Characterization of Runoff Particle Size Distribution (PSD), Nutrients, and Gross Solids from Roadways across North Carolina and Modeling Sediment Reduction in Roadway Stormwater Control Measures using a Coupled Particle Settling and Hydraulic Model

Written in partial fulfilment of NCDOT-NCSU BAE research partnership task order #6:
"Predicting the Effectiveness of Vegetated Stormwater Control
Measures Based on Sediment Size Distribution"

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Preface

This final report has been written to satisfy NCDOT research contract 2011-35: "NCSU BAE-NCDOT Research and Training Partnership," specifically task order #6: "Predicting the Effectiveness of Vegetated Stormwater Control Measures Based on Sediment Size Distribution." This report will focus on the two major efforts supported by this task order: (1) the collection of field data to characterize runoff quality from roads across North Carolina, including sampling for Particle Size Distribution (PSD), nutrients, total suspended solids (TSS), and gross solids, and (2) development and testing of a coupled sediment settling and hydraulic spreadsheet model to predict TSS reductions in grass swales and vegetated filter strips (the two most common highway stormwater control measures [SCMs]). Other final reports submitted in partial fulfilment of research contract 2011-35 have been prepared and submitted in 2013-2015. The authors wish to thank NCDOT for funding this project and for their support and aid throughout the project. Two other publications have been submitted to the ASCE *Journal of Environmental Engineering* based upon this research: (1) "Characterizing runoff from roadways: Particle size distributions, nutrients, and gross solids" by Winston and Hunt (expected publication 2016) and (2) "Modeling sediment reduction in grass swales and vegetated filter strips using particle settling theory," by Winston et al. (expected publication 2016).

Executive Summary

Stormwater runoff from roadways is one source of pollutant loading to surface waters. The North Carolina Department of Transportation (NCDOT) is required, through its National Pollutant Discharge Elimination System (NPDES) permit, to implement stormwater control measures (SCMs) in the linear environment. Grassed filters, such as swales and vegetated filter strips, are the two most commonly-used SCMs by DOTs across the United States. The primary pollutant removal mechanism employed by these practices is sedimentation; therefore, knowledge of the particle size distribution (PSD) in roadway runoff is critical to determining expected pollutant removal in these SCMs.

Particulate matter, nutrients, and gross solids from roadways contribute non-point source pollution to waterways. To inform roadway runoff management, a field monitoring study was undertaken at eight roadway sites across North Carolina. Runoff was characterized for typical chemical constituents such as TSS and nutrients, as well as for gross solids. These particles, greater than 5 mm in nominal diameter, are not sampled when using an autosampler, and are therefore an omitted portion of the total nutrient load. Additionally, particle size distributions (PSD) of all edge-of-pavement runoff samples were performed to understand the granulometry of the particulate matter. Knowledge of PSDs is critical when attempting to understand sediment fate and transport through SCMs. For 43 storm events, median particle size varied from 31 to 144 µm. The median PSD from hot mix asphalt (HMA) was 2.6% clay, 44.8% silt, and 52.6% sand. PSD was not correlated to roadway classification or ecoregion; however, PSD was significantly correlated to the presence of a permeable friction course (PFC) overlay, which is a layer of porous asphalt placed over traditional HMA. The median d_{90} for PFC (131 µm) was significantly smaller than for HMA (428 µm), with 11.5% less sand fraction present in the PFC runoff. Smaller particles emitted from PSD will result in a reduction in performance for downslope highway stormwater control measures (SCMs), including swales and filter strips. Further evidence was provided that PFC (9.0 mg/L) produces lower median effluent TSS concentrations than HMA (23 mg/L). Dry mass of leaf litter from roadways in North Carolina was correlated to rainfall depth and peak rainfall intensity. N loads from gross solids varied between 0.2-0.9 kg/ha/yr, while P loads fell between 0.03-0.12 kg/ha/yr. These are about one order of magnitude less than TN and TP nutrient loads in stormwater runoff. Given the typical fraction of TN and TP that can leach into stormwater as leaves and organic matter break down, it was estimated that gross solids represent 0.6% of TN and 3.6% of TP yearly nutrient loading for the evaluated highway sites. This suggested that for nutrient control, gross solids were an inconsequential portion of the total nutrient load from roadways.

Research into existing SCM technologies is warranted to understand their performance as a function of design characteristics, so that these systems can be credited by regulatory agencies in a flexible manner, rather than the current "one size fits all" approach. Of particular interest to

Departments of Transportation are swales and filter strips, which are utilized throughout the world stormwater control measures proximate to roadways. A simple coupled hydraulics and particle settling model was created to predict swale and filter strip TSS reduction as a function of catchment area, longitudinal slope, side slope, cross-section type (triangular swale, trapezoidal swale, or filter strip), and length. The hydraulics model was based on Manning's equation and the Rational Method with the underlying assumption that the water quality design storm would not exceed the height of the grass. The particle settling model was constituted of a series of empirical equations based on runoff particle size distributions. For a given set of design characteristics, triangular swales produced the least and filter strips producing the most TSS removal; trapezoidal swales produced on average 9.3% better TSS removal than triangular swales. Performance of grass filter stormwater controls increased with: decreasing slope, increasing length, smaller catchment area, and shallower side slopes. Filter strips produced the majority of their TSS reduction within the first meter of their width, and were insensitive to increases in longitudinal slope. This water quality design storm modeling approach could be coupled with modeling for infrequent return interval storms to obtain dual benefits of sediment reduction and conveyance. This approach could provide regulatory agencies a method to provide variable TSS credit to swales and filter strips as a function of design.

The following report is divided into two parts: (1) a field monitoring study to characterize roadway runoff nutrient and sediment concentrations, particle size distributions, and gross solids, and (2) a modeling effort to characterize TSS removal as a function of design variables for swales and vegetated filter strips.

Keywords

Sediment, highway, litter, permeable friction course, pollution, particulate Matter, particle size distribution, solids, Stokes' Law, TSS, grass filters, stormwater

Part I: Field Monitoring of Roadway Runoff Quality

Introduction

Stormwater runoff from roadways is one contributor to the total wet-weather pollutant load in a watershed. Highways are a source of sediment, heavy metals, nutrients, hydrocarbons, and bacteria due to anthropogenic and atmospheric deposition processes (Kayhanian et al. 2007; Davis and Birch 2011). Anthropogenic sources of pollutants include pavement wear, tire wear, and vehicular contaminants (Kobriger and Geinopolis 1984). Successful attempts have been made to tie these pollutants to factors such as annual average daily traffic (AADT), roadway classification, pavement type, antecedent dry period (ADP), contributing drainage area, and rainfall depth and intensity (Kim et al. 2005; Opher et al. 2009). Since some pollutants, such as heavy metals and polynuclear aromatic hydrocarbons (PAHs) are preferentially bound to particulate matter, sediment control in highway stormwater control measures (SCMs) has become a priority (Legret and Pagotto 1999). Some metals, such as zinc, are predominantly bound to smaller particle sizes, suggesting that understanding the particle size distribution (PSD) may be key to predicting SCM performance (Roger et al. 1998).

Total suspended solids (TSS) and suspended sediment concentration (SSC) are two commonly used gravimetric indices for stormwater solids. While they are general indicators of sediment in runoff, they provide no indication of the fraction of sediment that might be settleable within a typical roadside SCM, such as a swale or filter strip. In order to characterize this, various PSD measurement techniques may be applied (Li et al. 2005). The output of these analyses is a volume fraction of particles within various bins of particle size, typically from 0.04-2000 μm. Thus, the sand, silt, and clay fractions within a stormwater sample can be enumerated, and the functionality of downstream SCMs predicted (Deletic 2005; Deletic and Fletcher 2006). For instance, Karamelegos et al. (2005) reported that a sand filter effectively removed particles with a diameter of at least 1μm. Without knowledge of the influent PSD, it would prove difficult to predict the percentage of particles retained within this SCM.

For typical highway SCMs, such as swales and filter strips, settling is the primary mechanism for sediment reduction. Thus, it is imperative to understand edge-of-pavement PSD to predict the fraction of sediment that may settle within these SCMs using Stokes' Law (Stokes 1845; Winston et al. 2015). For example, particles larger than 100 µm in diameter are easily settled, while those less than 100 µm require lengthy hydraulic retention time to be captured in an SCM (Andral et al. 1999).

Conventional highways are paved with concrete or hot mix asphalt (HMA) and drainage occurs due to the grading and cross-slope of the road. Drainage may be improved through the addition of an approximately 5 cm thick porous asphalt overlay known as a permeable friction course (PFC), with water flow through the porous pavement reducing hydroplaning (Berbee et al. 1999). PFC provides reduced noise levels relative to other pavement types (Stotz and Krauth 1994). Furthermore, additional water quality benefits have been observed in the US, France, New Zealand, and the Netherlands for highways with PFC overlays vis-à-vis HMA, with reductions observed for both solids and heavy metals (Berbee et al. 1999; Barrett, 2008; Eck et al. 2012; Winston et al. 2012; Moores et al. 2013). Results from recent studies suggest that these water quality benefits last for the structural life of the PFC, typically 10 years (Eck et al. 2012, Moores et al. 2013). While the water quality benefits are substantial, PSDs from PFC have not been reported in the published literature to date. Since there are substantial differences in TSS or SSC concentration from a PFC relative to HMA, it stands to reason that there may also be substantial differences in the PSD generated by these pavements.

Gross solids are a category of urban stormwater pollutant comprised of anthropogenic refuse, organic materials including leaves, branches, and grass clippings, and large particulate matter. They are generally characterized by a diameter larger than 5 mm; however a standard definition has not been fully determined (Allison et al. 1998a; Butler et al. 2002). Total maximum daily loads (TMDLs) for these pollutants have been established in watersheds across the U.S (California State Water Resources Control Board 2014). Therefore, it is important to understand the fraction of these pollutants that have their source in the highway land use. Characterizations of gross solids from urban watersheds have been undertaken in California, Wisconsin, Minnesota, Toronto, Canada, Cape Town, South Africa, and Melbourne, Australia (Prasad et al. 1980; Dorney 1986; Allison et al. 1998b; Marais et al. 2004; Kim et al. 2006; Kalinowski and Baker 2013). However, a dearth of literature exists on gross solids from the eastern US. These pollutants are typically not captured by autosamplers that are used for stormwater quality monitoring, so they are a source of nitrogen and phosphorus to surface waters that are often neglected. Given recent nutrient regulations in North Carolina (NC) and the Chesapeake Bay, an understanding is needed of the fraction of the annual loading of N and P represented by gross solids (NC Administrative Code 2009).

Research Goals

The primary goals of this study were to: (1) evaluate PSDs for roadways in NC, (2) determine causal variables for PSDs (road classification, wearing surface, ecoregion, AADT), (3) provide edge-of-pavement nutrient and TS characterization for roadway sites in NC, (4) determine the mass of gross solids that make up a portion of roadway runoff, (5) determine the relative fraction of gross solids in the annual runoff nutrient load and (5) utilize PSDs to predict the efficiency of roadside swales and vegetated filter strips using particle settling theory (see Part II of this document).

Description of Monitoring Sites

Runoff samples were captured at eight sites (Figure 1) across the three North Carolina ecoregions: mountains (2), piedmont (2), and coastal plain (4). The sites had varying characteristics, with different roadway classes, wearing surfaces, AADT, and catchment sizes (Table 1). Roadway classes represented the four major types present in NC: interstate highway, divided highway, primary route, and secondary route. All sites were paved with HMA except Benson, which had a PFC overlay. AADT varied from 540 and 34,000 vehicles per day. All watersheds monitored for PSD, nutrient, and sediment sampling were 100% impervious roadways.

Four locations were instrumented and monitored for gross solids (Figure 1). One site was located in the mountains, one in the piedmont, and two in the coastal plain. Three sites were interstate highways, with one site a divided highway (Table 1). At each site, a 15" diameter flume drain was retrofitted with a plastic mesh bag (nominal opening 5 mm) to capture all debris and gross solids from the catchment (Figure 2). A piece of white plastic flashing placed over the bottom of the netting insured that storm flow was conveyed through the netting. The netting was removed approximately weekly and all gross solids stored in a plastic bag for transport back to the laboratory. All watersheds monitored for gross solids were 100% impervious roadways.

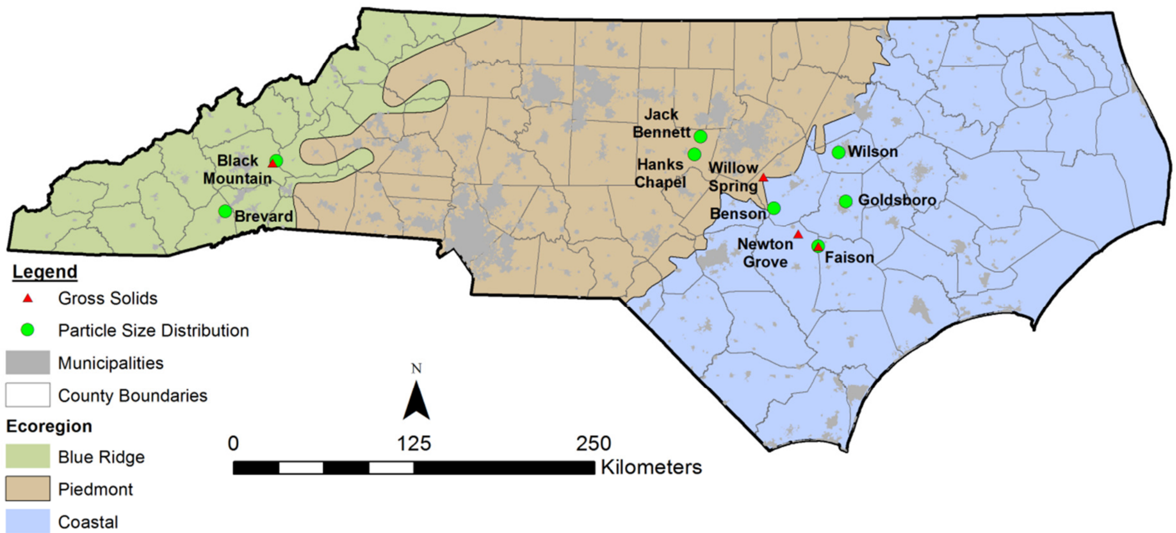

Figure 1. Particle size distribution and gross solids monitoring locations in North Carolina, USA.

Figure 2. 90˚ weir and sampling intake at the Brevard site (at left)
and monitoring gross solids at Black Mountain (at right).

Table 1. Location and characteristics of monitoring sites.

PSD Monitoring Sites								
Site Name	**Site Location**	**Ecoregion**	**Catchment Description**	**Roadway Classification**	**Pavement Type**	**AADT**	**Monitoring Location**	**Monitoring Device**
Black Mountain	Interstate 40 at MM65	Mountain	East and Westbound Lanes (6 total)	Interstate Highway	HMA	34000	Drop Inlet	Rainfall Paced Sampling
Brevard	NC 280 at Northern Intersection with Old NC 280	Mountain	Four Lane Highway	Primary Route	HMA	13000	Drop Inlet	90˚ V-Notch Weir
Jack Bennett	Jack Bennett Road, 1 km West of Big Woods Road	Piedmont	Single Lane	Secondary Road	HMA	3400	Weir Box	90˚ V-Notch Weir
Hanks Chapel	Hanks Chapel Road, 1.4 km North of Providence Church Road	Piedmont	Single Lane	Secondary Road	HMA	520	Weir Box	90˚ V-Notch Weir
Faison	NC 117, 2.1 km East of Interstate 40	Coastal Plain	Eastbound Lane and Shoulder	Divided Highway	HMA	10000	Flume Drain	120˚ V-Notch Weir
Benson	Interstate 40 at MM330	Coastal Plain	Eastbound Lane and Shoulder	Interstate Highway	PFC	18000	Weir Box	30˚ V-Notch Weir
Goldsboro	Wayne Memorial Drive, 0.4 km South of West New Hope Road	Coastal Plain	Northbound Lanes (2) and Turn Lane	Primary Route	HMA	13000	Drop Inlet	90˚ V-Notch Weir
Wilson	NC 42, 0.2 km East of Interstate 795	Coastal Plain	Travel Lanes (2), Center Turn Lane (1), and Highway Entrance Ramp (1)	Primary Route	HMA	11000	Drop Inlet	90˚ V-Notch Weir

Gross Solids Monitoring Sites						
Site Name	**Site Location**	**Ecoregion**	**Catchment Description**	**Roadway Classification**	**Pavement Type**	**AADT**
Black Mountain	Interstate 40 at MM62	Mountain	Westbound lanes (1 lane and shoulder)	Interstate Highway	HMA	30000
Garner	Interstate 40 MM315	Piedmont	Eastbound Lane and Shoulder	Interstate Highway	HMA	50000
Newton Grove	Interstate 40 MM345	Coastal Plain	Eastbound Lane and Shoulder	Interstate Highway	PFC	17000
Faison	NC 117, 2.1 km East of Interstate 40	Coastal Plain	Eastbound Lane and Shoulder	Divided Highway	HMA	10000

Materials and Methods

Hydrologic Data Collection and Water Quality Sampling

At each monitoring site, flow proportional, composite water quality samples were obtained using ISCO 6712 water quality samplers. At all sites except Black Mountain, ISCO 730 bubbler modules were used to monitor stage over a weir on a two minute interval (Figure 2). At Black Mountain, samples were rainfall paced, with aliquots triggered every 1 mm of rainfall. Flow rates were calculated using standard weir equations for the chosen v-notch geometry. The mountain and piedmont sites were monitored between June and September 2012. The coastal plain sites were monitored between September 2012 and February 2013 (Table 2).

