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Crop and Soil Sciences

Research Update
March 2017

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Crop and Soil Sciences
North Carolina State University

Optimizing Flocculation/Screening

- 22 soils from projects around the state collected, tested for flocculation by PAMs
- Comparisons between shake versus jar (paddle) testing made
- Optimal energy inputs determined
- Translation to field conditions

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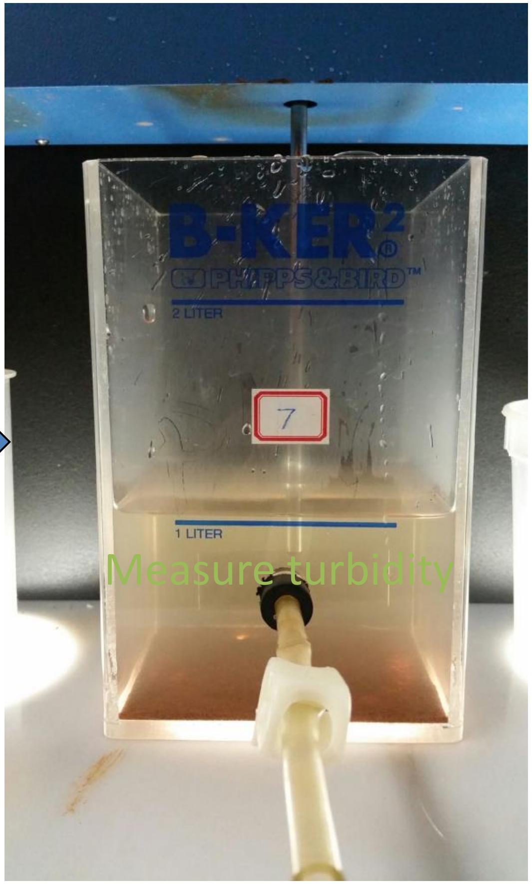
Traditional Jar Testing

Mix for set time



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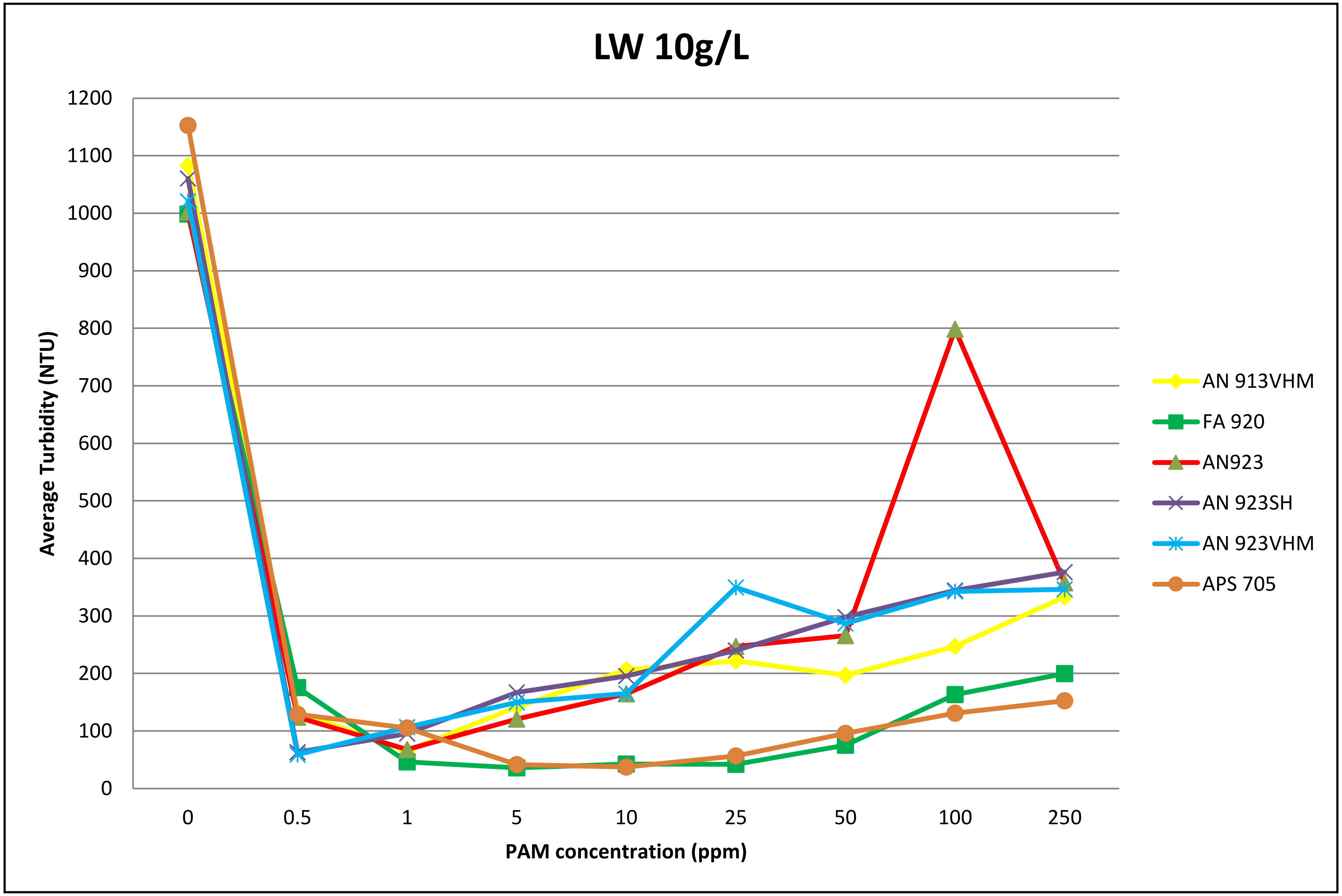
Example Screening Test

Hand Shake Method



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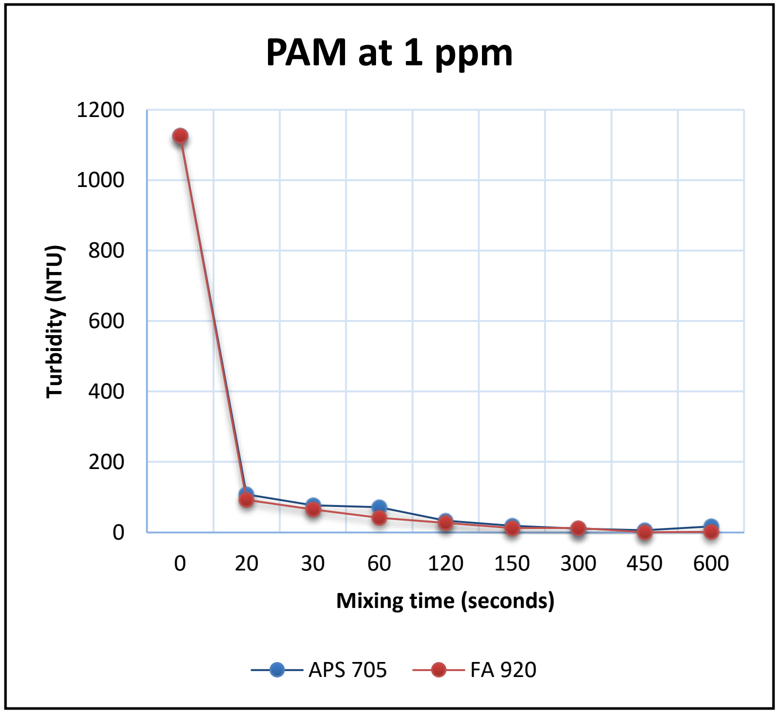
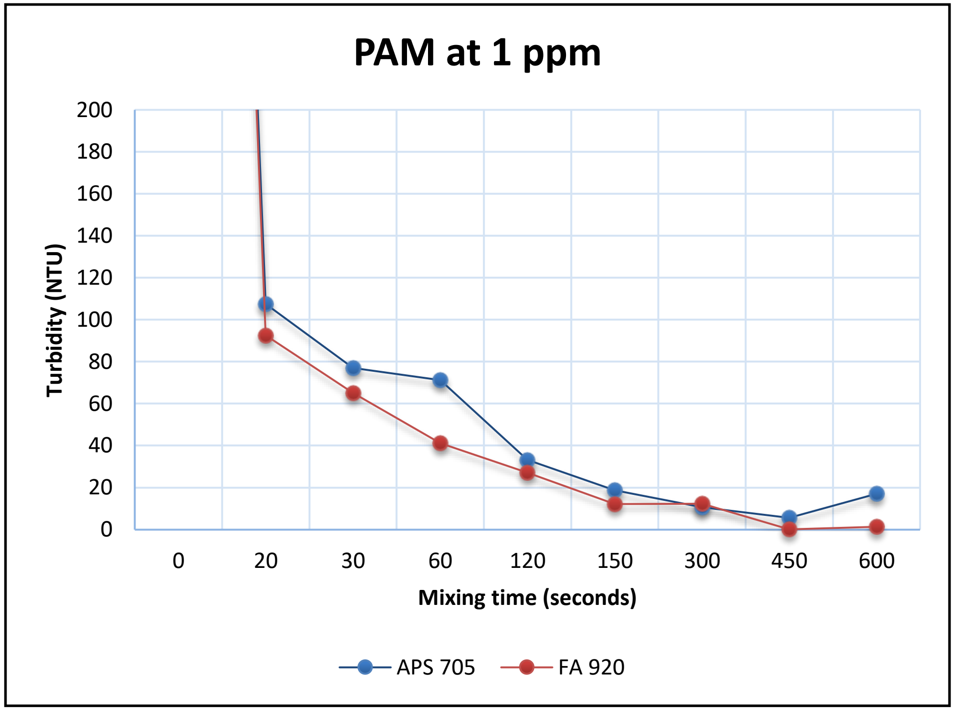
Optimizing Mixing Time

Paddle Mixer (Jar Test)





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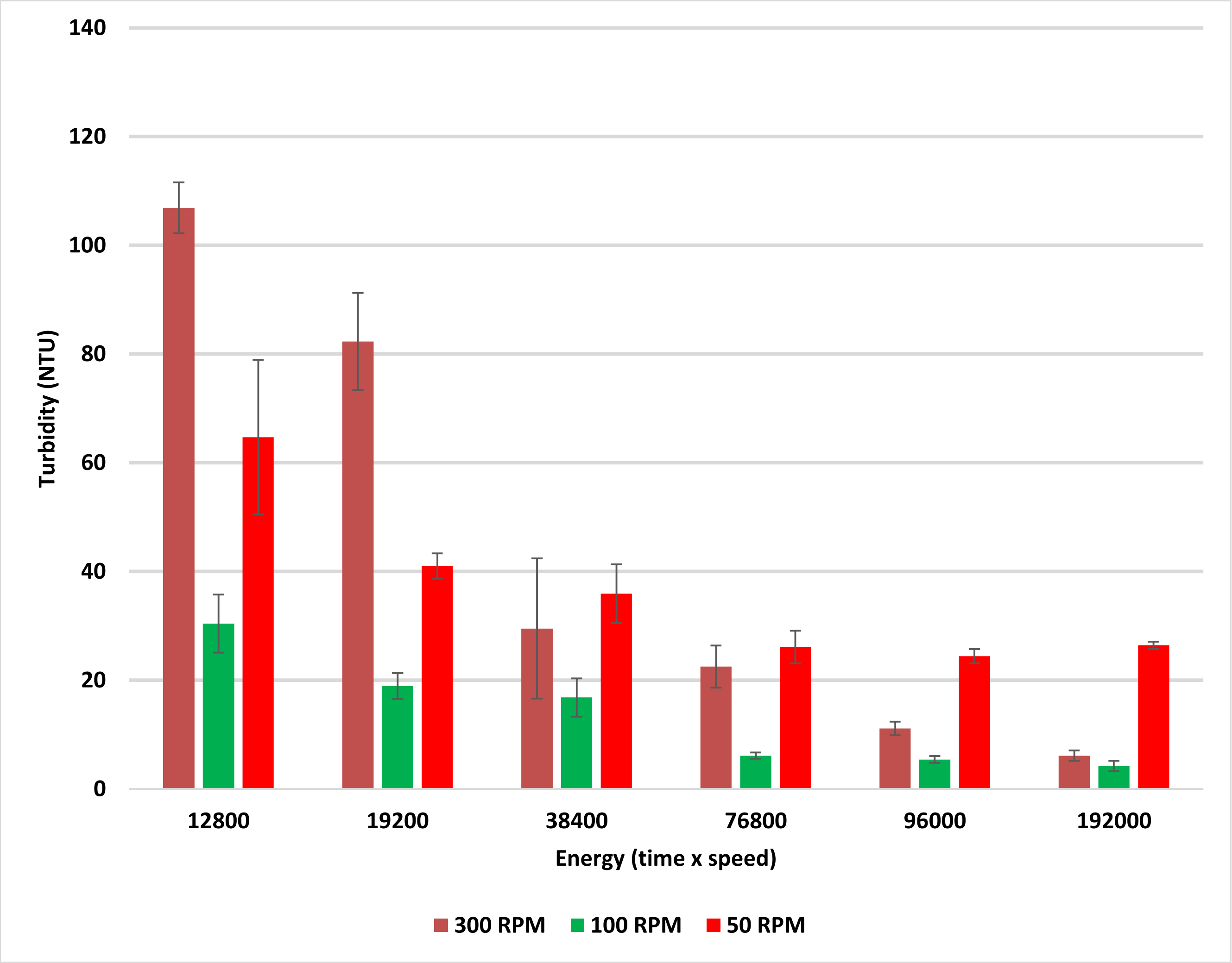
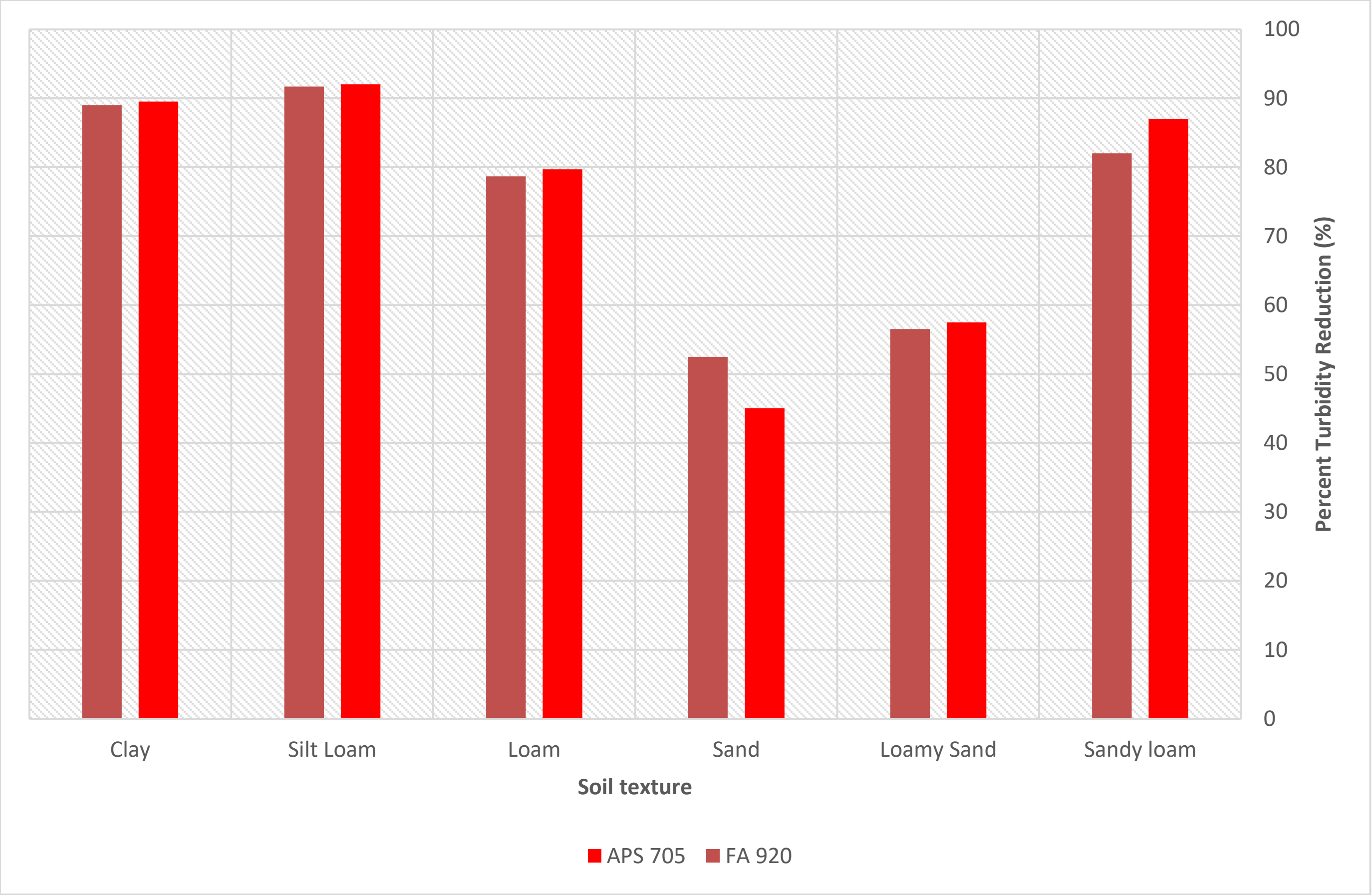
Mixing Time/Energy Effects



