How-To Lessen Stresses on Vegetation in Green Stormwater Infrastructure

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CAUFC 2022

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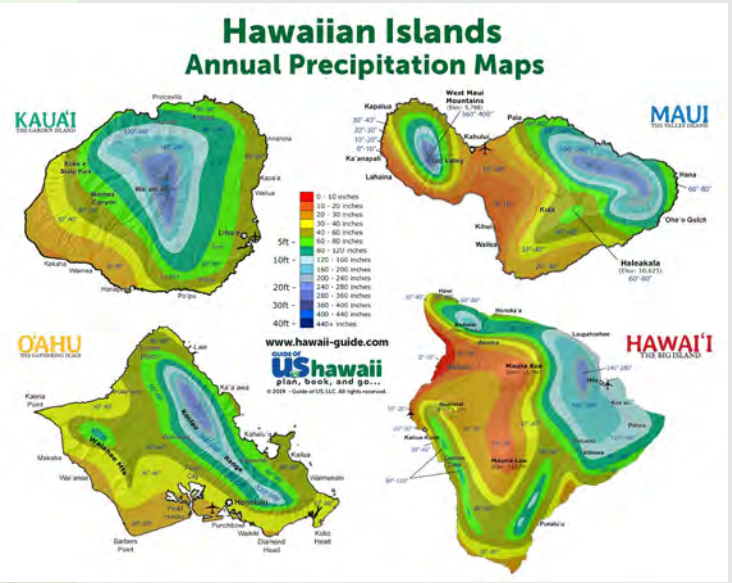
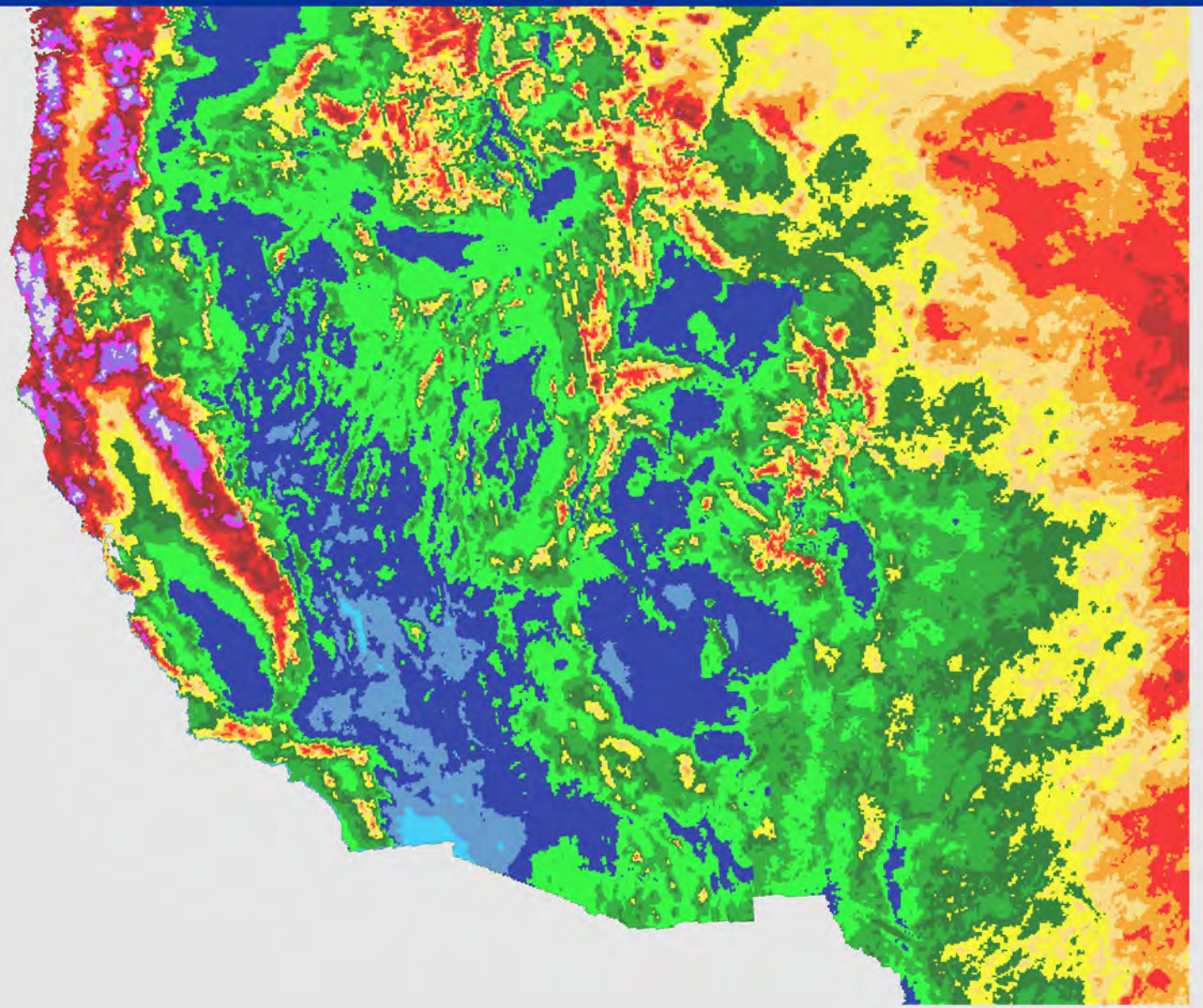
- Soil Moisture: The Most Important Factor for Young Tree Survival
- Successful Tree Planting Projects Require More than Just Passion
- Does Green Stormwater Infrastructure Work?
- Road Salt and Urban Forestry
- Landscape Architects, Designers and Contractors: Give your plants a better chance to survive and thrive!
- Managing Soil Moisture with "'Solid Water' with Air Pockets"
- Pitching green infrastructures to political leaders: not just benefits, but also tax $
- Soil Oxygen: the most neglected component in your landscape
- Above- & Under-ground Partners: that is what urban trees are missing

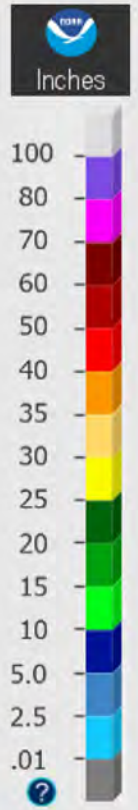
October 01, 2019 Water Year (Oct. 1) Observed Precipitation

Created on: June 05, 2021 - 12:31 UTC

Valid on: October 01, 2019 12:00 UTC







California

cbs8.com

LOCAL

'That's not dirt': SF residents endure flooded homes as sewer pipes back up in storms

Dominic Fracassa, Anna Bauman

Dec. 10, 2019 | Updated: Dec. 10, 2019 10:40 a.m.

Rain Ove

By Jia-Rui Chong

Jan. 12, 2005 12

Times Staff Writ

The series of power

and untreated was

overburdening sew

than 10 times the u

m

Updated: 6:48 PM PST January 29, 2021

Hawaii

TOP NEWS

Hawaii health officials urge the public to stay out of Manoa stream and Ala Moana Boat Harbor after sewage spill

By Mindy Pennybacker March 19, 2021

Environmental Services said in a press release this afternoon.

The department said heavy rains had caused a sanitary sewer overflow of untreated wastewater, which discharged out of a manhole at 27or Lowrey Ave. in Manoa; the address was changed Friday from an earlier report of 2710 Kaaipu Ave.

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Live News COVID-19 Vaccinating Hawaii Weather Sunrise Podcasts Sports HI Now ETC

Series of rain-triggered sewage spills spur new concerns about Oahu's wastewater system

lina

n. 27, 2021 at 11:01 PM EST

Hawaii (HawaiiNewsNow) After heavy rains Monday triggered multiple sewer spills on Oahu, environmental groups has a long way to go to fixing its wastewater system.

ayor Rick Blangiardi agrees the aging system will be a priority in his administration

artment of Environmental Services said stormwater did get into the sewers, but the volume of water diluted the that escaped.

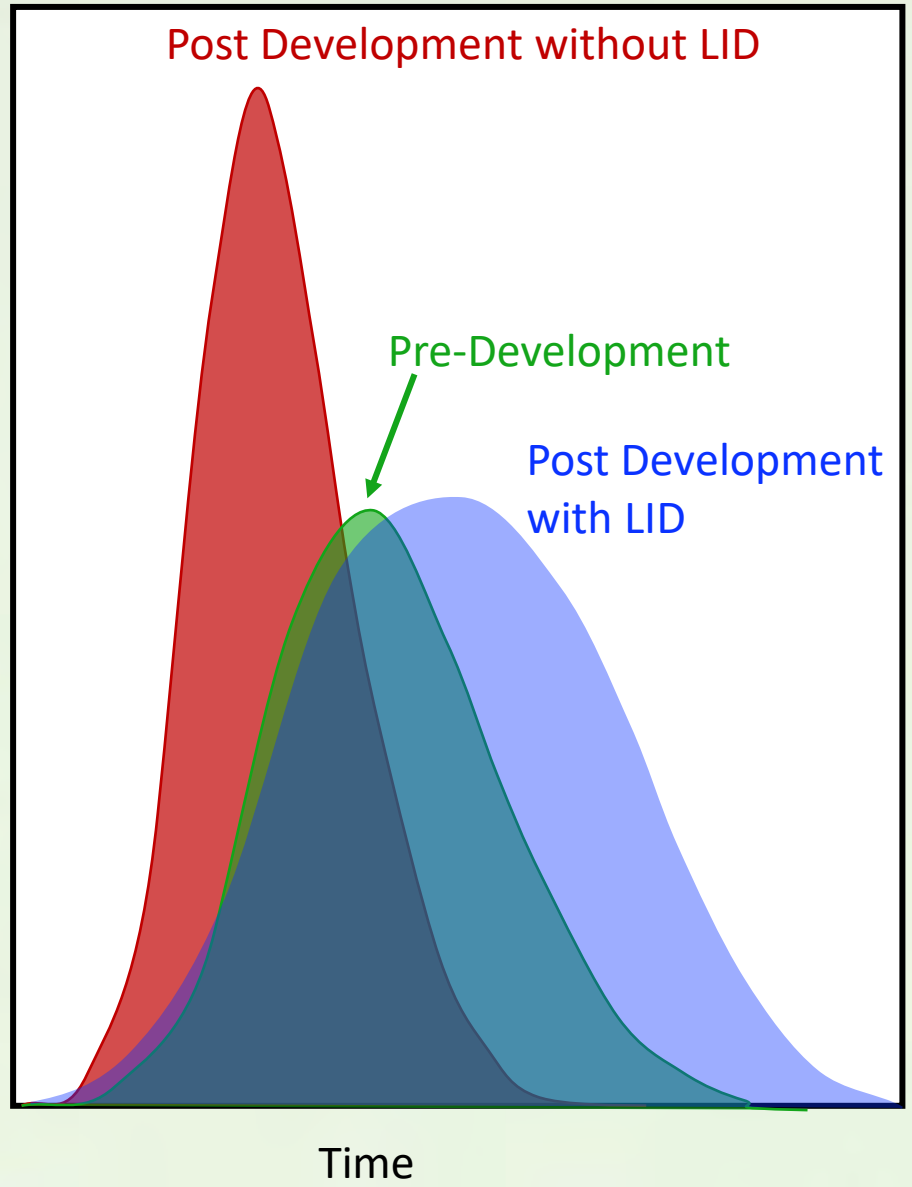
f Hawaii Civil and Environmental Engineering Professor Tao Yan said that isn't supposed to happen — even with heavy

Low Impact Development

EPA: *Low impact development* (LID) refers to systems and practices that use or mimic natural processes that result in the infiltration, evapotranspiration or use of stormwater in order to protect water quality and associated aquatic habitat.

Use plants to intercept, detain, retain, & clean up rainwater.

"Flatten the Curve"



Benefits of LID

- Improved water & air quality
- Reduced stormwater runoff rate
- Reduce load on conventional stormwater treatment
- Increased natural habitat, recreational space
- Improved groundwater recharge
- Community beautification and increased property values
- Multifunctional space use

https://tataandhoward.com/wp-content/uploads/2015/05/stormwater_management.jpg

…is both sustainable and cost-effective!