An ISCO® 674 tipping bucket rain gauge (0.25 mm per tip) was installed at each monitoring site to record precipitation depth at 2-minute intervals. The rain gages were located to eliminate interference from tree canopies. Storm events were separated by a minimum antecedent dry period of 6 hours and had a minimum depth of 5 mm. Storm events statistics are presented in Table 2. Peak five minute and hourly rainfall intensities represented the maximum rainfall depths over a contiguous five or sixty minute period.

At each site, between three and eight storm samples were collected between Fall 2012 and Winter 2013 (Table 2). Runoff samples were field composited and then sub-sampled into laboratory containers on site for analysis. All water quality samples were collected within 24 hours of the end of precipitation, filtered (as necessary), and preserved on ice. Samples were analyzed in the lab for total Kjeldahl nitrogen (TKN), nitrate and nitrite nitrogen (NO_x), total ammoniacal nitrogen (TAN), orthophosphate (PO_4), total phosphorus (TP), total suspended solids (TSS). Total nitrogen (TN) was calculated as the sum of TKN and NOx. Organic nitrogen (ON) was calculated as the difference between TKN and TAN. Nutrient and TSS concentrations were determined using U.S. EPA (1983) or American Public Health Association (APHA) methods (APHA et al. 1995). All analytes were analyzed for the Jack Bennett, Hanks Chapel, Goldsboro, and Wilson sites. Due to the distance to the laboratory from Faison, Benson, Brevard, and Black Mountain, these samples were only analyzed for TSS.

Water quality samples were evaluated in the laboratory for PSDs using a Beckman-Coulter 13-320 Laser Diffraction Particle Size Analyzer equipped with a Universal Liquid Module. The particle size range that it was capable of measuring was 0.04 – 2000 µm. The output was given in 117 bins of particle sizes covering the range of sand, silt, and clay particle sizes. For each particle size bin, the output was a percentage of the total volume of particles in the sample, allowing for characterization of the fraction of particles as a function of particle diameter.

Gross Solids Sampling

At each monitoring site, gross solids samples were obtained on a weekly to monthly basis over a 2-3 month window (Table 2); this meant that multiple storms were often analyzed within the same sample. Six samples were analyzed from the Black Mountain and Benson sites, while seven were captured at Newton Grove and Faison. The mountain gross solids site was monitored during June and July 2012, while the piedmont and coastal plain sites were monitored between September 2012 and February 2013. All sites monitored for gross solids were located on either an interstate highway or NC highway. At each of the gross solids monitoring sites, a tipping bucket, recording rain gauge was installed to determine rainfall characteristics.

Samples were obtained by installing an approximately 2 meter long, purpose-built mesh bag into a roadside flume drain (Figure 2). All flow from the roadway was forced through this bag, with the 5 mm opening screening out all particles larger than this nominal diameter. Gross solids samples were bagged and taken to the North Carolina Department of Agriculture waste analysis laboratory. Only organic debris was analyzed in the laboratory; plastics, cardboard, rubber, *et cetera* were discarded prior to laboratory analysis. Typical litter composition in urban catchment has been shown to be more than 50% (Marais et al. 2004) and nearly 80% (Allison et al. 1998b) composed of organic material. Observation of the gross solids samples in this study suggested that more than 90% of the sample (by volume) was organic debris. Samples were dried in an oven for 48 hours to achieve a constant mass and dry mass was recorded. Nitrogen and carbon concentrations were determined using oxygen combustion gas chromatography with an elemental analyzer. Phosphorus, heavy metal, and micronutrient concentrations were analyzed with an inductively coupled plasma spectrophotometer after open vessel nitric acid digestion. Nutrient and heavy metal concentrations were then transformed into a pollutant loading using equation 1:

$$L = \sum_{i=1}^{n} [\frac{C_i * m_i}{P_i}] * \frac{P_a}{A_c} \quad (1)$$

Where L is the annual pollutant loading (kg/ha/yr), n is the number of gross solids samples at a monitoring site, C_i is the pollutant concentration (mg/kg) for sample i, m_i is the dry mass (kg) of gross solids for sample i, P_i is the precipitation depth (mm) during the monitoring period representative of sample i, P_a is the 30-year normal precipitation (mm) for the monitoring location (SCONC 2014), and A_c is the catchment area (ha) for the monitoring site. This equation provides a representative gross solid loading that can be compared against other research.

Table 2. Description of PSD and gross solids monitoring sites including rainfall characteristics.

Particle Size Distribution Monitoring Sites								
Site Name	**Monitoring Period**	**Catchment Area (ha)**	**Number of Events**	**Rainfall Depth (mm)**	**Antecedent Dry Period (days)**	**Peak 5-Minute Rainfall Intensity (mm/hr)**	**Peak Hourly Rainfall Intensity (mm/hr)**	**Rainfall Duration (hrs)**
Black Mountain	June - July 2012	1.11	8	4.3-29.2	0.4-9.4	7.6-82.3	2-29.2	0.8-10.2
Brevard	June - July 2012	0.029	4	15.5-21.6	0.9-9.2	12.2-77.7	6.1-21.6	0.8-10.5
Jack Bennett	June - September 2012	0.0104	5	3.3-35.1	0.4-28	10.7-86.9	3-17.8	0.8-9
Hanks Chapel	June - September 2012	0.0097	4	6-35.1	0.8-9.7	18.3-57.9	3.6-18	0.4-9
Faison	September - December 2012	0.051	3	5.3-27.4	1.9-14.7	6.1-36.6	2.5-12.4	4.2-28.5
Benson	September 2012 - February 2013	0.0041	5	6-24.9	1-20.9	4.6-114.3	2.8-17.5	1.8-13.3
Goldsboro	October 2012 - February 2013	0.084	7	4.6-30.2	0.4-19.8	4.6-44.2	1.8-6.1	5-17.9
Wilson	October 2012 - February 2013	0.102	6	3.8-32.3	0.4-15.3	3-62.5	1.3-7.1	3-13.9
Gross Solids Monitoring Sites								
Site Name	**Monitoring Period**	**Catchment Area (ha)**	**Number of Samples**	**Duration of Sampling Period (days)**	**Rainfall Depth (mm)**	**Total Antecedent Dry Period (days)**	**Peak 5-Minute Rainfall Intensity (mm/hr)**	**Rainfall Duration (hrs)**
Black Mountain	June - July 2012	0.047	6	6-13	11.1-55.1	5-12	21.3-82.3	8.2-43.7
Garner	December 2012 - February 2013	0.065	6	3-28	6.4-75.4	3-23	3-42.7	6.7-49.5
Newton Grove	December 2012 - February 2013	0.049	7	3-28	3.6-93	2.5-22.5	3-48.8	7.5-49.5
Faison	September - December 2012	0.051	7	3-31	6.1-43.9	6-29.5	6.1-79.2	4.4-60.7

Statistical Methods

Statistical analyses were performed to ascertain differences in runoff PSD based upon pavement type (HMA or PFC), roadway classification (interstate highway, divided highway, primary road, or secondary route), and ecoregion (mountains, piedmont, or coastal plain). To simplify the analysis, the d_{10}, d_{50}, and d_{90} particle diameters were utilized in the analyses. For the paired comparison case (pavement type), the PFC dataset was quite small, so bias corrected and accelerated (BCA) bootstrapping was applied (Efron 1987). Confidence intervals (CIs) for

HMA and PFC were then compared to determine statistical significance. For multiple comparison cases (roadway classification and ecoregion), the omnibus test was the Kruskal-Wallis k-sample test (Kruskal and Wallis 1952). When the omnibus test showed statistically significant differences between the three or four data sets, further paired comparisons were made using Tukey's honest significant difference (HSD) test (Higgins 2004). Correlations to causal variables, such as climatic conditions, were performed with the non-parametric Spearman's Rank Correlation for both PSD and gross solids data (Higgins 2004).

All data analysis was completed using R software version 2.15.2 (R Core Team 2014). For this study, a criterion of 95% confidence (α=0.05) was used unless otherwise noted. A value of one-half the detection limit was substituted for concentration data that were below the detection limit (Antweiler and Taylor 2008). This substitution was utilized twice in the OP and TSS datasets.

Results and Discussion

Particle Size Distribution

For each storm event, the d_{10}, d_{50}, and d_{90} particle sizes were calculated based on the 43 collected PSDs, and are presented on a site-by-site basis in Table 3. Median particle size varied between 36 µm at Jack Bennett to 167 µm at Hanks Chapel. These differed substantially when compared to median particle diameters between 2-8 µm for three highway sites in Los Angeles, CA (Li et al. 2006). However, the median particle diameters for eight roadway sites in France were between 10-20 µm, more similar to values presented in Table 3. Geometric mean diameters from eight sampled storms in a watershed in Baton Rouge, LA varied from 32-440 µm (Kim and Sansalone 2008), similar in size to very fine sand. Perhaps differences were due to sampling methodologies, where Li et al. (2006) utilized grab sampling techniques.

At half of the sites studied, the d_{50} would be characterized as sand (>50µm, USDA 1975). Based on USDA classification, PSDs by site were between 27-83% sand, 16-66% silt, and 1-6% clay (USDA 1975). The median PSD for the 43 monitored events was 49.8% sand, 47.6% silt, and 2.5% clay (USDA 1975). Because the median PSD is weighted to the sand and silt fraction, this suggests that settling within a short hydraulic retention time (minutes to hours) within a swale or filter strip might be possible (Winston et al. 2015). Coefficient of Uniformity (C_u) varied between 5.2 and 7.4, indicating that the d_{60} and d_{10} varied substantially. The Coefficient of Curvature (C_c) varied from 1.3 and 2.6, and all sites except Faison would be considered well graded, since Cu is greater than 6 and C_c is less than 3. This appeared to not be related to underlying soil type (i.e. ecoregion), as Goldsboro (sandy underlying soil) had the lowest sand fraction and Hanks Chapel (clayey underlying soil) had the highest sand fraction in their respective PSDs. AADT appeared to have little effect on PSD, as the site with the lowest AADT (Hanks Chapel) had the largest d10 and d50 (Table 3). Additionally, the standard asphalt interstate highway site (Black Mountain), which had the highest AADT, had PSDs with moderate d10, d50, and d90 values.

Table 3. Median summary statistics for PSDs sampled at each of the eight sites. Sample size varies between three and nine at each site. Particle sizes presented are in units of µm.

Statistic	Black Mountain	Brevard	Jack Bennett	Hanks Chapel	Faison	Benson	Wilson	Goldsboro
d10	14	22	9	31	30	9	10	11
d50	67	112	36	167	101	41	44	32
d90	426	594	113	591	522	131	506	72
Cu	5.3	6.3	5.1	6.2	4.2	5.9	5.8	4.1
Cc	1.1	1.2	1.4	1.3	1.3	1.5	1.3	1.4

Particle size distributions from the 43 sampled storm events are presented in Figure 3, where each particle size bin is represented by a separate boxplot. Thus, the median, 1st and 3rd quartiles, and interquartile range for each particle size bin can be interpreted. The median PSD in this study is formed by drawing a line between the median of each boxplot. The clay-sized particles exhibited very little inter-sample variability, while the interquartile range was largest for the silt fraction. On a volume basis, very few particles larger than 1000 µm were observed in the samples.

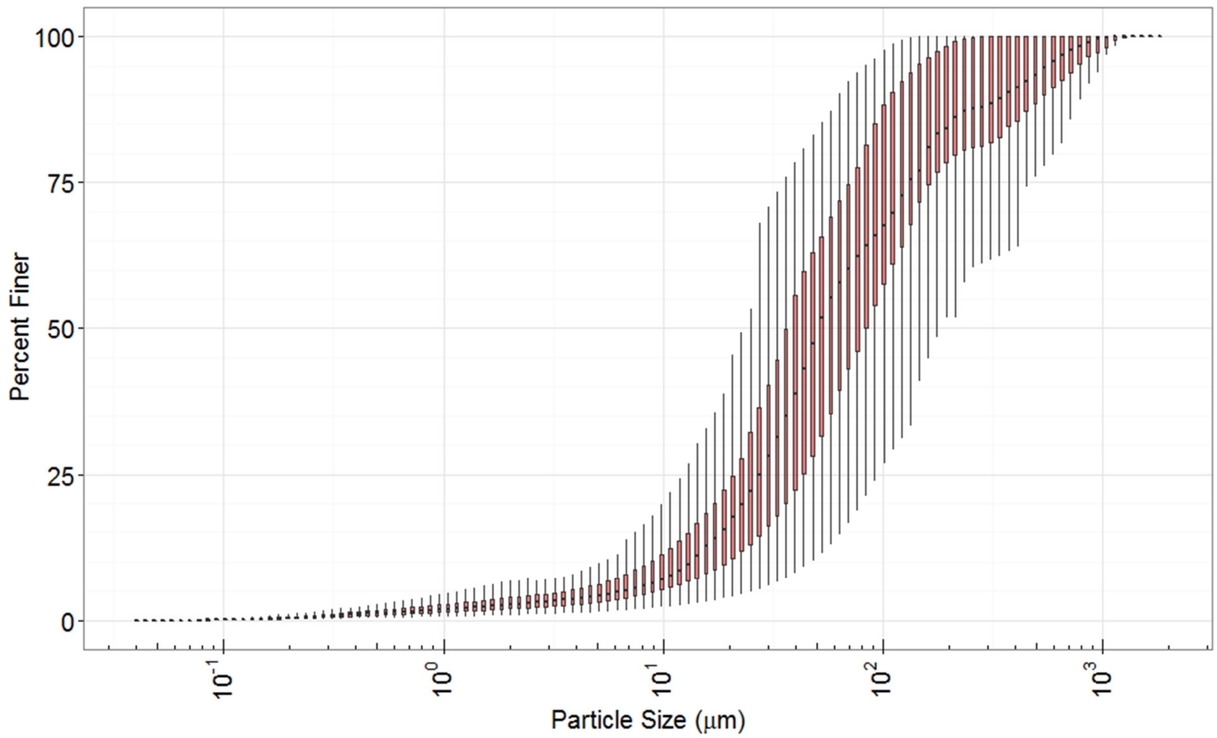

Figure 3. Particle size distributions for the 43 roadway runoff samples in NC. Each boxplot represents the variability in particle size for that particular bin. The upper and lower bounds of the boxplot represent the first and third quartiles. The upper and lower fences represent 1.5 quartiles above and below, respectively, the interquartile range.

