The State of the Science & Practice using Urban Trees as a Stormwater Control Measure

PRESENTED BY:
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APWA Phoenix AZ

8.1”/Type 2

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5 KEYS to a SUCCESSFUL URBAN FOREST
Become Part of Stormwater System

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4. SHOW STORMWATER VALUE of TREES
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Trees Require Portion of Stormwater Budget

Does it Rain? or Storm?
Loam? Sand? Rock?

USA Mainly Storms
Type II

Europe
Mainly Rain
Type 1A

Sand, Rock, Loam
North of the Alps & Pyrenees

Loam Here

What's So Great About Big Trees?

Stormwater Interception by Hackberries versus Age of Tree

150 gal.
Year 5

5000 gal.
Year 40
Actual conditions: Average street tree has access to between 0.9 m³ (32 ft³) to 1.8 m³ (64 ft³) of soil.

Soil & Canopy Size?

Pride & Joy

A “Special Tree”...

Spilled Diesel?

Hours of Idling Machines?

Concrete & Sheetrock Soil Amendments?

String Trimmer Bark Treatments?

Deep Trunk Immersion?

Once Yearly Watering?

Salt Spray Foliar Feedings?

&

Ran out of Money?

MSP MN: Honeylocust (Gleditsia triacanthos)
Zone 4; Type II Storms; 31” Annual Precipitation
Let’s End Magical Thinking about Trees

Abracadabra!
Ta Da!

*Peter MacDonagh
The Kestrel Design Group

KEY #1: LARGE (>1,000 CF) ROOT SOIL VOLUME = 95% GOOD TREES

Walt Disney World Orlando FL
USDA Zone 9; Type III Storms; 51” Annual Precipitation

- Define Tree Success: Good, Fair, Poor, Dead
- Relationships: Soil Vol & Tree Condition
- Test Applicability: Soil Vol Recommendations

GOOD CONDITION
- 100% of Trees in 1,500 CF (Cubic Feet)
- 95% of Trees in 1,000 CF
- 84% of Trees in 500 CF
- 65% of trees in 100 CF

Grabosky, Trowbridge and Bassuk (2002)

"Ideal" Conditions

1 in the AIR 2 in the GROUND
1,000 CF Per Tree
Blue: # of cities with this minimum soil volume standard

Median = 875 c.f.
Average = 760 c.f.

Minimum Soil Volume Standards
Research vs. Adopted

Minimum soil volume for equivalent of 30' diameter tree (c.f.)

METASTUDY: RESEARCH RESULTS - Minimum Rootable Tree Soil Volumes based on Field Studies or Water or Nutrient Requirements vs ADOPTED POLICY STANDARDS - Minimum Tree Rootable Soil Volume Standards in North American Municipalities


Median = 1500 c.f.
Average = 1507 c.f.

KEY #2: SPECIES DIVERSITY (<5% UTC per GENUS)

What We Had & Lost
SuperTrees that Can Grow Anywhere?
BUT Can't survive monocultures

American Chestnut:
Chesnut Blight

American Elms:
Dutch Elm Disease

American Ash:
Emerald Ash Borer

In the Late 1800s, American Elm made up 90% of the boulevard trees in Minneapolis

1963: First Dutch Elm Disease Detected in Trees
1977: 31,000 Elm Trees Removed
1978: 20,000 Elm Trees Removed
2004: 10,000 Elm Trees Removed
2005-2015: 2,700 Elm Trees Removed Annually
There is a correlation to loss of tree canopy and water clarity. Following the removal of Elm trees during the late 1970s and early 1990s, there was a marked decrease in water clarity depth in the Chain of Lakes, yet building development stopped in 1953 throughout the contributing sub-watershed around Lake Calhoun.
Relationship of Tree Species Diversity and Water Quality

Dutch Elm Disease & Emerald Ash Borer

Elm Canopy Loss

Potential Ash Canopy Loss

KEY #3: DIRECT STORMWATER TOWARDS TREES

Sheet Flow / Curb Cut
KEY #4: SHOW STORMWATER VALUE of TREES
Directly Connected Impervious Drainage Area (DCIA)

NCSU Research

- Pond liner
- Runoff from street directed via a catch basin & sump into distribution pipe into the Silva Cells (see A)
- Underdrains with upturned elbows slow water, denitrify, then direct runoff into the Wilmington's MS4 (see B)

Water Quality Results

Silva Cells at Wilmington DARKER vs. Mean Traditional Bioretention Results From Peer Reviewed Literature LIGHTER
Significantly less bypass is expected at typical Silva Cell installations because:

1) Pond liner was used so no exfiltration was possible – for typical Silva Cell installations pond liner is NOT so exfiltration is possible.
2) Drainage area to these Silva Cell systems (1 tree per 0.1 acre) was significantly greater than typical installations.

