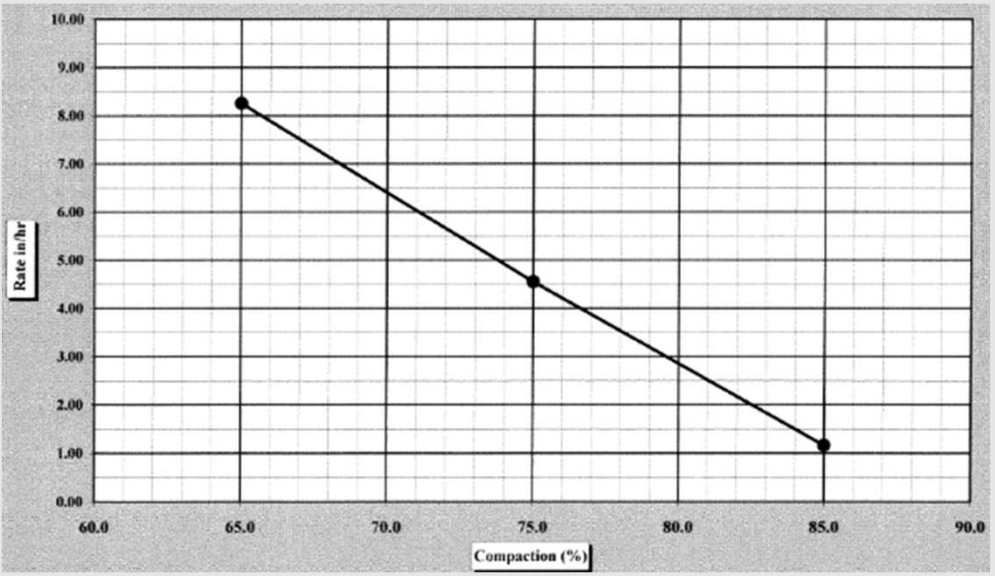
deeproot

Trees, Stormwater, and Suspended Pavements

Research and Reality

Compaction, Filtration and Plant Health

Infiltration reduction

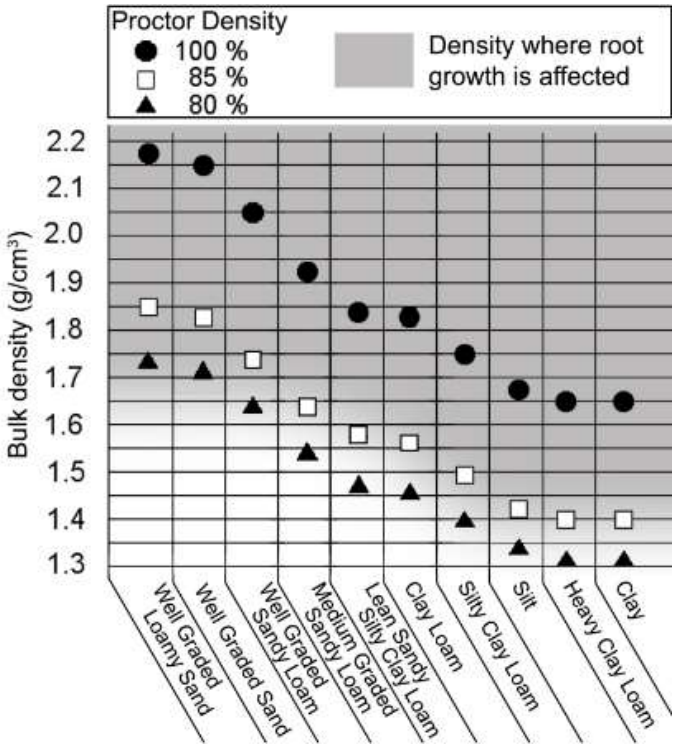


Source: www.bae.ncsu.edu/stormwater

Compaction affects infiltration rate of soil and plant growth

Suspended pavement mitigates both issues

Root Restriction



Source: James Urban; Up by Roots;
Adapted from Daddow and Warrington USFS 1983

What is Suspended Pavement?

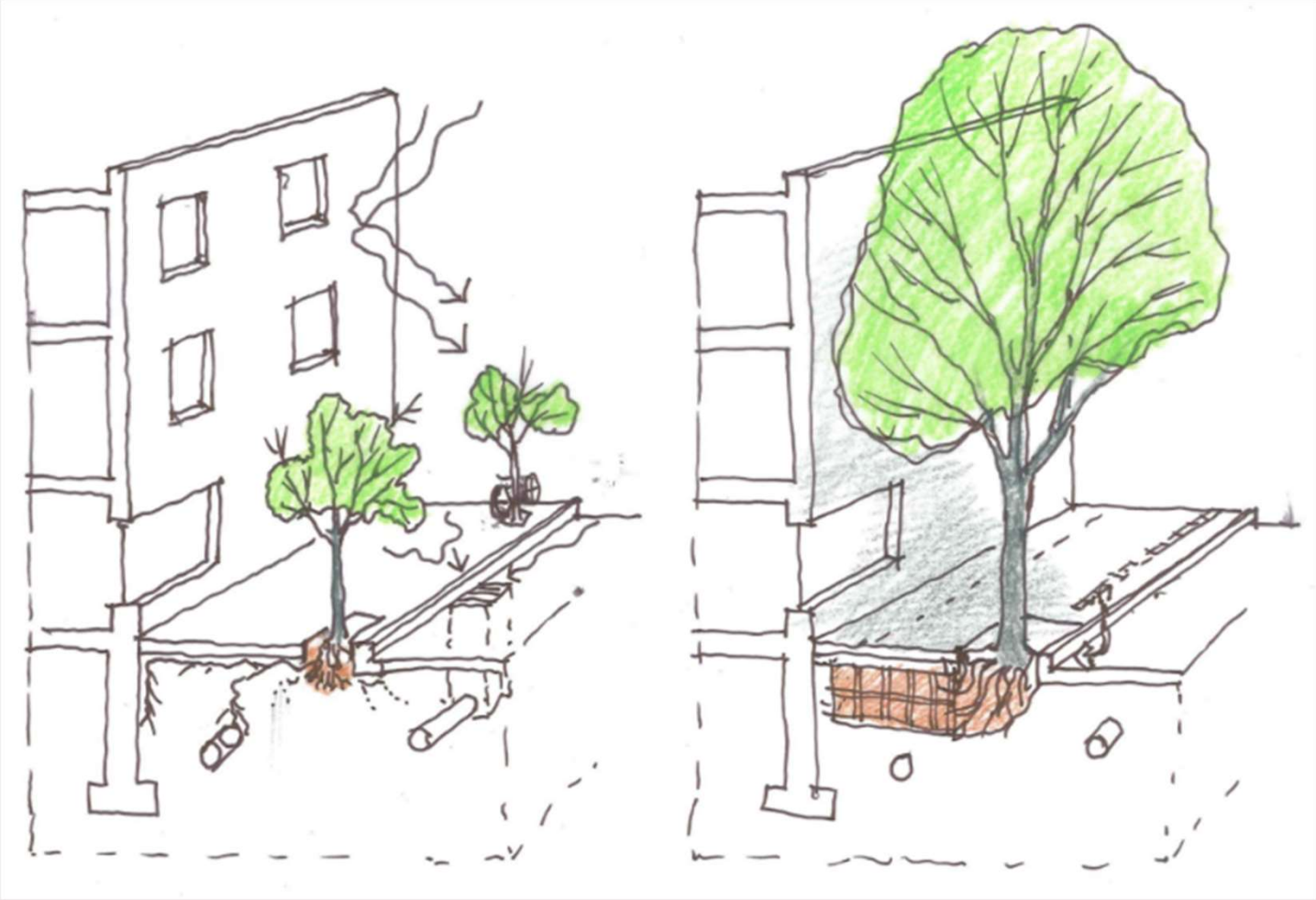
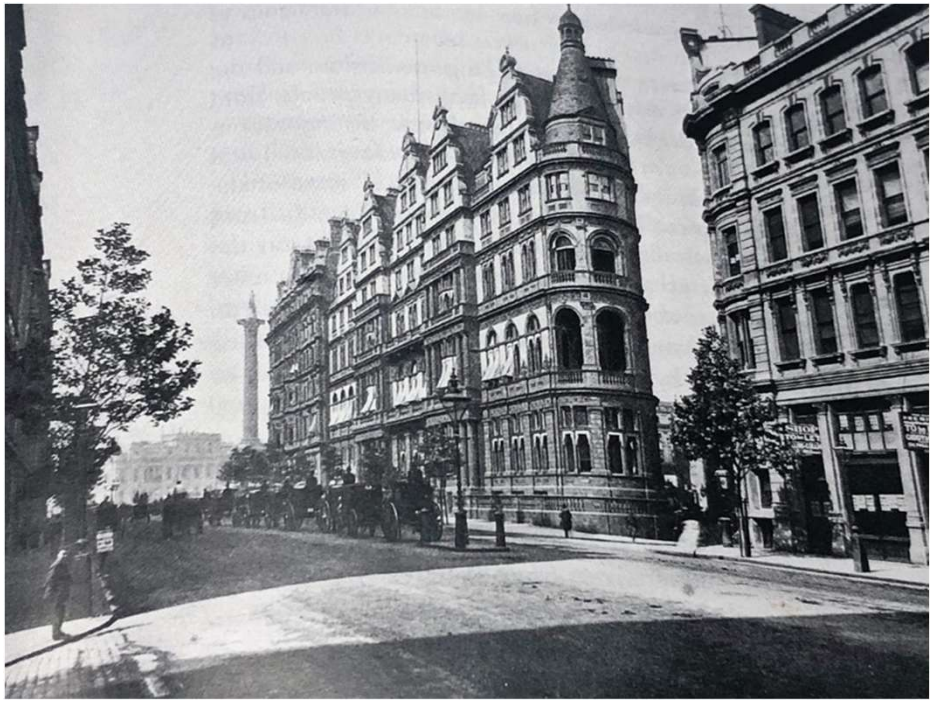


Image: James Urban

Northumberland Avenue, London UK 1898- 2018

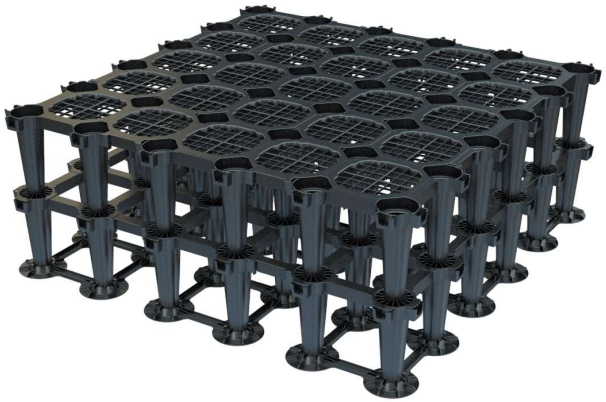


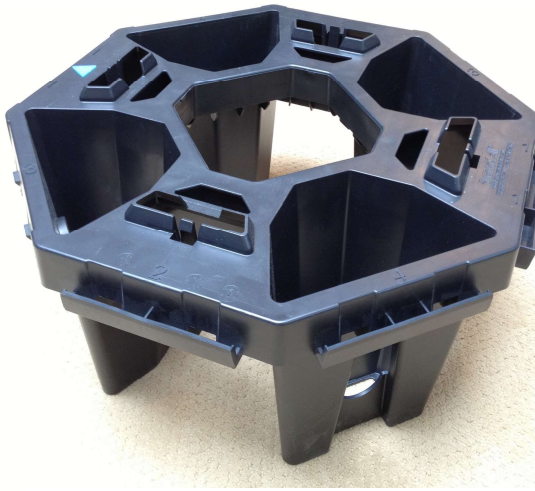
Courtesy of Mark Johnson: Street Trees in Britain- a History" Windgather Press, 2017

