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UNILOCK DESIGNED TO CONNECT.

Hydro International

filtrexx CANADA SUSTAINABLE TECHNOLOGIES let nature do it.

SOLENO Mastering Storm Water

GEMS

Credit Valley Conservation inspired by nature

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TRIECA – 21Mar18

# NC Stormwater: Look Back, Look Forward

Stantec

NC STATE UNIVERSITY Bio&Ag ENGINEERING

# Bill Hunt, Ph.D.,PE

- Extension Professor with North Carolina State University
- Since 2000, has designed, installed, and/or monitored more than 180 projects including
  - bioretention,
  - green roofs,
  - permeable pavement,
  - water harvesting/cistern systems,
  - bioswales,
  - regenerative stormwater conveyance, and
  - level spreader/ filter strips.
- Works throughout the eastern US, including Northeast Ohio
- Consults around the world, including Sweden, Singapore, China, and Jordan

# Relationship with Stantec

For over 3 years, Stantec and Dr. Hunt have partnered to meet our clients Low Impact Development (LID) and Green Infrastructure (GI) needs

Dr. Hunt has been involved in client seminars, training sessions, and QA/QC for innovative stormwater projects completed by the Stantec LID team

Dr. Hunt also offers his vast experience in design, installation and monitoring; allowing Stantec to deliver projects that are designed using the latest knowledge and research on LID

# Agenda

1. Why You? Hunt Background
2. Nice Job: Good Practices in MOECC
3. Why small is OK: Fingerprinting Practices
4. Adding new stuff: Regenerative Stormwater Conveyance
5. Keep Talking: The Role of Communication
6. Wrap Up

# Why You? Hunt Background

# My Background

Research & Outreach since 1997

180+ Installations for design, monitoring, & maintenance

Inspection & Maintenance Focus

Assists NCDEQ (Our MOECC) with SCM Design

# Representative Chris Millis

## 2017-2018 Session

**Republican - District 16**

**Onslow, Pender**

N.C. House of Representatives
300 N Salisbury Street, Room 633
Raleigh, NC 27603-5925
919-715-9664
Chris.Millis@ncleg.net

| | |
|---|---|
| **Office:** | 633 Legislative Office Building |
| **Terms in House:** | 3 (0 in Senate) |
| **Occupation:** | Professional Civil Engineer |
| **Address:** | PO Box 878, Hampstead, NC 28443 |
| **Phone:** | 910-352-1740 |
| **Legislative Assistant:** | John Ganem |

# Trying to Get a Permit?

DEQ
Department of Environmental Quality

Regional Offices

HOME CONTACTS OTHER REGIONAL OFFICES - Text +

## Wilmington Regional Office

Show 10 entries Search:

| Last Name | First Name | Title | Organization(s) | Email | Location | Phone |
|---|---|---|---|---|---|---|
| Cox | David | Environmental Specialist | Water Quality | david.w.cox@ncdenr.gov | Wilmington Regional Office | 910-796-7318 |
| Cox | Heidi | Regional Engineering Supervisor | Water Resources Public Water Supply Section | heidi.cox@ncdenr.gov | Wilmington Regional Office | |
| Dail | Jason | Field Rep | Coastal Management | jason.dail@ncdenr.gov | Wilmington Regional Office | 910-796-7302 |
| Farrell | Sean | | Coastal Management | sean.farrell@ncdenr.gov | Wilmington Regional Office | |
| Gaines | Amanda | Environmental Specialist | Water Quality Aquifer Protection Section | amanda.gaines@ncdenr.gov | Wilmington Regional Office | 910-796-7380 |
| Gregson | Jim | Surface Water Protection Supervisor | Water Quality Surface Water Protection Section | jim.gregson@ncdenr.gov | Wilmington Regional Office | 910-796-7386 |
| Hare | John | Environmental Senior Specialist | Waste Management Solid Waste Section Field Operations Branch | wes.hare@ncdenr.gov | Wilmington Regional Office | 910-796-7405 |

# NC DEQ – Regional Offices

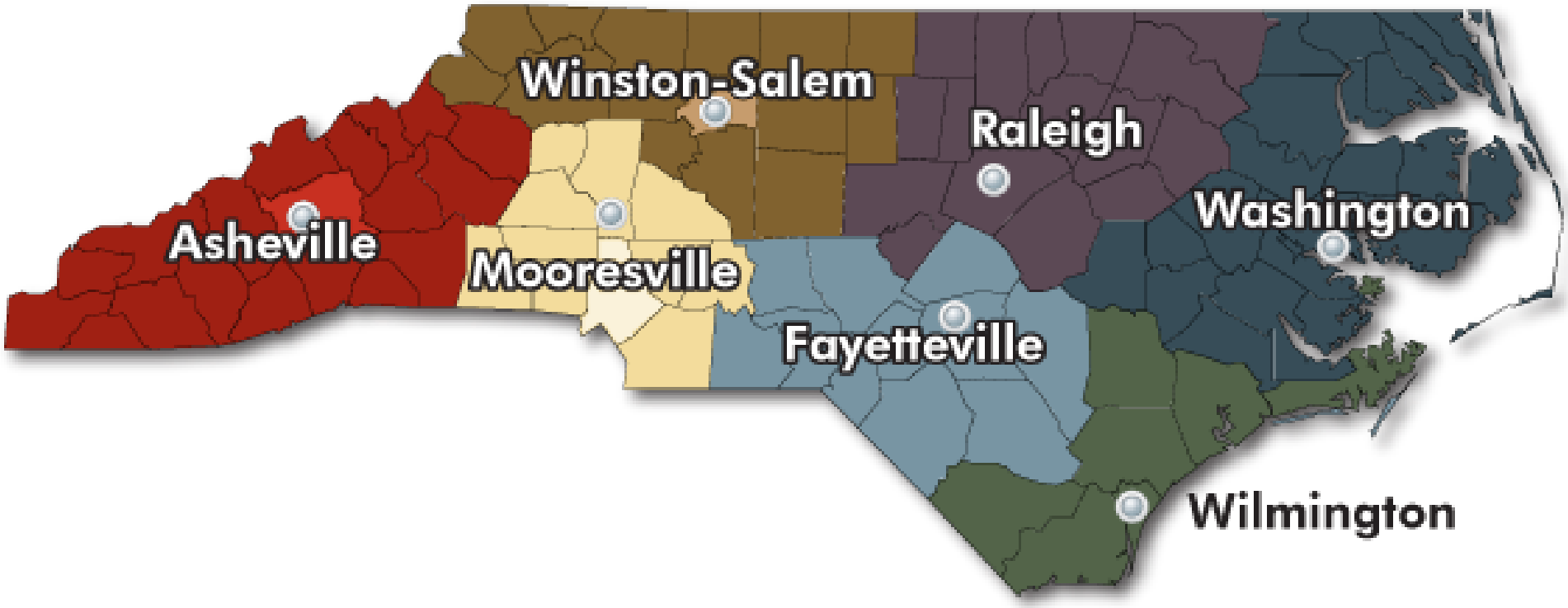



Image courtesy of NC DEQ


Consistency!!!

# Introducing Minimum Design Criteria (MDCs)…

# *Legislature defines "MDC"*

All-inclusive list of requirements for siting, design, construction, and O&M for the fast-track stormwater permitting program.

# The MDC Team

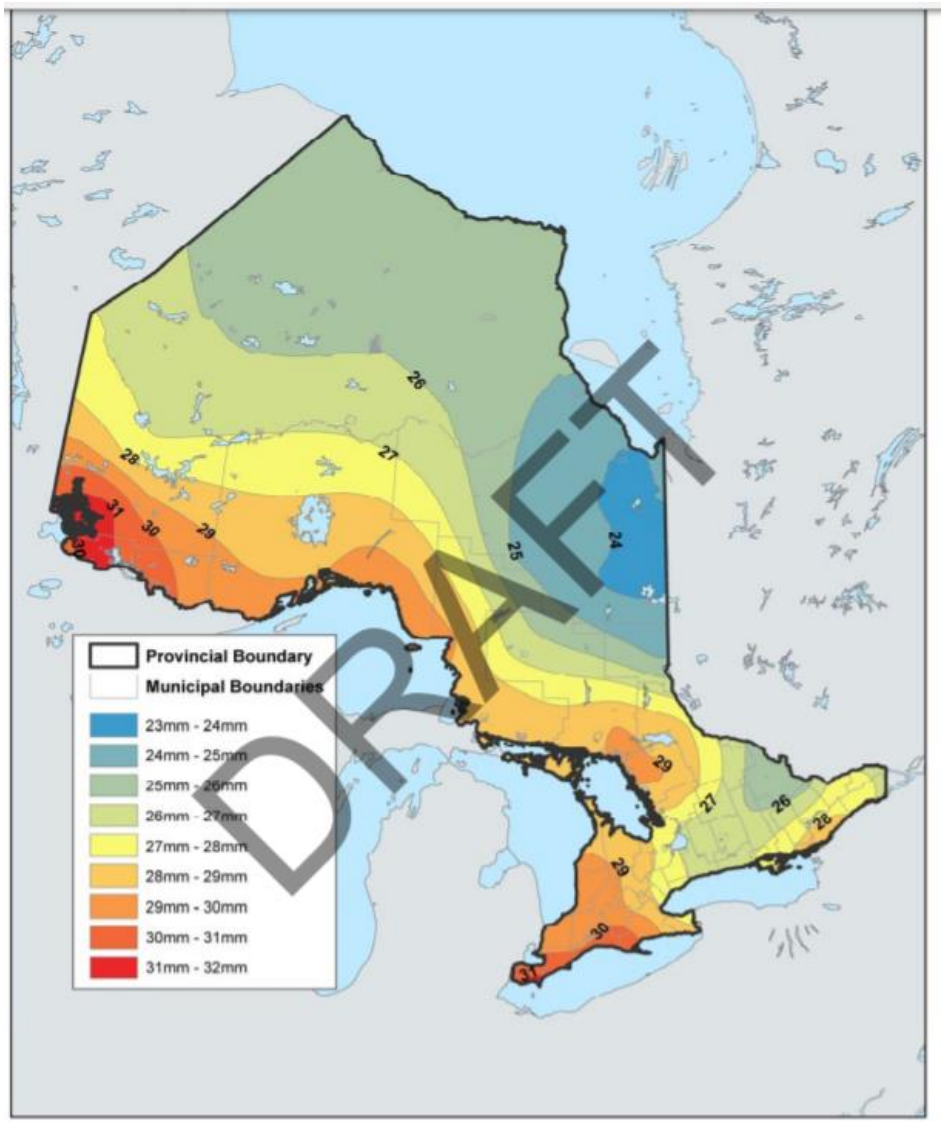
Engineering/design community (8)
Home Builder's Association (1)
Construction (1)
Local government (4)
Environmental Group (2)
Landscape Architect (1)
Academia (2)
Soil Scientist (1)
DOT (1)
DEQ(4)

# Nice Job! Great Practices in MOECC

Nice Job!

# 90% Precip

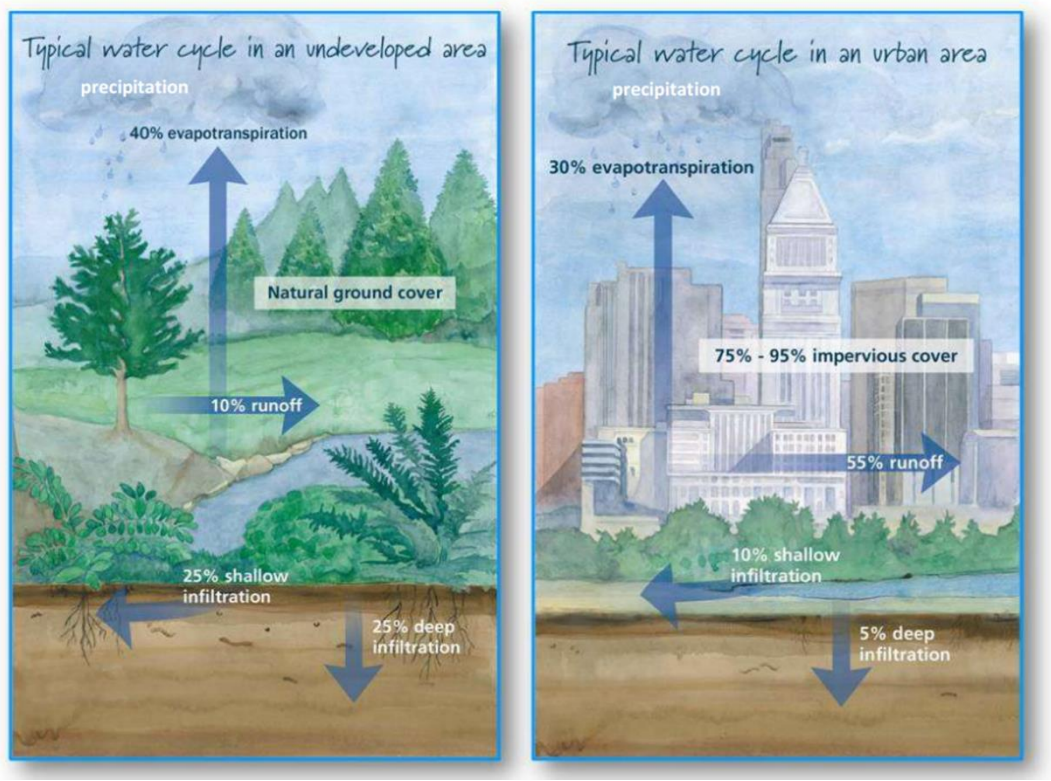
- Not tons of variation across Ontario (24 to 31 mm)
- Will allow > 90% of all pollutants to be captured.
- In keeping with 80-90% capture used across North America.