Green Stormwater Infrastructure

Use of planted areas to treat the first flash of dirty water off roads, parking lots, and other impervious surfaces

More Examples

Reference: Hudson County Planning Board

Infiltration beds

Bioretention swale

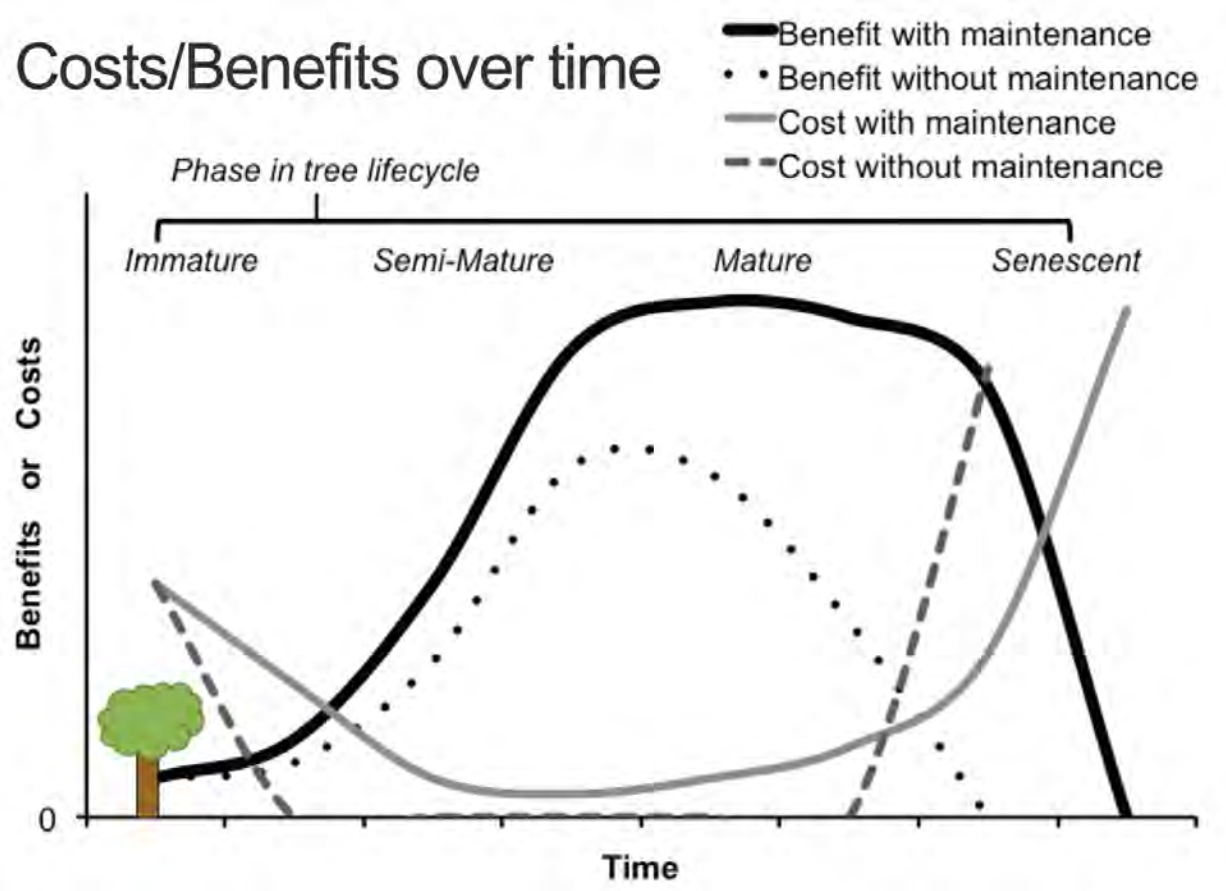
Urban Bioswale

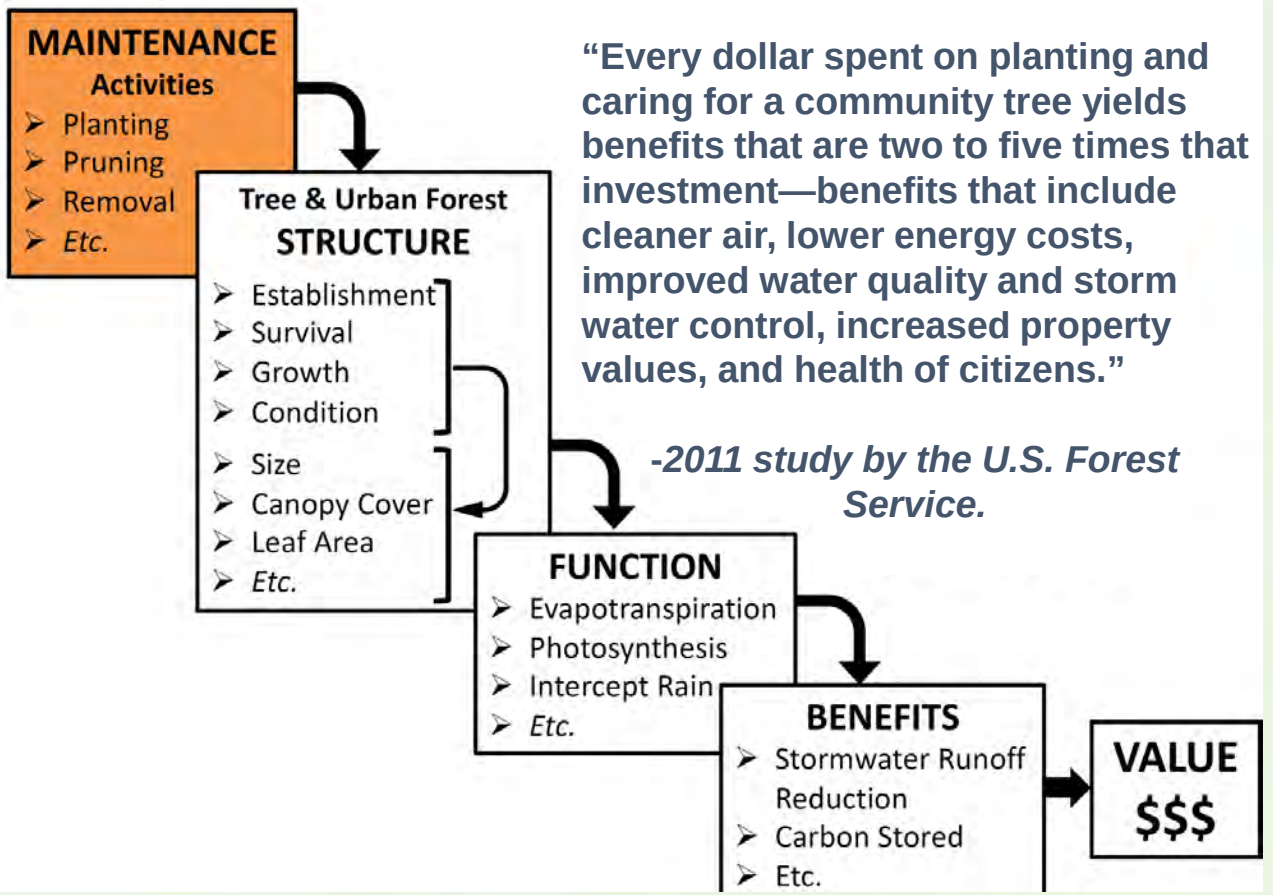
Rain Garden

Residential Rain Garden

Streetside Bioswale

The Costs and Benefits of Urban Trees





"Every dollar spent on planting and caring for a community tree yields benefits that are two to five times that investment—benefits that include cleaner air, lower energy costs, improved water quality and storm water control, increased property values, and health of citizens."

-2011 study by the U.S. Forest Service.

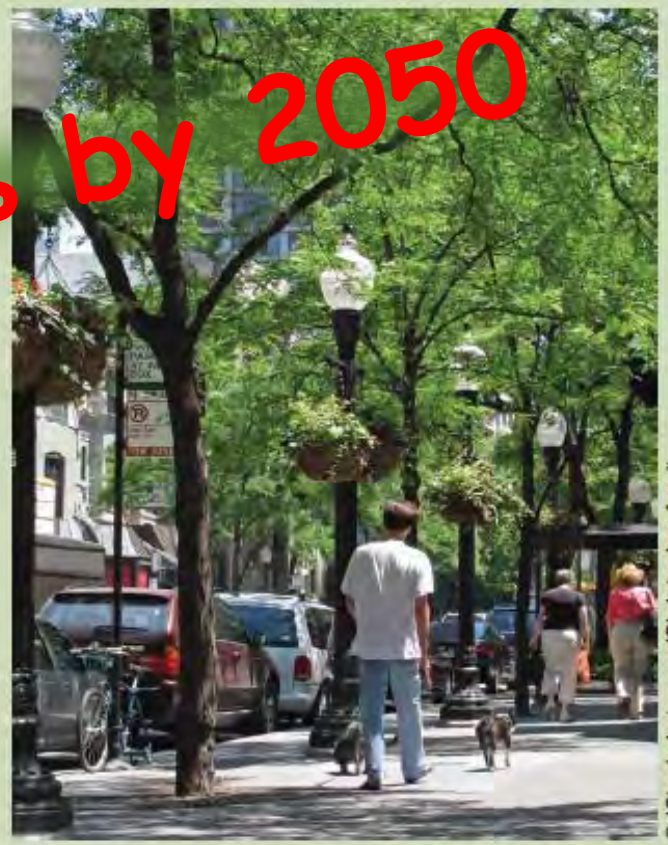
J Vogt, RJ Hauer & BC Fischer, Arboriculture & Urban Forestry 2015 41(6): 293-323

USDA/Forest Service
Sustaining America's Urban Trees and Forest (2010)

URBAN AMERICA
(lower 48 states)

~~3.5%~~ 8.1% by 2050
of land mass

82%
of population



© iStockphoto.com/Christopher Arndt

Urban forests provide green space in the urban landscape.

America's Green Infrastructure

America's forests are sometimes referred to as "green infrastructure" to emphasize the critical public benefits they provide. The term has been defined as "an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations" (Benedict and McMahon 2002). Urban forests are an integral part of this structure, providing a lattice of green in an otherwise artificial landscape. "The value of an urban forest is equal to the net benefits that members of society obtain from it" (McPherson et al. 1997).

"… urban forests will become increasingly critical to sustaining environmental quality and human well-being in urban areas."

What Can Trees Do to Stormwater?

“Every dollar spent on planting and caring for a community tree yields benefits that are two to five times that investment—benefits that include cleaner air, lower energy costs, improved water quality and storm water control, increased property values, and health of citizens.”

-2011 study by the U.S. Forest Service.

https://youtu.be/pjtlEoGulvg

Ballard Corners Park…Seattle WA

Presented to the public before installation 2009

* Illustration represents approximately 3 years growth following installation. Plants may change over time.

Rain gardens like the one here at Ballard Corners Park
http://www.seattle.gov/util/cs/groups/public/@spu/@drainsew/documents/webcontent/1_036048.pdf

Right After Installation

News report: Rain gardens like the one here at Ballard Corners Park
https://www.westsideseattle.com/robinson-papers/2009/07/31/city-starts-tests-install-natural-drainage-ballard

Figure 4. Planting Strip Design (30th Avenue Raingarden)

Figure 5. Typical Flow Pathway through the 30th Avenue Raingarden

Half year later!!!

Seattle WA
29th Ave and 77th St NW

A blog started by residents to ask the city to remove them!