Soil Properties Effect?



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Testing Mixing in Simulated Ditches

- 1% vs 3% slope
- Without/with 1 or 3 check dams
- Measured turbidity reduction compared to lab conditions (optimal)

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Soils and Check Dams

Soils Tested

Soil County	% Sand	% Silt	% Clay	Texture
Wake	55	26.2	18.8	Sandy Loam
Lee	34.9	44.4	20.7	Loam
Burke	29.9	51.5	18.6	Silt Loam
Rowan	28.4	31.4	40.2	Clay

Check dams in “ditch”

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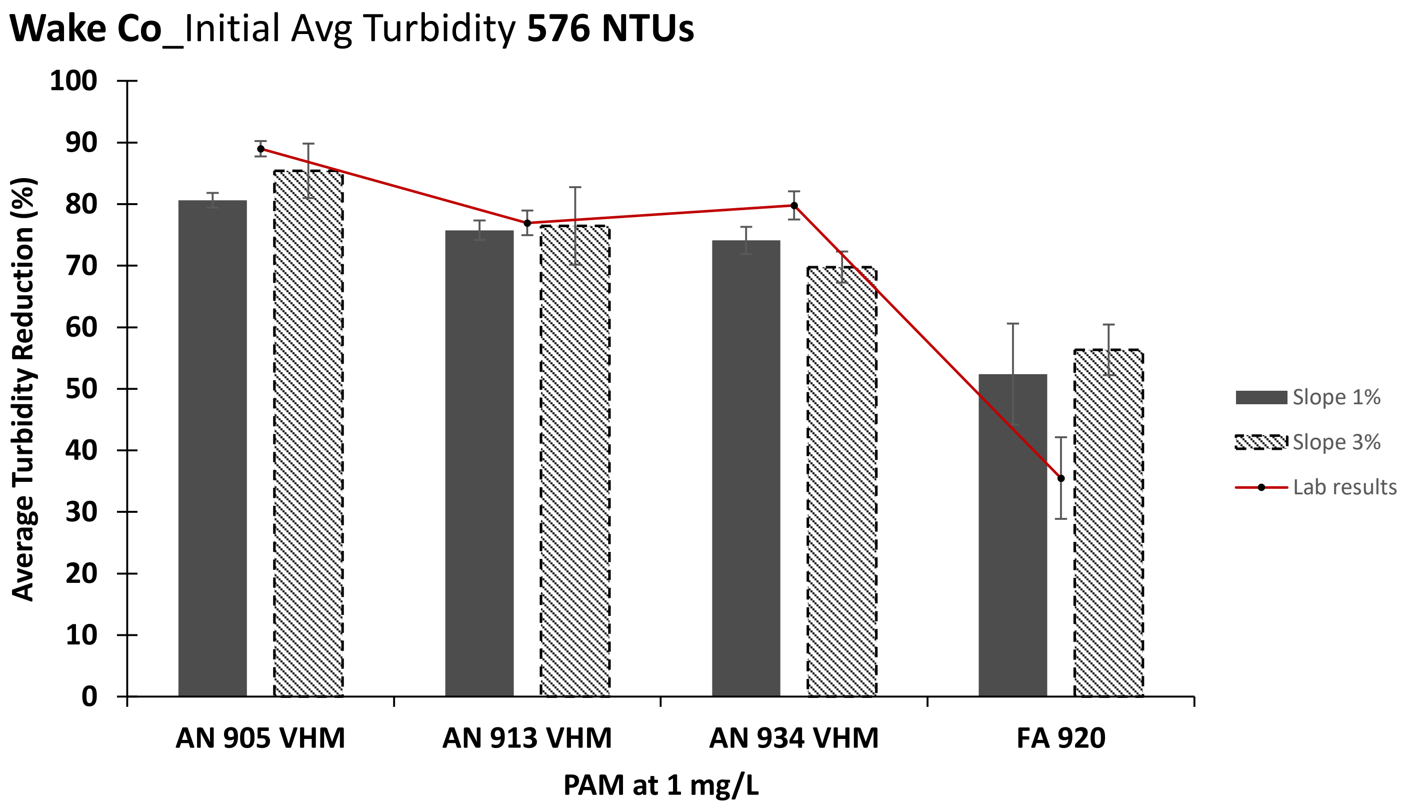
Wake Soil: No Check Dams



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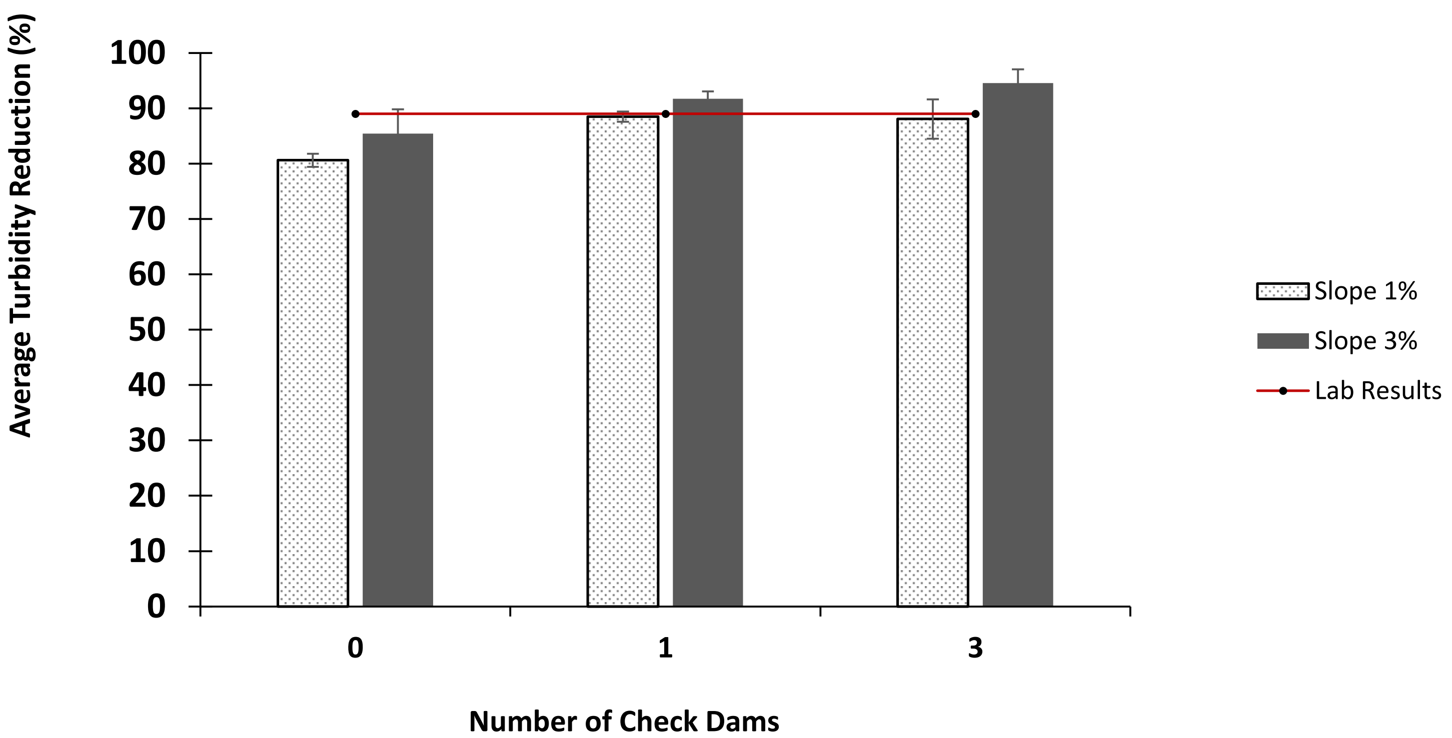
Wake Soil: Check Dams

Wake Co._Initial Avg Turbidity **576 NTUs**

PAM: AN 905 VHM



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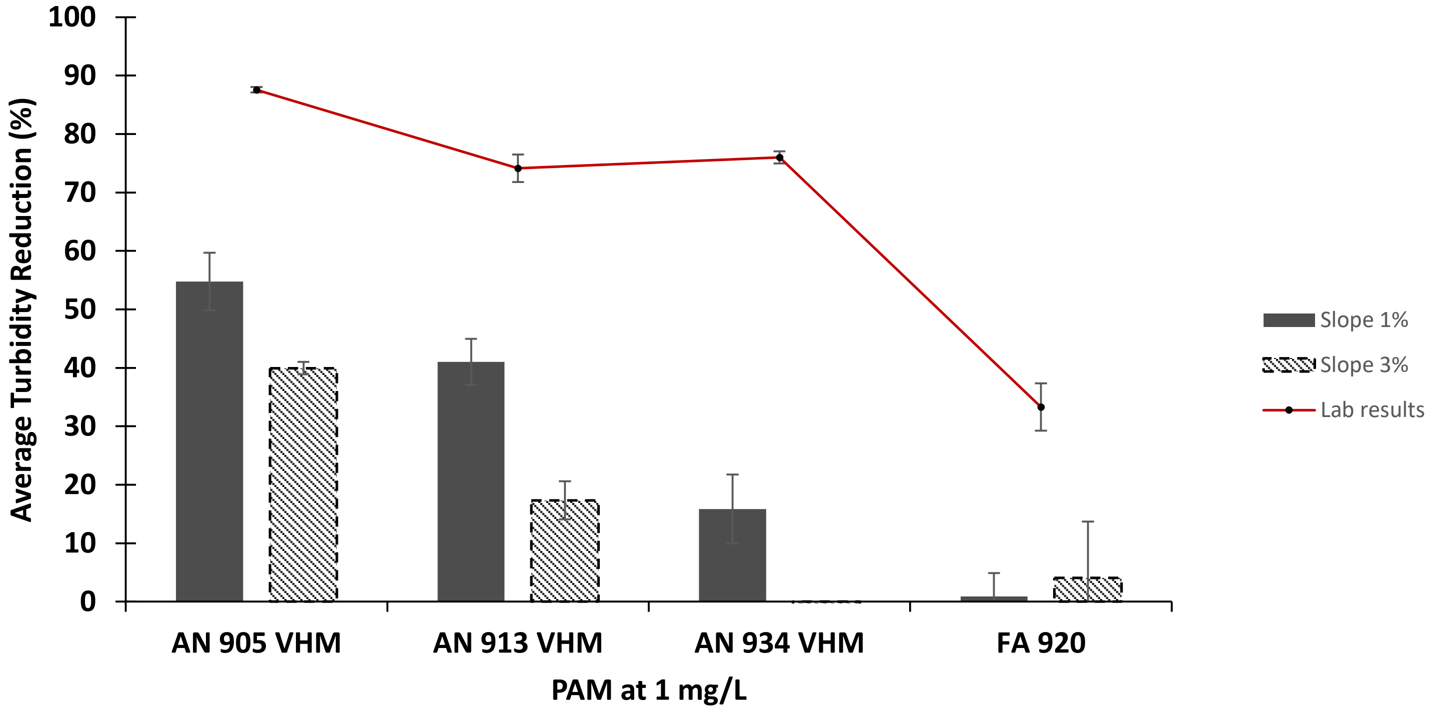
Rowan Soil: No Check Dams

