Volume Reduction Provided by Eight Disconnected Downspouts in Durham, NC with and without Soil Amendments

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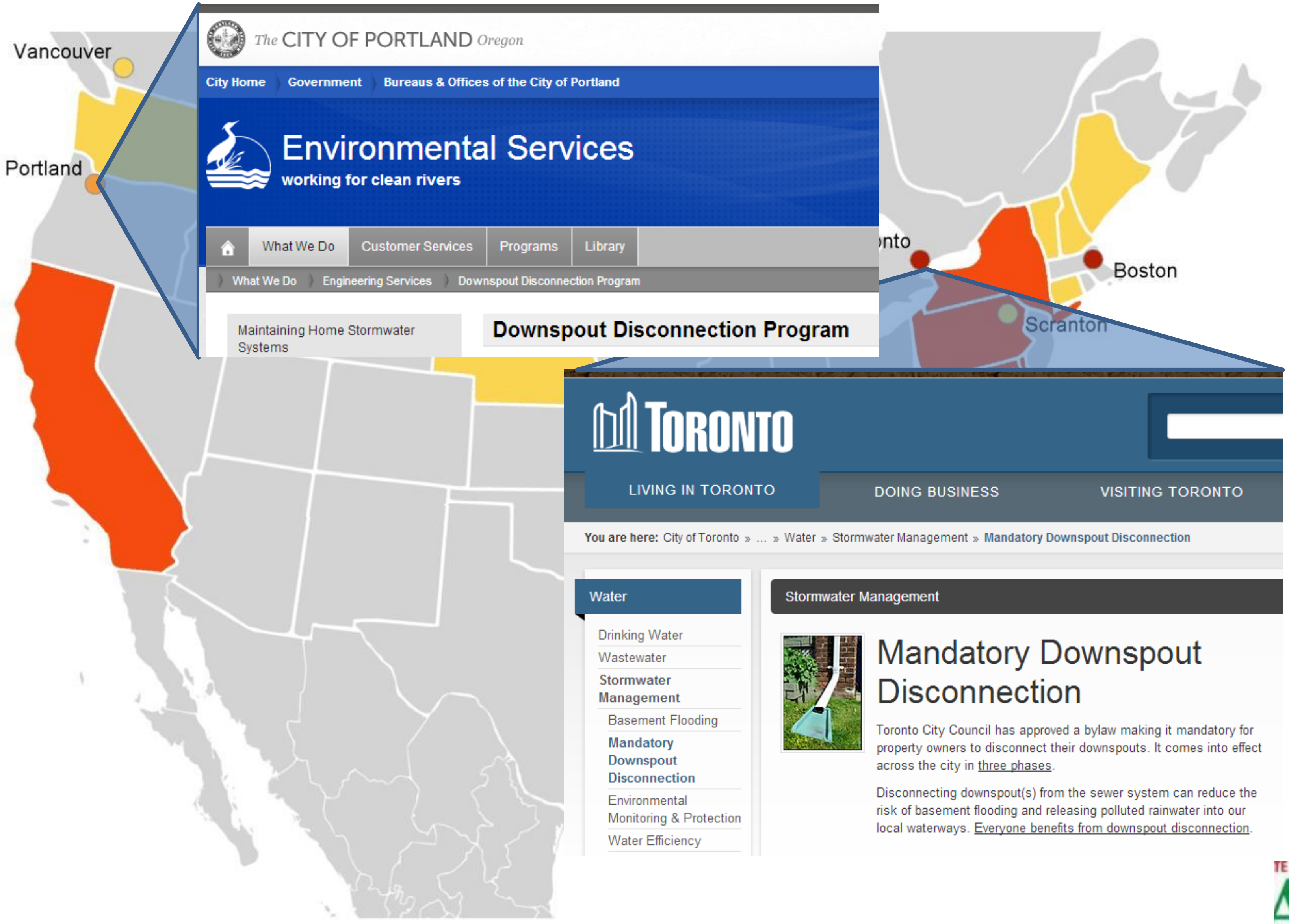
DSD in North America



DSD Research

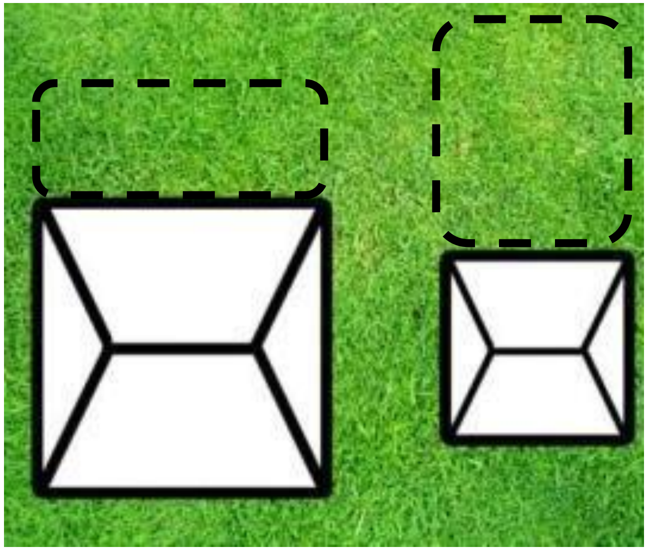
- Part of **Rain Catchers** program developed by the City of Durham to introduce 250 site-scale stormwater retrofits to Improve South Ellerbe Creek.
- Goals: quantify **volume and peak flow reduction** from DSD.

