Disclaimer

GI Evaluation in Urban Areas: Strategies and Challenges

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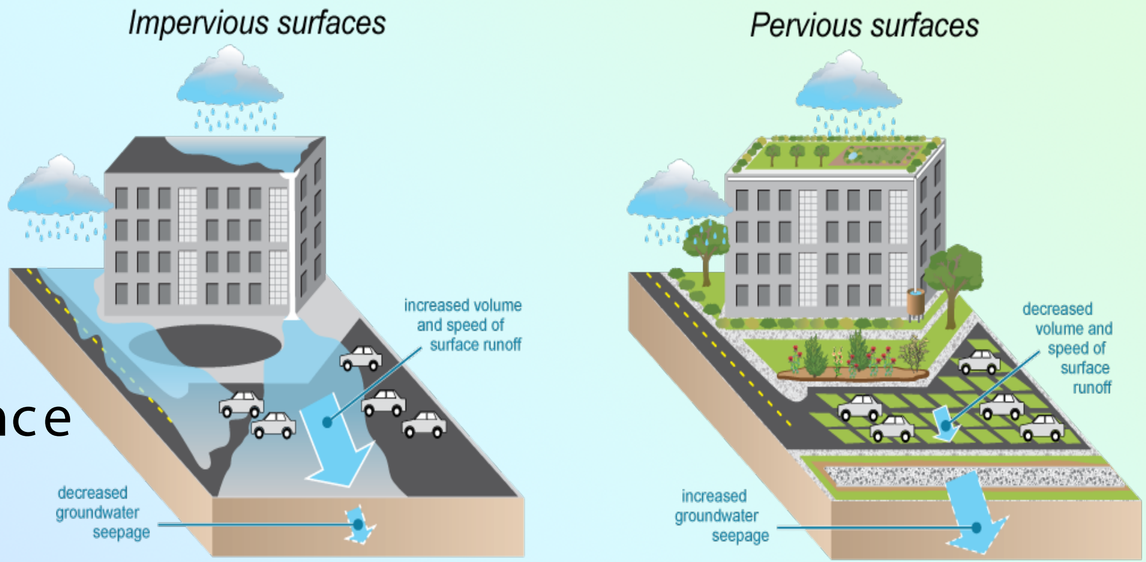
This research has been supported by a grant from the U.S. Environmental Protection Agency's Science to Achieve Results (STAR) program.

The goal of monitoring is to evaluate the performance of GI

- Stormwater capture
- Infiltration
- Sustainabilty / maintenance



- Impact (CSO reduction, groundwater mounding, surface ponding, neighborhood)

What do we monitor?

- Rainfall
- Topography
- Inflows
- Outflows
- Storage
- Infiltration rates
- Water table
- Soil properties
- Plant health

What are the monitoring costs?

- Rain gauges $
- Water level loggers $
- Communication $ to $$
- Soil moisture loggers $$
- Flow meters $$
- Calibration $ to $$
- Construction $$ to $$$
- Drilling$$$
- LiDAR (airborne or surface) $$$
- Geophysics $$ to $$$
- Infiltration surveys $
- Compaction surveys $
- Maintenance $$

Calibration

- Technical support $$$
- **$ 100’s $$ 1000’s $$$10000’s**

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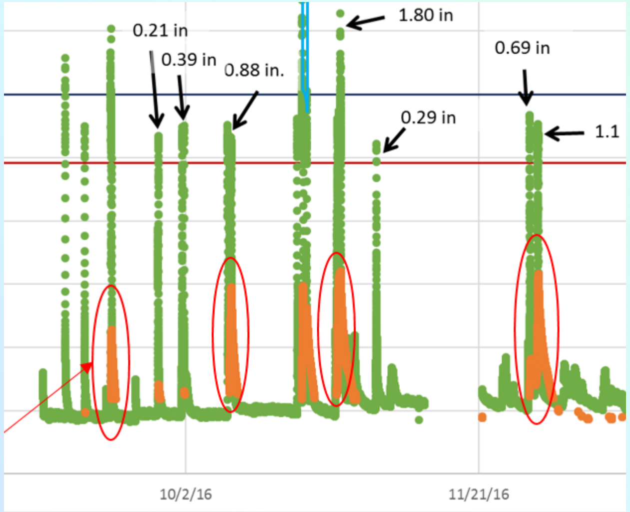
Geophysical survey

- Technical support $$$
- **$ 100’s $$ 1000’s $$$10000’s**

Monitoring presents challenges

- Equipment failure
- Power
- Communication
- Cost
- Reliability
- Seasonal variation
- Heterogeneity

- And more…

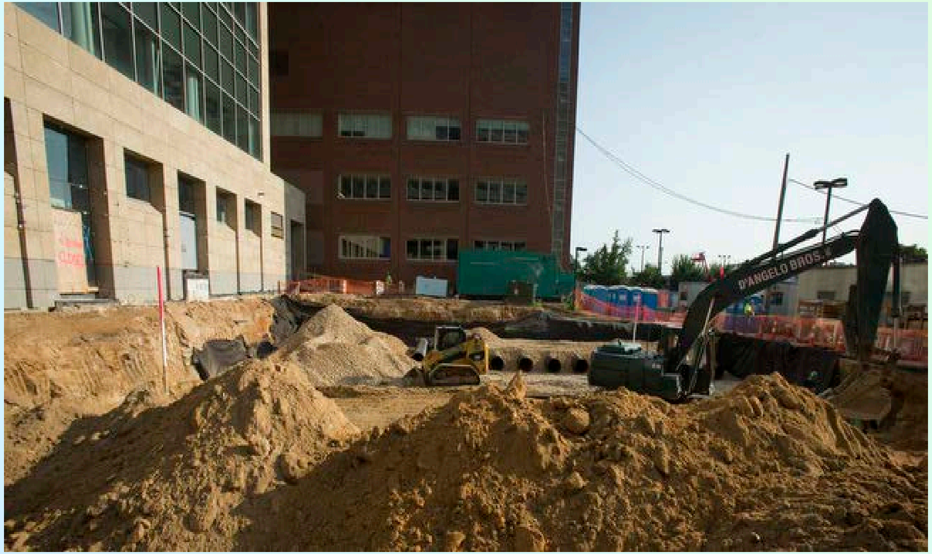


Data gaps

All-weather monitoring

Some challenges are unique to urban settings

- Permits
- **Infrastructure**
- Community acceptance
- Equipment disturbance
- By pass
- Clogging
- Heterogeneity