Rowan Co_Initial Avg Turbidity **913 NTUs**



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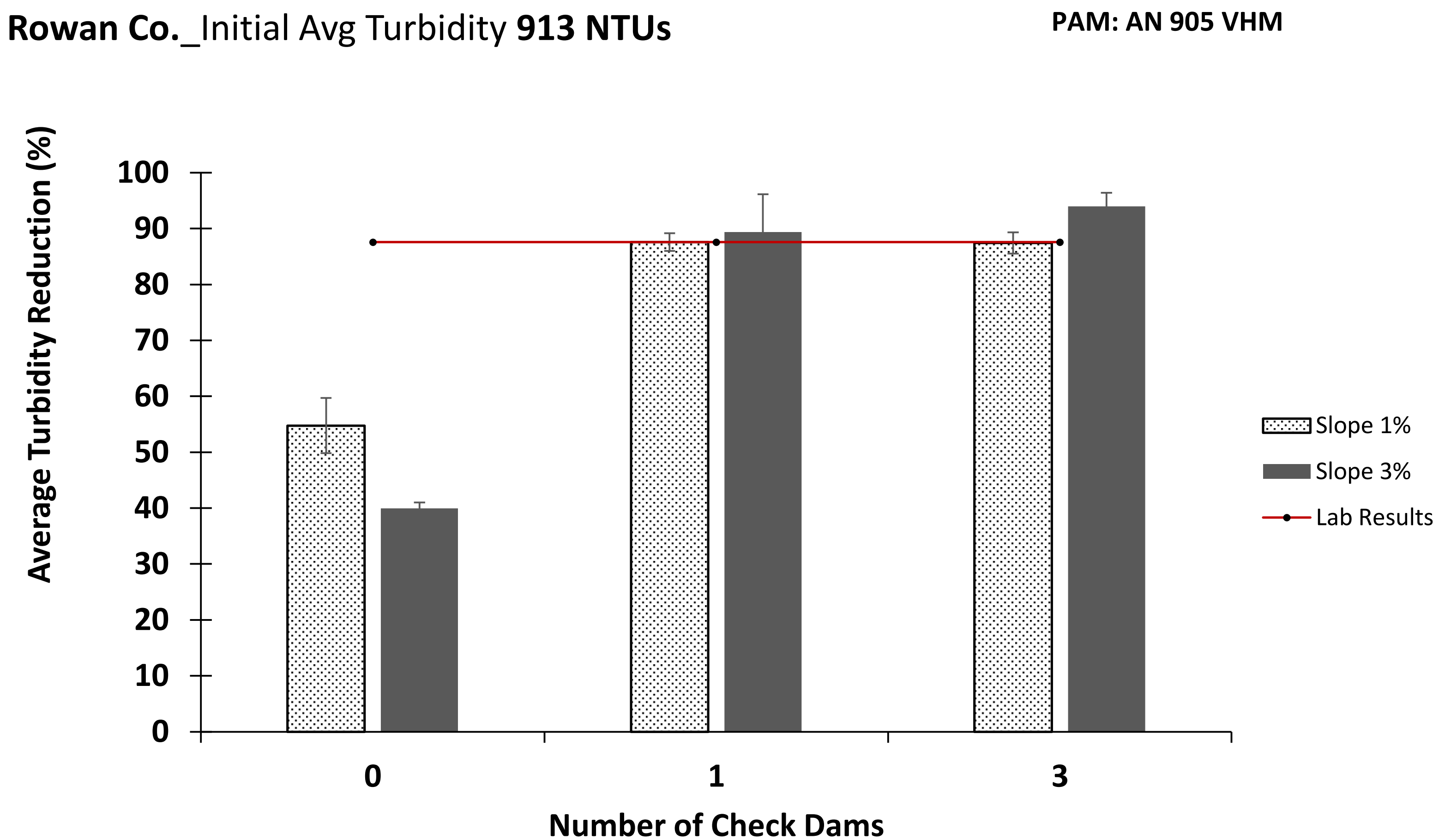
Rowan Soil: Check Dams



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Check Dam Effect

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Spray-On Ditch Liner?

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What About Ditches?

- Previous studies suggested that a large portion of the sediment reaching basins originated inside the ditch, not on the slopes.
- These are often unlined until final grade.

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Methods

- Determine erosion in ditches left bare or lined with jute, jute + PAM, excelsior, or Posishell (spray-on concrete product)
- Conduct tests under controlled conditions (flume at SECREF) and at active project sites
- Compare viability of spray-on lining vs. rolled products

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Cost Estimate Comparison

Product	Cost (not installed), sq ft	Install Time (per 100’)
Jute	0.10	15 min
Jute + PAM (50 lb/ac)	0.101	16 min
Excelsior	0.08	15 min
Posishell	0.12	2 min

- Staples included in rolled products
- Mixing time for Posishell might be 10 min
- Full tank (400 gal) might cover 300’

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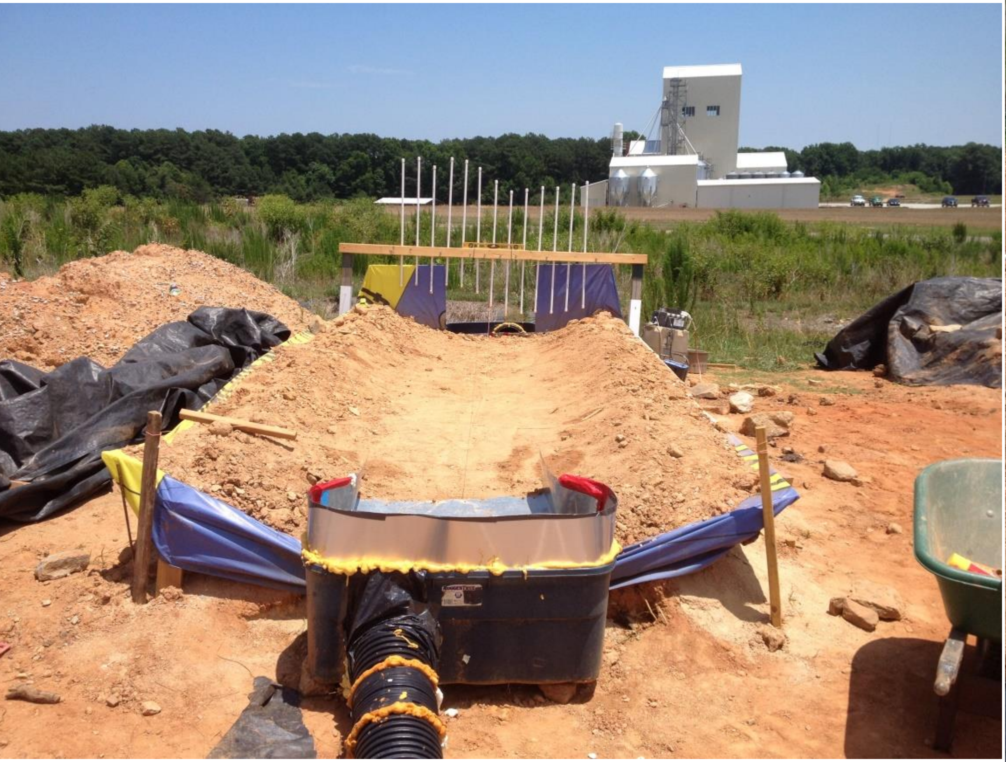
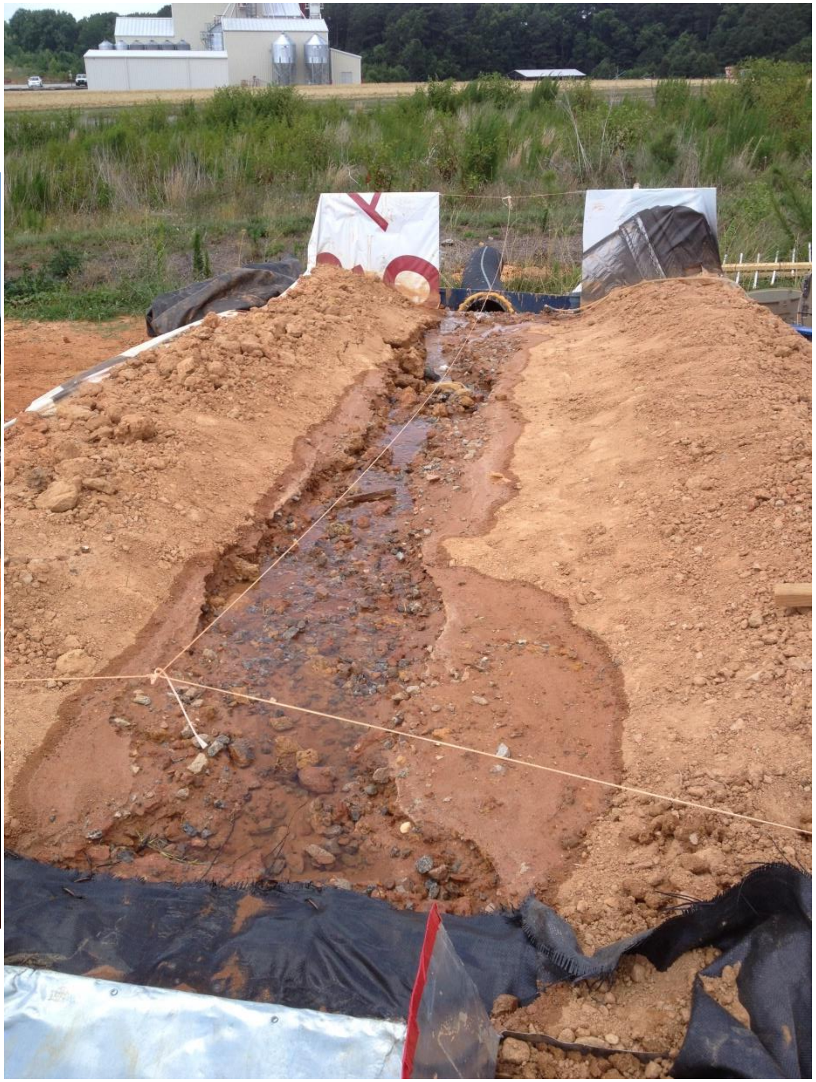
Flume Testing





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Example Test

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Erosion Under Blanket

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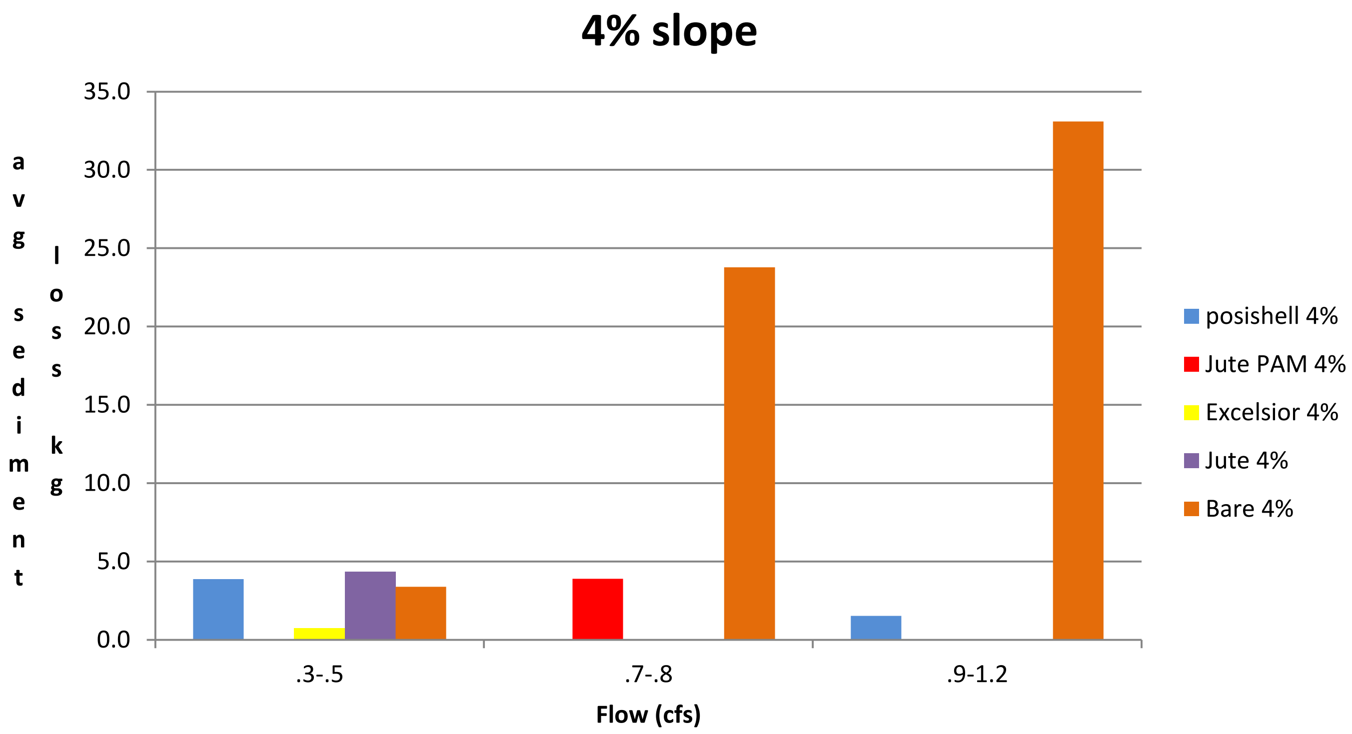
Flume Test Erosion



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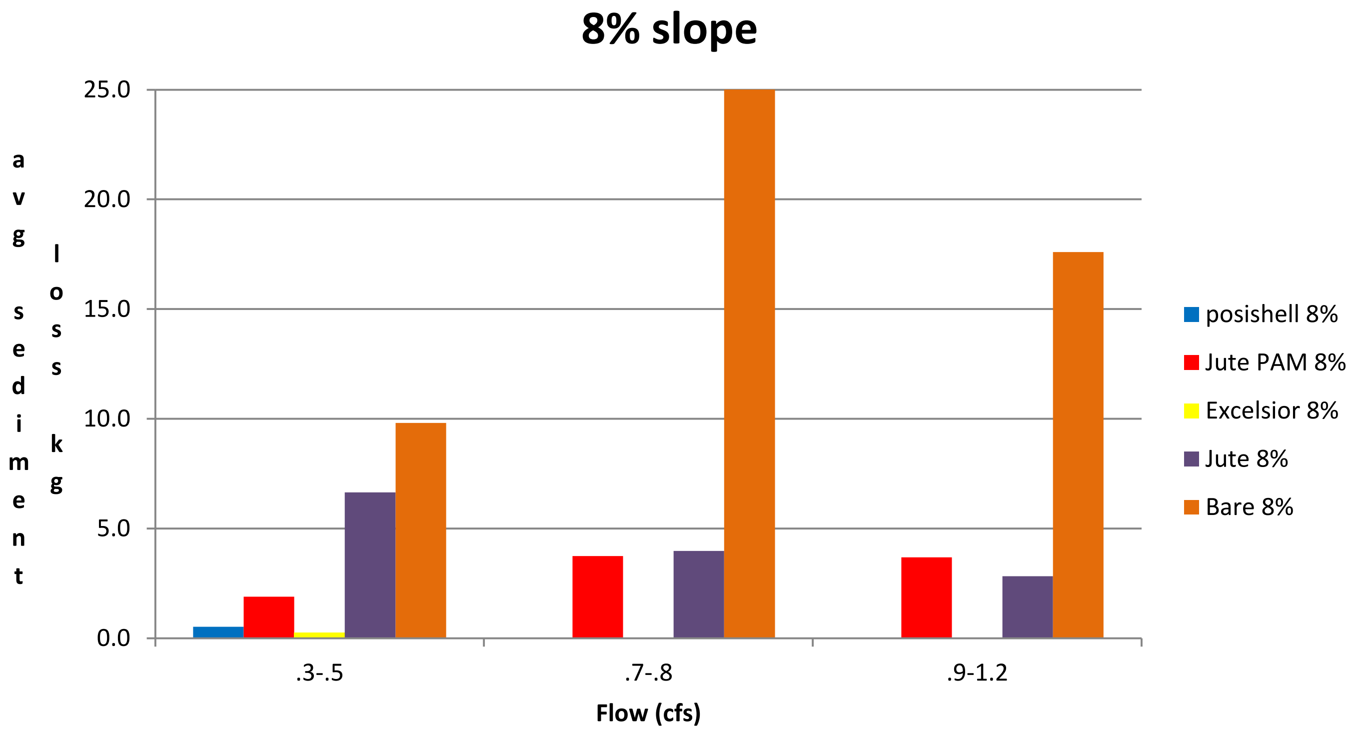
Flume Test Erosion