https://ballardraingardengue.wordpress.com/pictures/

Google Map Streetside Images

Tree Well-Fairfax County

McLean Metro Station, 4/27/2019

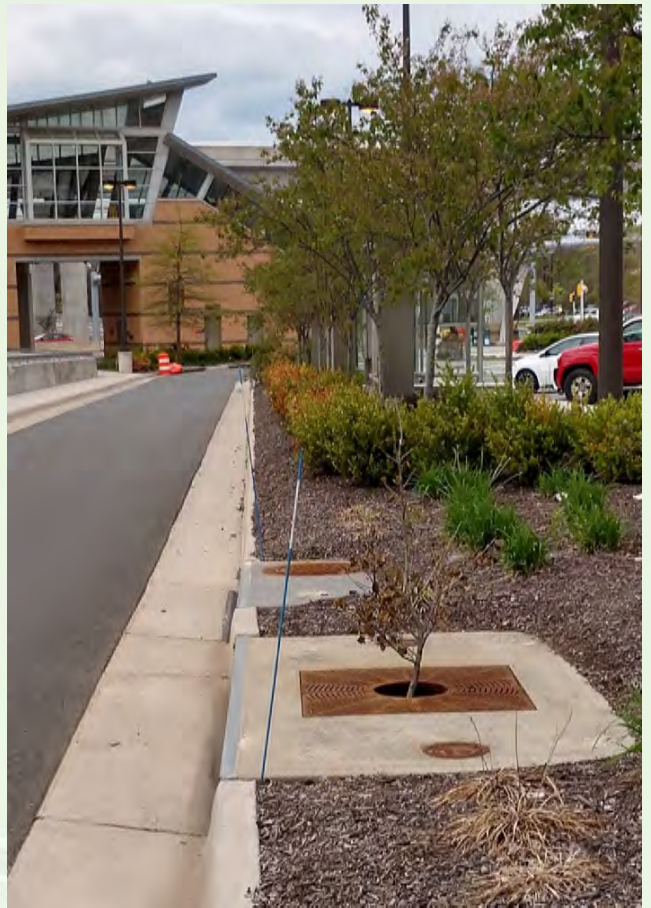
Tree Well-Fairfax County

McLean Metro Station

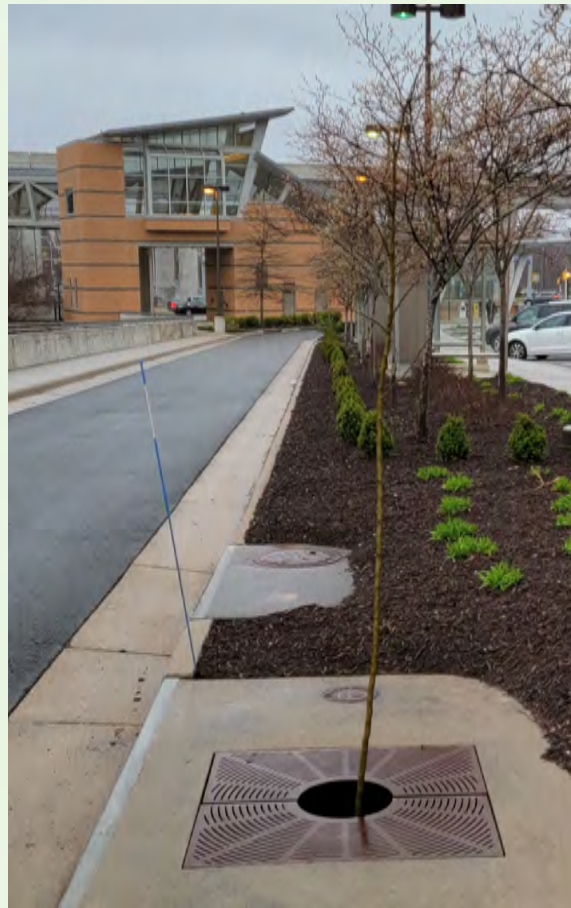
4/27/2019

12/22/2019

04/17/2021



03/13/2022



Fredericksburg, VA…Aug 2016

Fredericksburg, VA…Jun 2017

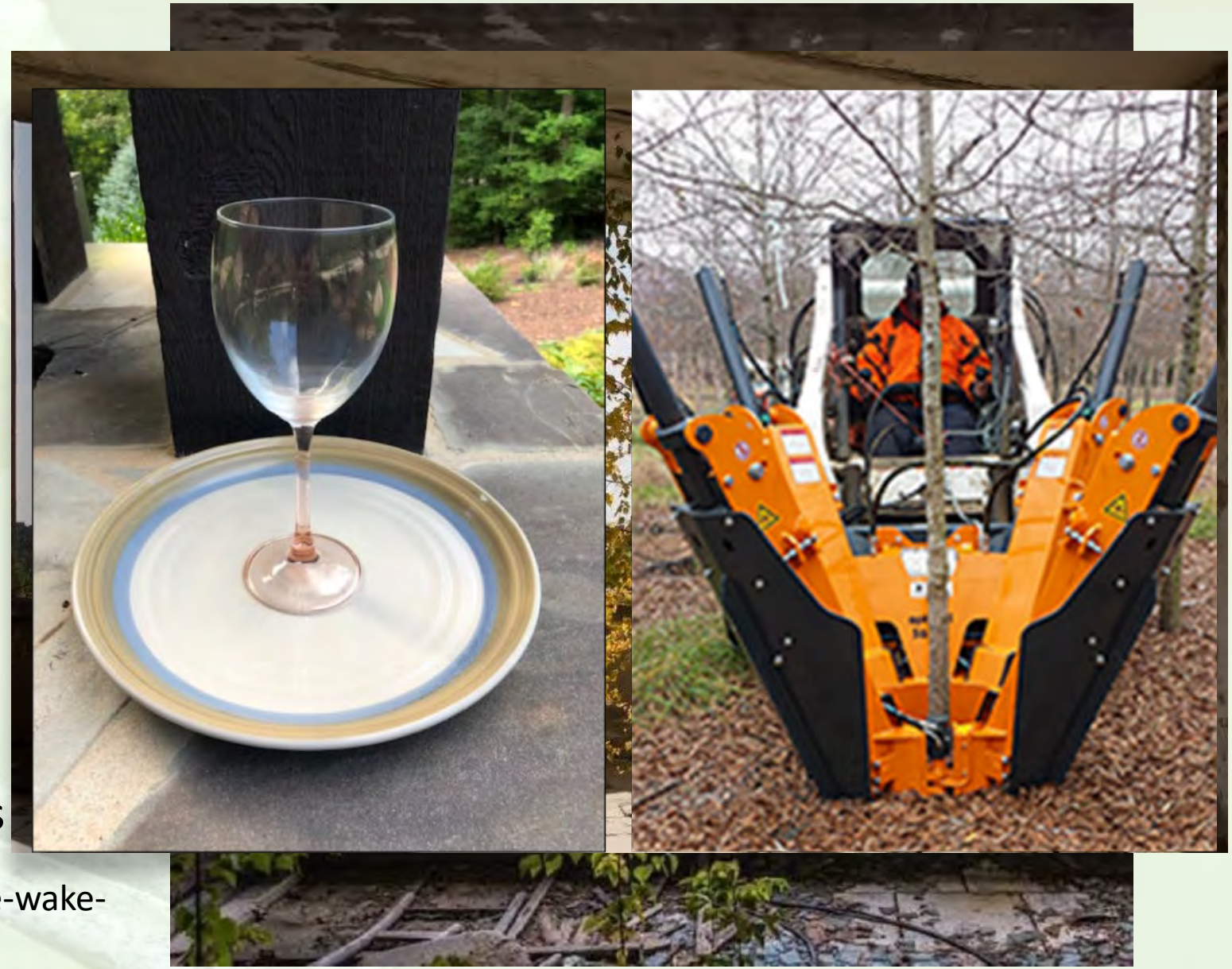
Fredericksburg, VA…May 2018


aurantiaco plasticus

Does Green Stormwater Infrastructure Work?

Why do we need to do anything for plants in GSI?

- Plants are tough: hundreds millions of years of existence on the earth is the best proof.
- But plants in their natural environment don't move, typically!
  - When moved by people, the majority of a tree's root system is left behind
  - Container-grown plants are irrigated regularly in nurseries



https://cosmosmagazine.com/biology/in-the-wake-of-chernobyl-plants-thrive/

Reasons for Plant Decline/Death

- Incompatibility of species for environment (*design*)
- Insufficient soil volume to sustain tree (*design and site*)
- Poor growing practices at grower (*horticultural*)
- Soil compaction (*site and inhabitants*)
- Improper soil moisture (*design, site and horticultural*)
- Inept planting practices (*horticultural*)
- Pathogens and Pests (*environmental*)
- Natural disasters (*environmental*)
- Unnatural disasters (*inhabitants*)
- Unnatural substances and poor maintenance practices (*inhabitants*)
- Old age (*THE ULTIMATE GOAL*)

Improper Soil Moisture

This is the most common reason for tree decline/death in your designs.

It is also an issue that can be resolved with proper planning and management.

Total Cost per Tree Planted

- New York City: "… payment per tree, $2,150, is based on actual tree planting costs incurred by NYC Parks."

Retrieved from www.nycgovparks.org/trees/street-tree-planting/tree-fund on Oct 27, 2020

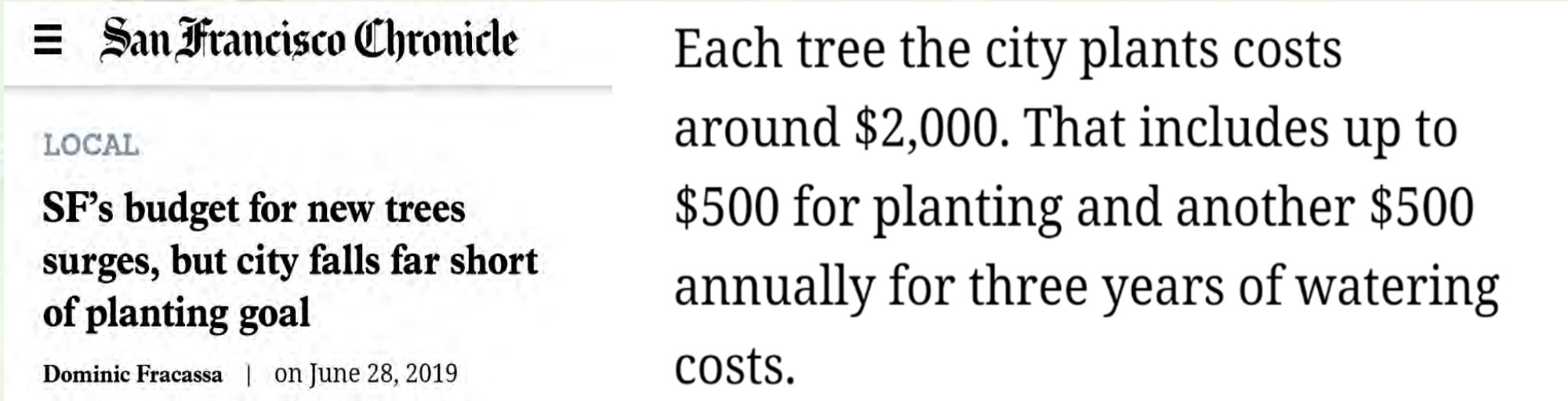
- Richmond: $256 per tree planted only

"$256 per tree planted by contractors"

Urban Forestry Department in Charge of Maintenance as of 2013.

- San Francisco, CA: $2,000

www.sfchronicle.com/bayarea/article/SF-s-tree-planting-budget-surges-but-removals-14056408.php



San Francisco Chronicle

LOCAL

SF's budget for new trees surges, but city falls far short of planting goal

Dominic Fracassa | on June 28, 2019

Each tree the city plants costs around $2,000. That includes up to $500 for planting and another $500 annually for three years of watering costs.

Watering Options for GSIs

Rainfall

Irrigation System

Manual

Slow Release

How much of the water do trees actually get?

Natio nt
https:

Challenges faced by GSI professionals

Survey among 36 stormwater experts

- Do you use Green Infrastructures for Stormwater Management?
  - 33 Yes; 3 No/Never/Doesn't work
- What is the No. 1 challenge of Green Infrastructures?
  - 21 Maintenance; 10 Construction; 1 Regulation; 1 Misunderstanding
- What is the No. 1 problem associated with maintenance?
  - 16 Plant Establishment; 3 Sediments; 2 Training/Vetting of Contractor
- What is the No. 1 problem with Construction?
  - 4 Soil work; 3 Construction process itself; 3 Sizing

VA 711 project


VDOT
SWB#
72012

Sediments During Construction


Buy One mowing service
Get One pruning service **Free**

2 years later

July 2021

The Process of Green Stormwater Infrastructure

1. Plan
   - Regional, City, Community level planning
   - Transportation, Waste Water, Water, Environmental
2. Preparation and Design
   - Site information, **Soil Work**, Hydrology, Design
3. Construction
   - Civil Engineering
   - Heavy Construction Equipment

Does anyone do another soil work at this point?

4. Operations and Maintenance
   - Foot traffic from maintenance crew
   - Lawn care equipment

How about the soil compaction and infiltration rate at this point?

Soil Compaction and Planting Failure

Soil Bulk Density (g/cm^3) or (lb/ft3)		**Planting Success Rate:**
1.25 – 1.34	78-84	100%
1.34 – 1.44	84-90	60%
1.45 – 1.54	91-96	33%
1.55 – 1.64	97-102	10%
>1.65	>102	0%

Dr. Glynn Percival, Bartlett Tree Research Lab and Reading University
Percival, G C (2007). Pre-planting– getting to the root of the problem. Essential ARB. Issue 22. June Edition

Soil bulk density on Roadside after construction: **1.8-2.0 g/cm^3**

Common red brick: **1.9 g/cm^3**

Concrete: **2.4 g/cm^3 (150 lb/ft^3)**

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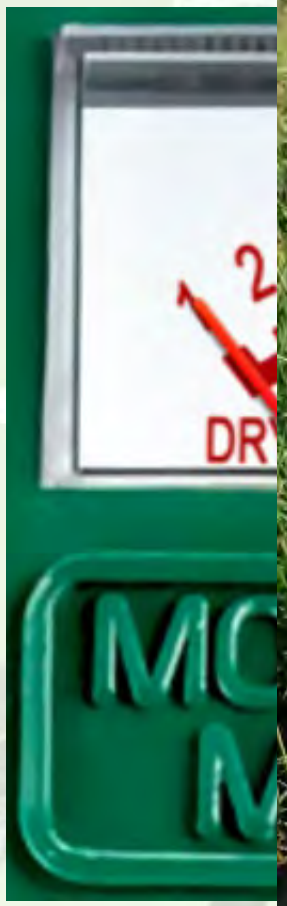

DR

What is the problem with plants in the green infrastructure?

Soil Moisture

Two Unique and Intrinsic Features of Green Infrastructures

1. **Flooded during storms!**
   - ⇨**High soil moisture**
2. Drains/Dries fast to make room for future storms
   - ⇨very porous media
   - ⇨dries fast, low soil moisture in between storms and during drought

Overwatering

“85% of planted trees die of drowning...

...by peope thought they were under watered!”

Kurt Peacock

Certified Arborist

Chula Vista , CA

“I often see trees overwatered to the point of wilting and people still want add more water”

Kyler Neuman.

Aurora Public Schools, Aurora, CO

“Overwatering is a huge problem. We constantly tell property owners that irrigation needs only to be run when soil conditions dictate. Many times you will go by properties and the irrigation is running during a rain storm. Proper irrigation education and maintenance is a huge issue.

We lose more plants to over watering.”

