Gravel Bed Stormwater Retention System
Greenhouse Demonstration Project

Introduction

To better understand belowground processes of tree roots growing in gravel-based stormwater detention systems, a greenhouse demonstration was developed. This project is designed to simulate various scenarios that trees may encounter in larger stormwater retention gravel beds in or adjacent to parking lots. The purpose of this document is to provide an overview of the project including methods, proposed/expected outcomes of root morphology over a growing season, chronological observations, and actual results of root growth when available. To be clear, this project is not a designed research project. It is simply a demonstration project to help better understand root growth of trees in gravel-based stormwater systems to support field studies in Knoxville, TN, Chattanooga, TN, Baton Rouge, LA and Roanoke, VA.

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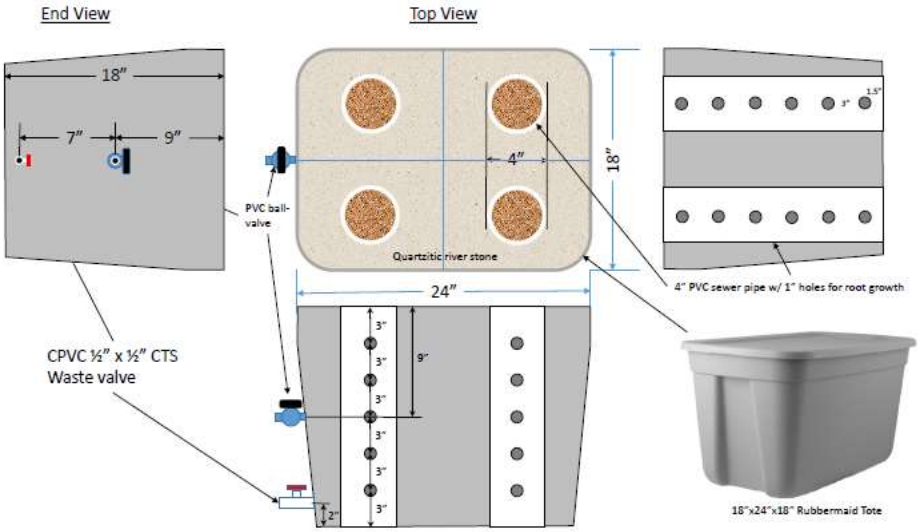
Project Design



Six inch PVC pipes with multiple 1" diameter drain holes bored along the sides were filled with potting soil into which trees were transplanted. Planted PVC pipes were set in large, plastic tubs fitted with a ½" ball valve (to simulate the system underdrain) at approximately the middle of the tub and a ½" gate valve near the bottom of the tub. The tubs were then filled with washed #57 granite.

Schedule 40 PVC pipes were cut to 15" lengths and 1" diameter holes were bored along four sides at 3" intervals. Holes bored along the north/south walls began at 3" from the top edge. Holes bored along the east/west walls began at 1.5" from the top edge.

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Each section was wrapped in black, woven, synthetic landscape fabric to help prevent migration of potting soil within the pots to the gravel profile during watering.

Large, plastic tubs were fitted with 1/2" PVC ball valves and brass gate valves to help control water volume within the system. The ball valves act as the under-drain and the gate valve functions as the belowground infiltration of the soil surrounding the system.

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Originally 1-gallon, container-grown seedlings were to be transplanted into 4" diameter PVC tubes for this project. Unfortunately, the nursery only had 3-gallon container stock, so the size of the PVC tubes was modified to 6" diameter. Root pruning was necessary for several of the trees (specifically the bald cypress – see image on the right).

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Transplanted trees in PVC tubes were placed four to a tub. Washed #57 granite filled the tub around each tube. All tubs were filled with water to help settle the stone. More stone was added as needed.

Species Selection

Four tree species showing tolerance for wet and dry conditions and commonly used in urban settings were chosen for this project: red maple, London planetree, overcup oak, and bald cypress. One of each species was subjected to each of 4 treatments for a total of 16 trees (4 species x 4 treatments).

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Treatment Scenarios

Four separate treatment scenarios were chosen ranging from droughty to wet (see image and treatment definitions below).

Scenario 1: Maximum system volume (far left-hand tub)

- With all valves closed, fill system to capacity weekly
- Open ball valve to drain excess water in upper portion of system
- Keep gate valve closed to allow remaining water to be removed by evapotranspiration
- This represents a lined system or a system surrounded by clay or compacted soil with no infiltration to surrounding soil

Scenario 2: Low exfiltration volume reduction (second from the left)

- With all valves closed, fill system to capacity weekly
- Open ball valve to drain excess water in upper portion of system
- Open gate valve slightly until water begins to drip out of tub slowly
- Allow system to drain slowly over the week to mimic a slow exfiltration rate
- Irrigate soil around trees if needed to keep trees alive
- This represents an unlined system where water infiltrates into the surrounding soil slowly

Scenario 3: High exfiltration volume reduction (second from the right)

- With all valves closed, fill system to capacity weekly
- Open ball valve to drain excess water in upper portion of system
- Open gate valve fully
- Allow system to drain quickly to mimic a high exfiltration rate
- Irrigate soil around trees if needed to keep trees alive
- This represents an unlined system where water infiltrates into the surrounding soil quickly

Scenario 4: Drought conditions (far right-hand tub)

- Leaving gate valve open, add enough water to the system weekly until water begins to drip from the gate valve
- Irrigate soil around trees if needed to keep trees alive
- This represents an unlined system that receives very little runoff throughout the growing season

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Proposed / Expected Outcomes of Root Morphology over the Growing Season

At the end of the growing, each treatment will be carefully dismantled and the trees within each treatment will be examined. After removing the landscape fabric, I expect to see the following root-growth patterns:

Scenario 1 (Maximum system volume)	Scenario 2: Low exfiltration volume reduction	Scenario 3: High exfiltration volume reduction	Scenario 4: Drought conditions
			

Because the landscape fabric is a woven, synthetic material, I do not expect roots to migrate into the gravel profile, but will grow between the fabric and outside of PVC tube.

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Chronological Observations

March 25-26, 2019 – Demonstration project constructed

April 15, 2019 – Transplanted trees beginning to break bud and leaves expanding on all plants

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April 25, 2019 – Greenhouse fans malfunction
Excessive heat over multiple days in greenhouse causes stress and death of some project trees.




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May 3, 2019 – Greenhouse side panels removed to allow for cross ventilation
Six of 16 trees dead due to excessive heat.

Scenario 1 (Maximum system volume)	Scenario 2: Low exfiltration volume reduction	Scenario 3: High exfiltration volume reduction	Scenario 4: Drought conditions
			
All trees survived. Bald cypress sprouted at base.	Overcup oak survived. All other trees dead after leafing out.	Overcup oak and bald cypress survived. Red maple and London planetree dead after initially leafing out. Bald cypress sprouted from base.	London planetree dead after initially leafing out.

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May 30, 2019
Tree survivability stabilized and trees showing strong vitality and growth.

Scenario 1 (Maximum system volume)	Scenario 2: Low exfiltration volume reduction	Scenario 3: High exfiltration volume reduction	Scenario 4: Drought conditions
			

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September 3, 2019
Study period ends. Trees removed from gravel systems and root growth observed.

Scenario 1 (maximum system volume)
root growth for red maple, overcup oak, baldcypress, and London planetree

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Scenario 2 (Low exfiltration volume reduction)
Root growth for overcup oak


Scenario 3 (High exfiltration volume reduction)
Root growth for overcup oak

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Scenario 4 (drought condition) overcup oak, red maple, and baldcypress root growth

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Comparison of root growth for overcup oak by treatment

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