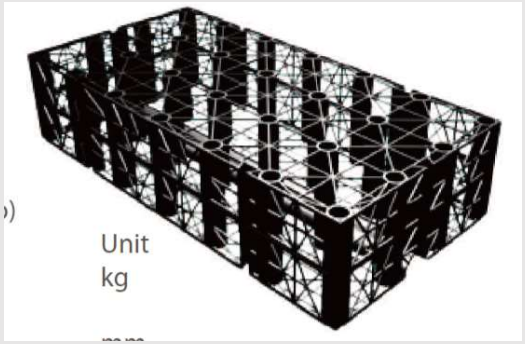
Christian Science Center, Boston, MA; 1968

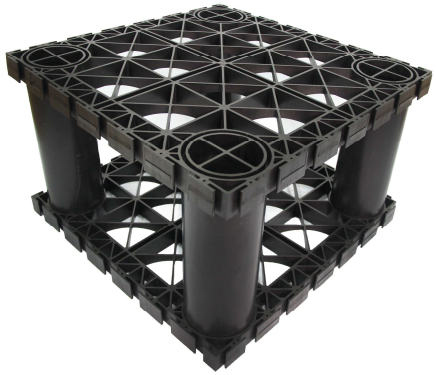
Structural Cells- Approx. 15 Types

Only Soil Cell Made in North America





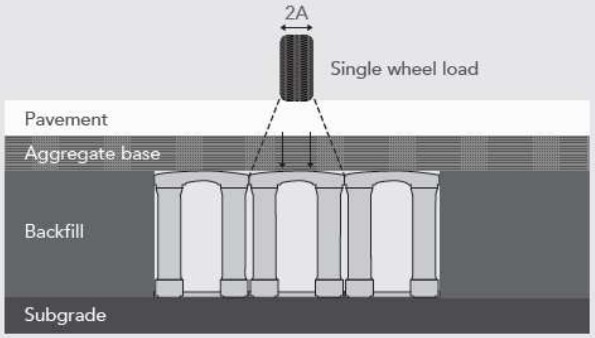




Pay attention to specs

ULIMATE WHEEL LOAD BY STANDARD PAVEMENT TYPE

The table below provides the maximum load that can be on any single wheel (tire), or per axle, for a given pavement section, assuming tires have a contact area equal to either the AASHTO H-20 standard of a 14.25" radius or the AASHTO HS-20 standard of a 10"x 20" rectangle. For more details, please refer to the Silva Cell 2 Engineering Report and Testing Conclusions.



Some configurations are untested

Silva Cell 2 System Type	Traffic Loading Standard	Pavers 3.15" pavers 1" sand base 12" of aggregate		Asphalt 4" of asphalt 12" of aggregate		Concrete 4" of concrete 4" of aggregate		Pavers with Concrete 2.36" pavers 5" concrete	
		Wheel	Axle	Wheel	Axle	Wheel	Axle	Wheel	Axle
1X	H-20	30,200 lbs	60,400 lbs	40,600 lbs	93,200 lbs	34,900 lbs	69,800 lbs	38,600 lbs	77,200 lbs
	HS-20	31,800 lbs	63,600 lbs	48,700 lbs	97,400 lbs	35,900 lbs	71,800 lbs	41,100 lbs	82,200 lbs
2X	H-20	33,200 lbs	66,400 lbs	51,200 lbs	102,400 lbs	38,300 lbs	76,600 lbs	42,200 lbs	84,800 lbs
	HS-20	34,900 lbs	69,800 lbs	53,500 lbs	107,000 lbs	39,500 lbs	79,000 lbs	45,200 lbs	90,400 lbs
3X	H-20	28,200 lbs	56,400 lbs	43,500 lbs	87,000 lbs	32,600 lbs	65,200 lbs	36,000 lbs	72,000 lbs
	HS-20	29,700 lbs	59,400 lbs	45,500 lbs	91,000 lbs	33,600 lbs	67,200 lbs	38,400 lbs	76,800 lbs

PSI is not an accurate measure of load

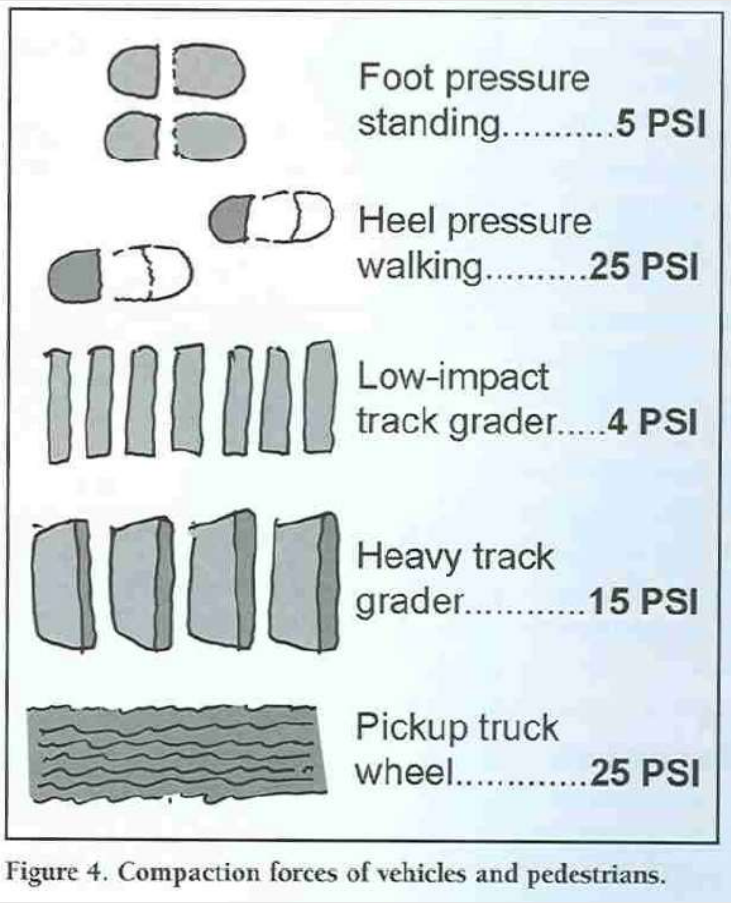


Figure 4. Compaction forces of vehicles and pedestrians.

False Creek Esplanade, Vancouver, BC 2008

False Creek Esplanade, Vancouver, BC-2008-2017

Selected NY Projects

Julliard School (65th Street, NYC) 2008-2018

Lincoln Center Bosque NYC 2008-2018

East Midtown Greenway 2021-2023

East Midtown Greenway 2021-2023

Riverbank West, 2018

February

July

Plaza de las Americas NYC 2015-2018

Hunter’s Point, Queens NYC

2019: Hunter’s **Point South** wins **national ASLA Honor Award** for Design “The jury applauded the designers for demonstrating that the ‘highest standards of design excellence and the strongest environmental practices are fully compatible’ and that ‘public spaces built by public agencies can at once look good, serve public needs, and be successfully resilient.”