Dan Hildebrand

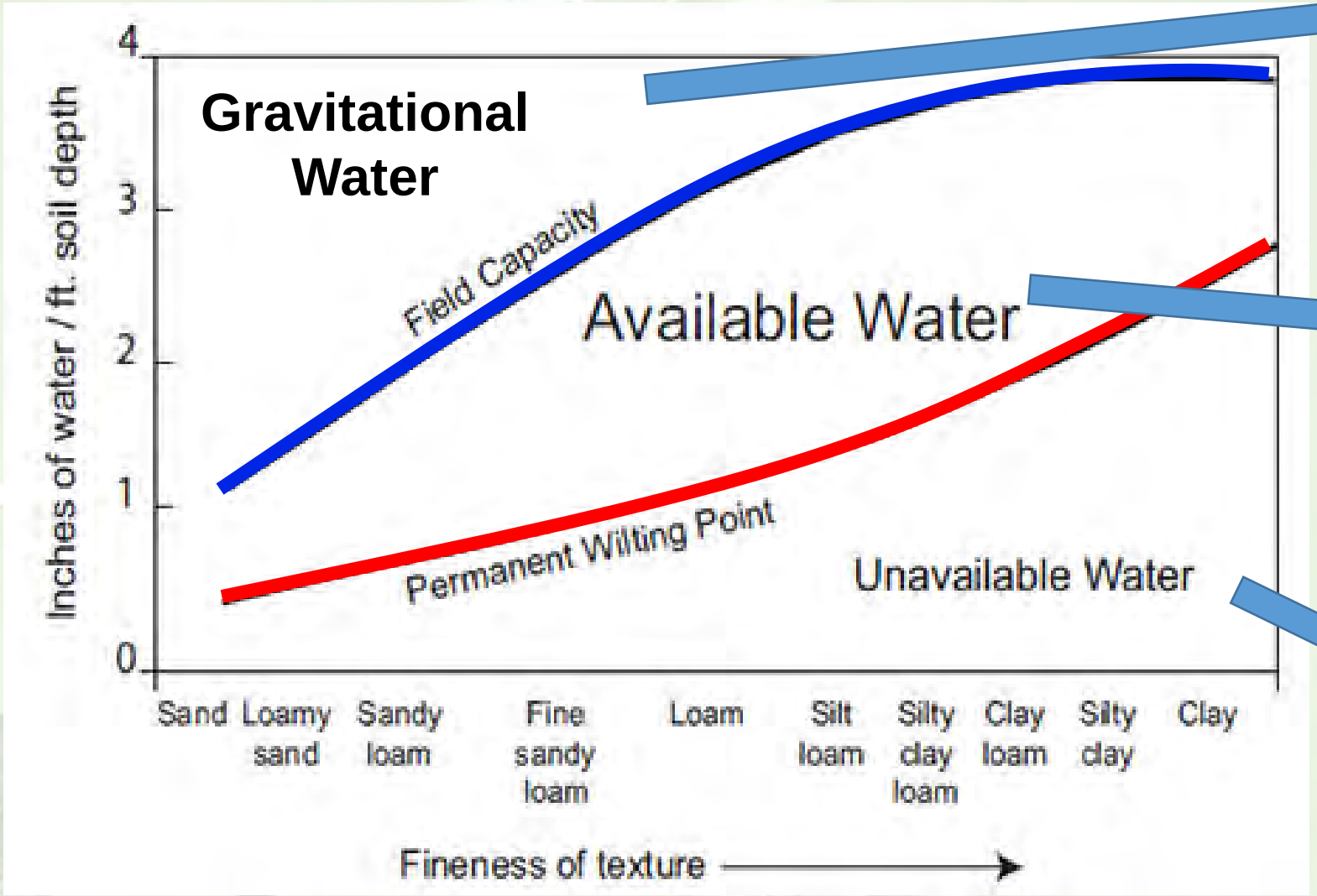
VP and Co-Owner

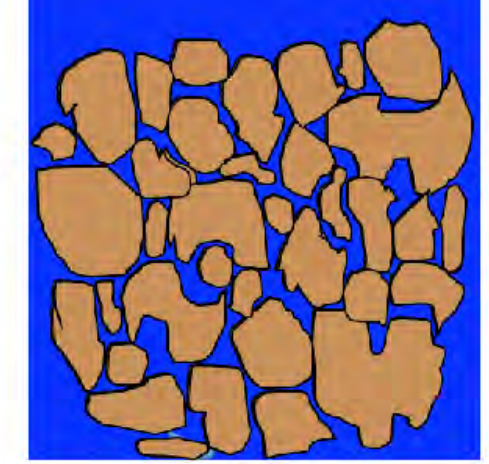
James River Nurseries Inc.

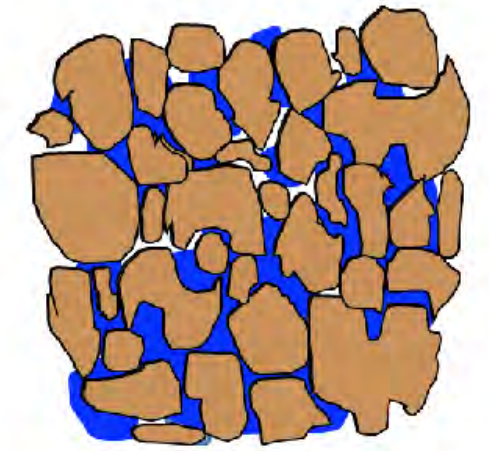
Richmond VA

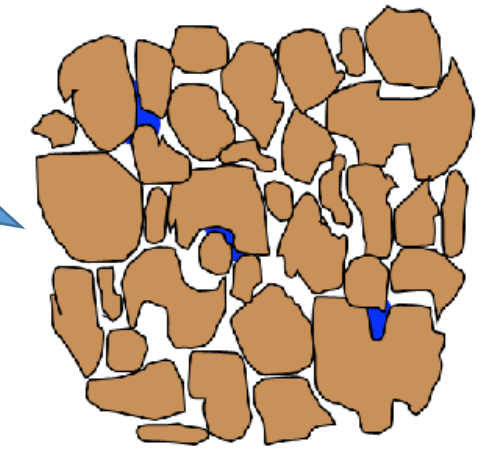
$15 M revenue in landscaping services

Plant Available Water



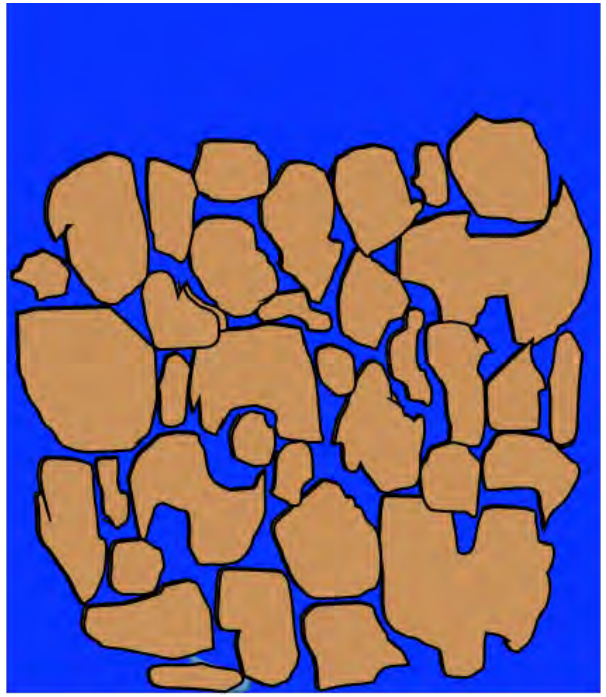




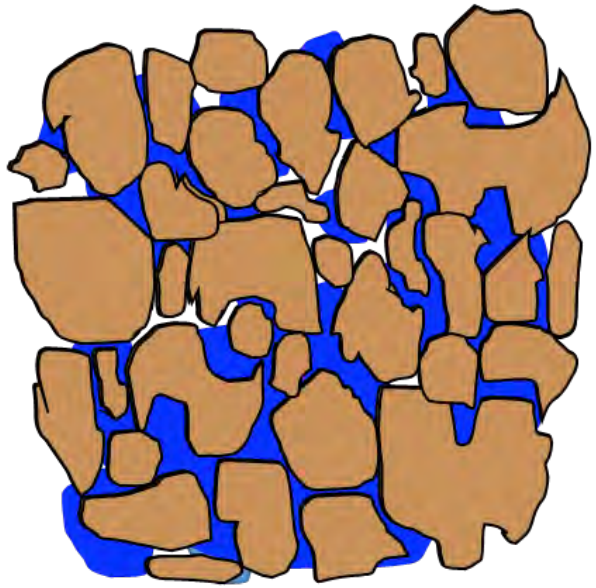


Source: Ohio Agronomy Guide, 14th Ed, Bulletin 472-05

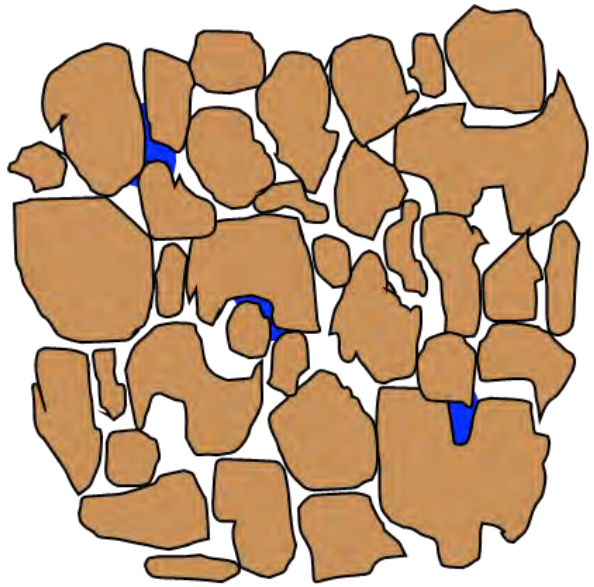
Plant Available Water



SATURATION
All pores are full of water. Gravitational Water may be around.



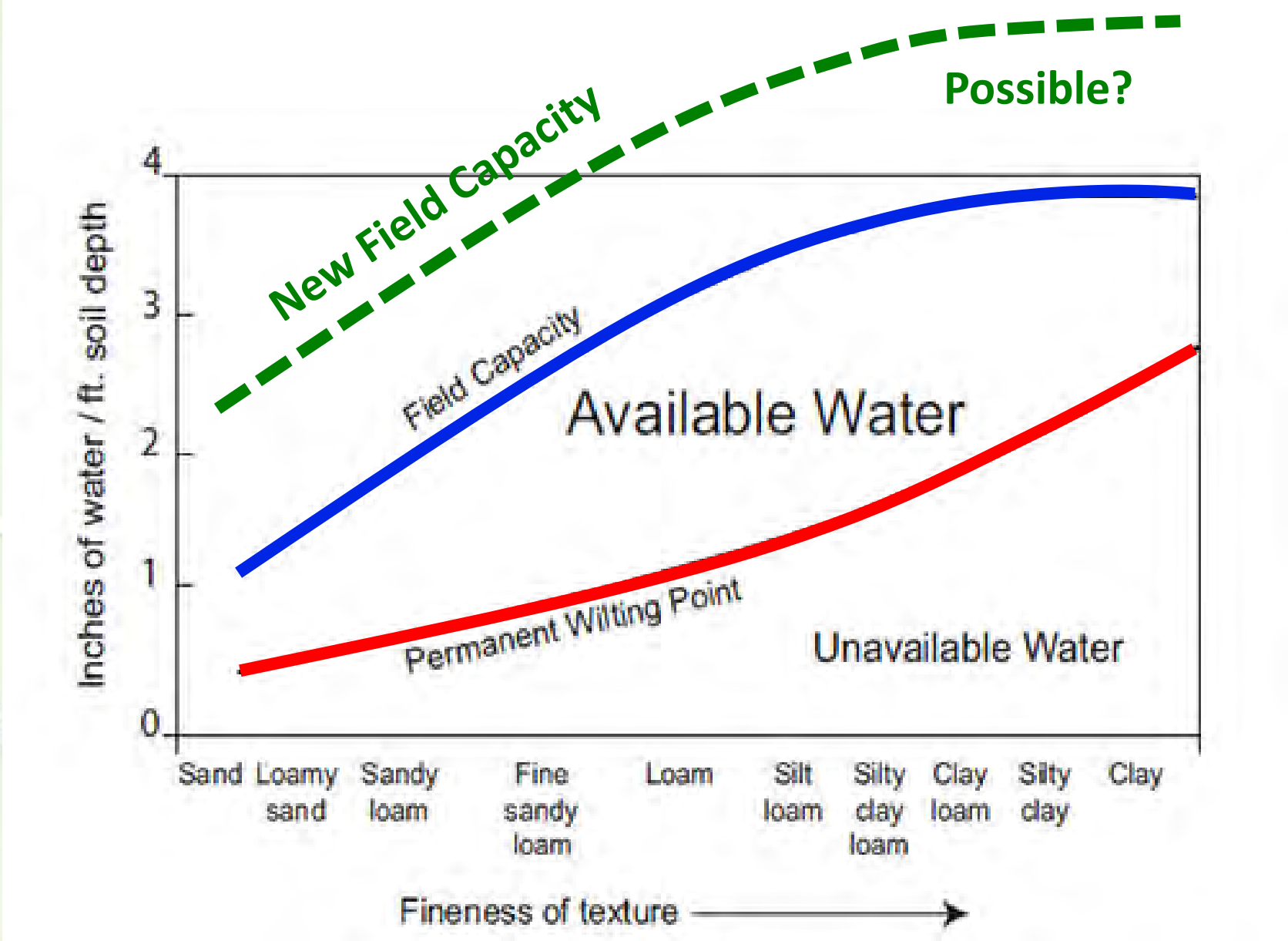
FIELD CAPACITY
Available water for the plant growth. Enough oxygen for roots to breath.