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- **Heterogeneity**

If It Doesn’t Get In, We Can’t Measure It

Surface flow bypassing trench drain

Effects of post-construction enhancements

Inflow backing up due to debris and clogging

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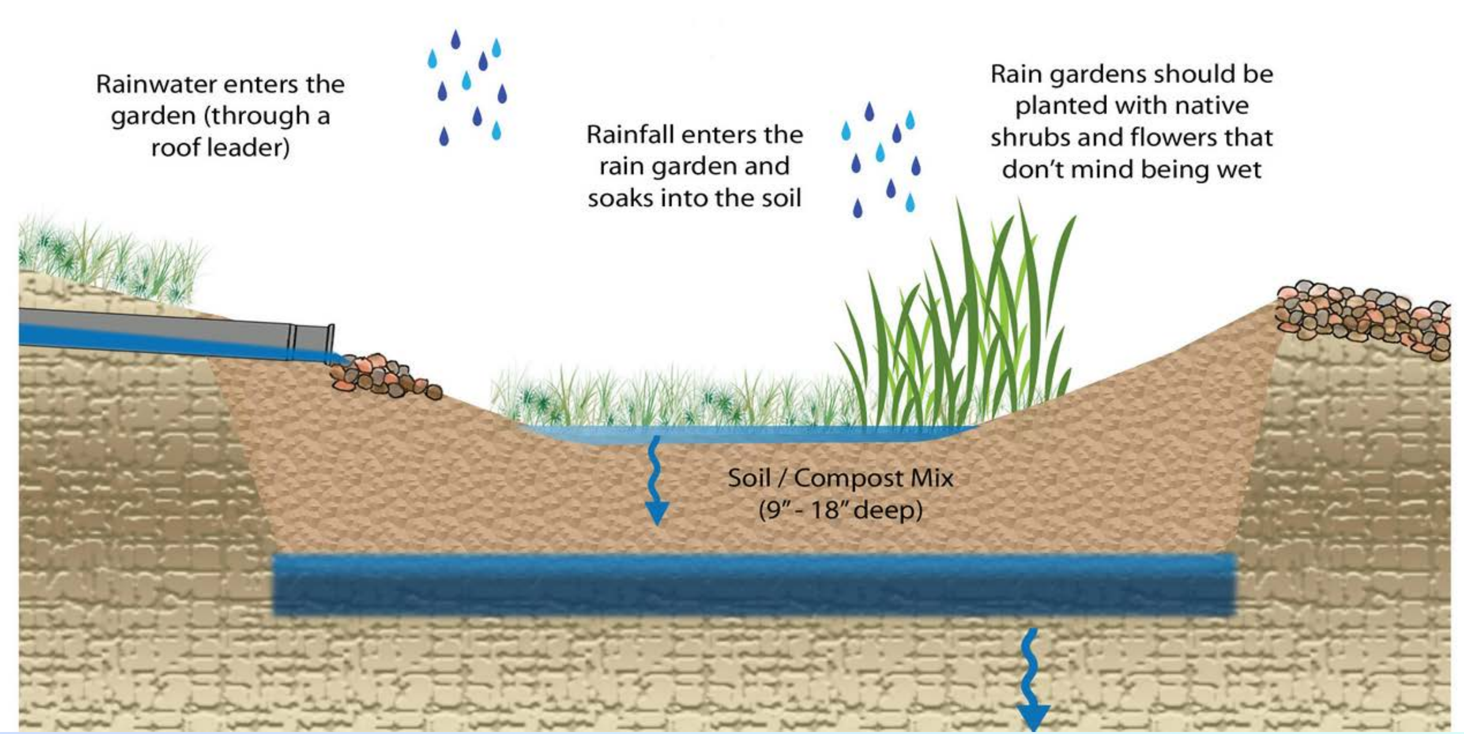
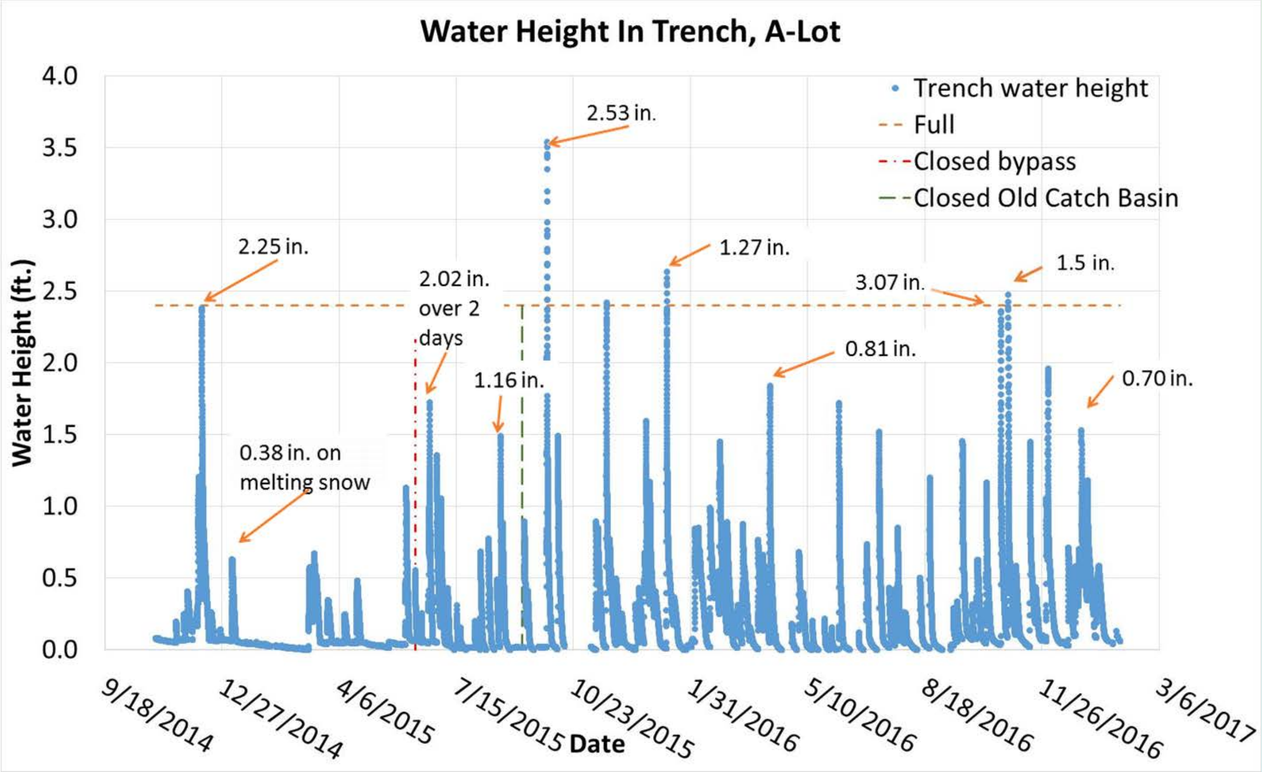
What are we learning from monitoring?

- Comparison of design strategies
- Modeling input
- Old versus new design
- Oversizing

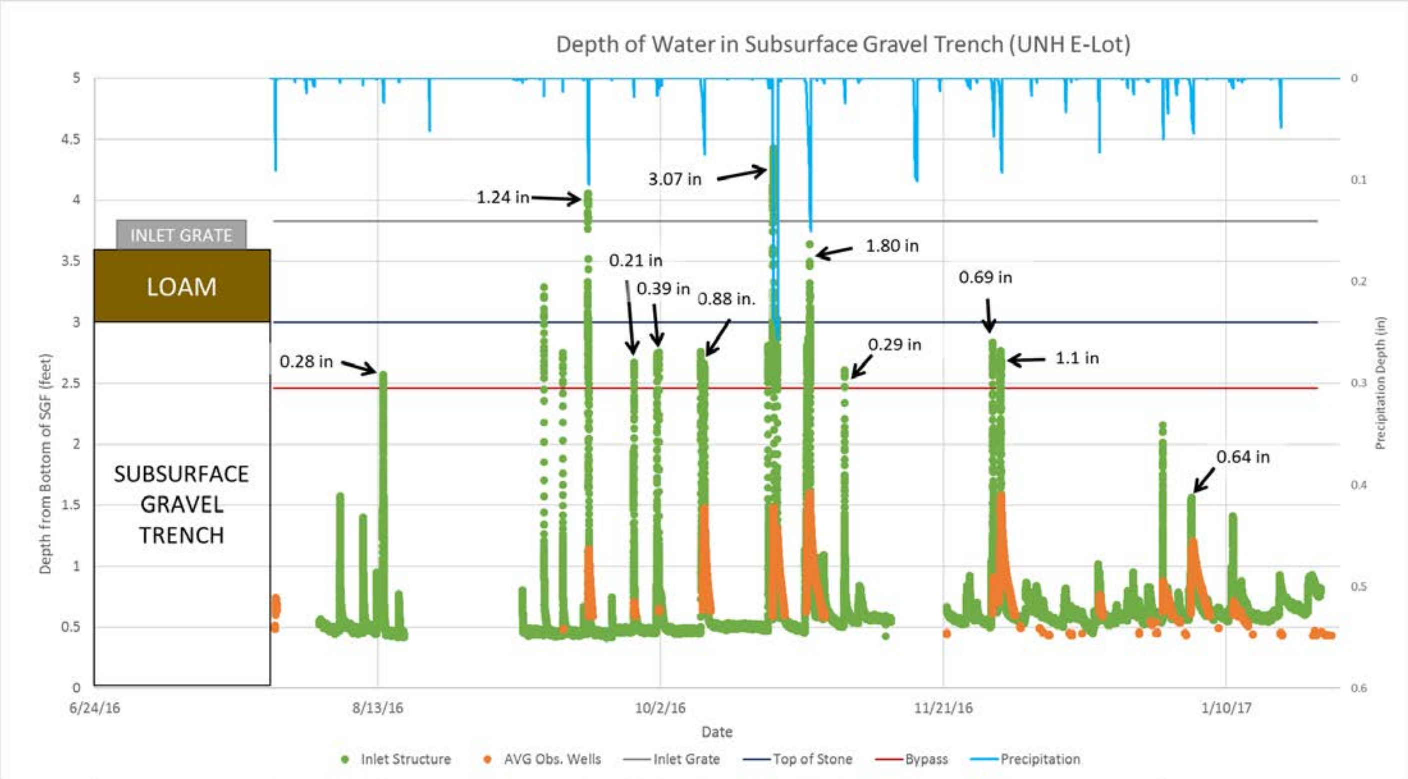
Comparison of upflow and downflow design



