NC STATE UNIVERSITY

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Bioretention Maintenance: It's Impact & Recommendations

Bill Hunt, PE, PhD

Associate Professor & Extension Specialist

NC State University

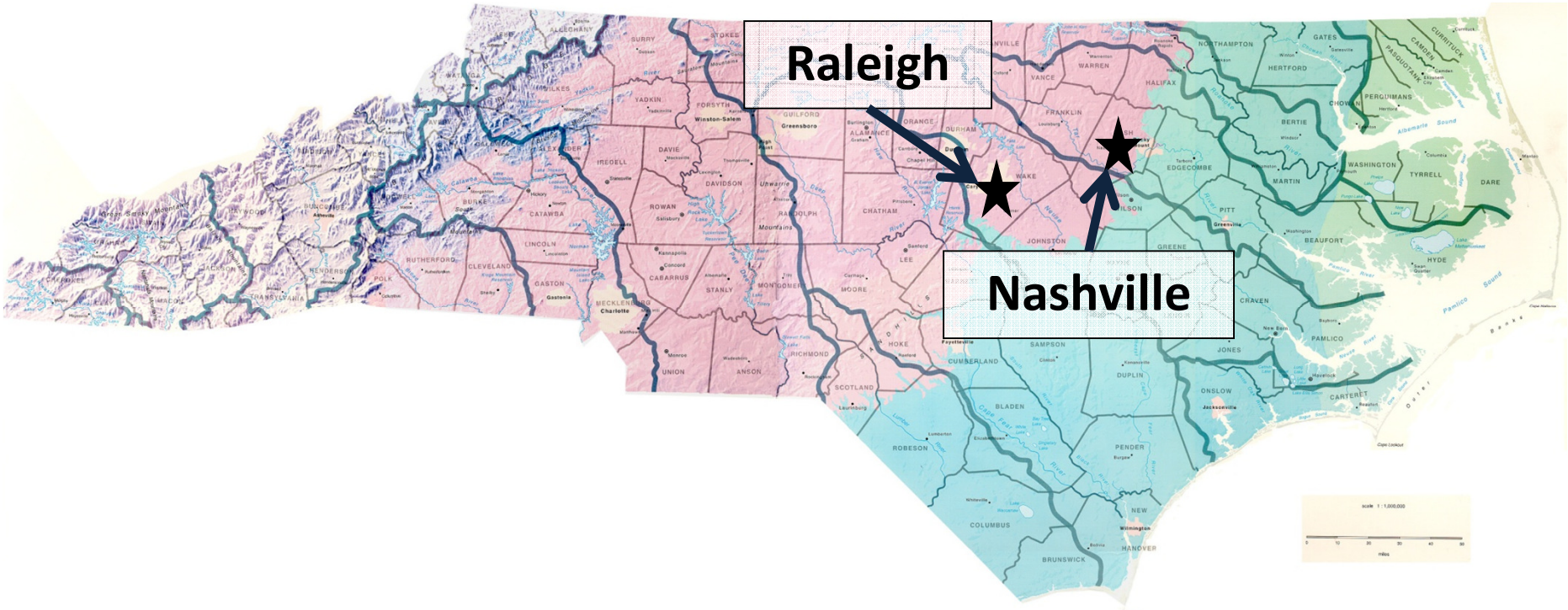
www.bae.ncsu.edu/stormwater

