Greenville County

November 7, 2018

Introduction to Construction and Post-Construction Design

Agenda

	During Construction
9:15	Hydrology
9:25	Sedimentology
10:15	**BREAK**
10:30	County's Construction WQ Regulations
11:00	BMP Specs and Details
11:15	Woolpert BMP Audit Results
12:00	**LUNCH**

	Post-Construction
12:30	Hydrology and Water Quality Constituents
1:00	Peak Flow Control and Permanent WQ Treatment
1:30	Overview of County's Regulations
2:00	**BREAK**
2:15	BMP Specs and Details
2:45	Introduction to IDEAL Model
3:15	Message from Greenville County

Class Purpose

To increase the accuracy and effectiveness of designs for ESC and postconstruction stormwater management submitted to Greenville County,
which will decrease the need for re-submittals and reduce costs for the County, designers, and developers.

Principles of Sedimentation

Principles of Erosion

- Erosion on most disturbed sites occurs in the following forms:
  - Sheet
  - Rill and interrill
  - Gully
- Two concepts for erosion to occur:
  - Detachment
  - Transport

Principles of Erosion

- Clear water has a greater affinity for sediment than does sediment-laden flow.
- Runoff and resulting transport does not occur until rainfall intensities exceed infiltration rates of the soil media.

Principles of Erosion

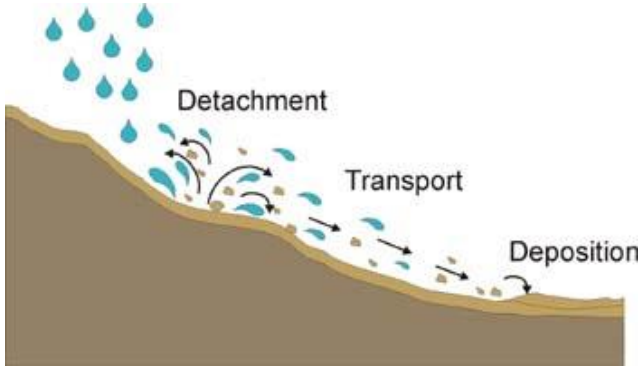
- Sheet erosion is a result of overland flow from disturbed areas.
  - Occurs on flatter slopes
- As this flow concentrates, interrills and rills begin to form.
  - Forms as the slope increases
- Once the flow concentrates into a single point, a gully may begin to form.
  - Forms on steeper sections of the slope

Principles of Erosion

- Two primary means to prevent erosion from occurring.
  1. Source Protection
     - Most desirable alternative but, not always possible.
     - Protection encompasses a wide range of techniques most of which are management issues.
  2. Flow Control
     - Structural engineering solution.
     - Often times translates to diverting flow away from disturbed areas.
- Combination of these two solutions can be very effective in reducing erosion.

Principles of Sedimentation

- Detachment
  - Removal of soil particles due to raindrop splash or by shear stress from runoff
- Transport
  - Movement of soil particles by runoff
  - Clear flow
  - Sediment laden flow
- Settling/Deposition
  - The process of soil particles falling out of the transport media



Principles of Sedimentation

- Sedimentation occurs because storm water flow velocities decrease and the soil particles in the water are heavy enough to settle.
- Any factor that reduces velocity in a flow segment increases deposition.
- In general, larger size particles and aggregates settle at higher velocities while smaller sized particles require much lower flow velocity to settle out.
- Particle size distributions of an eroded soil have a great effect on the trapping efficiency of any sediment control structure.

Principles of Sedimentation

- Sedimentation starts to occur when the flow slows to a velocity of about 2.5 feet per second
  - Breaks in slope
  - Surface storage areas
  - Natural areas
  - Sediment Control BMPs

Water Quality Treatment During Construction

Sediment Control

- Factors Affecting Sediment Control BMPs
  - Disturbed Area
  - Duration of Construction
  - Peak Flow Rates
  - Slope
  - Soil Type

Factors Affecting Sediment Control BMPs

- Disturbed Area
  - Determines BMP selection
    - Large areas (> 5 acres require a sediment pond)
    - Medium area may require sediment traps
    - Smaller areas may be controlled with rock checks, silt fence, inlet protection, etc.

Factors Affecting Sediment Control BMPs

- Duration of Construction
  - Certain BMPs are practical for short periods of time (weeks) but may not be efficient for longer periods (months) unless a maintenance schedule is enforced.

Factors Affecting Sediment Control BMPs

- Peak Flow Rates
  - Determine selection of BMP
    - Certain BMPs will fail if they are used in situations where high flow rates are expected or concentrated flows are expected.
      - Silt fence not applicable for concentrated flows.

Factors Affecting Sediment Control BMPs

- Slope
  - Magnifies the amount of erosion
  - Increases detention time
  - Increases storage volume
  - Increases sediment storage volume

Factors Affecting Sediment Control BMPs

- Soil Type
  - Considered the most important factor in the design of sediment control BMPs
  - Is often the most overlooked and least understood factor in the design of sediment control BMPs

Soil Type

- Important Components
  - K factor (soil erodibility factor)
  - Eroded Particle Size Distribution

Soil Erodibilty Factor (K)

- Definition
  - The rate of erosion per unit of erosion index from unit plots of a given soil
  - Used in Universal Soil Loss Equation

Soil Erodibilty Factor (K)

- Factors Affecting Soil K Value
  - — Water Related Characteristics
    - Total water holding capacity
    - Infiltration
    - Permeability
  - — Physical Characteristics
    - Dispersion
    - Splashing
    - Abrasion

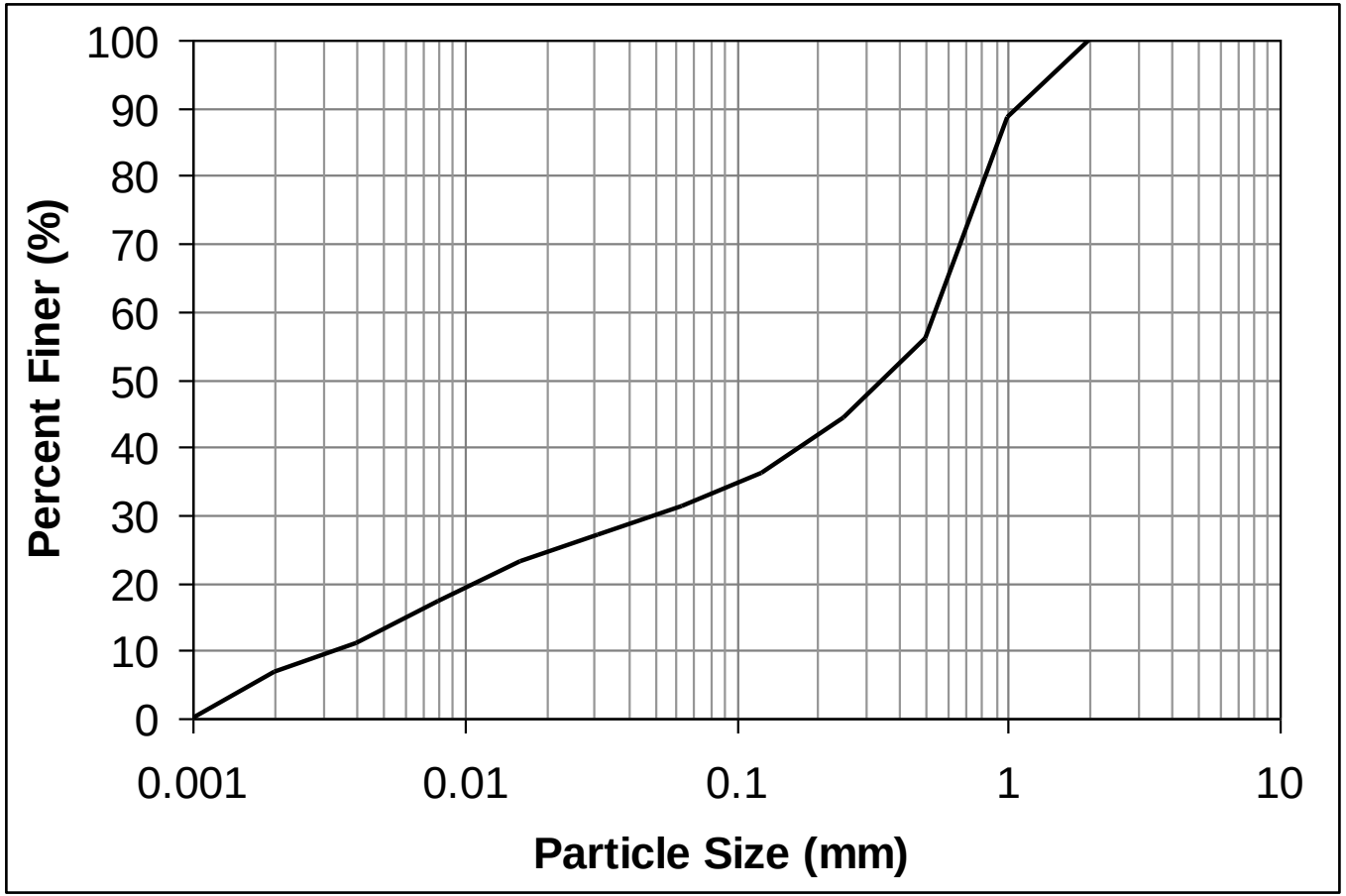
Eroded Particle Size Distribution (EPSD)

- Definition
  - Is soil size classification based on primary particles **and** aggregates
  - EPSD classifications are not the primary particle sizes used to determine soil texture (sand, silt, clay).

Eroded Particle Size Distribution (EPSD)

- Definition
- Percent Finer
  - Percent of the actual particles, by weight, which are smaller than the representative particle size
- D_{15}
  - Particle size where 15% of the sample by weight consists of equal or smaller particles

Reading a Percent Finer Curve



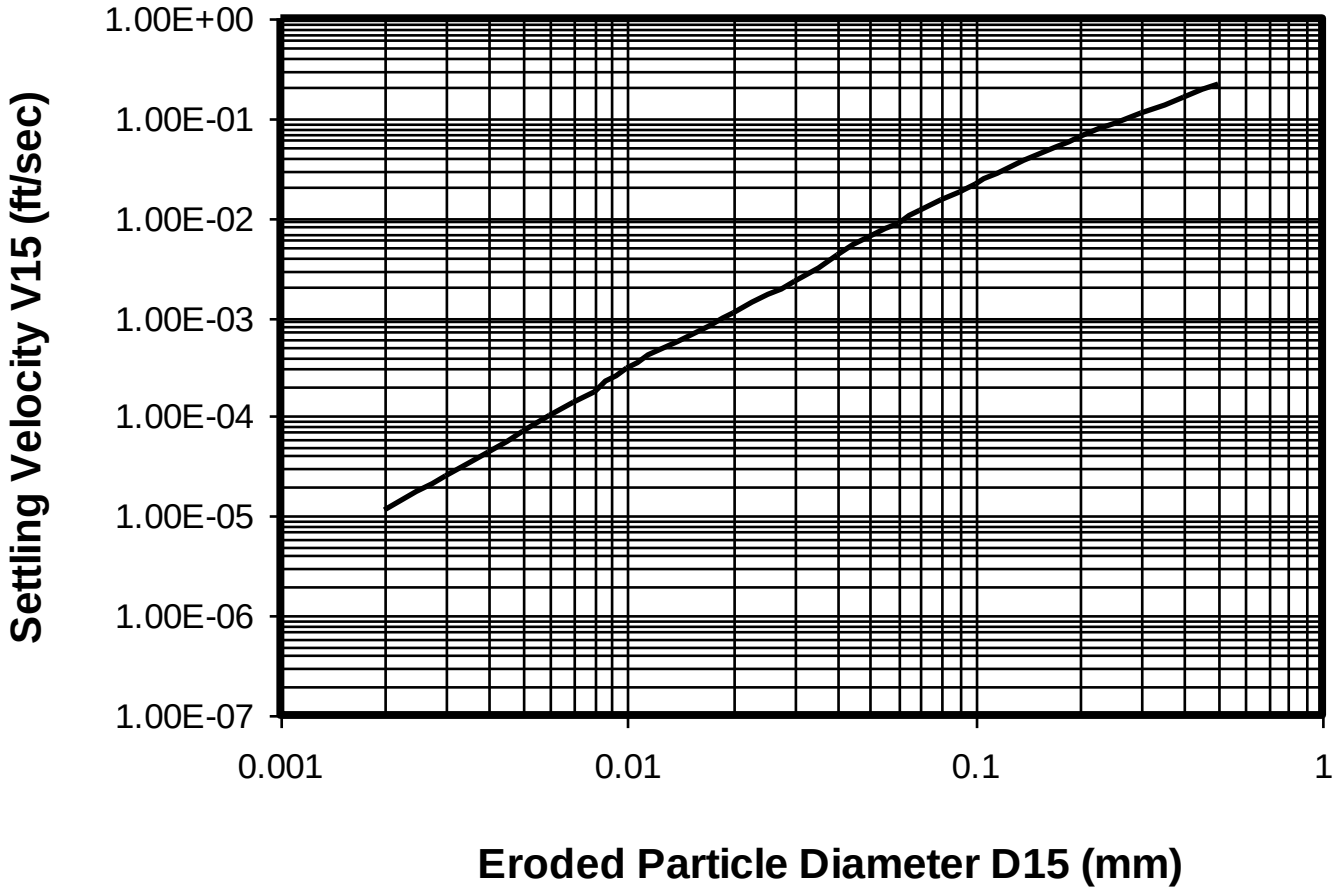
Eroded Particle Size Distribution (EPSD)

- Importance
  - Smaller the particle, longer the settling time (Stokes Equation)
  - Longer the settling time, the larger the detention area.

    - Particle 0.02mm has a settling velocity of 1.2E-3 ft/sec and takes **14 min to settle 1 foot**

    - Particle 0.01mm has a settling velocity of 3E-4 ft/sec and takes **55 min to settle 1 foot**

Settling Velocity

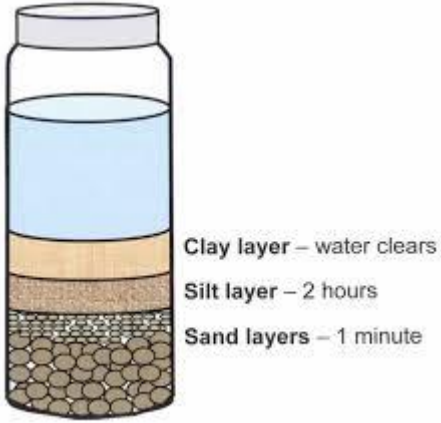


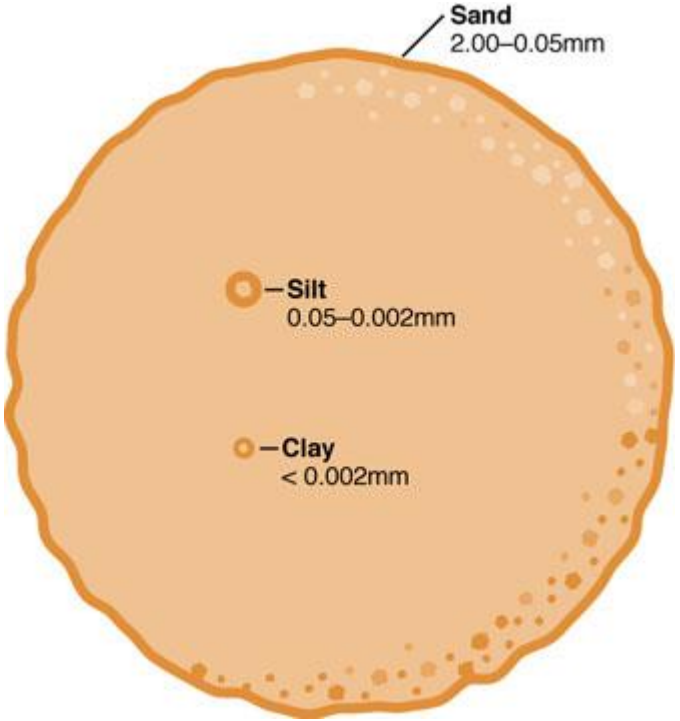
Techniques to Determine EPSD

- Site specific soil hydrometer testing
- Site specific rainfall simulation
  - Sieve testing
  - Pipette testing
- Equations (CREAMS-based)
  - Uses soil survey data
- Tables
  - Based off CREAMS equations

CREAMS-based EPSD

- Uses soil textural data contained in Soil Surveys to determine
  - Percent Sand
  - Percent Silt
  - Percent Clay





CREAMS-based EPSD

- CREAMS-based equations define 5 particle classes from primary texture

	Size	Time to settle 1 foot
Large Aggregate	0.300 mm	15 seconds
Sand	0.200 mm	16 seconds
Small Aggregate	0.060 mm	11 minutes
Silt	0.010 mm	1 hour
Clay	0.002 mm	1+ day

Can't see clay particle, even at this scale (~ 1:100)

CREAMS-based EPSD

- Estimates percent finer values for 9 particle diameters (mm)
  - 5.0
  - 1.400
  - 1.000
  - 0.063
  - 0.044
  - 0.038
  - 0.004
  - 0.003
  - 0.001

CREAMS-based EPSD

PERCENT FINER FOR SPECIFIED PARTICLE DIAMETERS

SOIL SERIES -HYDROLOGIC SOIL GROUP

DEPTH (in)	K	D15 (mm)	Percent Finer Than 1.4 (mm)	1.0 (mm)	0.063 (mm)	0.044 (mm)	0.038 (mm)	0.004 (mm)	0.003 (mm)	0.001 (mm)
CRIDER - HSG										
0 - 12	0.32	0.0054	100.0	93.1	77.4	67.1	64.4	7.3	4.6	0.0
12 - 38		0.0052	100.0	91.5	72.0	64.2	62.1	9.0	5.8	0.0
38 - 50		0.0239	100.0	75.1	18.1	15.5	15.5	13.1	9.8	0.0
50 - 96		0.0037	100.0	80.7	36.7	35.6	35.6	16.2	11.7	0.0

Eroded Particle Size Distributions

- Used:
  - For computer model input to calculate trapping efficiency
  - To determine characteristic particle size settling velocities for individual BMP design

Greenville County's Regulations for Construction

County's Construction WQ Regulations

- Greenville Stormwater Ordinance requires an EPSC plan be developed and approved, prior to initiating construction on land disturbing activities that are at least 5,000 square feet or require a building permit or as directed by a General Permit.