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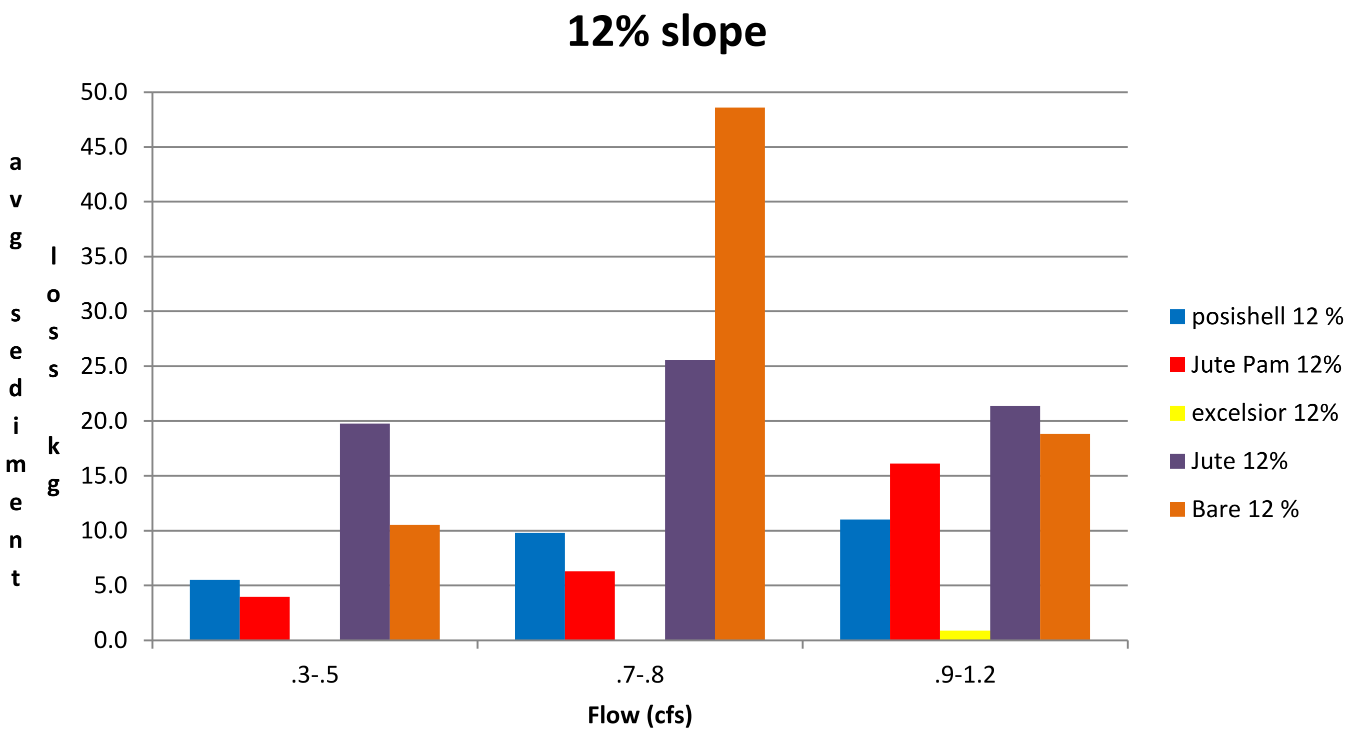
Flume Test Erosion



Preliminary Conclusions

- Posishell and excelsior seem to work well for a time, but after several months may have some erosion.
- Posishell is sensitive to mixing conditions and possibly slight variations in composition.
- Testing on active sites suggests installation is critical for all products.

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Second GSO Site

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Meeting Water Quality Goals

- Completed mussel testing, two manuscripts in review. Polyacrylamide is not toxic to mussels.
- Rainfall simulator completed.
- Still collecting data on turbidity sensors, surface outlets, and flocculant dispensers.

Flocculant Dosers installed: GSO

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Durham Float Valve Doser

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Preliminary Doser Conclusions

- Evidence that they are providing some benefits, but scale is an issue.
- Difficult to demonstrate on active site due to highly variable conditions (multiple inlets).
- Plans to re-deploy on more sites are underway.

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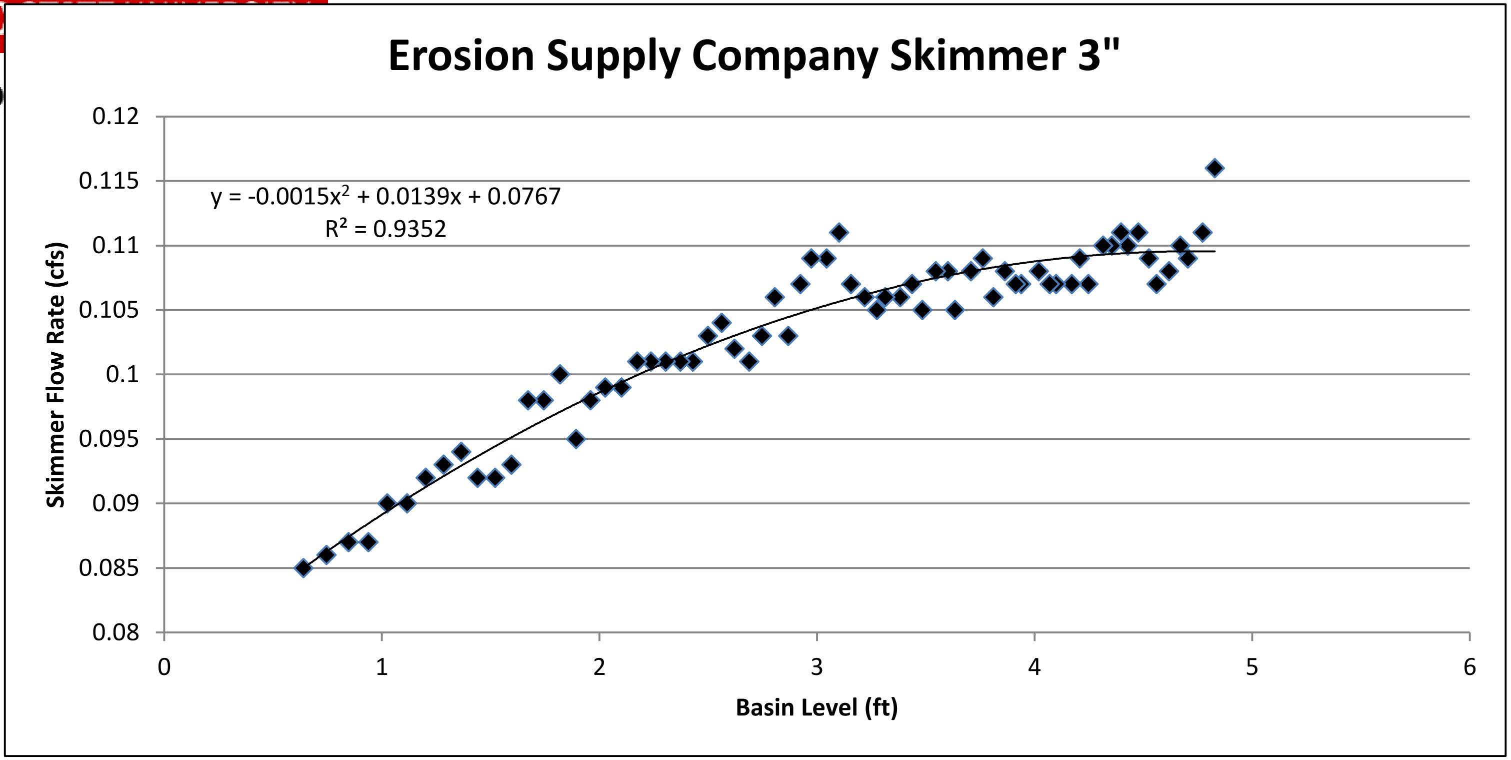
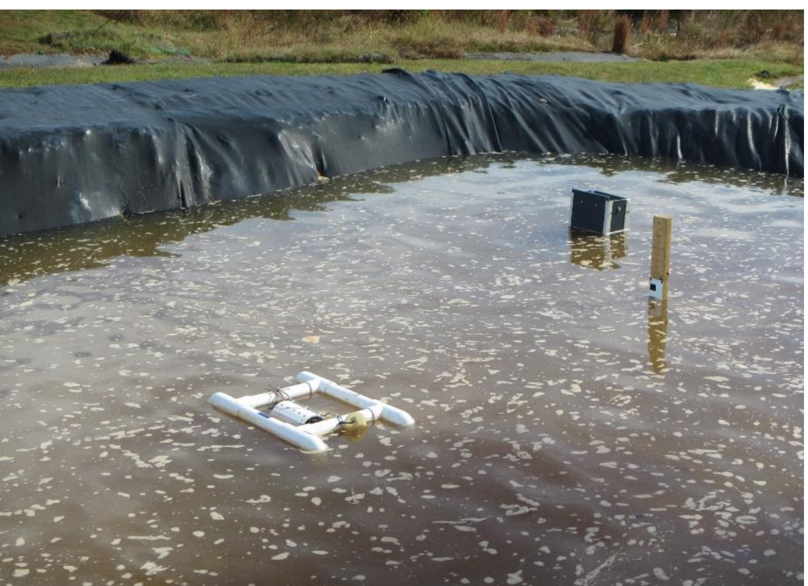
Skimmer Testing

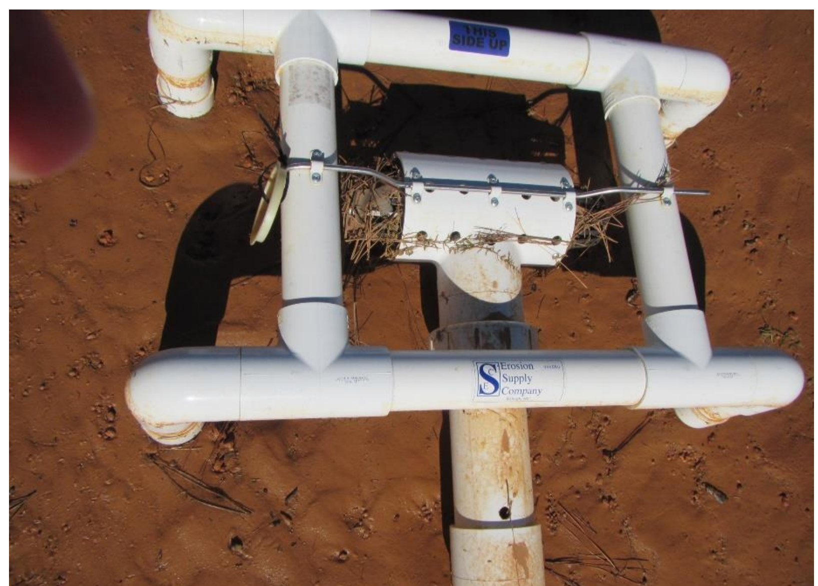
NC

Cro



Erosion Supply Company Skimmer 3"
$y = -0.0015x^2 + 0.0139x + 0.0767$
$R^2 = 0.9352$
Skimmer Flow Rate (cfs)
Basin Level (ft)
0.12
0.115
0.11
0.105
0.1
0.095
0.09
0.085
0.08
0
1
2
3
4
5
6





SIDE UP
Erosion
Supply
Company

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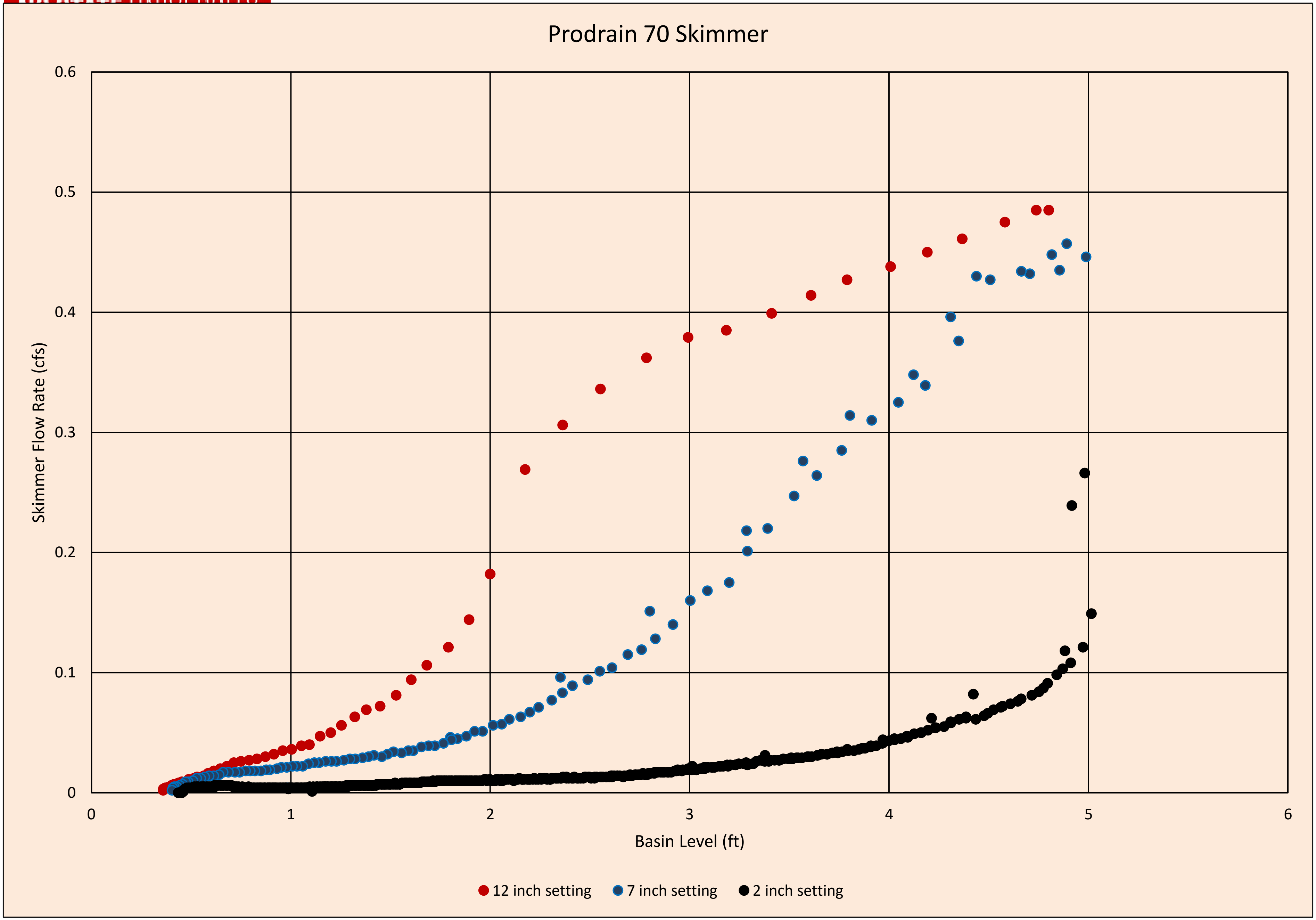
Prodrain 700