Phase I – Existing Conditions

Phase II – Soil Amendments

Project Design Factors

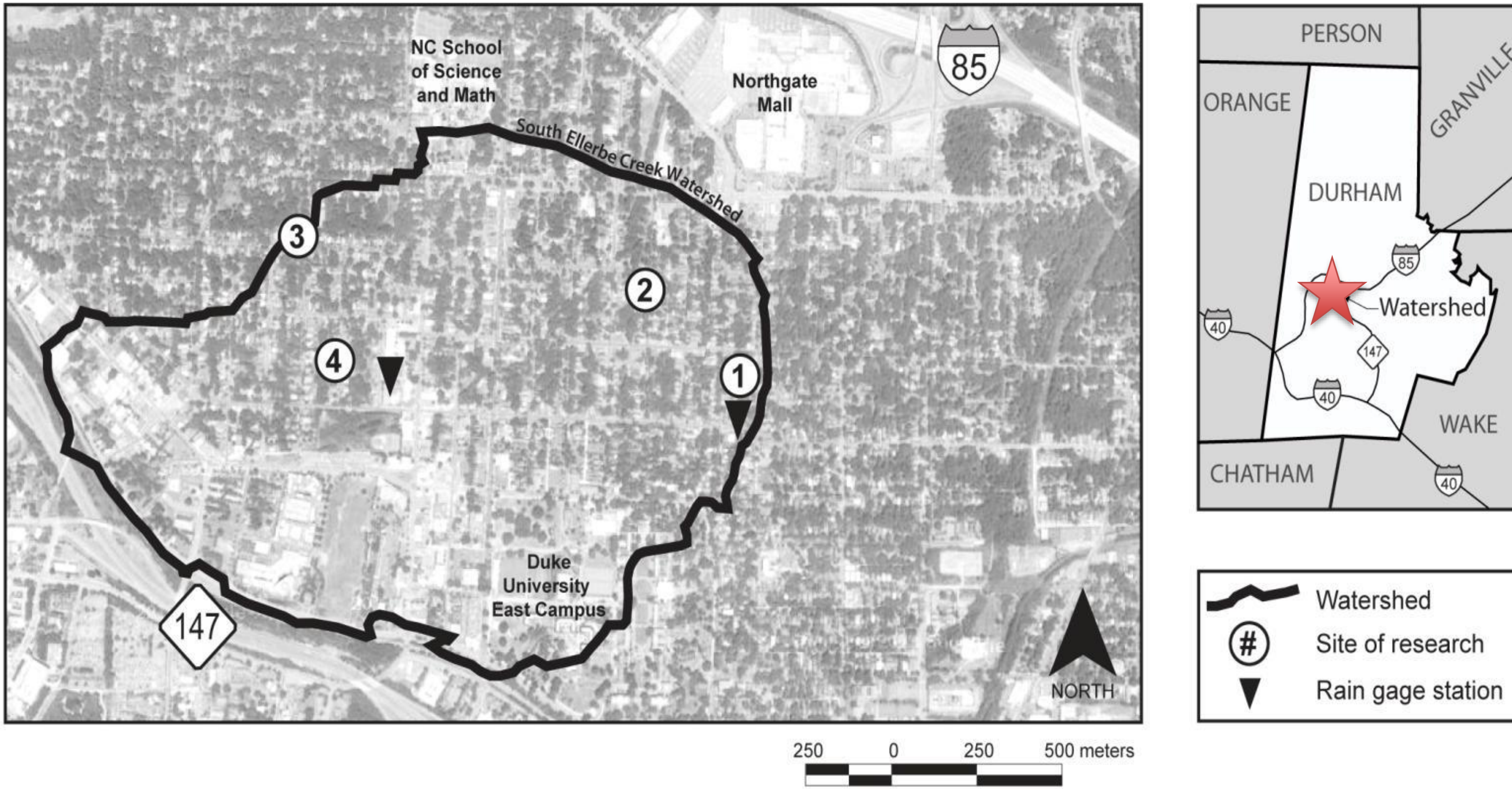
SLOPE



LOADING RATIO

DISTANCE

Site Locations




3


1
2
4
3

HOBO U20
water level logger
Onset Computer Corp.