Previous research has shown that PFC reduces the generation and washoff of TSS and sediment-borne pollutants, such as heavy metals, when compared to HMA roadways (Pagotto et al. 2000; Eck et al. 2012). The median summary statistics and confidence intervals for this comparison are presented in Table 4. The median d_{10} and d_{50} for HMA and PFC were very similar, with bootstrapped CIs overlapping. Thus, no significant difference was found for particles in the clay and silt ranges. However, the d_{90} varied greatly for HMA (428 μm) versus PFC (131 μm); since the confidence intervals do not coincide, this difference was significant (Figure 4). For the median event, runoff from HMA had a PSD that was 2.6% clay, 44.8% silt, and 52.6% sand (USDA 1975) The PSD of runoff from PFC was 4.2% clay, 54.9% silt, and 40.9% sand. This suggested that substantial reductions in TSS generation from PFC observed in past studies were due to reductions in the sand-size fraction (Barrett et al. 2006; Eck et al. 2012; Winston et al. 2012). Due to low runoff TSS concentrations (typically <20 mg/L) and a silt/clay skewed PSD from PFC, the performance of SCMs downslope of this pavement type will be reduced when compared to HMA (Winston et al. 2015). The coefficients of uniformity and curvature suggest that the median HMA PSD is well graded, while that of PFC is poorly graded.

Table 4. Median PSD summary statistics and confidence intervals for HMA and PFC.

Statistic	HMA	PFC	HMA Bootstrap CI	PFC Bootstrap CI
d10	13	9	13-19.5	6-20
d50	54	41	59-86	34-79
d90	428	131	319-518	108-277
Cu	5.8	5.9		
Cc	1.3	1.5		

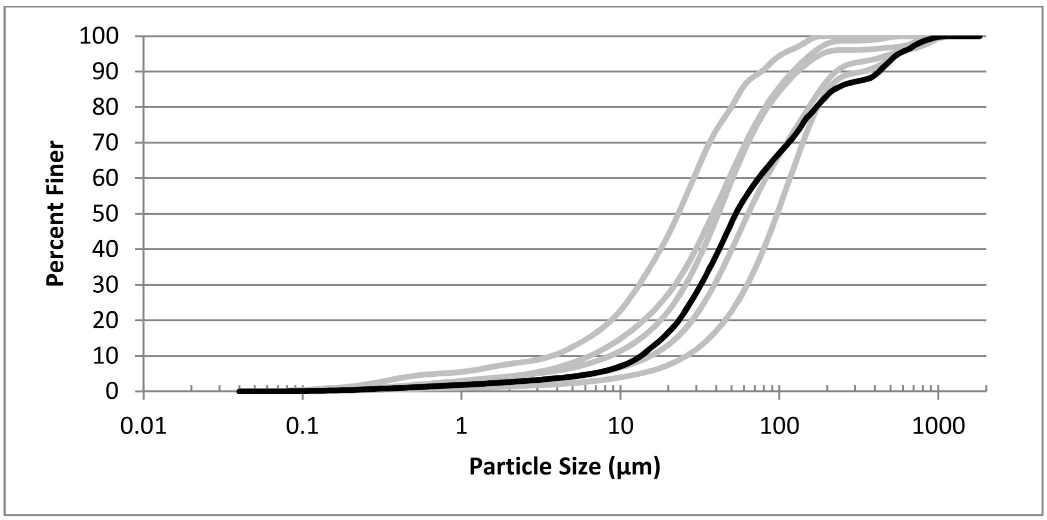

Figure 4. Median HMA PSD (black) shown against the five sampled PSD for PFC.

Further statistical testing was undertaken to determine if ecoregion in affected PSD. It was hypothesized that the typical underlying soil type in the Coastal Plain (sandy) would impact PSD from the roadways in this ecoregion. The Mountain and Piedmont ecoregions are characterized by clayey soils which might skew the PSD due to windborne sediment. Given that PFC affected PSD, the Benson site was dropped from these analyses so that all comparisons were among HMA roadways; this resulted in 13 PSDs (2 sites), in the Mountains, 9 PSDs (2 sites) in the Piedmont, and 16 PSDs (3 sites) in the Coastal Plain. Krustal-Wallis k-sample tests were applied to test for differences in d_{10}, d_{50}, and d_{90}. No significant differences were observed for d_{10} and d_{90}. For d_{50}, the omnibus test suggested differences, but pairwise comparisons using Tukey's

HSD showed no significant differences. Taken together, ecoregion (and therefore underlying soil type) does not seem to impact PSD from roadways.

Roadway classification is an indicator of both vehicle travel speeds and AADT. For instance, interstate highways have much higher AADT and perhaps double the travel speed of secondary roads (Table 1), which might impact the PSD generated during stormflow. Given that PFC affected PSD, the Benson site was dropped from these analyses so that all comparisons were among HMA roadways. This resulted in a data set of 9 PSDs (1 site) for interstate highways, 3 PSDs (1 site) for divided highways, 17 PSDs for primary routes, and 9 PSDs (2 sites) for secondary roads. The Kruskal-Wallis k-sample test was utilized to statistically test for differences in d_{10}, d_{50}, and d_{90} among the roadway classifications. Results showed no significant differences among the treatment groups, suggesting that roadway classification and by extension AADT and traffic speed, do not impact runoff PSD.

Potential causal variables were explored for their impacts on PSD in roadway runoff. These included rainfall depth, antecedent dry period, peak five minute rainfall intensity, peak hourly rainfall intensity, average rainfall intensity, and rainfall duration (Table 2). Spearman's rank correlation test was applied to correlate these storm event characteristics and TSS concentrations with d_{10}, d_{50}, and d_{90} for all monitored sites. For instance, it might be expected that peak five minute intensity would impact PSD, since higher intensities might mobilize particles with larger masses (and therefore diameters). Antecedent dry period and peak 5 minute rainfall intensity were the least correlated to particle size characteristics and TSS concentrations, suggesting that they did not impact the nature of runoff sediment (Table 5). Peak hourly rainfall intensity was significantly correlated to the d_{50} particle size at the α=0.1 level. This suggests that intense rainfall over extended durations may have more impact on PSDs than shorter bursts of rainfall. Rainfall depth apparently did not influence PSD, but was significantly negatively correlated to TSS concentrations at the α=0.1 level; TSS concentrations were higher during storms with smaller depths. This is directly related to the first flush effect of sediment in stormwater runoff (Flint and Davis 2007). As rainfall depth increases, the pollutants that build up on the roadway during the antecedent dry period are further and further diluted by increasing runoff volume.

Rainfall duration appeared to be the one parameter that was well correlated with d_{10}, d_{50}, d_{90}, and TSS concentration (all at α=0.05 level). All parameters were negatively correlated with rainfall duration, suggesting that as rainfall duration increases, particle size is smaller across the PSD, and TSS concentrations decline. Perhaps this is due to dilution that occurs during longer duration events. This was further supported by significant correlations between average intensity for d_{50} and d_{90}. Correlation coefficients of -0.19 (significant at the α=0.1 level) were found for relationships between TSS and d_{50} and TSS and d_{90}. This suggested that as TSS concentrations increased, the median and 90th percentile particle diameter decreased.

Table 5. Spearman rank correlation coefficients for rainfall characteristics, particle size characteristics, and TSS. Bolded values are significant at the α=0.1 level. Bolded and italicized values are significant at the α=0.05 level.

Parameter	d10	d50	d90	TSS
Rainfall Depth	-0.148	-0.02	0.086	**-0.203**
Antecedent Dry Period	-0.001	0.005	0.036	0.072
Peak 5-minute intensity	-0.044	0.091	0.043	0.0672
Peak Hourly Intensity	0.076	**0.249**	0.131	0.088
Rainfall Duration	***-0.257***	***-0.374***	***-0.242***	***-0.344***
Average Intensity	0.025	**0.249**	**0.226**	0.103

Water Quality

In order to determine the fraction of nutrient loading comprised of gross solids, stormwater sampling was undertaken for nutrients and TSS at the same locations as the PSD monitoring. TSS data are presented below in Figure 5 for the eight sites monitored herein. Additionally, the Benson*, I40B, I40C, and I40D sites are comprised of data from Winston et al. (2012) collected during 2008-2010. These four data sets and the Benson data set collected in this work comprise the five PFC sites monitored; the other seven sites monitored herein were HMA sites. By site, median TSS concentrations from PFC ranged from 5-17 mg/L, while those for the HMA sites ranged from 11-40 mg/L. The lumped median concentration for the PFC sites was 9.0 mg/L TSS. This very low median effluent concentration from PFC is corroborated by past research (Berbee et al. 1999; Pagotto et al. 2000; Eck et al. 2012; Winston et al. 2012), which showed effluent concentrations of 13 mg/L in France, 9-17 mg/L in North Carolina, 6-12 mg/L in Texas, and 17 mg/L in the Netherlands. For the seven HMA sites, the lumped median concentration was 23.0 mg/L TSS. It should be noted that these HMA TSS concentrations were quite low compared with past studies on roadway runoff, which were 194 mg/L in the Netherlands, 66 mg/L in California, and 91-142 mg/L in Austin, Texas (Barrett et al. 1998; Berbee et al. 1999; Kayhanian et al. 2003), perhaps due to the fact that only two highway sites (Black Mountain and Faison) were monitored and due to the relatively low AADT at each of the sites except Black Mountain (Table 1). In fact, only the Black Mountain site would be considered as low AADT for an urban area per Kayhanian et al. (2003)'s classification. All of the other sites, with AADT less than 18,000, would be considered nonurban roadways. Perhaps this affected the build-up of sediment on the roadways. Taken together, this study further confirms that PFC influences TSS concentrations in roadway runoff, and releases TSS at concentration similar to effluent from bioretention and sand filters (Barrett 2003; Davis 2007).

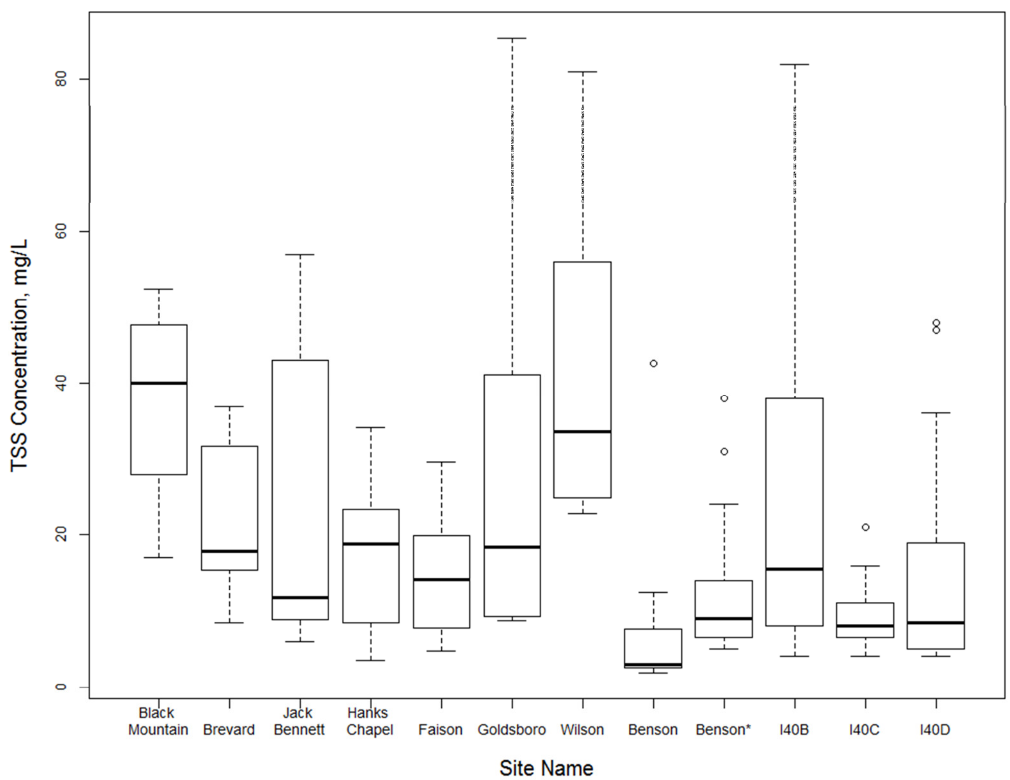

Figure 5. Boxplots of TSS concentration for all sites monitored herein and four PFC sites (Benson, I40B, I40C, and I40D) from Winston et al. (2012). Benson* is the data from I40A from Winston et al. 2012, and is the same monitoring location as Benson herein. Two outliers were removed to improve the clarity of the graphic: 154 mg/L at Wilson and 178 mg/L at I40B.

One of the goals of this manuscript was to determine the fraction of nutrient loading from roadways that gross solids represent. To do so, the event mean concentrations (EMCs) from these roadways must be first compared against the literature (Table 6). Pollutant loading for the aqueous portion of the runoff (vis-à-vis gross solids) will be derived in the next section of this manuscript. The Thomson et al. (1997) and Kayhanian et al. (2007) references present data from a highway in Minnesota and a compilation of 34 roadway monitoring sites in California, respectively. The Barrett et al. (2004) and Winston et al. (2012) data are highway runoff data from California and North Carolina, respectively.

The four sites monitored herein produced mean TN concentrations between 1.26-1.69 mg/L. Organic nitrogen represented between 34-54% of TN, while TAN comprised 23-41% of TN (Table 6). NOx, a dissolved constituent, was a relatively small fraction (16-29%) of the TN, suggesting that a substantial fraction of the TN in this roadway runoff might be removed through settling and filtration. Nitrate-nitrite, TN, and TKN concentrations were all much lower than those presented in past studies, perhaps due to the relatively low AADT at the four sites (maximum 13,000) and rural monitoring locations. Particulate-bound P was the dominant form of P in the runoff, similar to previous studies (Berretta and Sansalone 2011). At the four roadway sites studied, between 53-84% of TP was in the particulate form, with the remainder in the dissolved state. This again suggests that particle settling in roadside filter strips and swales at these sites could be a dominant mechanism for P reduction. Both dissolved (OP) and TP concentrations were within the ranges found in previous roadway runoff research across the U.S. (Table 6).

Table 6. Comparison of mean nutrient EMCs from this study to past roadway runoff research.

Site Name	TKN	NOx	TN	TAN	ON	TP	OP	PBP
Jack Bennett	1.41	0.27	1.69	0.66	0.75	0.14	0.07	0.07
Hanks Chapel	1.15	0.46	1.61	0.41	0.73	0.07	0.01	0.06
Goldsboro	1.04	0.34	1.39	0.57	0.48	0.16	0.07	0.09
Wilson	0.98	0.28	1.26	0.30	0.68	0.17	0.05	0.12
Previous Research	**TKN**	**NOx**	**TN**	**TAN**	**ON**	**TP**	**OP**	**PBP**
Thomson et al. (1997)	1.77	0.73	2.39	-	-	0.56	-	-
Barrett et al. (2004), Sacramento	1.7	0.44	2.14	-	-	0.4	0.17	-
Barrett et al. (2004), Redding	1.32	0.45	1.79	-	-	0.14	0.04	-
Barrett et al. (2004), Cottonwood	1.9	0.81	2.81	-	-	0.19	0.05	-
Barrett et al. (2004), Yorba Linda	1.4	0.67	2.07	-	-	0.09	0.06	-
Kayhanian et al. (2007)	1.4	0.6	2	-	-	0.18	0.06	-
Winston et al. (2012), Site A	0.97	0.51	1.48	0.41	0.56	0.08	-	-
Winston et al. (2012), Site B	1.26	0.41	1.66	0.46	0.79	0.11	-	-
Winston et al. (2012), Site C	1.32	0.71	2.03	0.62	0.71	0.10	-	-
Winston et al. (2012), Site D	1.27	1.32	2.60	0.55	0.72	0.13	-	-

Gross Solids

Gross solids samples were analyzed for dry weight, nutrient, and heavy metal content (Table 7). Vegetative matter dry weight varied from 16.2-74.3 grams per sampling event, with a median value of 29.2 grams. Catchment area normalized dry weight varied from 226 to 1589 g/ha. Median values for the Faison, Black Mountain, Newton Grove, and Garner sites were 779, 1127, 422, and 329 g/ha respectively, for the approximately weekly samples. These were in the same range as those reported by Allison et al. (1998b), wherein 48-1294 g/ha was collected (approximately weekly) from a 50 ha watershed composed of 65% residential, 30% commercial, and 5% light industrial in Melbourne, Australia.