Prodrain 70 Skimmer
Skimmer Flow Rate (cfs)
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
5
6
Basin Level (ft)
12 inch setting
7 inch setting
2 inch setting

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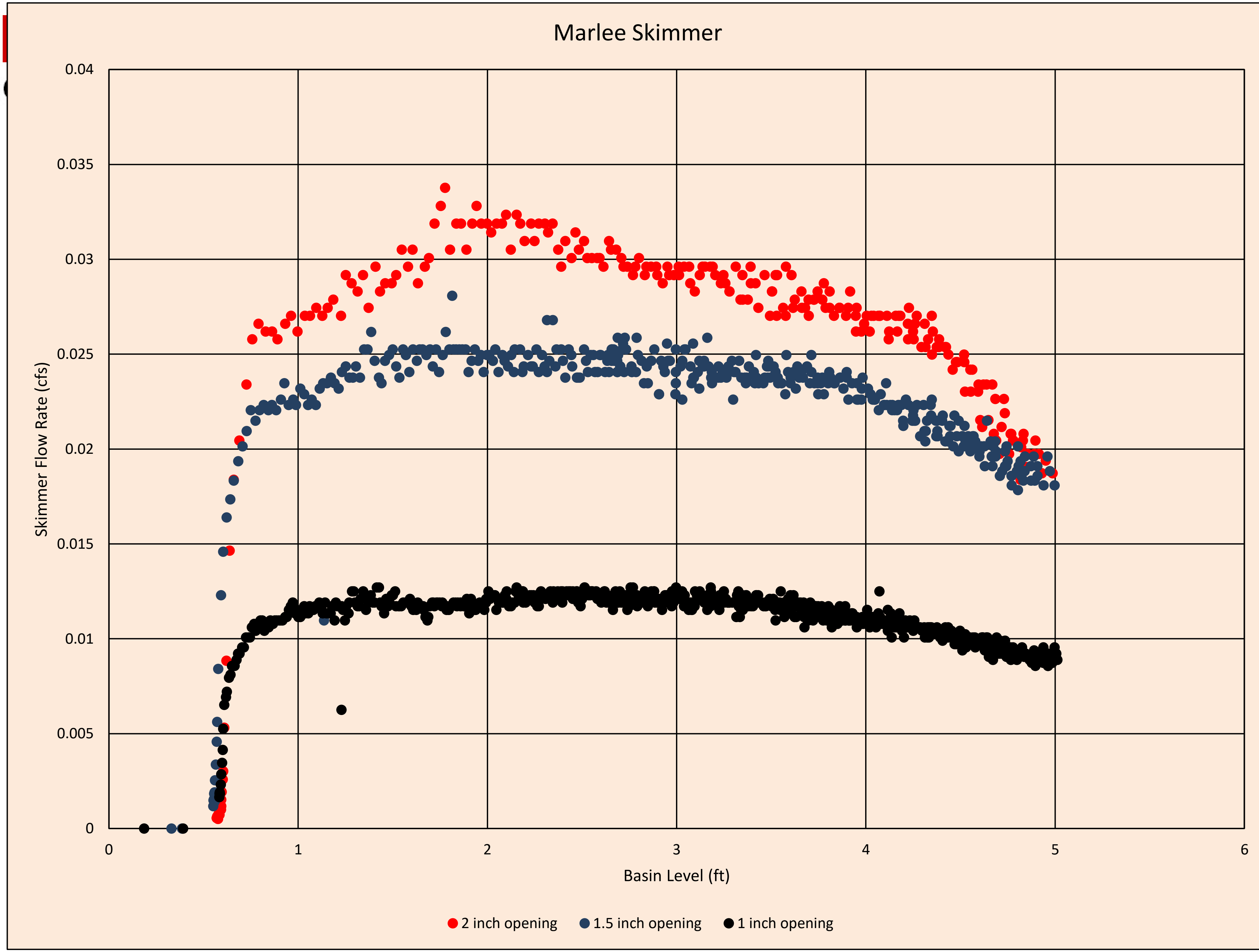
Marlee Skimmer



Marlee Skimmer
Skimmer Flow Rate (cfs)
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0
1
2
3
4
5
6
Basin Level (ft)
2 inch opening
1.5 inch opening
1 inch opening

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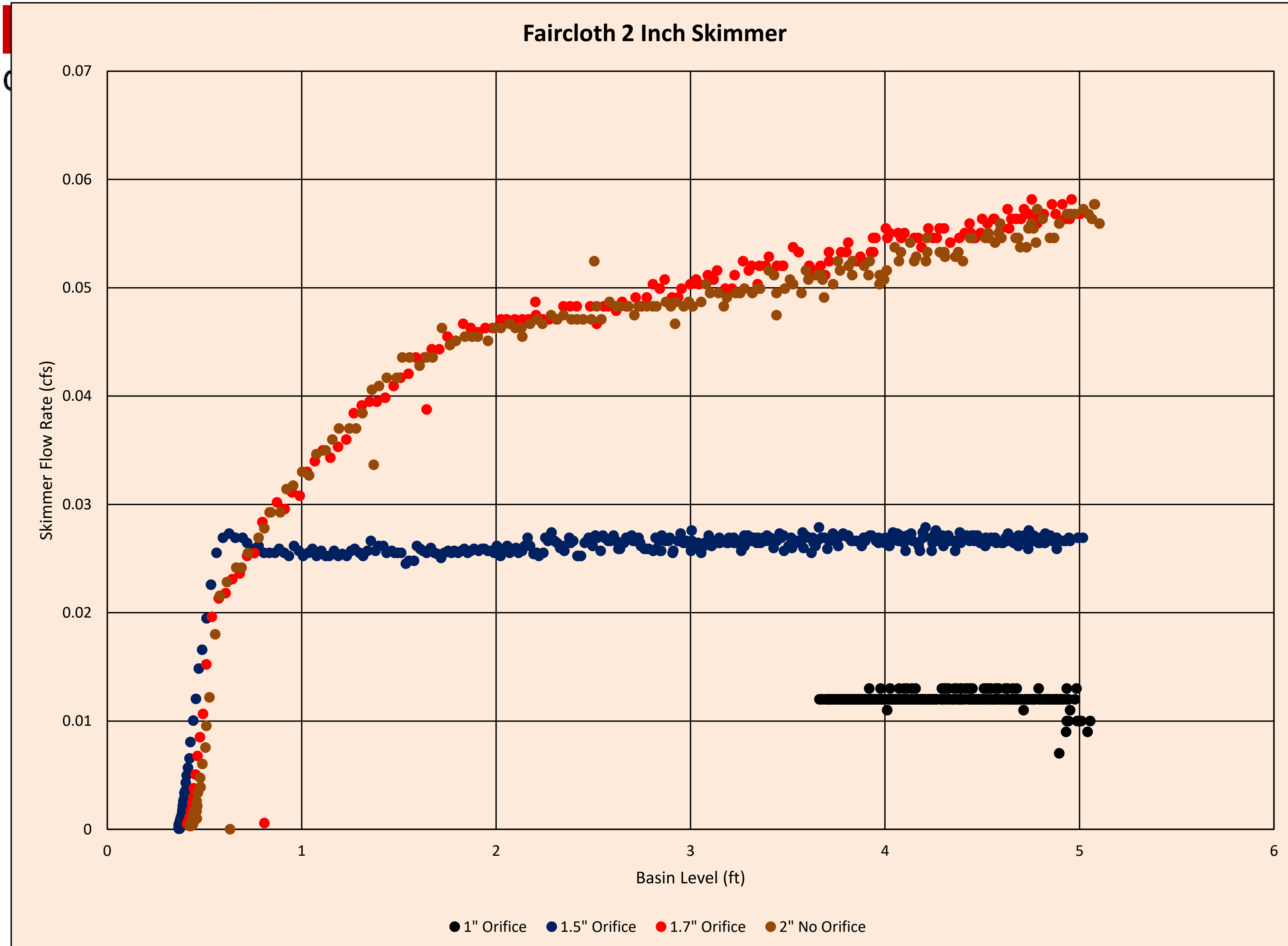
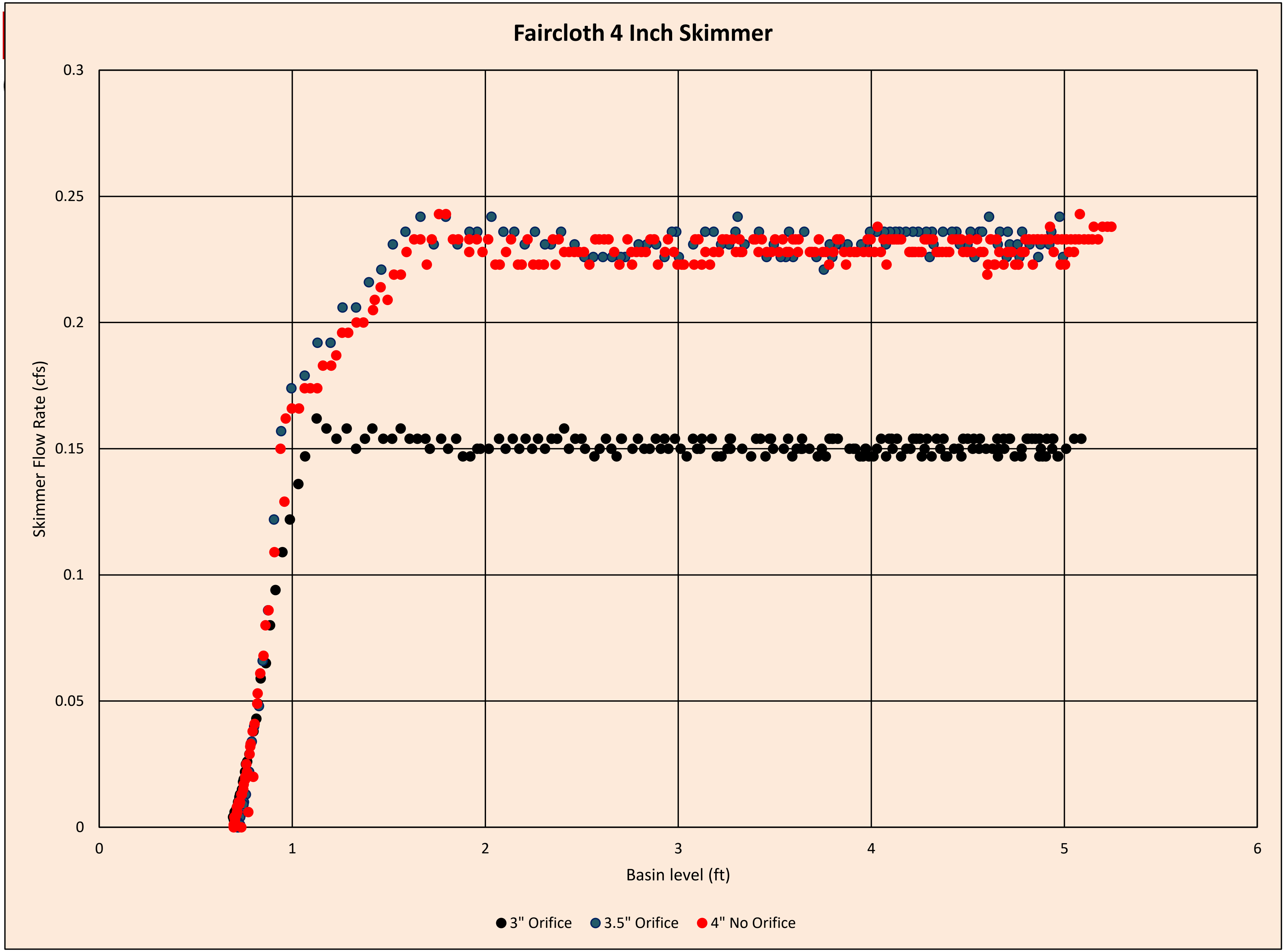
Faircloth Skimmer


Faircloth 2 Inch Skimmer
Skimmer Flow Rate (cfs)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
1
2
3
4
5
6
Basin Level (ft)
1" Orifice
1.5" Orifice
1.7" Orifice
2" No Orifice


Faircloth 4 Inch Skimmer
Skimmer Flow Rate (cfs)
Basin level (ft)
0
0.05
0.1
0.15
0.2
0.25
0.3
0
1
2
3
4
5
6
3" Orifice
3.5" Orifice
4" No Orifice