WILTING POINT
No more water is available to plants.

Adapted from http://www.h2grow.nz/2016/12/soil-moisture-101.html

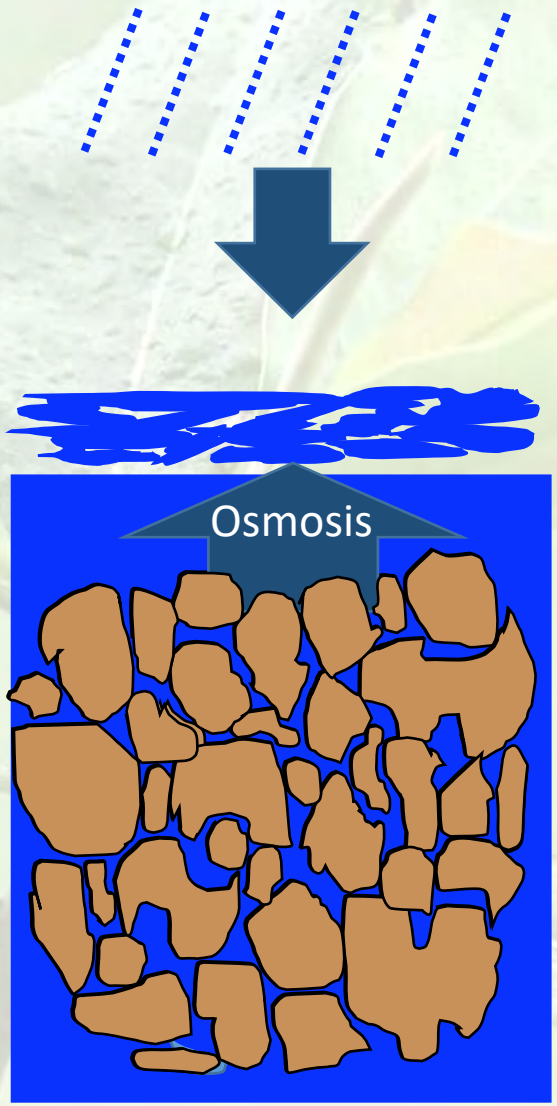
Plant Available Water



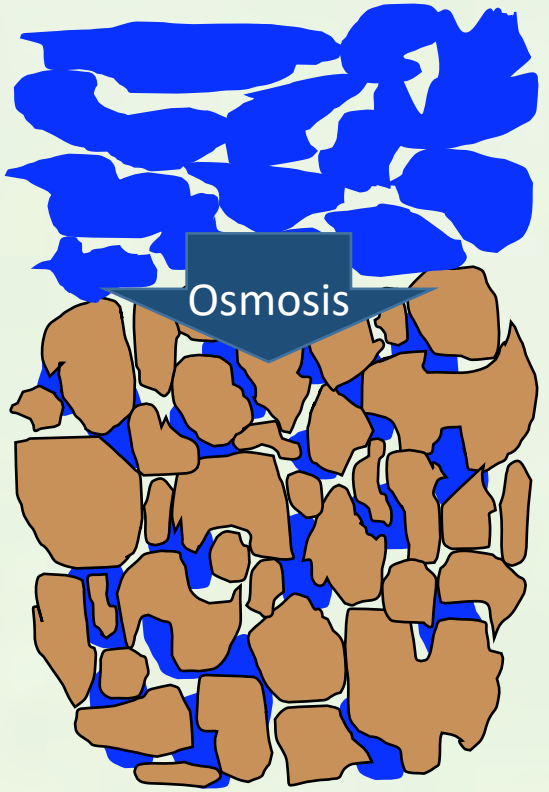
Source: Ohio Agronomy Guide, 14th Ed, Bulletin 472-05

“Solid Water” with Air Pockets

Charging with Rain/Irrigation

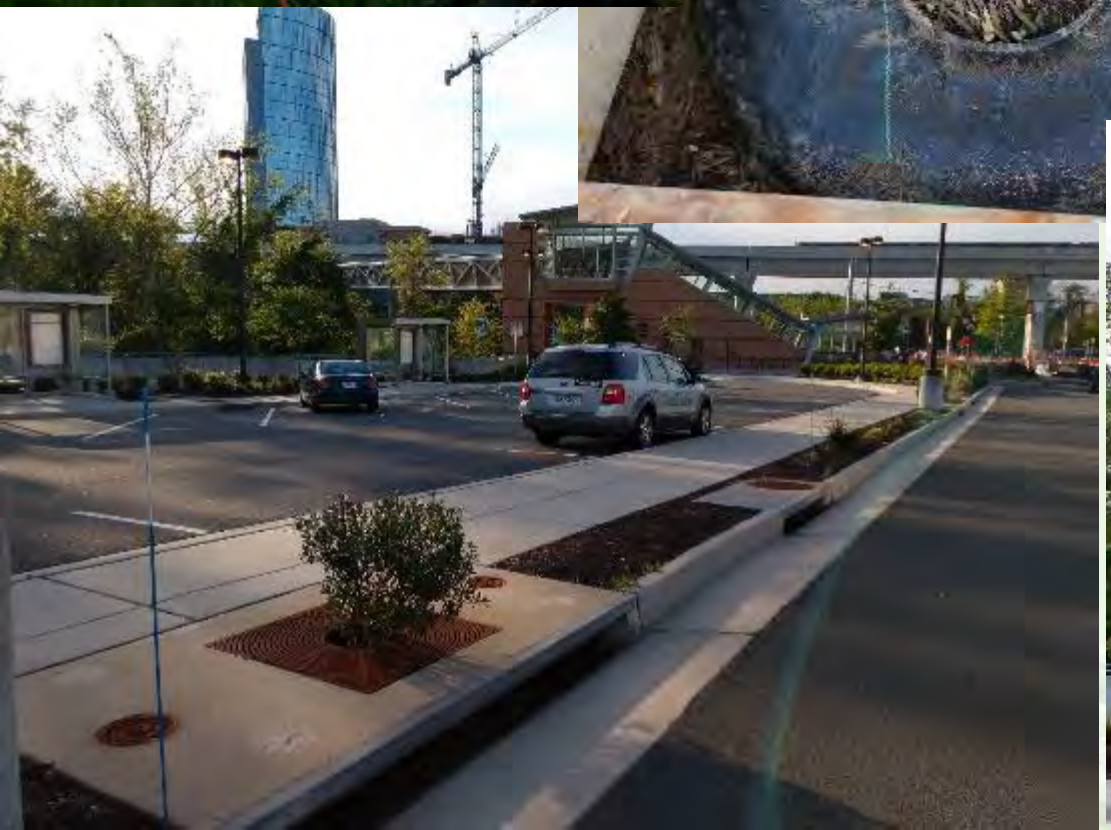


Discharging Only
When Soil Dries



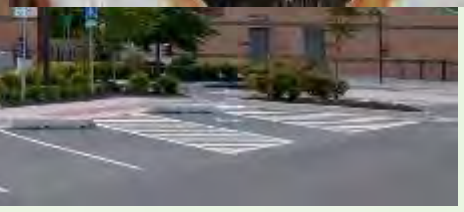
Tree Well-Fairfax County

McLean Metro Station, 4/27/2019



Trial Objects:

1. Retain H2O
2. Stabilize Soil Moisture
3. Save Plants
4. Reduce Maintenance



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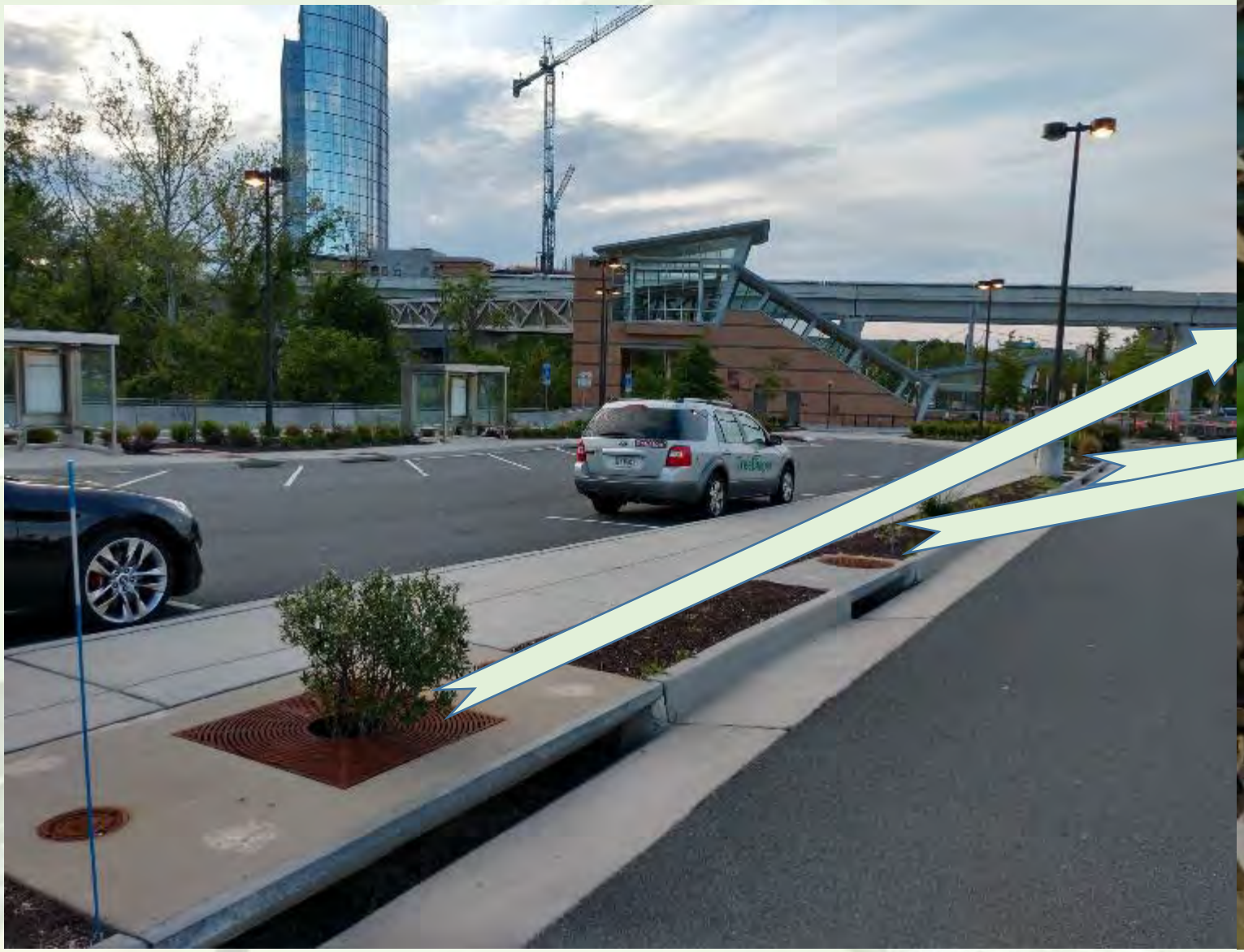