Nice Job!

# Pre-Development Water Balance

- Maintaining Natural Pathways (ET, Infiltration, Runoff)
- How will this be implemented?
- In NC, they just said match runoff pre- & post-
  - Acknowledging that ET v. Infiltration Matching may be too tough




San Antonio River Authority

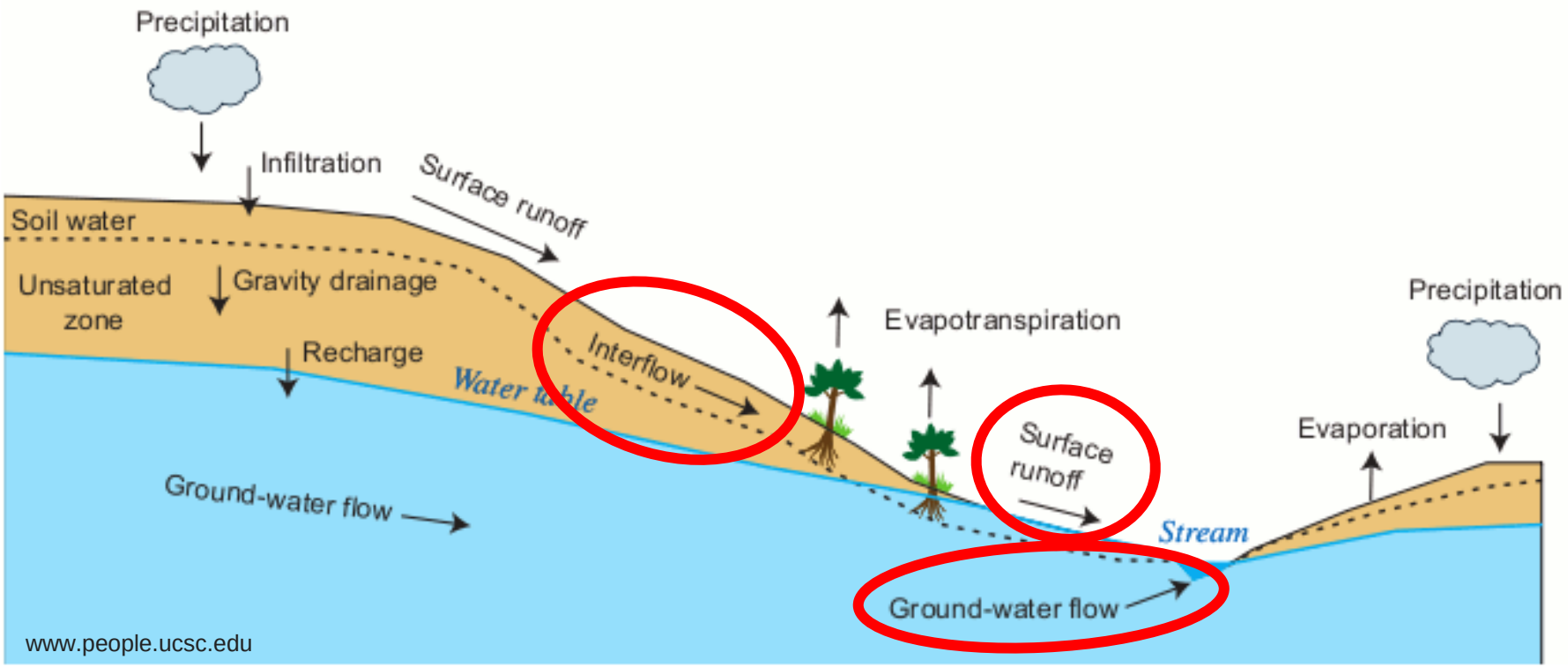
Nice Job!