Davis Instruments tipping bucket rain rage

Double Ring Infiltrometer

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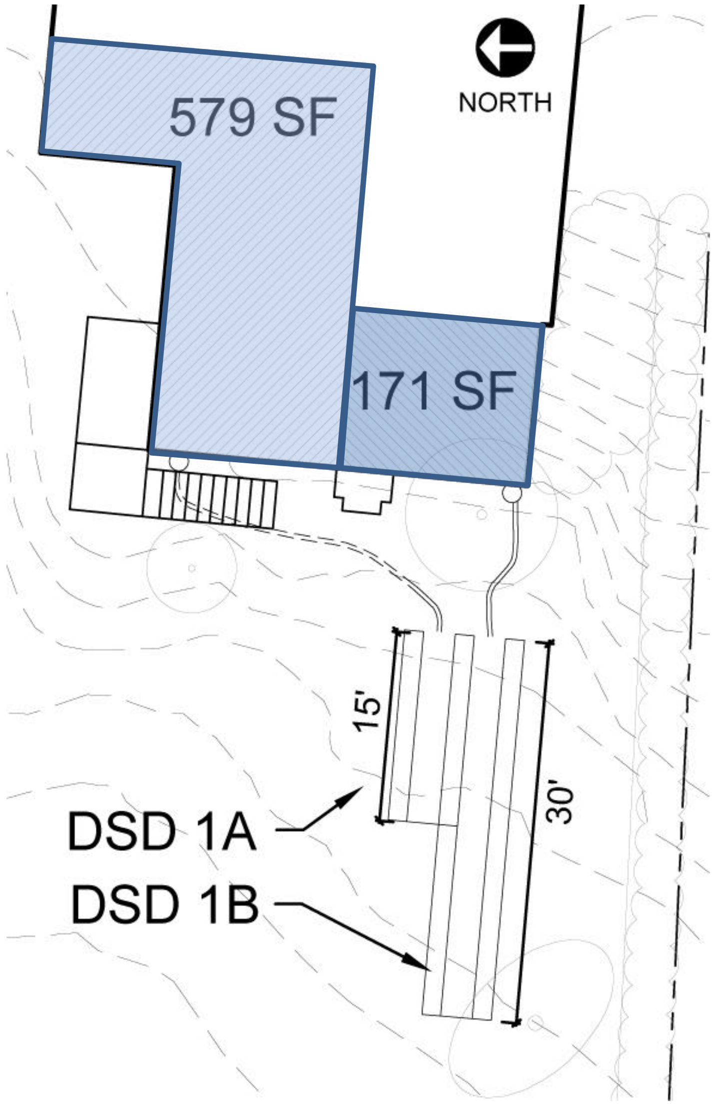
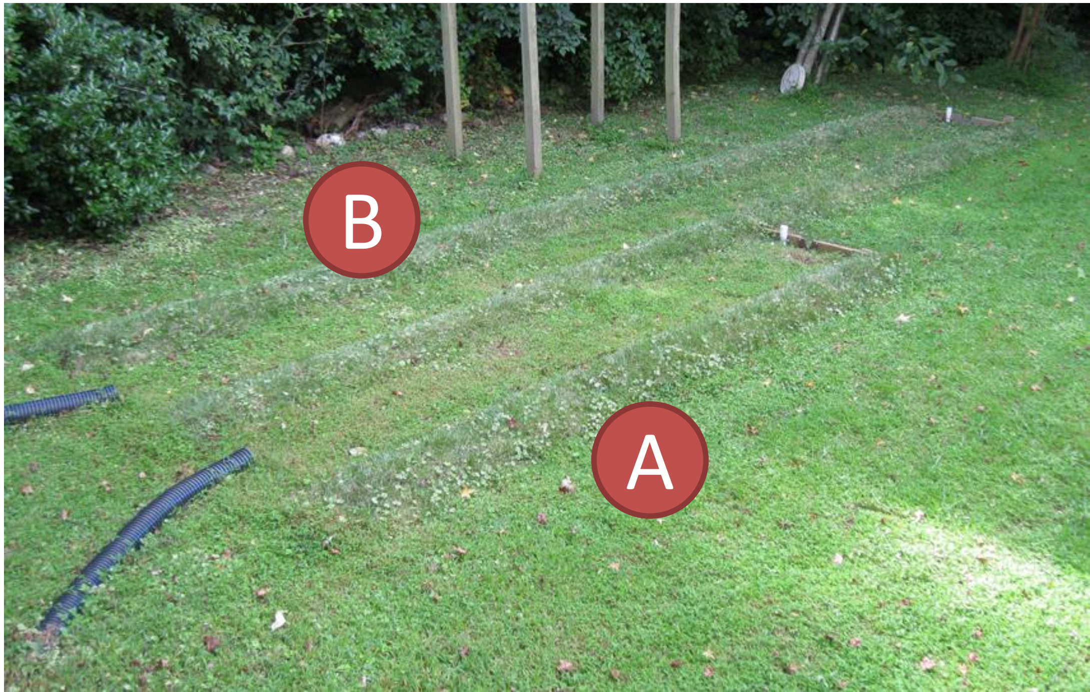
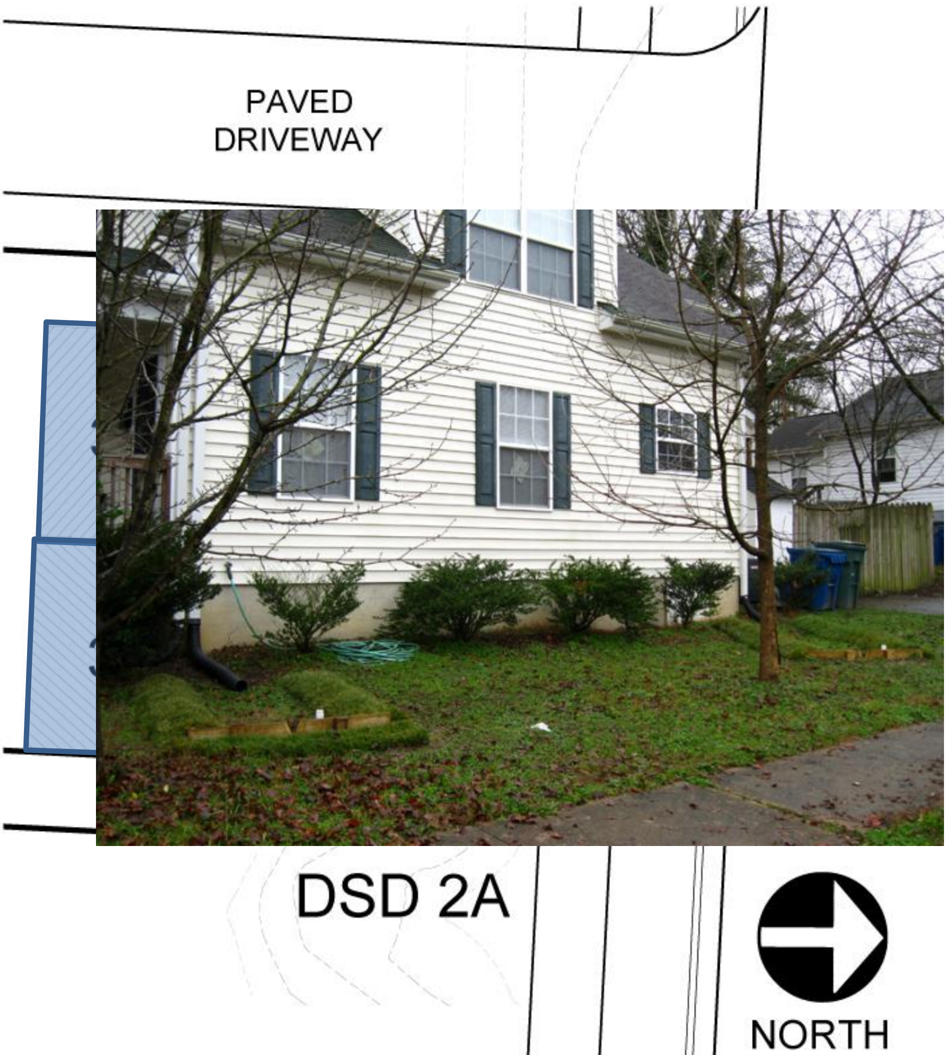
1 LENGTH