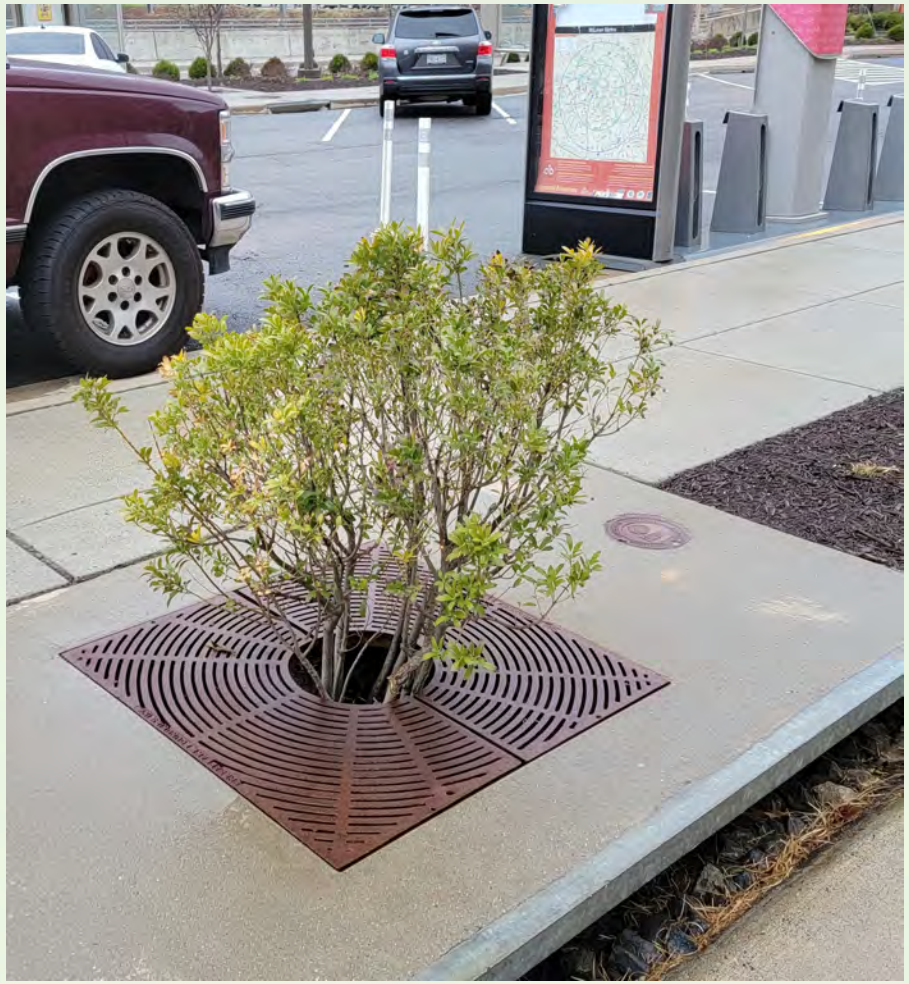
Tree Well-Fairfax County

McLean Metro Station

12/22/2019

04/17/2021

03/23/2022



Portland Oregon

909 E Burnside St

Google Map Streetside Image
Jun 2019

Portland Oregon

909 E Burnside St

Google Map Streetside Image Aug 2019

Portland Oregon
909 E Burnside St

The Difference in Sept 2019

Fredericksburg, VA…Aug 2019

Fredericksburg, VA…Jul 2020

April 17 2021

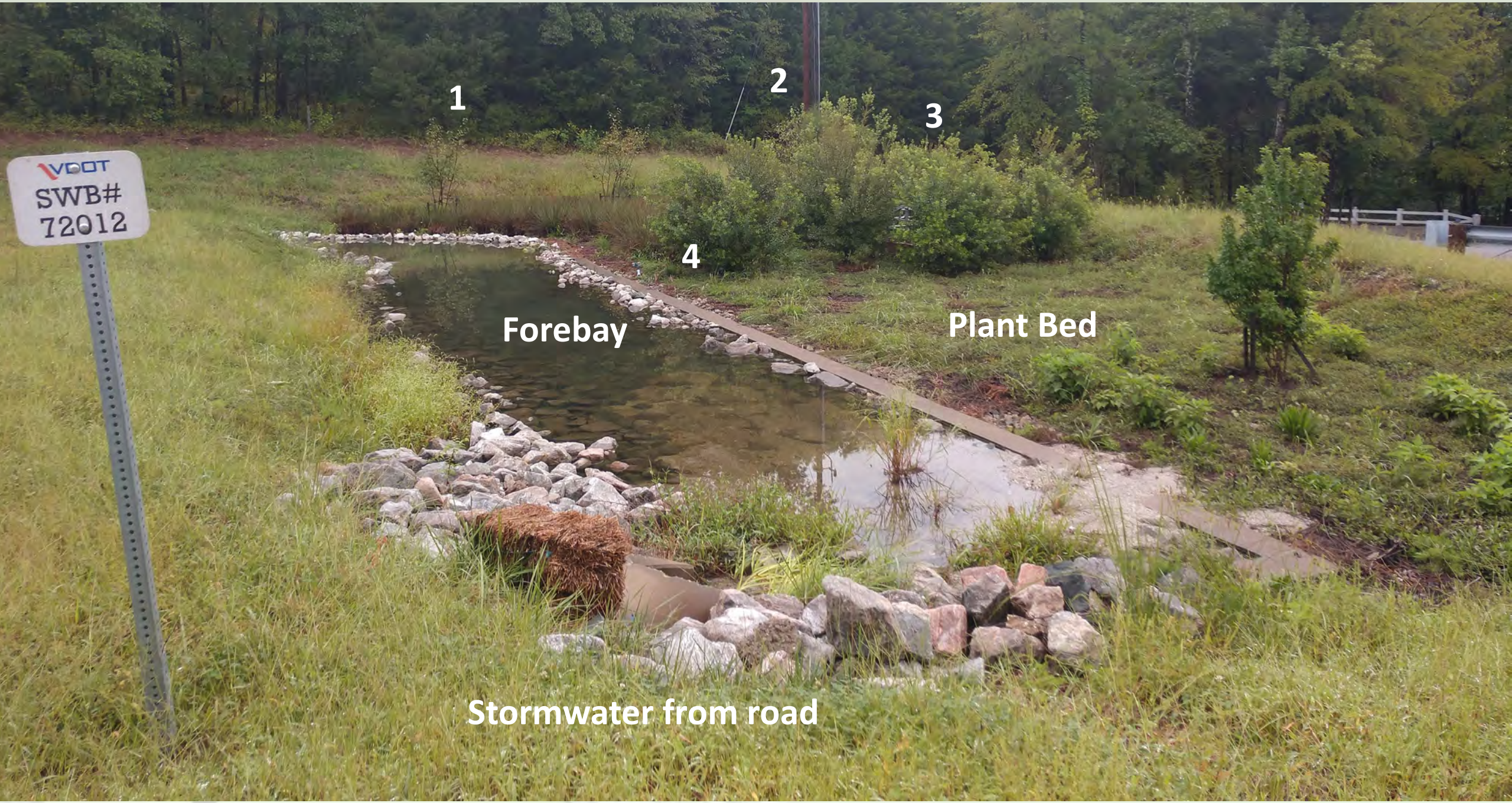
In the surrounding area

Under “Solid Water”

05/08/2022


SOUTH
218
1
TO
INTERSTATE
95
SOUTH
NORTH
BUSINESS
BUSINESS
17
17
Butler Rd
Warrenton Rd
Cambridge St
89-062


1
2
3
4
VDOT
SWB#
72012


1
2
3
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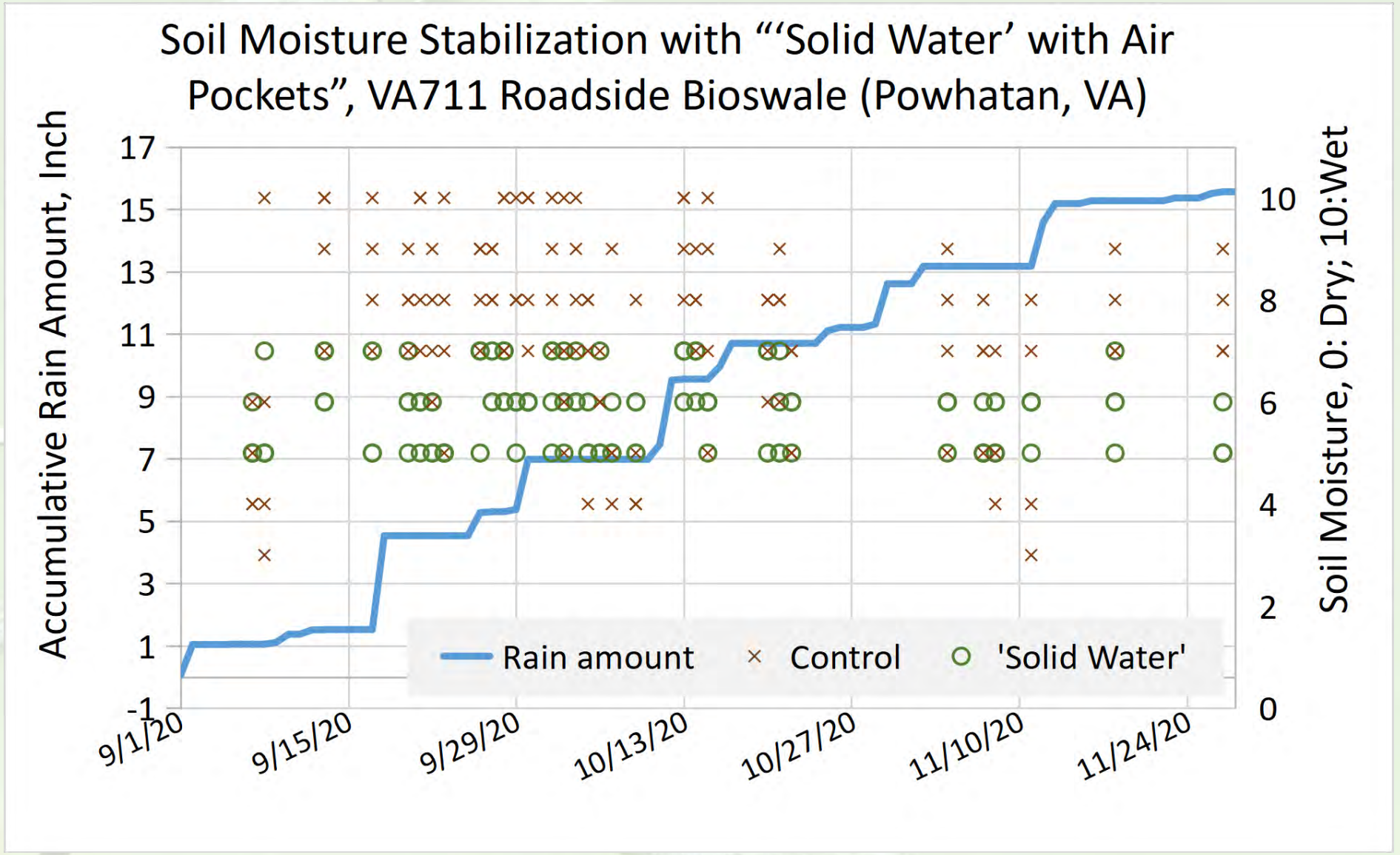
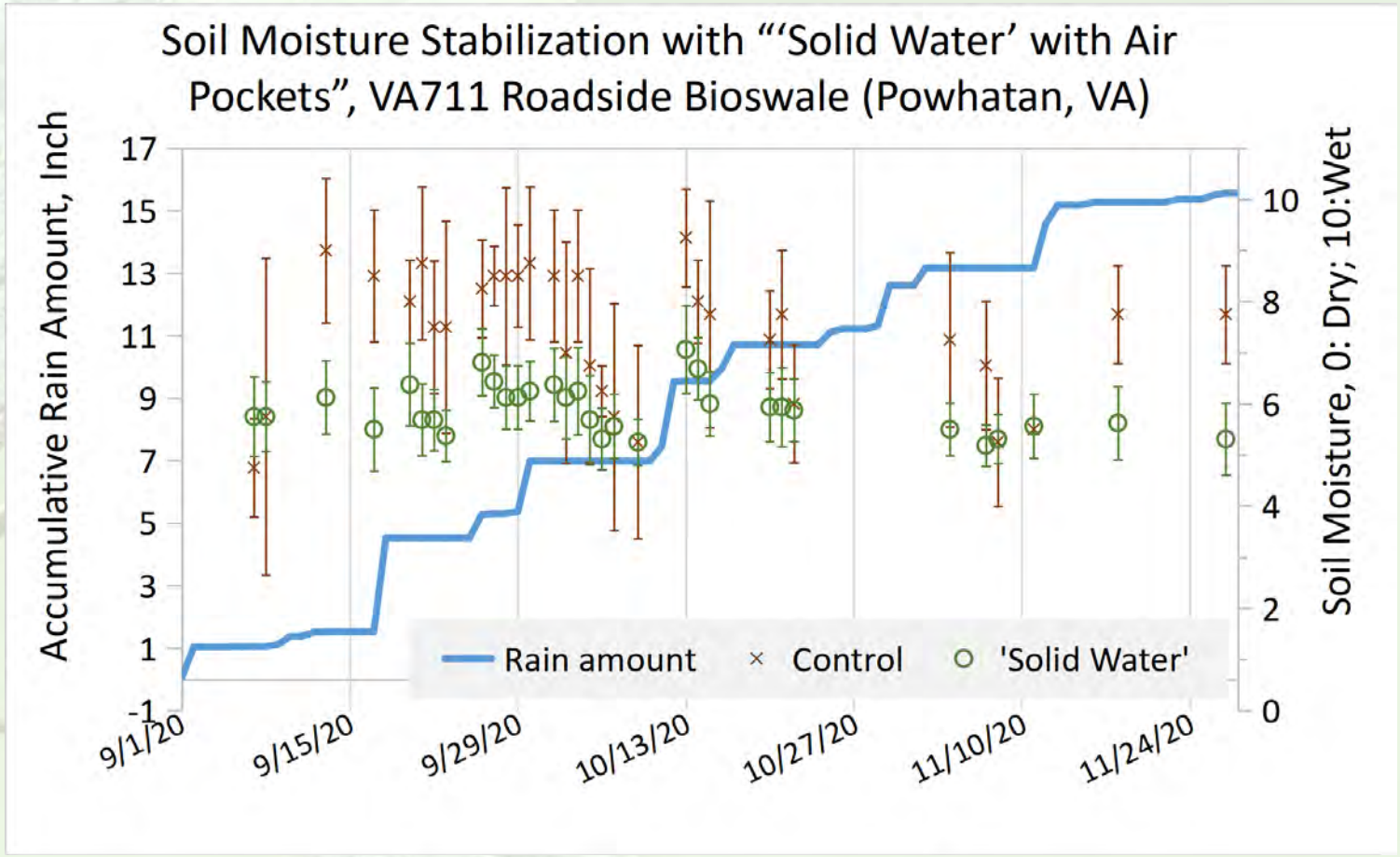
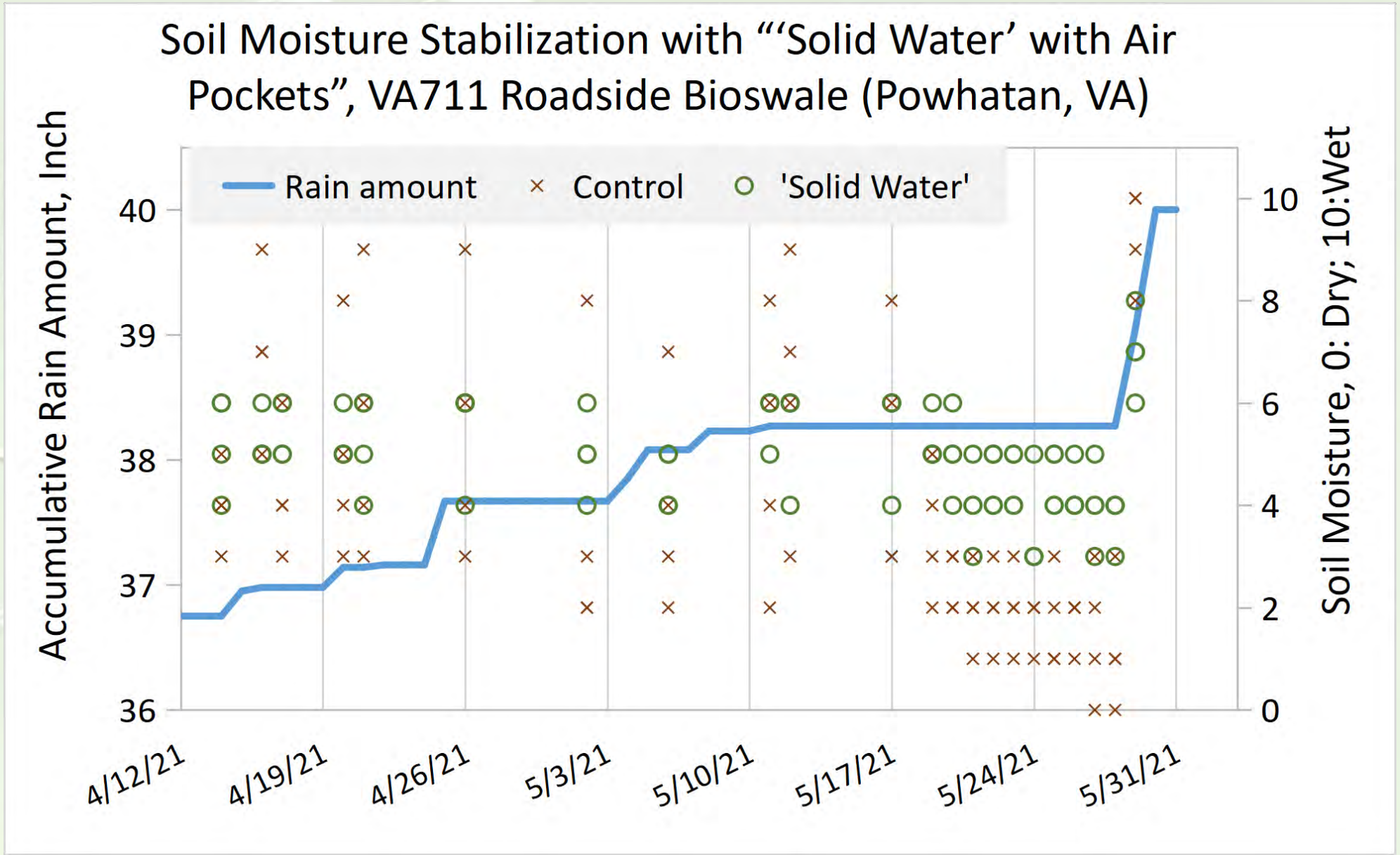
VDOT
SWB#
72012
Forebay
Plant Bed
Stormwater from road