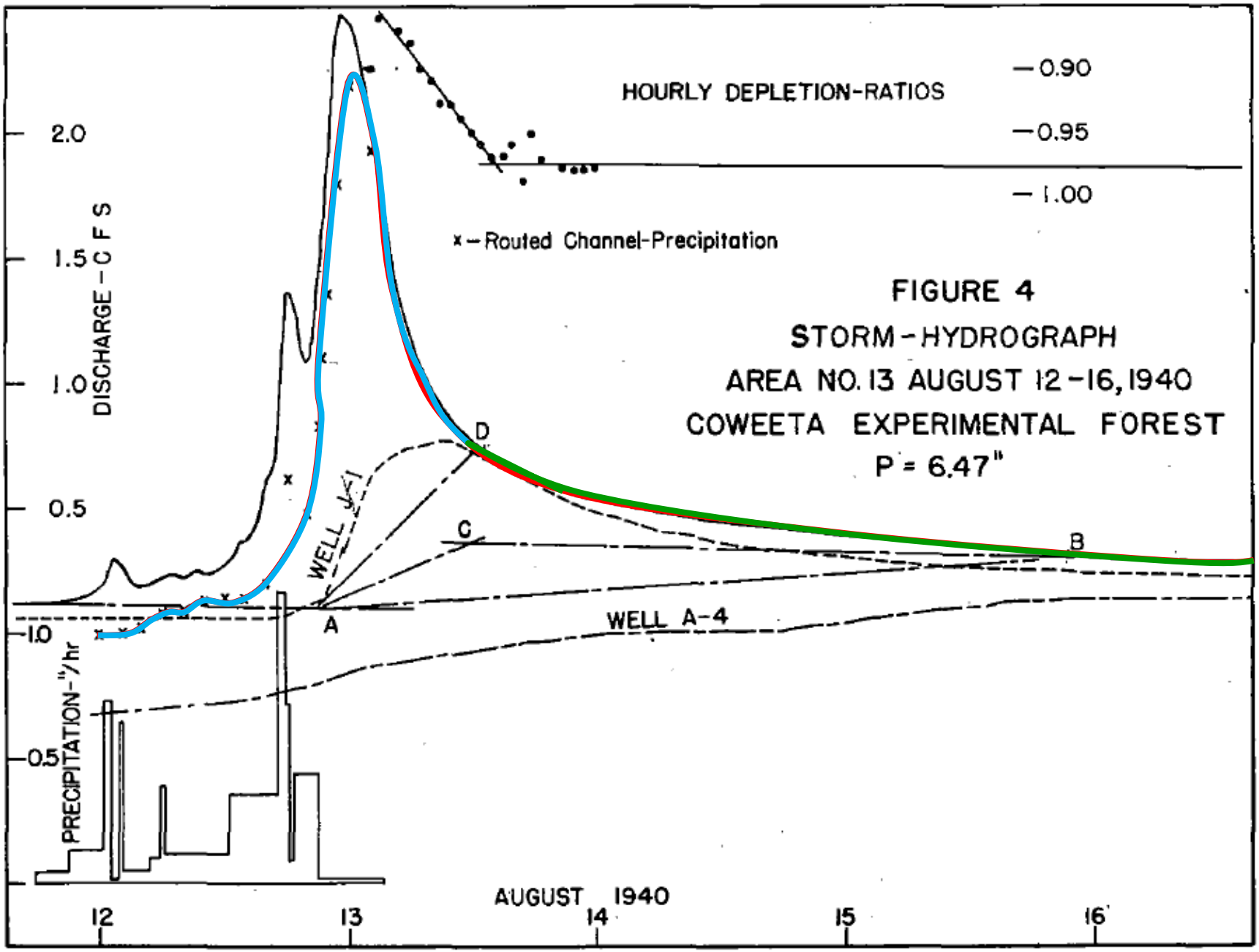
# Control Hierarchy Priorities 1, 2 & 3

1. Complete Retention
2. LID Catch & Release *
3. Other Detain & Release


* Could become one of your better friends

# HYDROLOGIC CYCLE UNDER NATURAL CONDITIONS






Hursh and Brater, 1941

Graham BR

Greensboro BR

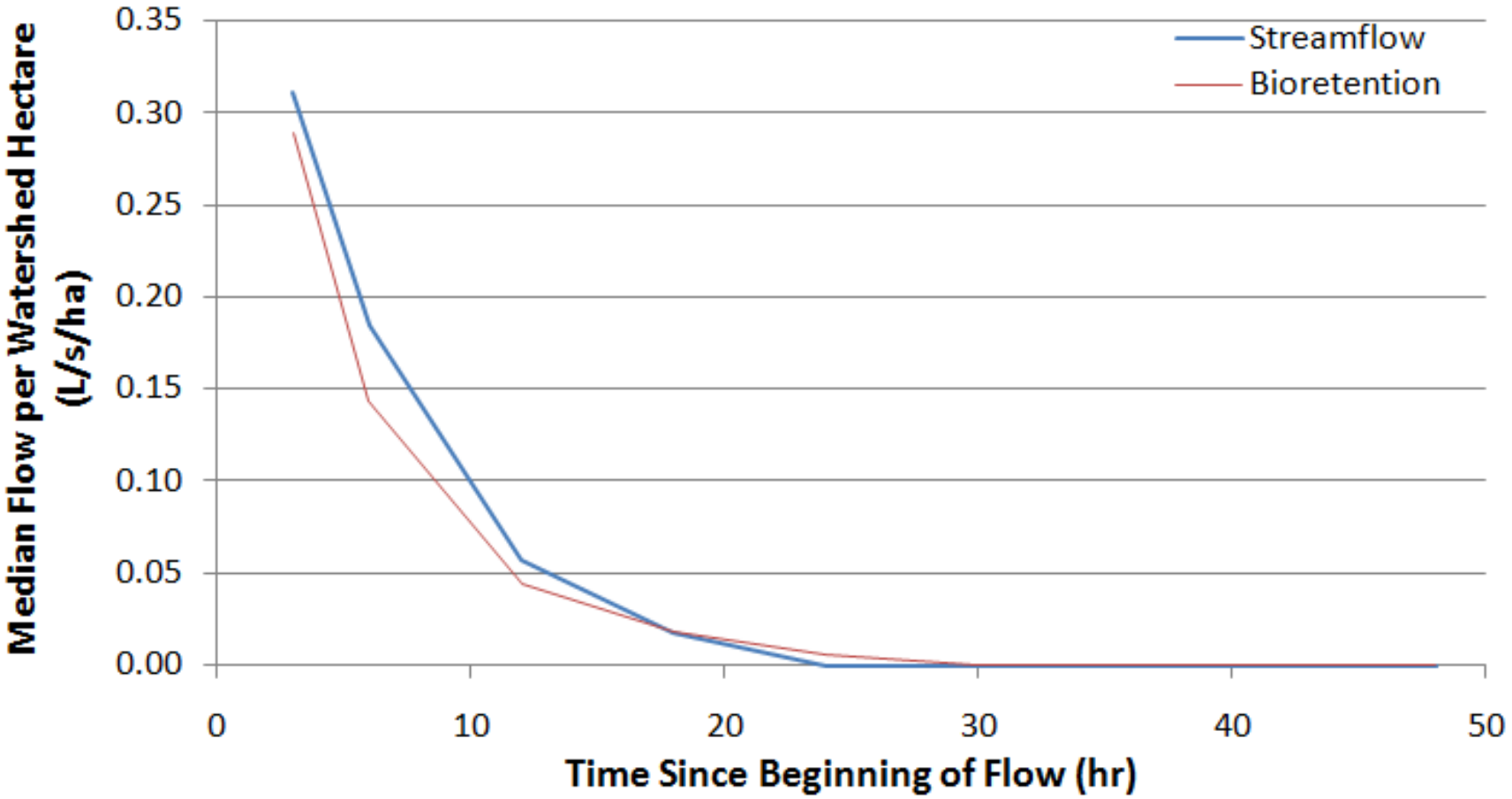
Louisburg BR

Hal Marshall BR

Stream sites

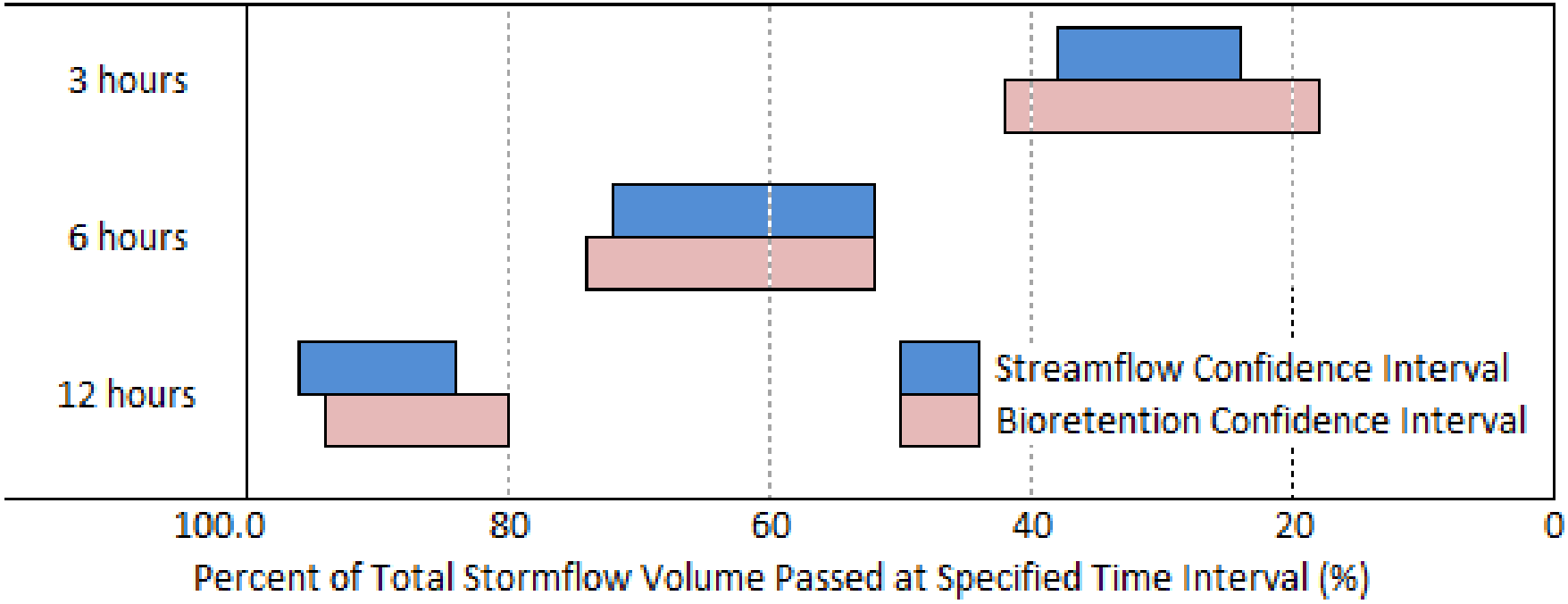
# Bioretention Study Sites

# Median Flow Rates per Watershed HA



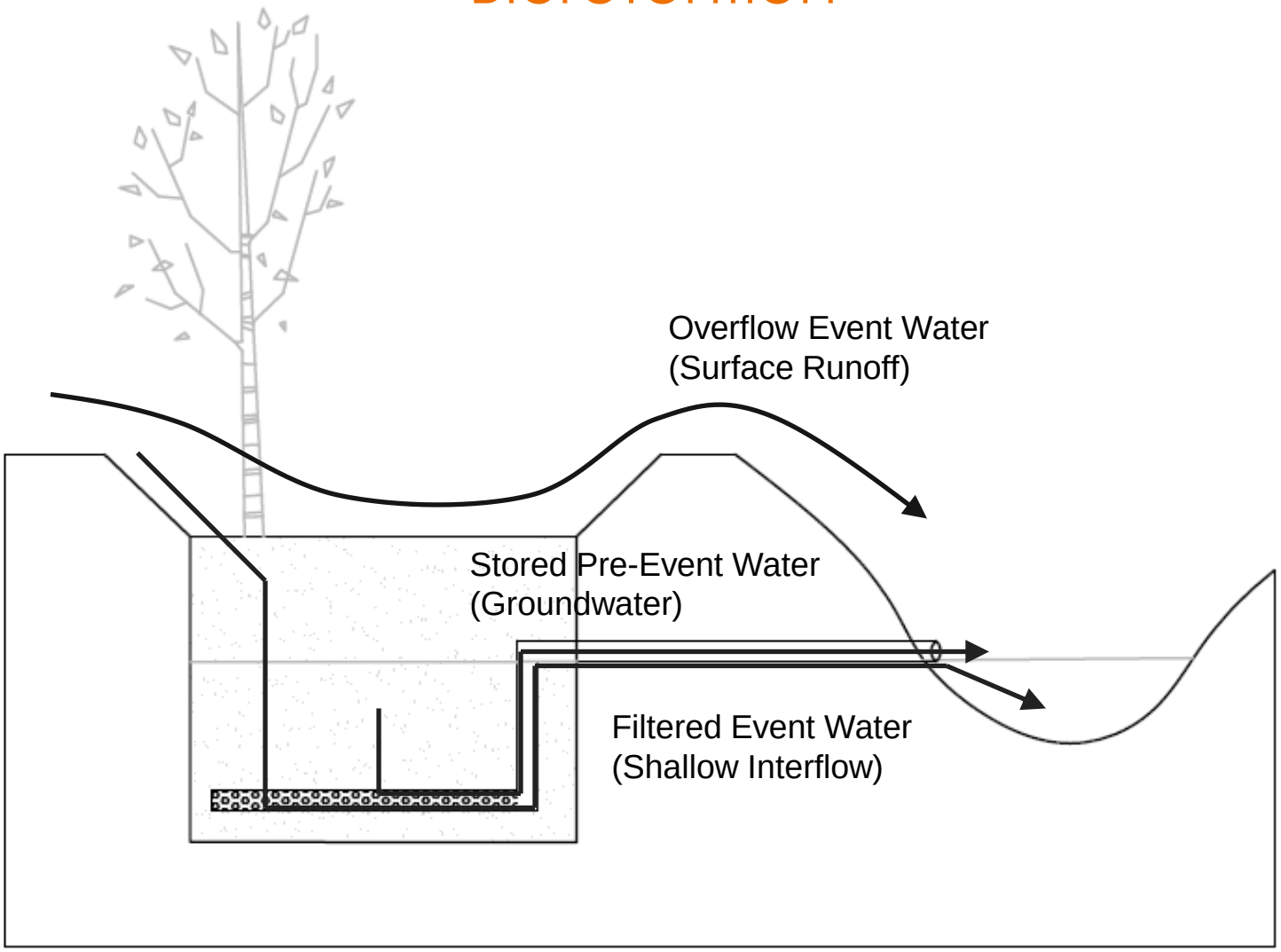

DeBusk et al., JHE, March 2011

# Confidence Intervals: Percent of Total Volume Passed




DeBusk et al., JHE, March 2011

# Application for Stormwater Management - Bioretention




Cizek and Hunt, 2013. Ecological Engineering

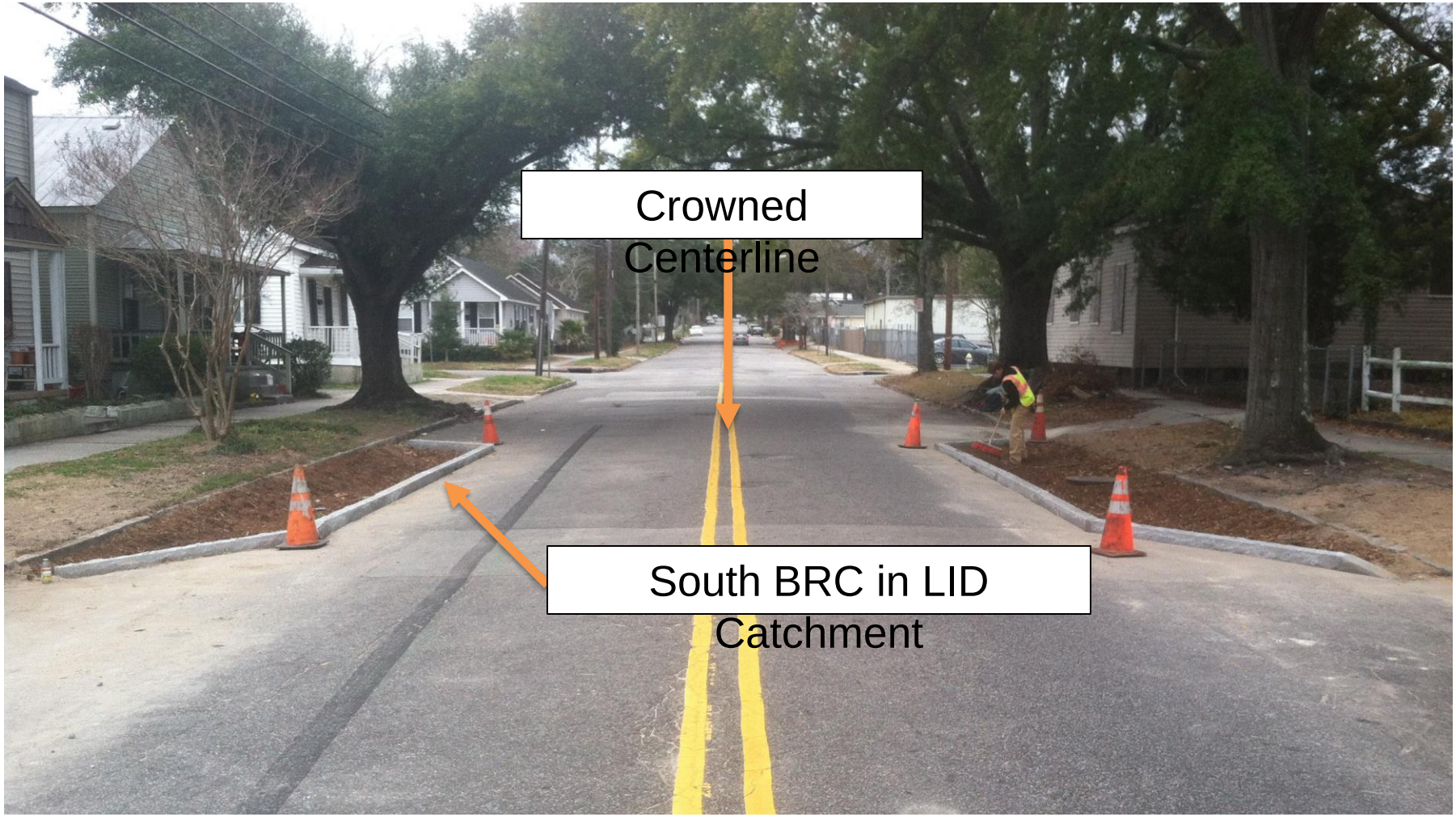
# Why Small is OK: Role of Fingerprinting


GREYHOUND

# Fingerprinting Retrofits - Wilmington


*New Hanover County Orthophoto*

# SCMs: Construction: BRCs



# SCMs: Permeable Pavement

# SCMs: Filterra® Unit



*Photo Credit: Google Earth*

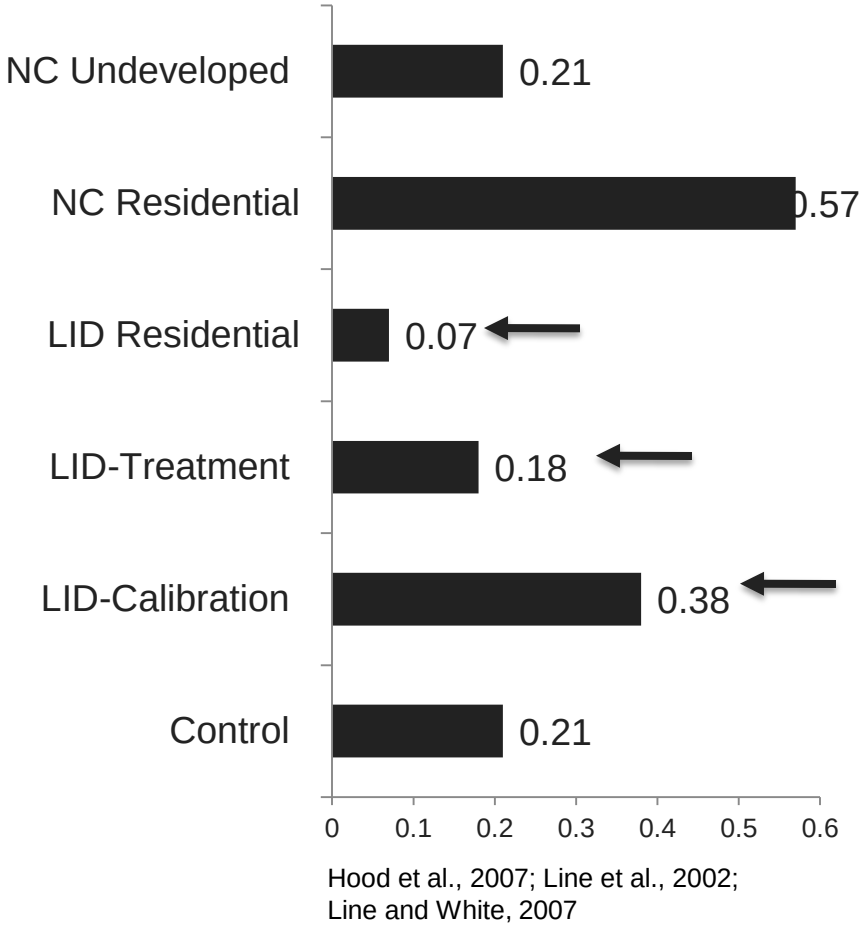
# Results: Runoff Coefficient ($C_R$)

$C_R$: fraction of rainfall converted to runoff

- $$C_R = \frac{RO_{Measured}}{P_{Measured}}$$

Post-retrofit, LID $C_R$ decreased 47%

Hood et at. (2007): LID $C_R$=0.07




Hood et al., 2007; Line et al., 2002; Line and White, 2007

Page et al. (2015). J. Hydrology

# Results: Nutrient and Sediment Loads

Nutrient and sediment export rates (kg/ha/yr)

| Station | $C_R$ | n | TKN | TAN | $NO_{2,3}$-N | TSS | O-$PO_4^{3-}$ | TP |
|---|---|---|---|---|---|---|---|---|
| Control | 0.21 | 24 | 2.6 | 0.3 | 0.4 | 113 | 0.2 | 0.6 |
| LID-Calibration | 0.38 | 8 | 2.8 | 0.2 | 0.3 | 157 | 0.3 | 0.7 |
| LID-Treatment | 0.18 | 16 | 0.5 | 0.1 | 0.1 | 12 | 0.1 | 0.2 |
| **LSM Difference** | | | **-78%*** | **-61%*** | **-46%** | **-91%*** | **-55%*** | **-73%*** |
| LID Residential[1] | 0.07 | | 0.9 | 0.0 | 0.3 | 8 | - | 0.2 |
| NC Residential[2] | 0.57 | | 20.7 | 2.4 | 3.2 | 387 | - | 2.3 |
| NC Undeveloped[3] | 0.21 | | 5.3 | 0.2 | 1.0 | 349 | - | 0.5 |

