Measurement of Parameters Affecting the formation and breakage of floc

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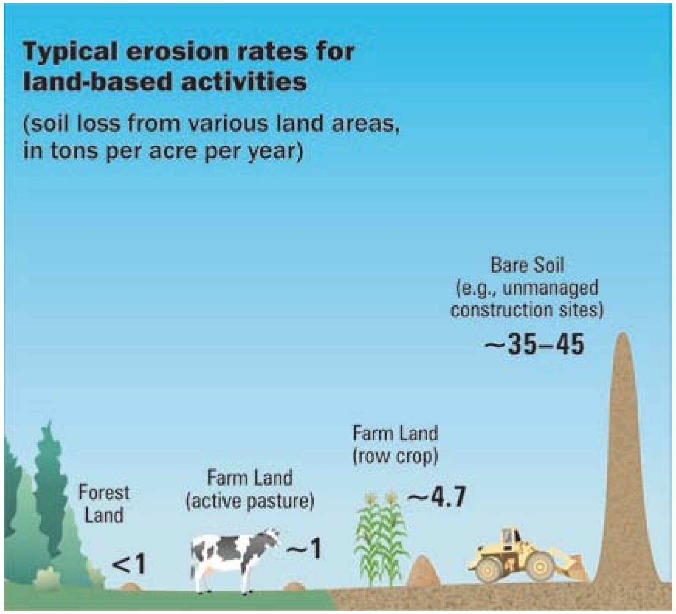
Contents

Introduction

* Sediments from construction site are the primary pollutant in stormwater runoff

* Construction sites can add up to 35-45 tons of sediment per acre each year

* Excess sediment can impair the streams, cause ecological damage and also impede navigation



Source: EPA

BMP for Sediment and Runoff Control

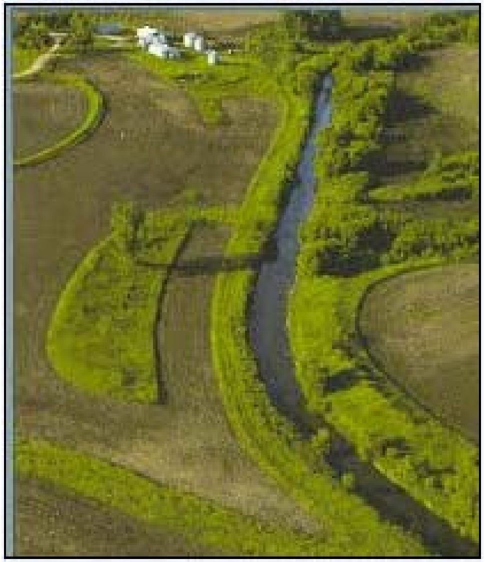
Sedimentation Basin

Grass lined channel

Fiber rolls

Silt Fence

Vegetative Filter Strip



Source: EPA

Flocculation

* Most commonly used in water and wastewater treatment
* Two step process: Coagulation and Flocculation
* Coagulation: Particle destabilization
* Flocculation: Particle aggregation and growth

Source: Environmental Outlook

Objectives of the project

"Develop a model which can determine the parameters that affect the floc formation and breakage for a particular soil type"

Parameters Affecting Flocculation

* Collision of particles: Brownian Motion, Laminar or turbulent shear, Inertia in turbulent flow and differential settling

* Efficiency of the flocculation process depends
- *Collision frequency*
- *Stickiness coefficient*

* Breakage of the flocs is caused by turbulent shear forces on the surface of the floc

Flocculation Model

* Flocculation model used is based on the research work done by Krishnappan and Marsalek (2002).

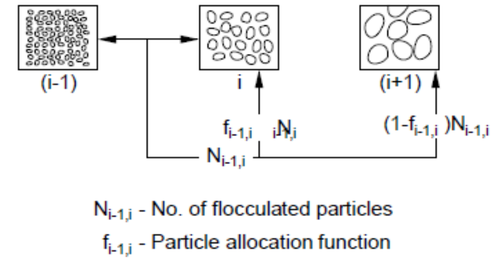
* The model consists of the following stages
  - Coagulation equation to determine the balance of the number of particles undergoing flocculation

  - Advection-diffusion equation for settling

Flocculation Model: Mathematical Formulation

$$\frac{dn_i}{dt} = -\sum_{j=i}^{N_{\max}} \beta_j K_{ij}^{eff} n_i n_j + \sum_{j=1}^{i} \beta_i f_{ij} K_{ij}^{eff} n_i n_j + \sum_{j=1}^{i-1} \left(1 - f_{i-1,j}\right) \beta_{i-1} K_{i-1,j}^{eff} n_{i-1} n_j$$

$\beta_{i/j}$= the coagulation factor
$K_{i,j}^{eff}$= the collision frequency function
n= number of particles
f= fraction of the particles