	A	B
Slope (%)	6.6	5.2
Length (ft)	15	30
Roof Area (sf)	579	171
Infiltration rate (cm/hr)	1.7	1.7



2 LENGTH



	A	B
Slope (%)	6	5.5
Length (ft)	5	10
Roof Area (sf)	300	300
Infiltration rate (cm/hr)	1.2	1.1

A

B

3 AREA

	A	B
Slope (%)	6.5	6.5
Length (ft)	12	12
Roof Area (sf)	142.5	300
Infiltration rate (cm/hr)	35.3	35.3

A B

4 SLOPE

	A	B
Slope (%)	27	4.8
Length (ft)	12	12
Roof Area (sf)	240	240
Infiltration rate	0.8	6.8

Calculations

$$Volume_{in} = [(P - I_a) * A_R] + [P * A_L]$$

- *P = precipitation (m)*
- *I_a = initial abstraction (m)*
- *A_R= effective roof area (m^2)*
- *A_L=contributing lawn area (m^2)*

$$Volume_{out} = \sum_{i=1}^{n} \left(30 * 2057 * H_i^{2.5}\right)$$

- *H_i = height of water above nappe of weir (meters)*

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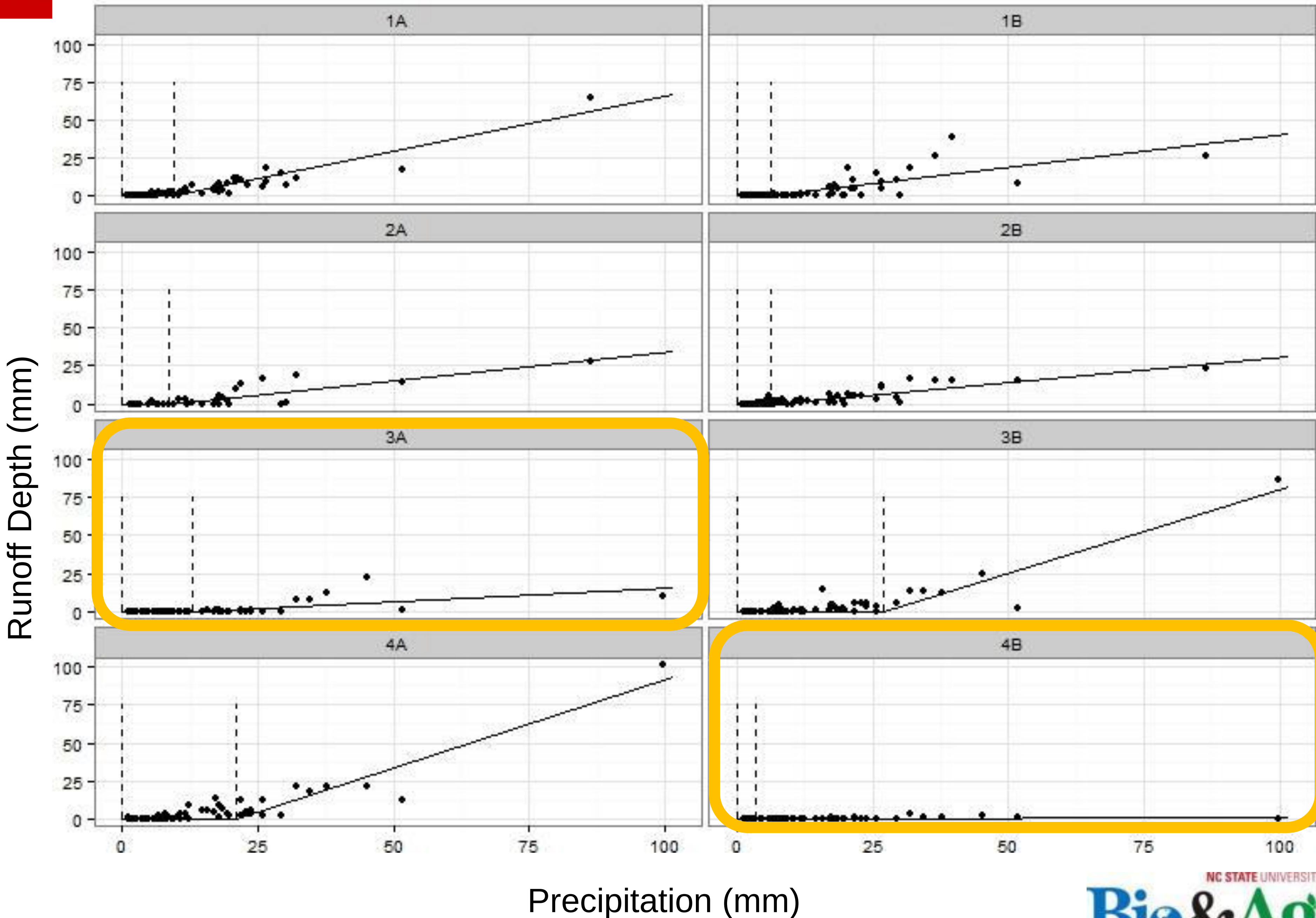
Phase I Results (Jan 22 – Oct 8, 2013)