NC STATE UNIVERSITY Bio&Ag ENGINEERING

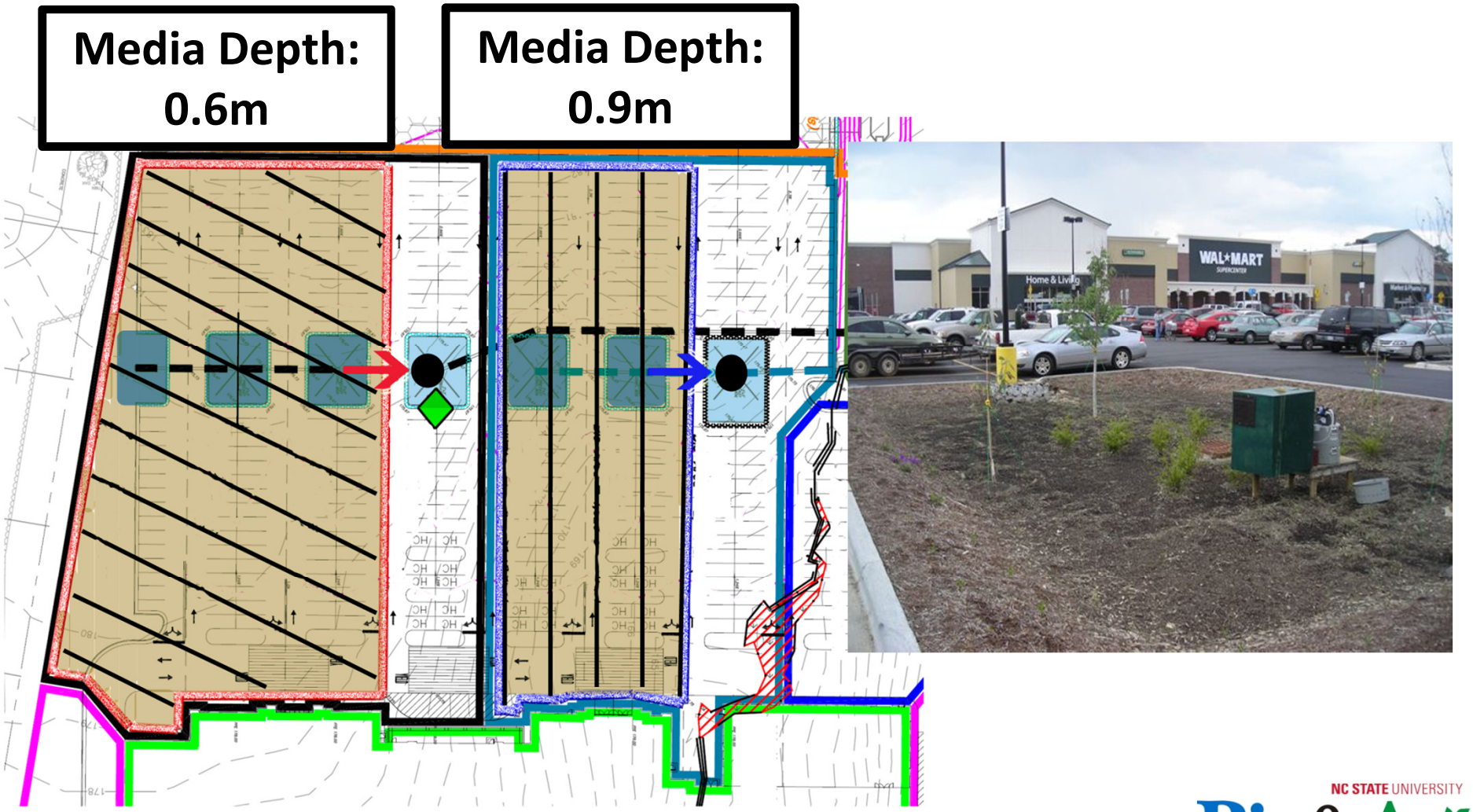
Is What We Design Going into (or staying in) the Ground?

e.g., Designers may call for bowl storage of 1 inch (25 mm) of Precipitation. Does this happen once built in the field? Construction? Maintenance?