- Ordinance also establishes standards for the design of EPSC plans to minimize the adverse impact and off-site degradation that may result from construction site runoff.

County's Construction WQ Regulations

- EPSC plans shall be developed to achieve an 80 percent design removal efficiency of total suspended solids (TSS) goal.
  - Simply applied, when a site is completely denuded of vegetation, the structural and nonstructural EPSC measures are designed to trap 80% of the TSS that are generated by the site.
- The design storm event associated with this level of control is the 10-year, 24-hour SCS Type II or newer appropriate NRCS distribution (based on NOAA Atlas-14 data) storm event.

County's Construction WQ Regulations

- Use SCS procedures to determine runoff amounts.
  - When a BMP is designed for the 10-yr, 24-hr storm event, BMP will have a greater trapping efficiency for more frequent events such as the 2-yr 24-hr storm event.
- Projects with a life span greater than 1 year should be more concerned with maximizing the multipurpose basin's ability to provide peak attenuation to the 2, 10 and 25-yr storm events.
- Sites located in environmentally sensitive watersheds, upstream of high safety risks, and/or are upstream of known flood prone properties, need to maximize the basin's ability to control peak rate runoff during construction.

County's Construction WQ Regulations

- If the site land disturbance exceeds 10 acres and plans indicate a multi-purpose basin will be utilized, use the following options:
  1. Phase the land disturbance by limiting the disturbance to no more than 10 acres at a time prior to disturbing other areas on site.
     - This option requires the areas of disturbance to be shown on the erosion control plan and phased on the construction sequence.

County's Construction WQ Regulations

2. Provide a treatment train upstream from the multipurpose basin with a series of BMPs (sediment traps, sediment basins) that can be utilized to help with sediment control and peak rate attenuation.
   - Sediment traps **may not** collect runoff from more than 5 acres.
   - More than 5 acres of drainage area requires a sediment basin.
   - Under this option, peak rate attenuation calculations for each sediment trap or sediment basin is required.
   - 80% trapping efficiency is still required with a detailed construction sequence of installation and removal of sediment trap/basin. A maintenance statement for each BMP will be required as well.

County's Construction WQ Regulations

- Calculating the appropriate sediment storage volume is important in sediment basin and sediment trap design.
- This volume is the storage occupied by the sediment deposited over the given design period.
- Design periods may be the life of the basin, or the time between designed/scheduled clean outs.
- Using computed sediment yields from the Universal Soil Loss Equation (USLE), along with the sediment bulk density, the sediment storage volume can be calculated.

County's Construction WQ Regulations

1. Determine the sediment yield from the site using the Universal Soil Loss Equation

$$\mathbf{A} = R \bullet K \bullet LS \bullet CP$$

Where :

A = Average soil loss per unit area (tons/acre/specified design period),

R = Rainfall erosive index (100-ft-tons/acre x in/hr) (EI Value for given design period * average annual R Value)

K = Soil erodibility factor (tons/acre per unit R),

LS = Length-slope steepness factor (length is the slope distance from the point of origin of overland flow to the point of concentrated flow or until deposition occurs (dimensionless), and

CP = Control practice factor (dimensionless).

County's Construction WQ Regulations

2. Determine the weight density (**W**) of the specific soil
   - Use the equation or soil bore tests and/or the Greenville County Soil Survey provide a soil bulk density usually given in grams/cm^3
   - Convert (grams/ cm^3) to (lbs/ ft^3) by multiplying by 62.43
   - **W** = (bulk density in grams/ cm^3 x (62.43) = lbs/ft^3

3. Convert sediment yield from (tons/acre) to acre-feet of sediment storage ($\mathbf{V_s}$)
   - Determine the total disturbed area **DA** (acres)
   - Determine the sediment yield in tons,
     - Calculated by Multiplying **A** from Step 1. * **DA** from Step 3 (tons/acre * Acres = tons)
   - Convert tons to pounds to get $\mathbf{Y_D}$
   - $\mathbf{Y_D}$ = (tons) * (2000 lbs/ ton) = pounds
   - **Sediment Storage Volume** $\mathbf{V_s = Y_D / (W * 43{,}560)}$

County's Construction WQ Regulations

4. The design professional can now determine what level the required sediment storage corresponds to, and require a clean out marking stake to be installed at this elevation.

- The contractor shall be required to clean out the basin or trap when this level is reached.
- Or the designer can simply state that based on the calculations, the basin or trap will be required to be cleaned out on a time period basis such as weeks, months or years.

BMP Specifications and Details

Erosion Prevention Specifications

Specification Number	BMP Type
EC-01	Surface Roughening
EC-02	Bench Terracing
EC-03	Seeding / Stabilization
EC-04	RECP
EC-05	HECP
EC-06	Rip Rap Aggregate
EC-07	Outlet Protection
EC-08	Dust Control
EC-09	Transition Mat
EC-10	Slope Interruption Devices
EC-11	Compost
EC-12	Biological Growth Stimulant

Erosion Prevention

- The most effective sediment control is erosion prevention.

- The best way to prevent (stop) erosion is stabilization.

Seeding / Stabilization

Mulch	Applicable Slopes (H:V)[1]	Minimum Application Rate (lbs/acre -dry)[2]
Wood Chip	≤ 4:1	500 CY/acre
Straw or Hay with Tackifier	≤ 4:1	2,000
HECP Type 1	≤ 4:1	2,000
HECP Type 2	4:1< S ≤ 3:1	2,500
HECP Type 3	3:1< S ≤ 2:1	3,000
HECP Type 4	2:1< S ≤ 1:1	3,500
	>1:1	4,000 (temp cover only)[3]
Compost Mulch	≤ 2:1	200 CY/acre

1 The maximum allowable continuous slope length for all mulch applications is 50 feet. Slope interruption devices or TRMs are required for continuous slope length longer than 50 feet.

2 Strictly comply with the manufacturer's mixing recommendations for the actual slope steepness and the actual continuous slope length of the application.

3 HECP Type 4 may be used for permanent cover applications on slopes 1:1 or greater at a minimum rate of 4,500 pounds per acre.

Seeding / Stabilization

ECB and TRM APPLICATION TABLE

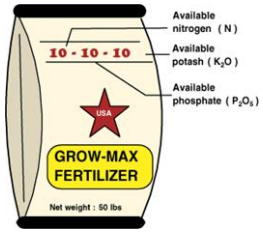
ECB/TRM Type[1]	Slope (H:V) [2]	Minimum Slope Length (ft)
Temporary ECB or Type 1 TRM	≤ 2:1	5
Type 2 TRM	≤ 1.5:1	5
Type 3 TRM	≤ 1:1	5

1 Strictly comply with the manufacturer's specifications.

2 The maximum allowable continuous slope length for ECBs is 50 feet. Slope interruption devices or TRMs are required for continuous slope length longer than 50 feet.

Seeding / Stabilization

- Simplified Seeding Schedule
- Detailed Seeding Schedule
- Soil Amendments
- Lime
  - Agricultural
  - Fast Acting
- Fertilizer
  - Use fertilizer that incorporates a minimum of 50% water insoluble (slow release) nitrogen. Animal by-product or municipal waste fertilizers are not acceptable under this Specification.
- Compost/Topsoil
- Biological Growth Stimulants



- Temporary Erosion Control Blanket ECB

Property	Temporary ECB
Functional Longevity[5]	Up to 12 months
Maximum Slope Application	2.0H:1V
Vegetation Establishment	200% min
Cover Factor[2]	C ≤ 0.05
Tensile Strength[3]	75 lb/ft
Shear Stress[4]	1.75 lb/ft^2

- Turf Reinforcement Matting TRM

Property	Test Method	Type 1	Type 2	Type 3
Performance				
Maximum Slope Application	Observed	2.0H:1V	1.5H:1V	1.0H:1V
Shear Stress[5]	ASTM D 6460	4.0	8.0	12.0

Hydraulic Erosion Control Products (HECPs)

4 Classes

- Type 1

- Type 2

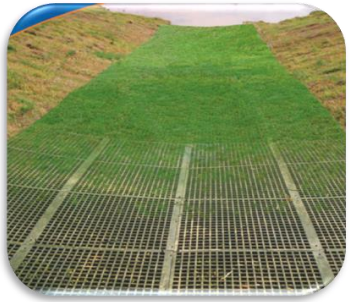
- Type 3

- Type 4

HECP Property	Test Method[1]	HECP Type 1	HECP Type 2	HECP Type 3	HECP Type 4
Physical					
Color	Observed	Colored to contrast application area, shall not stain concrete or painted surfaces.			
Organic Matter	ASTM D2974	90% minimum			
Water Holding Capacity	ASTM D7367	400% minimum	500% minimum	600% minimum	700% minimum
Acute Toxicity	ASTM 7101 EPA 2021.0-1	Non Toxic			
Endurance					
Functional Longevity	SCDOT Approved Testing Methods[4]	Up To 60 days	Up To 90 days	Up To 180 days	Up To 365 days
Performance					
Maximum Slope Application	Observed	**4.0H:1V**	**3.0H:1V**	**2.0H:1V**	**1.0H:1V**
Rainfall Event (R-factor)	ASTM D6459[2,3]	NA	75 < R	140 < R	175 < R
Cover Factor	ASTM D6459[2,3]	≤ 0.50	C ≤ 0.10	C ≤ 0.05	C ≤ 0.01
Vegetation Establishment	ASTM D7322[2]	200% minimum	300% minimum	400% minimum	500% minimum

Transition Mat

- Use Transition Mats as a permanent replacement for rock rip rap at culvert and pipe outlets, parking lot discharge areas, and overflow structures.



Transition Mat

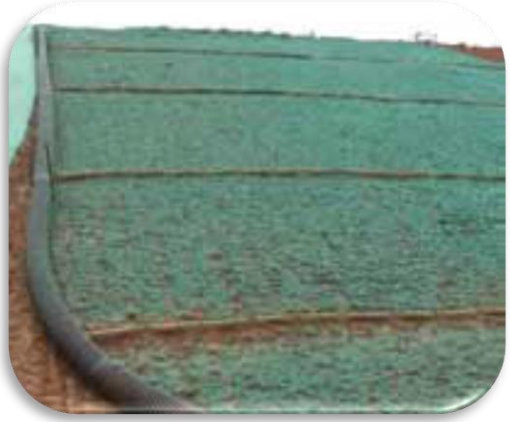
- Additional applications include stream bed protection, stream bank stabilization, and shoreline protection. Use in conjunction with soil anchors and appropriate soil cover to prevent erosion.
- Vegetation provides functional and aesthetic benefits, but is not required for transition mat performance.

Table 1: Reference Table

Pipe Diameter (inches)	Discharge (cfs)	Transition Mat Width x Length
12	8	4' x 4'
24	30	4' x 8'
36	75	8' x 12'
48	100	12' x 16'
60+	150	12' x 20'

Slope Interruption Devices

- Slope Interruption Devices are temporary devices placed along slopes to minimize concentrated flow from forming on the face of the slope.
- The maximum allowable continuous slope length for HECP (Hydraulic Erosion Control Products) and ECB (Temporary Erosion Control Blanket) applications is 50 feet. Provide Slope Interruption Devices for continuous slope length longer than 50 feet.



Slope Interruption Devices

- Maximum continuous slope length for straw and hay mulch, HECP, compost mulch, and ECB applications is 50 feet.

Compost

- Provide compost from compost producer that participates in United States Composting Council's (USCC) Seal of Testing Assurance (STA) program.
- Compost feedstock may include, but is not limited to, the following:
  - Leaf and yard trimmings
  - Food scraps
  - Treated biosolids
  - Manure
  - Agricultural residuals
  - Forest residuals
  - Tree wood
  - Bark
  - Paper

- Sediment Tubes
- Compost Mulch
  - Slopes up to 2H:1V and max continuous slope length of 50 ft. Sheet flow areas, Do not use on areas that receive concentrated flows.
- Compost Soil Amendment

Biological Growth Stimulant

- Provide biological growth stimulants for all permanent cover and temporary cover by seeding applications.
- Use biological growth stimulants that provide an immediate seedbed adjustment to help stimulate seed germination, improve the availability of nutrients to the plant, increase the number and depth of root development, and generate robust plant growth which is more tolerant of changes in environmental conditions
- Animal by-products or municipal waste products are not acceptable biological growth stimulants under this specification.
- Liquid fertilizers are not acceptable as biological growth stimulants under this specification.
- Provide biological growth stimulants composed of non-toxic materials.

Sediment Control Specifications

Specification Number	BMP Type
SC-01	Surface Outlet and Baffle Sediment Basin
SC-02	Sediment Trap
SC-03	Silt Fence
SC-04	Rock Ditch Check
SC-05	Sediment Tube Ditch Check
SC-06	Construction Entrance
SC-07	Storm Drain Inlet Protection
SC-08	Rock Sediment Dike
SC-09	Construction DeWatering
SC-10	Floating Skimmer
SC-11	Porous Baffles
SC-12	Perimeter Control for Small Sites
SC-13	Polymer / Coagulant / Flocculant
SC-14	Concrete Washout

Sediment Basin

- Description:
  - Used for drainage areas 5 acres and larger
  - Designed to capture sediment from storm water runoff before it leaves construction site.
  - Constructed before any grading takes place within drainage area.
  - Dewatering achieved through riser and pipe leading to outlet on downstream side of embankment

Sediment Basin

- Important Design Considerations:
  - Sediment Storage
    - Use Universal Soil Loss Equation to determine soil loss
    - Convert soil loss to volume
    - Ensure basin has the required sediment storage
    - Calculate proper maintenance schedule

Surface Outlet and Baffle Sediment Basin

Temporary:

- Do not require peak flow reduction to pre-development conditions with no perforations in the Primary Riser structure.
- Implements three spillway devices:
    1. Primary Riser Spillway, solid riser with no staged discharges or low flow orifices connected to an Outflow Barrel.
    2. **Floating Skimmer** attached to bottom of the Primary Riser dewatering the runoff volume below top elevation of Primary Riser in a time period ranging between 24 to 72 hours.
    3. Stabilized Emergency Spillway that safely passes the 100-year 24-hr storm event with a minimum 1.0-foot of freeboard.

Surface Outlet and Baffle Sediment Basin

- Multipurpose:
  - Require peak flow reduction to keep the 2-year 10-year, and 25-year 24-hour storm disturbed-state peak flow rates from the Basin less than or equal to the pre-disturbance peak flow rates with orifices and weirs incorporated into the Primary Riser structure.
  - Ensure that all Multipurpose Surface Outlet and Baffle Sediment Basins are designed in accordance with Chapter 7 of the Design Manual and the Post Construction Dry Pond Specifications and Post Construction Wet Pond Specification.

Surface Outlet and Baffle Sediment Basin

- Forebays:
  - Sediment Basins that will be converted to permanent detention basins require forebays.
  - The function of the forebay is to trap the majority of the coarse fractions of the suspended solids in the runoff before it enters the main dry detention area.