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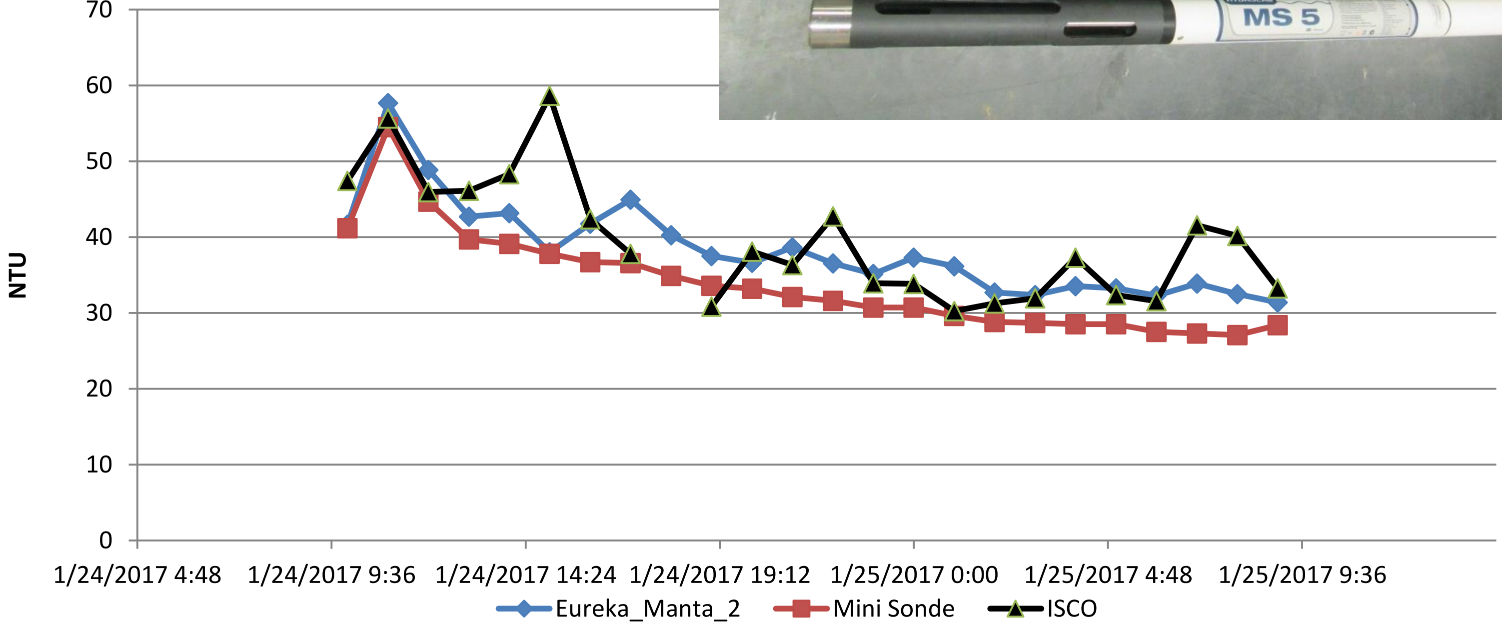
Turbidity Measurement: Sonde vs. Sampler over 24 hours



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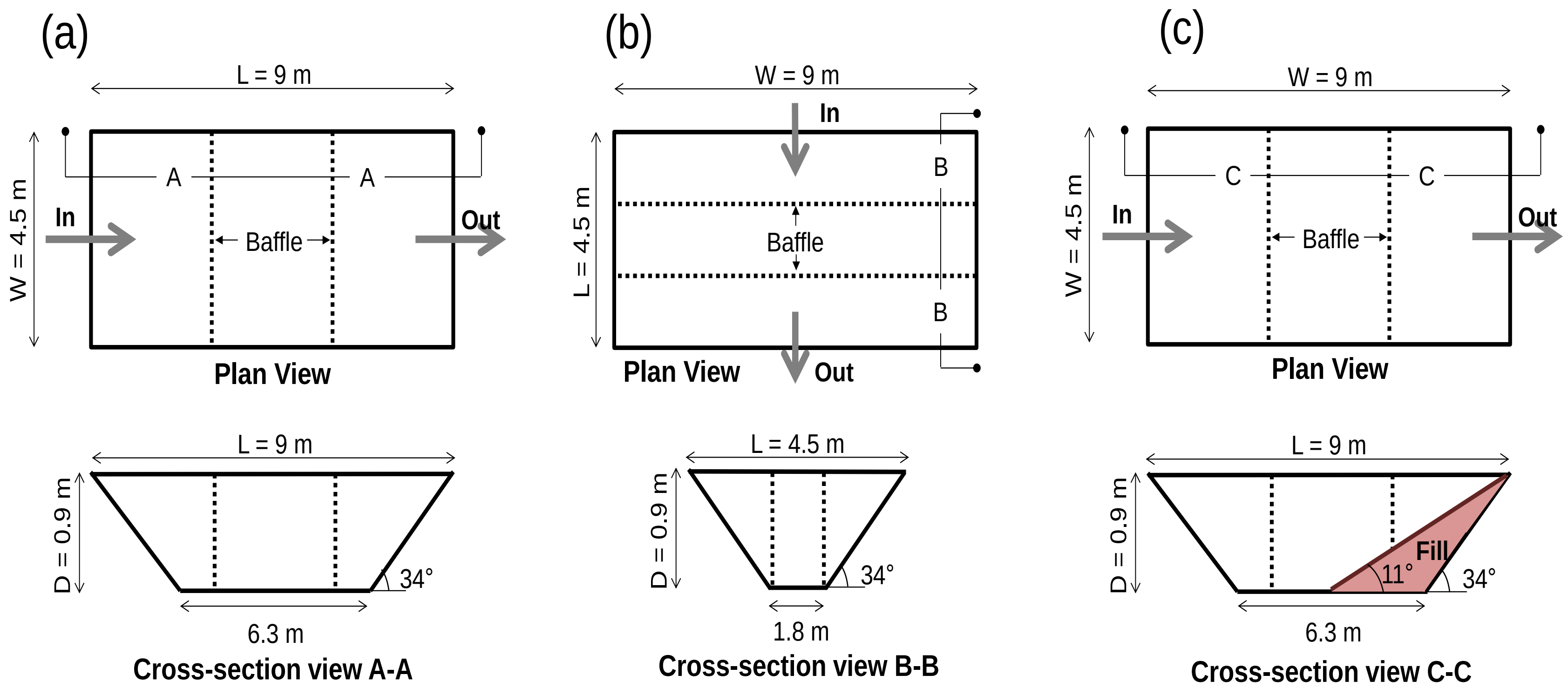
Basin Designs



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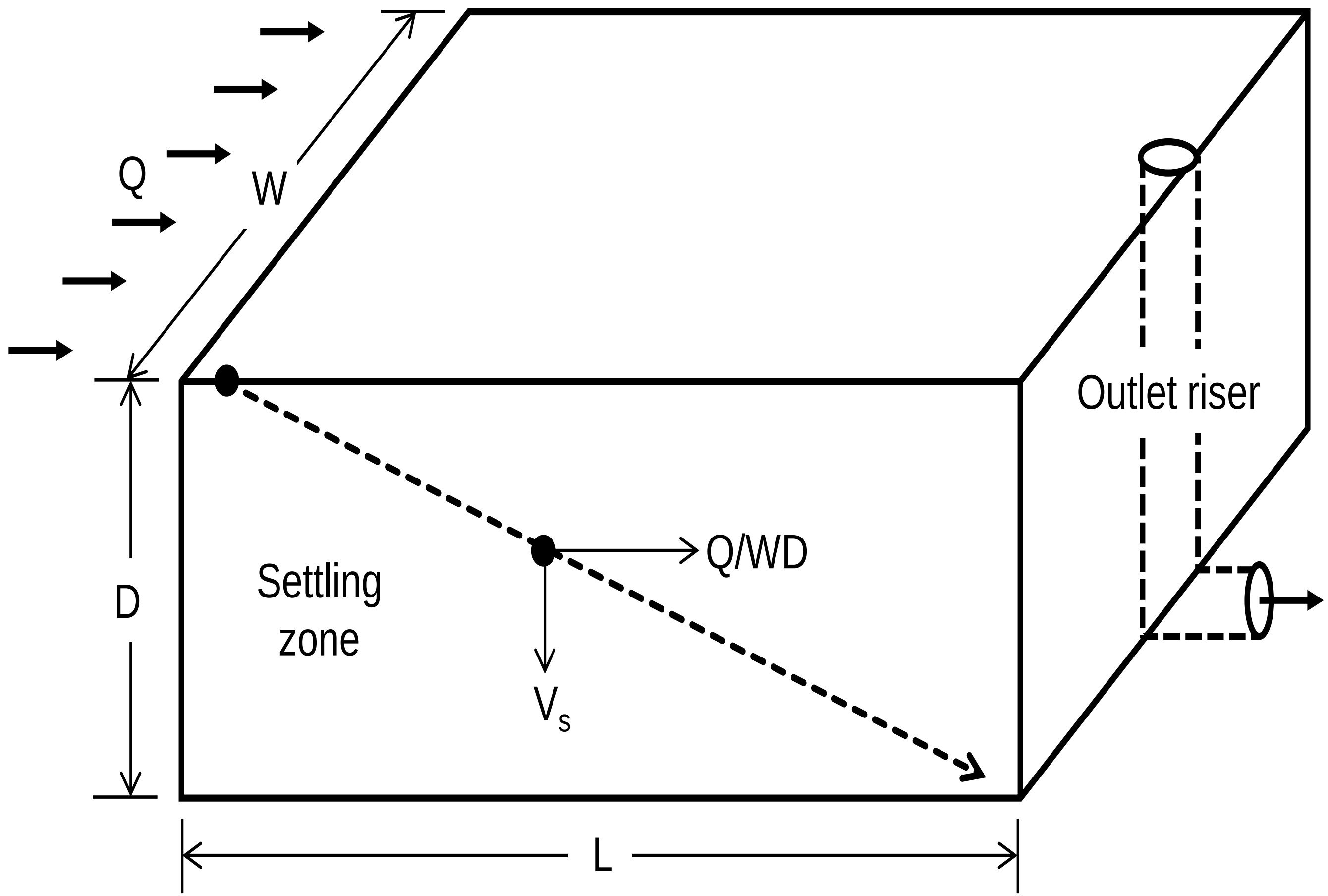
Idealized Settling



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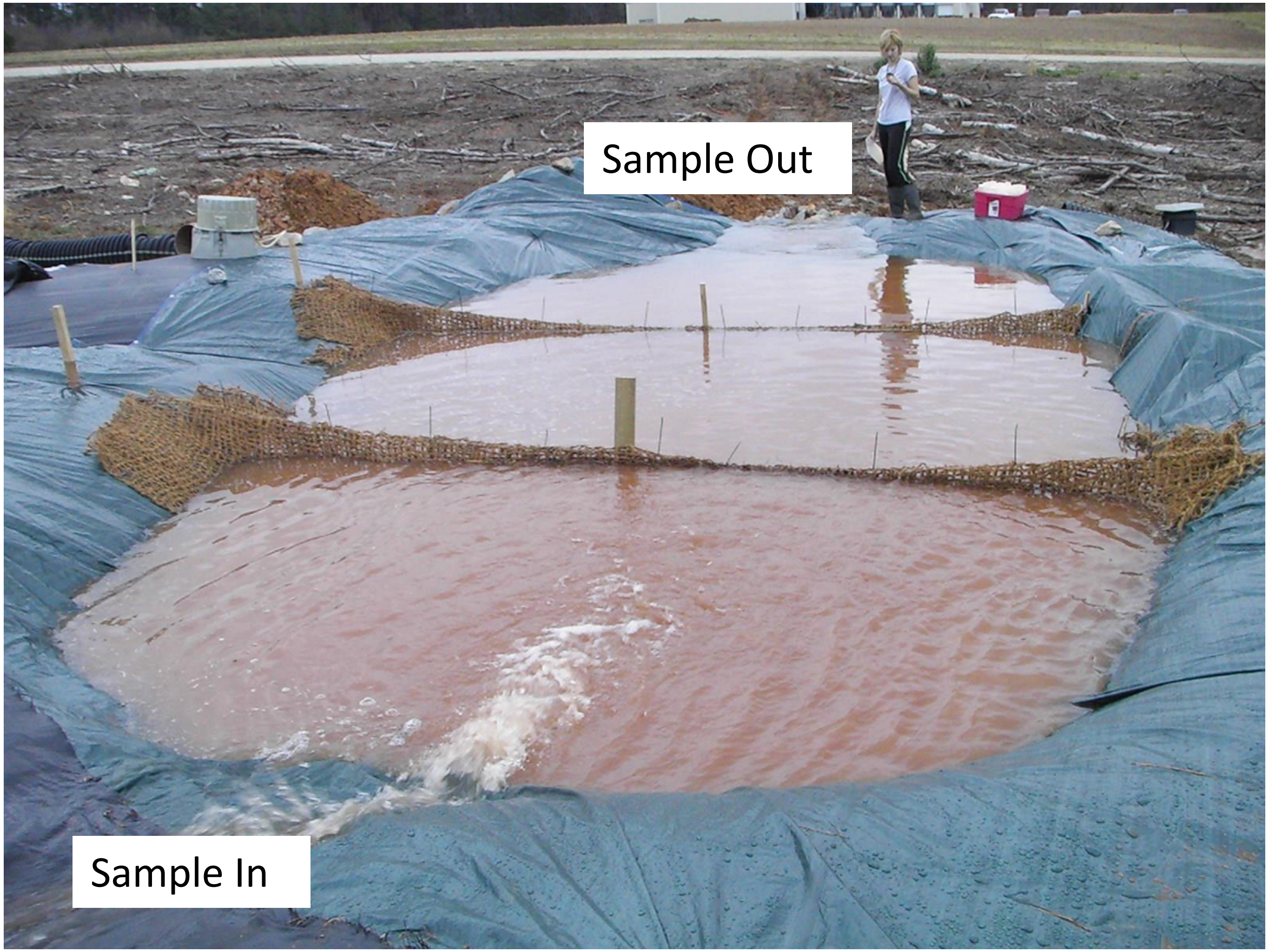
Normal 2:1 Basin



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2:1 With “Ramp”

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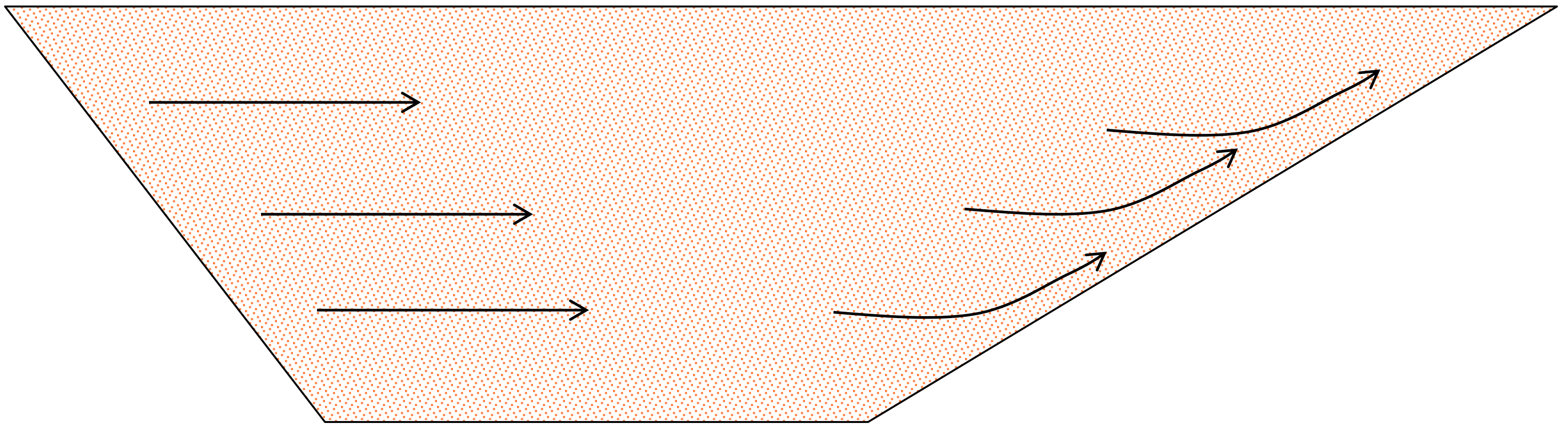
Sloped Outlet Concept



“Sideways” 1:2 Basin

Basin Configuration Effects
No Flocculation

		Turbidity (NTU)			TSS (mg L^{-1})	
PAM	Basin	Ditch exit	Basin exit		Ditch exit	Basin exit
None	Horizontal	268 ± 25 a	197 ± 27 a		995 ± 79 a	125 ± 3 b
None	Ramp	262 ± 24 a	162 ± 19 a		1,121 ± 122 a	195 ± 14 a
None	Standard	271 ± 21 a	234 ± 22 a		1,258 ± 107 a	239 ± 30 a

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Basin Configuration Effects With Flocculation

		Turbidity (NTU)	
PAM	Basin	Ditch exit	Basin exit
None	Horizontal	268 ± 25 a	197 ± 27 a
None	Ramp	262 ± 24 a	162 ± 19 a
None	Standard	271 ± 21 a	234 ± 22 a
PAM	Horizontal	96 ± 20 b	30 ± 5 b
PAM	Ramp	98 ± 14 b	23 ± 4 b
PAM	Standard	78 ± 18 b	34 ± 5 b

Basin Size: Flocculation Effect

Parameter	Unflocculated sediment	Flocculated sediment
Settling velocity (m s^{-1})	0.0017	0.004
Particle diameter (D_{56}, µm)[a]	46	74
Surface area requirement (m^2 per m^3 s^{-1})	700	300
Required basin surface area (m^2)	40	17

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Turning Your Soil Green

Richard A. McLaughlin, Fatemeh Mohammadshirazi, Joshua L. Heitman, and Virginia K. Brown

Department of Soil Science

North Carolina State University

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Green Car?