Downflow design treats more water than expected



Upflow design creates stormwater bypass



Wakefield raingarden instrumentation

- Tensiometers(red dots)
- Wells and water level loggers (yellow dots)

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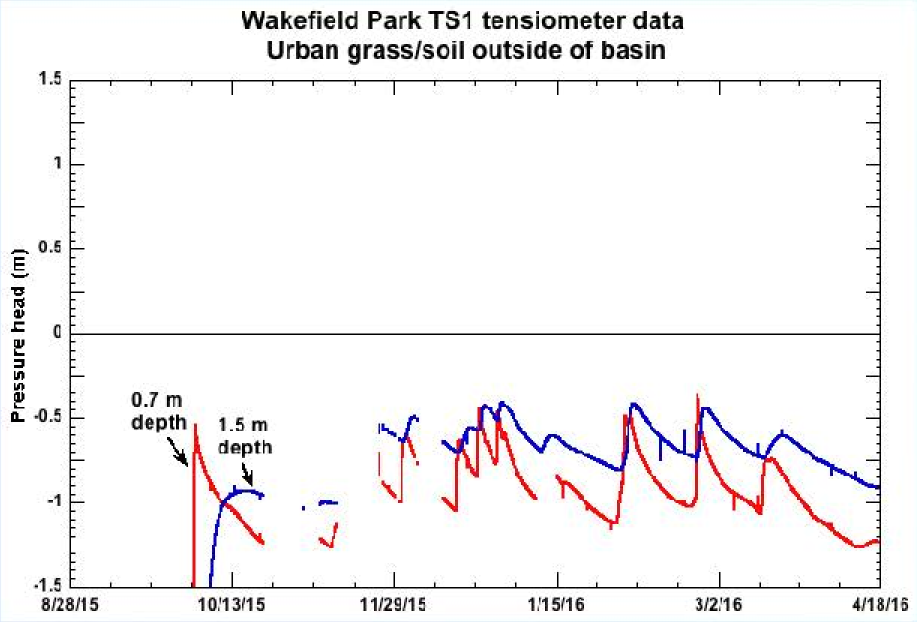
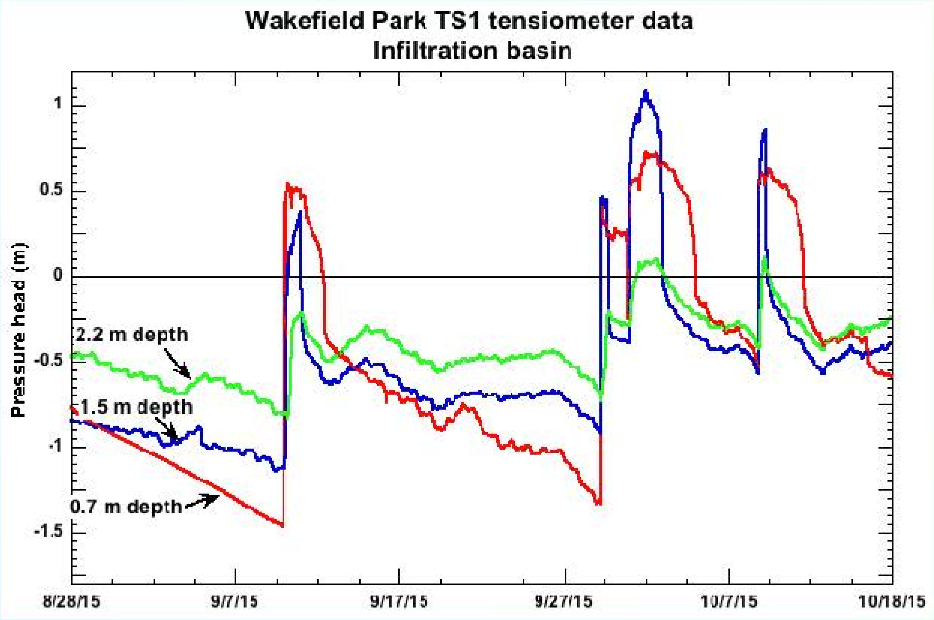
Tensiometer data used to calibrate model





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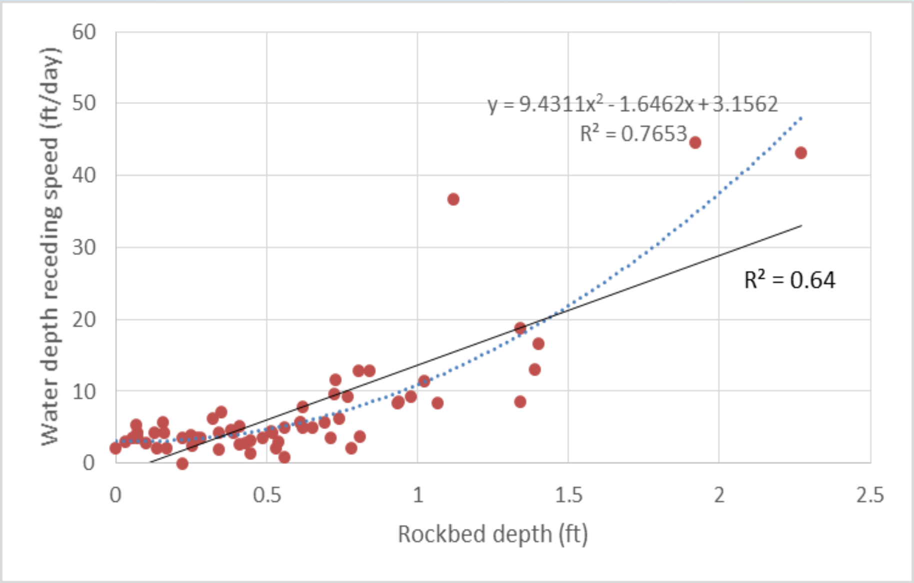
Oversized trench keeps stormwater from pits