Site	*Design Factor*	*Infiltration Rate (cm/h)*	*Slope (%)*	*Length (m)*	*Loading Ratio (n:1)*	*Bulk Density (g/cm3)*	*Volume Reduction (%)*
1A	Length	1.73	6.6	4.6	9.6	1.39	56
1B		1.73	5.2	9.1	1.4	1.39	72
2A	Length	1.23	6	1.5	15.0	1.67	80
2B		1.07	5.5	3.0	7.5	1.66	76
3A	Loading Ratio	35.31	6.6	3.7	3.0	1.23	92
3B		35.31	6.6	3.7	6.3	1.23	73
4A	Slope	0.75	27	3.7	4.6	1.53	62
4B		6.75	4.8	3.7	5.0	1.34	99



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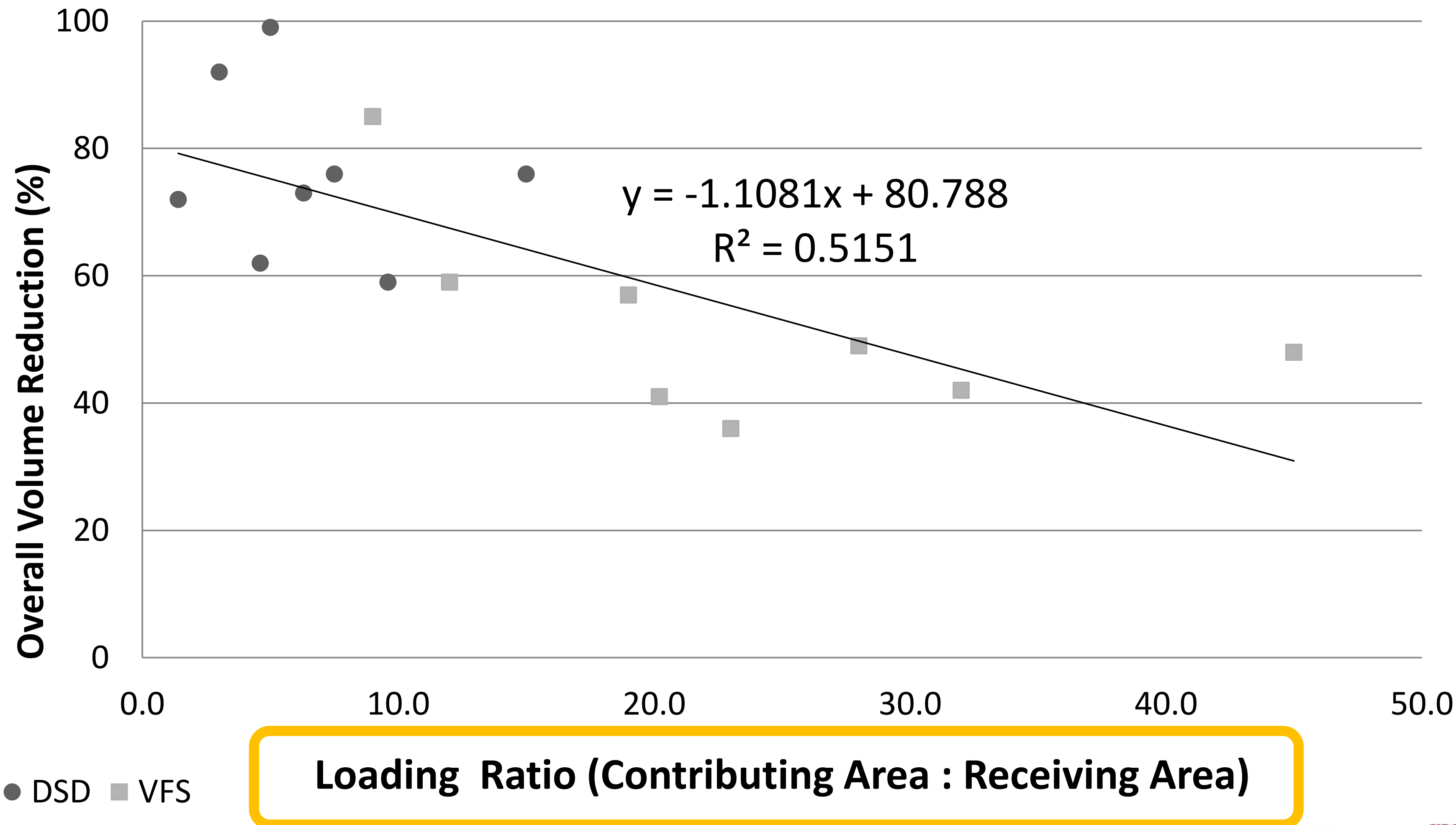
DSD and LS-VFS total Volume Reduction as function of Loading Ratio



Research Application

NCDENR Stormwater BMP Manual — Chapter Revised: 2-3-14

Disconnected Impervious Surface (DIS)

Description

Disconnected Impervious Surface (DIS) is the practice of directing stormwater runoff from built-upon areas to properly sized, sloped and vegetated pervious surfaces. Both roofs and paved areas can be designed as DIS. DIS is low cost and has been proven to reduce the volume, flows and pollutant loads associated with stormwater runoff.

Siting & Use

Yes	High SHWT
Yes	Tight soils
No	Very steep sites
No	Highly impervious sites
Yes	Pathogen removal
Yes	Temperature control

Design Objective

DIS directs stormwater from impervious surfaces to a vegetated area for treatment via infiltration and filtration. The loading ratio shall be at a minimum of 7:1 for (rooftop area : vegetated area) or 10:1 for (pavement area : vegetated area).

Stormwater Credits

Runoff Reduction	Varies from 30% to 100% based on the soil type and size of vegetated receiving area. See Section 13.2.
TSS removal	Varies from 30% to 85% based on the soil type and size of vegetated receiving area. See Section 13.2.
Nutrient removal	Varies from 30% to 70% based on the soil type and size of vegetated receiving area. See Section 13.2.
BUA Status	For the purpose of high density/low density calculations, the footprint of the roof or paved area shall be considered impervious and the footprint of the vegetated receiving area shall be considered pervious.