The Faison site was the only site monitored during leaf-fall (October-December). Dry weights of samples collected during this period were lower than those from September, suggesting that seasonality may not be a factor (Table 7). While deposition of tree leaves occurs to a greater extent during the Autumn, perhaps the four monitoring locations along interstate or NC highways did not allow leaves to build up due to: (1) the posted 105 km/hr speed limit and (2) the 10 meter clear recovery zone. Vehicles travelling at this rate of speed would force leaves and other low weight organic debris to the side of the roadway, where it would not be captured in the edge-of-pavement sampling techniques used herein. A minimum 10 meter grassed shoulder is associated with interstate highways, suggesting that leaves falling from trees may be located further from the road than in a residential or commercial setting.

Predictors of gross solid dry weight were determined using Spearman's rank correlation across the 26 samples (Table 8). Length of the sampling period, antecedent dry period, and rainfall duration were not correlated with dry weight. Peak five minute rainfall intensity was positively correlated at the $\alpha=0.1$ level, suggesting that bursts of intense rainfall mobilized a larger mass of gross solids. Additionally, dry weight was heavily positively correlated ($\alpha=0.05$) to rainfall depth. This suggests that if gross solids capture is the goal, the largest and most intense rainfall events may need to be controlled, as opposed to the typical LID goal of retaining the 2.5 cm storm. Thus, catch basin inserts designed for low rainfall intensities or depths may prove ineffective (Kostarelos et al. 2011).

Nutrient concentrations in vegetative litter varied from 0.5%-2% (TN) and 0.05%-0.35% (TP) of total dry mass. The median value of total gross solid dry mass was 1% for TN and 0.1% for TP. Similar results were presented for leaves from five species of trees in Minnesota, where TN represented 0.96%-1.57% and TP 0.1-0.16% of leaf mass (Hobbie et al. 2014). TN represented 0.7-2.2% of leaf litter dry mass in a study of a watershed in Melbourne, Australia; TP was 0.08-0.28% of the dry mass (Allison et al. 1998b). While some variability exists across species type (Qiu et al. 2002), it should be noted that TN and TP are a very small percentage of the total organic biomass in stormwater.

Furthermore, leaf litter and plant detritus must decompose into aqueous nutrient forms before it can become available for primary processes responsible for eutrophication (Hobbie et al. 2014). Therefore, a number of studies have been carried out to ascertain the fraction of TP and TN within leaves that may leach to the surrounding stormwater. Dorney (1986) collected leaves from 13 urban street tree species in Wisconsin; the author found that between 4.5-13.4% of TP was leachable from the leaves within 2 hours. A study in Australia found that between 11-47%

of TP in leaves leached into water in 24 hours of contact time (Qiu et al. 2002). Hobbie et al. (2014) examined leaf decomposition within urban street gutters; they found that the majority of leached N was as dissolved organic N, and that within 24 hours less than 10% of the initial N was leached. However, 28-88% (median 40%) of the initial P leached from the leaves in 24 hrs. Taken together with the fraction of dry mass that was TN and TP in this study, this suggests that 0.05%-0.2% and 0.02%-0.14% of dry leaf litter mass would decompose and contribute TN and TP, respectively, to the water column.

Zinc and Mn represented less than 0.1% of gross solids total dry weight (Table 7). Plant tissue copper fraction was negligible. Fe was present in gross solids at up to 0.57% by dry mass. Given their relatively small percentage of the mass of gross solids, it is suggested that watershed managers invest efforts in targeting aqueous and particulate-bound metals as opposed to gross solids in watersheds with metals TMDLs.

Table 7. Nutrient and heavy metal concentrations in gross solid samples from NC roadways. Nutrient and metals parameters are expressed as a percentage of total dry mass.

Site	Date	Sampling Period Duration (days)	Monitoring Period Rainfall Depth (mm)	Dry Weight (kg)	TN	TP	Zn	Cu	Mn	Fe
Faison	9/7/2012	6	23.1	0.041	0.76	0.09	0.040	0.003	0.008	0.127
	9/19/2012	8	19.8	0.070	1.03	0.13	0.015	0.002	0.012	0.032
	10/6/2012	13	11.2	0.045	0.65	0.09	0.014	0.002	0.009	0.032
	10/8/2012	8	52.8	0.036	0.69	0.11	0.017	0.002	0.008	0.029
	10/22/2012	6	24.4	0.040	0.90	0.08	0.010	0.001	0.004	0.020
	11/16/2012	8	55.1	0.023	1.16	0.10	0.006	0.001	0.035	0.034
	12/13/2012	8	18.3	0.025	1.22	0.14	0.012	0.005	0.032	0.046
Black Mountain	6/6/2012	5	24.1	0.072	1.49	0.14	0.046	0.005	0.016	0.445
	6/14/2012	28	75.4	0.074	1.23	0.12	0.031	0.003	0.012	0.232
	6/27/2012	14	9.1	0.040	1.48	0.14	0.042	0.004	0.018	0.454
	7/5/2012	3	6.4	0.049	1.19	0.09	0.049	0.003	0.021	0.391
	7/11/2012	8	22.1	0.020	2.02	0.35	0.034	0.003	0.033	0.183
	7/19/2012	16	30.5	0.056	1.74	0.20	0.026	0.004	0.024	0.411
Newton Grove	12/13/2012	4	10.9	0.019	0.89	0.11	0.024	0.002	0.036	0.053
	12/17/2012	28	93.0	0.033	0.50	0.05	0.063	0.002	0.043	0.093
	1/14/2013	4	21.3	0.020	0.83	0.11	0.027	0.002	0.007	0.037
	1/18/2013	10	3.6	0.016	1.43	0.22	0.057	0.004	0.011	0.062
	1/28/2013	3	5.6	0.030	0.80	0.24	0.034	0.002	0.006	0.098
	1/31/2013	8	6.4	0.021	1.11	0.10	0.036	0.003	0.009	0.085
	2/8/2013	3	6.1	0.029	0.97	0.13	0.039	0.005	0.010	0.093
Garner	12/13/2012	12	13.5	0.017	0.82	0.10	0.024	0.003	0.095	0.226
	12/17/2012	17	29.2	0.016	1.25	0.10	0.027	0.015	0.114	0.167
	1/14/2013	3	27.4	0.053	0.76	0.10	0.056	0.008	0.032	0.538
	1/28/2013	13	6.9	0.015	1.08	0.09	0.038	0.003	0.061	0.249
	1/31/2013	25	15.5	0.025	0.91	0.09	0.100	0.006	0.066	0.498
	2/8/2013	31	43.9	0.026	0.64	0.09	0.079	0.006	0.036	0.565

Table 8. Spearman's rank correlation coefficients for gross solids weight as a function of sampling window duration and climatic parameters. Bolded values are significant at the α=0.1 level. Bolded and italicized values are significant at the α=0.05 level.

Parameter	Correlation Coefficient
Sampling Window Duration	-0.104
Rainfall Depth	***0.33***
Antecedent Dry Period	-0.133
Peak 5 Minute Intensity	**0.246**
Rainfall Duration	0.187

Correlation analysis suggested that rainfall depth rather than sampling window duration was the best predictor of gross solid dry weight. Thus, pollutant loading per unit rainfall depth will be presented, as opposed to per unit time. Based on monitored flow volumes during each storm, nutrient concentrations and gross solids dry weight were utilized to extrapolate gross solids yearly loading for TN and TP using equation 1. These values were compared against yearly loading estimated for aqueous and sediment-bound nutrients in runoff during a previous study in NC (i.e. not including gross solids, Winston et al. 2012) and from the four sites that were monitored for nutrients in this study (Jack Bennett, Hanks Chapel, Goldsboro, and Wilson). Nitrogen loadings were generally an order of magnitude larger than phosphorus loadings for both gross solids and aqueous phase nutrients (Table 9). For gross solids, N loads varied between 0.2-0.9 kg/ha/yr, while P loads fell between 0.03-0.12 kg/ha/yr. It is noted from Table 9 that gross solids loads of TN and TP determined herein were approximately an order of magnitude less than those in the aqueous phase of stormwater runoff. While gross solids and water quality monitoring locations were not co-located, TN from gross solids represented between 0.9%-11.5% (median 5.8%) of the total TN loading from the stormwater. For TP, gross solids represented between 1.9%-27.8% (median 9.0%) of the total TP loading. This suggests that, at least in highway catchments, gross solids are a relatively small portion of the total yearly nutrient loading.

Given the median values of 5.8% of TN and 9.0% of TP yearly loading that were related to gross solids, and given that approximately 10% and 40% of TN and TP leach into the stormwater from leaves (Hobbie et al. 2014), an effective yearly gross solids nutrient load of 0.6% TN and 3.6% TP was estimated. An order of magnitude lower metals loading was present in gross solids when compared to typical dissolved and sediment-bound stormwater metals loading (Davis et al. 2001; Table 9). This suggested that for roadway sites, gross solids represent about a two order of magnitude smaller nutrient loading contribution than those measured in water samples of stormwater, similar to results presented in Allison et al. (1998b). However, exports of TN and TP among six urban watersheds varied proportionately to tree canopy cover (Hobbie et al. 2014), so the lack of tree cover in the linear environment may influence results presented herein. In residential or commercial catchments, the relative N and P loading from gross solids might be higher due to greater accumulation of leaf litter and other organic detritus due to curb and gutter drainage systems.

Table 9. Normalized nutrient and heavy metal loading (kg/ha/yr) in gross solids and runoff samples from roadway sites in North Carolina (Winston et al. 2012; SCONC 2014).

Sample Type	Site	30-yr Average Rainfall (mm)	TN	TP	Zn	Cu	Mn	Fe
Gross Solids	Faison	1247	0.87	0.10	0.021	0.0021	0.010	0.057
	Black Mountain	1234	0.69	0.07	0.018	0.0018	0.008	0.173
	Newton Grove	1232	0.69	0.12	0.032	0.0024	0.011	0.072
	Benson	1161	0.24	0.03	0.019	0.0016	0.017	0.110
Aqueous (Runoff)	I-40 Site A	1219	7.59	0.35				
	I-40 Site B	1232	11.84	0.68				
	I-40 Site C	1237	13.77	0.8				
	I-40 Site D	1247	27.26	1.35				
	Jack Bennett	1214	9.55	0.76				
	Hanks Chapel	1214	11.67	0.52				
	Goldsboro	1265	15.20	1.25				
	Wilson	1196	10.80	1.49				

Conclusions

Two often overlooked facets of stormwater quality were monitored during this field research study on roadway runoff: PSD and gross solids. In order to understand sediment trapping within vegetated filters that are omnipresent in the linear environment, the runoff PSD is needed to model particle settling. Additionally, analysis of gross solids in the linear environment was desired to understand the fraction of the nutrient loading that was represented by leaf litter. The following conclusions were drawn from this work:

1) At the eight PSD monitoring sites, d_{10} ranged from 9-31 µm, d_{50} from 32-167 µm, and d_{90} from 72-591 µm. Very little variability existed in the percentage of clay sized particles in the runoff. For the median event, runoff from HMA had a PSD that was 2.6% clay, 44.8% silt, and 52.6% sand. Correlation analysis showed that PSD was significantly negatively correlated to rainfall duration and sometimes positively correlated to peak hourly rainfall intensity and average rainfall intensity. PSD was not correlated to peak 5-minute rainfall intensity, antecedent dry period, or rainfall depth.

2) Statistical analysis showed no significant variation in d_{10}, d_{50}, and d_{90} based on roadway classification or ecoregion. This suggested that underlying soil type, which varied greatly from heavy clay to sandy soils, did not affect PSDs for the roadway. The AADT of a roadway did not appear to modify the PSD. The one significant factor was presence or absence of a PFC overlay, which significantly reduced the d_{90} particle size; the median d_{90} varied greatly for HMA (428 µm) versus PFC (131 µm), suggesting that PFC reduces this particle size in the runoff. PFC contained 11.5% less sand sized particles by volume, suggesting greater percentages of silt and clay. This in combination with low TSS effluent concentrations from PFC will reduce the performance of downslope highway SCMs, such as filter strips and swales (Winston et al. 2015).

3) TSS generation from roadways with a PFC overlay was again shown to be substantially less than HMA. Median runoff TSS concentrations in this study were 9.0 mg/L for PFC, within the range of values from previous studies from the US, France, the Netherlands, and New Zealand. The corresponding concentration for HMA was 23.0 mg/L. The low TSS concentration for HMA in this study was attributed to the low AADT values at most of the monitoring sites. Nutrient concentration data, which were utilized in extrapolating the fraction of nutrient loading represented by gross solids, were within ranges of previous research on nutrients from roadways around the world.

4) Dry mass of gross solids from roadways was positively correlated to both rainfall depth and peak five minute intensity. This suggests that catch basin inserts need to be designed for infrequent return interval events. Nutrient concentration in leaf litter varied from 0.5-2.0% for TN and 0.05-0.35% for TP. Given leaf decomposition and nutrient leaching rates from gross solids into stormwater, it was predicted that 0.6% of TN and 3.6% of TP yearly nutrient loading was represented by leaf litter. Perhaps this fraction would be larger for commercial or residential watersheds, where trees are located in closer proximity to roads.

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Part II: Modeling Sediment Deposition in Grassed Highway SCMs

Introduction

Stormwater runoff is a major source of impairment to surface waters around the world through contributions of nutrients, sediment, heavy metals, bacteria, and oils and greases (U.S. EPA 2007). One of the most common pollutants in stormwater is sediment, which is typically generated through erosion in the watershed or in-stream, through poor erosion control practices, row-crop agriculture, breakdown of pavement, and tire wear. Suspended sediment causes harm to fish through reduced feeding rates and growth, impaired respiration, increased physiological stress, and reduced tolerance to toxicants (Newcombe and Jensen 1996). Species that are visual predators (such as trout) have reduced foraging ability and growth rates in waters with high suspended sediment (Sweka and Hartman 2001). Increased sediment loads due to urbanization also cause the useful life of reservoirs to shrink (Caputo and Carcione 2013).

In urban areas, paved surfaces are a source of sediment, with abrasion from tire-pavement interactions being the major cause (Muschack 1990). In one study, pavement accounted for 40-50% and tires for 20-30% of sediment generated from roadways (Kobriger and Geinopolis 1984). Since pollutants build up during inter-event periods, research has shown that factors such as antecedent dry period, contributing drainage area, total event rainfall, and annual average daily traffic (AADT) may impact highway runoff event mean concentrations (EMCs) (Kayhanian et al. 2007). Highway runoff EMCs for TSS often exceed 100 mg/L, suggesting that treatment by stormwater control measures may be needed before discharge to surface waters (Thomson et al. 1997).

As part of sediment control strategies, engineers implement stormwater control measures (SCMs) to reduce sediment concentrations from roadways, construction sites, and other urban developments. Two of the most commonly used surface conveyances are grassed filter strips (FS) and grassed swales, which are primary treatment devices for highway runoff applications. Within these SCMs, particulate-bound pollutants, such as heavy metals, TSS, and a fraction of TN and TP, are primarily removed through settling and filtration (Winston et al. 2012). The shoulder of the roadway acts as a filter strip, where stormwater sheet flows through the grass, reducing its velocity and filtering sediment. Swales are triangular or trapezoidal in cross-section, and are utilized to convey flow in a concentrated form. Research in Texas found that filter strips along highways result in the majority of total suspended solids (TSS) reductions, rather than swales (Barrett et al. 1998). FS and swales reduce peak flow rates, foster infiltration, and improve runoff quality, primarily through sedimentation (Bäckström 2002; Deletic 1999; Deletic and Fletcher 2006; Winston et al. 2011; Yu et al. 2001). However, few efforts have been made to model TSS reduction in these SCMs as a function of design variables.

Since sediment particles have varying diameters, they settle at differing rates based on Stokes' Law (Stokes 1845). In order to predict TSS reduction, the particle size distribution (PSD) of sediment from a typical urban catchment must be determined. The PSD provides insight into the volumetric distribution of particle diameters, which greater insight into sedimentation and filtration within SCMs.

In North Carolina, a stormwater sampling effort was undertaken to characterize PSD in roadway runoff from eight sites distributed across the state (Winston et al. 2015). PSDs were obtained from standard hot mix asphalt (HMA) roadways as well a road with a permeable friction course (PFC) overlay. PFC is an innovative surface layer of pervious asphalt that is placed over traditional HMA to improve drainage, motorist safety, and water quality (Eck et al. 2012). PFC has been shown to significantly improve TSS concentrations vis-à-vis HMA, and also to modify the PSD by reducing the d_{90} particle size (sand size fraction) within the stormwater runoff (Eck et al. 2012; Winston et al. 2015).