Stormwater tree trench

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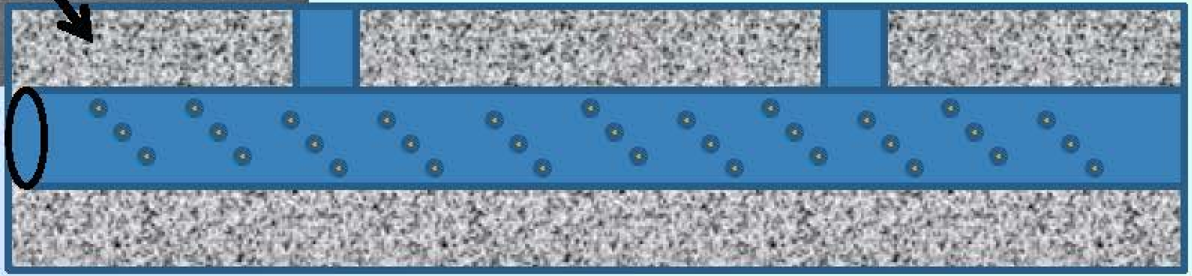
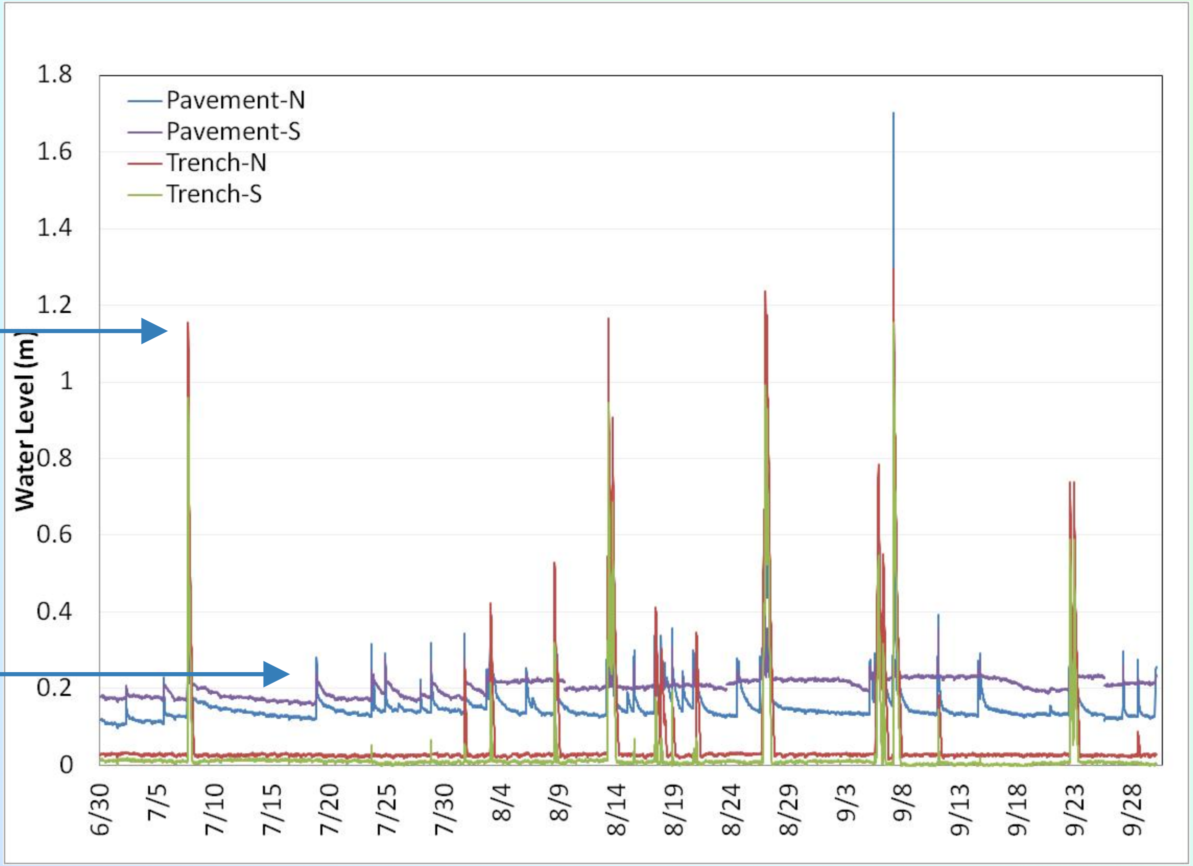
Old versus new stormwater control



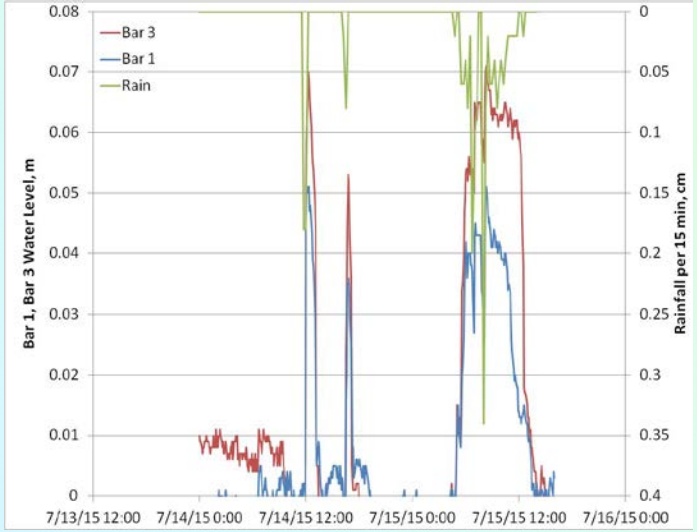
Infiltration trench: 82 m by 2.4 m

- The trench responded only to big storms
- The old pipe design responded to every storm



Monitoring helps assess what happens when GI isn't working

- Groundwater mounding
- Bypassing
- No storage
- Season variations
- Infiltration difficult to predict



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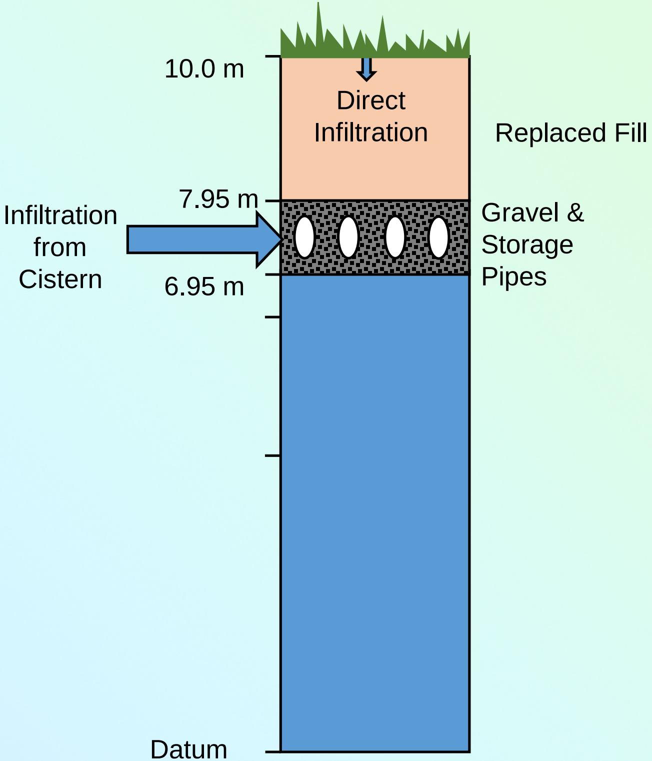
Infiltration basin received water from roof of new science building