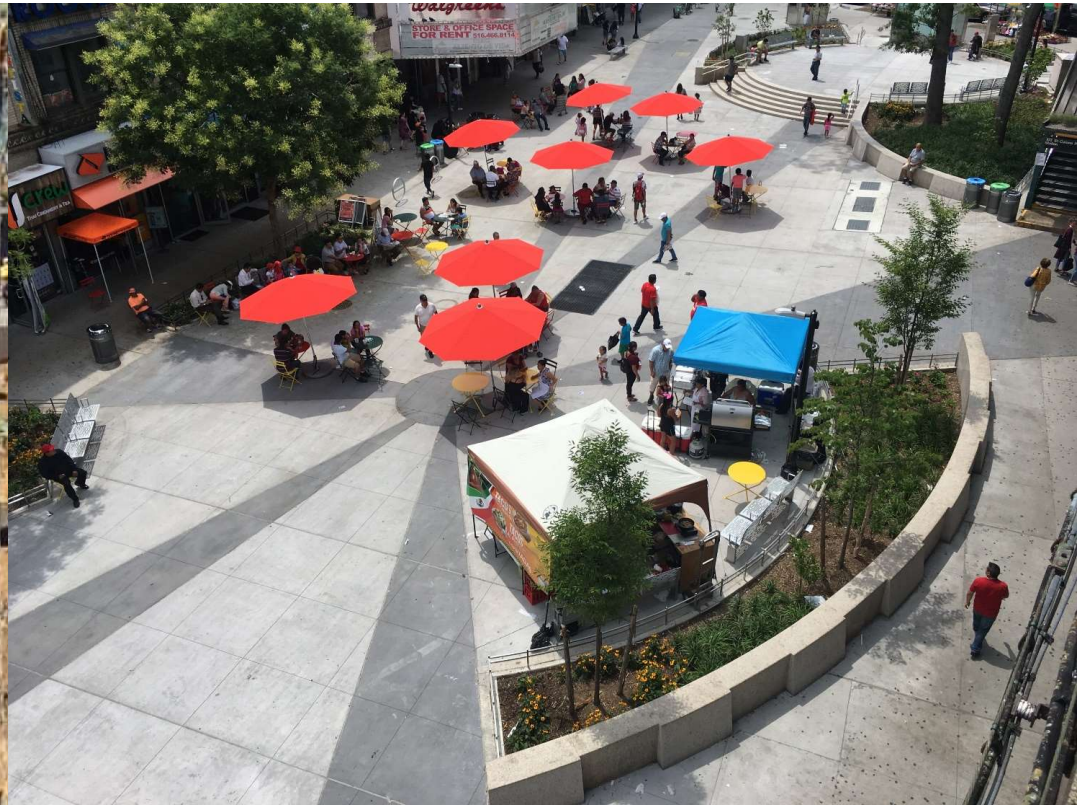
NYC Environmental Protection

NYC/EDC

NEW YORK STATE

Hunter’s Point Long Island City, NY 2015-2017

Corona Plaza, Queens NYC 2016-2018



PS 78, Bronx NYC 2010- 2017

PS78 Bronx NYC 2010-2017

1 Ridgefield Road, Yonkers NY 2013-2017

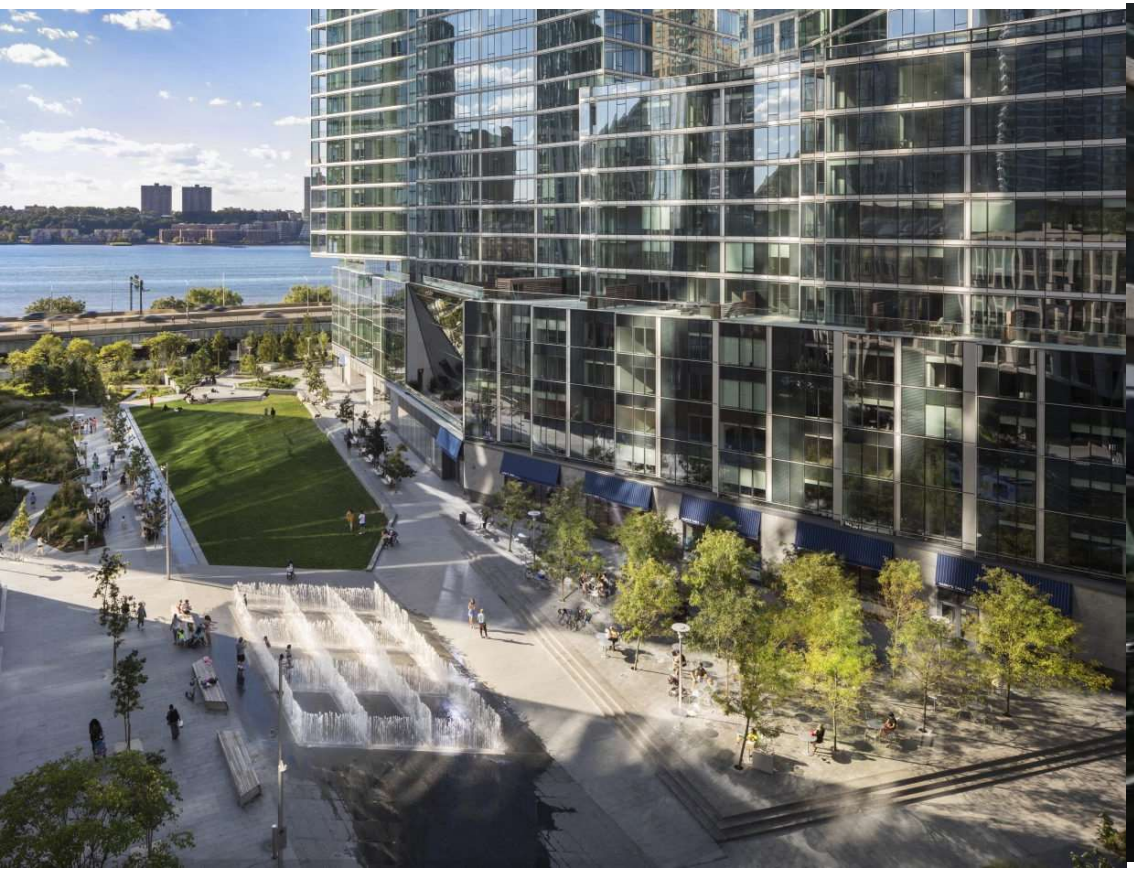
Arthur Ashe Stadium NYC 2016-2019

Cooper Hewitt Museum NYC- 2015-1018


Metropolitan Museum of Art NYC, August 2019

University Avenue, Syracuse, NY 2012-1016

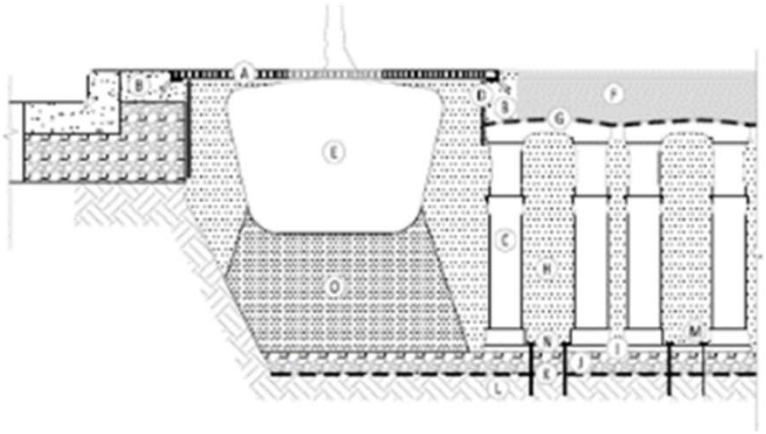
Waterline Square, NYC

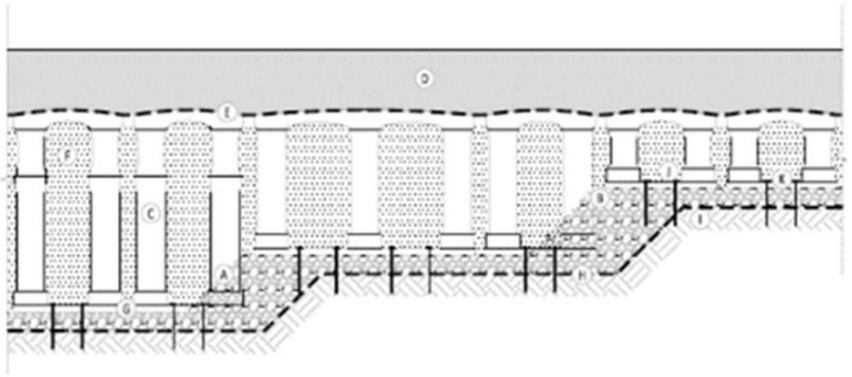


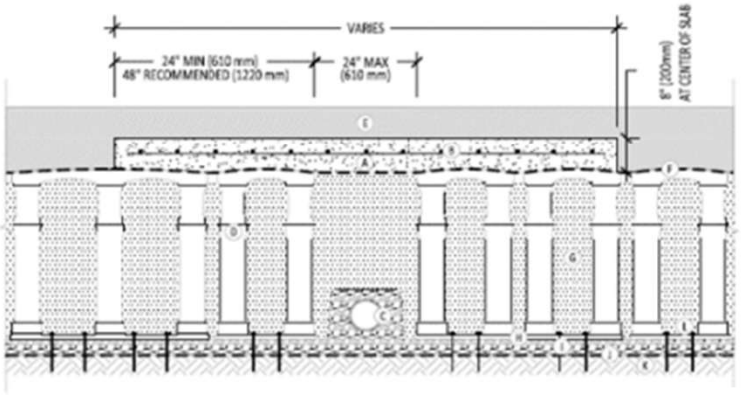
- Photo by Elizabeth Felicella

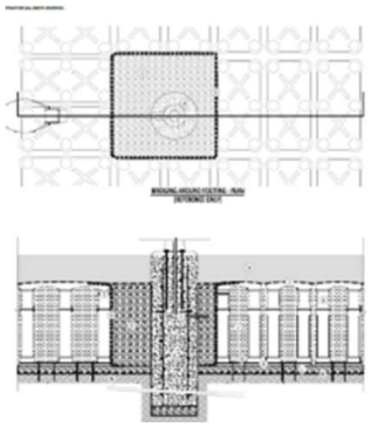
Utility Installation, Maintenance and Repair

Incorporation of Utilities detailing







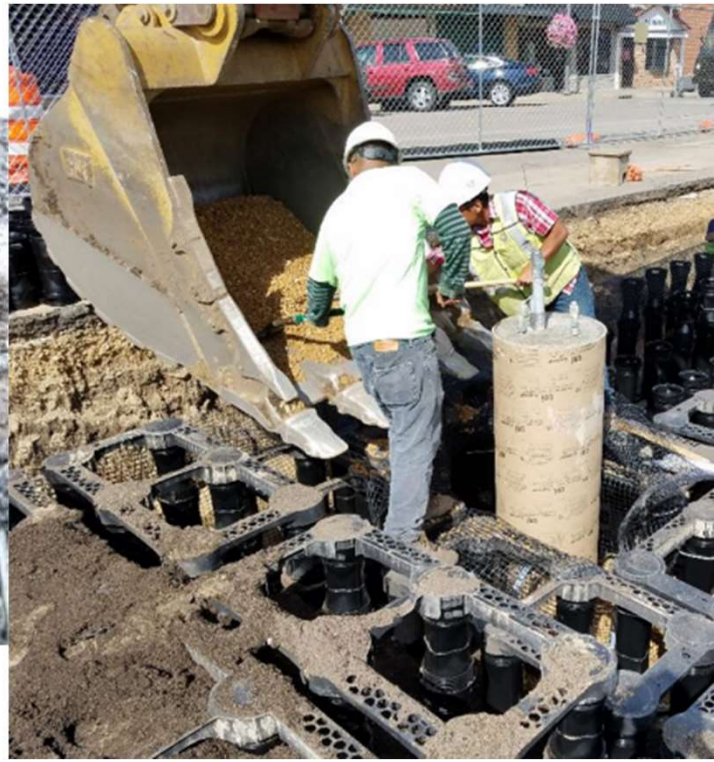


Independent stacking units

Unconnected design enables:

- **Ability to field-fit Soil Cells by adjusting spacing**
- **Ability to limit damage of unplanned excavation**
- **Easy removal for future utility work**

Incorporation of Utilities Installation & Planning



Emergency Water Main Repair (Toronto, ON)

In an emergency you can dig right through the Soil Cells – treat them like dirt as they are 90% dirt.

Emergency Water Main Repair (Toronto, ON)

The adjacent Soil Cells are not damaged or disturbed as they are not connected.

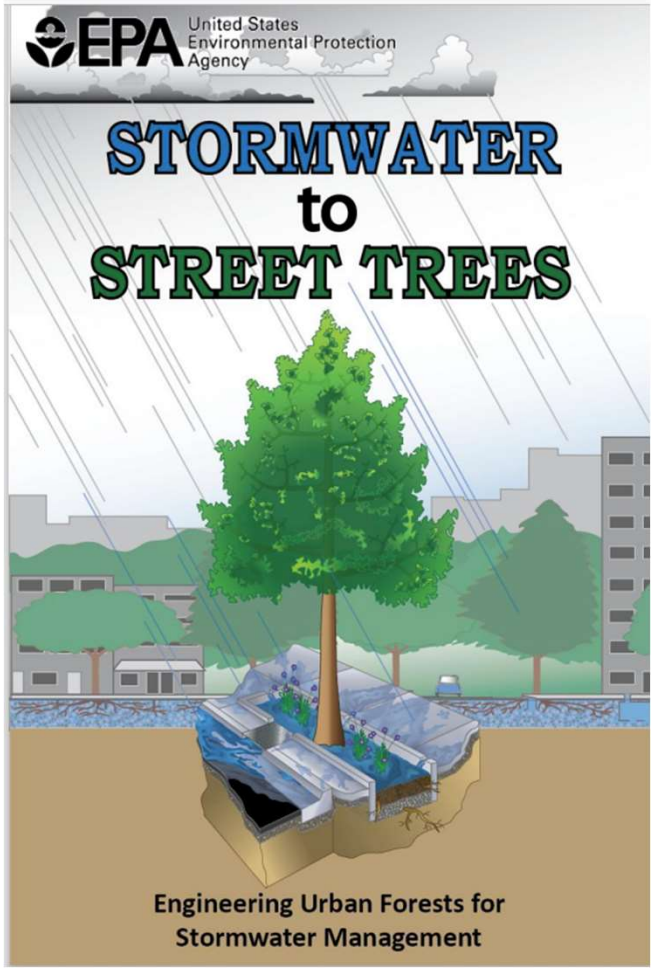
- No cross beams
- to interfere with
- Utilities

- Up to 14” Pipe

Stormwater Applications

Recommended by EPA

Structural cell installation in an urban streetscape; frames and decks pictured (below). Completed installation showing trees growing in the structural cell system (right). Photos courtesy of Deep Root Partners, L.P.

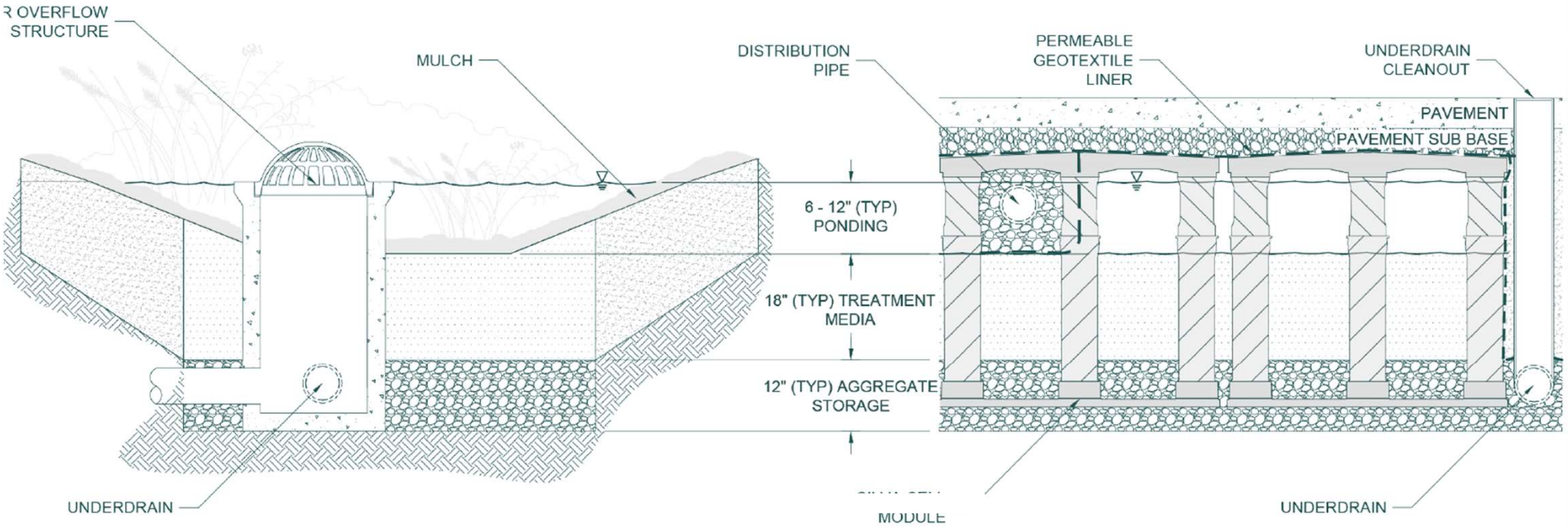


Soil Cell as Equivalent to Bioretention

Bioretention Under Pavement

Typical Bioretention

Soil Cell Bioretention



BIORETENTION NOTES:

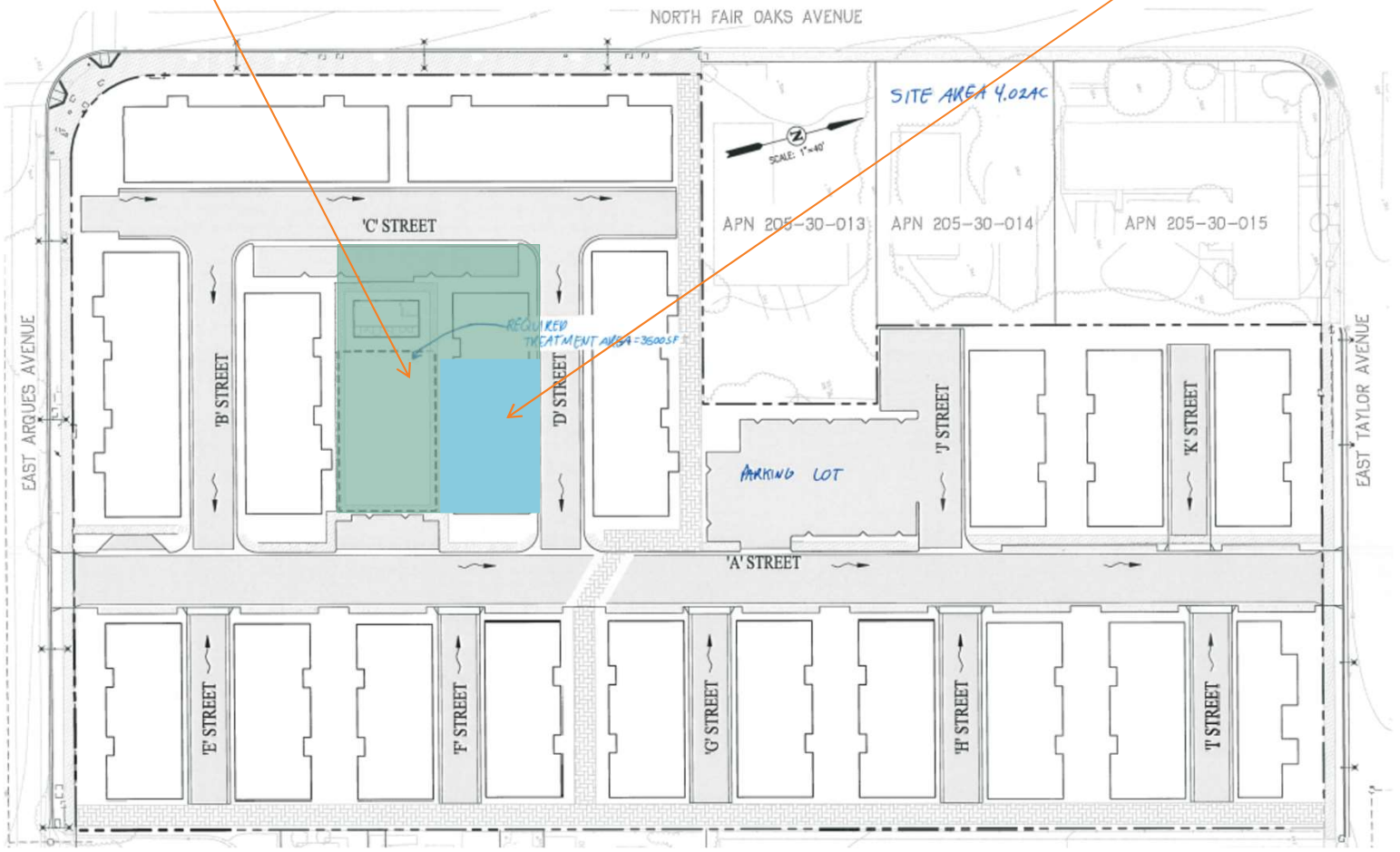
- TYPICAL BIORETENTION CROSS SECTION ADAPTED FROM SAN FRANCISCO PUBLIC UTILITIES COMMISSION (SFPUC) TYPICAL DETAILS (2017)

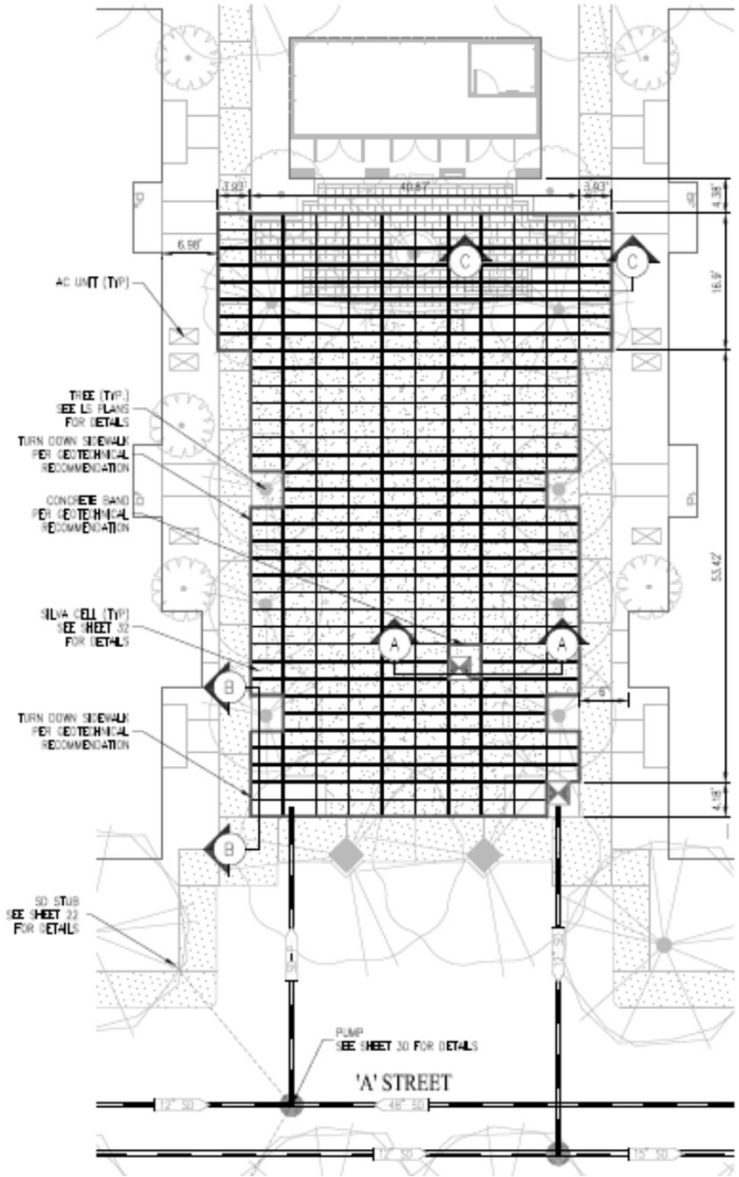
East Arques Ave, California

4 acres catchment area

Original Stormwater Pond with setbacks and berm

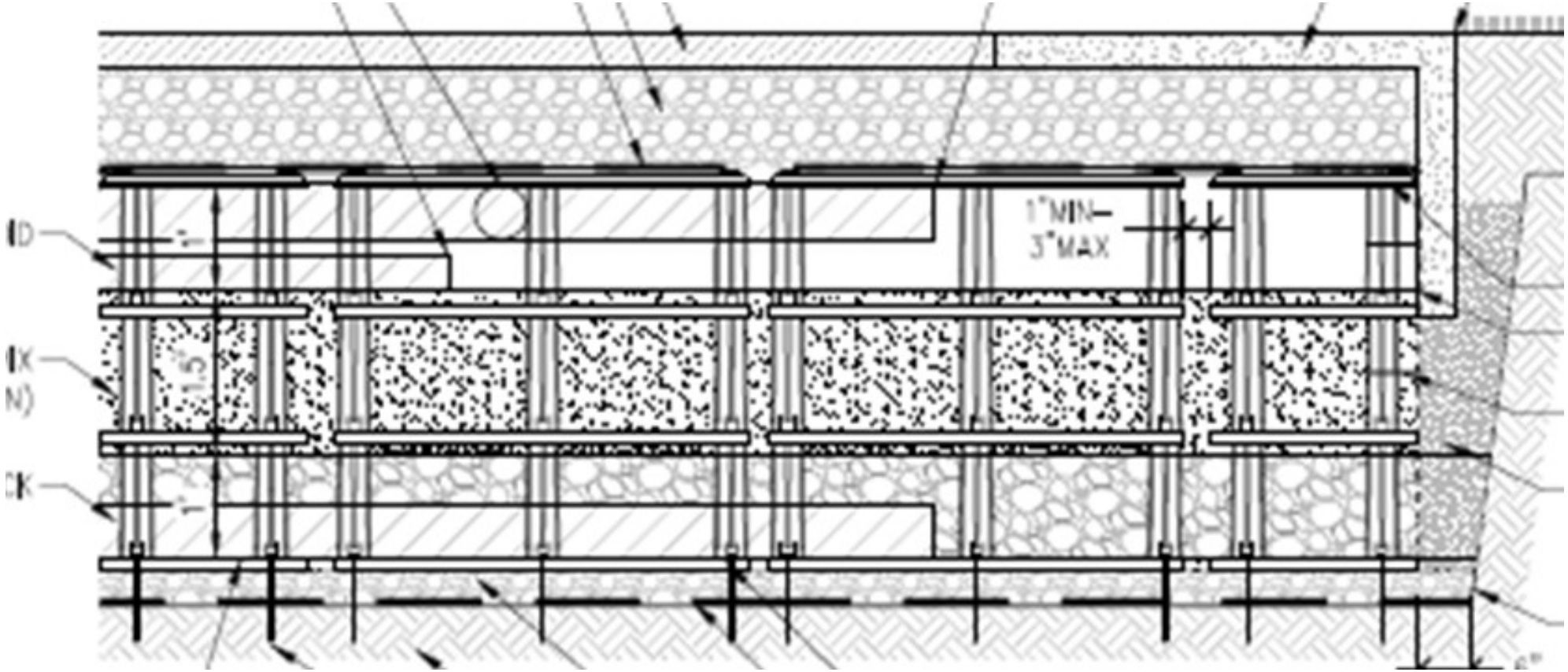
Soil Cell Central Plaza and Stormwater Treatment Area (3500ft2)