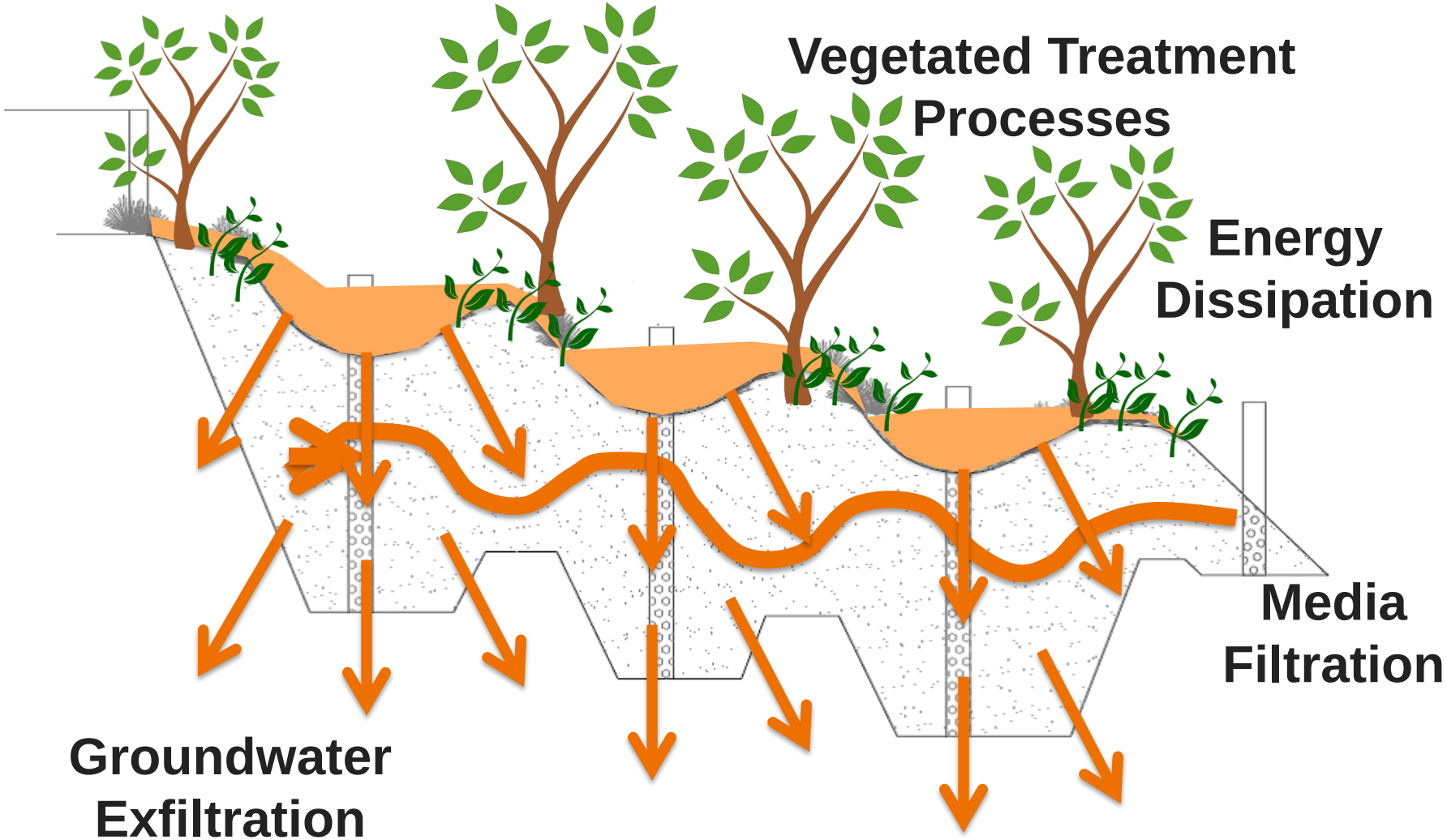
*Statistically significant change

Page et al. (2015). J. Env. Eng.

Regenerative Stormwater Conveyance (RSCs)

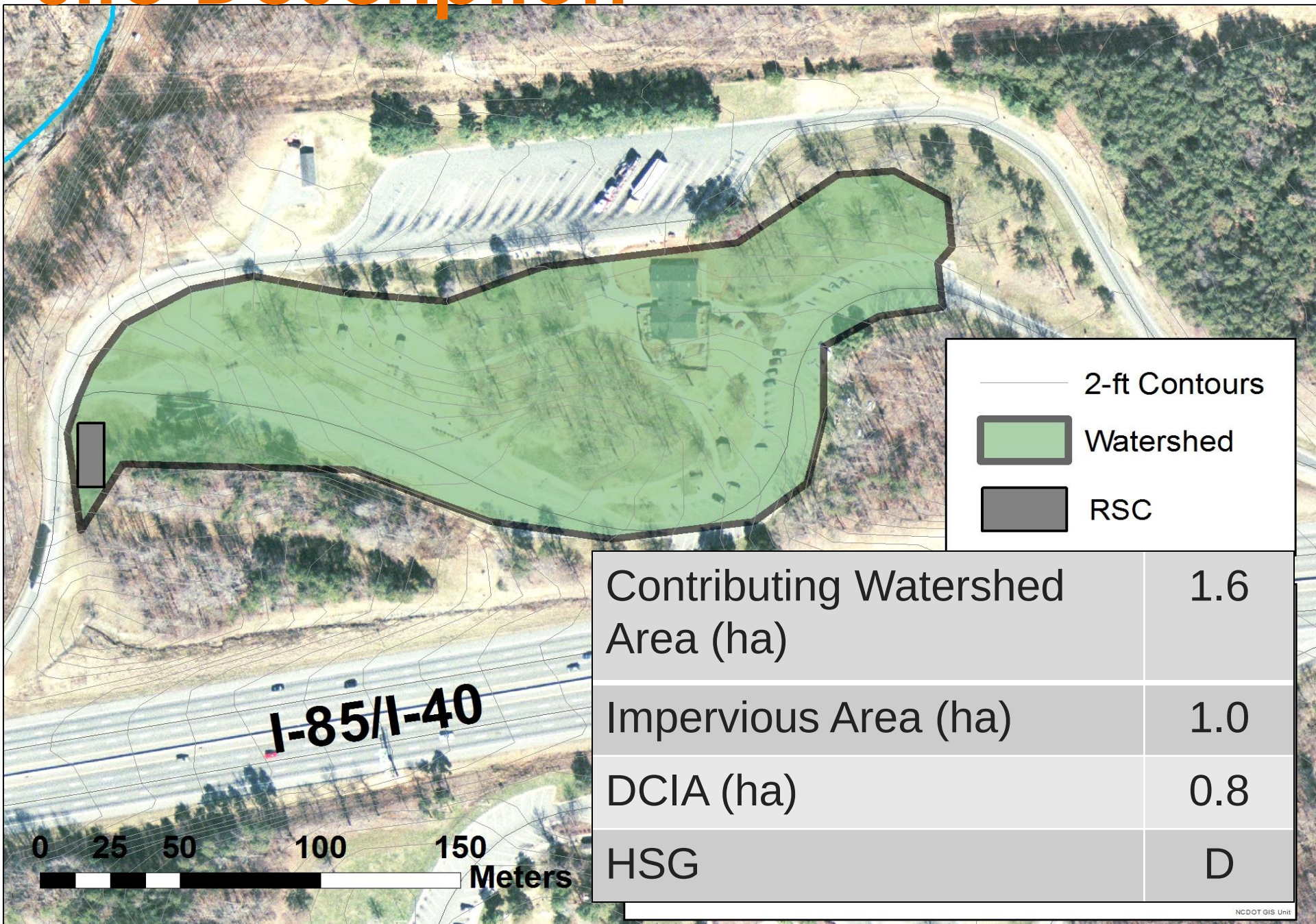
# Adding New Stuff

**RSCs are…** a series of pools and riffles designed to convey, manage, and treat stormwater runoff

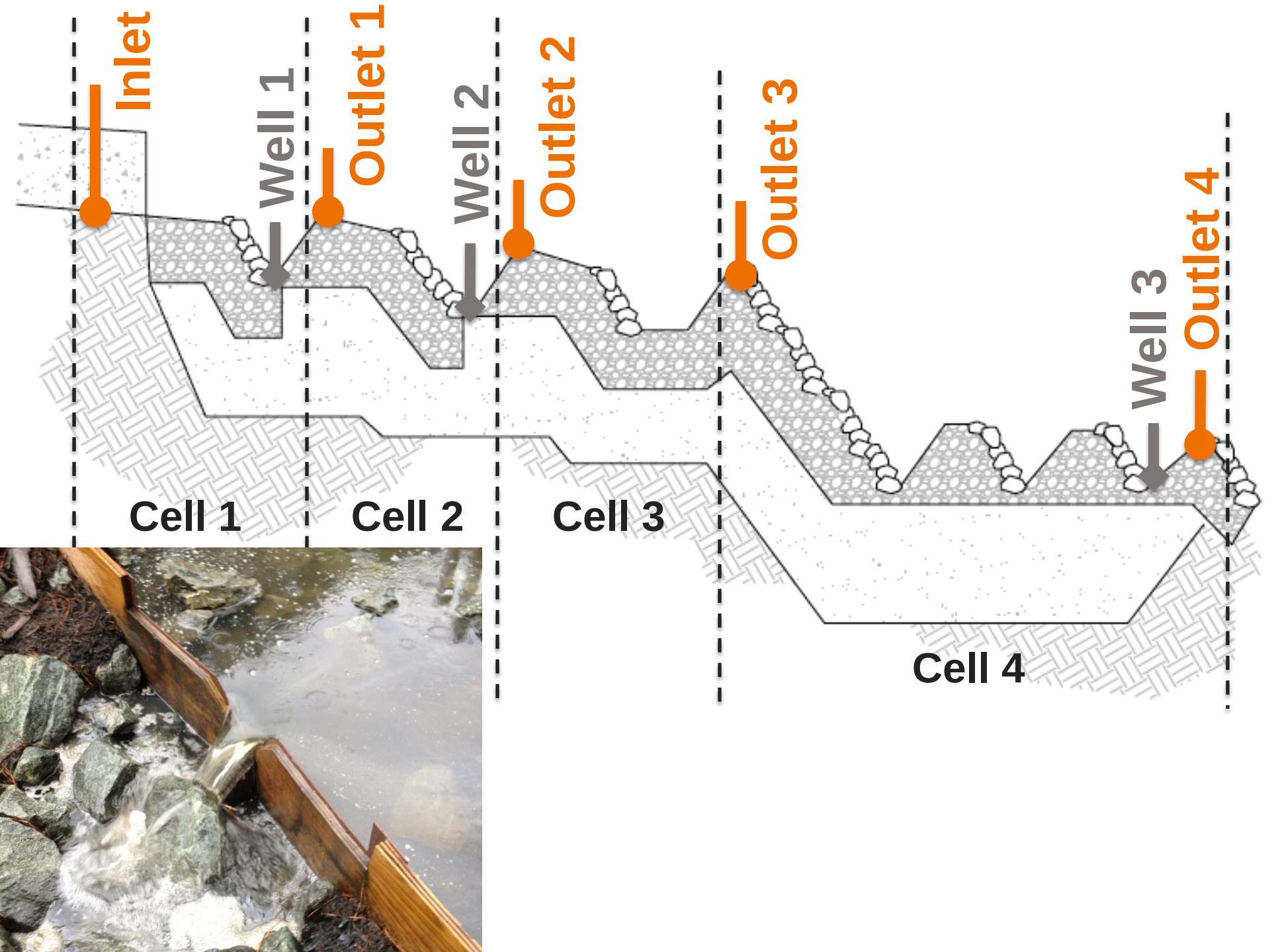


# Alamance County, North Carolina

# Site Description




| | |
|---|---|
| Contributing Watershed Area (ha) | 1.6 |
| Impervious Area (ha) | 1.0 |
| DCIA (ha) | 0.8 |
| HSG | D |


Inlet
Well 1
Outlet 1
Well 2
Outlet 2
Outlet 3
Well 3
Outlet 4
Cell 1
Cell 2
Cell 3
Cell 4