Research Site Map



Site Layout



‘Crush and Run’ Base

Sedimentation & Clogging Layer

Drawdown

- NC recommended bowl drawdown rate
  - 12 hours (25 – 50 mm/hr)
- Actual drawdown rate
  - 48+ hours (2.5 – 12 mm/hr)

Bioretention Characteristics

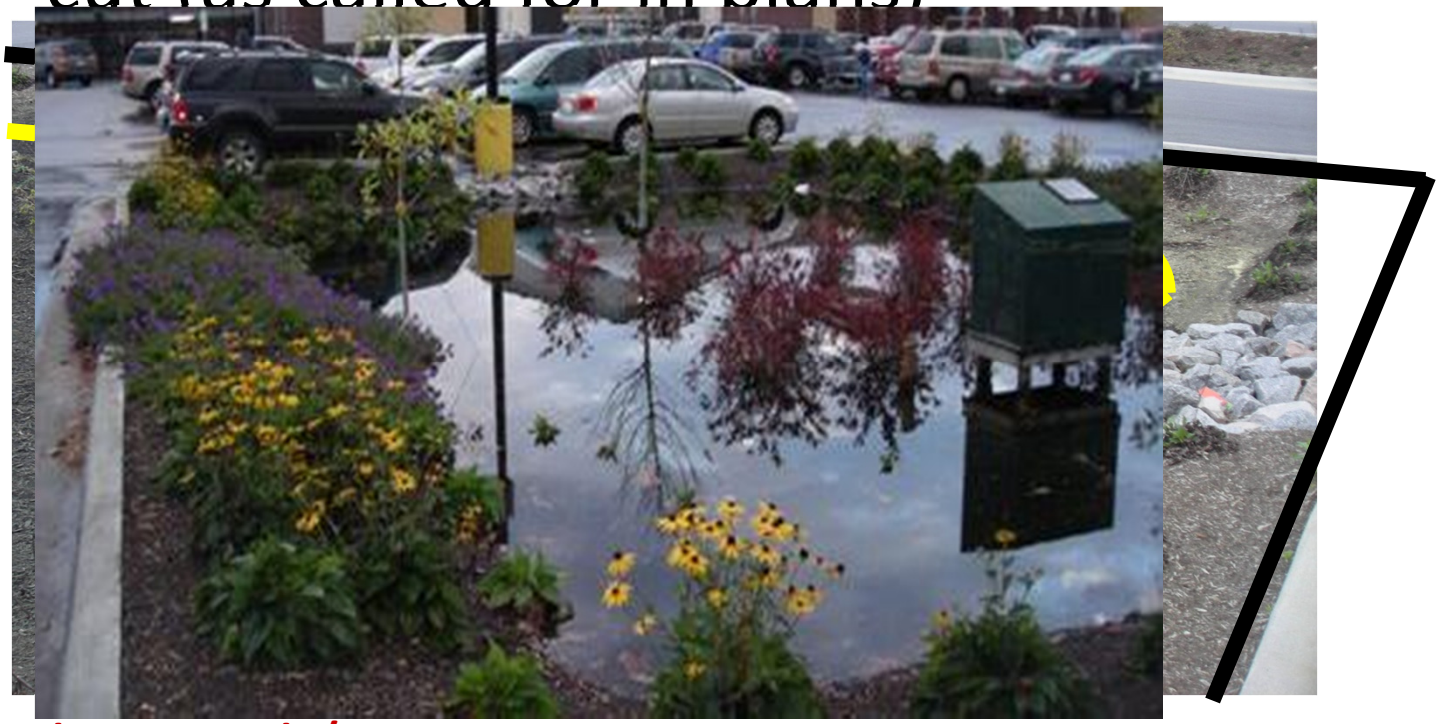
Characteristics	0.6m Media	0.9m Media
Number of Cells	3	2
Drainage Area	6610 m^2 (1.63 ac)	4530 m^2 (1.12 ac)
Drainage Area to BRC Surface Area	23:1	22:1
Impervious Area	87 %	100 %
Fill Media Depth	60 cm (2 ft)	90 cm (3 ft)
P-Index (Fill Media)	11-18 (Low)	
Fill Media Composition	86-89% Sand & 11-14% Fines (Loamy Sand)	

Problem #1 – Under-designed

- Design event: 1-inch (25mm)
- Using discrete CN method
  - 0.6m Media Depth: 78% of storage vs. required
  - 0.9m Media Depth: 76% of storage vs. required
  - Reason: avg. design ponding depth reported as 23cm, where 30cm should have been required