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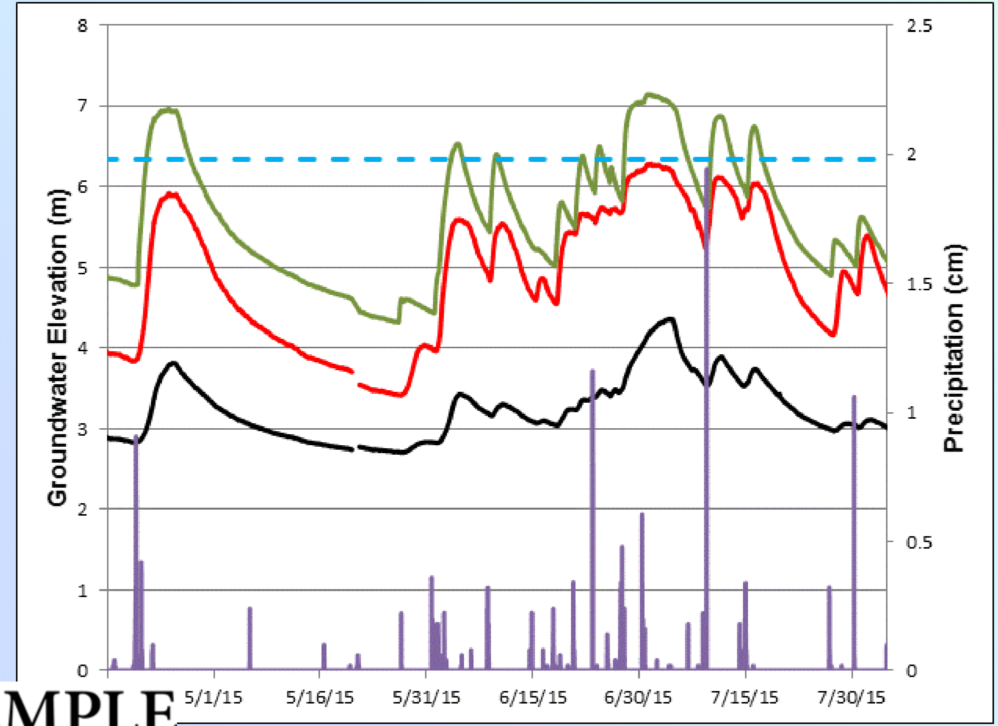
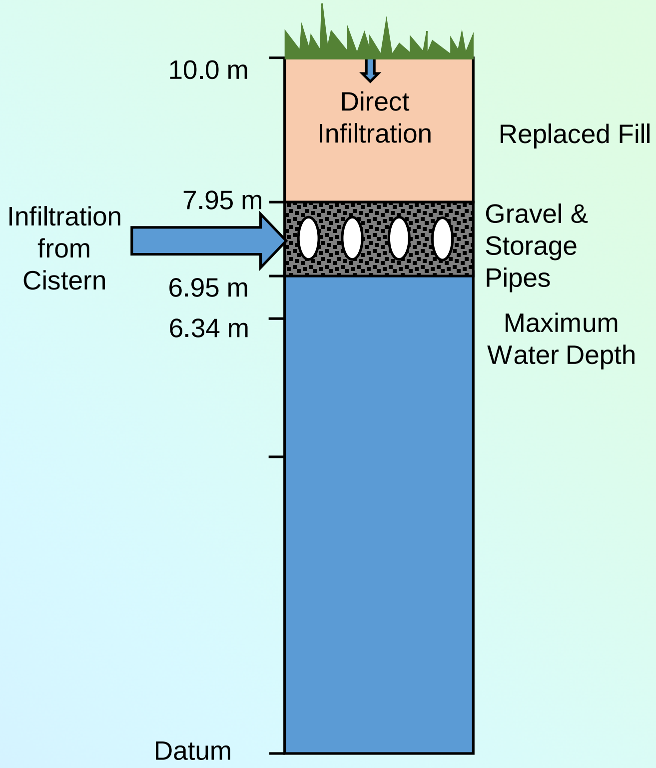
Stormwater mounding should not be within 0.6 m of trench





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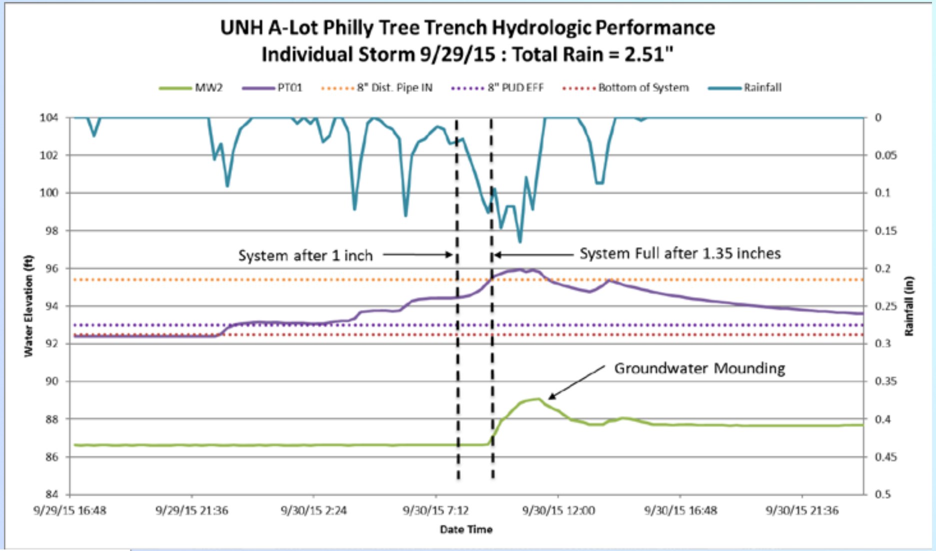
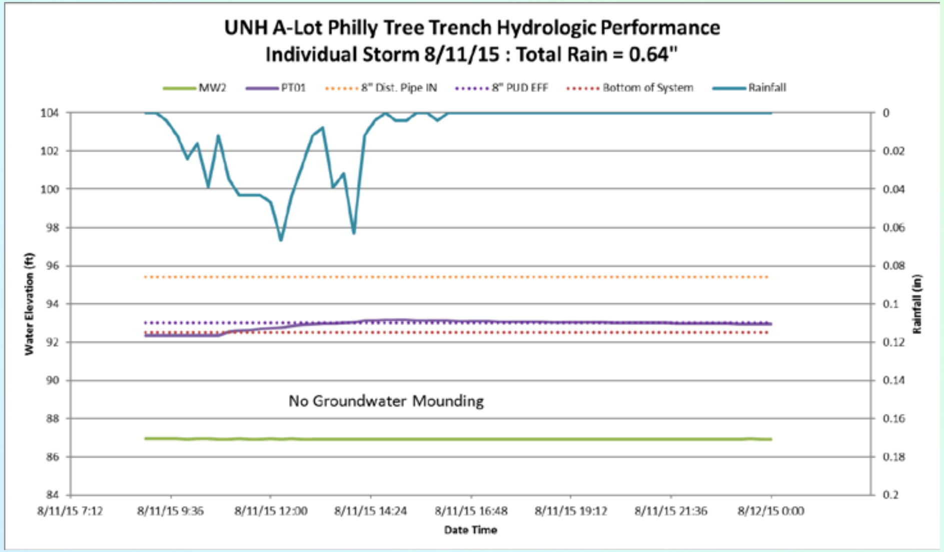
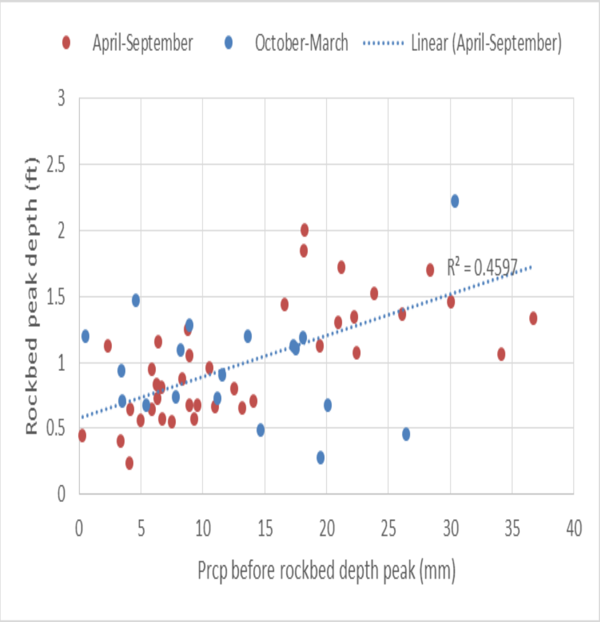
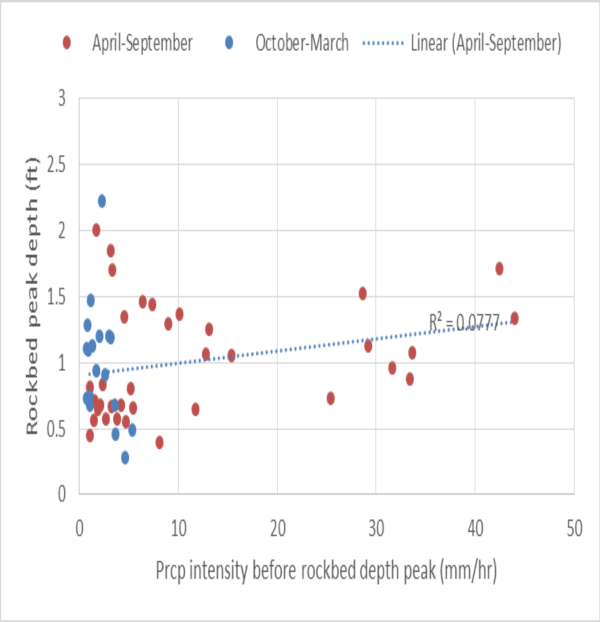
Storm with and without mounding in tree trench