# Storm Summary

Monitored 43 inflow producing events between July 2013 and June 2014

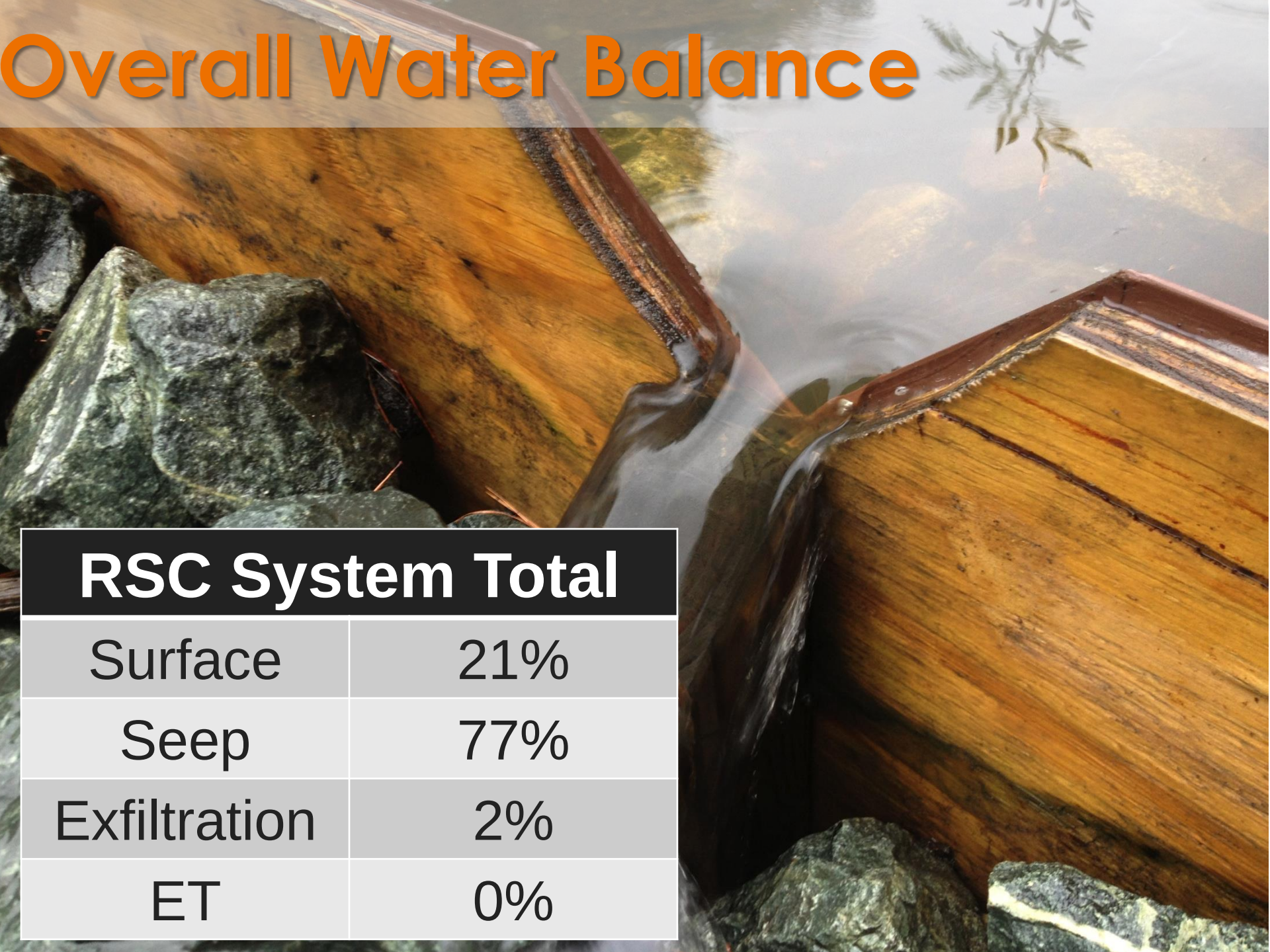
Max Rainfall Depth = 81 mm,  15 cm/hr

- Inflow Volume =  660 $m^3$, peak flow = 246 L/s
- Outflow Volume = 235 $m^3$, peak flow = 102 L/s

***57% Volume Reduction***
***68% Peak Flow Reduction***

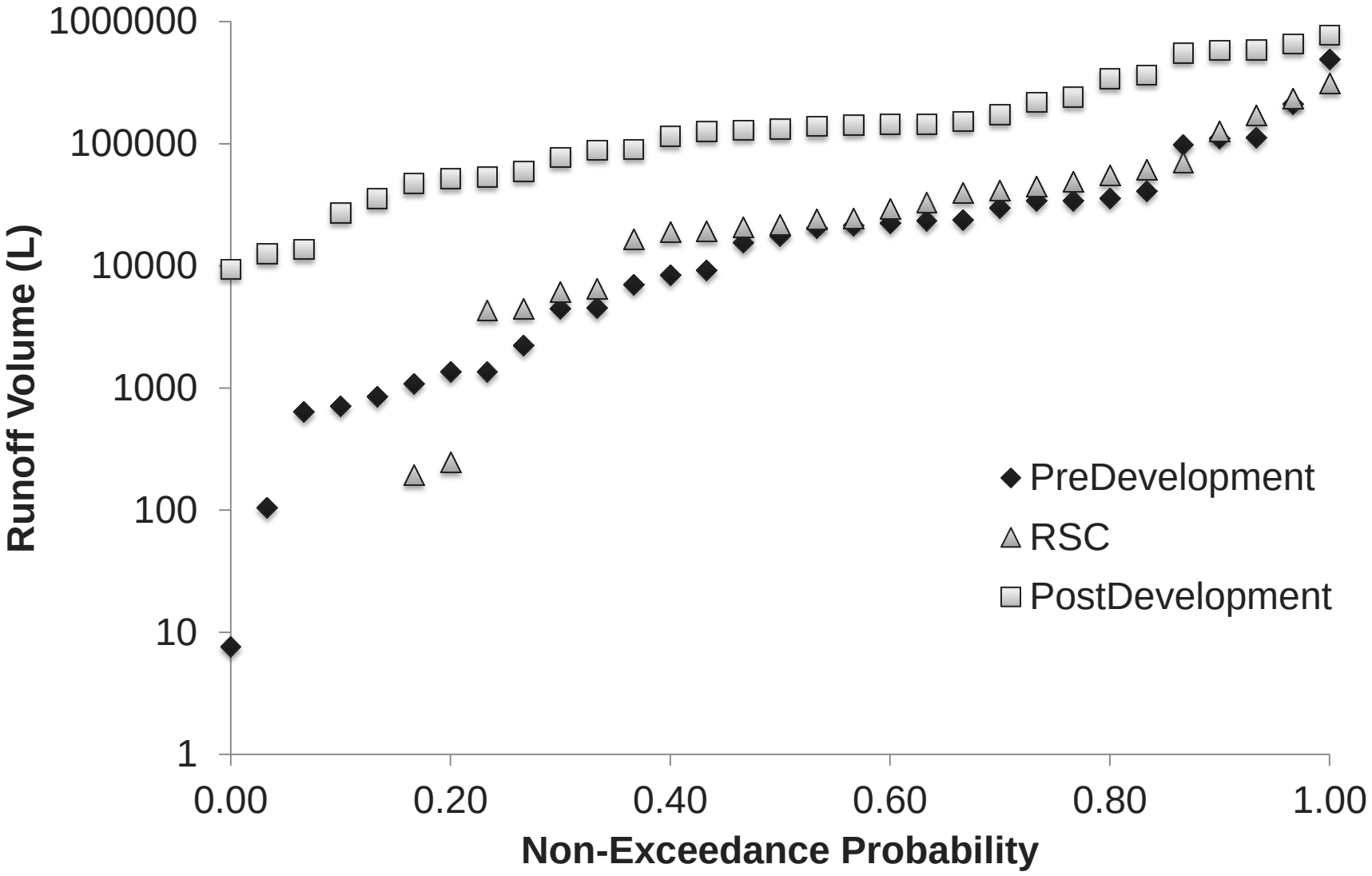
***Median Volume Reduction = 84%***
***Median Peak Flow Reduction = 80%***

# Overall Water Balance

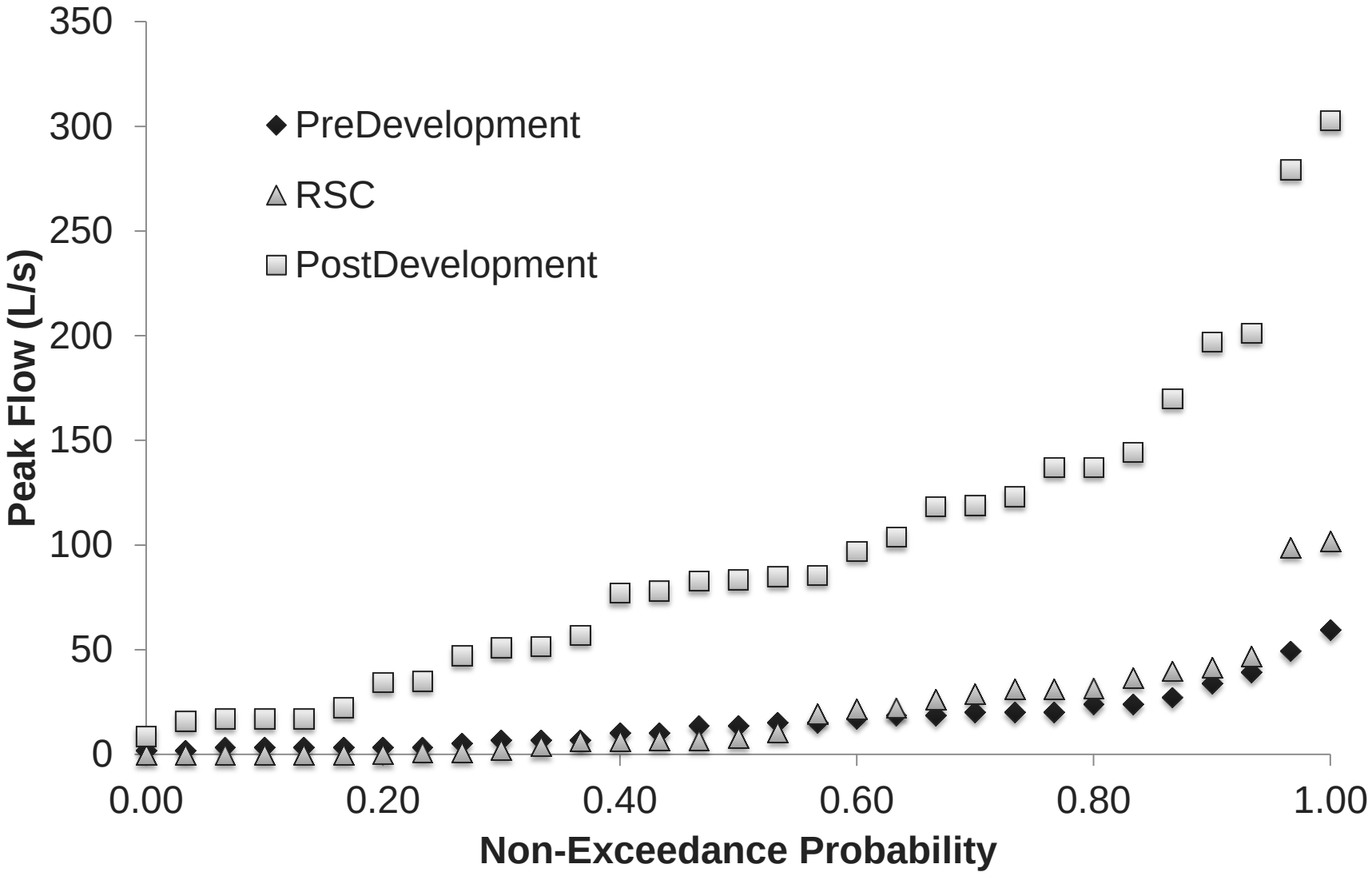


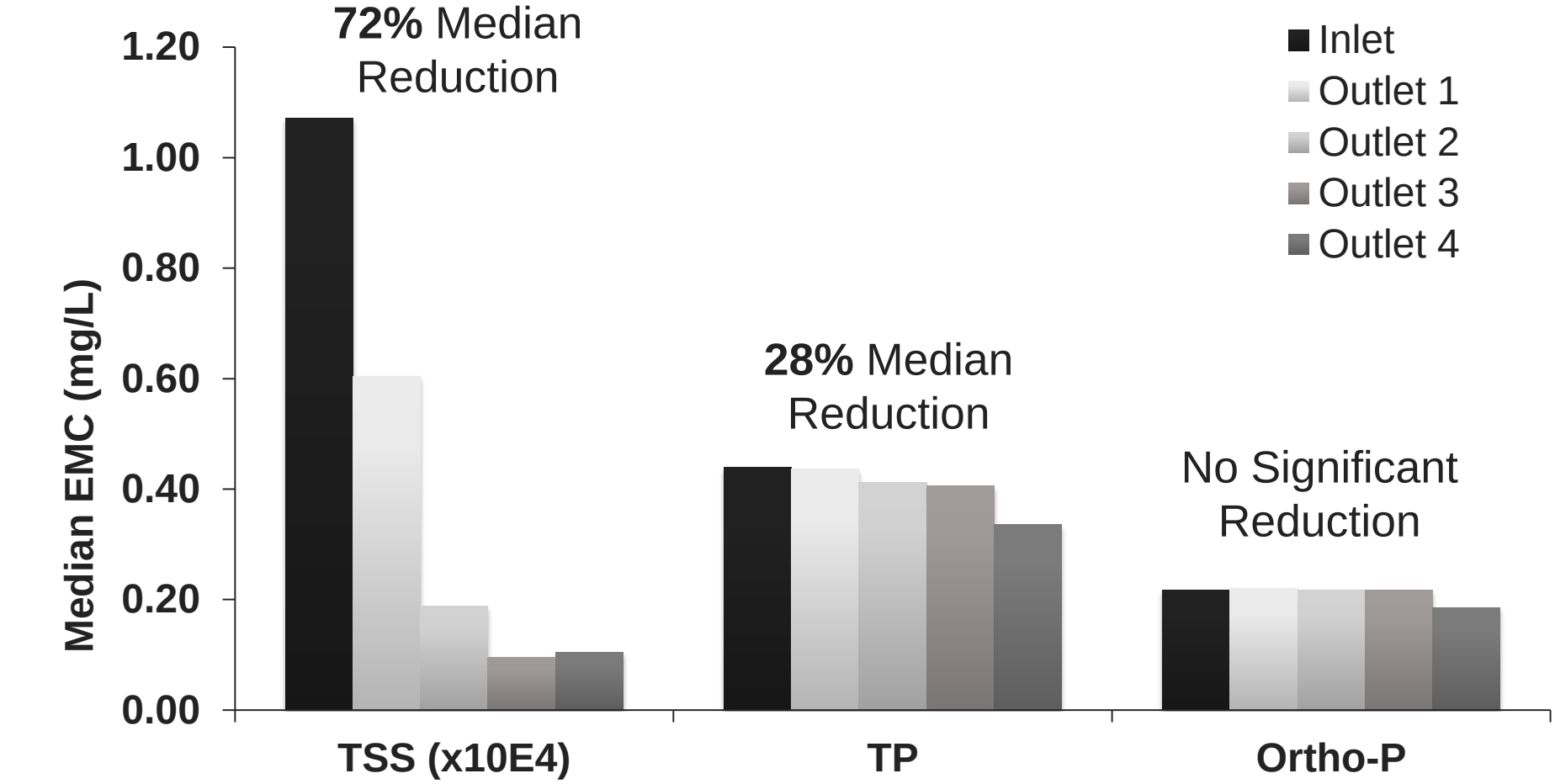
| RSC System Total | |
|---|---|
| Surface | 21% |
| Seep | 77% |
| Exfiltration | 2% |
| ET | 0% |