Currently, states across the U.S. credit swales and filter strips for total nitrogen, total phosphorus, and total suspended solids (TSS) reduction using a "one size fits all" approach (i.e. giving a static amount of credit as long as design guidance is met; TCEQ 2005; IADNR 2010; ARC 2012). In North Carolina, for example, grassed swales receive 35% TSS, 20% TN, and 20% TP credits if they have 5:1 or shallower side slopes, a length of 50 m or longer, and a design velocity no greater than 30 cm/s during the 10-yr design storm (NCDENR 2009). It would be advantageous to provide TSS removal credit as a function of design characteristics, so that a swale or FS could be built to meet the regulations at hand. To predict vegetated filter performance as a function of swale length, side slope, longitudinal slope, grass height, and cross-sectional geometry, a simple model is desired to couple hydraulics and particle settling predictions. This model has been tested against field-collected swale performance data from Auckland, New Zealand and Knightdale, North Carolina, USA (Hunt et al. 2015).

Research Goals

The primary goals of this study were to: (1) create a simple model coupling both hydraulics and particle settling within vegetated filter stormwater controls, (2) utilize existing PSDs for both HMA and PFC roadways as inputs to the model, and (3) perform a sensitivity analysis to determine TSS reduction as a function of swale and filter strip designs, including varying the following parameters: catchment area, side slope, longitudinal slope, swale length or filter strip width, and SCM type (triangular swale, trapezoidal swale, or vegetative filter strips).

Materials and Methods

Stormwater PSD samples were obtained from eight roadway sites across North Carolina (Winston et al. 2015). A total of 43 samples were collected from separate storm events. For HMA and PFC, 38 and 5 samples were collected for the purposes of the modeling herein. For additional information on sample collection, sample processing, and trends in the PSD data, refer to Winston et al. (2015).

This modelling effort utilized the field-collected PSDs to predict particle settling as a function of design variables for roadside swales. This sensitivity analysis involved 1890 modeling runs in a spreadsheet-based, coupled hydraulic and sediment settling model. The hydraulics model was based on the underpinning assumptions in Hunt et al. (2015). The rational method (equation 1) was utilized to calculate peak flow from various catchment area (0.1, 0.2, and 0.3 ha) assuming a 25 mm/hr design rainfall intensity (Mulvany 1851). This rainfall intensity represented 98.5th percentile of rainfall rate for Raleigh, NC over the previous 30 years (Hunt et al. 2015).

$$Q = 0.278*C*i*A \qquad \text{(Equation 1)}$$

Where C = runoff coefficient, i = precipitation intensity (mm/h), and A = area (km^2). This predicted peak flow rate was input into Manning's equation to predict flow depth and velocity as a function of swale design variables (Manning 1891).

$$Q = \frac{A * {R_h}^{2/3} * s^{1/2}}{n}$$

Where Q = open channel flow rate (m^3/s), n = Manning's roughness coefficient (dimensionless), A = channel cross-sectional area (m^2), R_h = hydraulic radius (m), and s = slope (expressed as a decimal). A Manning's n value of 0.35 was applied to represent the underpinning assumption that flow was not permitted to overtop the grass height, set at either 10 or 15 cm (Hunt et al. 2015). These elevated Manning's n values were based on previous research that showed that grass imparts as much as ten-fold more resistance when flow depth does not exceed the grass height (Bäckström, 2002; Kirby et al. 2005). Within the hydraulic model, iterations of design variables included: cross-section type (triangular swale, trapezoidal swale, and filter strip), longitudinal slope (0.5%, 1%, 1.5%, 2%, 3%, 4%, 5%, 7.5%, and 10%), swale length (7.6 m, 15 m, 30 m, 60 m, 90 m, 150 m, and 300 m), and side slope (3:1, 4:1, 5:1, and 6:1).

Given this simple hydraulics model, a particle settling model is needed to determine TSS capture within typical highway SCMs. The catalyst for sediment-borne pollutant removal is settling or deposition of solids. The settling rate (Vs) of particulates is governed by Stokes Law.

$$Vs = (g / 18\mu) (\rho_s - \rho) d_s^2$$

where, g = gravity, μ= dynamic viscosity of water (kg/s/m), ρ_s is particle density (kg/m^3), ρ = water density (kg/m^3), and d_s = particle diameter (m).

Accordingly, particle removal by settling is a function of the size and density of the particles, and the residence time in the swale. The design hydraulic residence time (T_{ahr}) in the swale is determined by:

$$T_{ahr} = L_{swale} \div V$$

where L_{swale} is the length of the swale and V is the peak flow velocity during the design storm event.

It is known that with adequate T_{ahr} particles with $Vs \geq V$ will be removed. Therefore, it could be argued that the hydraulic retention time and Stokes' Law equations may be simply used to determine the swale length for a target sediment removal rate if the particle size distribution (PSD) for that location is known. Unfortunately, it has been repeatedly shown that this is not a straightforward procedure, since Stokes' Law does not strictly apply to the case of shallow flows over grassed surfaces (Tollner et al. 1982, Hayes et al. 1984, Deletic 2005). Alternatively, for grass swales and filter strips, Tollner et al. (1982) and Deletic (2005) suggest that the particle "fall number," N_f, may be used for determining whether a particle is trapped. This model was specifically designed for urban stormflow and the low to moderate concentrations of sediment associated with the developed (i.e. not active construction) condition. The fall number is calculated as:

$$N_f = \frac{x * V_s}{h * V}$$

Where x is the width of the grassed filter strip or length of the swale (m), V_s is the particle settling velocity (calculated using Stokes' Law) (m/s), h is flow depth (m), and V is flow velocity (m/s). For the purposes of this modeling work, particle density was taken at a constant 2.65 g/cm^3 the median value found in PSDs by Andral et al. (1999). This study found particle densities between 2.38 and 2.86 g/cm^3 for particles between 2 and 1000 μm in diameter. Particle diameter was derived from the field-collected PSDs (Winston et al. 2015). N_f is integral to the empirically-derived Aberdeen equation which predicts TSS trapping efficiency (Deletic 2005):

$$Tr_s = \frac{{N_f}^{0.69}}{({N_f}^{0.69} + 4.95)}$$

Where Tr_s is the sediment trapping efficiency (in decimal form). The model can be used to set the design parameters of the swale or FS to meet a target removal rate for TSS (for instance 50%). The roadway runoff PSDs are critical to this calculation; the median PSD of the HMA or

PFC data (as specified) will be used for the remainder of the discussion herein, since it represents the central tendency of the data (Winston et al. 2015). Triangular swales were modeled with a bottom width of 0 m, while trapezoidal swales had a bottom width of 1.67 m.

Results and Discussion

Swale Modeling

Triangular and trapezoidal swales were modeled for TSS removal as a function of design characteristics. For the 25 mm/hr design rainfall intensity, triangular swales had difficulty meeting the maximum flow depth requirement of 15 cm, and only provided a flow depth less than 10 cm in the 6:1 side slope, 10% slope, and 0.1 ha watershed case (Table 10). Especially for low slopes, flow depth in triangular swales quickly progressed beyond the height of the grass, negating the validity of the model. For 0.3 ha or larger watersheds, triangular swales were essentially not an option for conveyance of the water quality rainfall intensity without overtopping the height of the grass. This is contrasted with results for the trapezoidal swale, which allowed more flow area per unit depth. For the smallest hydraulic loading (0.1 ha), flow depth requirements were met for both the 10 cm and 15 cm flow depths. For the 0.2 and 0.3 ha cases, flow depths were exceeded only for low slope cases, which caused flow depth to increase due to reduced velocities. Modeling results suggest that where a triangular swale is desired, the shallowest possible side slopes should be utilized. Trapezoidal swales proved to be more effective at filtration and sedimentation of particulates, since the grass height is often not exceeded during the water quality rainfall intensity (Table 10). Their side slopes generally have less impact on water quality, since the bottom of the swale provides the majority of the contact area.

Table 10. Flow depths for triangular and trapezoidal swales as a function of slope and catchment size. Locations with dark hatching could not meet the 10 or 15 cm flow depth requirements; locations filled with a grey color met the 15 cm but not the 10 cm flow depth requirement; locations not shaded met both the 10 and 15 cm flow depth requirements.

Slope (%)	3:1 Triangular			4:1 Triangular			5:1 Triangular			6:1 Triangular		
	0.1 ha	0.2 ha	0.3 ha	0.1 ha	0.2 ha	0.3 ha	0.1 ha	0.2 ha	0.3 ha	0.1 ha	0.2 ha	0.3 ha
0.5												
1												
1.5												
2												
3												
4												
5												
7.5												
10												
Slope (%)	3:1 Trapezoidal			4:1 Trapezoidal			5:1 Trapezoidal			Trapezoidal 6:1		
	0.1 ha	0.2 ha	0.3 ha	0.1 ha	0.2 ha	0.3 ha	0.1 ha	0.2 ha	0.3 ha	0.1 ha	0.2 ha	0.3 ha
0.5												
1												
1.5												
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7.5												
10												

Trends for TSS reduction predicted by the Deletic model are presented in Figure 6; data are presented assuming a triangular cross-section swale with 5:1 side slopes and 7.6 m swale length. Between 25% and 37.5% TSS reduction was provided depending on design characteristics. TSS removal increases with decreasing swale slope due to greater hydraulic retention time, which allows for further particle settling. However, as slope decreases, flow depth through the swale increases, potentially invalidating the model as flow overtops the grass height. For instance, in Figure 6 below, the 0.3 ha watershed places too much hydraulic loading on the swale, and the 15 cm grass height restriction is exceeded at all slopes (Table 10). Regardless of watershed size, there is no design that can meet the 10 cm grass height, suggesting that other swale cross-sections should be used if that is this desired mowing height.

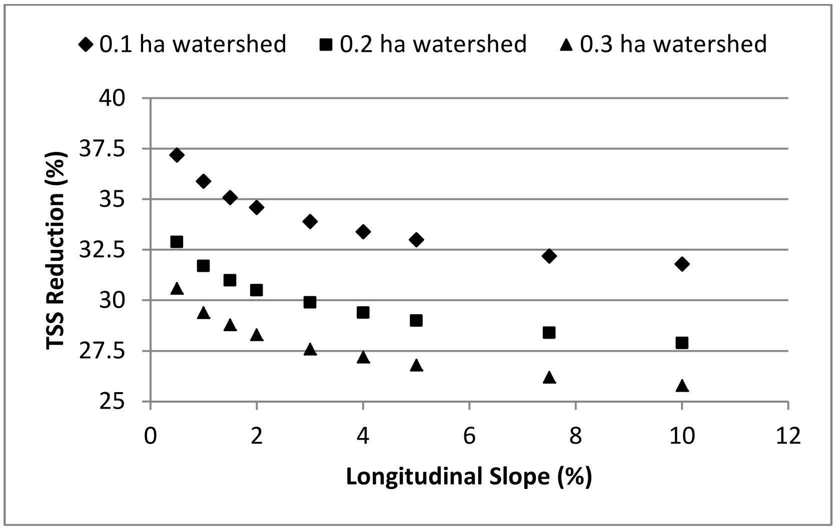

Figure 6. TSS reduction as a function of slope and contributing catchment area for a triangular swale with 5:1 side slopes and 7.6 m length.

While side slope plays a marked role in whether or not a triangular swale meets the grass height thresholds, it does not affect TSS reduction to a great extent (Figure 7). For swales with 7.6 m length and 0.1 ha watershed, the predicted difference in TSS reduction between 3:1 and 6:1 side slopes is between 4-4.5%. For each incremental increase in side slope, the model predicted a TSS reduction decrease of between 1-1.5%. This suggested that swales are more sensitive to increases in hydraulic loading, where an approximately 7% decrease in TSS reduction difference was observed from 0.1 to 0.3 ha watersheds (holding other inputs constant). However, the side slope in a triangular swale is a critical factor in meeting flow depth requirements (Table 10). With all other factors held constant, each 1% increase in longitudinal slope caused a decrease in TSS removal of between 0.2%-2.1%, with an average of 0.7%. The decrease in TSS removal was greater at lower slope (i.e. difference between 0.5% and 1.5% slopes, Figure 7) and lowest at higher slope (i.e. difference between 9% and 10% slopes). For each permutation of side slope, catchment area, and swale length, the difference in performance between a swale with 10% slope vs. 0.5% slope was on average 5.75% TSS reduction.

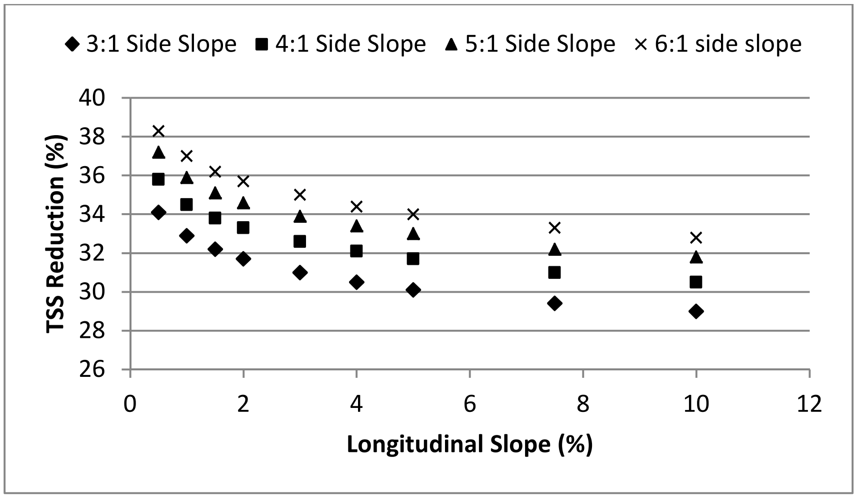

Figure 7. TSS reduction as a function of longitudinal and side slope for a 0.1 ha watershed and 7.6 m swale length.

Since the hydraulic model utilized herein is steady state, swale length does not have an impact on flow depth, and therefore can be adjusted without risk of overtopping the grass height. For instance, if a swale with 3:1 side slopes were desired to reduce space requirements and the watershed was 0.1 ha, Figure 8 could be utilized to choose a swale length to meet TSS reduction requirements. For instance, if the site in question had steep slopes (7.5%), and the desired TSS reduction was 50%, then a minimum swale length of 60 meters would be required. Table 10 would then need to be consulted to determine whether this swale met flow depth requirements.

As expected, as swale length increased, so too did TSS removal efficiency (Figure 8). This was simply due to the increased time for filtration and sedimentation to occur. The incremental improvement in TSS reduction for a given longitudinal slope is about 7% for each doubling of swale length. For instance, a 15 m swale at 2% longitudinal slope is predicted to result in 38.4% TSS reduction. At 60 m swale length, the same swale would result 53.3% TSS reduction. This rule of thumb is true across the ranges of hydraulic loading ratios and side slopes for triangular swales. This factor is closer to 7.5% for the trapezoidal swales modeled in this study (1.67 m bottom width). Of course, there are practical extents to this rule of thumb, as very few developers would choose to install a swale with a 300 m length, for instance.

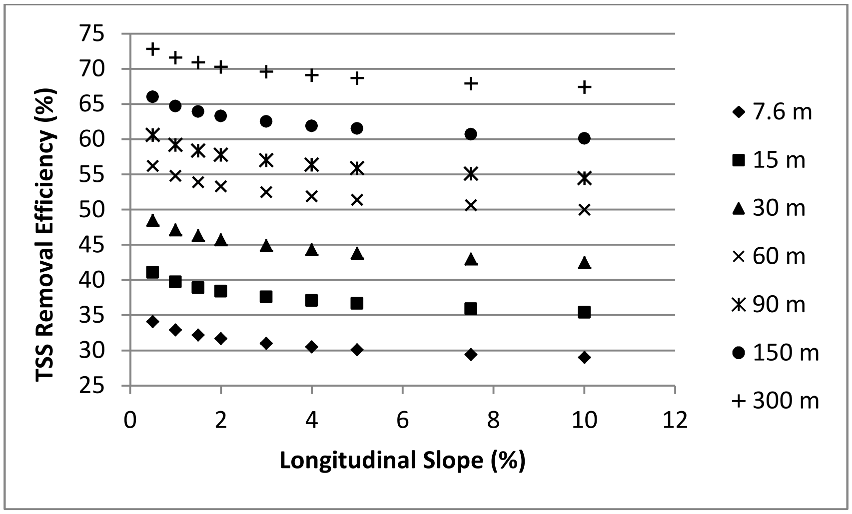

Figure 8. TSS removal efficiency for triangular swales of various lengths and longitudinal slopes. Watershed area and side slope were held constant at 0.1 ha and 3:1, respectively.