Surface Outlet and Baffle Sediment Basin

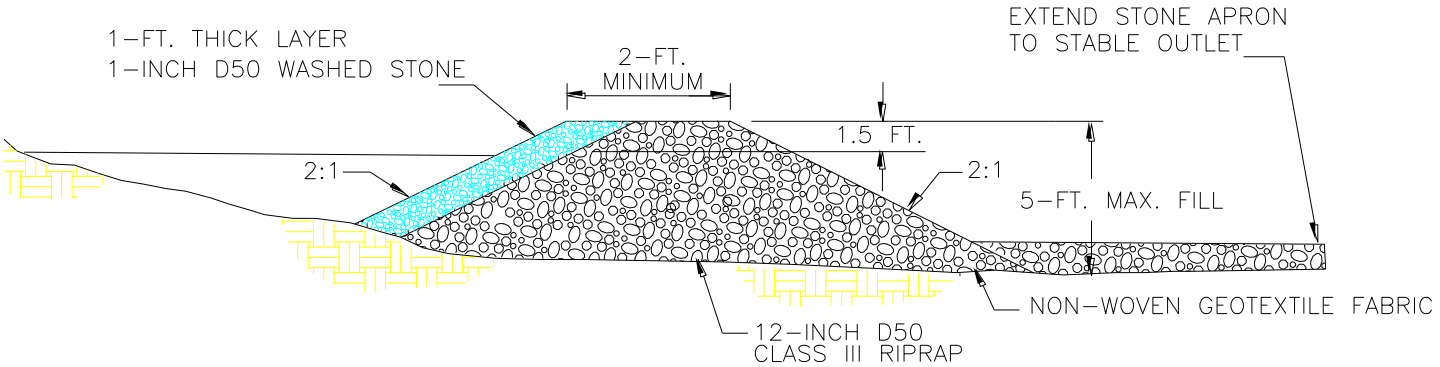
- Forebays:
  - When sizing permanent detention basins to capture post construction 85% of TSS based on annual loading, the forebay will include approximately 75 percent of the required sediment storage volume based on a minimum cleanout cycle of 5 years.
  - Each Forebay is sized according to the outlets contribution to the basin.
  - Provide a forebay for all inlets to a detention basins and place forebays upstream of the main detention.

Surface Outlet and Baffle Sediment Basin

- Forebays:
  - A forebay is not required for an outlet that contributes less than 10% of the total drainage area or to the basin.
  - Design forebay side slopes to be 2H:1V or flatter.
  - The forebay is separated from the larger detention basin area by berms, barriers, or baffles that may be constructed of earth, stones, riprap, gabions, or geotextiles. The berm, barrier, or baffles act as a trap for coarse sediments and minimize their movement into the main detention basin.
  - Design the forebay in a manner that it is accessible for easy cleanout because it will eventually fill in with coarse particles.
  - Design the access to the forebay with a maximum slope of 15-20 percent extending from the top of the embankment to the toe.

Sediment Trap

- Description:
  - Formed by excavating pond or by placing earthen embankment across low area or drainage swale.
  - An outlet or spillway is constructed using No. 5 or No. 57 washed stone and Class A or Class B riprap aggregate.



Sediment Trap

- Planning Considerations:
  - — Applicable for drainage areas less then 5 acres
  - — Used for Sediment Control
  - — A small, temporary basin formed with an embankment.
  - — Dimensions
    - Length to width ratio > 2:1
    - Avoid short-circuiting
  - — Life of 18 months.
  - — Outlet structure is usually rock.

Sediment Trap

- Stage Discharge:
  - Utilize equations and spreadsheets to calculate stage discharge
  - In addition to surface area, settling velocity and peak flow, additional inputs include:
    - Stone Diameter
    - Rock Outlet Dimensions
      - Flow length
      - Flow width
      - Side slopes

Silt Fence

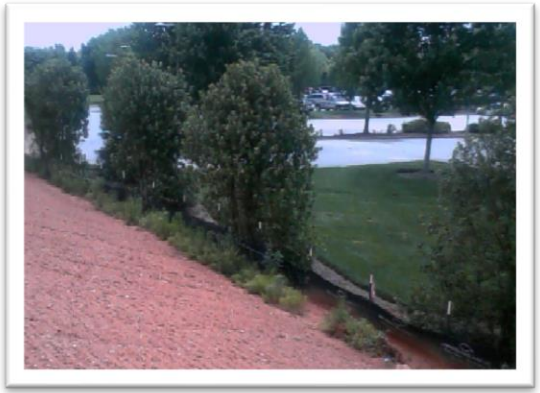
- Purpose:
  - Temporary perimeter control where there will be soil disturbance resulting from construction activities.
  - Serves as a fabric dam where water is temporarily ponded from sheet or shallow overland flow
    - Allows sediment to settle behind dam for later removal
    - Water passes through or over top before leaving site

Silt Fence

- Installation:
  - Place fence perpendicular to flow direction.
  - Install fence at proper distance from toe of steep slopes to provide sediment storage and access for maintenance and cleanout.
  - Can be single or double rows

Silt Fence

- Design Rule of Thumbs:
  - 100 ft max. slope length
  - 2H:1V max. slope to silt fence
  - 0.5 cfs per 100 ft max. sheet flow for design storm
  - 0.25 acres per 100 ft max. drainage area
  - Silt fence shall not overtop for design storm
  - Min installed fabric height – 18 in
  - Max installed fabric height – 24 in
  - Min space between silt fence and creek or wetland – 10 ft
  - Tie backs or J-hooks every 100-ft



Silt Fence

- Design Rule of Thumbs:
  - Never place silt fence in concentrated flows
    - Ditches
    - Channels
    - Creeks

Silt Fence

- For entire state of South Carolina, **only 26%** of all soil types are capable of achieving 80% trapping with properly installed silt fence, which is equivalent to 26% of the land area in SC.
  - 70% of HSG A soil types capable of achieving 80% trapping, equivalent to 71% of the area of HSG A soils in SC.
  - 28% of HSG B soil types capable of achieving 80% trapping, equivalent to 21% of the area of HSG B soils in SC.
  - 13% of HSG C soil types capable of achieving 80% trapping, equivalent to 14% of the area of HSG C soils in SC.
  - 25% of HSG D soil types capable of achieving 80% trapping, equivalent to 26% of the area of HSG D soils in SC.

Silt Fence

- For Upper State, **only 18%** of all soil types are capable of achieving 80% trapping with properly installed silt fence, which is equivalent to 3% of the land area in the Upper State.
  - 58% of HSG A soil types capable of achieving 80% trapping, equivalent to 56% of the area of HSG A soils in Upper State.
  - 16% of HSG B soil types capable of achieving 80% trapping, equivalent to 2% of the area of HSG B soils in Upper State.
  - 7% of HSG C soil types capable of achieving 80% trapping, which equivalent to 0.6% of the area of HSG C soils in Upper State.
  - 15% of HSG D soil types capable of achieving 80% trapping, equivalent to 7% of the area of HSG D soils in Upper State.

Sediment Tube Ditch Check

- Sediment tubes for ditch checks are temporary erosion control devices for use along contours and in drainage conveyance swales to reduce the erosive forces of stormwater runoff.

Property	Test Method	Value
Pre-installed Tube Diameter	Field Measured	18.0-inch minimum 24.0-inch maximum

Slope (%)	Maximum Sediment Tube Spacing (feet)
< 2	150
2	100
3	75
4	50
5	40
6	30
> 6	25

Storm Drain Inlet Protection

- Type A Low Flow Inlet Filters
  - Inlets with **peak flow rates < 1 cfs**, the inlet drain area grade is less than 5%, and the immediate drainage area (5-foot radius around the inlet) grade is less than 1%.
- Type B Medium Flow, Low Velocity Inlet Filters
  - Inlets with **peak flow rates < 3 cf**s, the inlet drain area grade is less than 5%, and the flow velocity to the inlet does **not exceed 3 ft/sec**.
- Type C Medium Flow, Medium Velocity Inlet Filters
  - Inlets with **peak flow rates less than 3 cfs**, inlet drain area grades less than 5%, and the flow velocity to the inlet does **not exceed 5 ft/sec**.
- Type D High Flow, High Velocity Inlet Filters
  - Drainage areas up to 2 acres, for inlets where **peakflow rates may exceed 3 cf**s, the inlet drain area grade may exceed 5%, and the flow velocity to the inlet **may exceed 3 ft/sec**.

Storm Drain Inlet Protection

- Type E- Surface Course Curb Inlet Filters
  - Protect Catch Basins after the road surface course is placed.
- Type F- Inlet Tubes (are classified in two categories: weighted inlet tubes and non-weighted inlet tubes.)
  - Use non-weighted Type F inlet tubes with drainage areas **< 1 acre** where stakes or posts can be driven.
  - Place on subgrade and are applicable until the road base course is placed.
  - Place weighted Type F inlet tubes on gravel, concrete, asphalt or other hard surfaces around drainage inlets where stakes cannot be driven.
- Type G - Suspended Internal Inlet Filters
  - Inlets with drainage areas **< 1 acre** and peak flow rates to the inlet **< 3 ft^3/sec**.

Storm Drain Inlet Protection

- Type A Low Flow Inlet Filters

- Type B Medium Flow, Low Velocity Inlet Filters

Storm Drain Inlet Protection

- Type D High Flow, High Velocity Inlet Filters

- Type E- Surface Course Curb Inlet Filters

Storm Drain Inlet Protection

- Type F -Inlet Tubes

Weighted

Non- Weighted

Type F - Slope Interrupters

Storm Drain Inlet Protection

- Type G -Suspended Internal Inlet Filters

Construction DeWatering

- Perform construction site Dewatering operation by using one of the following methods:
  1. Dewatering Bags.
  2. Pumping directly to a sediment treatment BMP such as a sediment trap or sediment basin
  3. Pumping to a vegetated filter strip (using a level spreader or hose discharge dissipation device).

Floating Skimmer

- Designed to completely dewater sediment basins from top of riser elevation in 24 to 72 hours.
- Excavate a shallow pit filled with riprap under the Floating Skimmer to account for sediment that accumulates on the sediment basin bottom around the skimmer.
  - Pit allows the skimmer to completely drain the basin.
  - At a minimum, the pit has dimensions of 4ft x 4ft with a minimum depth of 2 ft. Ensure the bottom of the pit is lower than the invert of the outlet barrel from the riser.

Porous Baffles

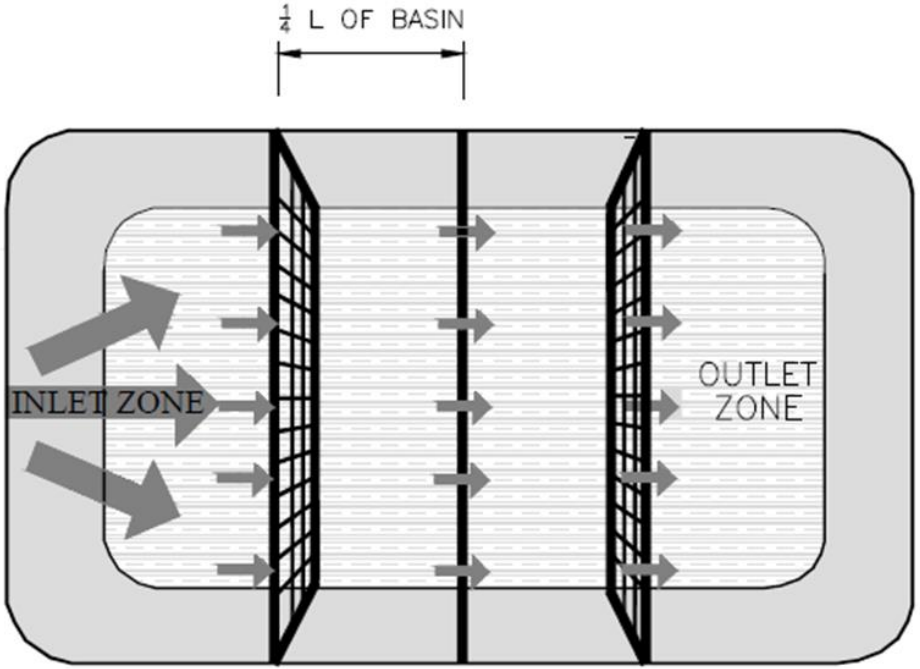
- Used inside sediment traps and sediment basins to reduce velocity and turbulence of water flowing through structure by spreading flow across entire width of basin (allow 0% dead space in design).
- Place at least 1 row of Baffles between Primary Riser structure and all pipes or channels discharging to Basin.
- Baffles may consist of Porous Baffles, or Riprap Baffles.

Porous Baffles

- Install 4-foot high Riprap Baffles consisting of Class A or B Riprap. Do not place washed stone on the face of the Riprap Baffles.
- Baffle Height as directed by the Design Engineer,
  - Height based on the 10-yr 24-hr design water surface elevation.
  - In no case will Baffle material height be higher than primary spillway.

Porous Baffles

- Install 3 rows of Baffles with a spacing of ¼ the basin length for Basins greater than 25 feet in length.



Perimeter Control

- Perimeter Control for Small Sites is used as a temporary sediment control practice around the perimeter of relatively flat (slopes ≤ 5H:1V) small sites (< 1 disturbed acre) and individual single lots where there will be soil disturbance due to construction activities.
- Maximum allowable slope length drainage to Perimeter Control is 100 feet.

Table 1: Minimum Perimeter Control Performance Requirements

Physical Property*	Test Method	Required Value
Height or Diameter	Measured	9-inch Min.
Filtering Efficiency Performance	ASTM D7351 or Equivalent	80% Total Suspended Solids (TSS)
Primary Material or Netting Ultraviolet Stability (retained strength after 500 hrs of ultraviolet exposure)	ASTM D 4355	70%

Concrete Washout

- Designed to minimize or eliminate the discharge of concrete waste materials to storm drain systems or to waterbodies.
- Located a minimum of 50 ft from storm drain inlets, open drainage facilities, waterbodies, creek banks, or perimeter control unless determined infeasible by the Design Engineer.
- Each facility should be located away from construction traffic or access areas to prevent disturbance or tracking.
- A sign should be installed within 30 feet each washout facility to inform concrete equipment operators to utilize the proper facilities.

Runoff Conveyance Specifications

Specification Number	BMP Type
RC-01	Pipe Slope Drain
RC-02	Subsurface Drain
RC-03	Runoff Conveyance Measures
RC-04	Stream Crossing

2016 BMP Audit

2016 BMP Audit Background

- Greenville County is required by its NPDES Permit to develop and implement a Construction Site Program to reduce erosion and sedimentation.
- New Construction General Permit was effective January 1, 2013.
- Greenville County has performed audits every 4-6 years since 2001 to assess and improve the Program.

Background and Previous Audits

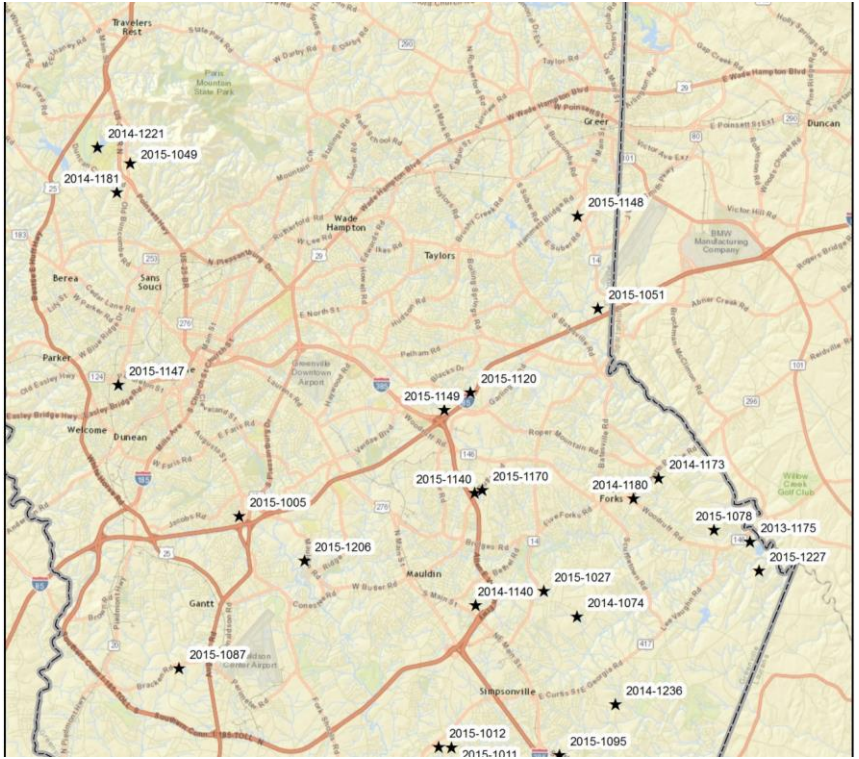
Previous Audits:

- Greenville County's 2001 EPSC Audit
- Greenville County's 2006 EPSC Audit
- SCDHEC's 2009 Stormwater Program Audit
- Greenville County's 2010 EPSC Audit

Audit Process

Site Selection:

- 72 potential active projects available
  - Classification
    - Single Family, Multi Family, Commercial, Industrial, Institutional
  - Size (Disturbed Area)
    - <1 ac, 1-10 ac, 10-25 ac, 25+ ac
  - BMPs present on site
  - Geographical location
  - Stages of construction
- 32 representative sites were randomly selected



Audit Process

Data Collection:

- General site data
- BMP specific data
  - 753 BMPs total
  - 24 BMPs/site average
- Consistency with previous audits
- Most common on individual home sites:
  - Silt Fence
  - Construction Entrance
  - Rock Ditch Check
  - Sediment Tube Ditch Check
  - Storm Drain Inlet Protection
  - Seeding/Stabilization

BMP Name	Number Audited
SC-01 Surface Outlet and Baffle Sediment Basin (or Multipurpose Basin)	28
SC-02 Temporary Sediment Trap	8
SC-03 Silt Fence*	180
SC-04 Rock Ditch Check	41
SC-05 Sediment Tube Ditch Check	9
SC-06 Construction Entrance	43
SC-07 Storm Drain Inlet Protection*	230
SC-08 Rock Sediment Dike	0
SC-09 Construction DeWatering*	1
SC-10 Floating Skimmer	26
SC-11 Porous Baffles	29
SC-12 Perimeter Control for Small Sites	0
SC-13 Polymer/Coagulant/Flocculant	0
SC-14 Concrete Washout	4
SC-XX Sediment Controls- Other	12
EC-01 Surface Roughening*	6
EC-02 Bench Terracing	0
EC-03 Seeding Stabilization*	33
EC-04 Rolled Erosion Control Products (RECPs)*	16
EC-05 Hydraulic Erosion Control Products (HECPs)	6
EC-06 Riprap or Aggregate	6
EC-07 Outlet Protection	34
EC-08 Dust Control	0
EC-09 Transition Mats	0
EC-10 Slope Interruption Devices	2
EC-11 Compost	0
EC-12 Biological Growth Stimulant	0
EC-XX Mulching	0
RC-01 Pipe Slope Drain	3
RC-02 Subsurface Drain	0
RC-03 Runoff Conveyance Measures*	34
RC-04 Stream Crossing	1
RC-XX Pump Around	0
WQ-13 Level Spreader	1
Total	**753**

Database and Scoring

Two scores were developed for each of the 32 sites:

- **Site Overall Score**
  - Based on data about site as a whole
- **Site BMP Score**
  - Average of individual scores for each type of BMP on site

Results: Site Scores

- Site Overall Scores:
  - 43% to 100%
  - Average of 75%
- Site BMP Scores:
  - 61% to 83%
  - Average of 72%

Project No.	Project Name	Site Overall	Site BMP
2013-1175	HAWTHORNE RIDGE SUBDIVISION (OLD PERMIT 06-6358)	95%	73%
2014-1003	AMBER OAKS FARM, PH 2 (SW/RD COMBO REVIEW - 75 LOTS)	71%	78%
2014-1074	HARTS COVE (STORMWATER & ROAD COMBO REVIEW)	67%	76%
2014-1123	LAUREL GROVE PHASE 2	52%	75%
2014-1140	BROOKWOOD TOWNES, PHASE II	67%	73%
2014-1180	TOWNES @ FIVE FORKS (FORMERLY KNOWN AS: THE MCDONALD TRACT)	67%	71%
2014-1181	HOLMES BIBLE COLLEGE	95%	68%
2014-1221	FURMAN LAKESIDE HOUSING	76%	72%
2014-1236	OAKS AT FOWLER	43%	71%
2015-1005	OUR LADY OF THE ROSARY	71%	66%
2015-1011	LONGLEAF (GRIFFIN-KNIGHTEN TRACT)	81%	72%
2015-1012	VILLAS (THE) AT WEST GEORGIA (AKA: BRIAR RIDGE S/D)	95%	77%
2015-1027	VILLAGE (THE) AT ADAMS MILL	71%	68%
2015-1028	ZAXBYS	67%	61%
2015-1049	PARIS MOUNTAIN BAPTIST CHURCH	86%	67%
2015-1051	MARLEY LILLY	90%	83%
2015-1072	SADDLEHORN SUBDIVISION SECTION 3 - (SW/RD COMBO REVIEW)	52%	70%
2015-1078	LOCKELAND PARK SUBDIVISION - (SW/ROAD COMBO REVIEW)	86%	70%
2015-1087	ROY METAL EXPANSION - (PART OF LCP # 12-1055 [MATRIX])	52%	69%
2015-1095	UPSTATE PODIATRY	100%	74%
2015-1100	FIRETHORNE SUBDIVSION (SW/RD COMBO REVIEW)	52%	67%
2015-1120	OAK GROVE ESTATES SUBDIVISION - (SW/ROAD REVIEW)	57%	78%
2015-1138	GREYMIST SUBDIVISION (SW/ROAD REVIEW - 6 LOTS)	90%	75%
2015-1140	QUIKTRIP #1135	86%	77%
2015-1141	HARRISON BRIDGE CENTER PHASE 2 - PLANET FITNESS	90%	74%
2015-1147	BRANDON MILL	71%	65%
2015-1148	PELHAM BATESVILLE FIRE STATION #2	95%	81%
2015-1149	BLE EXPANSION	62%	64%
2015-1170	RESTAURANT DEPOT	43%	51%
2015-1197	FAIRVIEW SELF STORAGE EXPANSION	67%	67%
2015-1206	LEAD ACADEMY CHARTER SCHOOL - (PART OF #15-1192)	90%	80%
2015-1227	EAST GEORGIA ROAD WEDDING BARN	95%	76%

Results: Site Scores

Comparison of 2016 Site Overall and BMP scores to previous audits:

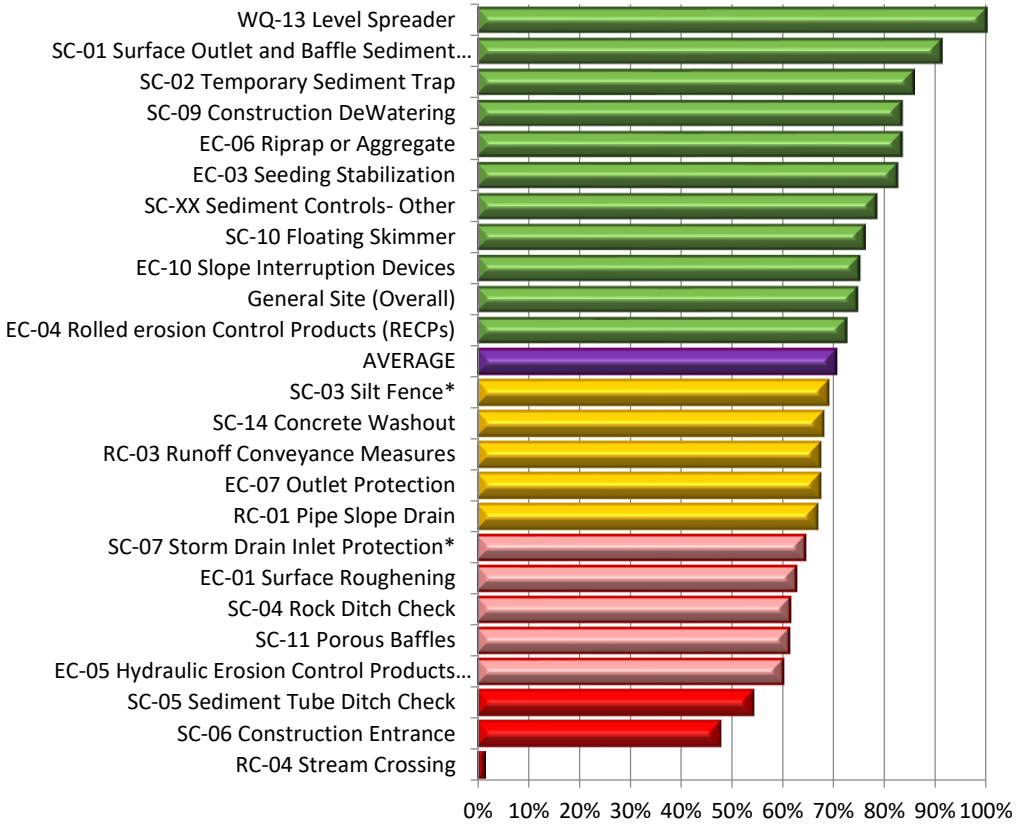
Note: Scores are relative to each other, NOT typical A-B-C-D grades.

Audit Year	Average Site Overall Score	Average Site BMP Score
2016	75%	72%
2010	73%	66%
2006	69%	75%
2001	56%	61%

Economy in 2010 was bad for development, bad for BMPs.

Results: Overall Individual BMP Scores

Overall BMP Score: Average score for each type of BMP audited



Results and Recommendations:

The Good, The Bad, and The Ugly

The Good:

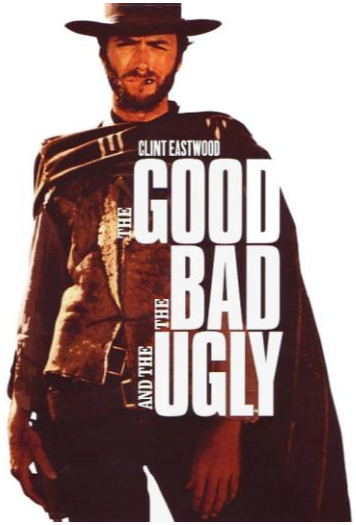
- Correct application, installation, and maintenance
- Functioning to protect water quality

The Bad:

- Incorrect application, installation, or maintenance
- Potential for off-site impacts

The Ugly:

- Serious problems with application, installation, or maintenance
- Failure of BMP or off-site impacts



Results and Recommendations

The Good

SC-01 Surface Outlet and Baffle Sediment Basin

Results and Recommendations

The Good

SC-02 Sediment Trap

Results and Recommendations

The Good

EC-06 Riprap Aggregate

Results and Recommendations

The Good

EC-03 Seeding/Stabilization

Results and Recommendations

The Good

EC-03 Seeding/Stabilization

Results and Recommendations

The Good

SC-10 Floating Skimmer

Results and Recommendations

The Good

SC-10 Floating Skimmer

Results and Recommendations

The Bad

SC-10 Floating Skimmer

Results and Recommendations

The Ugly

SC-10 Floating Skimmer

Results and Recommendations

The Ugly

SC-10 Floating Skimmer

Results and Recommendations

The Good

SC-11 Porous Baffles

Results and Recommendations

The Good

SC-11 Porous Baffles

Results and Recommendations

The Bad

SC-11 Porous Baffles

Results and Recommendations

The Bad

SC-11 Porous Baffles

Results and Recommendations

The Ugly

SC-11 Porous Baffles

Results and Recommendations

The Good

SC-07A Type A Inlet Protection – Filter Fabric

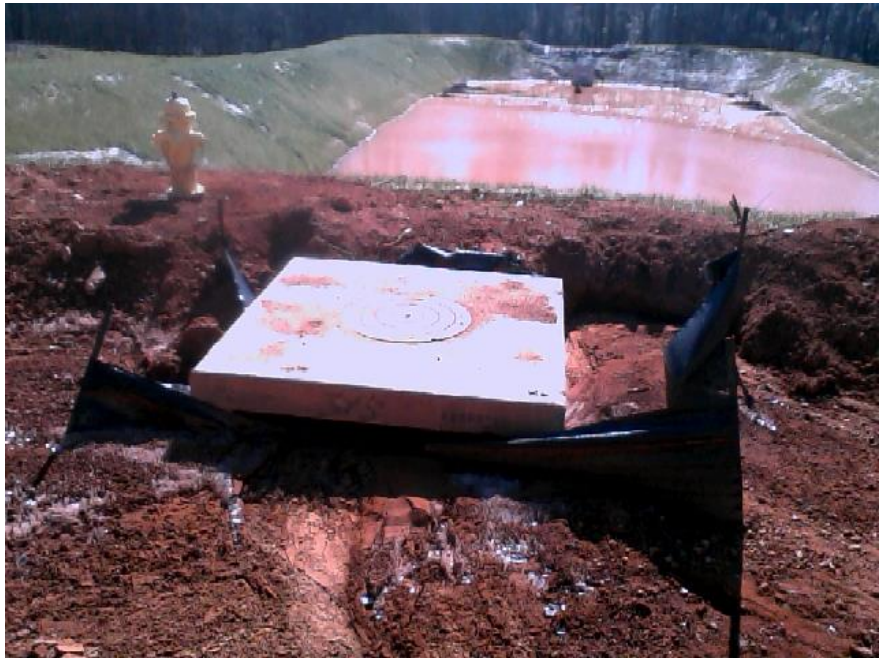
Results and Recommendations

The Bad

SC-07A Type A Inlet Protection – Filter Fabric

Results and Recommendations

The Bad



SC-07A Type A Inlet Protection – Filter Fabric

Results and Recommendations

The Ugly

SC-07A Type A Inlet Protection – Filter Fabric

Results and Recommendations

The Bad

SC-07A Type A Inlet Filter – Sediment Tube

Results and Recommendations

The Ugly

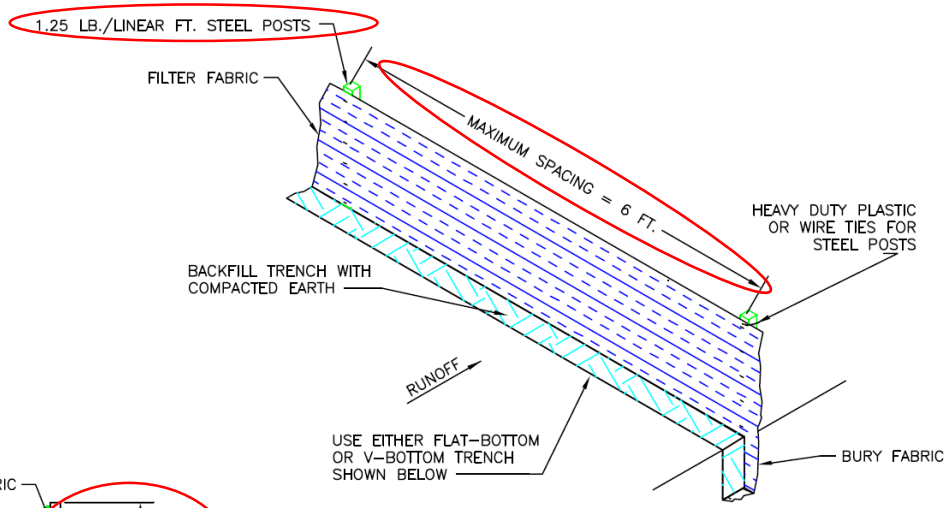
SC-07A Type A Inlet Filter – Sediment Tube

Results and Recommendations

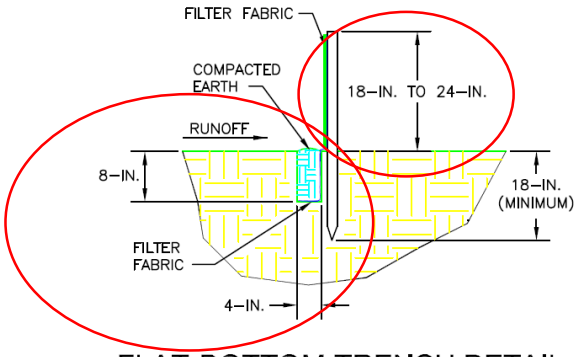
The Good

SC-03 Silt Fence

Greenville County Silt Fence Detail



SILT FENCE INSTALLATION



FLAT-BOTTOM TRENCH DETAIL

Greenville County
Storm Water Management

SILT FENCE

STANDARD DRAWING NO. SC-03A Page 1 of 2

APPROVED BY: GREENVILLE COUNTY STORM WATER MANAGEMENT

DATE: January, 2013

Results and Recommendations

The Bad

SC-03 Silt Fence

Results and Recommendations

The Bad

SC-03 Silt Fence

Results and Recommendations

The Ugly

SC-03 Silt Fence

Results and Recommendations

The Ugly

SC-03 Silt Fence

Results and Recommendations

The Good

SC-06 Construction Entrance

Results and Recommendations

The Bad

SC-06 Construction Entrance

Results and Recommendations

The Bad

SC-06 Construction Entrance

Results and Recommendations

The Ugly

SC-06 Construction Entrance

Results and Recommendations

The Good

SC-04 Rock Ditch Check

Results and Recommendations

The Bad

SC-04 Rock Ditch Check

Results and Recommendations

The Bad

SC-04 Rock Ditch Check

Results and Recommendations

The Ugly

SC-04 Rock Ditch Check

Results and Recommendations

The Good

SC-05 Sediment Tube Ditch Check

Results and Recommendations

The Bad

SC-05 Sediment Tube Ditch Check

Results and Recommendations

The Ugly

SC-05 Sediment Tube Ditch Check

Conclusions and Next Steps

Conclusions:

EPSC practices have generally improved over time since the first audit in 2001.