Schematization of allocation of flocculated particles

Source: Krishnappan and Marsalek (2002)

$$K_{i,j}^{eff} = K_{i,j}^{Kh,BR} + \sqrt{\left(K_{i,j}^{Kh,Sh}\right)^2 + \left(K_{i,j}^{Kh,IN}\right)^2 + \left(K_{i,j}^{Kh,DS}\right)^2}$$

Flocculation Model: Mathematical Formulation

Mechanism	Collision Frequency Function
Brownian motion	$K_{i,j}^{Kh,B} = \frac{2}{3}\frac{B_Z T}{\rho \nu}\frac{\left(r_i + r_j\right)^2}{r_i r_j}$
Turbulent shear	$K_{i,j}^{Kh,SH} = \frac{4}{3}\left(\frac{\varepsilon}{\nu}\right)^{0.5}\left(r_i + r_j\right)^3$
Inertia of particles in turbulent flow	$K_{i,j}^{Kh,IN} = 1.21\frac{\rho_{sj}}{\rho_j}\left(\frac{\varepsilon^3}{\nu^5}\right)^{0.25}\left(r_i + r_j\right)^2 abs\left(r_i^2 - r_j^2\right)$
Differential settling	$K_{i,j}^{Kh,DS} = \frac{2\pi g}{9\nu}\frac{\rho_{sj} - \rho_w}{\rho_w}\left(r_i + r_j\right)^2 abs\left(r_i^2 - r_j^2\right)$

$$\beta_{i/j} = \alpha_0\left(1 - \frac{R_{i/j}}{S+1}\right)^n$$

α_o= the stickiness coefficient
$R_{i/j}$= floc size in the bin
S= maximum floc size

Flocculation Model: Mathematical Formulation

Advection Diffusion Equation:

$$\frac{\partial C_k}{\partial t} + w_k \frac{\partial C_k}{\partial z} = \frac{\partial}{\partial z}\left(D \frac{\partial C_k}{\partial z} \right)$$

C_k= concentration of the particle
w_k= settling velocity of the particle
D= turbulent diffussion coefficient

Experimental Setup

Component	Description	Dimension/ Capacity
Soil Separator	Rectangular flume with overflow weir plate at the outlet	Flume :10ft x 8in x 4ft (LxWxH) Weir Plate: 12in x 8 in Weir depth= 1.18 in
Sediment injection system	Conical tank with backflow and normal flow systems and impeller for mixing	Capacity: 450 gallons
Flocculant injection system	Peristaltic pump system	Capacity of Flocculant Tank: 16 gallons
Oscillating grid Assembly	Three sets of oscillating grids each having three individual grids	Rod diameter: 3/16 in Grid dimension: 6in x 6in
Constant head tank	Rectangular tank with flow straighteners and V-notch weir at the outlet.	10 ft x 5 ft x 3 ft (LxWxH)
Sedimentation Basin	Rectangular Flume with sampling ports along the flume	30 ft x 1.5ft x 0.5ft (LxWxH)