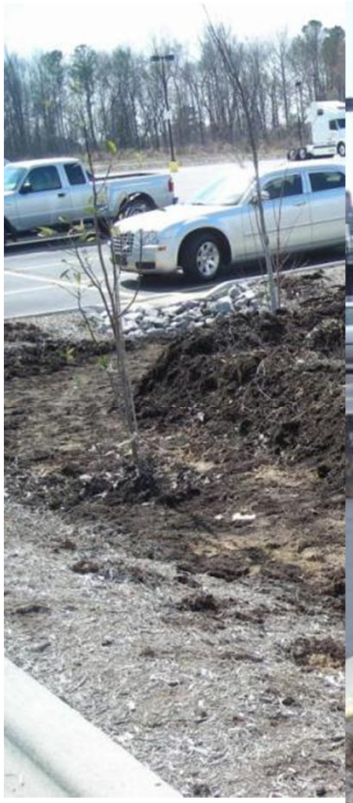
Problem #2 – Construction Errors

- Mulch layer too deep (150-200mm in areas)
- Ponding not achieved in all areas inside curb cut (as called for in plans)



Fixing Bioretention

- Remove clogging layer & top 75 mm of media to increase surface ponding volume

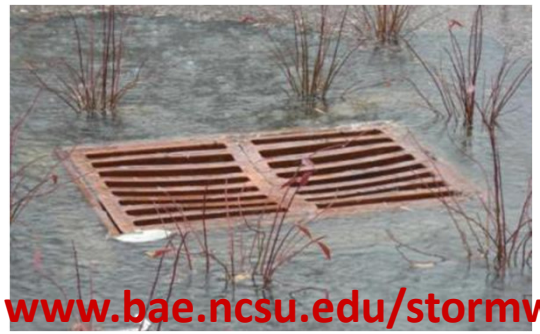


Repair Characteristics

- Improvements nearly doubled surface storage volume
- 0.6m Media Depth storage vs. required:
  - Was 28%, **now 53%**
- 0.9m Media Depth storage vs. required:
  - Was 35%, **now 66%**
- Faster drawdown rate
  - Was 2.5 – 12 mm/hr, **now 12 – 250 mm/hr**