There is room for improvement:

- Porous Baffles and Floating Skimmers in Ponds
- Inlet Protection
- Ditch Checks
- Construction Entrances
- Silt Fence

Next Steps:

Education of installers and maintenance personnel

Evaluating new and innovative EPSC products

Updating County Specifications and Design Manual

Future Audits to track progress and identify areas to improve

Post-Construction

Agenda for Post Construction

12:30	Hydrology and Water Quality Constituents
1:00	Peak Flow Control and Permanent WQ Treatment
1:30	Overview of County's Regulations
2:00	**BREAK**
2:15	BMP Specs and Details
2:45	Introduction to IDEAL Model
3:15	Message from Greenville County

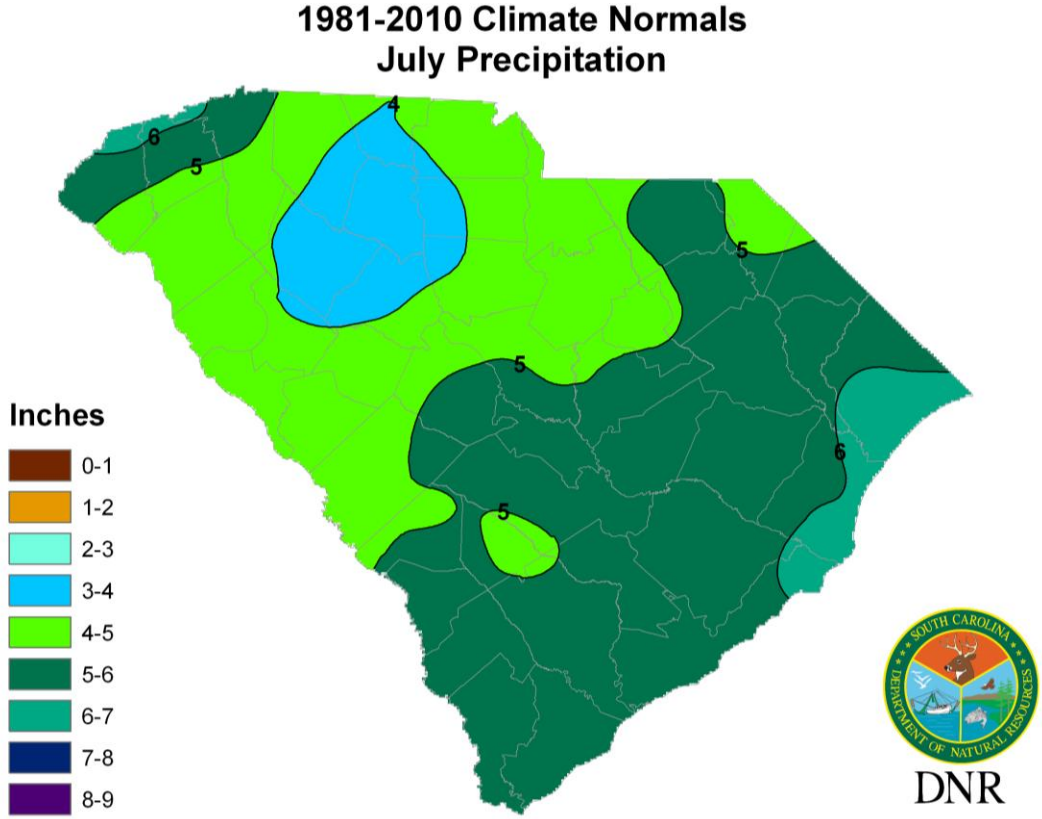
Hydrology & Water Quality Constituents

Calculating Runoff

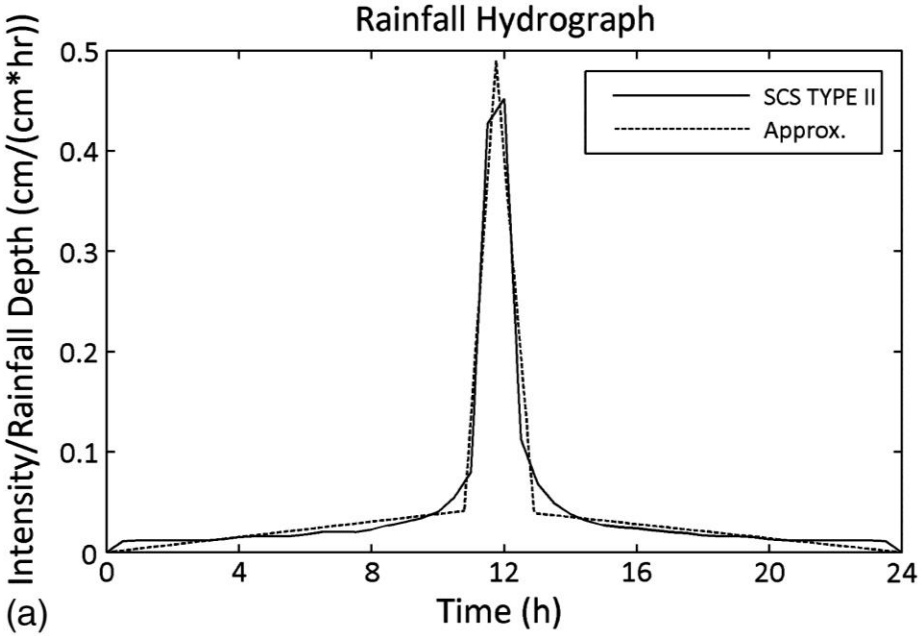
Four components of NRCS method:

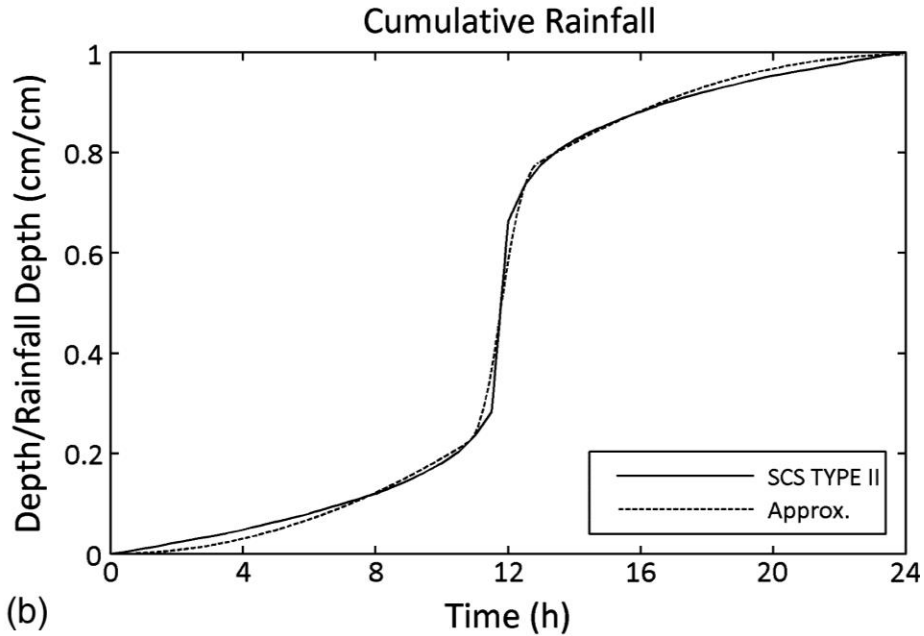
1. Rainfall magnitude and distribution
2. Time of concentration (TOC)
3. Runoff curve number (CN)
4. Dimensionless unit hydrograph

Rainfall Magnitude

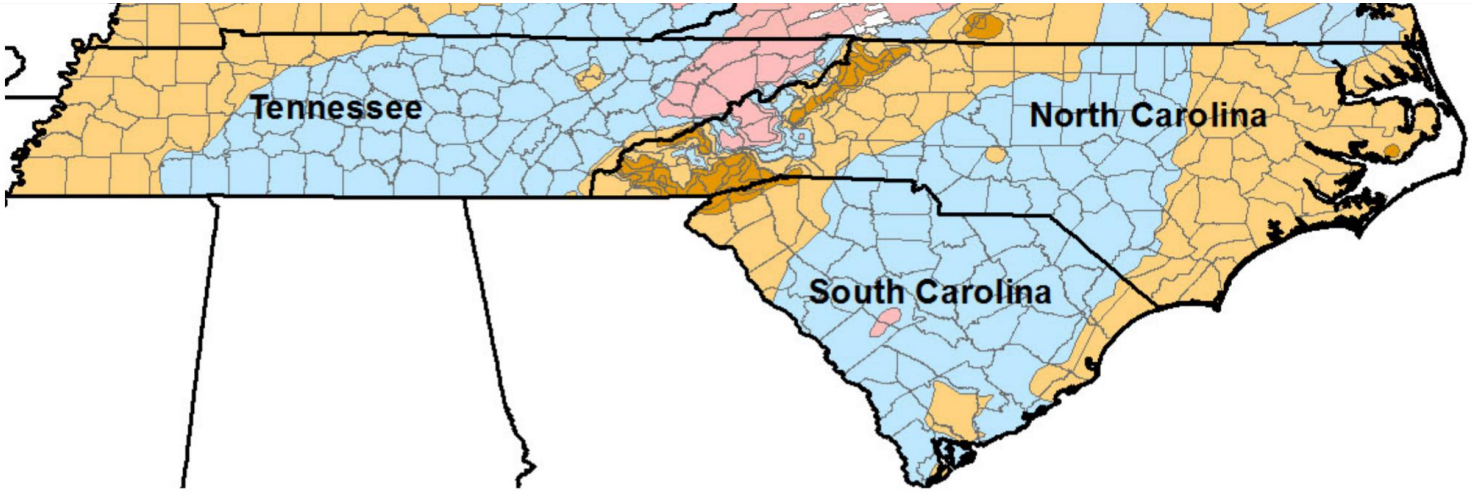


SCS Rainfall Distribution



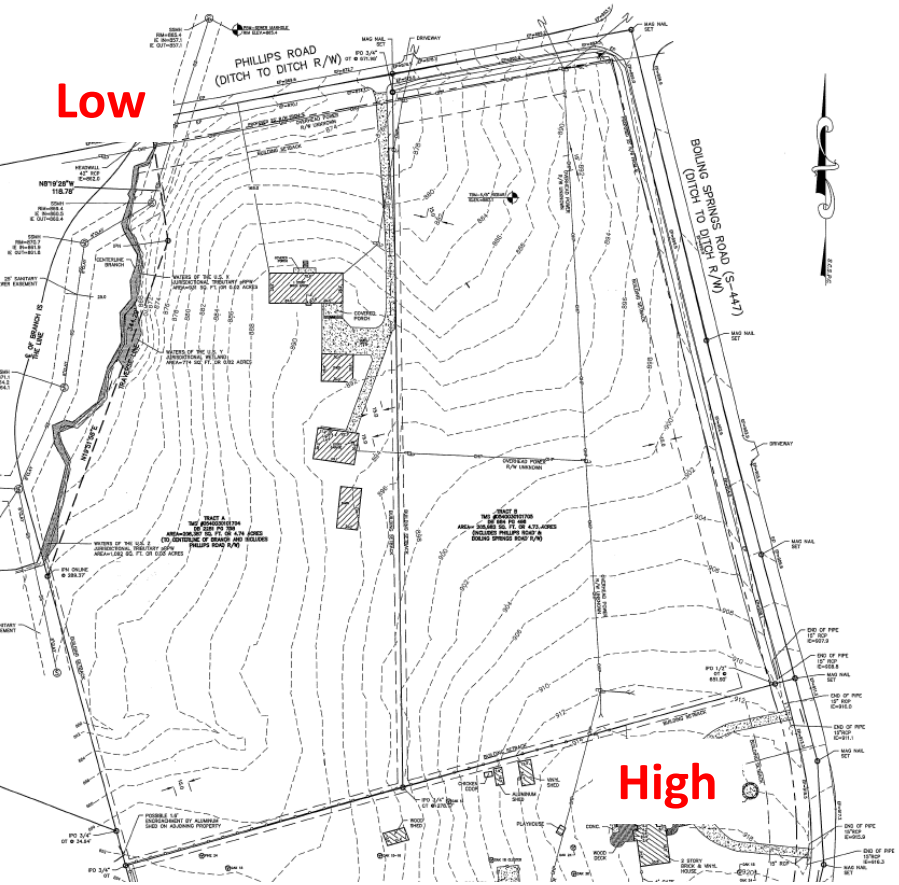


New Rainfall Distributions



RF_Region
- A
- B
- C
- D
- Undefined

Time of Concentration

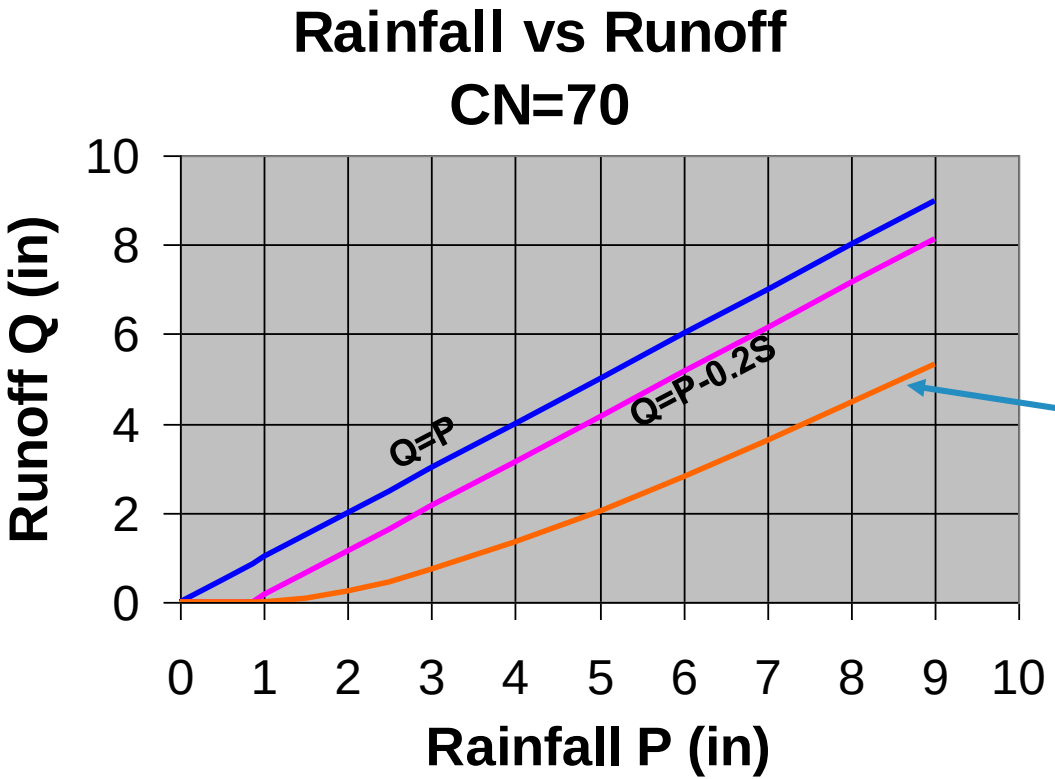


- Try multiple flow paths
- Use longest flow path
- Calculate using TR-55
  - Sheet flow (topography or max flow length)
  - Shallow concentrated flow
  - Channel/pipe flow
- Stop at outlet or other “end point”

Curve Number (CN)

- Used to calculate rainfall excess
  - Rainfall minus abstractions
- Abstractions
  - Infiltration (soil compaction, soil type, vegetation)
  - Interception and ET
  - Depression and detention storage
  - Karst, wetlands

CN Method



$$Q = \frac{(P - 0.2S)^2}{P + 0.8S}$$

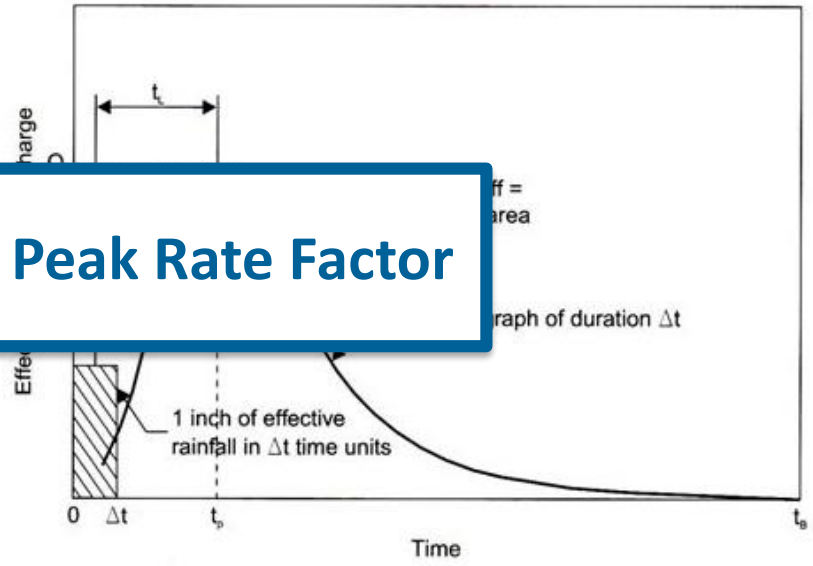
$$S = \frac{1000}{CN} - 10 \qquad 0 < CN < 100$$

Hydrograph

$$Q_{up} = \frac{484A}{t_p}$$

Q_{up} is peak 'unit' runoff, in ft³/s per inch of total runoff; *A* in mi², t_p in hr; for units of m³/s per km², and hr, coefficient is 2.08

484 = Peak Rate Factor



$$t_p = \frac{D_{rain}}{2} + t_L$$

$$t_L = 0.6t_c$$

To develop unit hydrograph for desired duration, multiply values on *x* and *y* axes of standard, dimensionless SCS hydrograph by t_p and Q_{up}, respectively. (Applicable for $D \leq t_c/6$.)