Since triangular swales often do not meet the 10 or 15 cm grass height thresholds (Table 10), trapezoidal swales with 1.67 m bottom widths and varying side slopes, hydraulic loading ratios, longitudinal slopes, and lengths were modeled. Generally, trapezoidal swales were able to meet the 15 cm grass height regardless of design characteristics (Table 10). At less than 1.5% and 3% longitudinal slope, the flow depth overtopped the 10 cm grass height requirement for 0.2 and 0.3 ha catchments, respectively. Contrary to triangular cross sections, the side slopes on trapezoidal swales have little influence as to whether a particular swale design meets the maximum flow depth requirement. This is due to the fact that the vast majority of the flow is passed through the flat bottom section and not above the side slopes. Therefore, trapezoidal swales are preferable to triangular swales for water quality treatment, since the flow depth increase per unit volume is reduced over triangular cross-sections. Since additional flow area exists, flow velocities also decrease substantially in trapezoidal swales. Figure 9 and Figure 10 show the TSS reductions for all modeled cases of triangular and trapezoidal swales, respectively. Data from these graphs should be corroborated against those from Table 10 to ensure that the grass height of interest is not exceeded, negating the validity of the model. Generally, for the same side slopes, swale length, watershed area, and longitudinal slope, trapezoidal swales had on average 9.3% greater predicted TSS reduction than triangular swales (Figure 9 and Figure 10). The minimum and maximum differences were 4.5% and 15.9%, respectively. Percent TSS reduction varied from a minimum of 32.8% to a maximum of 81.8% for trapezoidal swales. For triangular swales, corresponding TSS reductions were predicted to be 23.3% and 76.5%. These data suggest that sedimentation is substantially augmented by including a 1.67 m bottom width within a grassed swale. However, this improvement in TSS treatment is a trade-off for the additional trapezoidal swale surface area, resulting in less usable space in the development or more right-of-way purchase in the case of a roadway.

As an example, Figure 11 shows predicted percent TSS reductions as a function of swale length for a triangular and a trapezoidal swale with similar characteristics: 0.1 ha watershed area, 1.5% longitudinal slope, and 6:1 side slopes. An 8-9% difference exists between the two curves, with TSS reduction directly proportional to swale length. Checking the predicted flow depths against Table 10, a 6.8 cm flow depth was calculated for the trapezoidal swale, meeting both of the grass height requirements. However, for the triangular swale, the predicted flow depth was 13.8 cm, meeting the 15 cm but not the 10 cm grass height requirement. Based on all combinations of side slope, catchment area, and longitudinal slope (Table 10), triangular swales have only a 0.9% chance of meeting the 10 cm flow depth requirement and a 29.6% chance of meeting the 15 cm flow depth requirement. Trapezoidal swales met the 10 and 15 cm grass height requirements in 67.6% and 92.6% of cases due to the increased width per unit flow depth.

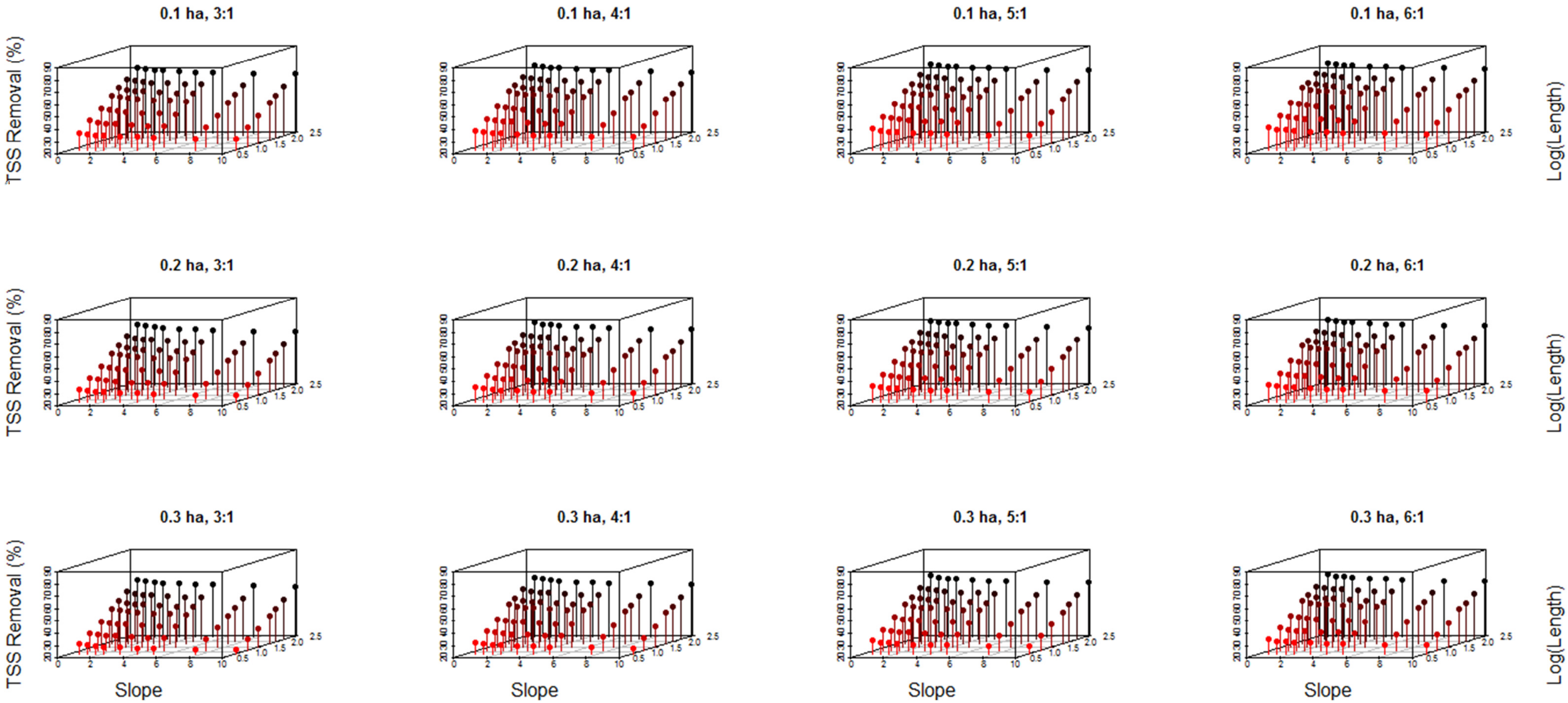

Figure 9. TSS reduction (%) as a function of watershed size, side slope, longitudinal slope, and length for triangular swales.

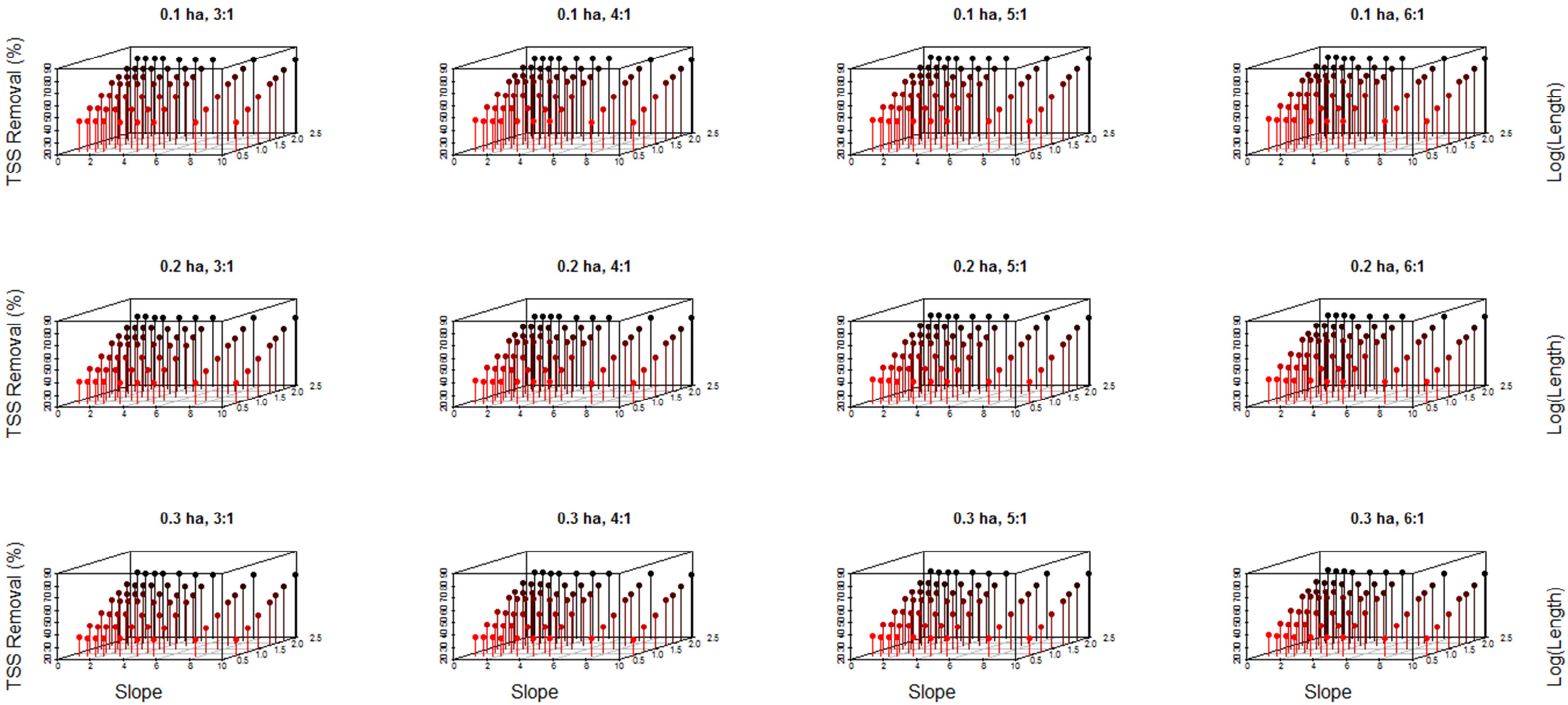

Figure 10. TSS reduction (%) as a function of watershed size, side slope, longitudinal slope, and length for trapezoidal swales.

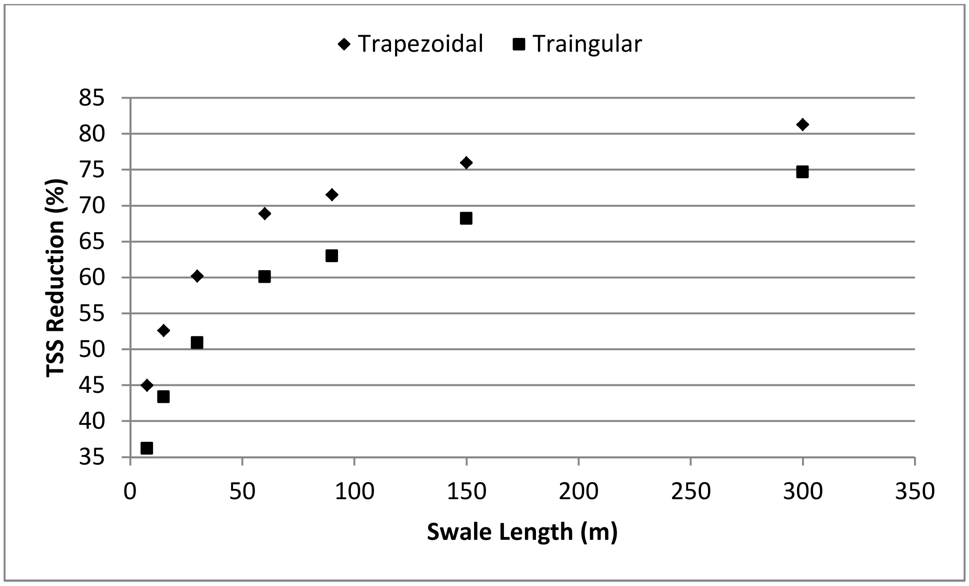

Figure 11. TSS reduction (%) as a function of swale length for triangular and trapezoidal swales with 6:1 side slopes, 1.5% longitudinal slope, and 0.1 ha catchment area.

Filter Strip Modeling

Modeling grassed filter strips suggested that for the same catchment area, FS will provide greater TSS reduction than a triangular or trapezoidal swale of the same longitudinal slope. However, field studies have shown that FS and swales with vegetative cover <80% can result in export of TSS (Barrett et al. 2004; Winston et al. 2012). Flow depths through the FS were reduced substantially vis-à-vis swales, such that even a 0.5% longitudinal slope FS with a 0.3 ha watershed (i.e. worst case scenario) would not exceed either the 10 or 15 cm grass height limits. This meant that a filter strip of any design would meet the hydraulic requirements of this model for all design scenarios. Since filter strips are generally located upslope of a swale along a typical highway, the filter strip is predicted to remove the majority of the sediment from the stormwater, as suggested by previous research (Barrett et al. 1998). Additionally, this model may not provide accurate results for FS and swales in series, since the PSD at the outlet of the FS (i.e. inlet to the swale) will be substantially different than that at the edge-of-pavement.

The FS model was not sensitive to longitudinal slope, suggesting that a filter strip would perform similarly for TSS removal no matter the slope (Figure 12). This was due to the sheet flow producing very low flow depths (maximum 3.2 cm) and therefore low flow velocities (maximum 5 cm/s). This allowed more hydraulic retention time for sedimentation and filtration to take place within the filter strip. For instance, a 3.67 m filter strip with a 0.5% slope or 10% slope draining 0.1 hectares was predicted to reduce TSS by 66.5% and 66.2%, respectively. Filter strip slopes of 25%, 33%, and 50% were modeled because these are common slopes used on highway shoulders. The model predicted the same TSS removal for these three cases (approximately 1% less TSS removal than the 10% slope case), suggesting that the model breaks down beyond 10% slope. This result was logical since the Aberdeen equation was derived from laboratory experiments on swales with a maximum longitudinal slope of 7%.