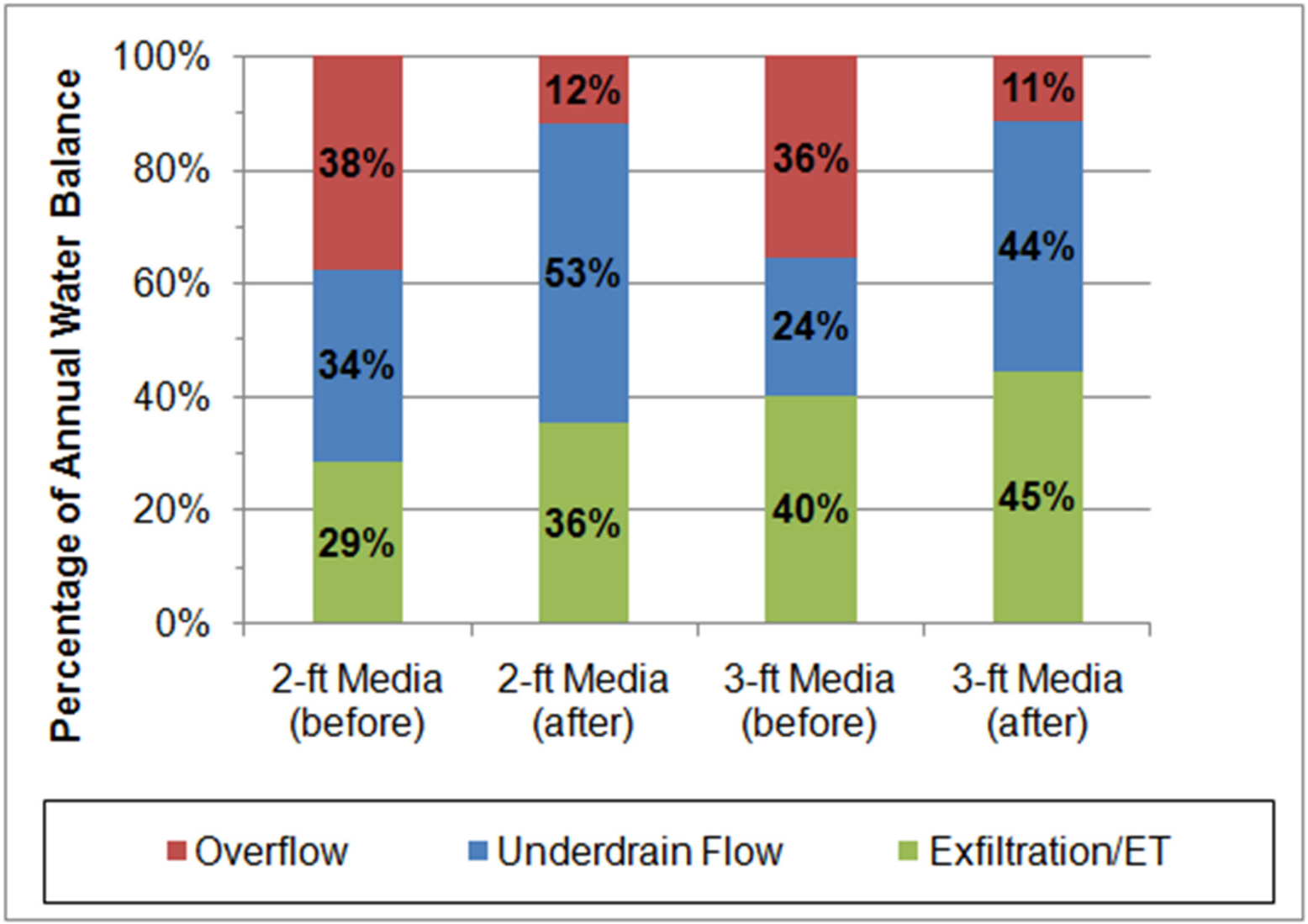
Frequency of Overflow

Monitoring Period	Before (Undersized)	After (Repaired)
Dates	3/31/08-3/11/09	3/12/09-3/24/10
Number of Events	**64**	**76**
Events > 25 mm	**11**	**14**
Events with Overflow *(% surface storage vs. required)*:		
0.6m Media Depth	**38** *(28% storage)*	**18** *(53% storage)*
0.9m Media Depth	**35** *(35% storage)*	**18** *(66% storage)*



<u>After repaired:</u>
Is this acceptably undersized?