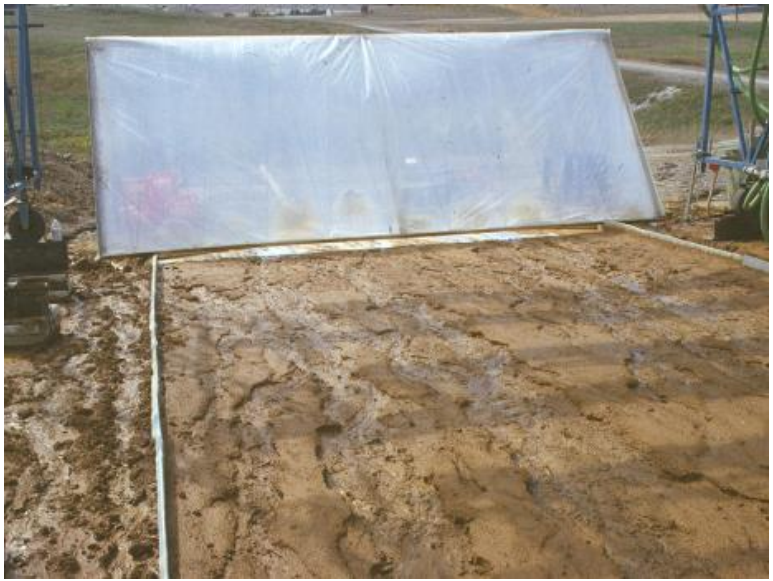
Water Quality Constituents

- Sediment
- Total Nitrogen
- Total Phosphorus
- Bacteria
- Metals
- Hydrocarbons
- Others…

Erosion

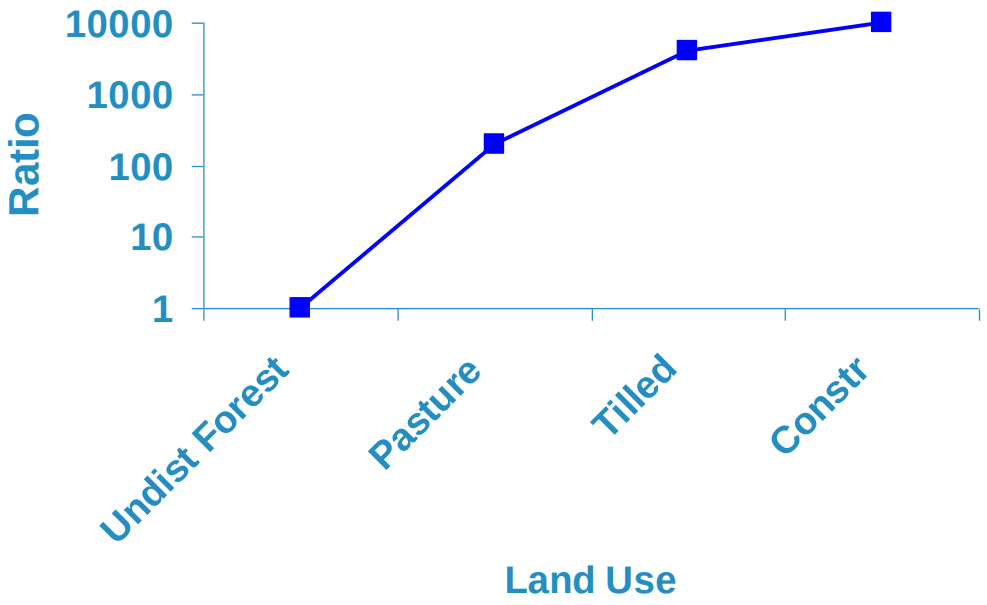
Erosion Models: Statistically Based
Late 50's – Mid 70's

- Musgrave equation
- USLE/RUSLE
    - A=RKLSCP
- RUSLE
    - USLE Revisited
    - Use subfactors to cover many more specific conditions
    - $C = C_1C_2C_3C_4$…..
- MUSLE



Ratio of Sediment Production

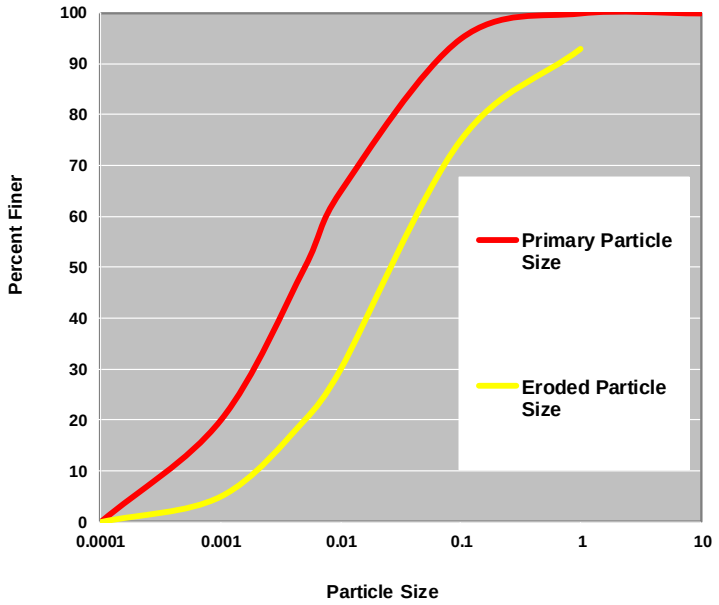
Changed LU/Undisturbed Forest



Sediment Size Distribution

- Eroded size distribution needed to predict transport and BMP effectiveness

- Methods available:
  - CREAMS based model
  - Empirical study



Eroded Size Distribution

- Aggregates and Primary particles – What's the difference?
- Settling velocities
- Chemicals and bacteria sorb to primary clay particles and particles in aggregates

Representative Diameters

	Size	Time to settle 1 foot
Large Aggregate	0.300 mm	15 seconds
Sand	0.200 mm	16 seconds
Small Aggregate	0.060 mm	11 minutes
Silt	0.010 mm	1 hour
Clay	0.002 mm	1+ day

- Can't see clay particle, even at this scale (~ 1:100)

Nutrients

- Chemical/Nutrient loading - equilibrium chemistry
- Relationships
    - Particulates
    - Dissolved chemicals
    - Sorbed chemicals

Nutrient EMCs

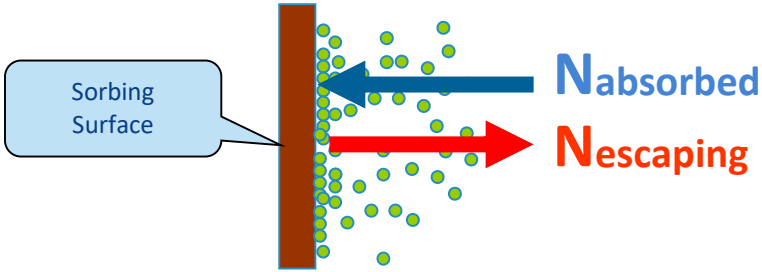
Calculates nitrogen and phosphorus loading based on user input of landuse or custom EMC

$$M_k = Q\ EMC_k\ Const$$

- M_k: Mass of Nutrient k (lbs)
- Q: Runoff Volume (cu ft)
- EMC_k: Event Mean Concentration of nutrient k (mg/liter)
- $Const$: Unit conversion constant

Isotherms

- Distributes nutrients between sorbed and dissolved states
- Assumes equilibrium



Equilibrium is when
$N_{escaping} = N_{absorbed}$

Bacteria Loading

- Fecal coliform and e. Coli
- Landuse-based
- Impact of wildlife

Approaches to Improving Permanent Water Quality

Improving Water Quality

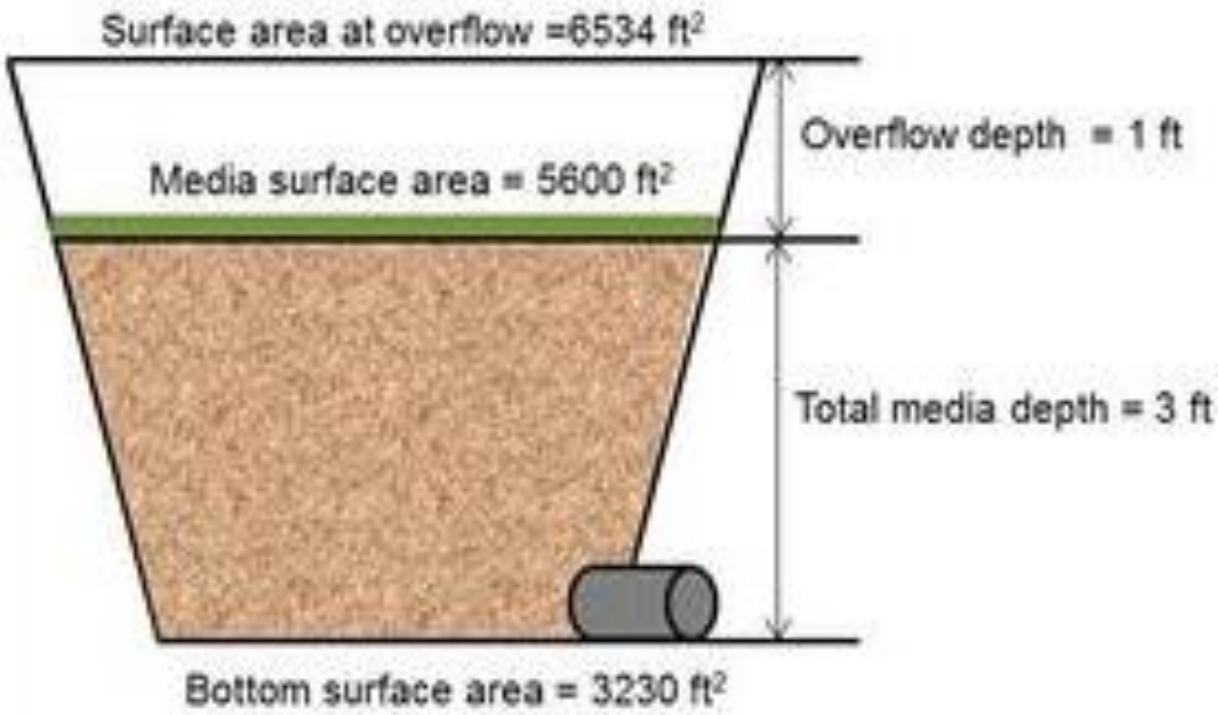
- Infiltration
- Filtration
- Detention time (settling)
- Hydrodynamic settling
- Vegetative or biological uptake

Infiltration

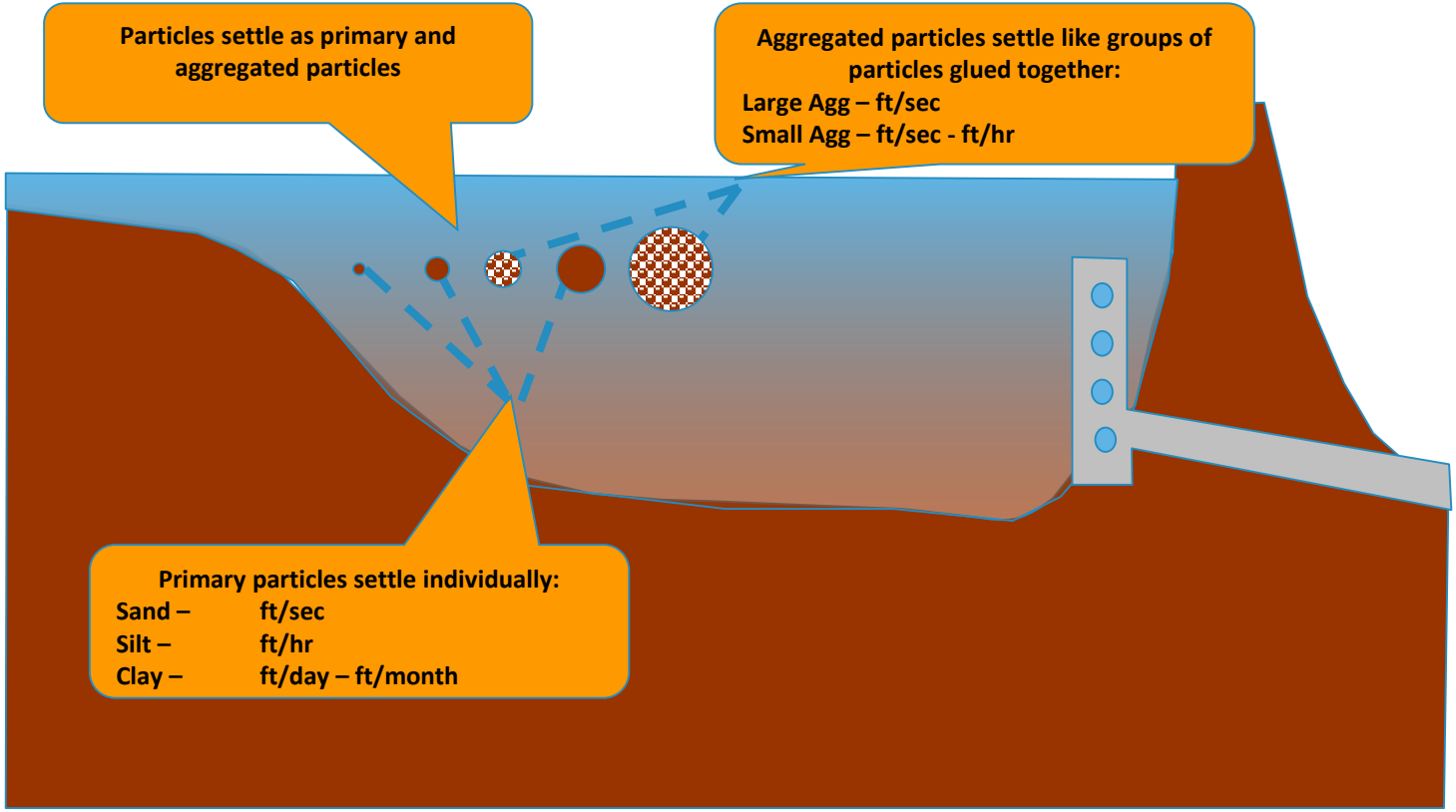
- 100% trapping of constituents
  - All sediment particle sizes
  - All aggregated sediment
  - Dissolved nutrients
  - Particulate nutrients
  - Sorbed nutrients
  - Bacteria

Filtration

- Bioretention cell
  - Clay particles
  - Organics
- Sand filter
  - Higher flow rate, less filtration

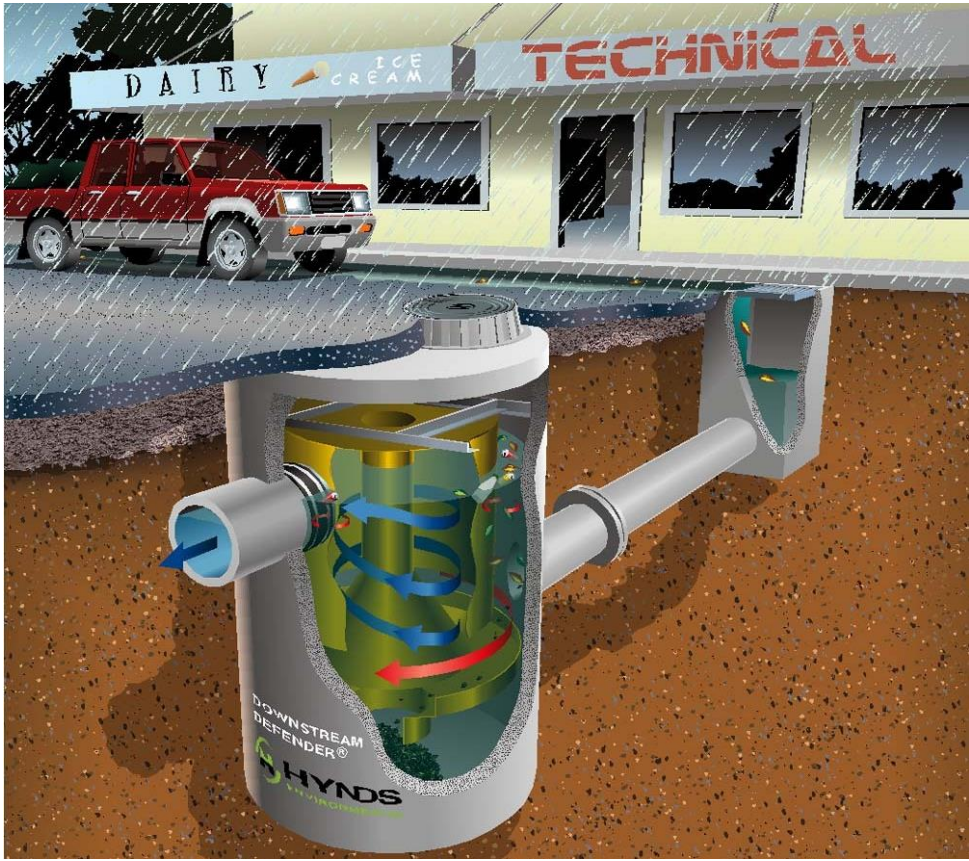


Detention Time – Settling



Detention Time – Hydrodynamics

- Same theory as settling, just faster
- Still doesn't get small particles effectively



Vegetative or Biological Uptake

- Not during storms
- Long term process
- Effectiveness questionable

Greenville County's Post Construction Regulations

Chapter 7 – Water Quantity

Post-development discharge rates from the entire development area shall not exceed pre-development discharge rates for the 2-, 10- and 25-year frequency 24-hour duration storm events. Additional restrictions may apply depending on the location of the project. The 50-year storm must be used in the Gilder Creek watershed and the 100-year storm must be used in the City of Mauldin. These and any other additional restrictions will be addressed during the Pre-design Meeting.