Despite pond liner and large drainage area, mean peak flow decreased 62% from 0.13 cfs to 0.05 cfs.

Full ET credit for a mature tree is given if 2 c.f. of soil is provided per 1 s.f. of canopy at planting.
Example Tree Credit Calculation Sample Scenario

http://stormwater.pca.state.mn.us/index.php/Trees

- Watershed: 270' long x 20' wide sidewalk (0.12396 acres)
- Tree SCM: 266' long x 16' wide x 2.58' deep
- Silva Cells with 9 large trees, 30' oc

BMP Parameters
Continued on next screen

DEPTH
2.58 ft.

AREA
4256 s.f.

9 TREES

Example Tree Credit Calculation Sample Scenario

http://stormwater.pca.state.mn.us/index.php/Trees

Chesapeake Bay
Tree Canopy SW Credits: 2016

Update Forest Conservation;
Individual Tree Planting;
Existing Tree Rescue

B3 (Minnesota Sustainable Building Guidelines)

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Case Study: Marquette & 2nd Avenues (MARQ2) Busway
Minneapolis, Minnesota
Stormwater Trees with Sidewalk Runoff to Pervious Pavers

- Average soil volume per tree: 650 ft³
- Catchment: 5.15 acres
- 167 Trees
- Total Silva Cells: 4,909 decks, 9,818 frames
- Installation: 2008-2009
- USDA Zone 4
- Type I Storms
- No Dry Season
- 13 Days >90°F, 11 Days <0°F
- Cloud Cover: 52% - 92%

Project Designer: SEH and URS
Technical Consultant: Kestrel Design Group

Overview of Yearly Growth:
2010-2013: 4' taller, 5.4' wider
Case Study: 2nd Avenue Streetscape, Calgary, Alberta; 2013
Stormwater Trees with Streetwater Runoff to Curb Cuts into Raingardens

• USDA Zone 3
• Type II Storms
• Annual Precipitation: 16.5" (422 mm)
• Dry Season
• 5 Days >90F, 17 Days <0F
• Cloud Cover 61% - 83%
• Average soil volume per tree: 603 gallons
• Installation: June 2013
• Project Design Team: Kestrel Design Group, DeepRoot, Calgary WR, Larson Engineering

Image courtesy City of Calgary

Manhattan NYC Lincoln Center; 2009
Trees in Loam Under Suspended Pavement......
5.5 Years Old 6" Caliper Average 600 cf of loam per tree
No transplant shock
>8"mm twig extension in 1st Season (2006)
>3"/762mm twig extension in 2nd Season
>5"mm twig extension in 3rd Season

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Trees Managing Stormwater at Scale

Largest Waterfront Project in the World

Trees / Rain Water and Silva Cells
Urban Streets
Infiltration
Structural Cells and Water Storage

Phase 1 Installed: 1,300 trees
All Phases: 16,800 trees

16 trees per acre capture
-1"/24 hour storm in: Soil
-16 trees @ 22" DBH capture
1.8"/24 hour storm in: Soil & Interception

Waterfront Toronto

Waterfront Toronto: Sugar Beach: 2009

2014
29 Year Old Trees in Suspended Pavement

Bartlett Tree Labs; Tom Smiley 2014

Suspended Pavement
Charlotte, NC – 1985
Tyron St. (29 years)

Willow Oaks:
40mm (19 inch) DBH
21.7m (91 feet) Tall
19m³ (700ft³) of loam soil / tree
98% survival rate (167/170)

Designed by McSween

41.6”/Type 3

San Francisco: Coastal Redwoods 1972-2014
42 Years = 120+ ft tall

47 Year Old Trees Loam under Suspended Pavement
Christian Science Center, Boston, MA

Little Leaf LIndens
700 c.f. of loam per tree average
100% Success Rate
Sasaki & Assoc. 1987

43.8”/Type 3
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Contact Information:
peter@tkdg.net

http://stormwater.pca.state.mn.us/index.php/Trees

Urban Trees MN Manual:
http://www.deeproot.com/products/silva-cell/case-studies

Love Tunnel Railway, Klevan, Ukraine

Case studies:
References


Completed Street – perspective view

Boulevard - Underground Details

Underground Assemblies

1. Engineered Fill
2. Continuous Trench

3. Sub Drain

4. Utilities - Telecom
8. Soil Cells

9. Rain Water Pipes

10. Growing Medium
### Cumulative Percent Removal by Depth

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Data on bioretention removal rates of pollutants such as ammonium and total phosphorus is variable, so has not been included here. Adapted from Prince George's County Bioretention Manual.