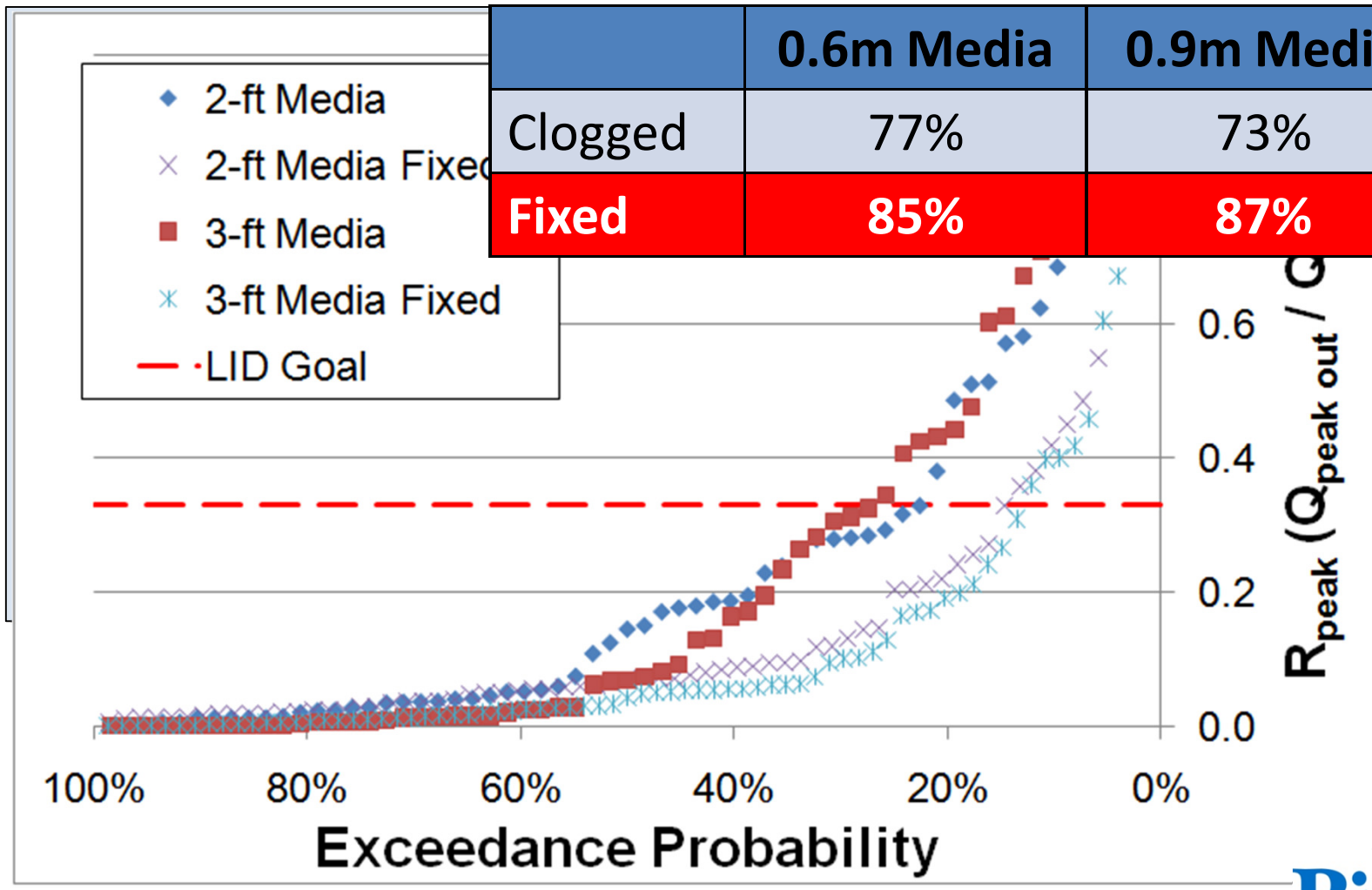
Nashville: Fate of Runoff



Peak Flow Reduction (Rf_{Peak})