Seasonality affects results





- Event rainfall depth is related to peak water level, but only Apr-Sept
- Long term monitoring is needed

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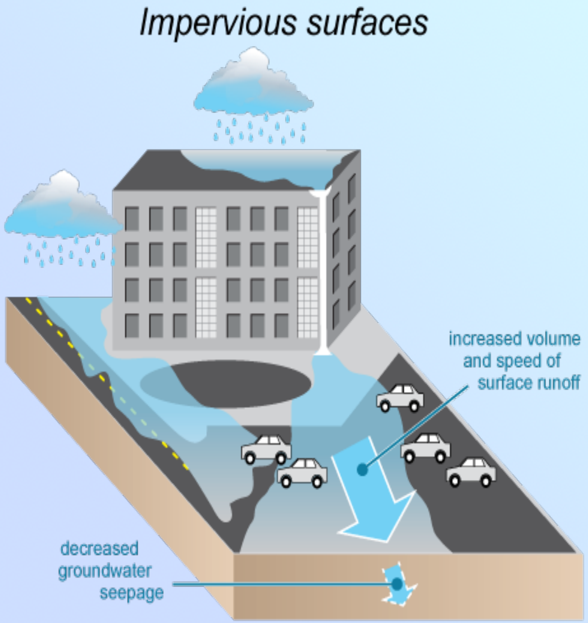
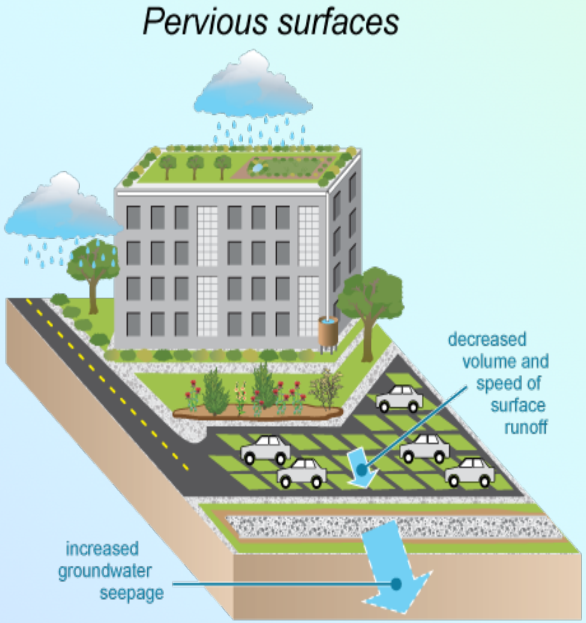
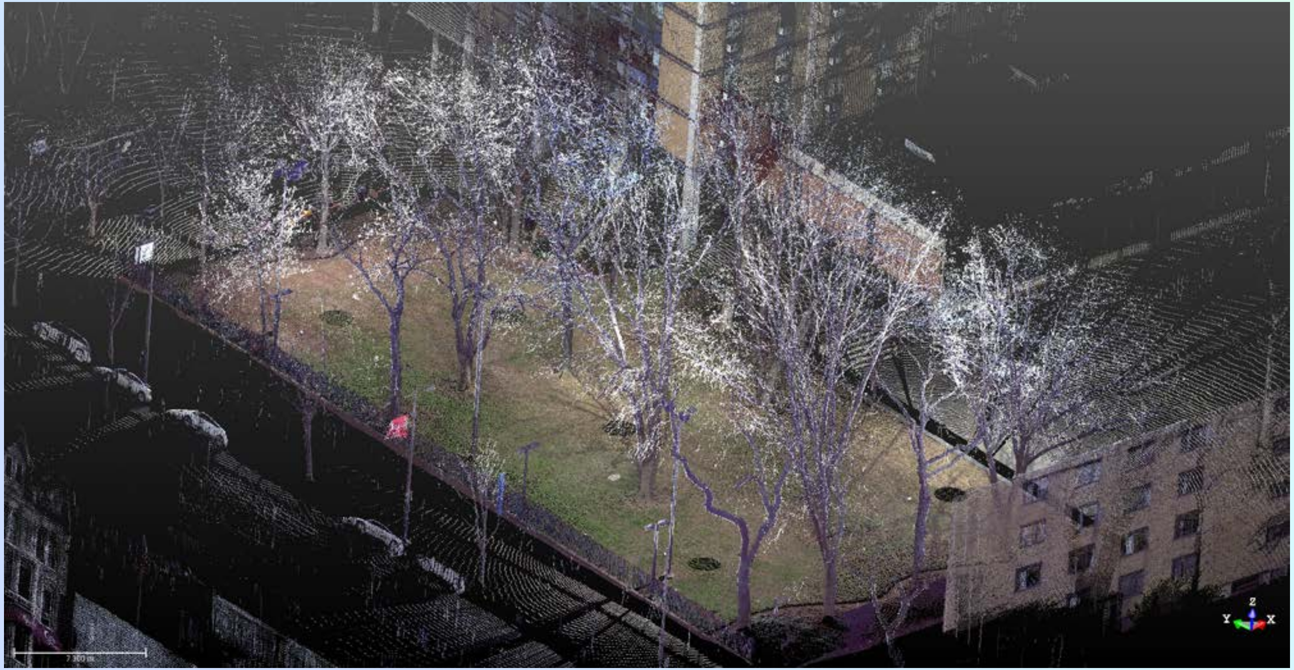
Bypassing means storm isn't fully captured