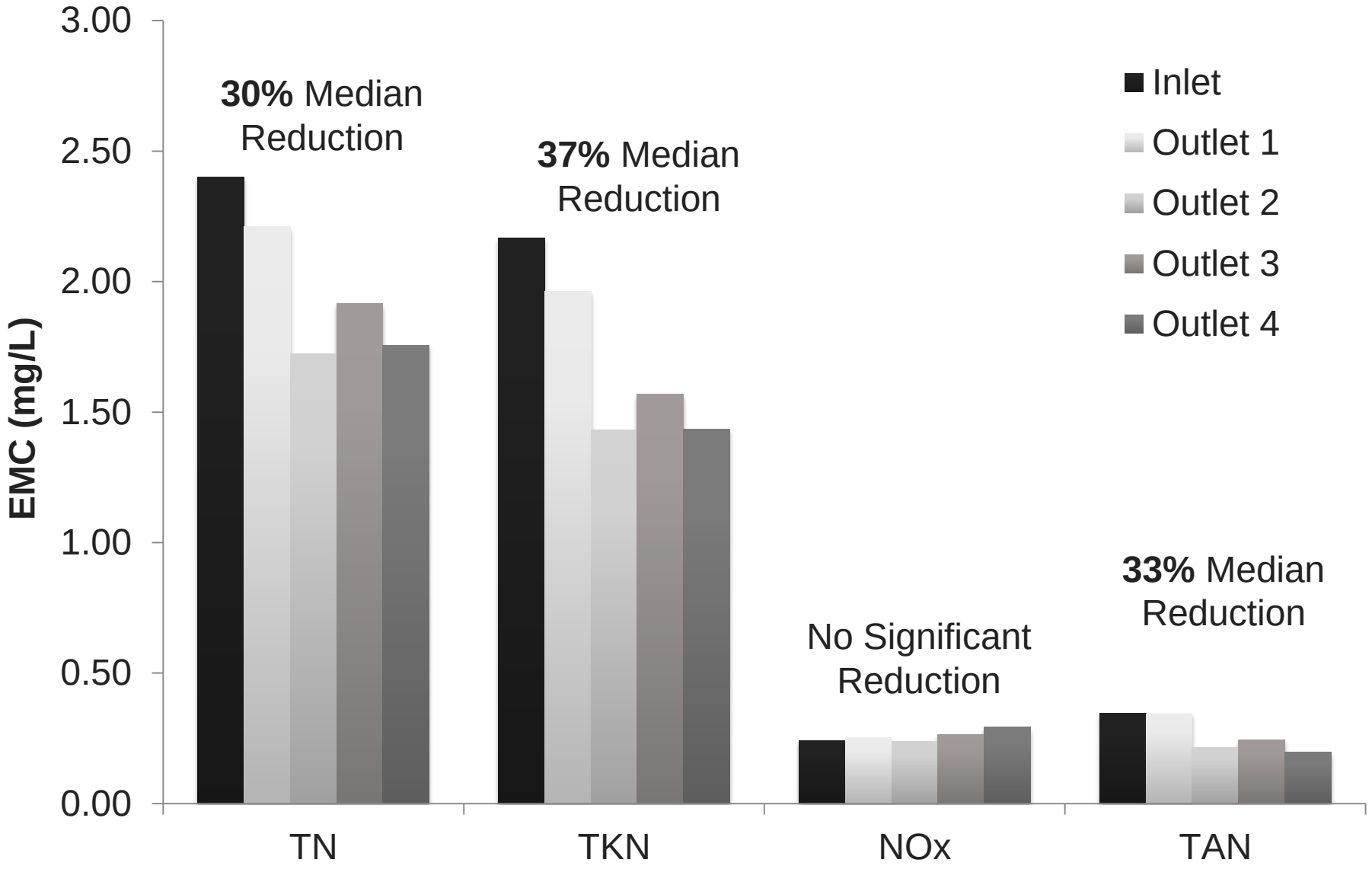
# Runoff Volume



# Peak Flow


350
300
250
200
150
100
50
0
Peak Flow (L/s)
PreDevelopment
RSC
PostDevelopment
0.00
0.20
0.40
0.60
0.80
1.00
Non-Exceedance Probability


72% Median Reduction
28% Median Reduction
No Significant Reduction
Inlet
Outlet 1
Outlet 2
Outlet 3
Outlet 4
Median EMC (mg/L)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
TSS (x10E4)
TP
Ortho-P


3.00
2.50
2.00
1.50
1.00
0.50
0.00
EMC (mg/L)
30% Median Reduction
37% Median Reduction
No Significant Reduction
33% Median Reduction
Inlet
Outlet 1
Outlet 2
Outlet 3
Outlet 4
TN
TKN
NOx
TAN

Stormwater-Treating Street Trees

# Adding New Stuff

# LianyunGang City (China)

# Oviedo, Spain

# London, Ontario

# Benefits of Urban Trees for Stormwater?

↑rban tree canopy cover → ↓ runoff volumes

- City-scale modeling scenarios[1,2]
- Canopy interception → up to 36% of direct rainfall[3]

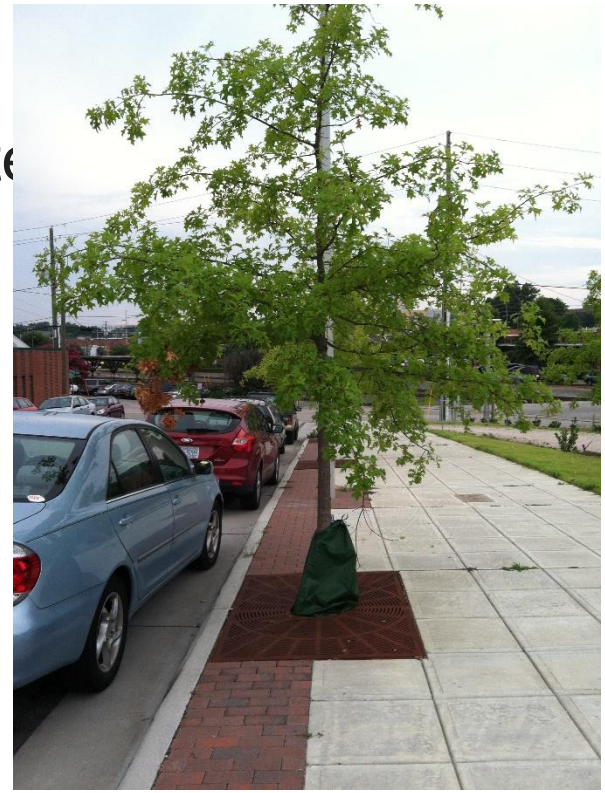
[1]Lormand, 1988; [2]Sanders, 1986, [3]Xiao et al., 1998

# Using a Single Street Tree to Treat Stormwater?

Limited peer reviewed literature available

The Silva Cell™ Suspended Pavement Syste

- Urban tree health and stormwater management



# Example Silva Cell Location: Sg

# Design and Monitoring Objective

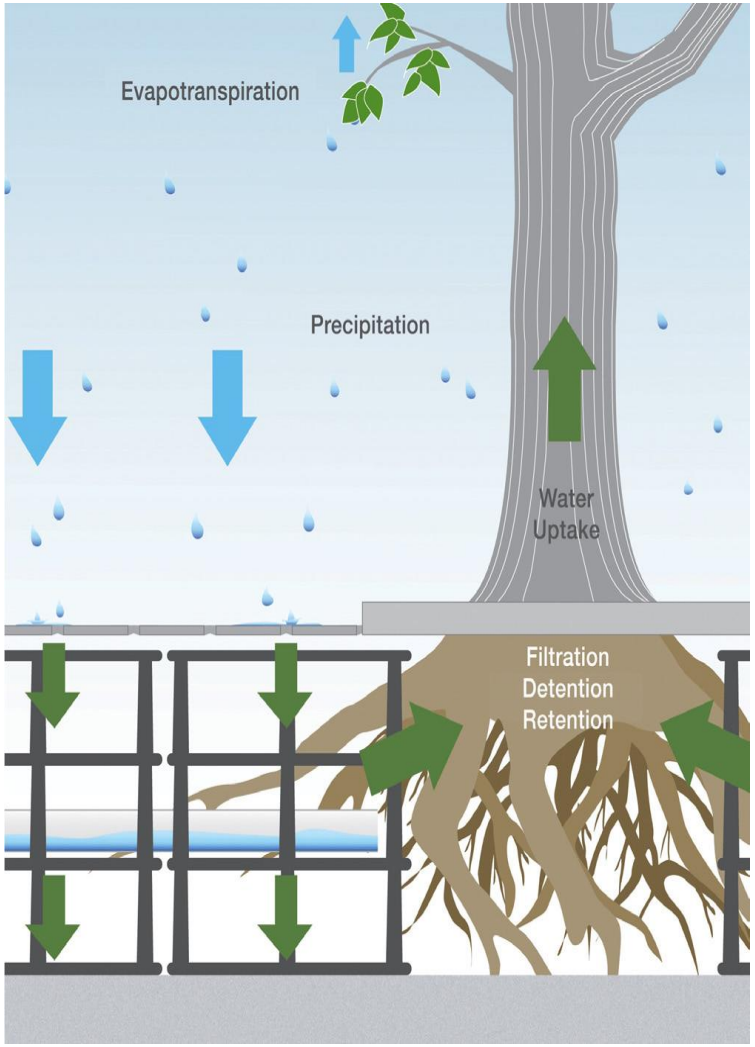
System designed for stormwater management

- Runoff routed from street surface
- Runoff volume (ROV) control
- Peak discharge (Qp) mitigation
- Water quality treatment

Quantify impacts of a single tree

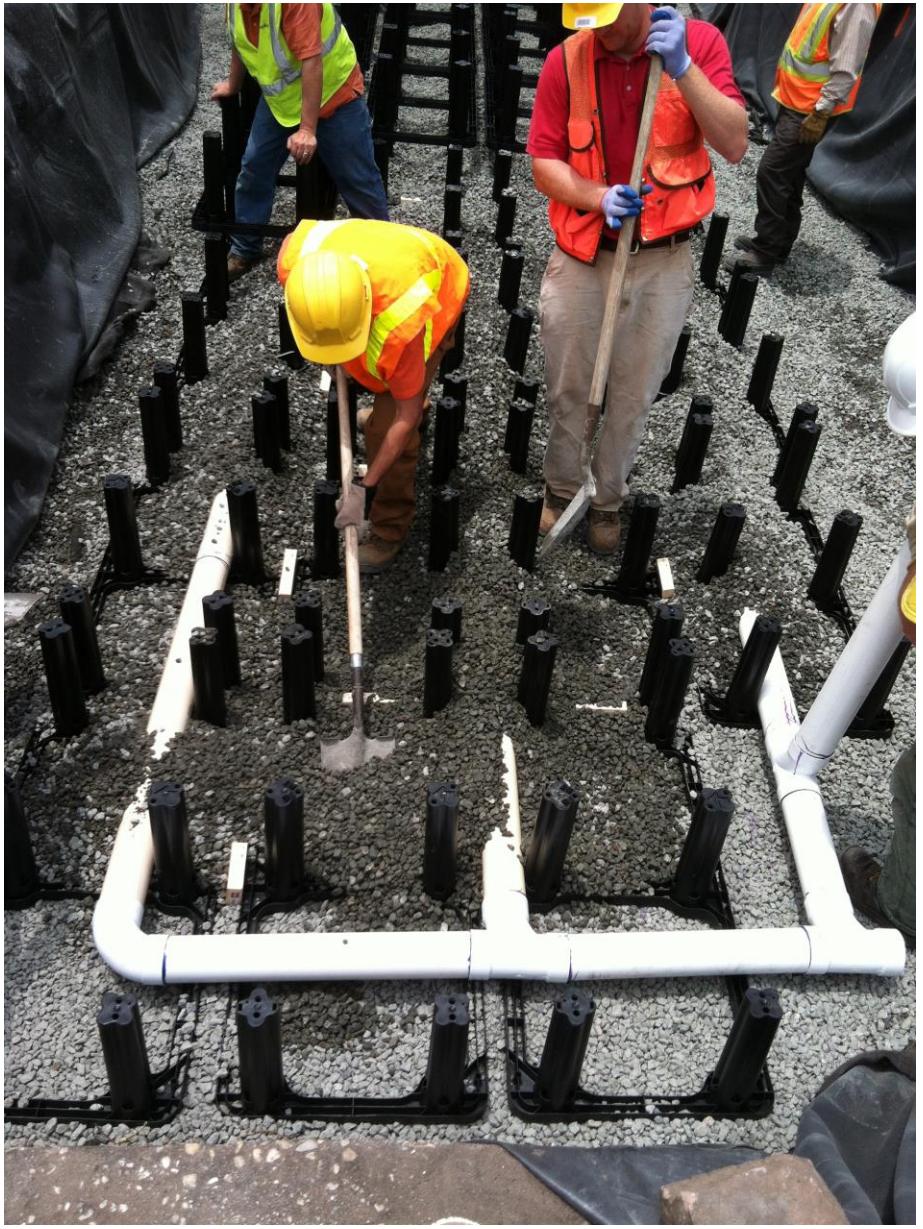
- Hydrology
- Water quality

Begin to develop design guidance




SPEED
LIMIT
25


WP 1550




CAT
304E
CR
CAT
TIRE PROS
EAGLE INN


214


SPEED LIMIT
25


**Tree Constraints:**

- Intersection sight distance
- Canopy height (i.e. overhead utilities)
- Minimum branch height
- Maximum trunk thickness