Green Pond?

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Impacts of Construction Activities on Soil

Extensive Disturbance, Traffic, Compaction

Subsoil Now At Surface

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After Construction?

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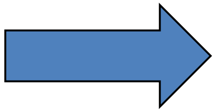
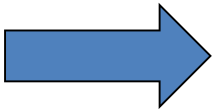
Soil Compaction: Poor vegetation establishment, high runoff rate





Actual Measurements

Matt Haynes, MS Thesis

Infiltration ≈ 0 cm h^{-1}

Bulk density ≈ 1.5 g cm^{-3}
(Clayey texture)

What are the options for fixing the compaction problems?

- Hope it fixes itself
- Add topsoil back
- Scarify
- Use a turf aerator ("plugger")
- Spread gypsum or other product
- Tillage (disk, rotary, chisel, ripper, etc.)
- Tillage - spader

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Tillage

- Many types of implements – good review (agricultural applictions) @ http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs141p2_036234.pdf
- In agricultural applications, where most research has occurred, tillage alone may improve infiltration for only one or a few seasons.
- Repeated tillage usually creates a compacted zone just below the depth the implement reaches.

Various Cultivation Equipment

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Tillage - Spader

- A spader uses a unique mechanism for tilling the soil which may not create a tillage pan

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Soil Conditions Critical

- Moisture: lubricates soil particles
  - Too much = damage to soil
  - Too little = poor penetration
- This all depends on soil texture!
- Problem: limited window for operation

Tillage: An Old Option

- Effectiveness
- Longevity
- Amendments
- Equipment
- Plant Selection

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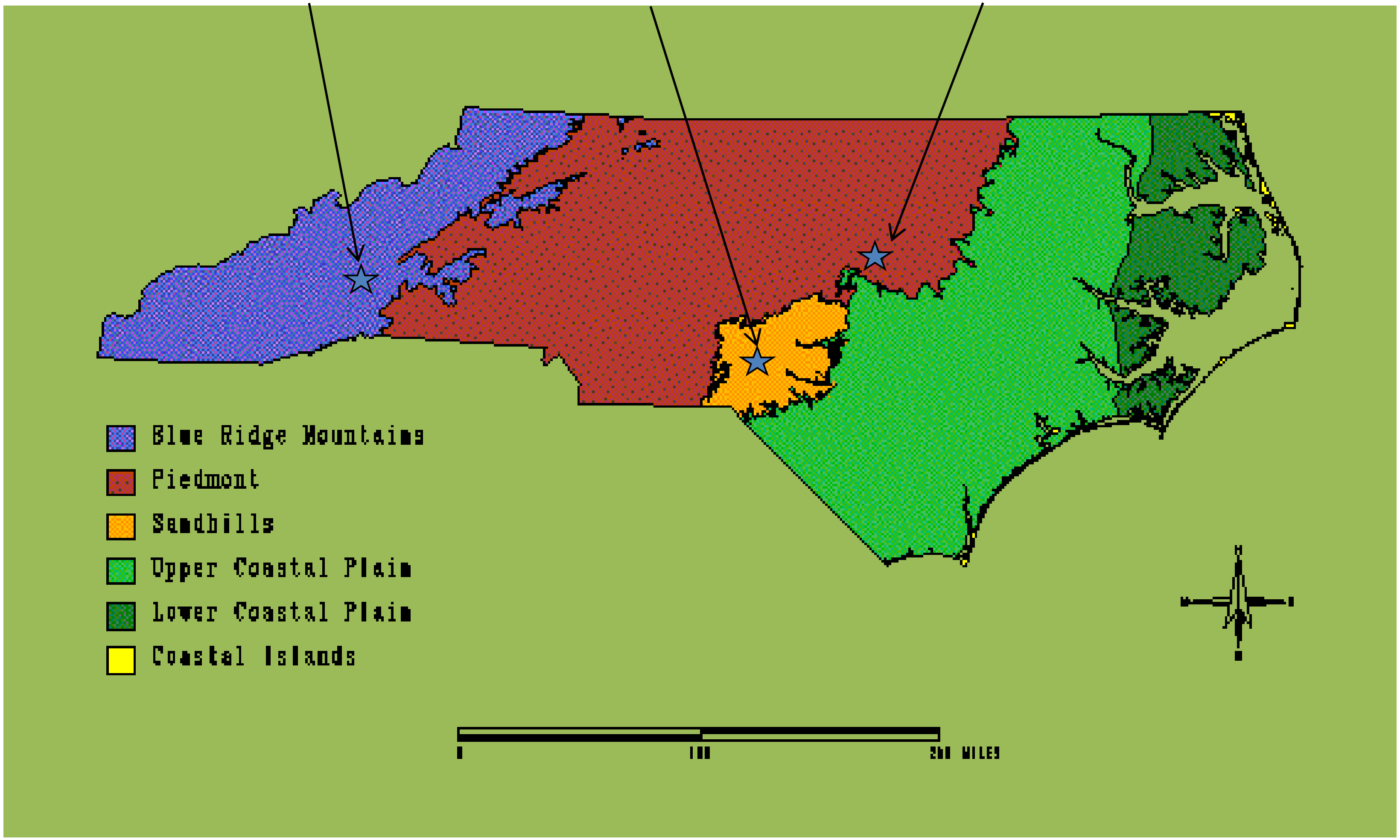
Large, Multi-Year, 3-Site Testing



Plots

ditions:

bsoil.

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Monitor Runoff

(Piedmont; first growing season only)

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Part of Plots Mowed (Traffic), string trimmer on other part (No Traffic)

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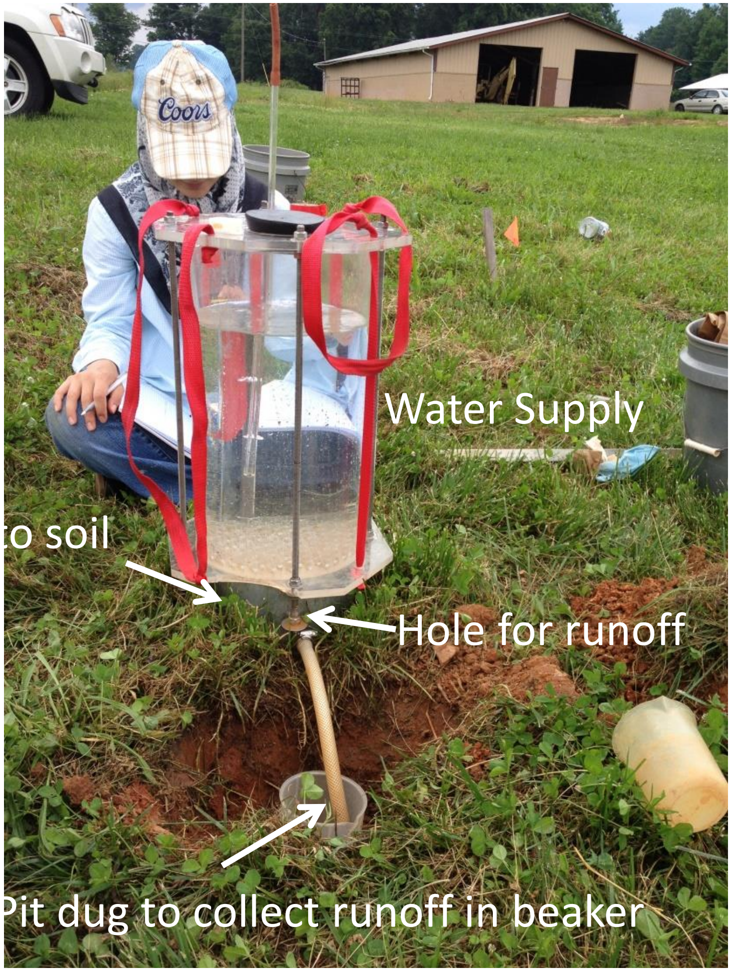
Infiltration Measurement

Cornell Sprinkle Infiltrometer – find steady-state infiltration rate



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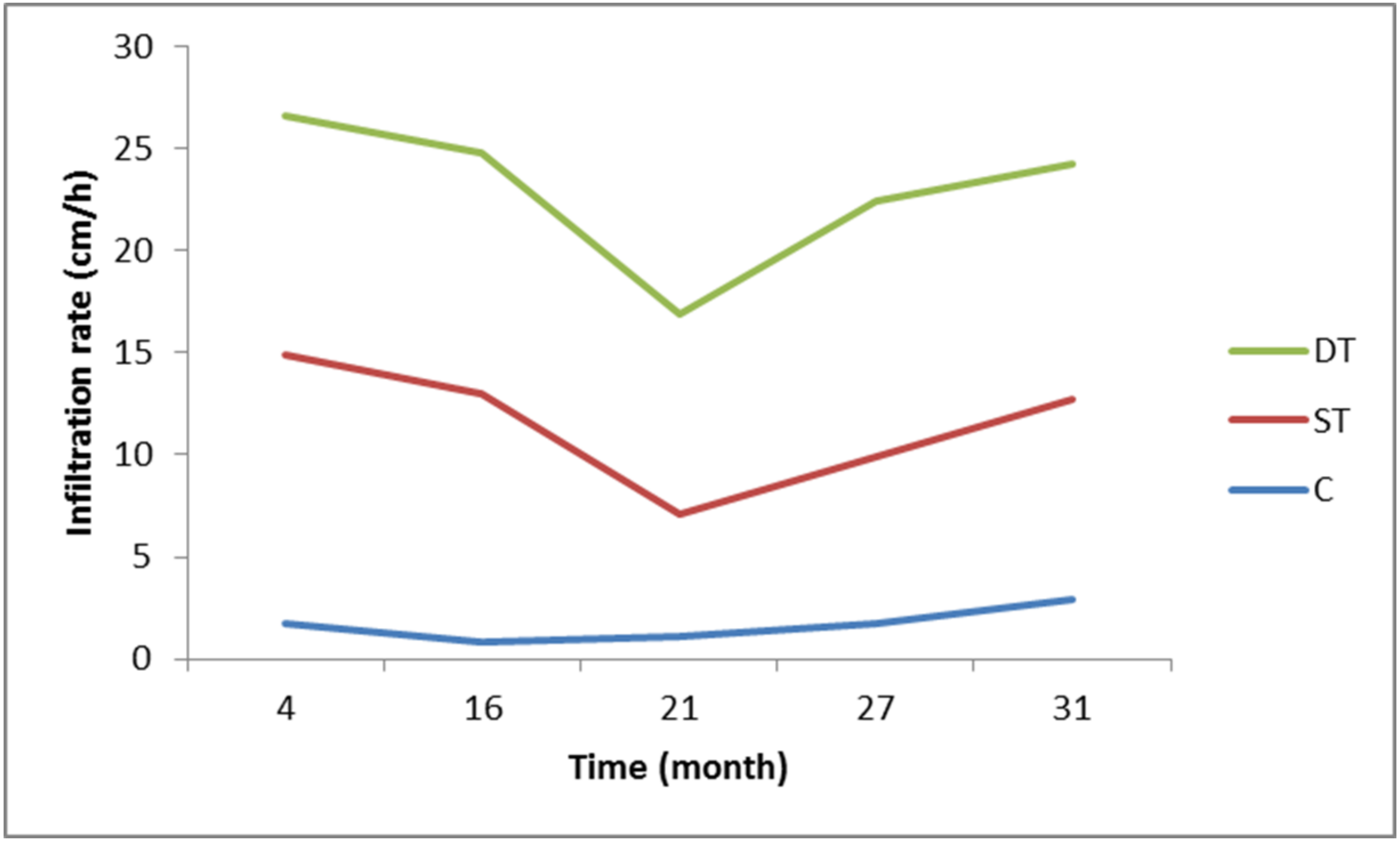
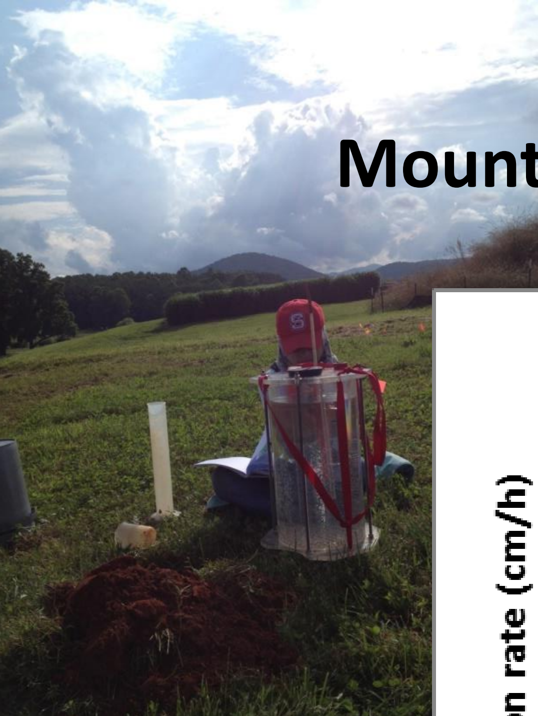
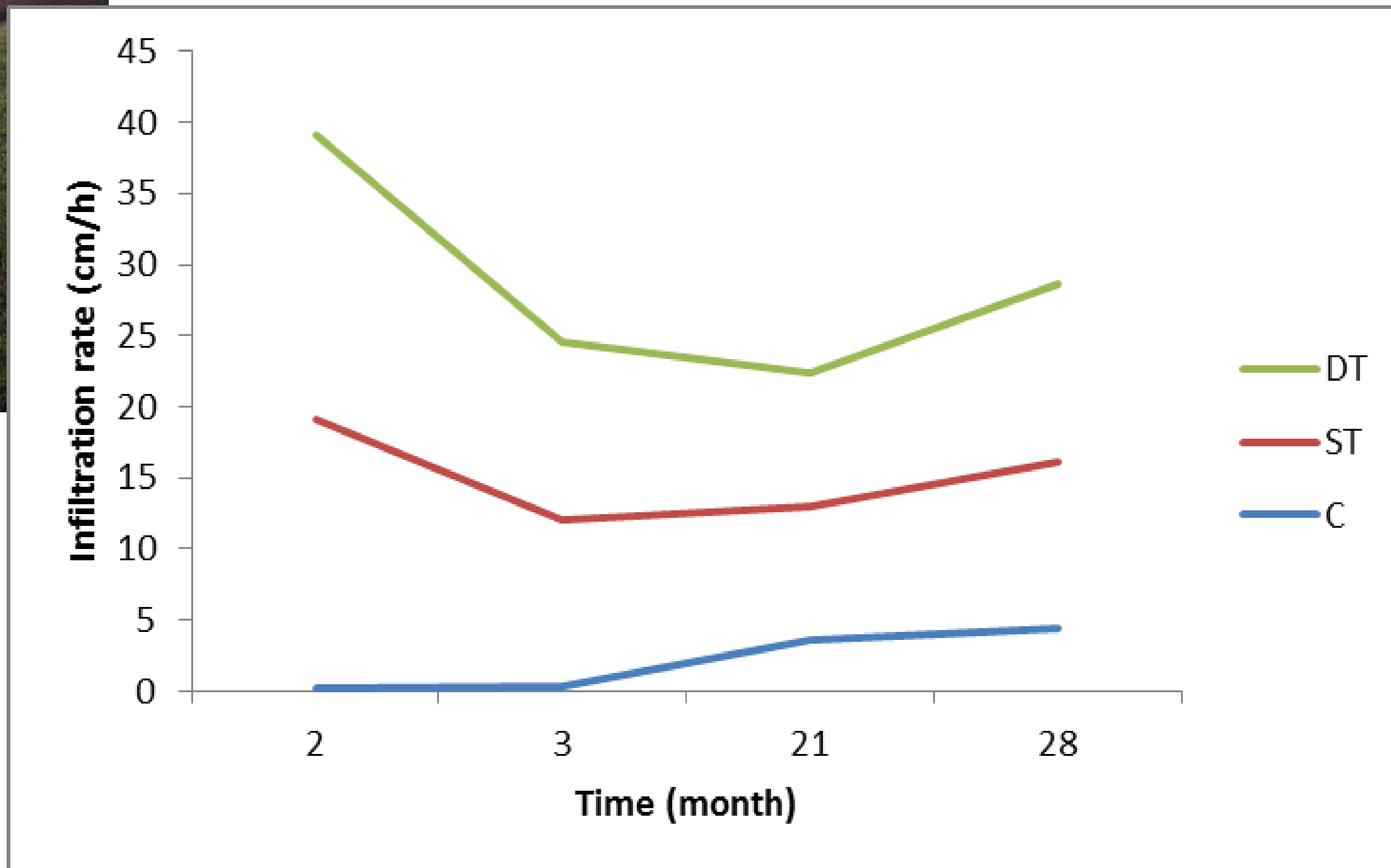
Piedmont #1 Infiltration Rate Over Time