Soil Cell Plaza

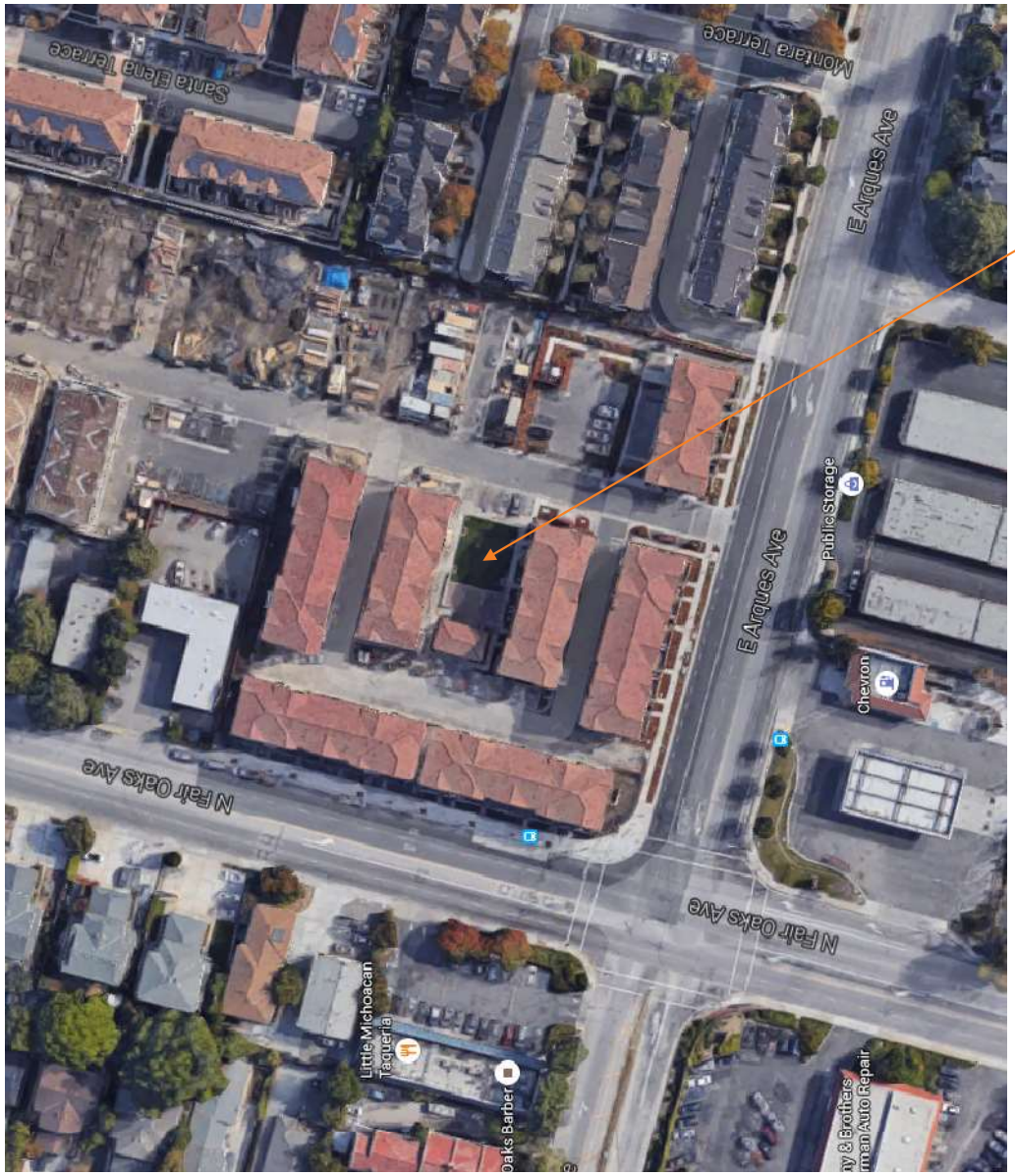
East Arques Bioretention Section




CAT
330D
CAT
Sanco
PIPELINES

Ponding Space

Overflow Structure



Plaza and Trees

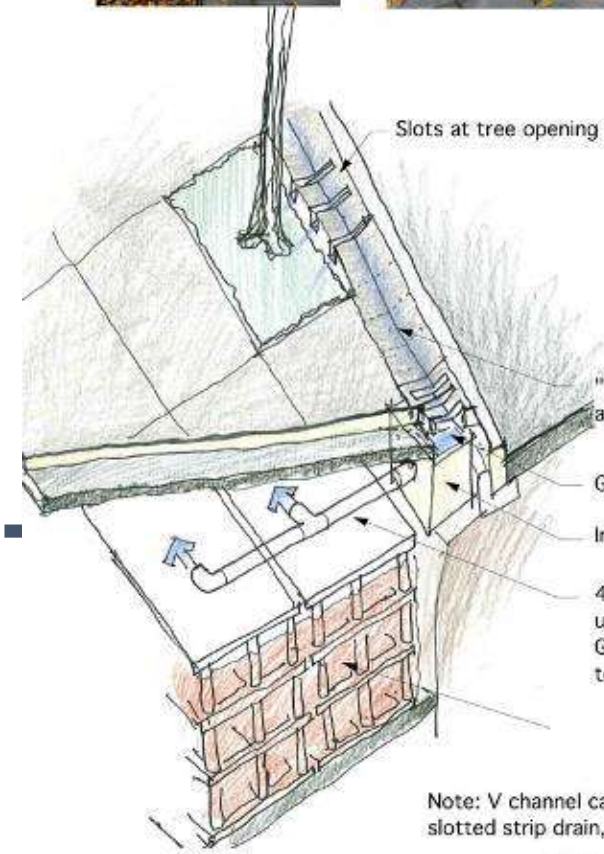
2014


2016

Pervious pavers

Pervious pavers

Pervious pavers
and slot drain through paving



Note: V channel can also be a trench drain, slotted strip drain, or curb inlet

Water Harvesting Options

Inlet with grit basin

Trench drain

Trench drain

Slot drain

Water In

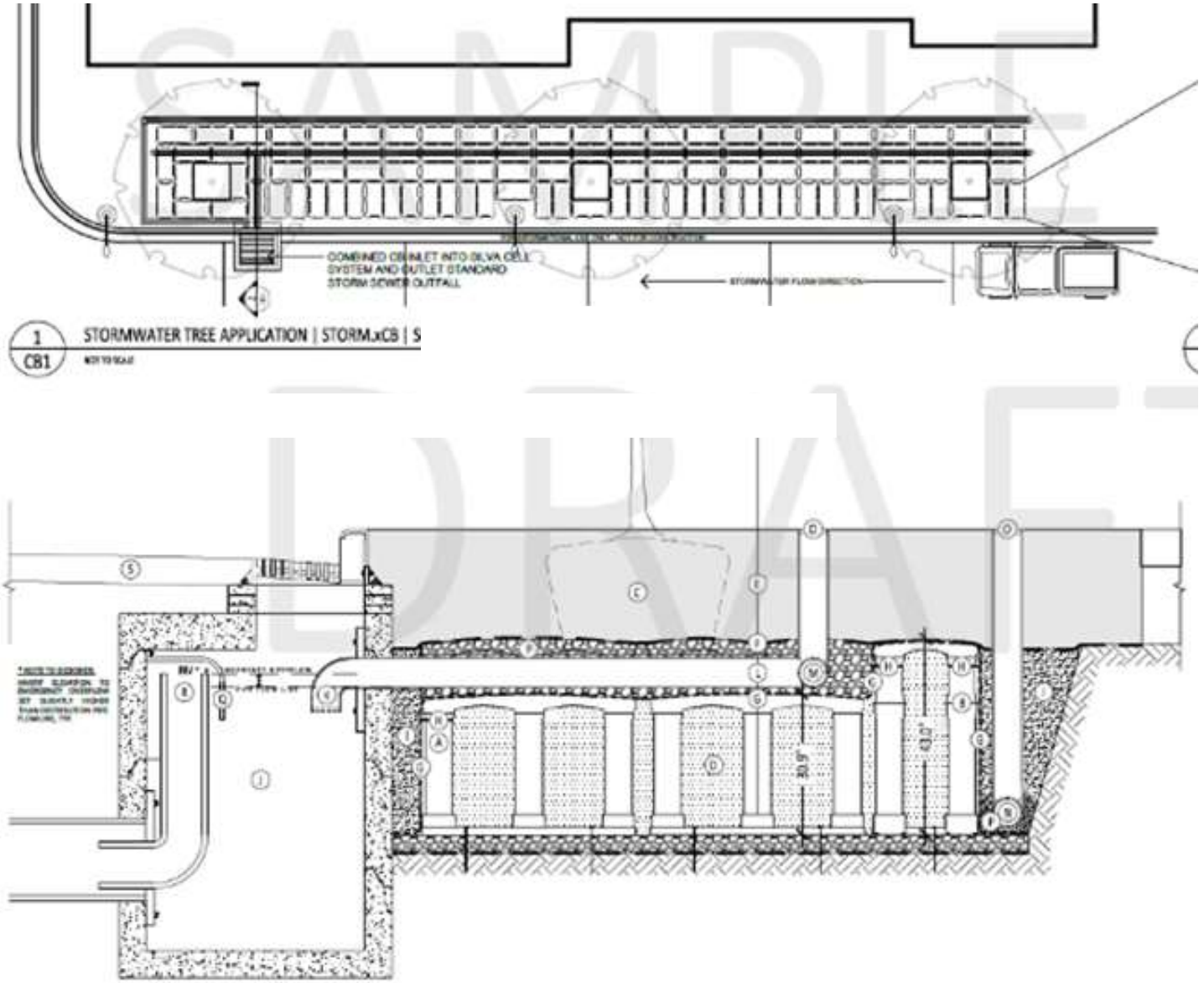
Curb inlet

Open jointed paver
water interception
into a planted area

Water Harvesting Options

Storm Water Detail, Typical

Soil Cell



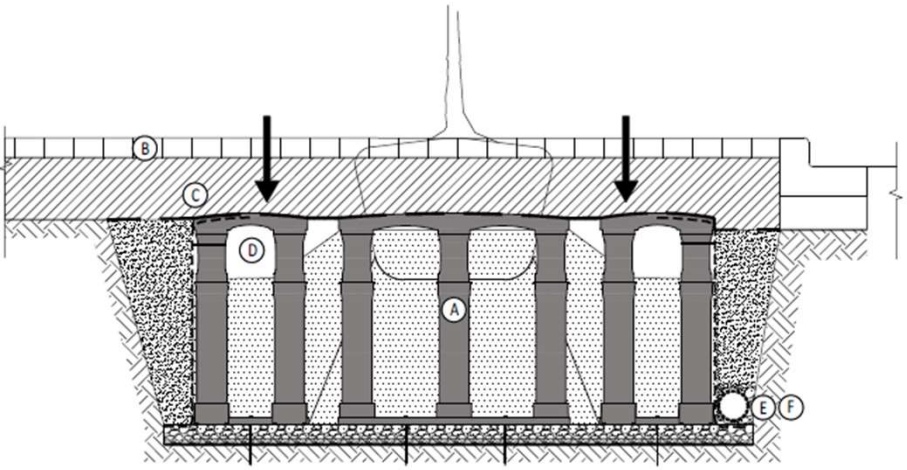
Under-drain
and cleanout

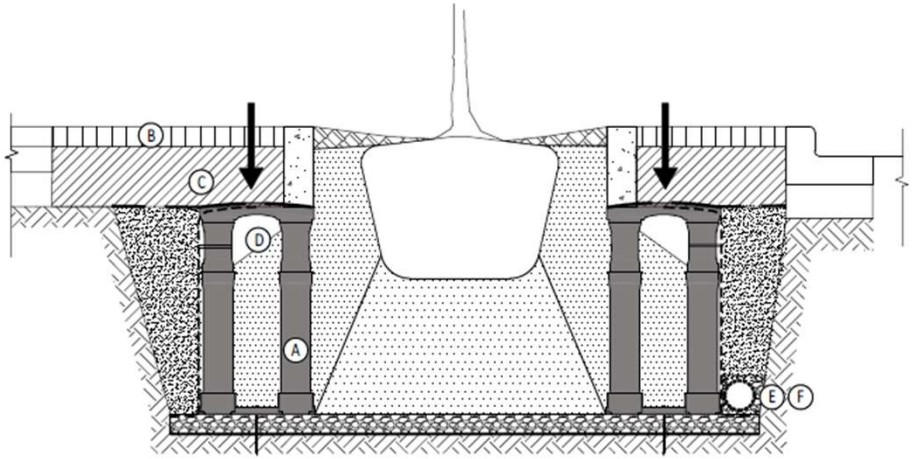
Lower cell in the back row will support the Stormwater distribution pipe