- Multi-stage control structures may be required to meet peak flow control requirements.
- The same hydrologic procedures shall be used in determining both the pre-development and post-development peak flow rates.

The maximum pond depth in the largest storm that must meet peak flow control requirements (typically the 25-year storm, but may be higher in certain areas like the Gilder Creek watershed [50-year] or the City of Mauldin [100-year]) must not rise higher than 0.5 feet below the emergency spillway crest.

Chapter 9 – Water Quality

Table 9-1: Water Quality Regulations by Location, Downstream Impairments, and Size

Development/ Redevelopment Location	Development/ Redevelopment Characteristics*	Water Quality Requirement
Any Development in Greenville County < 10,000 sf		None**
10,000 square feet – 0.99 acres OR other sites meeting criteria for Alternative TSS Standard (as described in Section 9.1.4)		Ensure annual Total Suspended Solids (TSS) load is ≤ 600 pounds per acre
Not within the Reedy River watershed	1 – 25 acres OR ≥ 25 acres and NOT discharging to impaired waterbody (TMDL or 303d)	Trap 85% of annual TSS load
	≥ 25 acres AND Discharging to impaired waterbody	Trap 85% of annual TSS load AND Anti-degradation Rules for Pollutant of Concern (POC)
Within the Reedy River watershed	1 - 25 acres OR ≥ 25 acres and NOT discharging to impaired waterbody	Trap 85% of annual TSS load AND No Increase in Annual Loading for Total Phosphorus (TP)
	≥ 25 acres AND Discharging to impaired waterbody	Trap 85% of annual TSS load AND Anti-degradation Rules for TP and POC

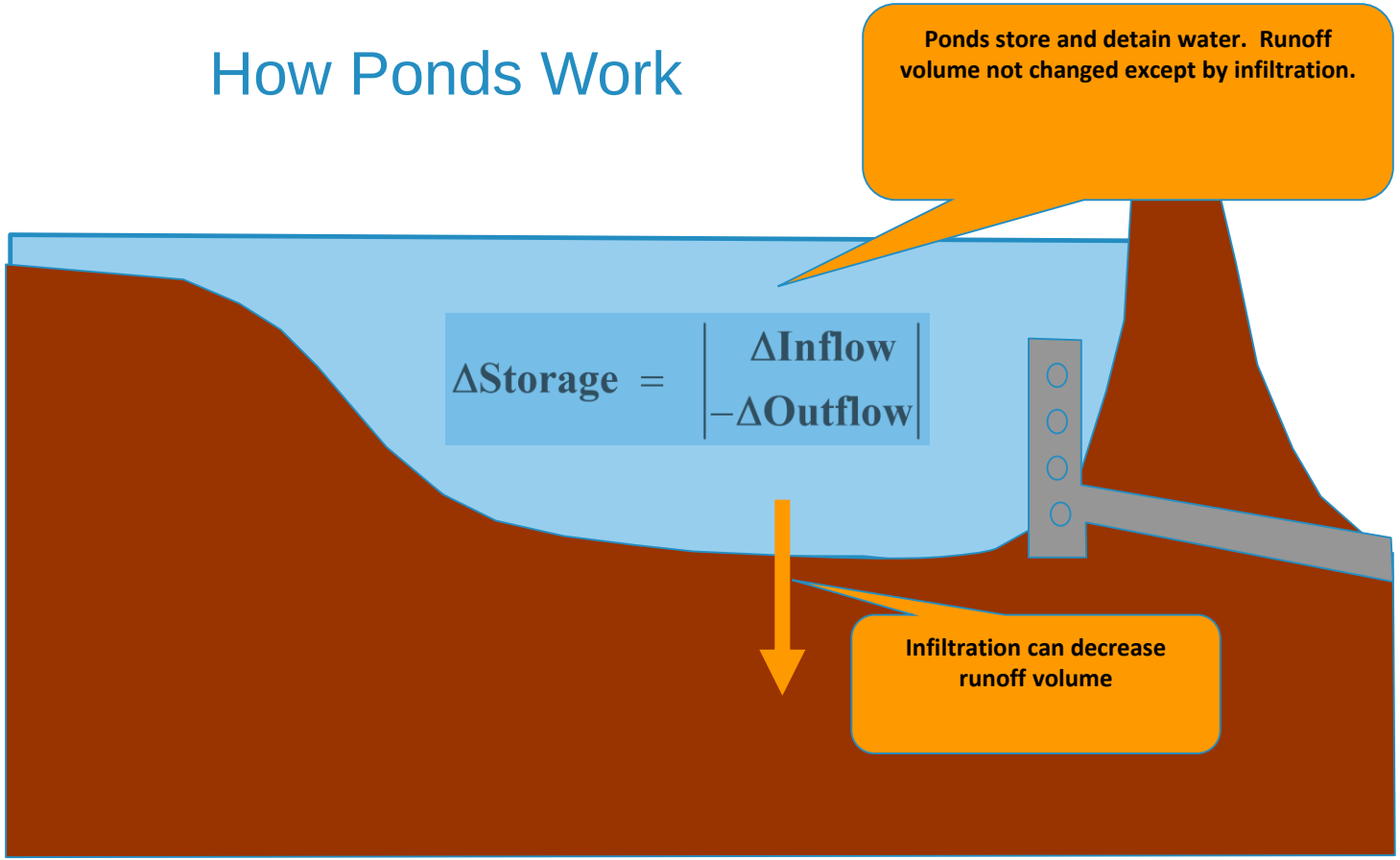
*Size refers to disturbed area. If a development project is part of a larger common plan of development, the total area disturbed by the larger common plan should be used for determining water quality requirements.

Best Management Practices (BMPs)

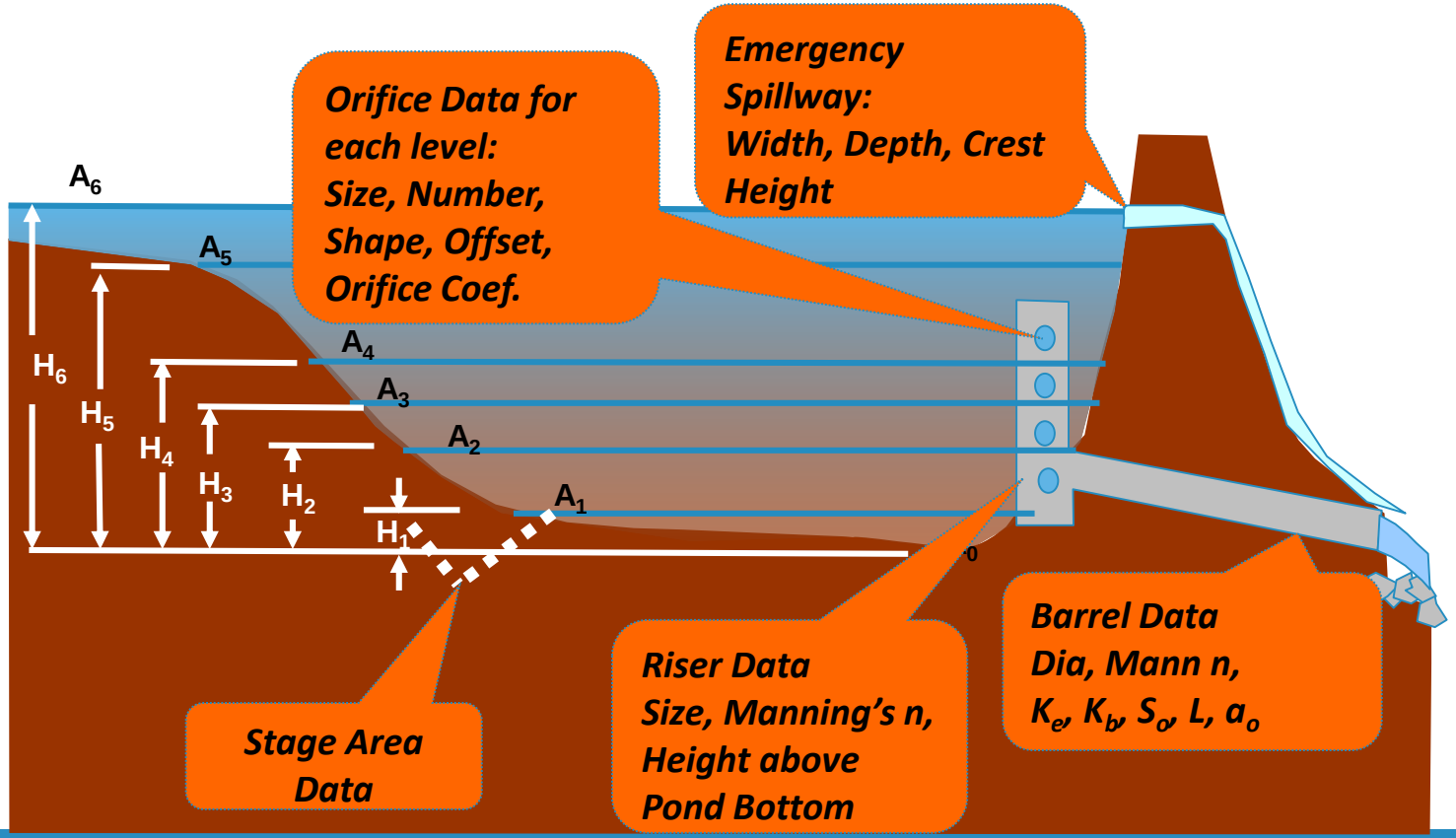
Dry Pond

Wet Pond

How Ponds Work



Detention Pond Hydraulics



Detention Pond Trapping

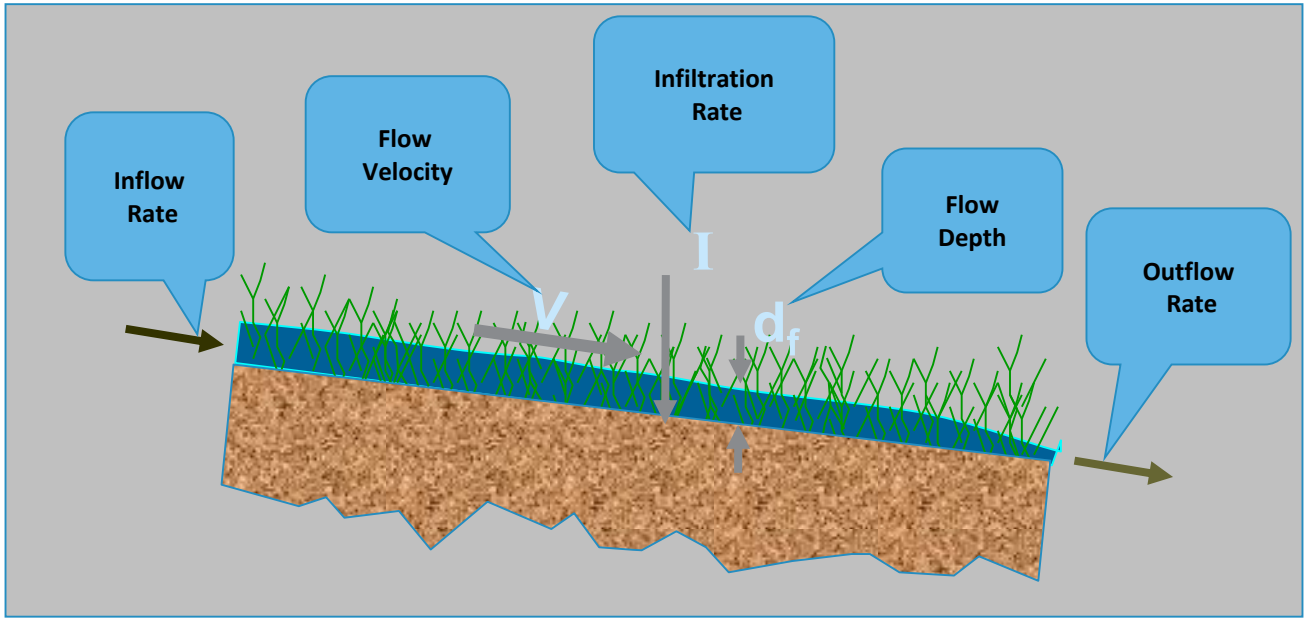
- Sediment
  - Settling velocity
  - Trapping equation
  - Effluent concentration
- Nutrients
  - Physics and chemistry involved
  - Trapping equations
  - Isotherms
- Bacteria
  - Trapping on trapped sediment
  - Death by exposure to light
  - Death by mortality (temperature dependent)

Vegetated Filter Strip (VFS)

VFS Details

- Can be put anywhere in the treatment train
- Typically used downstream of an impervious area
- Usually requires level spreader
- Calculates velocity with Manning’s Equation
- Sod preferred for instant stabilization
- Forested areas now an option

VFS Flow Hydraulics



Important hydraulic parameters

VFS Trapping

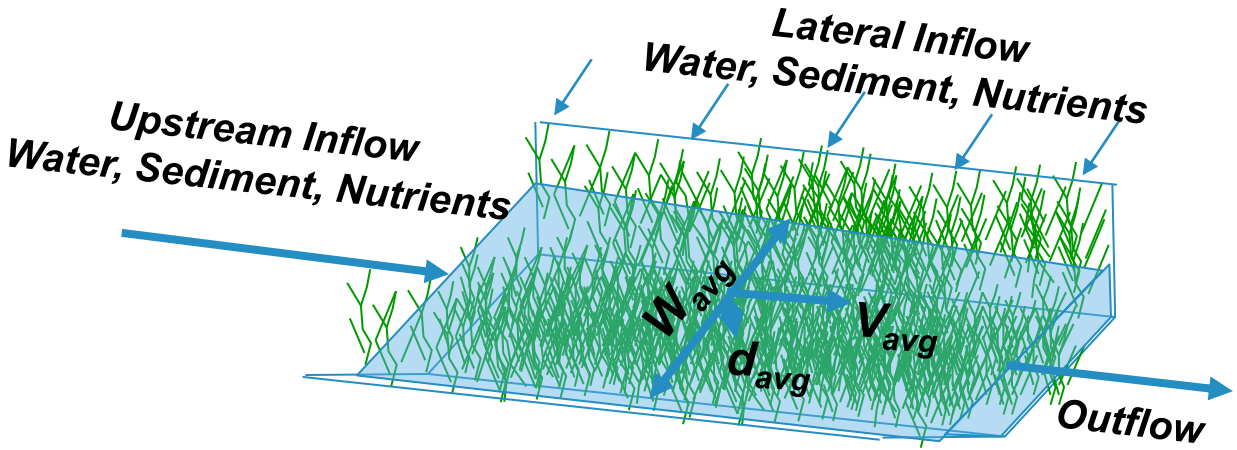
- Sediment
  - KY VFS Model - based on empirical relationship using Fall Number for each particle class and Reynold's Number to account for trapping
  - Repeated for all 5 particle classes
  - Infiltration movement into soil
- Nutrients/Bacteria
  - Based on sediment trapping with attached sorbed chemicals
  - Infiltration of water
    - Sorbed to infiltrating clay such as P
    - Dissolved material such as dissolved N