Soil Moisture Sept-Nov 2020, VDOT GSI (VA 711)

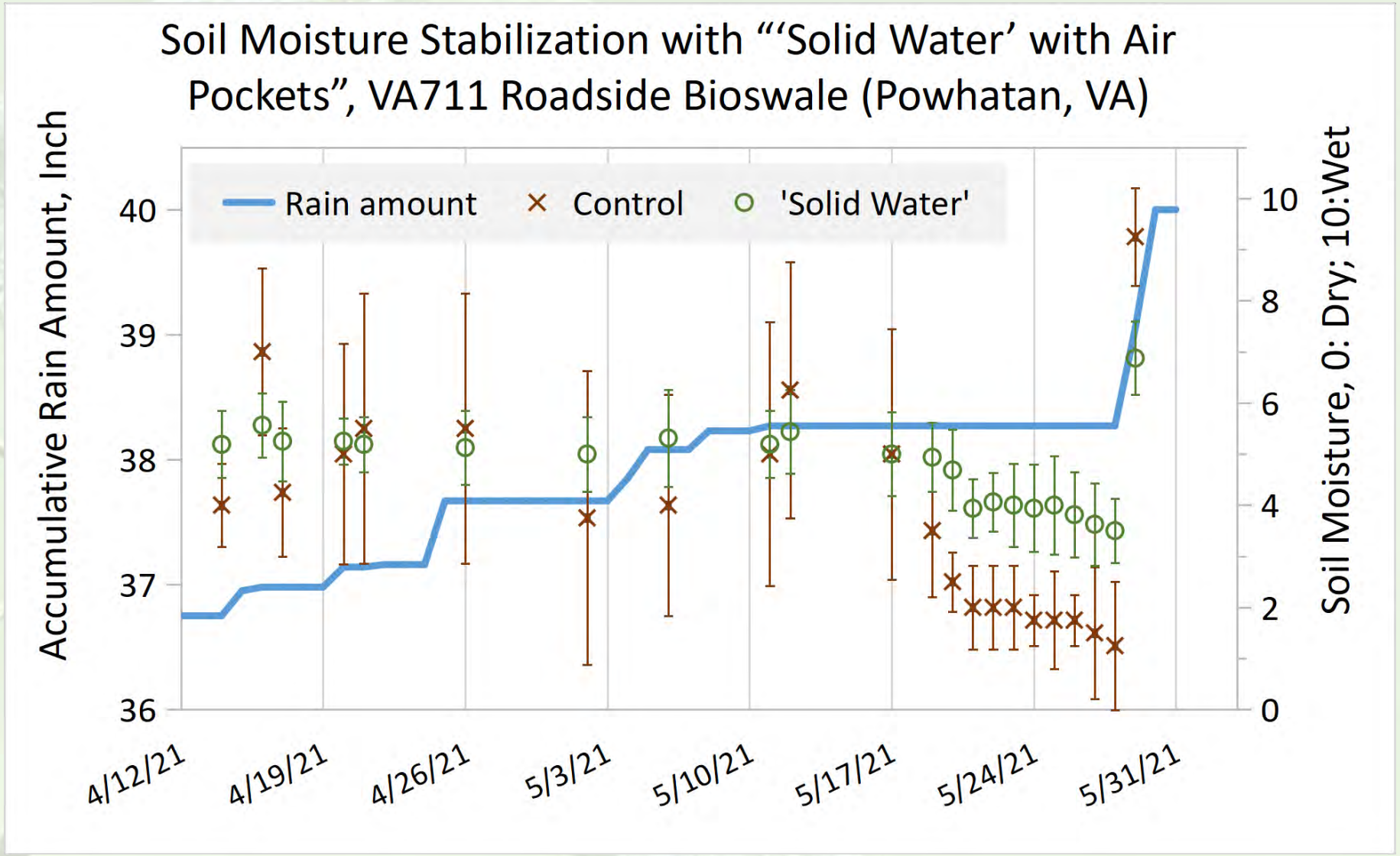



Soil Moisture Stabilization with "'Solid Water' with Air Pockets", VA711 Roadside Bioswale (Powhatan, VA)
Accumulative Rain Amount, Inch
Soil Moisture, 0: Dry; 10:Wet
17
15
13
11
9
7
5
3
1
-1
10
8
6
4
2
0
9/1/20
9/15/20
9/29/20
10/13/20
10/27/20
11/10/20
11/24/20
Rain amount
Control
'Solid Water'

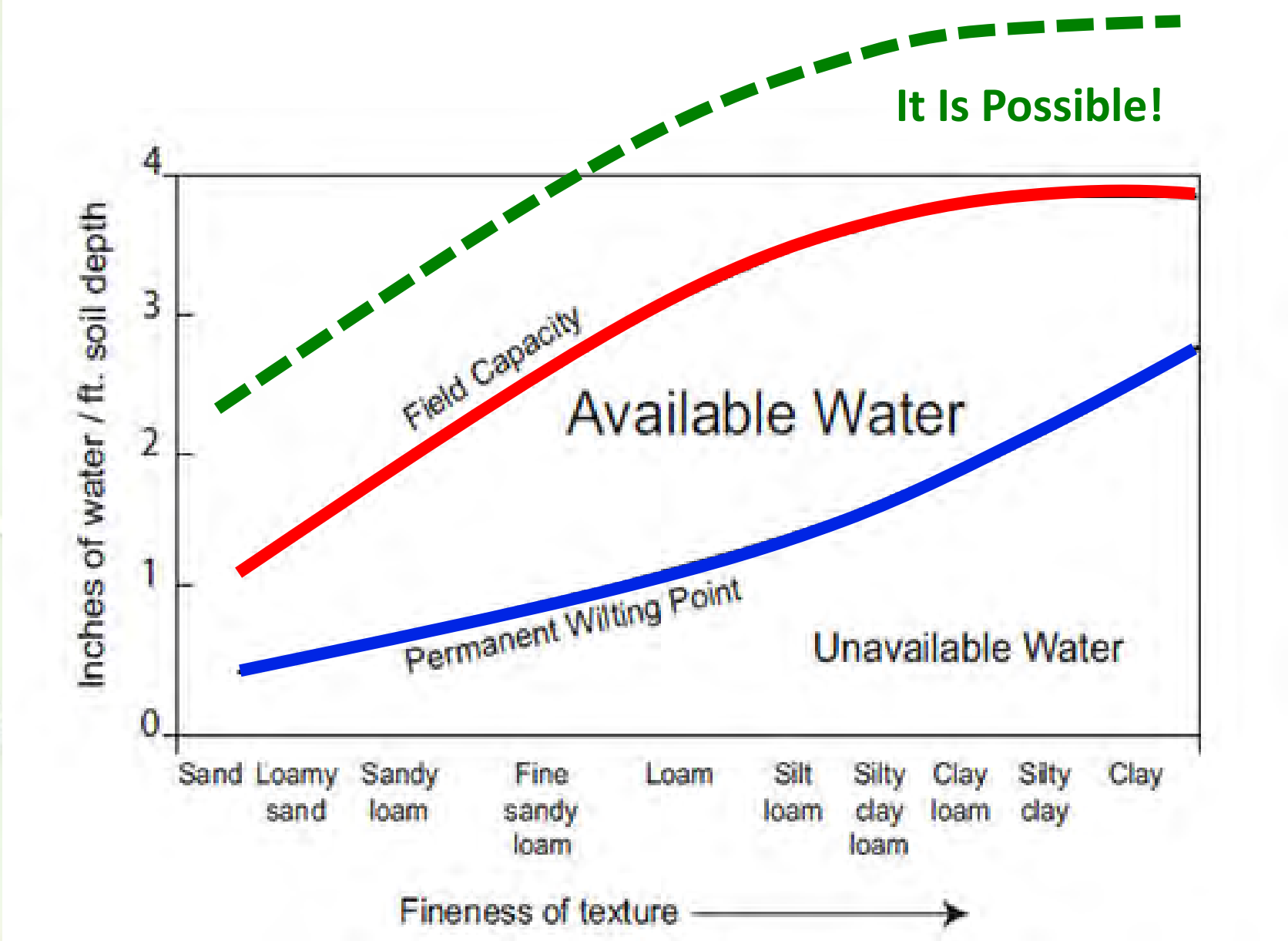
Soil Moisture April-May 2021, VDOT GSI (VA 711)



Soil Moisture April-May 2021, VDOT GSI (VA 711)