CAT
SPORTCHEK
Chinook Plaza
PARKING
Unicon

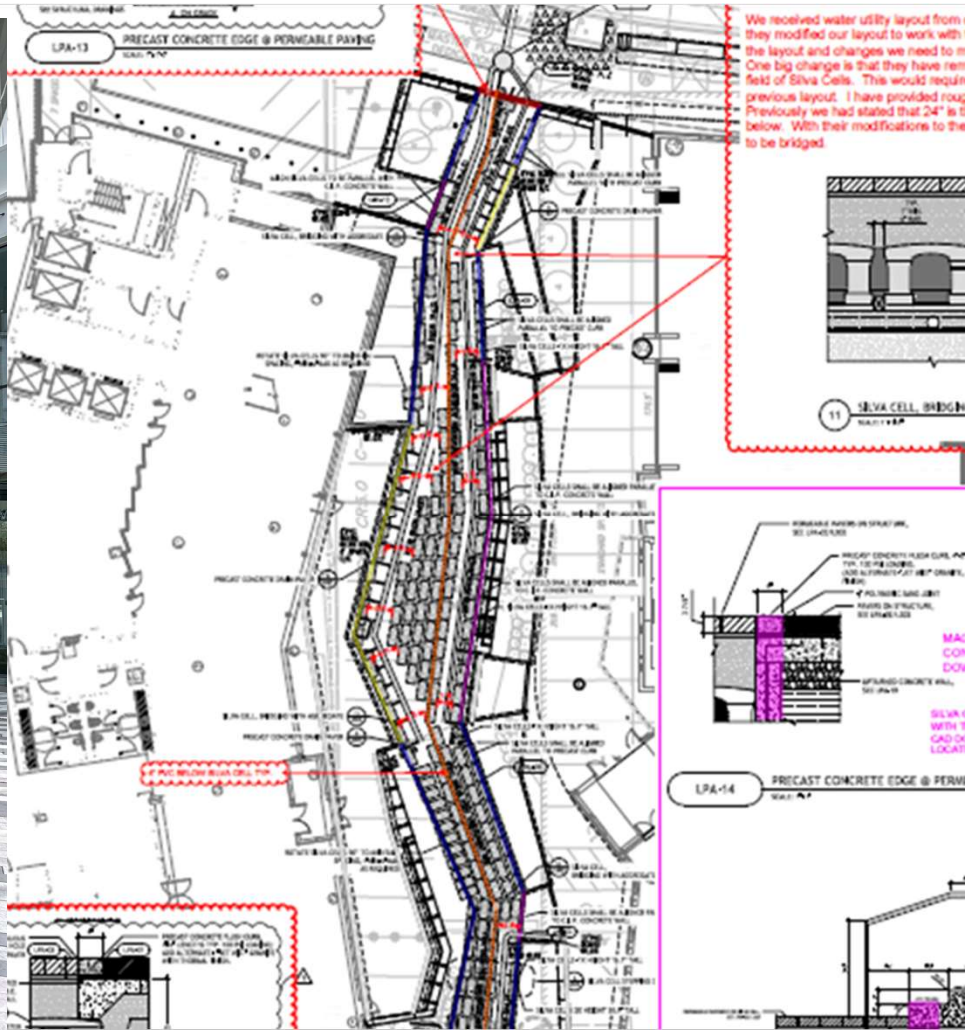
3 Years Old - 2019

Pervious Pavement Soil Cell

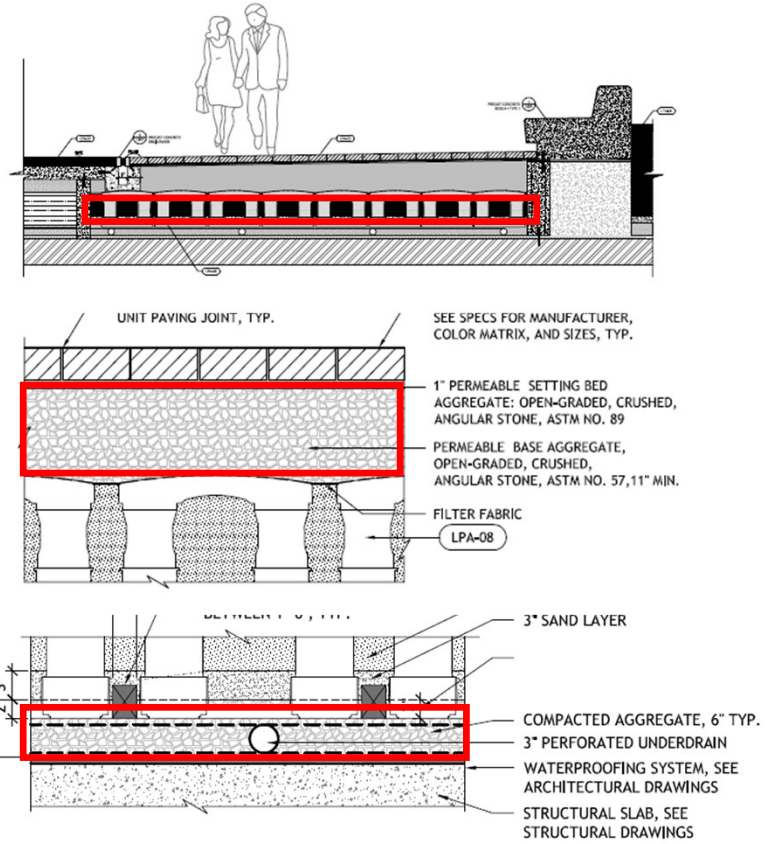




Marriott Headquarters, Bethesda MD



Basic Volume Calcs at Marriott



306 Cells at 10.33 ft2 each=3161 ft
Soil volume 1X&2x= 4792 ft3 media
40% holding allowed:
1917 ft3 of water

CA Base course over cells:10”
.833’x 3161= 2633 ft3 water
40% holding allowed
1053ft3 of water

Sub base under cells:
.5’x 3161’= 1581ft3
40% holding capacity allowed
632 ft3 water

Total Volume:

5,173 ft3

5173/3161= 19” rain event

38,697 gallons

Columns? Additional 7344 gallons

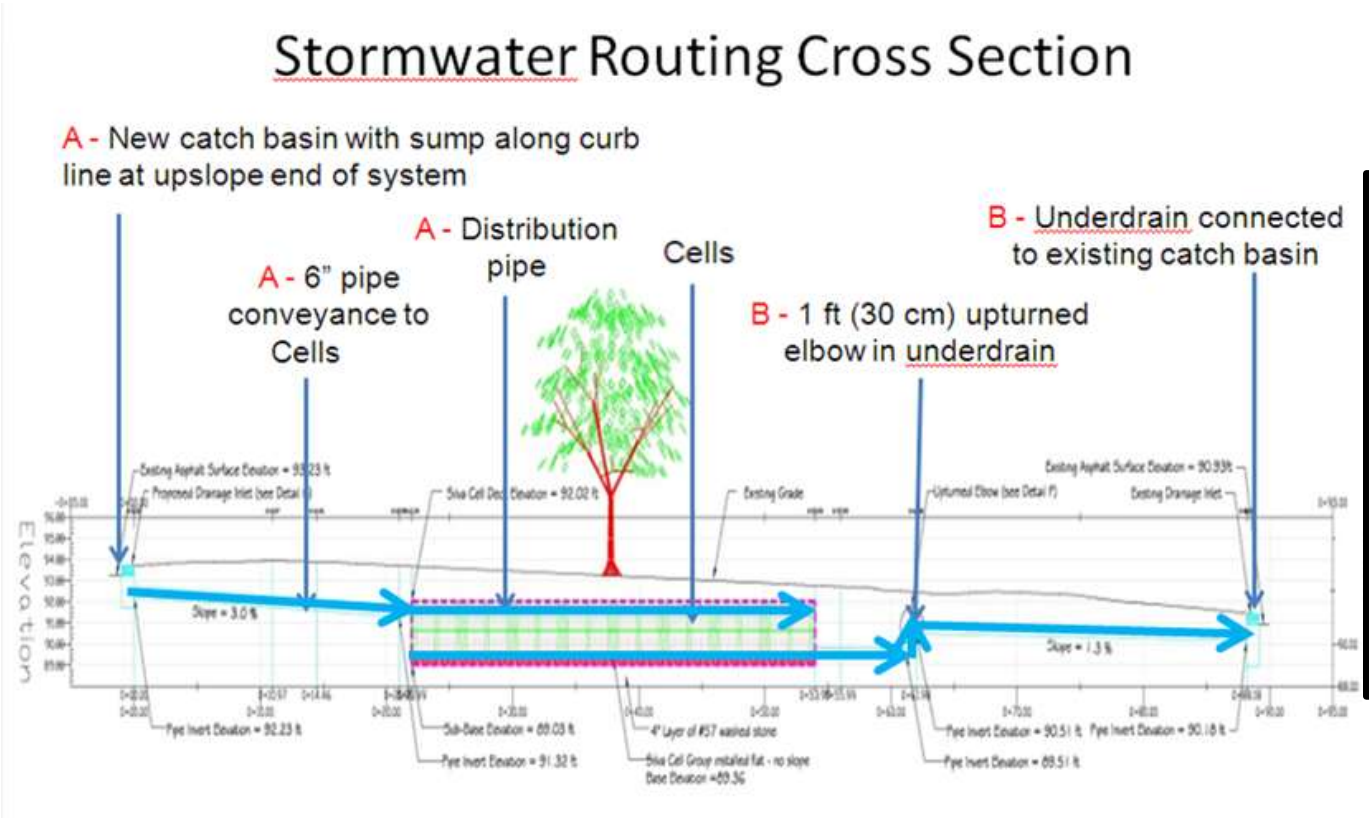
Research

Ryerson University; UNC Wilmington; U TN- Knoxville

Two Soil Cell Installations Wilmington, NC

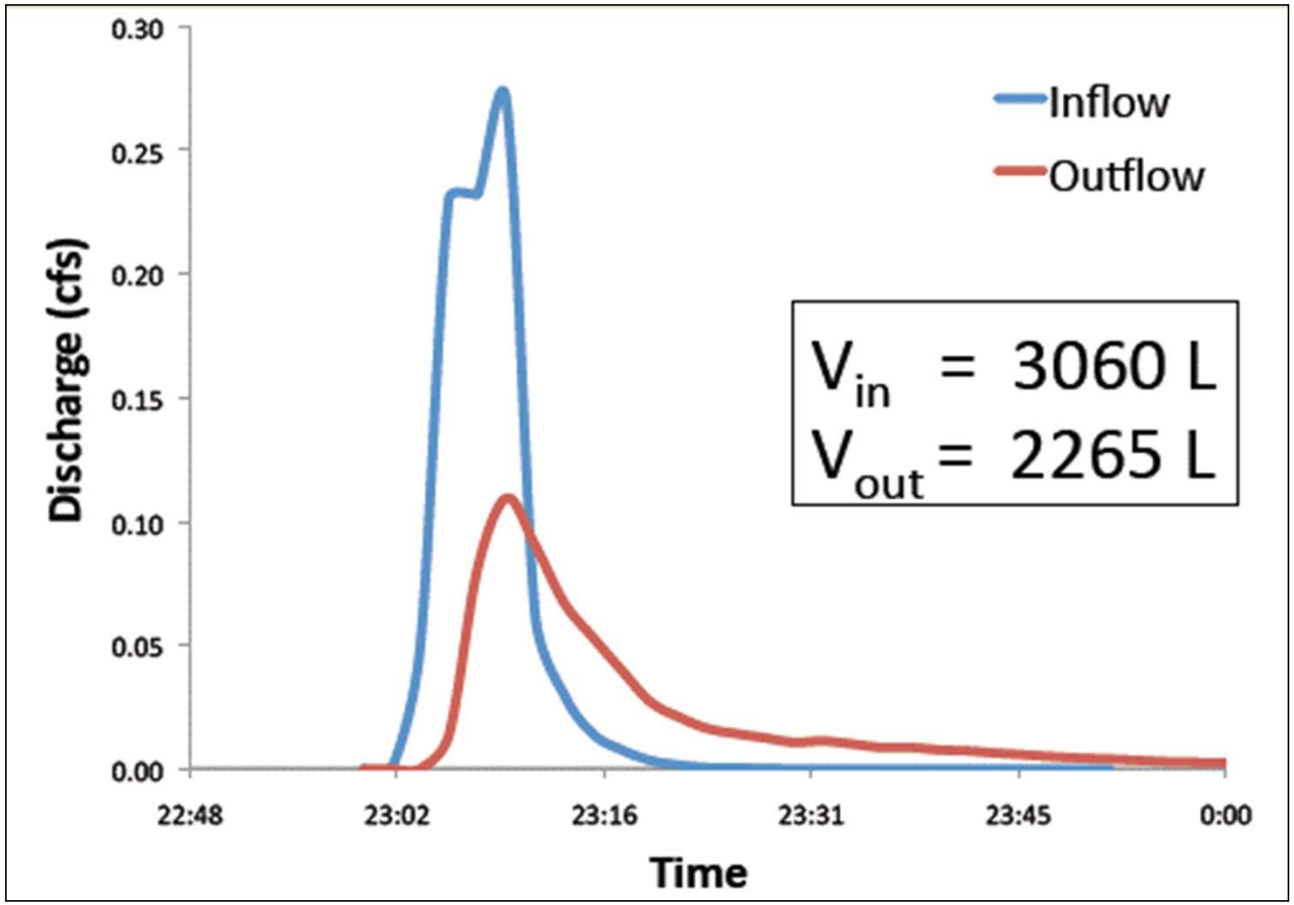
NCSU- Test site install

NCSU Soil Cell Schematic & Install



NCSU- Typical Data-Volume

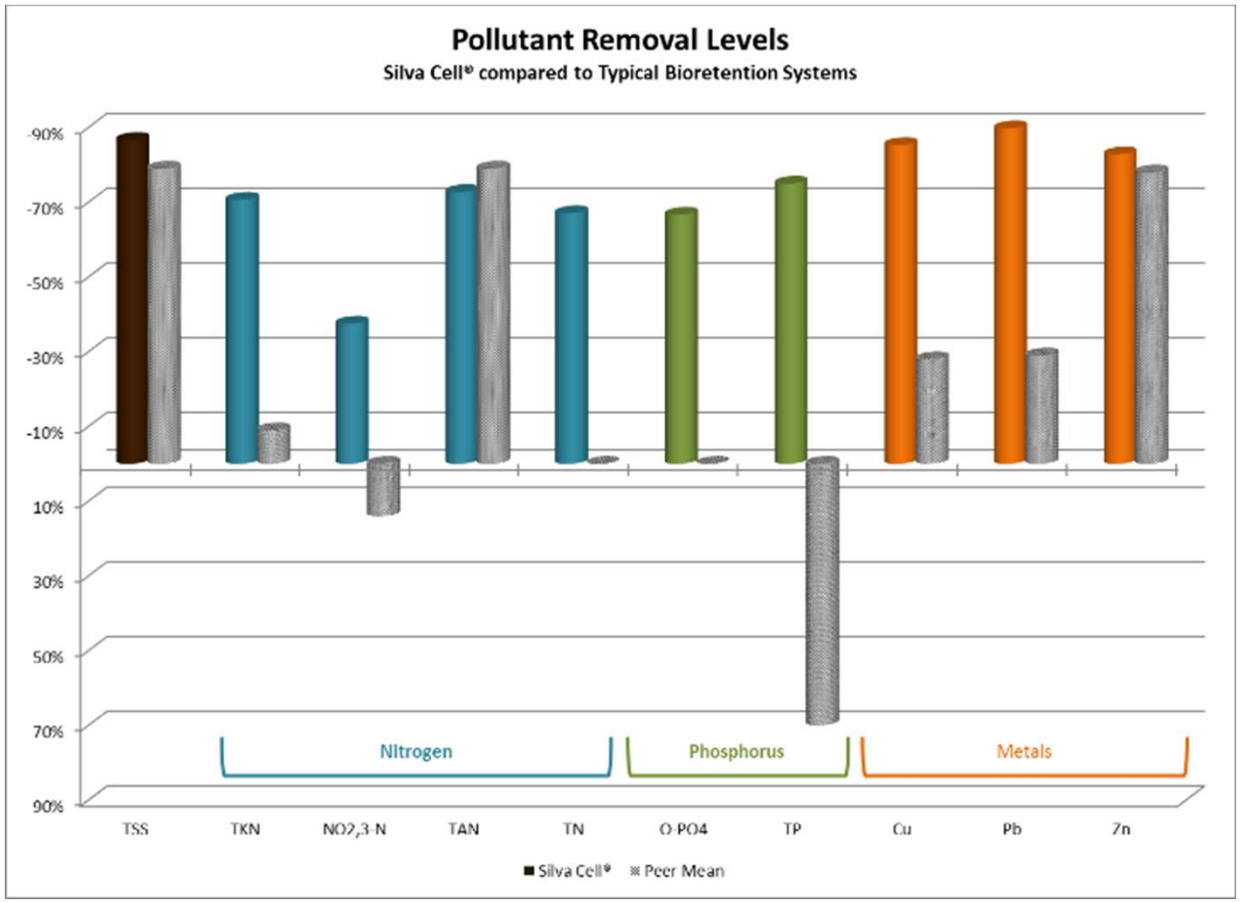
Hydrograph from 12.7 mm (0.5 in) storm on 9/6/12, Ann Street (typical street tree soil),



Source: Page, J.L., R.J. Winston, and W.F. Hunt, III. 2013. Field Monitoring of Two Soil Cell™ Installations in Wilmington, North Carolina: Preliminary Monitoring Report.

Demonstrated pollutant removal

- Removal rates ***at or above*** peer mean bioretention mixes
- Particularly good nutrient removal
  - **Nitrogen:** 72-74% removal vs. typical 14% leaching (nitrates)
  - **Phosphorus:** 35-60% removal vs. 70% leaching
  - Very Good TSS removal



Source: Page, J.L., R.J. Winston, and W.F. Hunt, III. 2013. Field Monitoring of Two Soil Cell™ Installations in Wilmington, North Carolina: Preliminary Monitoring Report.

deeproot.com

Ecological Engineering 82 (2015) 40–48

Contents lists available at ScienceDirect

Ecological Engineering

journal homepage: www.elsevier.com/locate/ecoleng

Soils beneath suspended pavements: An opportunity for stormwater control and treatment

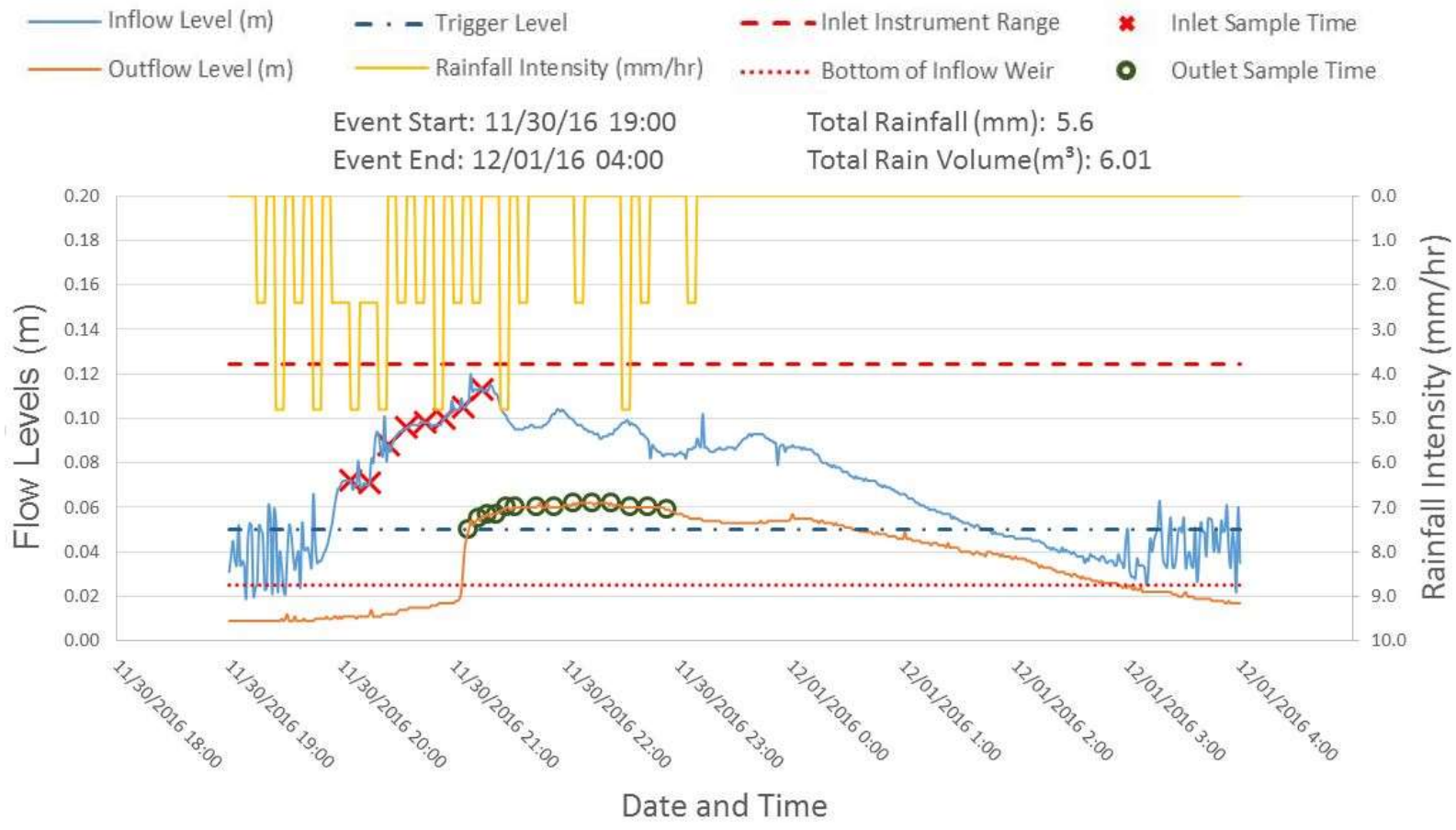
Jonathan L. Page *, Ryan J. Winston, William F. Hunt III

Department of Biological and Agricultural Engineering, North Carolina State University, Box 7625, Raleigh, NC 27695, USA

This proof-of-concept study illustrates that the soil–root matrix beneath a suspended pavement system can be used as a stormwater control measure (SCM) to concomitantly achieve water quality, pavement stability and urban forestry goals.

Queensway
Toronto ON

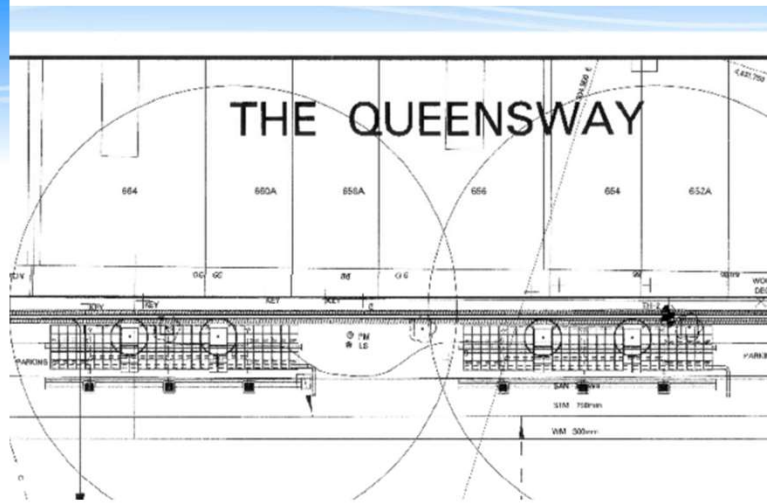
Queensway- Volume Typical Storm



Water Quality: Queensway Toronto, ON

Water Quality Improvement

November 2, 2016 Sample			
Parameter	Influent (mg/L)	Effluent (mg/L)	Percent Reduction
Aluminium	0.853	0.138	**83.8%**
Arsenic	0.000654	0.000287	**56.1%**
BOD	63.00	18	**71.4%**
Chloride	25.9	21.5	**17.0%**
Chromium	0.0079	0.00166	**79.0%**
Copper	0.0302	0.0144	**52.3%**
Iron	2.43	0.287	**88.2%**
Lead	0.00584	0.00064	**89.0%**
Manganese	0.175	0.013	**92.6%**
Nickel	0.00383	0.00316	**17.5%**
Potassium	8.59	4.47	**48.0%**
Total Phosphorus	0.607	0.082	**86.5%**
Total Suspended Solids	58	2	**96.6%**
Zinc	0.106	0.025	**76.4%**



The Queensway Sustainable Sidewalk Pilot Project

TORONTO Water


2014
654
Centre Tel
231-2908
MANUELE CHIROPRACTIC
CUSTOM FOOT ORTHOTICS
AUTO ACCIDENTS
WORK ACCIDENTS
- SPORTS INJURIES
- LASER THERAPY
- NUTRITIONAL ADVICE
OPEN
L.L.B.O.