- No lime effect (1x vs 2x)
- No mower traffic effect

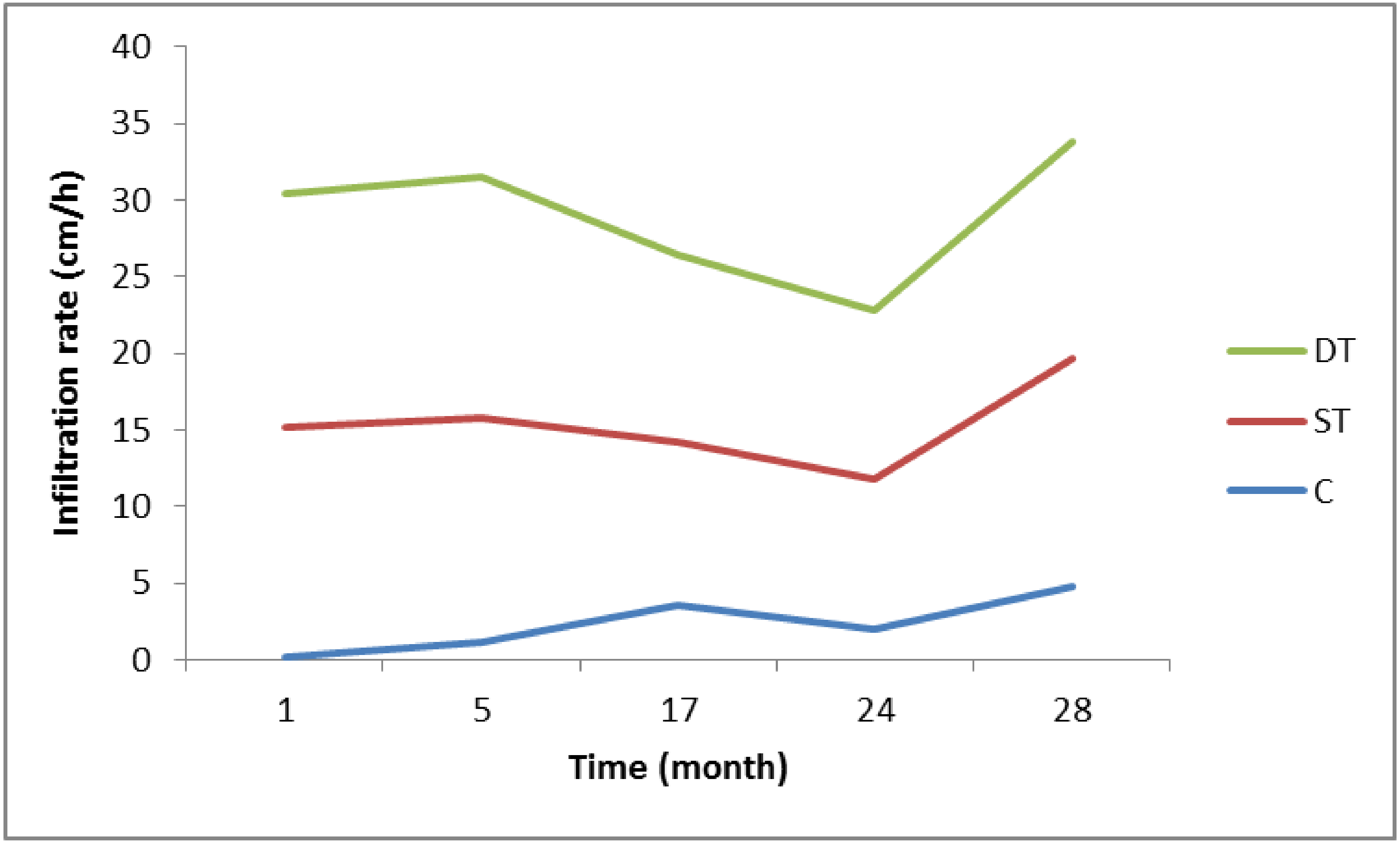
Mountain Site Infiltration Rate Over Time





- No effect of x-PAM and compost
- No effect of mowing (traffic)

Sandhills Site Infiltrate Rate Over Time



- Lime and compost didn't have sig. difference

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Piedmont #2 Infiltration Rate Over Time

	Time After Treatment (months)		
	6	13	18
Treatments	Infiltration Rate (cm/h)		
Control/Mower Traffic	0.6 b	2.8 b	6.0 b
Control/No Traffic	0.4 b	1.2 b	3.8 b

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Piedmont #2 Infiltration Rate Over Time

	Time After Treatment (months)		
	6	13	18
Treatments	Infiltration Rate (cm/h)		
Control/Mower Traffic	0.6 b	2.8 b	6.0 b
Control/No Traffic	0.4 b	1.2 b	3.8 b
Deep till/Mower Traffic	7.5 a	2.4 b	7.0 b
Deep till/No Traffic	14.8 a	7.0 b	16.8 a

Piedmont #2 Infiltration Rate Over Time

	Time After Treatment (months)		
	6	13	18
Treatments	Infiltration Rate (cm/h)		
Control/Mower Traffic	0.6 b	2.8 b	6.0 b
Control/No Traffic	0.4 b	1.2 b	3.8 b
Deep till/Mower Traffic	7.5 a	2.4 b	7.0 b
Deep till/No Traffic	14.8 a	7.0 b	16.8 a
Deep till+Compost/Mower Traffic	16.8 a	17.9 a	14.7 a
Deep till+Compost/No Traffic	20.6 a	17.5 a	17.6 a

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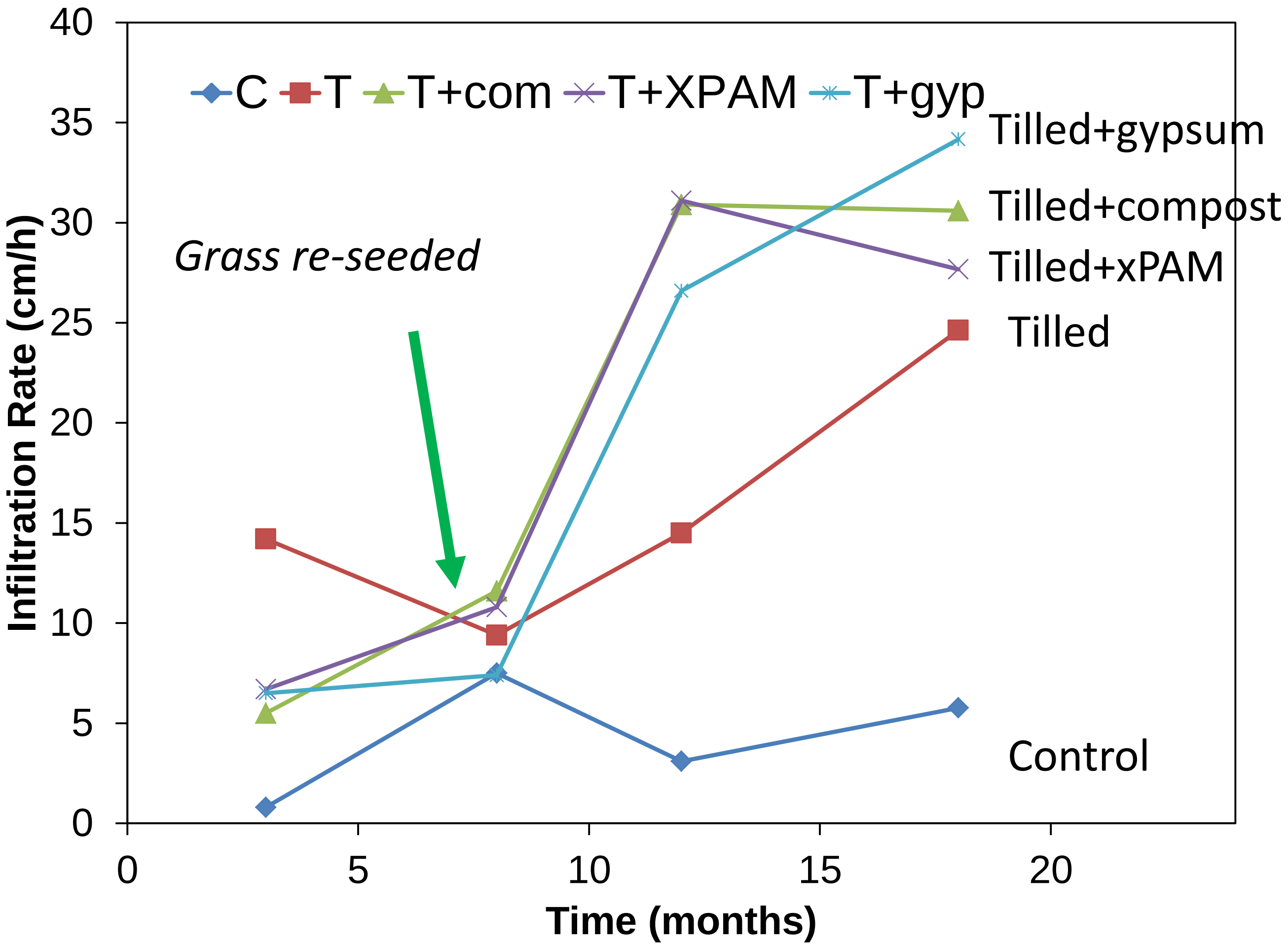
2013 Study: Fill Soil

NCDOT Funding

- Compare compost, gypsum, and cross-linked PAM (water absorbing) in compacted fill soil
- Greenhouse component for root growth
- Field testing on highway construction sites

Fill Soil Tests



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Conclusions To Date

- Compacted soil that was tilled and seeded to grass maintained high infiltration rates for almost 3 years of monitoring.
- Vigorous grass (vegetation) growth is needed, or the tillage effect can be lost.
- Infiltration rates were high enough to suggest runoff from impervious surfaces could be directed to these areas.

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Conclusions (cont.)

- Amendments were not clearly necessary to have high infiltration, but compost may add “resilience” to reduce re-compaction by traffic.

- Heavy equipment may be needed to achieve the “decompaction” level desired.

Plant Selection

- Some areas will need to be in grass (e.g. roadsides, parks, etc.).
- Some areas can go into woody plants (e.g. landscaping or unused "back side" of lots).
- Flowering plants for pollinators?
- Maintenance?

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Currently Testing on Roadsides

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Where Can We Apply This?

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Water Is Key!

- We have found that the success of **vegetating a site** is highly correlated to rainfall patterns.
- If water is not available on site, you might consider irrigating with a tanker truck, hydroseeder, or similar.

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Green Driveway and Bioswale 1960!