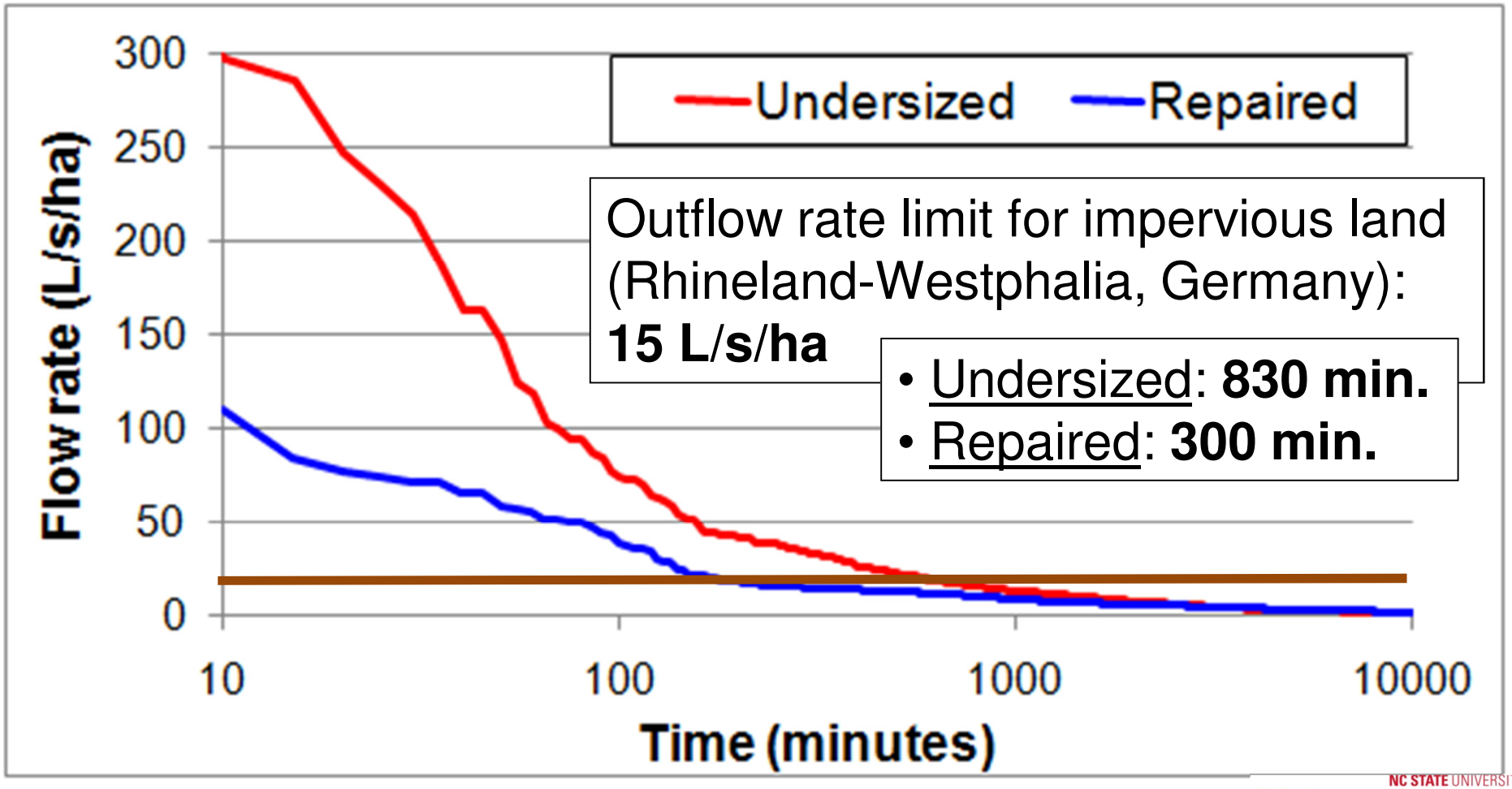
(Davis, 2008 – *Journal of Hydrologic Engineering*)

	0.6m Media	0.9m Media
Clogged	77%	73%
Fixed	**85%**	**87%**



Flow Duration Curve:

0.6m Media Depth



Outflow rate limit for impervious land (Rhineland-Westphalia, Germany): **15 L/s/ha**

- Undersized: **830 min.**
- Repaired: **300 min.**

Conclusions

1. Deeper media depth exfiltrates more runoff (greater pollutant load reduction)
2. Sizing of Bowl is more important than Media Depth for Peak Mitigation
3. Undersized bioretention cells can generate:
   1. Substantial overflow volume
   2. Frequent overflow
   3. Longer durations of high outflow rates

Conclusions

4. Clogged surface reduced drawdown rate, resulting in more overflow (limits intra-event drawdown)
   - Drawdown time 6 hours vs. 48+ hours
5. Efforts to ensure protection of surface of media are essential during construction
6. Construction oversight is key to bioretention performing as intended

Design Elements to Facilitate Maintenance

Bioretention Components: underdrain cleanouts

Underdrain cleanouts

Bad

Better

Gravel verges and grass filter strips = Treatment train

Gravel Verge Maintenance

Bioretention Forebays

Mulch Selection and Renewal

- Double or triple shredded hardwood bark is best
- Mulch should be renewed as needed
- Remove old mulch if mulch depth exceeds 75 mm
- Too much mulch displaces water storage

Maintenance Trigger: Mulch

- Mulch renewal – if oxidized
- Mulch removal – if too deep
- Mulch replacement – if contaminated or clogged