Plant Available Water



Source: Ohio Agronomy Guide, 14th Ed, Bulletin 472-05

Stresses in GSI

- Water
- Quality of Stock
  - Root (girdling root, planting depth, healthy root development)
  - Diseases
- Planting/Mulching
- Soil Compaction
- Site
- Soil Volume
- Other substances that harm trees in GSI, like salt
- Weather/Climate

Soil Compaction and Planting Failure

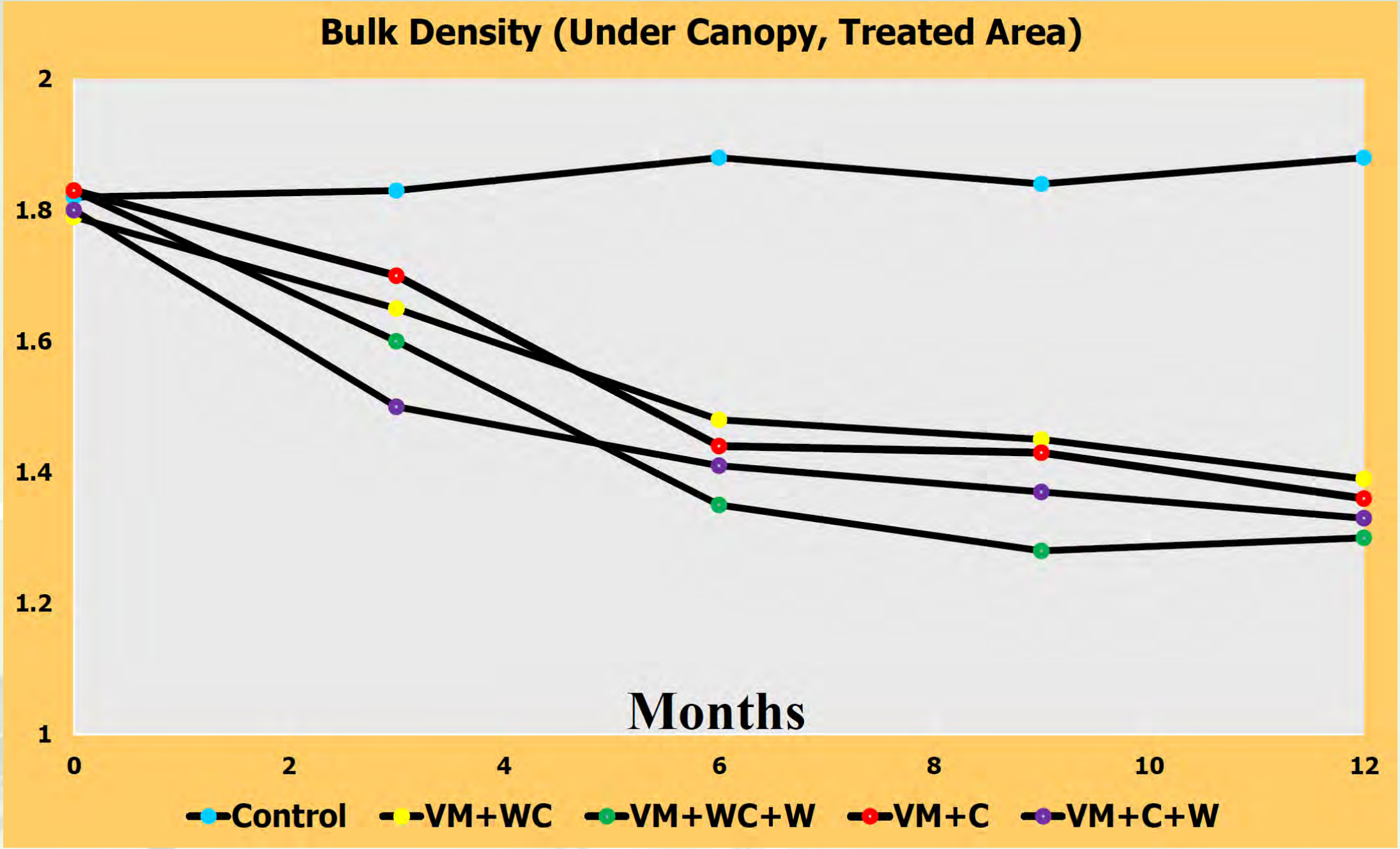
Soil Bulk Density (g/cm^3) or (lb/ft3)	**Planting Success Rate:**
1.25 – 1.34 78-84	100%
1.34 – 1.44 84-90	60%
1.45 – 1.54 91-96	33%
1.55 – 1.64 97-102	10%
>1.65 >102	0%

Dr. Glynn Percival, Bartlett Tree Research Lab and Reading University
Percival, G C (2007). Pre-planting– getting to the root of the problem. Essential ARB. Issue 22. June Edition

Soil bulk density on Roadside after construction: **1.8-2.0 g/cm^3**
Common red brick: **1.9 g/cm^3**
Concrete: **2.4 g/cm^3 (150 lb/ft^3)**

The use of vertical mulching and worm technology for long-term soil decompaction

Glynn Percival
Bartlett Tree Research Lab
Reading University



Dr. Glynn Percival, Bartlett Tree Research Lab and Reading University

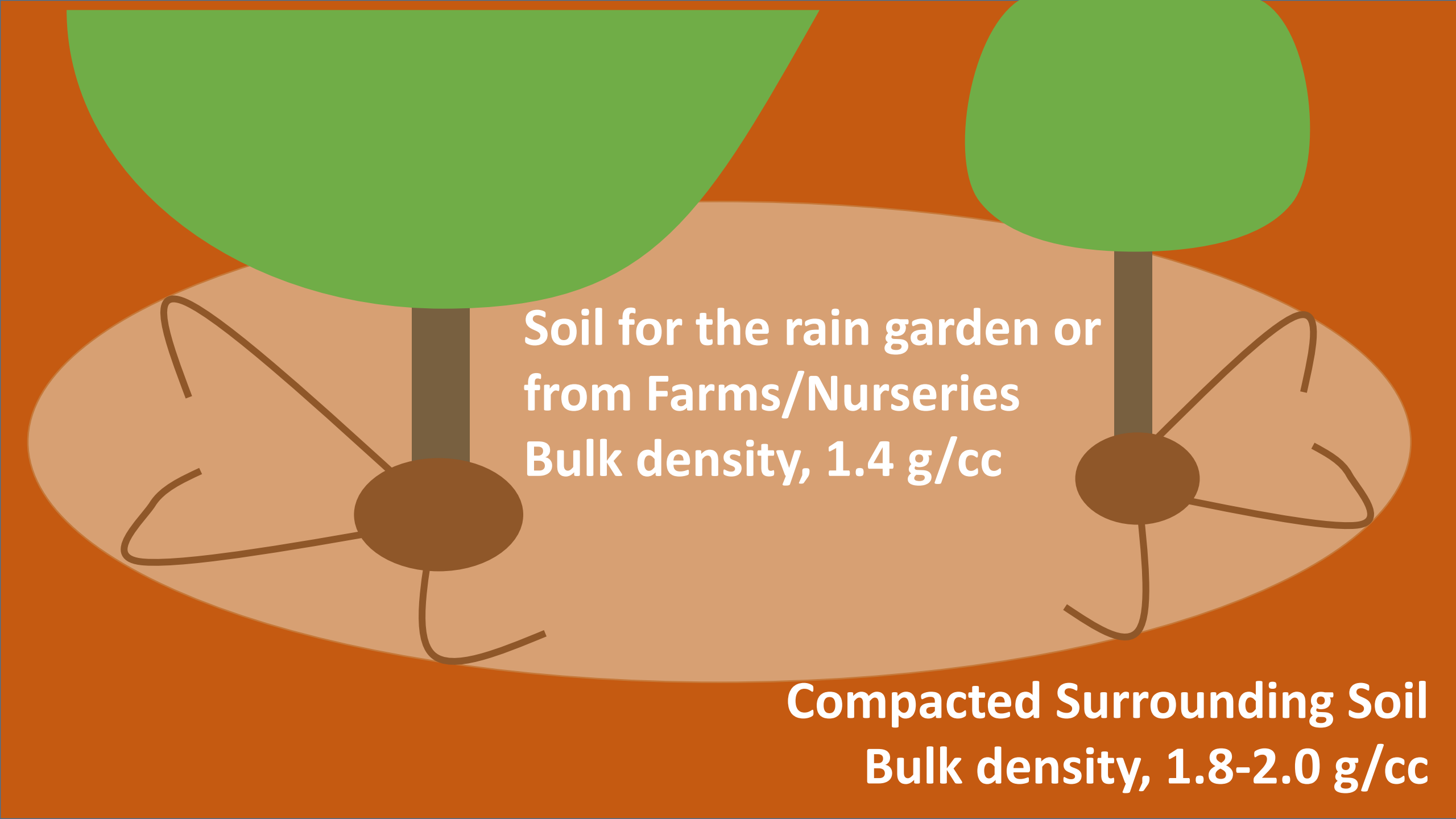
How about worms without vertical mulching?

Worm Free Compacted Soil

Leaves & “Solid Water”

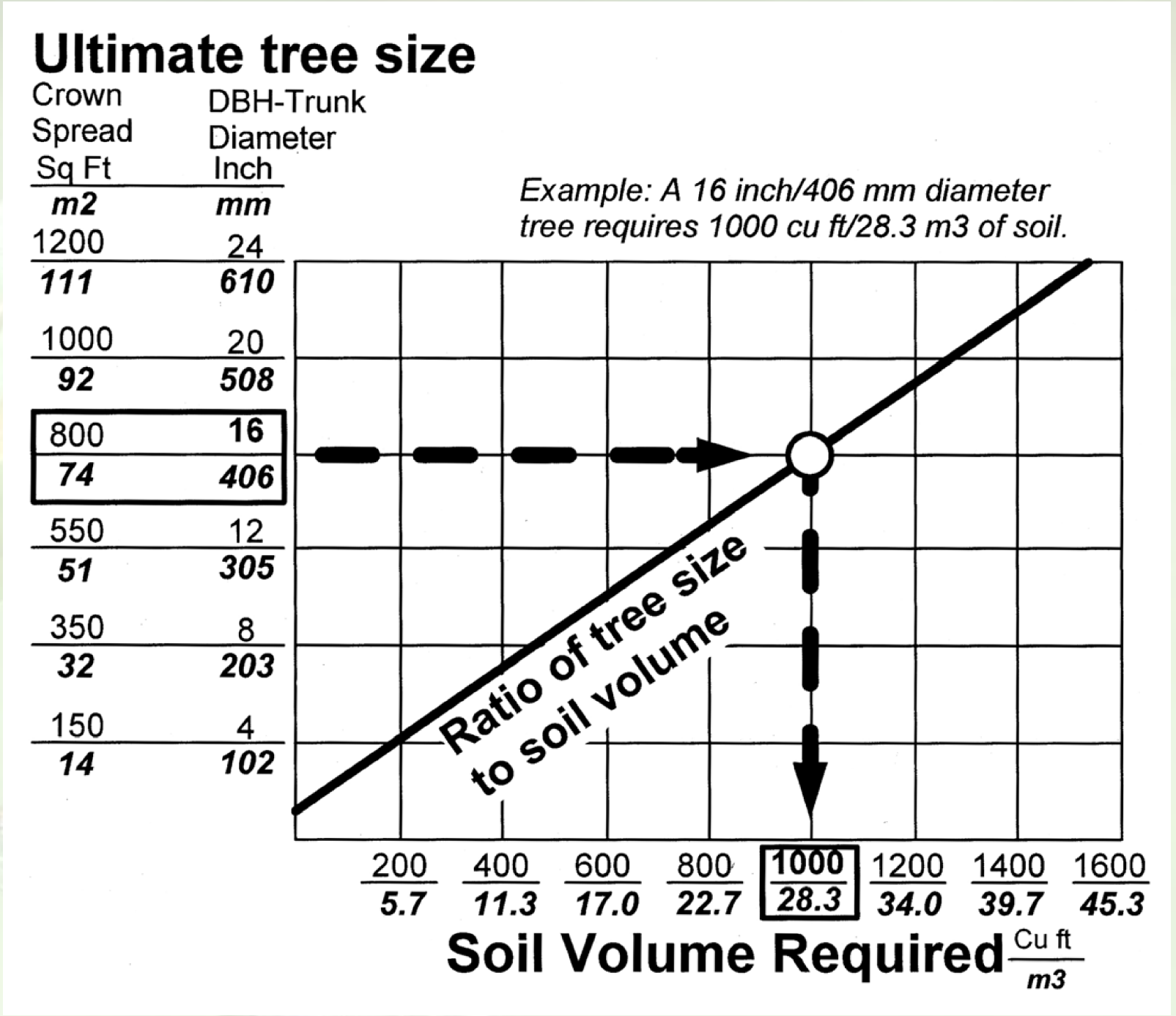
9 Mo Later

Moist Soil Loosened by Earth Worms


Soil for the rain garden or
from Farms/Nurseries
Bulk density, 1.4 g/cc
Compacted Surrounding Soil
Bulk density, 1.8-2.0 g/cc

Soil Volume

James Urban
Up By Roots
2008, ISA



Questions

Green Stormwater Infrastructure

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