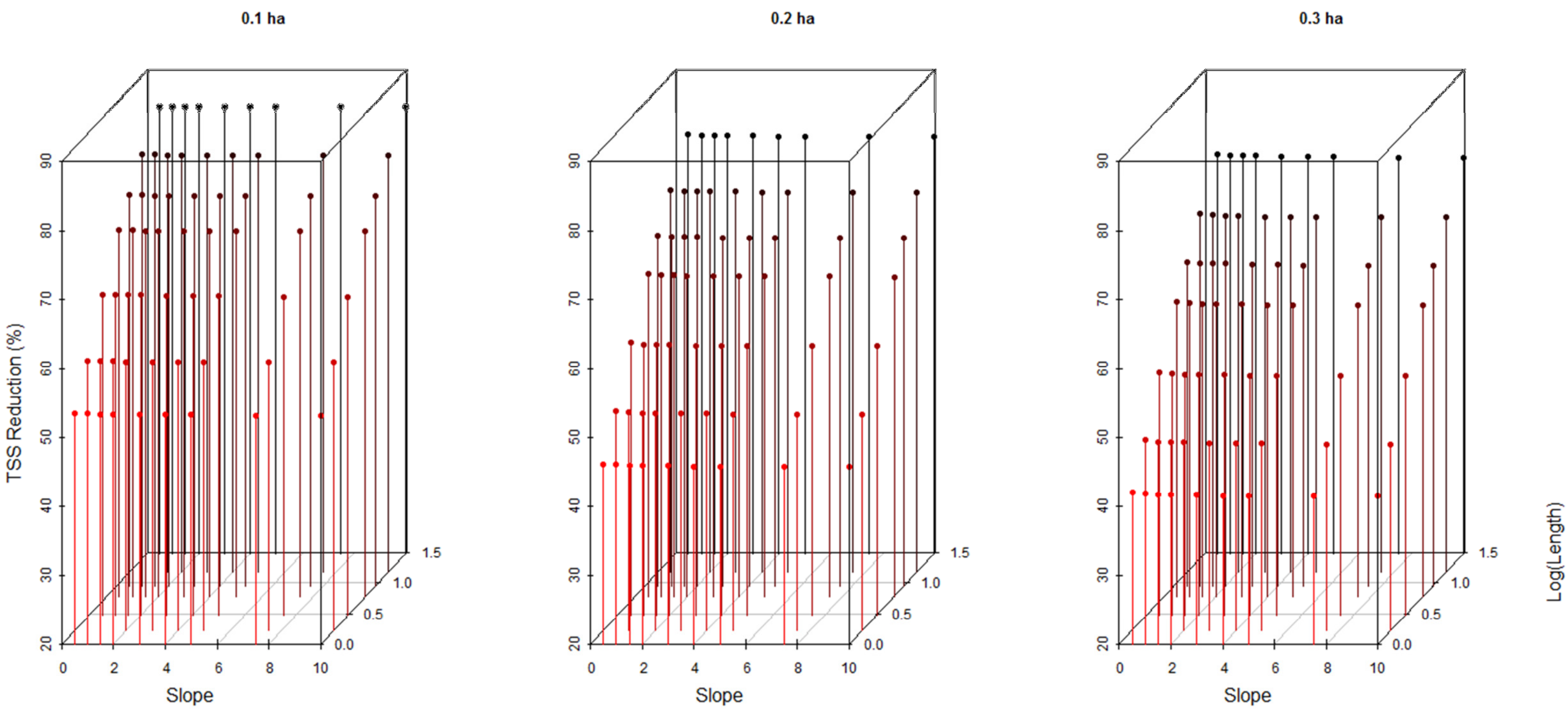

Figure 12. TSS reduction (%) as a function of watershed size, side slope, longitudinal slope, and length for grassed filter strips.

As suggested by previous researchers (Barrett et al. 2004), the model predicts that the majority of TSS removal will occur within the first meter of the filter strip (Figure 12 and Figure 13). Modeling suggested that steady state levels of TSS reduction were generally reached within a 7.6 m wide filter strip, similar to the 5 m width suggested by the field monitoring of Barrett et al. (2004). For a 1 m filter strip on a 1% slope, 53.5%, 46.1%, and 41.9% reductions are predicted for 0.1, 0.2 and 0.3 ha watersheds, respectively. At a 30 meter width (the maximum modeled), TSS reduction of 84.9%, 80.8%, and 77.8% were predicted. This means that there are diminishing returns for TSS removal as filter strip width increases. Increases in hydraulic loading were predicted to reduce filter strip performance (Figure 13).

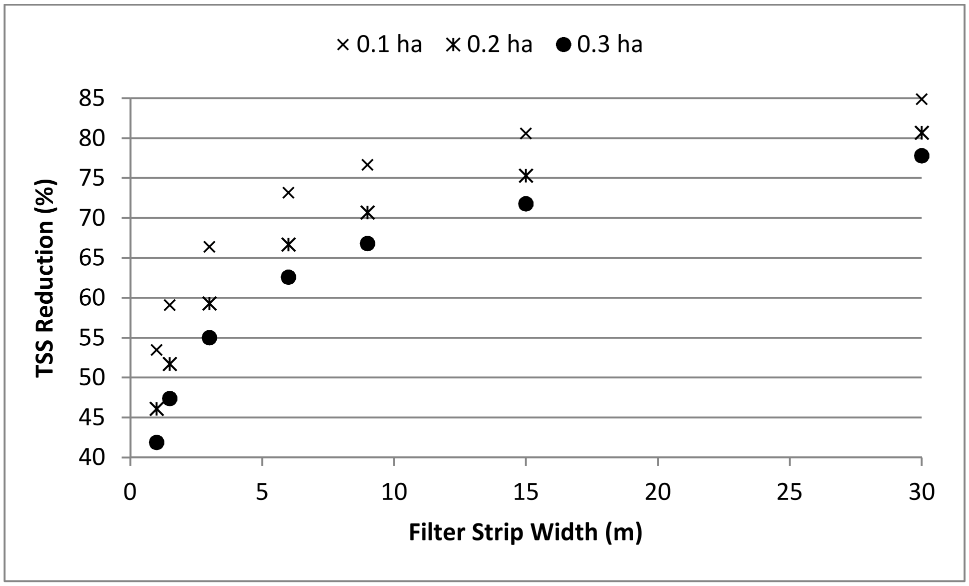

Figure 13. Predicted TSS reduction for a 1% longitudinal slope filter strip as a function of watershed size and filter strip width.

In the analysis above, filter strips were modeled for edge-of-highway situations, where the length of the filter strip is very long (modeled as 30 m). In some cases, the length of the filter strip will be considerably less due to land constraints. This might be the case in a commercial development, where the filter strip is often located between the parking lot and the receiving water body. Therefore, shorter filter strips on a 0.5% slope and 1 meter width were modeled for a 0.3 ha watershed (i.e. worst case scenario, Table 11). Even for very small lengths (5m), flow depth never exceeded the 10 cm or 15 cm grass height requirements, showing the versatility of filter strips. TSS removal efficiency for these scenarios varied from 24.9-41.1% (Table 11). Filter strips should be as long as practical to promote additional particle settling, however.

Table 11. TSS Removal efficiency for a 0.3 ha watershed for varying lengths of filter strip for a 0.5% slope and 1 meter width.

Filter Strip Length (m)	Flow Depth (cm)	TSS Removal Efficiency (%)
5	9.4	24.9
7.5	7.4	28.0
15	4.9	34.2
22.5	3.8	38.2
30	3.2	41.1

During engineering design, it is also important to compare options for conveyance (i.e. pipes versus surface flow devices such as filter strips and swales). Table 12 compares various designs of trapezoidal swales, triangular swales, and filter strips. Common to each practice was a 2% longitudinal slope, a 7.6 m length, and a 0.1 ha watershed. For the triangular swales, flow depth exceeds the 10 cm grass height requirement in all cases and the 15 cm grass height for 3:1 and 4:1 side slopes. The triangular swales produced TSS percent removals that were about 9% lower than trapezoidal swales with the same side slope. The larger surface area of the trapezoidal swale provided lower flow depths that did not exceed the grass height regardless of side slope. While the filter strip required the most land, it produced more than twice the expected TSS removal of the triangular swale. If 80 or 85% TSS removal was the goal, as it is in many states (TCEQ 2005; NCDENR 2009), the filter strip nearly met this goal. The trapezoidal or triangular swale would need to be coupled with a secondary SCM to meet these TSS removal targets. In order to provide similar TSS removal as the filter strip, a 150 meter long trapezoidal swale would be needed. Triangular swales, such as those commonly used along highway, were not predicted to reach this level of TSS trapping even at a 300 meter length.

Table 12. Comparison of swale and filter strip performance for 2% longitudinal slope, 7.6 m length, and a 0.1 ha watershed.

SCM Type	Side Slopes	Flow Depth (cm)	TSS Removal Efficiency (%)
VFS	NA	1.7	76.7
Triangular Swale	3:1	17.1	31.7
	4:1	15.3	33.3
	5:1	14.1	34.6
	6:1	13.1	35.7
Trapezoidal Swale	3:1	6.5	43.7
	4:1	6.4	44.1
	5:1	6.3	44.5
	6:1	6.3	44.8

Effect of Permeable Friction Course Overlays

A PFC overlay may be installed over typical hot mix asphalt for multiple benefits, including improvements to water quality (Eck et al. 2012; Winston et al. 2012). Research from Texas, North Carolina, and Europe has shown effluent concentrations from PFC around 10 mg/L, considerably lower than typical highway runoff (Berbee et al. 1999; Pagotto et al. 2000; Eck et al. 2012). Since edge-of-pavement PSDs differ substantially for PFC vis-à-vis HMA, there is a desire to model a median PSD for PFC using the methods presented herein (Winston et al. 2015). Since highways overlain with PFC typically drain to filter strips (fill slopes of the highway), filter strip modeling was the focus of this exercise.

Filter strip were modeled using input parameters of 0.1 ha, 0.2 ha, and 0.3 ha catchment area, varying longitudinal slope up to 25% (4:1), 33% (3:1), and 50% (2:1), and both the PFC and HMA particle size distributions. Due to a significantly smaller d_{90} and lack of particles above 1377 µm in diameter for PFC, predicted TSS reductions were lower by an average of 9% for filter strips adjacent to PFC than for those adjacent to HMA (Winston et al. 2015). The hydraulics were modeled the same way through the filter strip, so this is entirely due to differences in the PSD because of pavement type. However, since edge-of-highway TSS concentrations are inherently different from HMA versus PFC, the effluent concentration of the filter strip will be affected. For instance, Barrett et al. (2006) showed mean EMCs of 118 mg/L for HMA and 7.6 mg/L for PFC from a highway in Austin, Texas. For a 0.1 ha watershed draining to a 1 meter wide filter strip at 10% slope, the HMA would have a predicted highway FS TSS removal of 53.2%, whereas the PFC highway FS would be predicted to reduce TSS concentrations by 44.3% (Figure 14). While the FS percent TSS reduction for PFC was lower by abour 9%, the effluent concentration from the FS would still be much lower for PFC. Using Barett et al.'s (2006) edge-of-pavement TSS data, expected effluent concentrations for this filter strip would be 62.8 mg/L for HMA and 3.4 mg/L for PFC. So, while PFC will reduce the efficiency of downstream SCMs through modifications to the PSD, it is still far more efficient to use PFC on a roadway than to attempt to mitigate HMA-generated TSS with other SCMs.

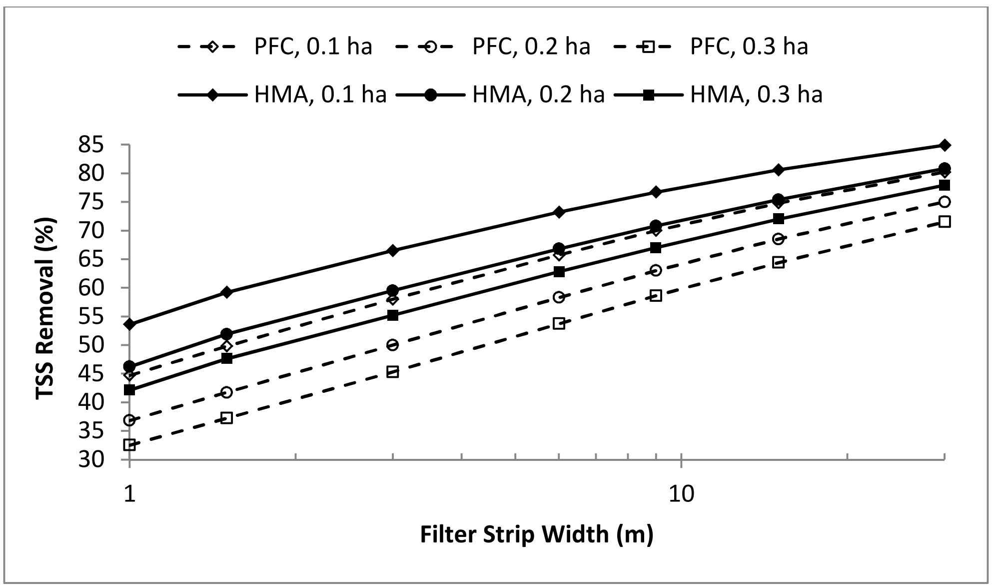

Figure 14. Predicted TSS removal for filter strips for PSDs generated from HMA and PFC.

Conclusions

Grassed swales and FS are often utilized in urban development projects, especially along roadways, but these SCMs are not credited for pollutant removal as a function of design variables. This is due to a lack of field research data on these SCMs (due to the complexity and cost inherent in monitoring them) and due to the large number of combinations of design characteristics, including: longitudinal slope, side slope, depth, cross-sectional geometry, watershed characteristics, vegetation type, grass height, etc. A simple hydraulic model coupled with an empirical particle settling model was utilized to predict TSS reduction within grassed swale and vegetated filter strip SCMs. Input variables were modified to understand TSS reduction and flow depth for each set of conditions. Results of this study were as follows:

1) Swales with a triangular cross-section, the most common type for typical roadway drainage, were unable in the vast majority of cases to meet the 10 cm maximum flow height requirement. The 15 cm flow height was met during 30% of modeled scenarios, with smaller watersheds, steeper longitudinal slopes, and flatter side slopes leading to a greater chance of meeting this cutoff. Trapezoidal swales met the 10 and 15 cm flow depth thresholds 68% and 93% of the time, exhibiting the additional flow area that they provide per unit increase in flow depth. Flow depth in FS was easily less than grass height requirements under all modeled scenarios.

2) Modeling runs suggested that swale performance improves as a function of increasing length, decreasing side slope, decreasing hydraulic loading, and decreasing longitudinal slope. Given similar input conditions, triangular swales were predicted to remove the least TSS, then trapezoidal swales, with filter strips reducing TSS concentrations by the greatest amount. Since filter strips are located upslope of swales in typical highway applications, they were predicted to remove the majority of sediment from highway runoff.

3) Swale performance was not sensitive to changes in side slope. Holding all other variables constant, each successive decrease in slope from 3:1 to 4:1 to 5:1 to 6:1 increased TSS removal by 1-1.5%. The sensitivity analysis showed that each increase in catchment area (from 0.1 to 0.2 to 0.3 ha) resulted in a decrease in TSS removal performance by 3.5%. For each doubling of swale length, with other factors constant, TSS removal performance increased by 7%. With all other factors held constant, each 1% increase in longitudinal slope caused a decrease in TSS removal of between 0.2%-2.1%, with an average of 0.7%. The difference between 0.5% and 10% slope swale TSS removal was 5.75% on average.

4) For the same side slopes, swale length, watershed area, and longitudinal slope, trapezoidal swales had on average 9.3% greater predicted TSS reduction than triangular swales. The minimum and maximum differences were 4.5% and 15.9%, respectively. Percent TSS reduction varied from a minimum of 32.8% to a maximum of 81.8% for trapezoidal swales. For triangular swales, corresponding TSS reductions were predicted to be 23.3% and 76.5%.

5) Due to sheet flow and low flow velocities, filter strips performed similarly regardless of longitudinal slope. Modeled FS TSS trapping efficiencies were between 41.5% and 84.9%, depending on design considerations. The model predicted that the majority of the TSS reduction occurs within the first meter of the filter strip, with diminishing returns for each increase in filter strip width.

6) When compared to HMA, PFC modified edge-of-pavement PSD through a reduction in sand-sized particles. This caused a decrease in the d_{90}, which will reduce the effectiveness of downslope swales or filter strips. Filter strips adjacent to PFC had an average of 9% lower TSS removal efficiencies when compared to those proximate to HMA. However, since the expected effluent TSS concentrations from PFC are typically one order of magnitude lower than those from HMA, filter strips adjacent to PFC are still expected to release much lower TSS concentrations than those next to HMA. This suggested that for TSS control, the use of PFC was preferable to attempting to treat HMA runoff with other SCMs.

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Appendix A: Photos of the Particle Size Distribution and Gross Solids Field Monitoring Sites

Figure A.1. Photos of the catchment (top left) and monitoring setup (top right - rainfall pacing; bottom left - sample intake in catch basin) at Black Mountain, NC particle size distribution monitoring location.

Figure A.2. Photos of the catchment (left) and monitoring setup (right - sample intake and weir in catch basin) at Brevard, NC particle size distribution monitoring location.

Figure A.3. Photos of the catchment (left) and monitoring setup (right – weir box) at Jack Bennett, NC particle size distribution monitoring location.

Figure A.4. Photos of the catchment (left) and monitoring setup (right – weir box) at Hanks Chapel, NC particle size distribution monitoring location.

Figure A.5. Photos of the catchment (top left) and monitoring setup (left – roadway catchment; right - weir and sample intake) at Faison, NC particle size distribution monitoring location.

Figure A.6. Photos of the catchment and slot drain (top left) and monitoring weir box (right) at the Benson, NC particle size distribution monitoring location.