Disconnected Built-Upon Area — 13-1

Overall Design Elements

- The vegetated receiving area shall not include any impervious surface. In addition, a minimum **5-foot** distance between building foundation and vegetated area receiving runoff is recommended.
- The vegetated receiving area shall have a max **slope of 7%** with land graded to promote diffuse flow. Except A soils, where up to **15% slope** is allowed.
- Vegetative cover shall be established dense **lawn** with no clumping species.
- All sites built within the past fifty years shall be **tilled** down to eight inches prior to vegetation establishment.

Phase II – soil amendments

Previous Research

- Khaleel *et al.*, 1981
- Martens and Frankenberger, 1992
- Weindorf *et al.*, 2006
- Wilekens *et al.*, 2014

Amendment Process

- Remove existing vegetation
- Till soil to depth of 6-8 inches
- Apply lime to maintain ideal levels as recommended by NCDA &CS Agronomic Division
- Amend with plant based compost
- “Spectrum” seed from local seed distributor
- Excelsior fiber matting
- Water generously

Soil Analysis

- Infiltration
- Bulk Density
- Soil Classification
- Particle Size Analysis

Phase II Results (Jan 2 – Sep 30, 2014)

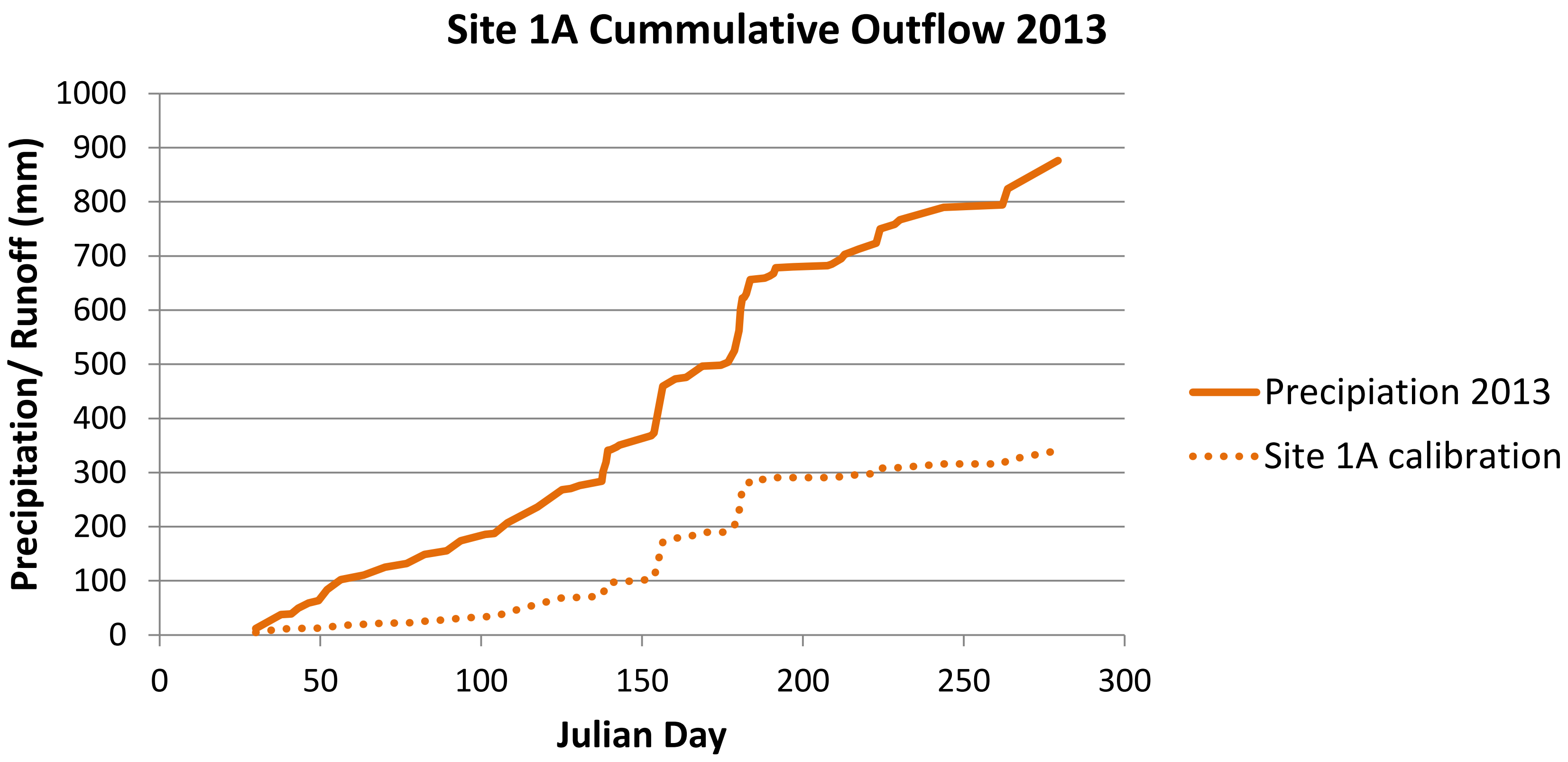
Site	***Volume Reduction***		***Bulk Density (g cm^{-3})***		***Infiltration (cm hr^{-1})***	
	Cal.	***Treat.***	***Cal.***	***Treat.***	***Cal.***	***Treat.***
<u>*1A**</u>	56	37	1.39	1	1.2 - 2.7	1.3
1B	72	59		1.2		**0.4**
<u>*2A*</u>	80	99	1.67	1.44	0.3 - 3.0	0.6
2B	76	70	1.66	1.57	0.7 - 1.3	**2.6**
3A	92	94	1.23	1.17	17.9 - 55.1	26.2
<u>*3B*</u>	73	94		0.96		34.9
<u>*4A*</u>	62	48	1.53	1.18	0.2 - 1.3	0.5
4B	99	96	1.34	1.17	4.6 - 10.3	8.6