Ecological Engineering 134 (2019) 39–46

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Suspended pavement systems as opportunities for subsurface bioretention

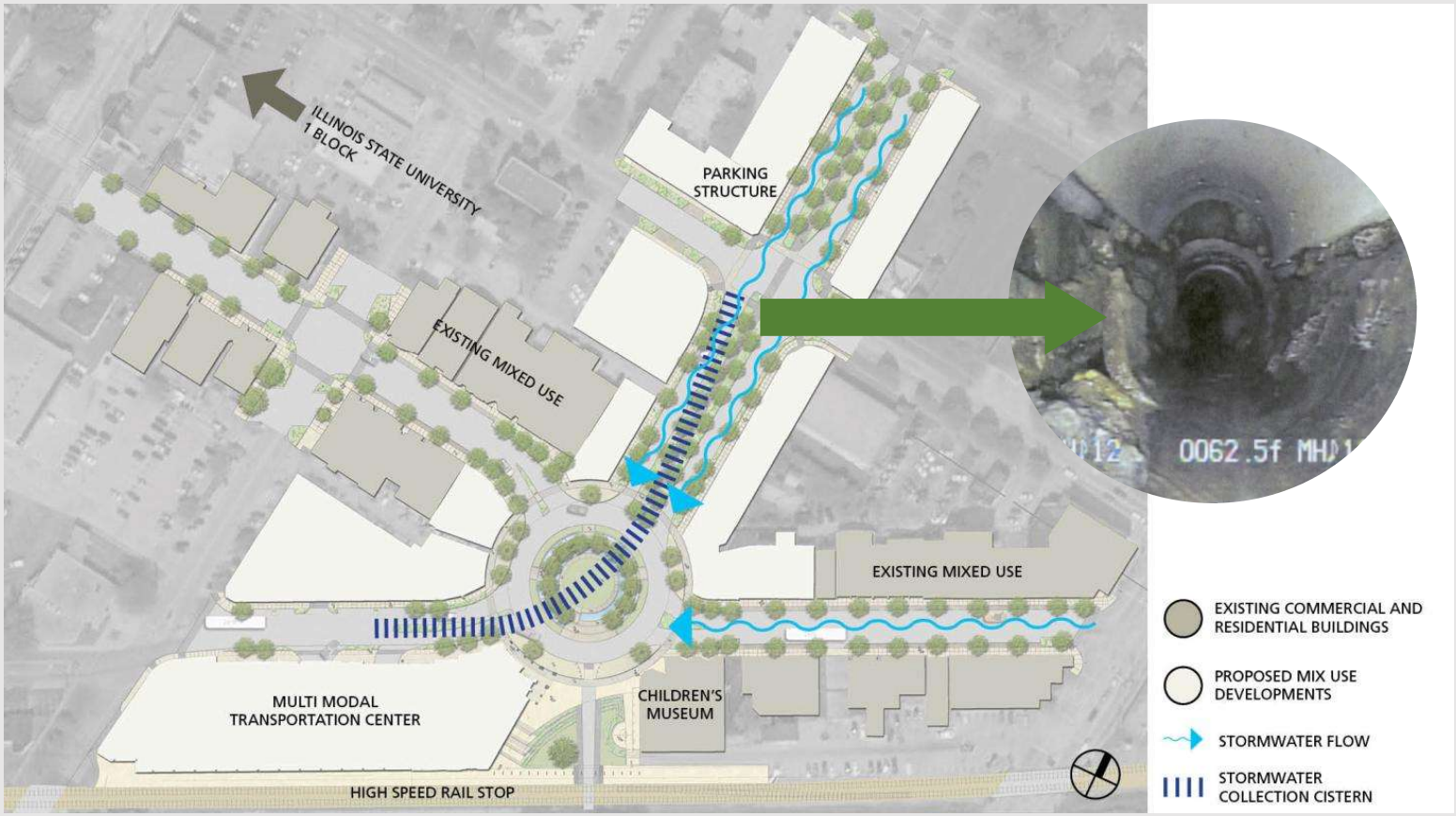
R. Andrew Tirpak[a,*], Jon M. Hathaway[a], Jennifer A. Franklin[b], Eric Kuehler[c]

[a] Dept. of Civil and Environmental Engineering, University of Tennessee, 325 John D. Tickle Building, 851 Neyland Dr., Knoxville, TN 37996, USA
[b] Dept. of Forestry, Wildlife and Fisheries, University of Tennessee, 134 Plant Biotechnology Building, 2341 Joe Johnson Dr., Knoxville, TN 37996, USA
[c] USDA Forest Service Southern Research Station, 320 Green St., Athens, GA 30602, USA

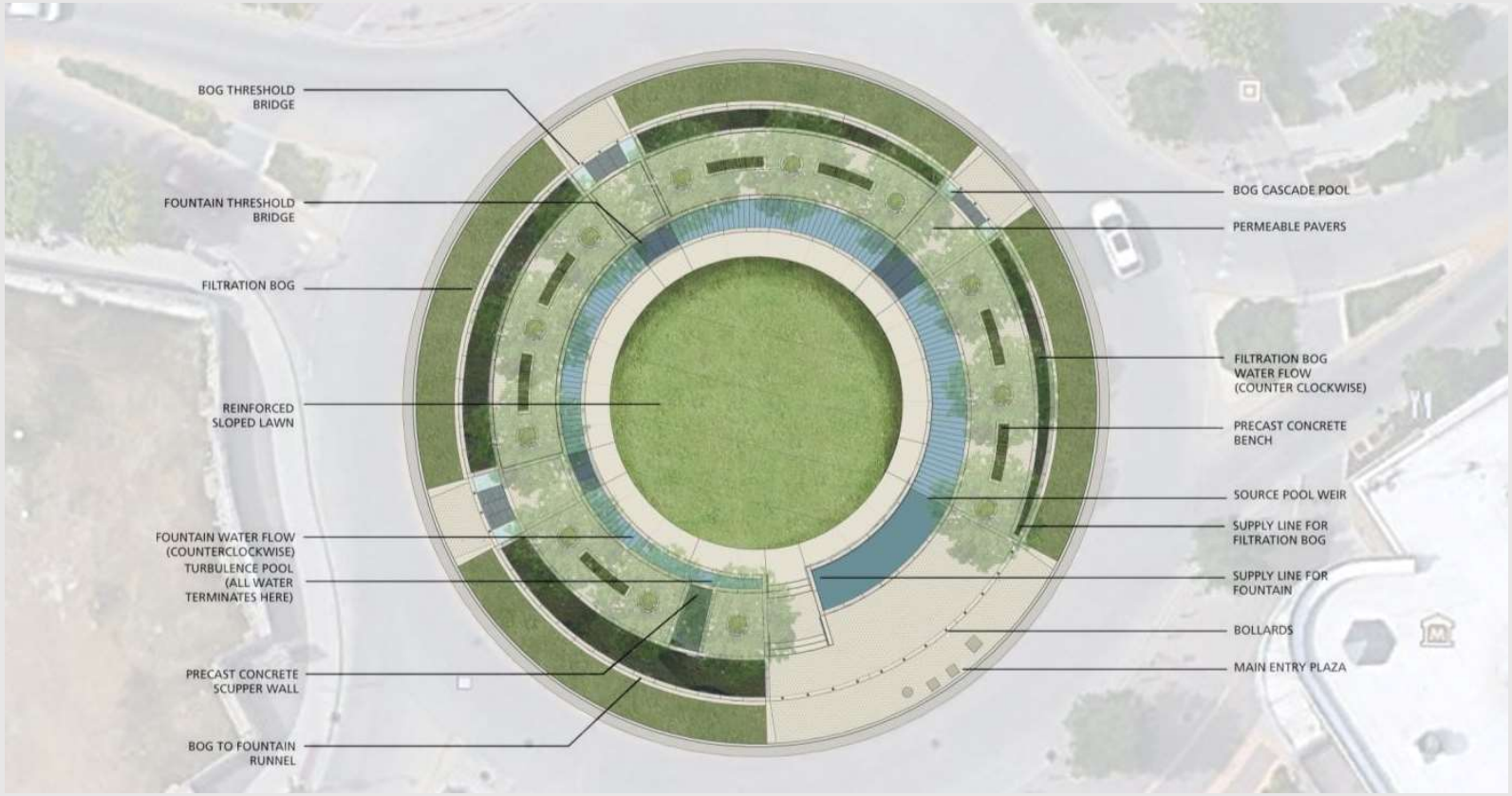
This study demonstrates the viability of field-scale suspended pavement systems in a stormwater management application and illustrates the hydrologic and pollutant removal capabilities of these systems to manage urban stormwater runoff.

Signature SW Project
Uptown Normal IL

Uptown Normal Redevelopment



The Circle

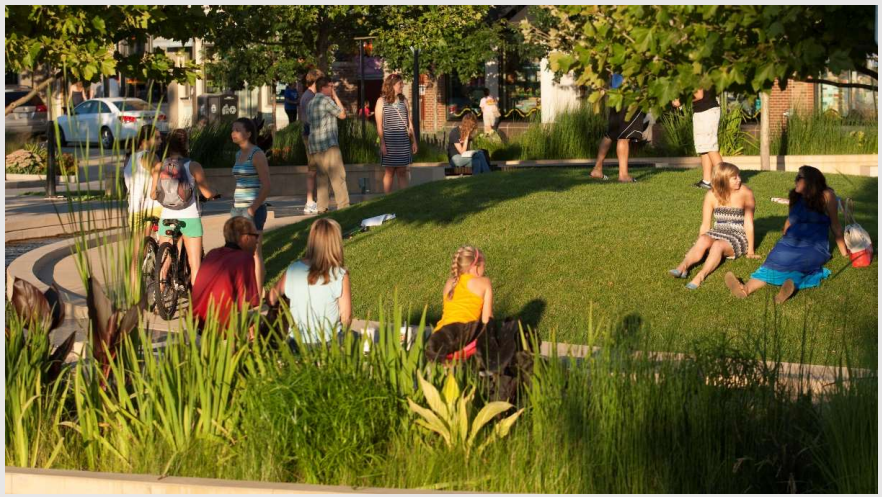

BOG THRESHOLD BRIDGE
FOUNTAIN THRESHOLD BRIDGE
FILTRATION BOG
REINFORCED SLOPED LAWN
FOUNTAIN WATER FLOW (COUNTERCLOCKWISE)
TURBULENCE POOL (ALL WATER TERMINATES HERE)
PRECAST CONCRETE SCUPPER WALL
BOG TO FOUNTAIN RUNNEL
BOG CASCADE POOL
PERMEABLE PAVERS
FILTRATION BOG WATER FLOW (COUNTER CLOCKWISE)
PRECAST CONCRETE BENCH
SOURCE POOL WEIR
SUPPLY LINE FOR FILTRATION BOG
SUPPLY LINE FOR FOUNTAIN
BOLLARDS
MAIN ENTRY PLAZA

Uptown Normal, IL

2010

2017


ROAD
CLOSED



Uptown Normal, IL 2010-2015

Uptown Normal, IL

2010

2017


UPTOWN STATION
UPTOWN CIRCLE

deeproot

Thank you!

Albert L. Key, Jr Aff. M. ASCE
alkey@deeproot.com
M (917)991-3121
DeepRoot Green Infrastructure, LLC
@deeproot_al