**Crape Myrtle = Comfort for COW**

# August 2014

# Another Example: PICP Pre-treatment

# System Hydrology

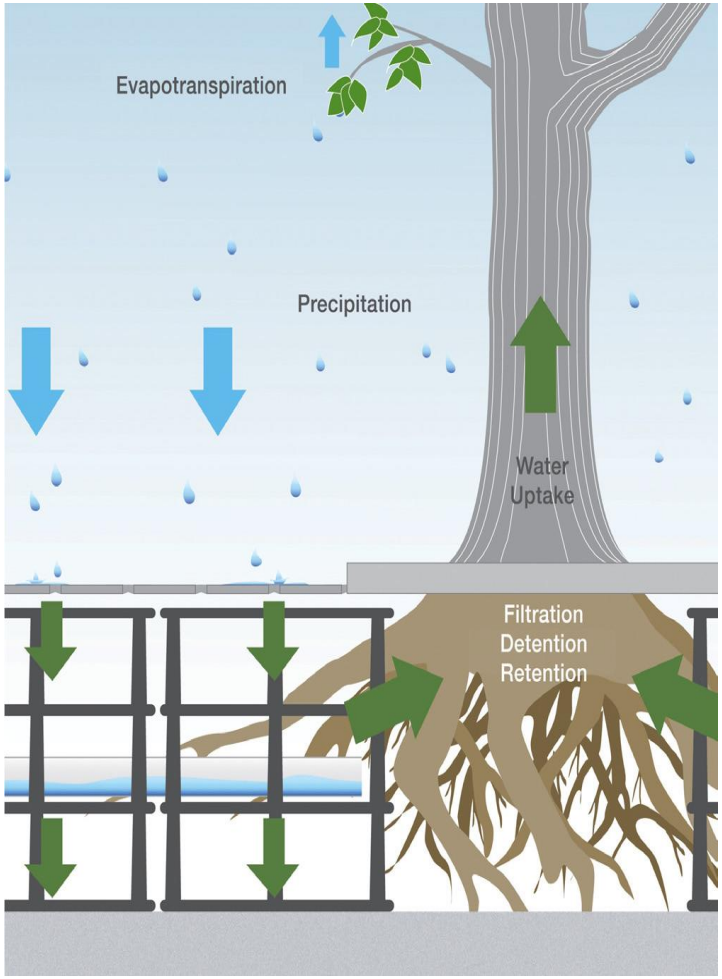
Available storage in system:

- 22 $m^3$ of soil volume
- Half is saturated due to IWS
- Remaining storage:
- 22/2 = 11 x (0.34-0.18) =

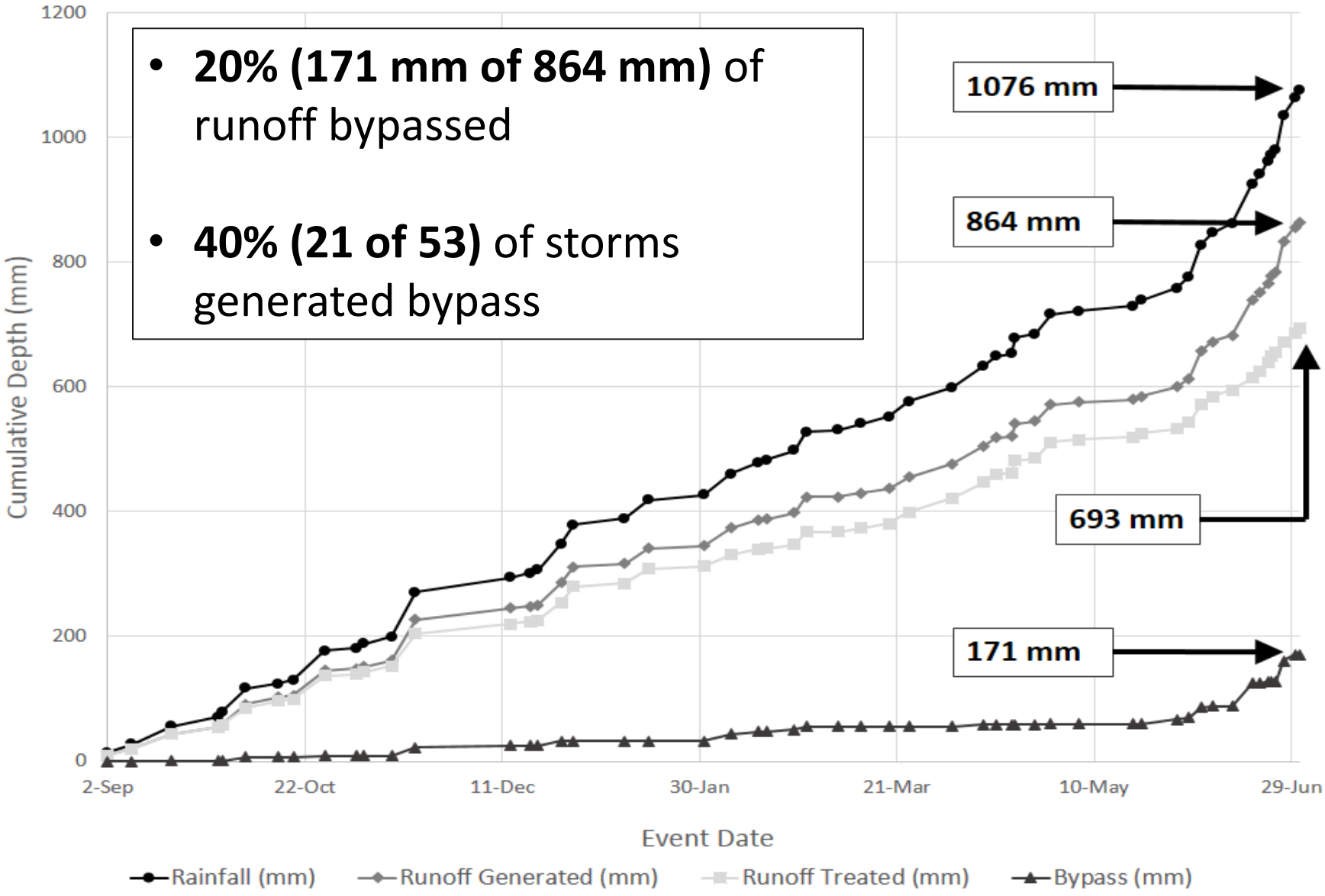
→ **1.8 $m^3$ or a 5 mm storm**

Systems function primarily as a flow-through filter

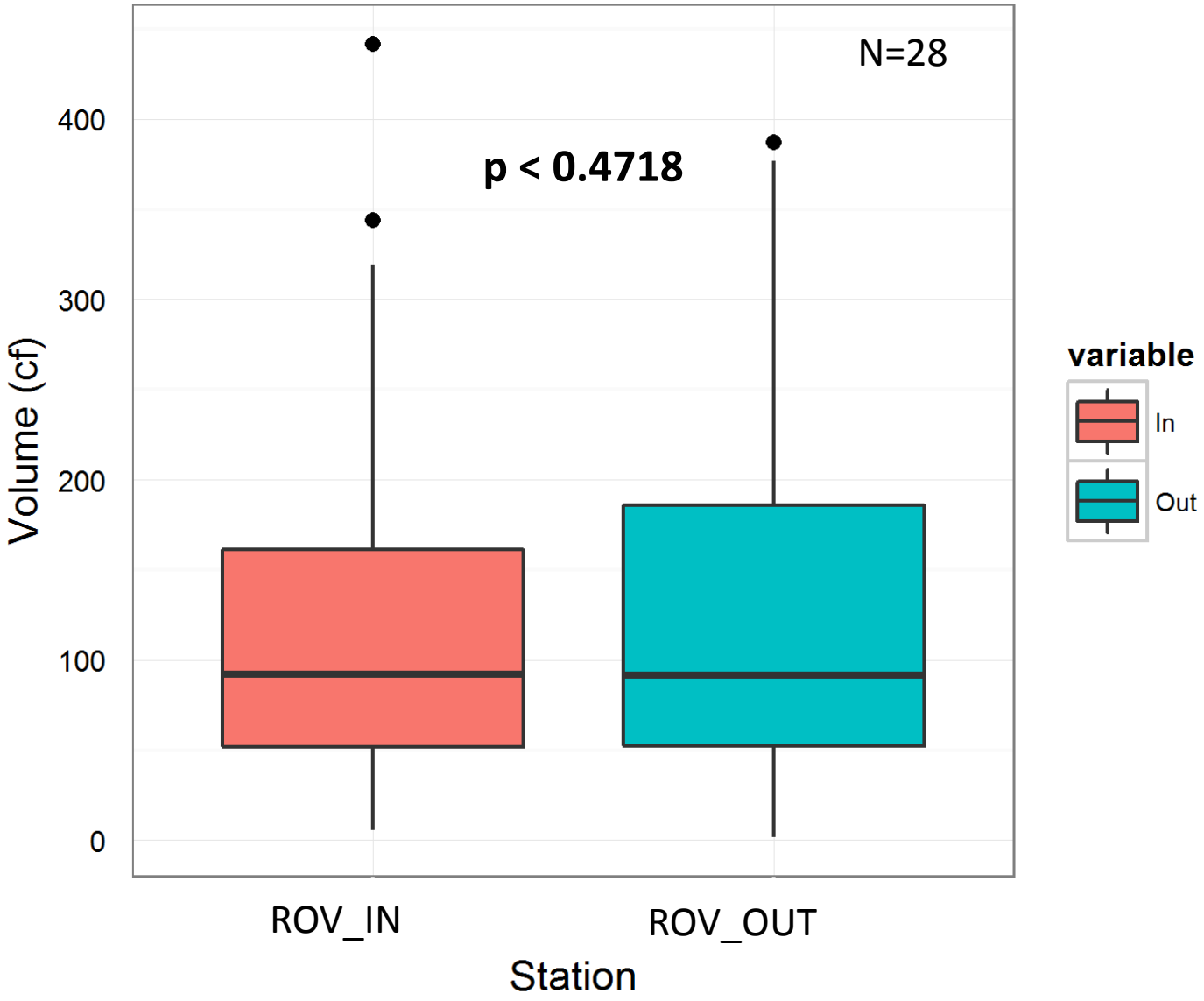
- ROV reduction negligible do to impermeable liner
- Potential for some $Q_p$ mitigation