* rain gage and atmospheric pressure gage present on site

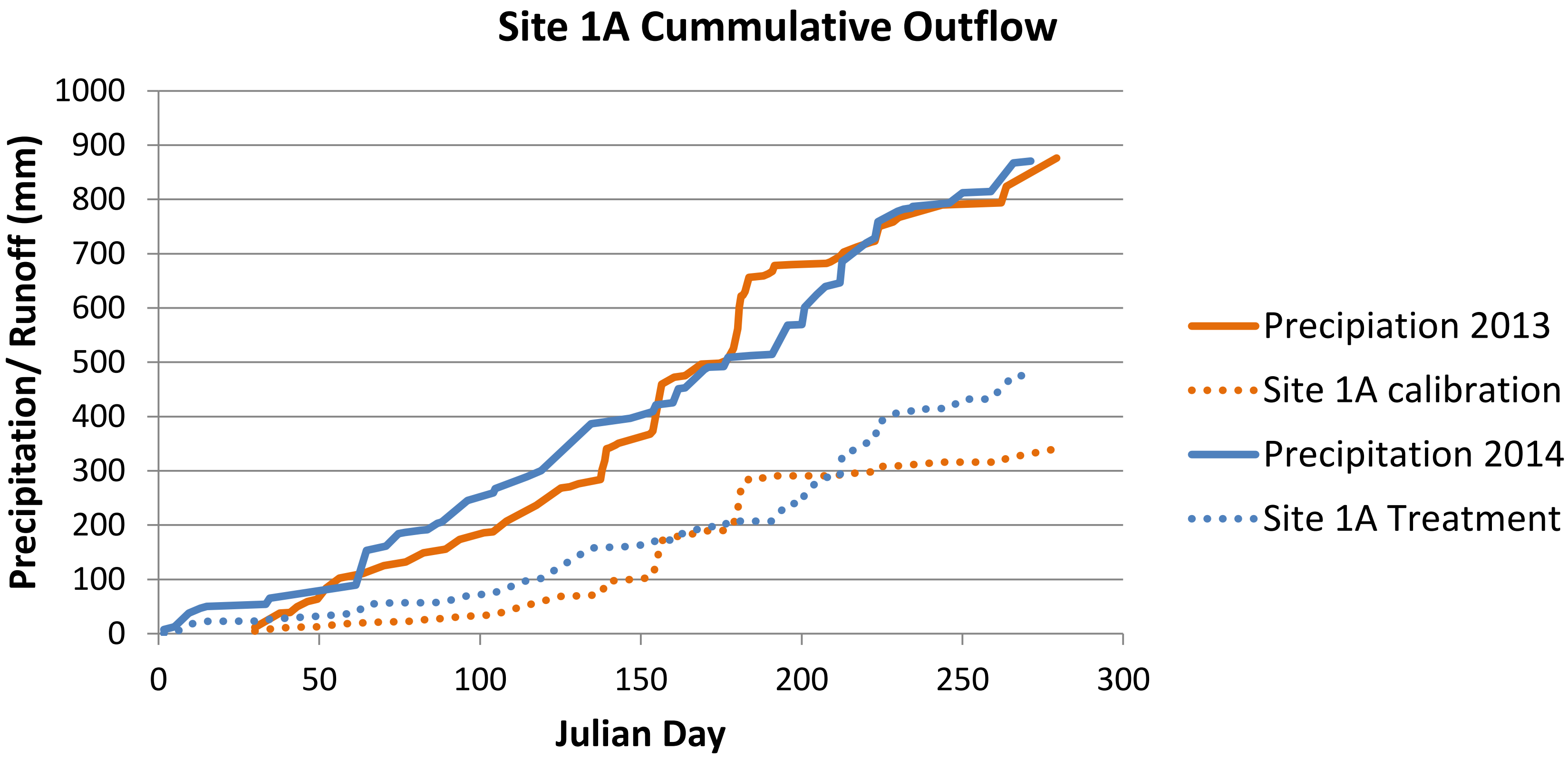
bold values indicate variation in 2013 and 2014 observed infiltration rates