Experimental Setup

Soil Separator

Sediment injection system

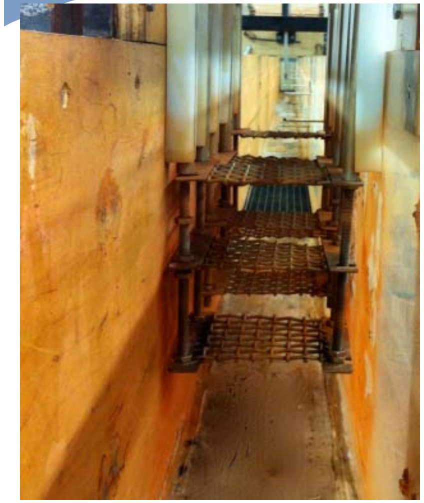
Experimental Setup

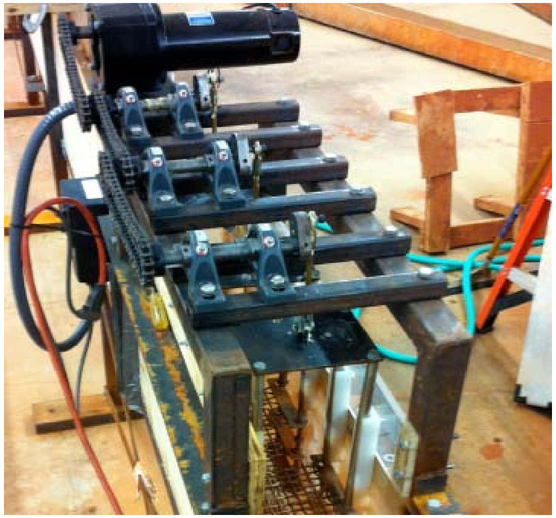
Constant Head Tank

Flocculant injection system

Experimental Setup

Oscillating grid assembly





Flume with sampling ports

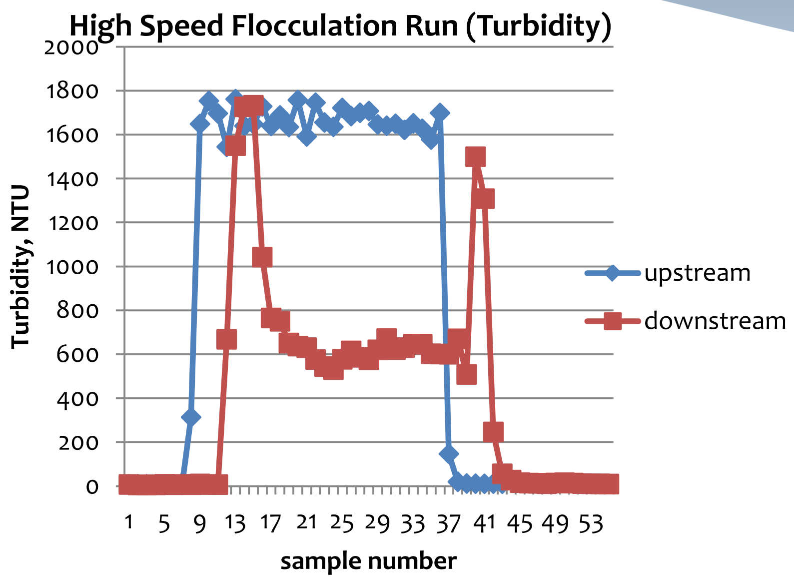
Experimental Setup

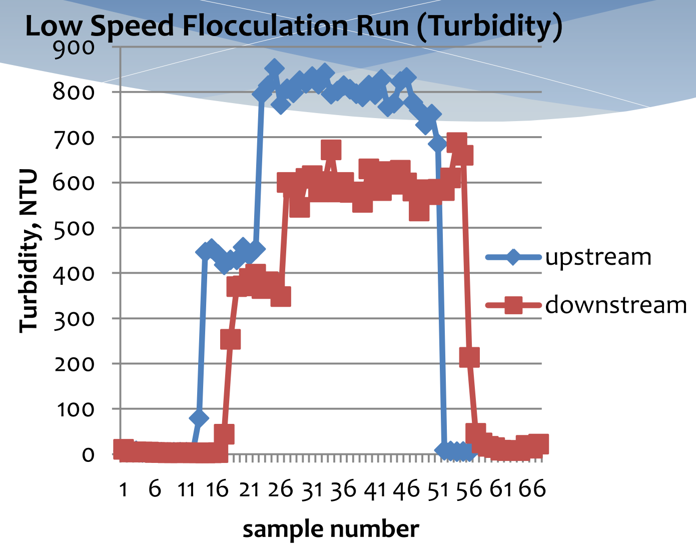
* Three soils from Greenville county of South Carolina were tested : Hiwassee, Pacolet and Cecil
* Flow rate of water in the flume: 0.1 cfs (6 in flow over V notch)
* Concentration of the flocculant in flume: 0.05 g/L
* Four types of experimental runs
- Control run with agitation
- Control run without agitation
- Low speed flocculation run
- High speed flocculation run

