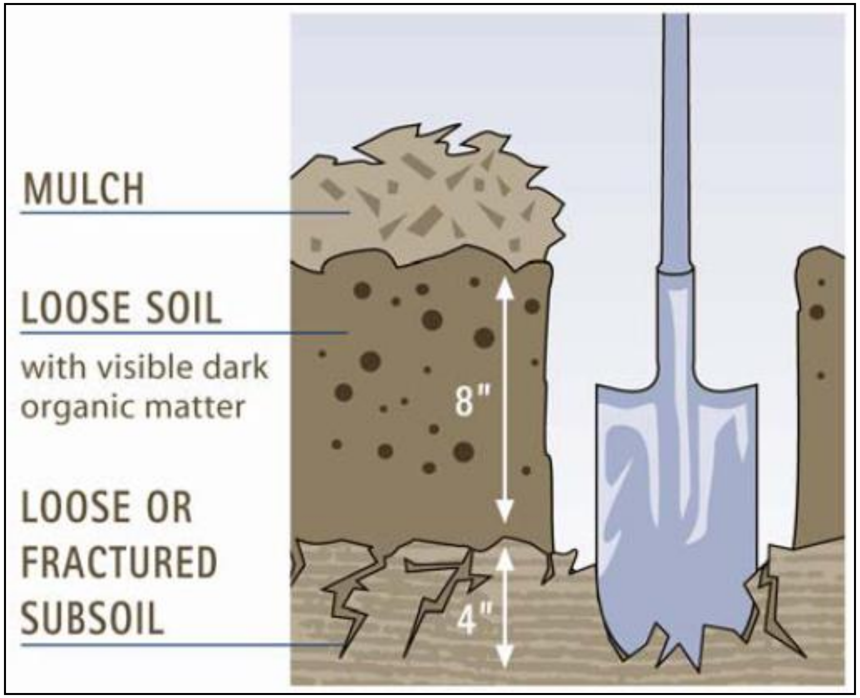
❑ **Product #1:** ______ ❑ **Quantity:** ______ **cu. yds.**
❑ **Test Results:** ___ **% organic matter** ____ **C:N ratio <25:1** (except mulch, or <35:1 for native plants) ____ **"stable"** (yes/no)
❑ **Product #2:** ______ ❑ **Quantity:** ______ **cu. yds.**
❑ **Test Results:** ___ **% organic matter** ____ **C:N ratio <25:1** (except mulch, or <35:1 for native plants) ____ **"stable"** (yes/no)
❑ **Product #3:** ______ ❑ **Quantity:** ______ **cu. yds.**
❑ **Test Results:** ___ **% organic matter** ____ **C:N ratio <25:1** (except mulch, or <35:1 for native plants) ____ **"stable"** (yes/no)

Date:	**Inspector:**	**Approved:**	**Revisions Required:**
Date:	**Inspector:**	**Approved:**	**Revisions Required:**

COMMENTS: ______

Verifying post-construction soil quality and depth

- Native vegetation and soil preservation areas remain undisturbed;
- Provision of the appropriate depth of topsoil (20 cm for turf and planting beds, 60 cm for tree pits);
- Provision of the appropriate total depth of uncompacted soil (30 cm for turf and planting beds, 90 cm for tree pits);
- Placement of 5 to 10 cm mulch on planting beds and tree pits



Verifying post-construction soil quality and depth

Step 1: Compare site conditions with approved Soil Management Plan

Step 2: Inspect delivery tickets for compost, imported topsoil, mulch

Step 3: Verify depth of topsoil and total uncompacted soil depth

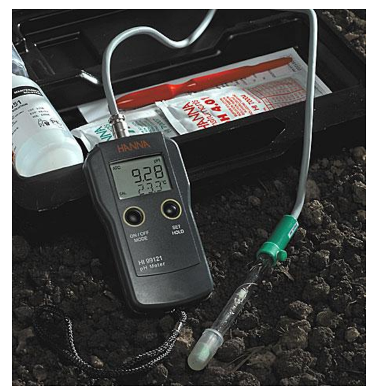
Step 4: Check for soil compaction in several locations

Step 5: Check mulch depth

Step 6: Record results on Field Inspection Form

Next steps

- Develop implementation tools (soil amendment calculator, template specifications for construction contracts);
- Half or full day training courses on guide content;
- Field demonstrations and effectiveness evaluations (cost, runoff reduction, plant growth/health);
- Further consultation on tools for effective implementation.



Acknowledgements

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REMEDIAL ACTION PLAN

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Pêches et Océans Canada

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