Bioswale

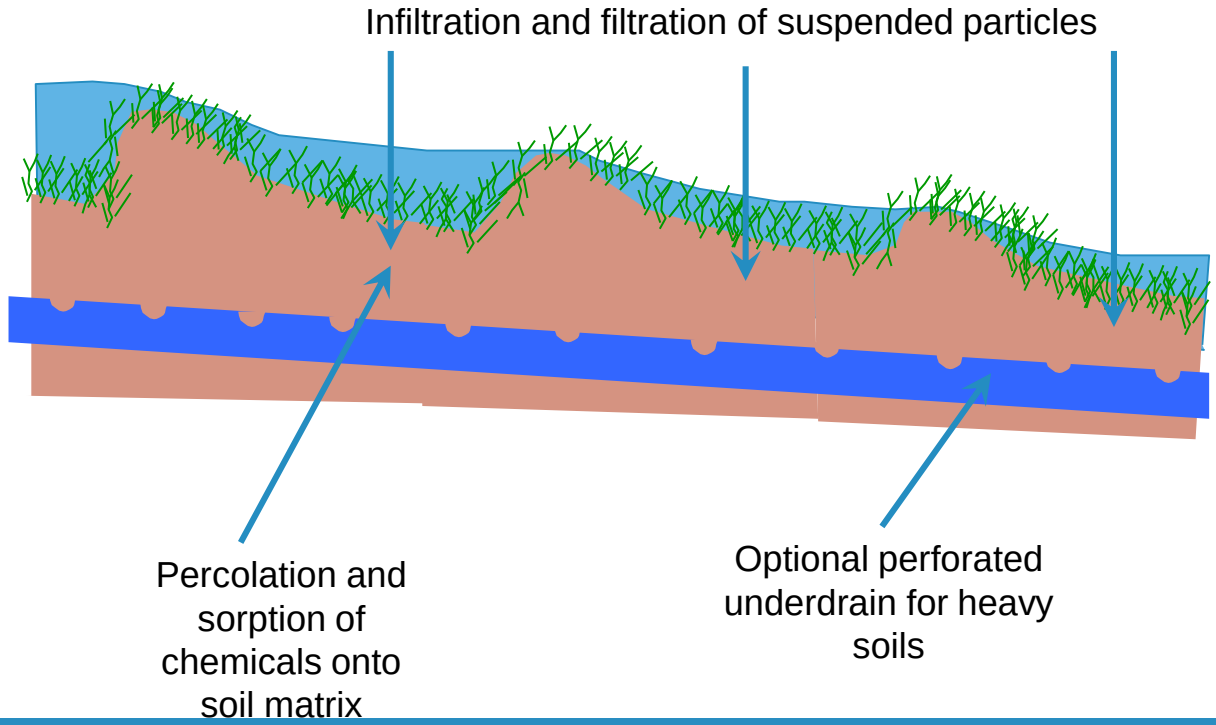
Enhanced Bioswale

Bioswale Flow Hydraulics

- Calculate flow velocity and rate using ARS/NRCS grass waterway equations from Ag Handbook 667
- Determine an average depth for sediment transport calculations



Enhanced Bioswale



Bioswale Trapping

- Similar mechanisms to VFS
- Settling
  - Based on sediment trapping and sorbed chemicals
- Infiltration
  - Sorbed to infiltrating clay
  - Dissolved material

Infiltration Trench

Infiltration Trench Hydraulics

- Flow
- Trapping
    - Sediment
        - Transport
        - Infiltration of sediment
    - Nutrients/Chemicals/Bacteria
        - Settling
        - Infiltration

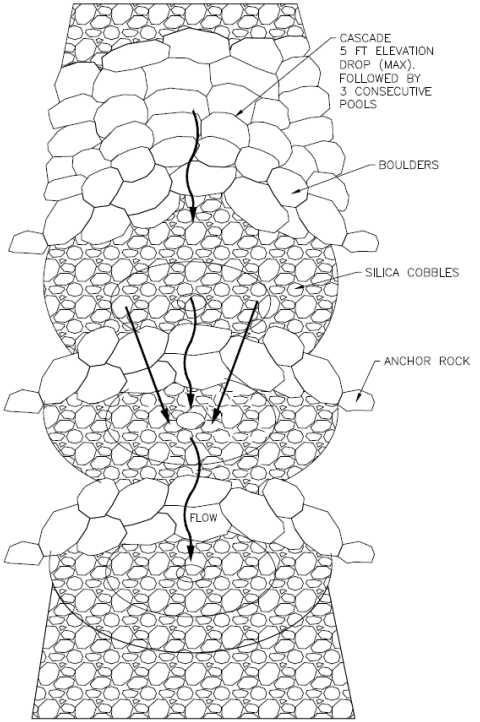
Porous Pavement

Porous Pavement Hydraulics

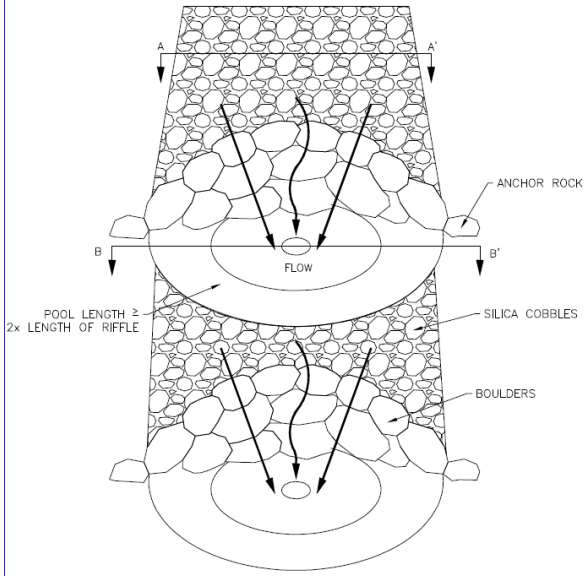
- Infiltration through porous pavement
- Storage beneath the pavement
- Discharge through pipe
- Infiltration into subgrade

Bioretention Cell

Regenerative Stormwater Conveyance (RSC)



CASCADE SEQUENCE



RIFFLE - POOL SEQUENCE (TYPICAL)

Greenville County
Storm Water Management

REGENERATIVE SW CONVEYANCE PLAN

STANDARD DRAWING NO. WQ-15B

APPROVED BY: GREENVILLE COUNTY STORM WATER MANAGEMENT — January 2018 DATE

Bioretention Cell

Actual underdrain discharge from bioretention cell in Greenville Co.

Bioretention Cell Hydraulics

Above ground portion

- Shallow highly pervious detention basin
- Most effective in small storms without overflow
- Similar to a pond – settling, detention time

Filtration through media

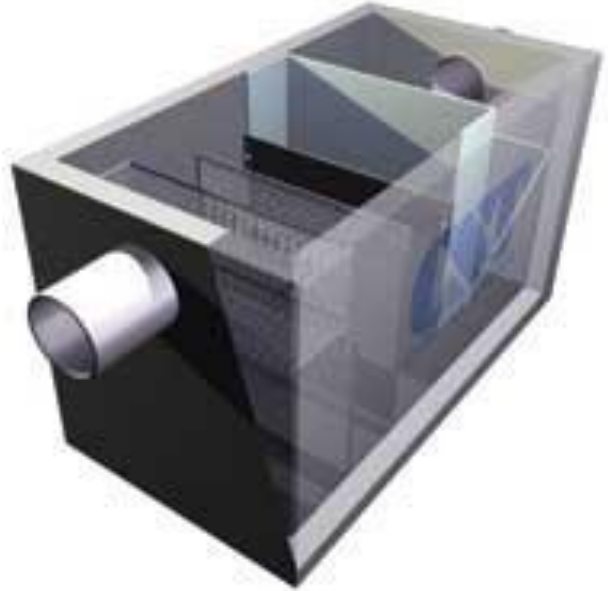
- Nutrients and bacteria adsorb to clay particles
- Higher clay and organic content = higher trapping, but lower permeability
- Not highly effective in removing nitrates

Bioretention Cell Hydraulics

Infiltration

- After filtration, this is the portion that doesn't enter underdrain system
- Decreases runoff volume
- Removes 100% of sediment, metals, and nutrients from infiltrated volume
- Designed to recover infiltration capacity between storms

Manufactured Treatment Devices (MTDs)



Manufactured Treatment Devices

- DO NOT use the manufacturer's claimed TSS trapping efficiency
- Testing done with larger particles

Table 2: TSS Table for Trapping Efficiency for User Input Particle Classes

Manufacturer Provided Lab TSS Trapping Efficiency (%)	Clay (%)	Silt (%)	Sand (%)	Small Aggregate (%)	Large Aggregate (%)
≥ 90	2	90	100	100	100
85	1.5	85	100	99	100
80	1	80	99	98	100
75	0.5	75	99	98	100
70	0	70	98	98	100
60	0	56	98	97	99
50	0	42	98	95	99
40	0	32	98	94.5	99
30	0	22	98	94	99
≤ 20	0	13	98	93	99

Conclusions

Effectiveness of BMPs is dependent on many factors that impact trapping.

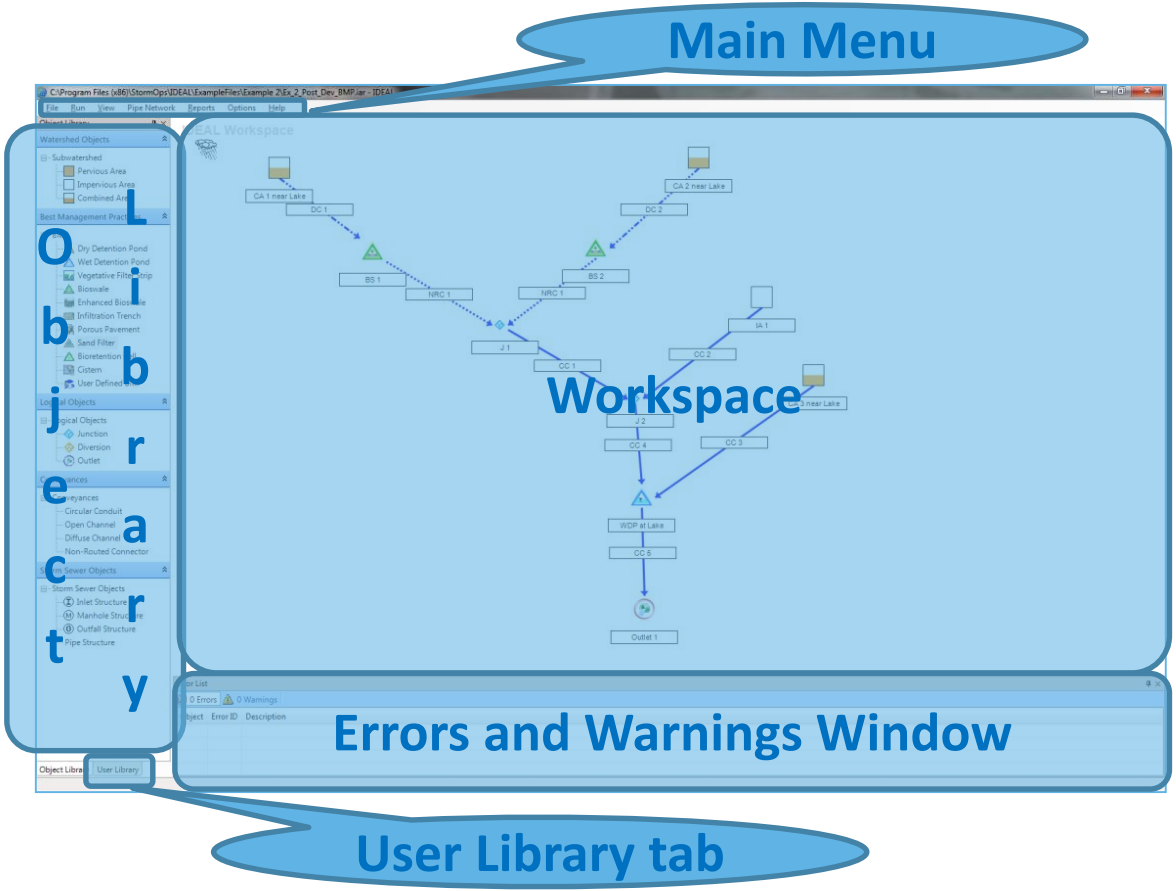
- Design for what you want to trap
- Maintenance is particularly critical and frequently needed, especially for smaller structures
- Structures that rely on infiltration ***cannot*** withstand sediment loads
- Recognize that no one structural BMP is a silver bullet

Introduction to IDEAL

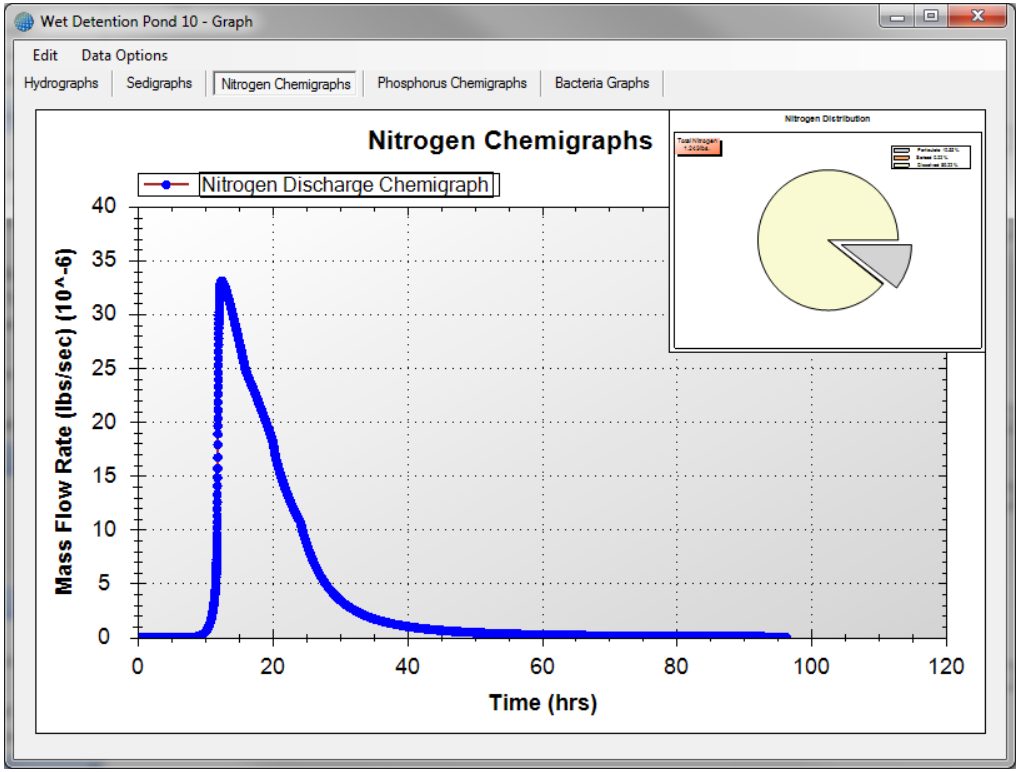
Model Components

- Location and Hydrologic Information
- Treatment Train
  - Subwatersheds – generate runoff, sediment, nutrients, and bacteria
  - Conveyances – assumed stabilized; no generation or treatment
  - BMPs – remove runoff, sediment, nutrients, and bacteria
  - Outlet
- Model Runs for single storm or APDS

Modeling Preview



Output



WDP at Property		
Name	WDP at Property	
Description	Wet pond as a BMP in the Development	
General Input		
Parameter	**Value**	**Units**
Infiltration Method	GreenAndAmpts	-
Soil_Texture	Sandy Loam	-
Degree Of Saturation	0.3	-
Depth to Water Table Growing Season	10	ft
Depth to Water Table Dormant Season	12	ft
TE Calculation Method	EPAMethod	-
Pond Efficiency Parameter	2	-
Riser Input		
Parameter	**Value**	**Units**
Riser Type	Drop Inlet	-
Riser Shape	Circular	-
Riser Height	5.5	ft
Riser Diameter	24	in
Barrel/Outlet Pipe Input		
Parameter	**Value**	**Units**
Barrel Crest Height	0	ft
Barrel Slope	0.3	ft/ft
Barrel Length	80	ft
Barrel Diameter	18	in
Manning's Roughness Coefficient	0.013	-
Entrance Loss Coefficient	0.5	-
EMS Input		
Parameter	**Value**	**Units**
EMS Type	Broad Crested	-
EMS Cross-Section	Trapezoidal	-
EMS Crest Height	6	ft
EMS Width	12	ft
Bacteria Input		

IDEAL Improvements

- New rainfall distributions
- Summary Output Report
- Forested vegetated filter strip options (for stream buffers and conserved open space)
- Upturned elbow in bioretention cell

IDEAL Contacts

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