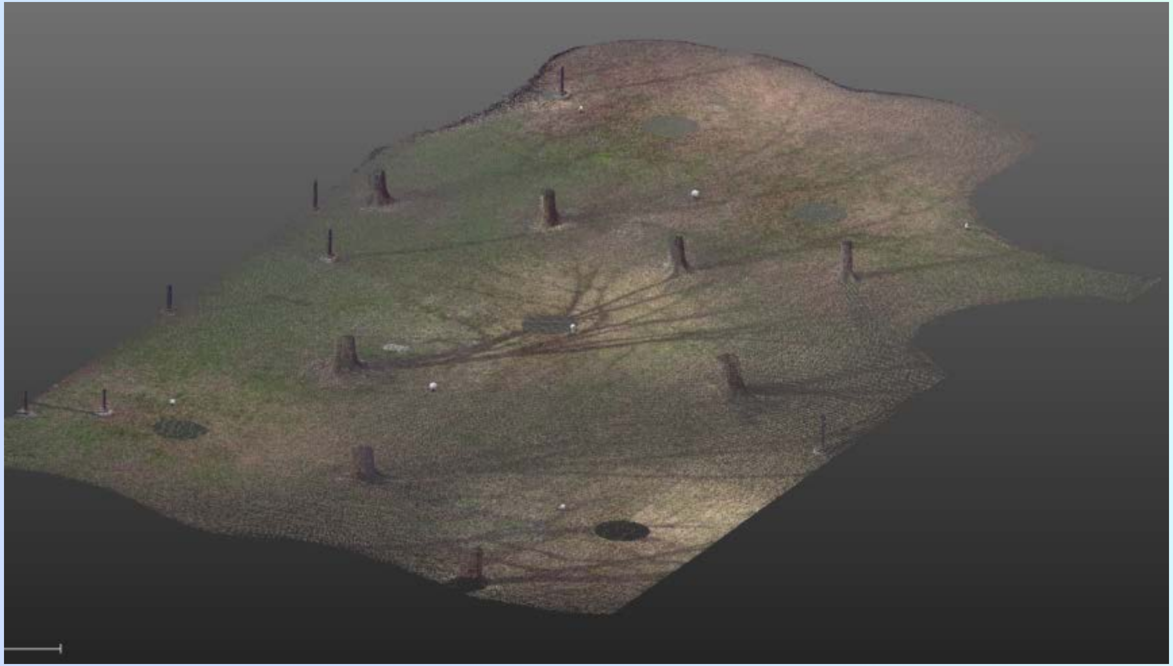


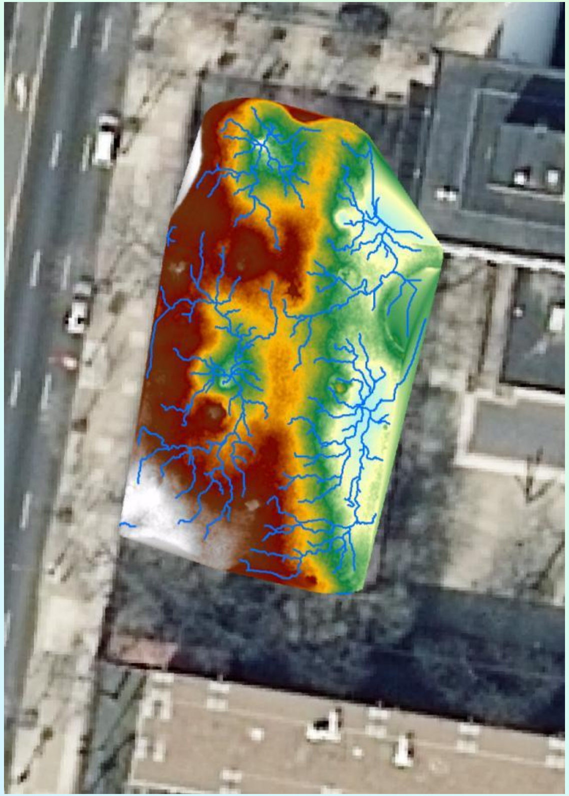


Ground-based LiDAR may determine capture areas better



Trim the trees & delineate capture areas





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Football field basin designed to capture street overflow

Football field basin designed to capture street overflow, but doesn’t

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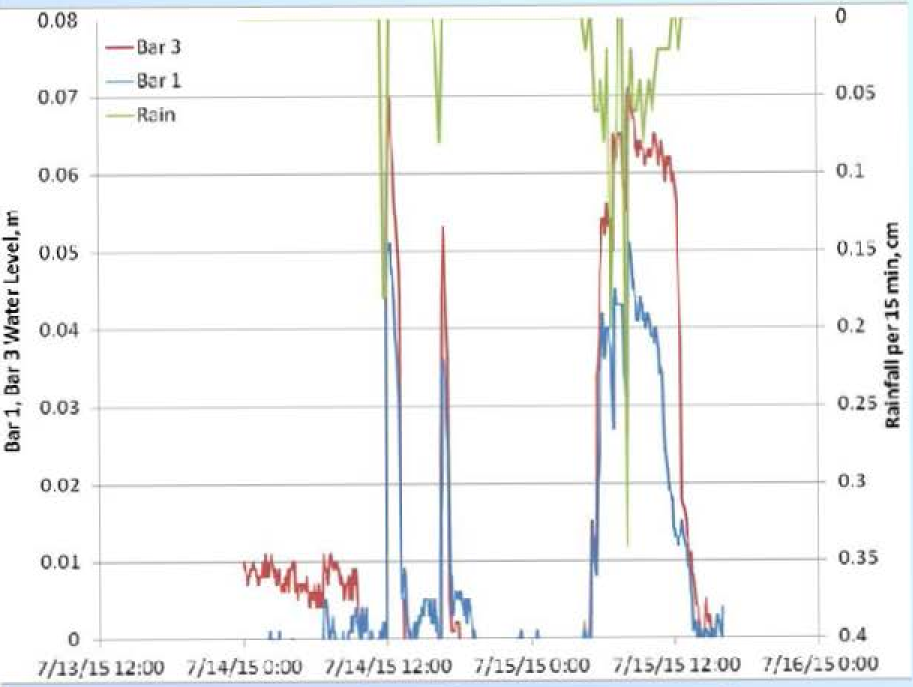
Blue roof was not storing water



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Retrofit with $5 supplies from hardware store

- Reduce size of overflow holes on one roof
- Leave the other roof as original size

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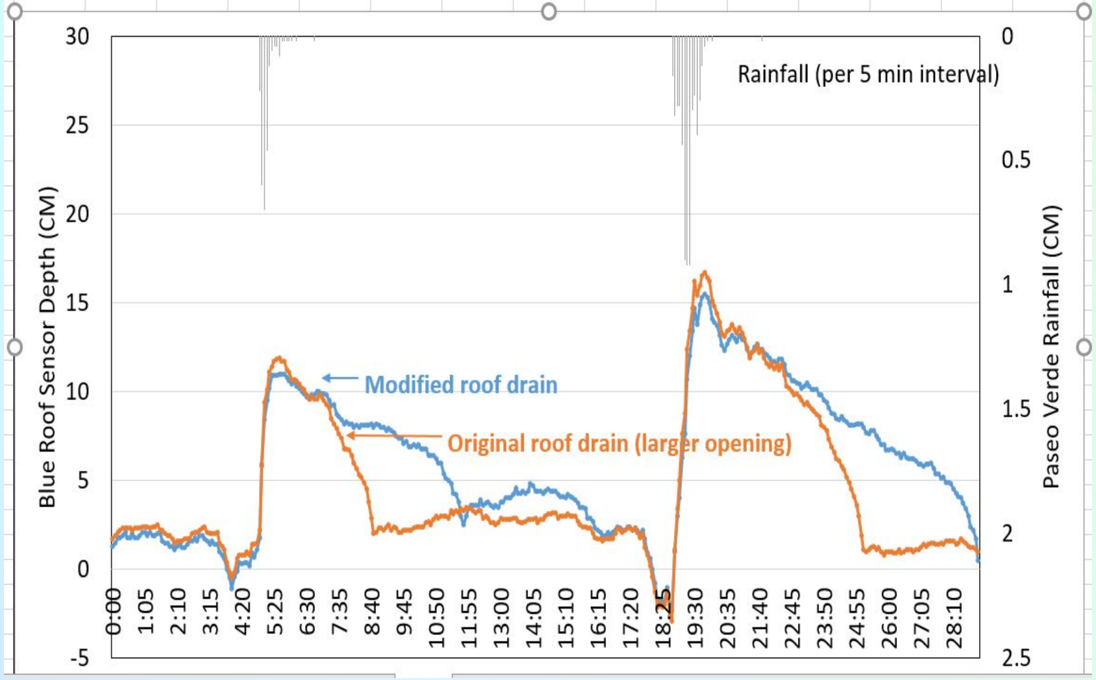
Success! Now need to watch out for clogging