<u>*Italicized and underlined*</u> sites indicate amendment treatment applied

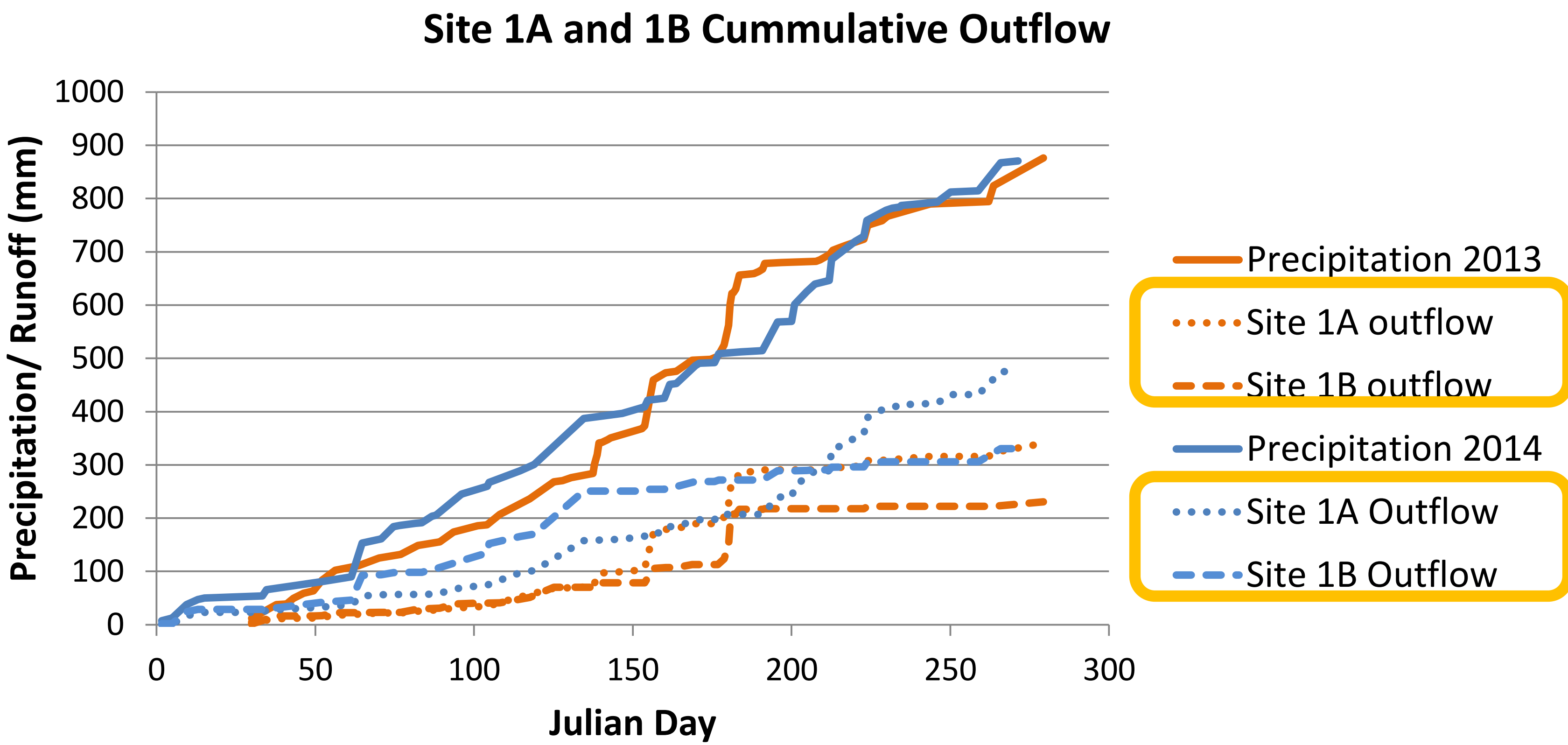
Data Analysis



Data Analysis



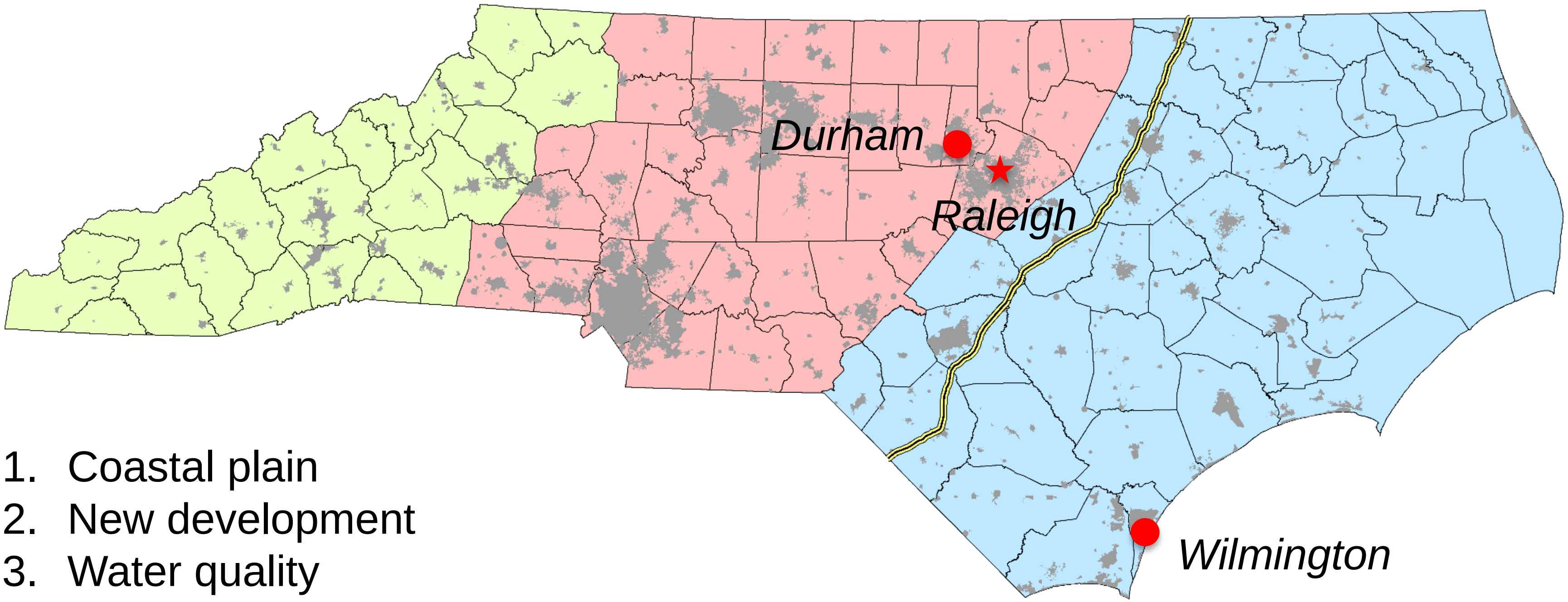
Data Analysis



Benefits of DSD

- Able to infiltrate 100% of small storms
- Enable smaller downstream treatment facilities
- Reduce number of CSO events
- Phase I and Phase II showed peak flow reduction
- Soil amendment appears to improve performance in some scenarios

This was a NC baseline…
Next steps:



1. Coastal plain
2. New development
3. Water quality

⚠WARNING
6712
ISCO
6712
ISCO

Acknowledgements:

- The City of Durham
- NC Clean Water Management Trust Fund
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Questions?

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