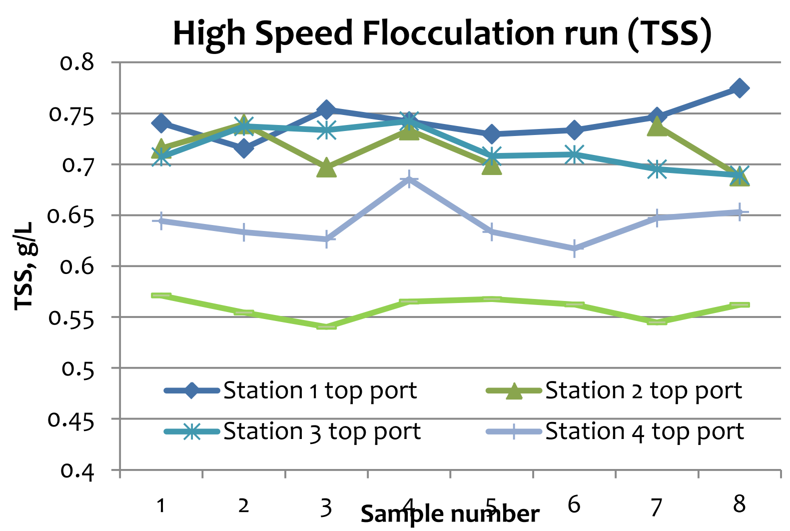
Experimental Setup

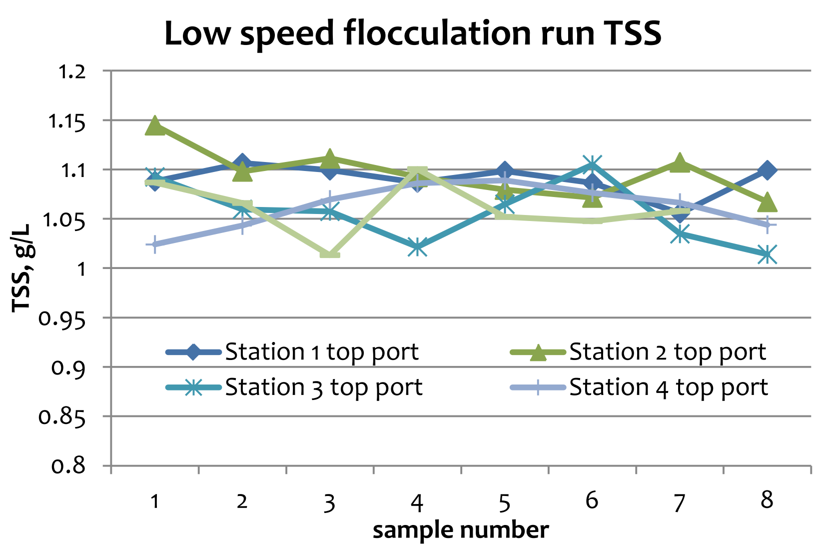
* Duration of Experimental run : average 15 minutes
* Sampling: 10 samples at five stations were collected from top and bottom port
* Sampling interval: 90 seconds
* Sampling volume: 250 ml
* Turbidity measurement: Inlet and outlet of the flume