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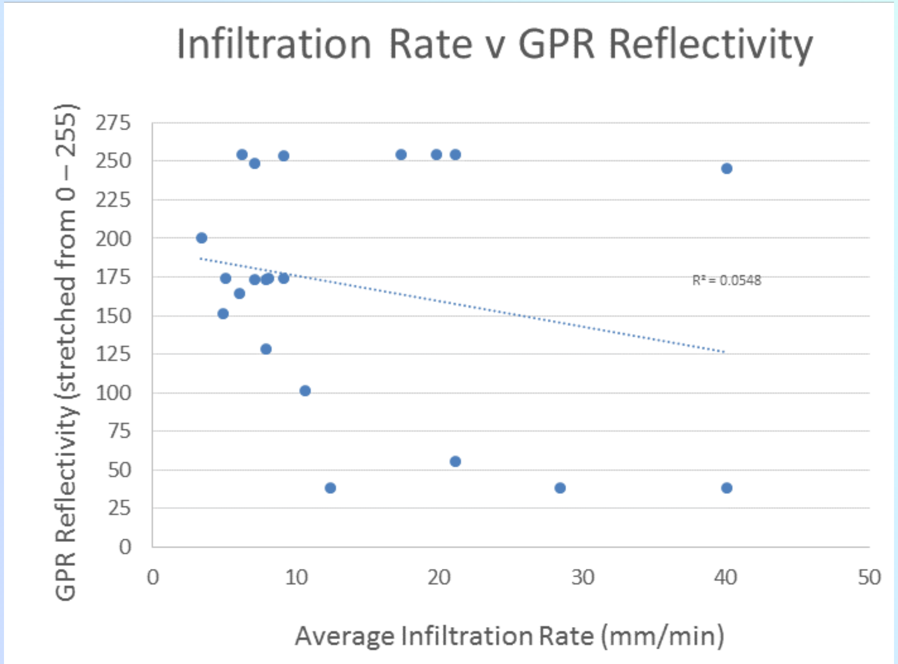
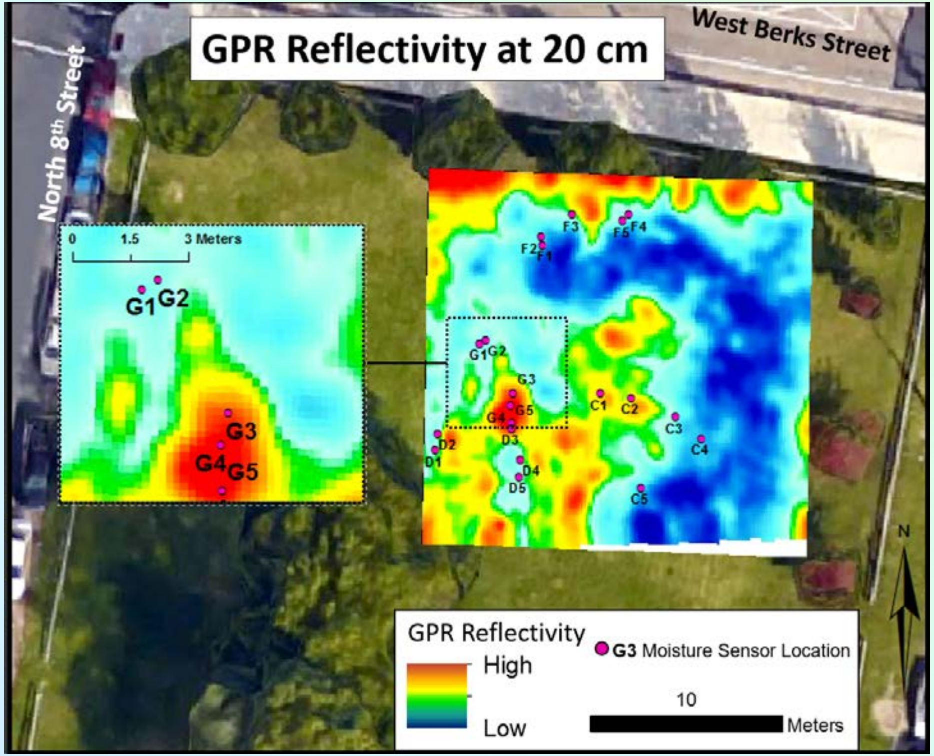
Can geophysics help?

- Finding infrastructure: yes, but it adds to the cost

- Monitoring infiltration: mixed results

GPR did not predict infiltration rate in urban soil





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Electrical resistivity was tried next

- If it doesn’t rain, use a sprinkler
- EM profiler survey in rows

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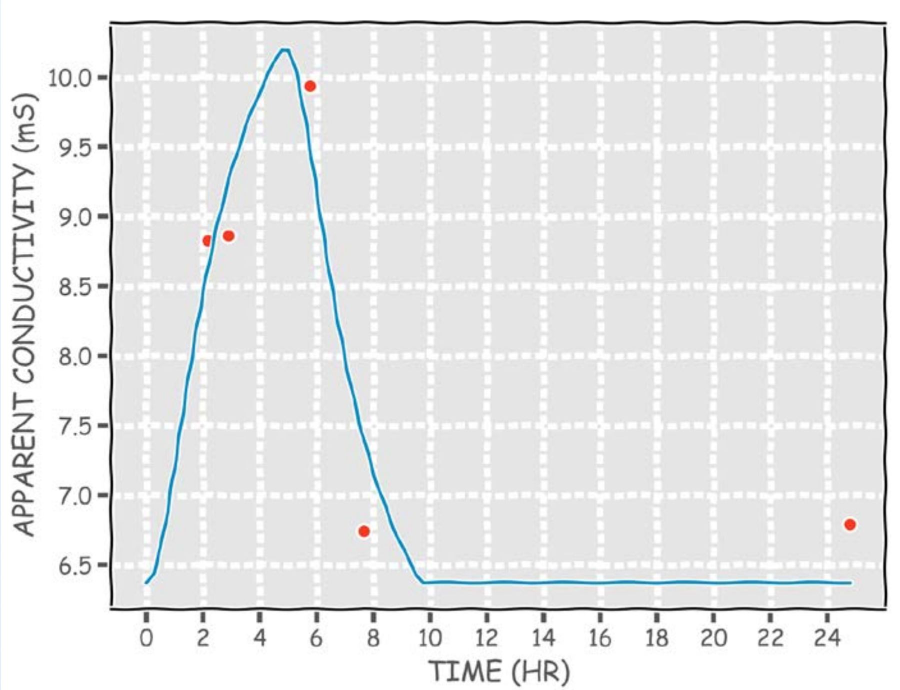
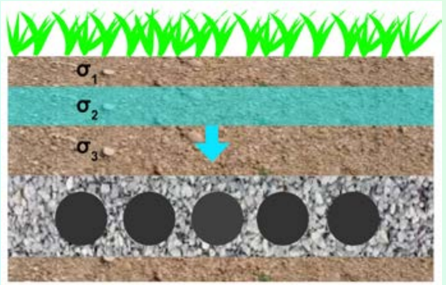
Results are promising using an inversion model to calculate infiltration





$\sigma_{dry} = 9.4\, mS$

$\sigma_{wet} = 15.0\, mS$

Thickness = 1.0 m

Velocity = 0.37 m/hour

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Long term monitoring should include

Community driven

- Inspection & maintenance
- Vegetation surveys

CHECKLIST FOR INSPECTION OF BIORETENTION SYSTEM / TREE FILTERS

Location:
Inspector:
Date:
Time:
Site Conditions:
Days Since Last Rain Event:

Inspection Items	Satisfactory (S) or Unsatisfactory (U)	Comments/Corrective Action
1. Initial Inspection After Planting		
Plants are stable, roots not exposed	S U	
Surface is at design level, no evidence of preferential flow/shoving	S U	
Inlet and outlet/bypass are functional	S U	
2. Debris Cleanup (1 time/year minimum, Spring/Fall)		
Litter, leaves, and dead vegetation removed from the system	S U	
Prune/mow vegetation	S U	
3. Standing Water (1 time/year and/or after large storm events)		
No evidence of standing water after 24-48 hours since rainfall	S U	
4. Vegetation Condition and Coverage		
Vegetation condition good with good coverage (typically > 75%)	S U	
5. Other Issues		
Note any additional issues not previously covered.	S U	

Corrective Action Needed	Due Date
1.	
2.	
3.	
Inspector Signature	Date

Some maintenance requires technical support (PWD program)

Long term monitoring should include

Performance effectiveness

- Sensor installation
- Solar panels
- Routine data collection & synthesis
- Updates on land use

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Low cost solar panel data loggers

GI Evaluation in Urban Areas

We've come a long way,
but questions remain

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FUTURE MONITORING ISSUES

- What is the scalability and transferability of our approaches?
- Effectiveness is not constant. How do we account for changing variables such as plants, ET, seasons, land use?
- How can our results be used to improve designs from a maintenance perspective? Leads to greater acceptability in GI installation.
- How are monitoring for operation, maintenance and design linked?

QUESTIONS continued

- How can we use monitoring information to inform future design?
- How can we use monitoring to better calibrate models?
- What are key characterization strategies to recommend?
- Do we have a “minimum effective” monitoring strategy?
- How would that vary from site to site?
- What is a good way to convey the lessons learned to practitioners?