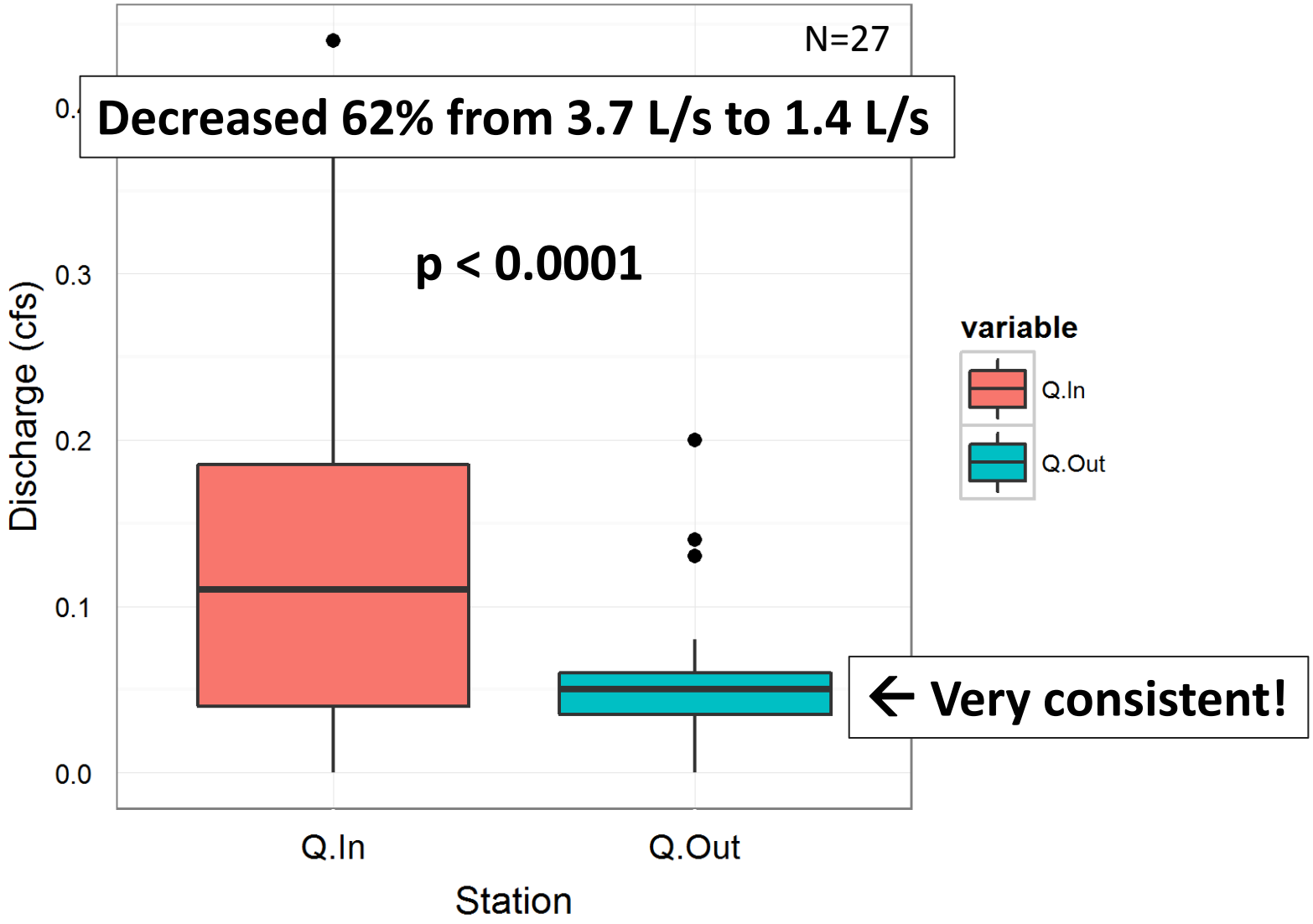

STOP

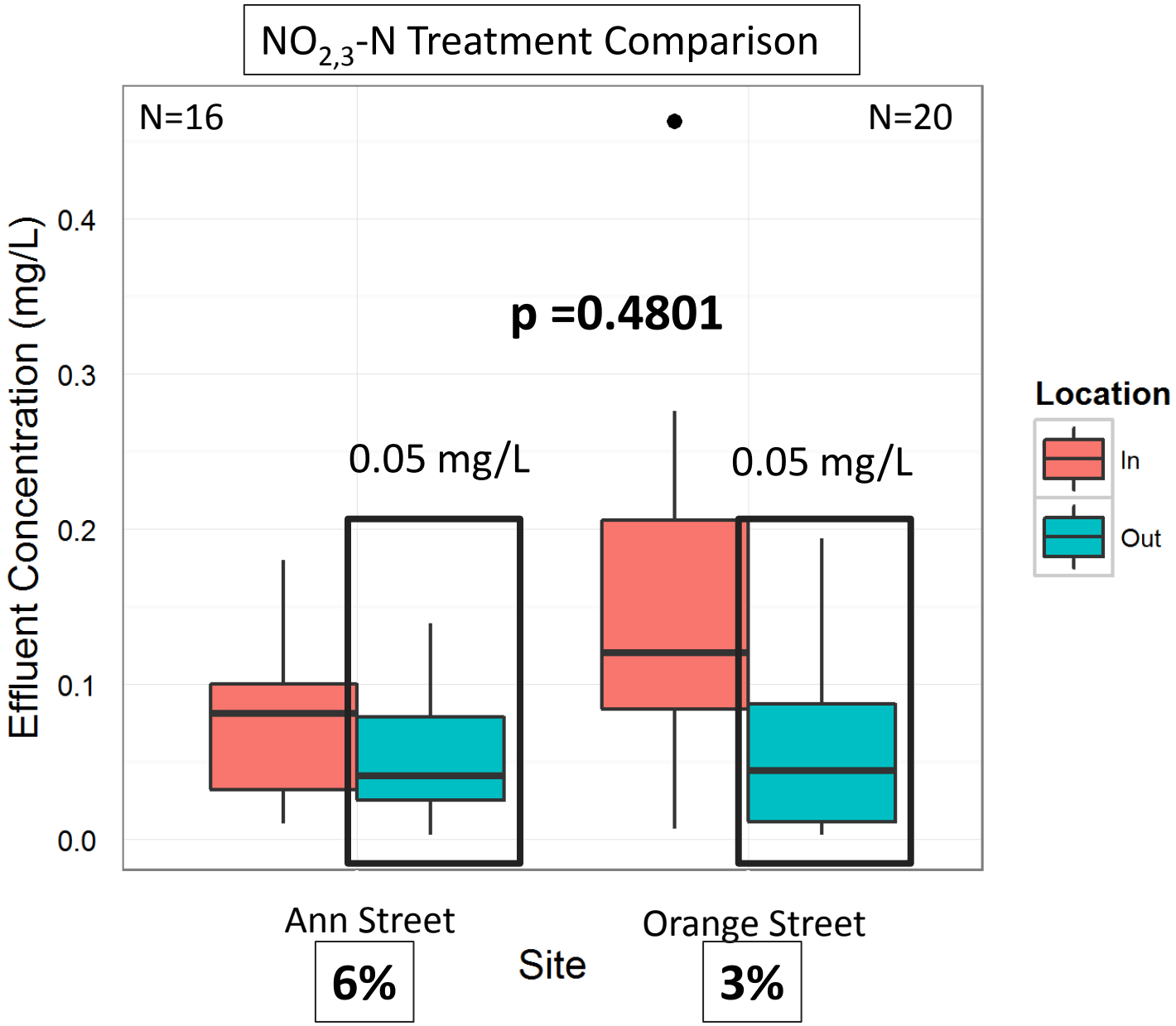

• 20% (171 mm of 864 mm) of runoff bypassed
• 40% (21 of 53) of storms generated bypass
1076 mm
864 mm
693 mm
171 mm
Cumulative Depth (mm)
1200
1000
800
600
400
200
0
2-Sep
22-Oct
11-Dec
30-Jan
21-Mar
10-May
29-Jun
Event Date
Rainfall (mm)
Runoff Generated (mm)
Runoff Treated (mm)
Bypass (mm)

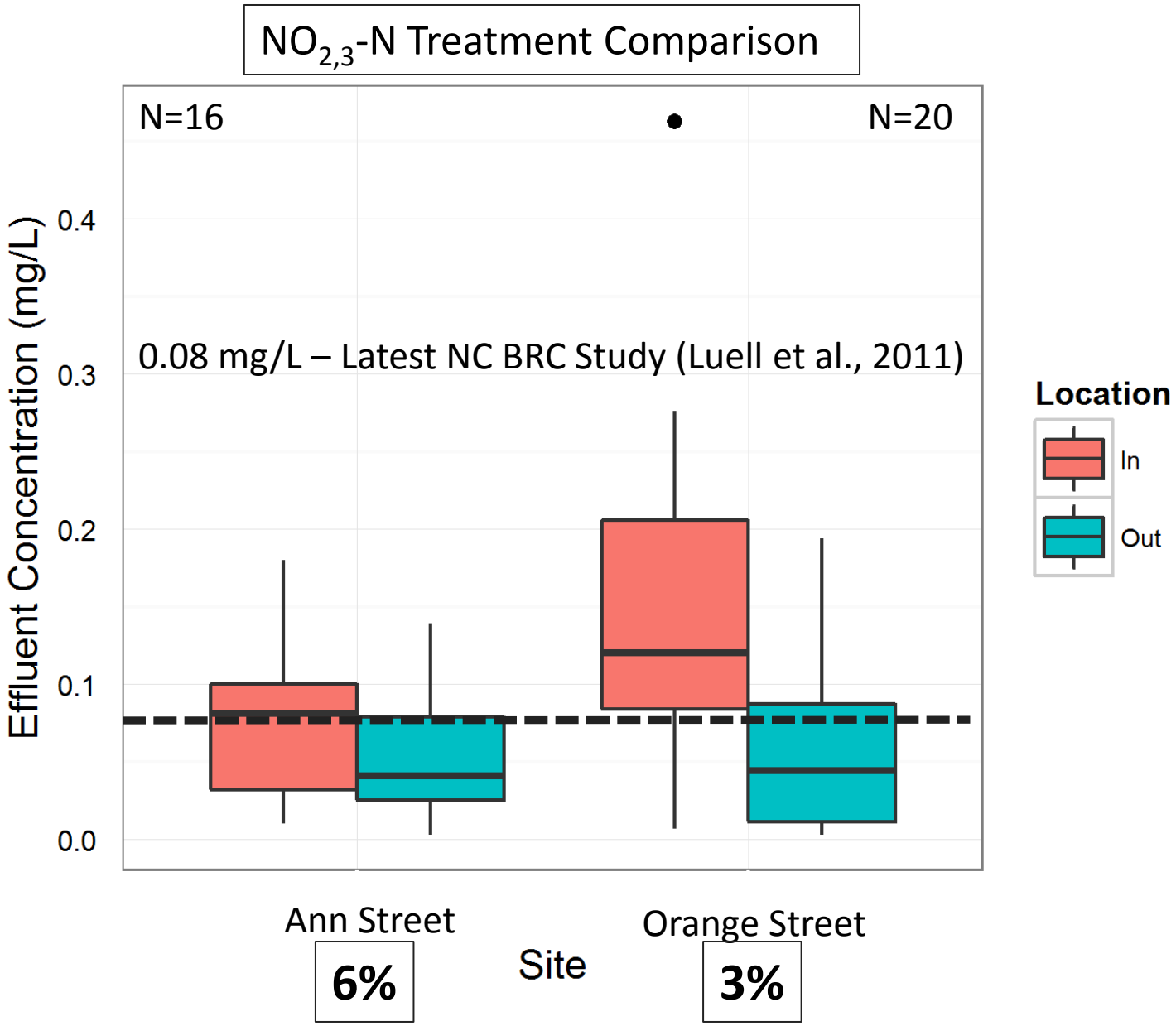
# Results: Ann Street Runoff Volume



# Results: Ann Street Peak Discharge




$NO_{2,3}$-N Treatment Comparison
N=16
N=20
p =0.4801
0.05 mg/L
0.05 mg/L
Effluent Concentration (mg/L)
0.0
0.1
0.2
0.3
0.4
Location
In
Out
Ann Street
Orange Street
Site
6%
3%


$NO_{2,3}$-N Treatment Comparison
N=16
N=20
0.08 mg/L – Latest NC BRC Study (Luell et al., 2011)
Effluent Concentration (mg/L)
0.4
0.3
0.2
0.1
0.0
Location
In
Out
Ann Street
Orange Street
Site
6%
3%

# Results: Water Quality

| Pollutant | Ann Street Pollutant Load Summary (kg/ha/yr) | | | |
|---|---|---|---|---|
| | Pre-retrofit | Post-retrofit | Mass Retained | % Retained |
| **TN** | 8.47 | 4.02 | 4.45 | 53% |
| **TP** | 1.43 | 0.51 | 0.92 | 59% |
| **TSS** | 556 | 170 | 416 | 69% |
| **Cu[a]** | 0.18 | 0.04 | 0.15 | 70% |
| **Pb[a]** | 0.14 | 0.06 | 0.07 | 58% |
| **Zn[a]** | 0.86 | 0.35 | 0.51 | 60% |

- No volume reduction
- Recall: 20% of total runoff volume bypassed

# Keep Talking: The Role of Good Communications

Keep Talking…

# Feedback from Research Community

Enables Regulators to Fine Tune Designs

Underpins introduction of new practices

Enables a large swath of designers to learn

Keep Talking…

# Practices with Major Design Modifications: Bioretention

- New Media Requirements: Composition & Depth
- Allowable Vegetation
- Required Underdrain Configuration (IWS)
- Credit for Undersizing Systems

Keep Talking…

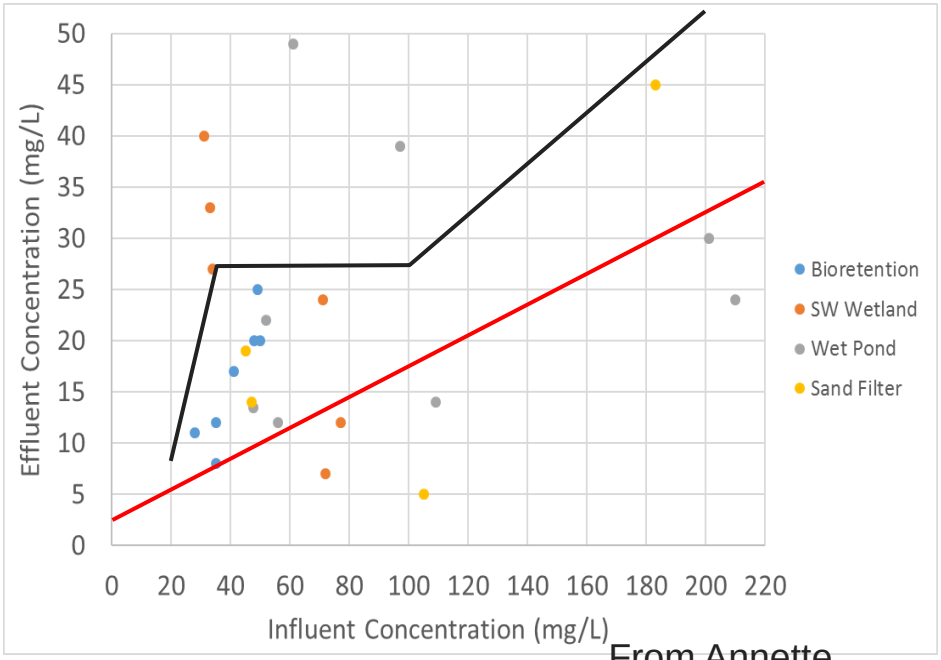
# Practices with Major Design Modifications: Permeable Pavement

- Maximum allowable run-on from asphalt
- Required Soil Testing & Preparation
- Recommended Underdrain Configuration (IWS)
- Elevation to “Primary Practice-hood”

Keep Talking…

# Adding Proprietary Practices

- StormFilter ™
- Silva Cell ™
- Filterra ™ (en route)
- Each is treated as ‘Primary’ Practice




From Annette Lucas of NCDEQ

Without change there is no innovation, creativity, or incentive for improvement. Those who initiate change will have a better opportunity to manage the change that is inevitable.

**William Pollard**

# February 2018 – Ocean Isle Beach, North Carolina, USA

# TRIECA 2018 CONFERENCE

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R&M CONSTRUCTION

UNILOCK DESIGNED TO CONNECT.

Hydro International

filtrexx CANADA SUSTAINABLE TECHNOLOGIES let nature do it.

SOLENO Mastering Storm Water

GEMS

Credit Valley Conservation inspired by nature

TITAN ENVIRONMENTAL CONTAINMENT

armtec Solutions for a Better World

York Region

Lake Simcoe Region conservation authority

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