Data Analysis : Hiwassee Soil

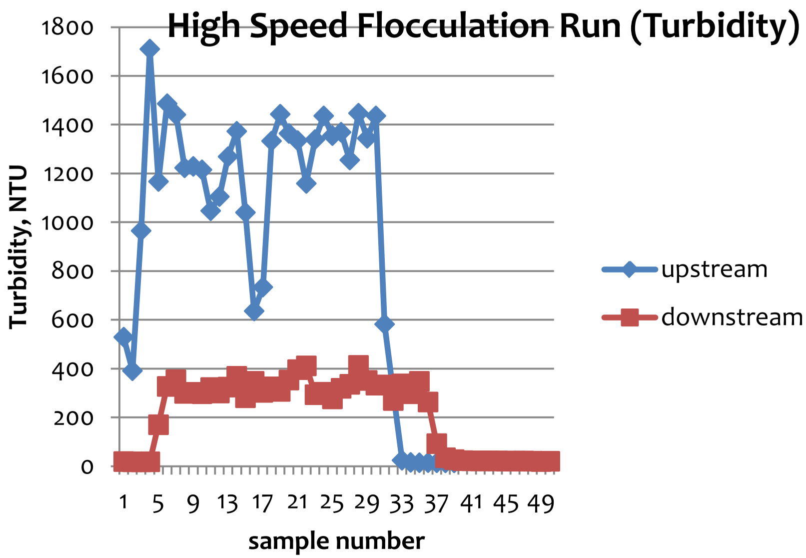


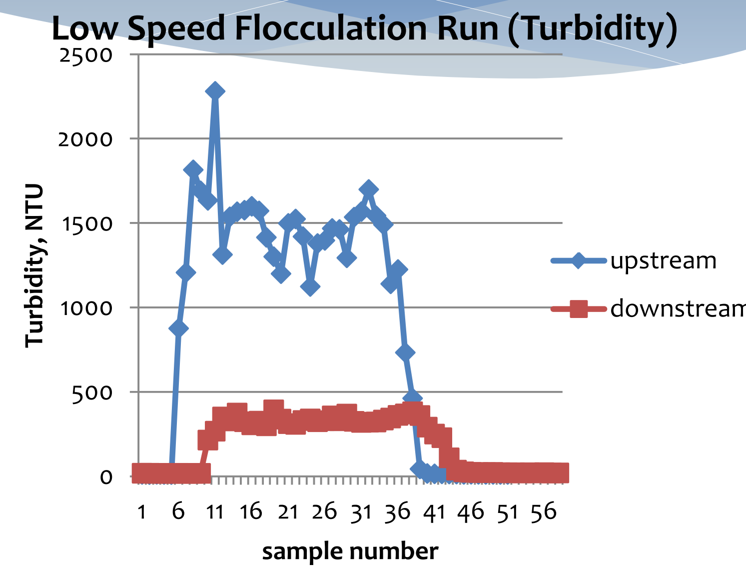


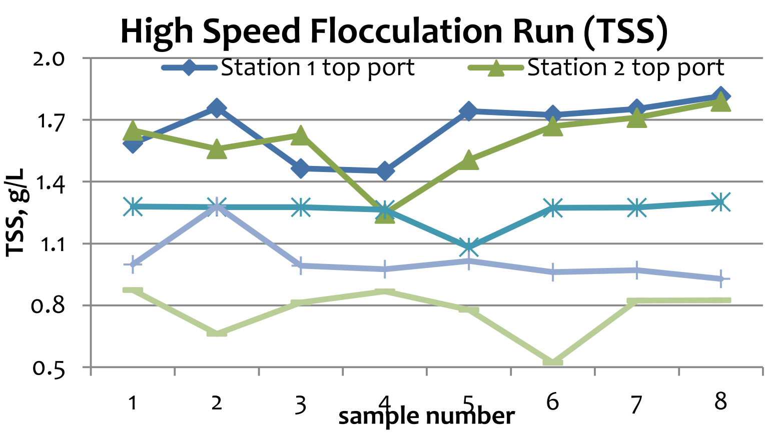


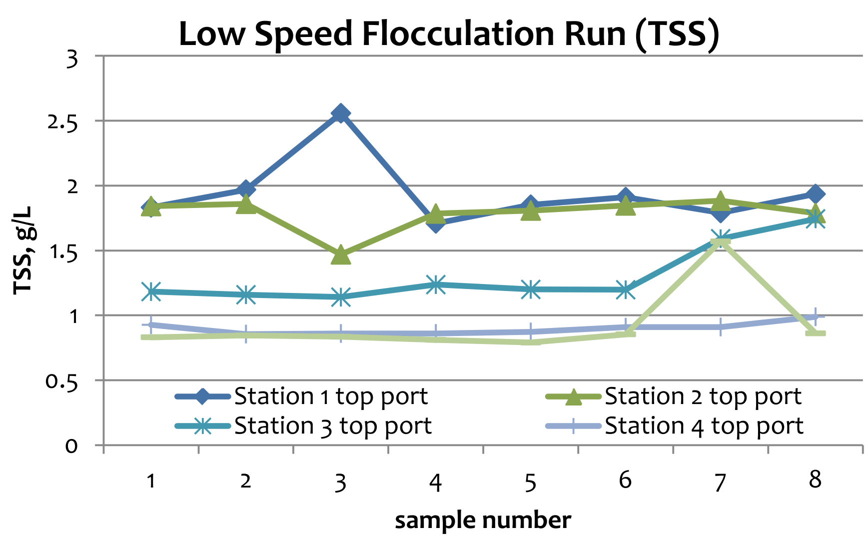


Data Analysis: Pacolet Soil

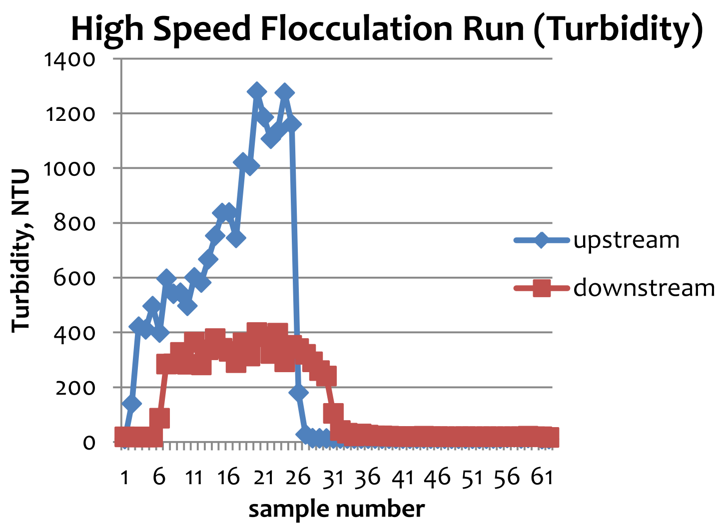


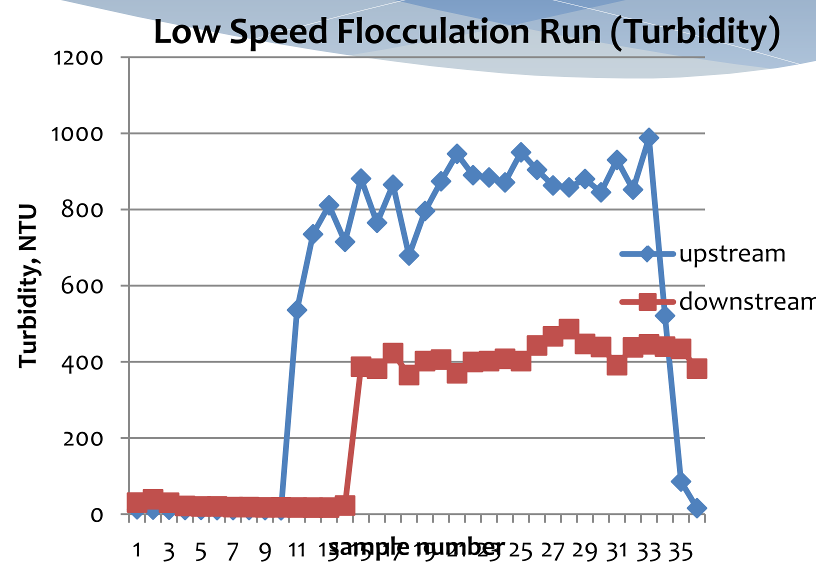


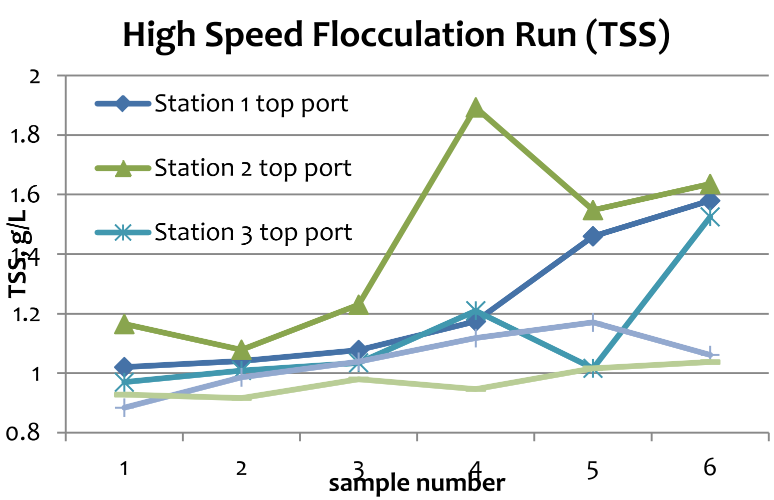


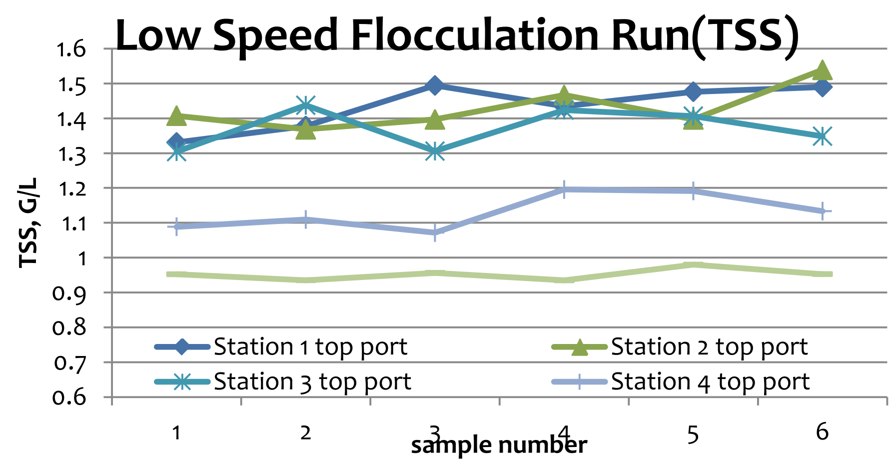


Data Analysis: Cecil Soil

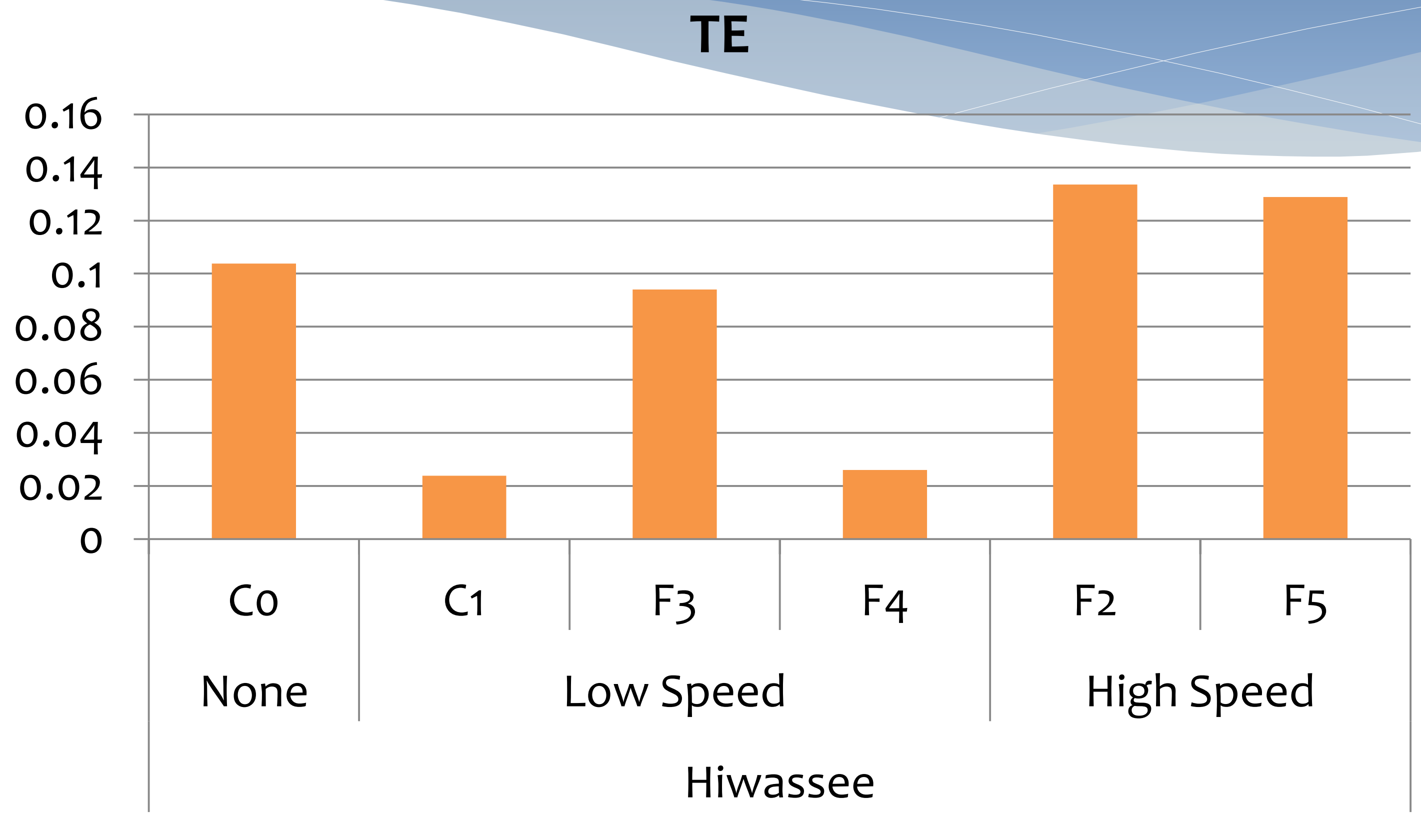




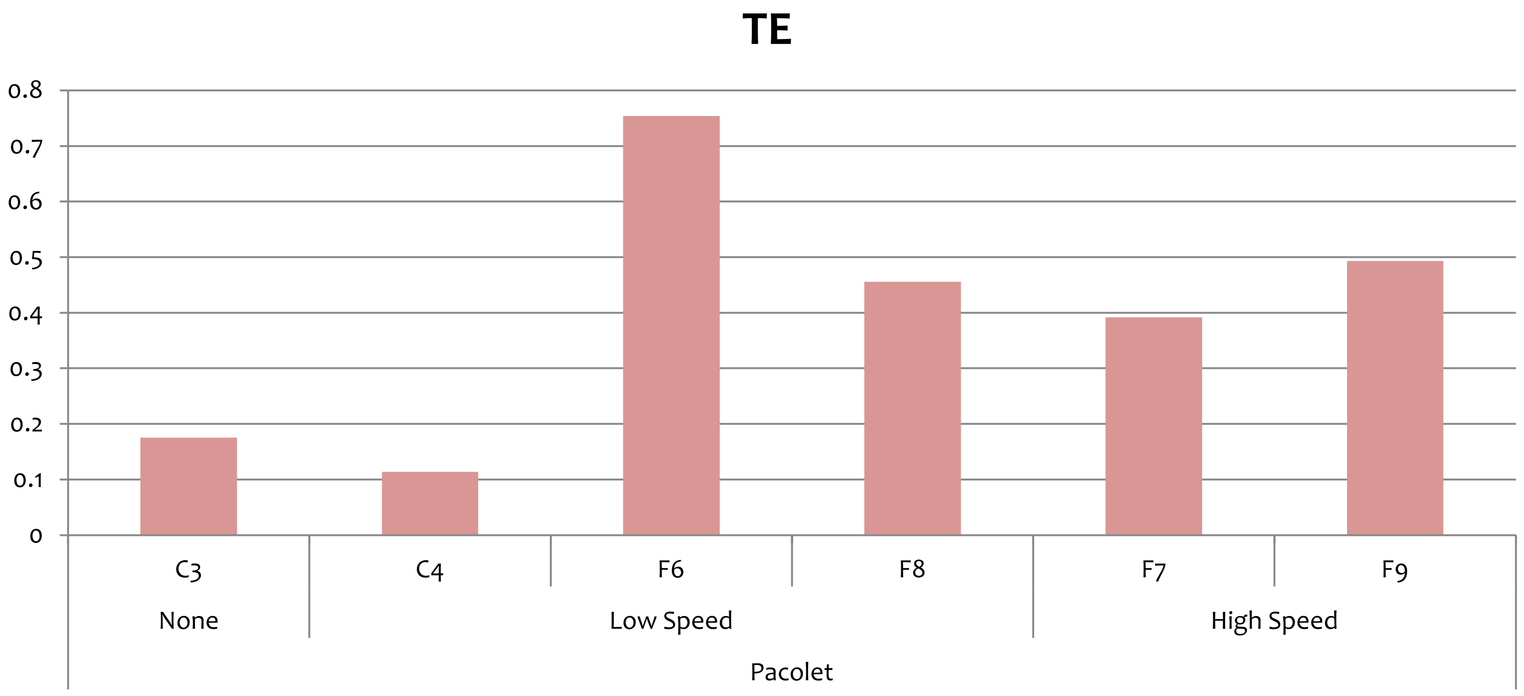




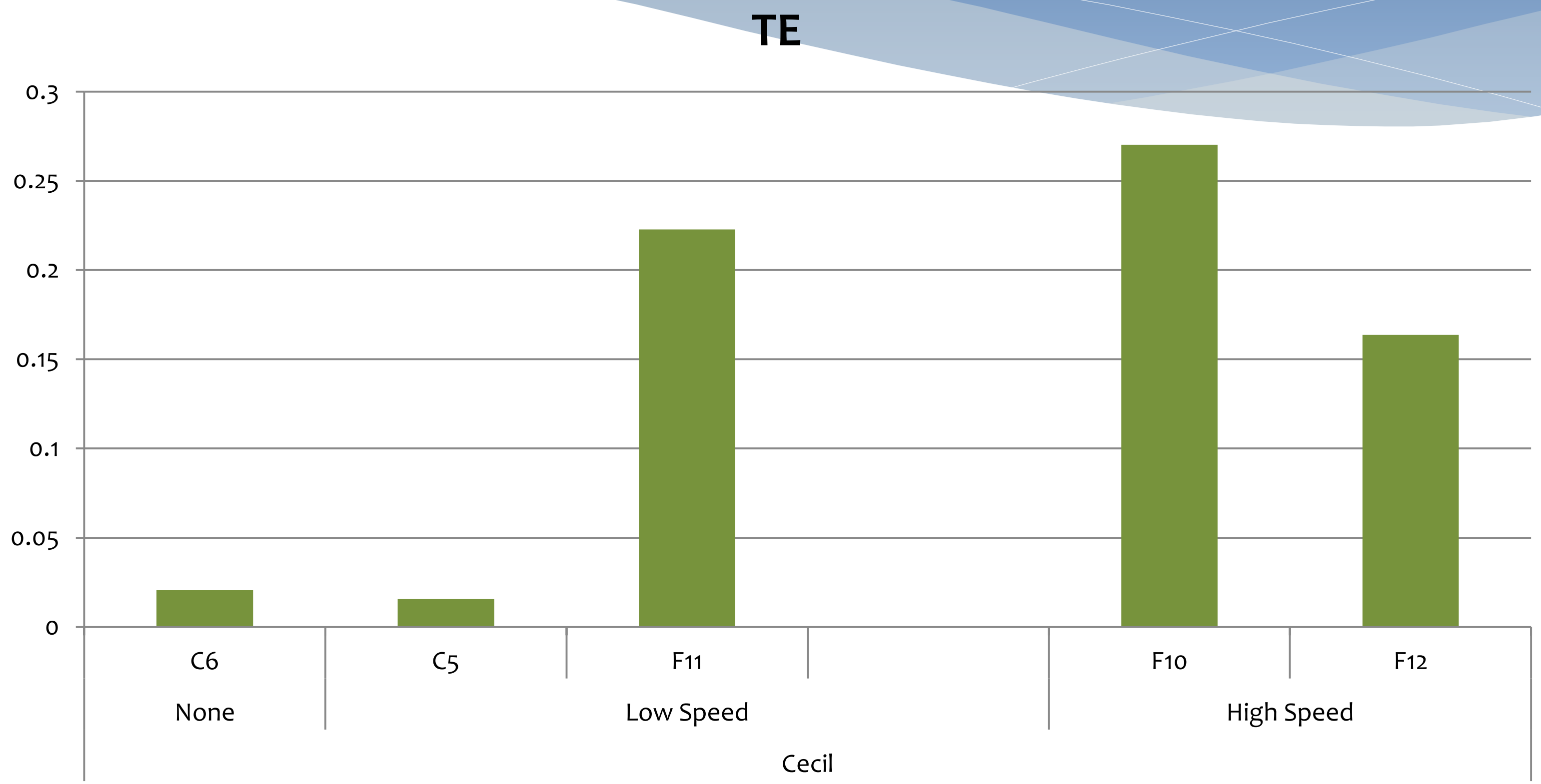
Data Analysis: Trapping Efficiencies



Data Analysis: Trapping Efficiencies



Data Analysis: Trapping Efficiencies



Data Analysis: Local Soil

Current Modeling Stage and Future Work

* The model is being coded using Visual Basic
* The model will be tested using the experimental data
* The stickiness coefficient will be estimated for the three soils
* More soils will be tested to validate the model

Contributors

Faculty advisors : Dr. Jason Vogel, Dr. Daniel Storm

Subject Matter Specialist: Dr. Billy Barfield

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Greenville county, South Carolina

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Questions ??