Figure A.7. Photos of the catchment (top left) and monitoring setup (right - sample intake in catch basin) at the Wilson, NC particle size distribution monitoring location.

Figure A.8. Photos of the catchment (left) and monitoring setup (right - sample intake in catch basin) at the Goldsboro, NC particle size distribution monitoring location.

Figure A.9. Photos of the catchment (left) and monitoring setup (gross solids monitoring mesh in drain) at the Faison, NC gross solids monitoring location.

Figure A.10. Photos of the catchment (left) and monitoring setup (gross solids monitoring mesh in drain) at the Black Mountain, NC gross solids monitoring location.

Figure A.11. Photos of the catchment (left) and monitoring setup (gross solids monitoring mesh in drain) at the Willow Spring, NC gross solids monitoring location.

Figure A.12. Photos of the catchment at the Newton Grove, NC gross solids monitoring location.

Appendix B: Particle Size Distribution Raw Data

Table B.1. Particle size distributions (percentage by volume) from runoff samples at Black Mountain, NC.

Channel Diameter	Black Mountain								
	6/1/12	6/6/12	6/11/12	6/22/12	7/2/12	7/3/12	7/10/12	7/11/12	7/14/12
0.03999	0.000413	0.00063	0.000484	0.000454	0.000357	0.000392	0.000323	0.000809	0.000593
0.0439	0.000538	0.000824	0.000628	0.000596	0.00047	0.000514	0.00042	0.001054	0.000773
0.048191	0.000852	0.00131	0.000992	0.00095	0.000753	0.000819	0.000665	0.001669	0.001226
0.052903	0.001717	0.00264	0.001998	0.001911	0.001519	0.001651	0.001337	0.003351	0.002461
0.058075	0.0036	0.005525	0.004194	0.003995	0.00317	0.003454	0.002802	0.007017	0.005152
0.063753	0.006664	0.010229	0.007768	0.007413	0.005871	0.006396	0.005197	0.013032	0.009571
0.069985	0.010072	0.015501	0.011732	0.011303	0.008942	0.009707	0.007884	0.019832	0.014584
0.076827	0.013215	0.020392	0.015378	0.014965	0.011838	0.012802	0.010368	0.026142	0.019268
0.084338	0.016226	0.02508	0.018874	0.018508	0.014641	0.015795	0.012748	0.032172	0.023788
0.092584	0.019414	0.030066	0.02257	0.022317	0.01766	0.019004	0.015273	0.038566	0.028619
0.10164	0.022624	0.035114	0.026285	0.026241	0.020773	0.022286	0.017826	0.045049	0.03357
0.11157	0.025607	0.03981	0.029744	0.029956	0.023717	0.025383	0.020204	0.051076	0.038244
0.12248	0.028566	0.044407	0.033217	0.033604	0.026588	0.028455	0.022557	0.056938	0.042867
0.13445	0.031382	0.048838	0.036499	0.037217	0.029441	0.031464	0.024817	0.06259	0.047396
0.1476	0.033982	0.053007	0.039494	0.04075	0.032257	0.034366	0.026921	0.067884	0.051741
0.16203	0.036422	0.056951	0.042295	0.044209	0.035027	0.037188	0.028905	0.072867	0.055955
0.17787	0.038989	0.061001	0.045297	0.047787	0.037869	0.040154	0.030985	0.077935	0.060368
0.19526	0.041607	0.065162	0.048335	0.051571	0.040878	0.043275	0.033128	0.08313	0.065009
0.21435	0.044175	0.069282	0.051283	0.055487	0.044013	0.046484	0.035255	0.088231	0.069758
0.2353	0.046651	0.073282	0.0541	0.059471	0.047222	0.049738	0.037324	0.093128	0.074549
0.25831	0.049138	0.077164	0.056971	0.063449	0.050408	0.053053	0.039404	0.097792	0.079392
0.28356	0.051489	0.080879	0.05961	0.067422	0.053615	0.056359	0.041402	0.102184	0.084171
0.31128	0.053656	0.084247	0.062001	0.071209	0.05669	0.059549	0.043258	0.106046	0.088719
0.34172	0.0556	0.087235	0.064093	0.074777	0.059611	0.062586	0.044934	0.109335	0.092984
0.37512	0.05746	0.089871	0.066129	0.078109	0.062323	0.06554	0.046542	0.112068	0.097052
0.4118	0.059232	0.092371	0.06796	0.081443	0.065065	0.068516	0.04811	0.114549	0.101068
0.45206	0.060908	0.094636	0.069594	0.0847	0.067774	0.071474	0.049617	0.116617	0.104965
0.49625	0.062423	0.096599	0.070949	0.087797	0.070408	0.074335	0.050999	0.11819	0.108625
0.54477	0.063825	0.098174	0.072148	0.090632	0.072875	0.077085	0.052292	0.119146	0.111987

Channel Diameter	Black Mountain								
	6/1/12	6/6/12	6/11/12	6/22/12	7/2/12	7/3/12	7/10/12	7/11/12	7/14/12
0.59803	0.06515	0.099554	0.073136	0.09337	0.075338	0.079806	0.053564	0.119766	0.115168
0.65649	0.066399	0.100706	0.073897	0.095986	0.077788	0.082479	0.054797	0.119975	0.118132
0.72068	0.067505	0.101558	0.074354	0.098372	0.080168	0.085017	0.055944	0.119695	0.120741
0.79113	0.068491	0.102053	0.074568	0.100452	0.082416	0.0874	0.057016	0.118859	0.122927
0.86848	0.069397	0.102281	0.074559	0.102258	0.084561	0.089666	0.058095	0.117625	0.12473
0.95338	0.07025	0.102298	0.074326	0.103812	0.08661	0.091819	0.059191	0.116034	0.126164
1.0466	0.071012	0.10206	0.07384	0.104985	0.08848	0.093789	0.060306	0.114061	0.127112
1.1489	0.071735	0.101645	0.073178	0.105768	0.090175	0.095595	0.061455	0.111821	0.127591
1.2612	0.072494	0.101146	0.072477	0.106162	0.091681	0.097292	0.062742	0.109483	0.127679
1.3845	0.073392	0.100798	0.071847	0.106316	0.093111	0.098968	0.064215	0.107312	0.127574
1.5199	0.074513	0.100754	0.071405	0.106269	0.094545	0.100693	0.065956	0.105492	0.127387
1.6685	0.075986	0.101287	0.07128	0.106155	0.096193	0.102571	0.067994	0.104321	0.127304
1.8316	0.078007	0.102663	0.071727	0.106108	0.09828	0.104779	0.070471	0.104119	0.127564
2.0107	0.080789	0.105307	0.072976	0.106444	0.1012	0.107529	0.073485	0.105339	0.12855
2.2072	0.084622	0.109686	0.075333	0.107544	0.105449	0.111115	0.07721	0.108457	0.130738
2.423	0.089709	0.116237	0.078989	0.109777	0.111586	0.115743	0.081695	0.113883	0.13455
2.6599	0.096347	0.125397	0.084264	0.113543	0.120237	0.121713	0.08708	0.122056	0.140448
2.92	0.104746	0.137535	0.091415	0.119256	0.132036	0.129268	0.093466	0.133383	0.148883
3.2054	0.115212	0.153118	0.100771	0.127515	0.147716	0.138752	0.101013	0.148333	0.160485
3.5188	0.127846	0.172402	0.112485	0.138818	0.167892	0.150312	0.109756	0.167109	0.175751
3.8628	0.142761	0.195614	0.126713	0.153646	0.193149	0.164091	0.1197	0.189875	0.195125
4.2405	0.159987	0.222768	0.143583	0.172315	0.223861	0.180161	0.130901	0.216684	0.218891
4.6551	0.179563	0.253972	0.163212	0.195284	0.260337	0.198596	0.143364	0.24766	0.247431
5.1102	0.20155	0.289368	0.185775	0.223115	0.302768	0.219497	0.157231	0.282915	0.281251
5.6098	0.225838	0.329035	0.21122	0.256279	0.35114	0.242729	0.172372	0.322372	0.320702
6.1582	0.252504	0.373102	0.239701	0.295189	0.405316	0.268331	0.188941	0.366108	0.366151
6.7603	0.281404	0.421539	0.271167	0.340115	0.46489	0.296087	0.206828	0.414077	0.417766
7.4212	0.312987	0.47496	0.306192	0.392052	0.529755	0.3264	0.226555	0.466978	0.476549
8.1467	0.347405	0.534079	0.345127	0.452523	0.599763	0.35932	0.248269	0.525344	0.543951
8.9432	0.385411	0.600345	0.388957	0.523986	0.674962	0.395432	0.272695	0.59038	0.622459
9.8175	0.427294	0.674711	0.438397	0.60874	0.75462	0.434806	0.300286	0.66289	0.714351
10.777	0.474044	0.75852	0.494807	0.709403	0.837454	0.478254	0.332368	0.744469	0.8224
11.831	0.526439	0.853099	0.559418	0.829052	0.921738	0.526469	0.370201	0.836654	0.949855
12.988	0.585983	0.960962	0.634173	0.972255	1.00648	0.580974	0.41566	0.94185	1.10151
14.257	0.654679	1.08521	0.721728	1.14426	1.09168	0.64392	0.471137	1.06309	1.28292

Channel Diameter	Black Mountain								
	6/1/12	6/6/12	6/11/12	6/22/12	7/2/12	7/3/12	7/10/12	7/11/12	7/14/12
15.651	0.735159	1.22914	0.825464	1.34999	1.17826	0.718314	0.539704	1.20409	1.49939
17.181	0.831189	1.39634	0.949902	1.59345	1.26836	0.808685	0.625556	1.36978	1.75546
18.861	0.946374	1.58975	1.09956	1.87688	1.36527	0.919775	0.732706	1.56479	2.05364
20.705	1.08491	1.81201	1.27966	2.19997	1.47398	1.05707	0.865741	1.79352	2.39365
22.729	1.24893	2.06195	1.49374	2.5557	1.59905	1.22366	1.02778	2.05662	2.76815
24.951	1.43857	2.33283	1.74333	2.92726	1.74233	1.42001	1.2213	2.35033	3.16009
27.391	1.65023	2.60949	2.0259	3.28562	1.8993	1.64217	1.44687	2.66529	3.54067
30.068	1.87719	2.86986	2.33444	3.59339	2.0577	1.88275	1.70338	2.98841	3.87371
33.008	2.11147	3.09049	2.65854	3.81406	2.19971	2.1332	1.98807	3.30684	4.12452
36.235	2.34558	3.25279	2.98517	3.92141	2.30607	2.3855	2.29626	3.61006	4.26911
39.778	2.57457	3.34907	3.29986	3.90688	2.36187	2.6336	2.62142	3.89056	4.30062
43.667	2.79461	3.38272	3.58542	3.77921	2.35991	2.87144	2.95317	4.13936	4.22797
47.936	3.00041	3.36431	3.82118	3.55955	2.3014	3.09083	3.27606	4.34092	4.07051
52.622	3.18236	3.30566	3.98421	3.27515	2.19485	3.28039	3.56941	4.4715	3.85161
57.767	3.32594	3.21515	4.0542	2.95462	2.05383	3.42731	3.81024	4.50344	3.59463
63.414	3.41595	3.09796	4.02155	2.62663	1.89523	3.5221	3.97923	4.41723	3.32279
69.614	3.44285	2.95952	3.89388	2.31966	1.73721	3.56275	4.06668	4.21406	3.05955
76.42	3.40871	2.8096	3.69676	2.05965	1.59604	3.55583	4.0761	3.92204	2.82681
83.891	3.32821	2.6635	3.46658	1.86544	1.48293	3.51325	4.02225	3.59021	2.64016
92.092	3.22359	2.53794	3.23858	1.74338	1.40128	3.44651	3.92502	3.27209	2.50378
101.1	3.11644	2.44532	3.03667	1.68561	1.34769	3.36301	3.8018	3.00756	2.40911
110.98	3.01987	2.3892	2.86927	1.67247	1.31487	3.26528	3.66155	2.81188	2.33879
121.83	2.93545	2.36379	2.73215	1.67893	1.29575	3.15346	3.5038	2.67579	2.27339
133.74	2.8517	2.35405	2.61193	1.68024	1.28354	3.02507	3.3189	2.57199	2.19505
146.81	2.74762	2.33771	2.49056	1.6559	1.26965	2.87411	3.09274	2.46407	2.08714
161.17	2.59644	2.28484	2.34549	1.58815	1.23983	2.68777	2.81057	2.31336	1.92992
176.92	2.37571	2.16404	2.15384	1.46239	1.17665	2.44984	2.46494	2.08911	1.70392
194.22	2.07945	1.95394	1.90034	1.27247	1.0674	2.15086	2.06352	1.77182	1.39745
213.21	1.73059	1.66066	1.58983	1.03162	0.916985	1.80337	1.6361	1.36889	1.02355
234.05	1.38352	1.32944	1.25827	0.782102	0.754134	1.4531	1.23553	0.921181	0.630629
256.94	1.10613	1.03484	0.967217	0.586129	0.623562	1.16901	0.92255	0.503137	0.313298
282.06	0.950291	0.844263	0.776886	0.490509	0.561511	1.0128	0.739998	0.231437	0.149606
309.63	0.933363	0.787411	0.718236	0.514504	0.583623	1.01517	0.697878	0.119326	0.121106
339.9	1.04057	0.85281	0.791253	0.653769	0.680233	1.17212	0.782239	0.126559	0.211944
373.13	1.22325	0.99166	0.966488	0.876325	0.81839	1.43611	0.95536	0.212423	0.414353

Channel Diameter	Black Mountain								
	6/1/12	6/6/12	6/11/12	6/22/12	7/2/12	7/3/12	7/10/12	7/11/12	7/14/12
409.61	1.40287	1.1175	1.17574	1.10809	0.938947	1.70688	1.14983	0.325519	0.653899
449.66	1.50513	1.14605	1.32921	1.2675	0.988856	1.8646	1.28859	0.357482	0.793924
493.62	1.50693	1.04753	1.3633	1.31442	0.949234	1.83301	1.32602	0.251339	0.768304
541.88	1.45147	0.872339	1.2712	1.26738	0.869762	1.62096	1.27	0.106895	0.621393
594.85	1.41837	0.722375	1.11109	1.19308	0.825605	1.32829	1.17063	0.020708	0.437131
653.01	1.46564	0.669559	0.951993	1.15685	0.887265	1.06512	1.0835	0.001495	0.312672
716.85	1.58852	0.73265	0.837565	1.19494	1.081	0.887867	1.03576	0	0.263517
786.93	1.69383	0.87352	0.761507	1.32811	1.41383	0.779996	1.00783	0	0.215078
863.87	1.64372	0.985442	0.675339	1.49723	1.83396	0.665304	0.957397	0	0.138476
948.32	1.34486	0.819052	0.53005	1.63154	2.28314	0.451206	0.851488	0	0.039215
1041	0.811596	0.44506	0.309137	1.60454	2.68142	0.205178	0.70286	0	0.005089
1142.8	0.324401	0.108107	0.117238	1.19195	3.06826	0.044401	0.562577	0	0
1254.5	0.062729	0.010762	0.021211	0.611099	3.4369	0.003754	0.457902	0	0
1377.2	0.004832	0	0.001436	0.143908	3.78204	0	0.372929	0	0
1511.8	0	0	0	0.015018	3.96633	0	0.244682	0	0
1659.6	0	0	0	0	4.01384	0	0.137821	0	0
1821.9	0	0	0	0	3.96608	0	0.022337	0	0
2000									

Table B.2. Particle size distributions (percentage by volume) from runoff samples at Brevard, NC.

Channel Diameter	Brevard			
	6/12/2012	7/2/2012	7/5/2012	7/9/2012
0.03999	0.0005037	0.000255	0.000358	0.000313
0.0439	0.0006542	0.000336	0.00047	0.000408
0.048191	0.0010333	0.000538	0.000749	0.000648
0.052903	0.0020756	0.001085	0.001505	0.00131
0.058075	0.0043534	0.002266	0.003145	0.002747
0.063753	0.0080822	0.004196	0.005843	0.005075
0.069985	0.0122697	0.006385	0.00894	0.007641
0.076827	0.0161504	0.008443	0.011874	0.010007
0.084338	0.0198858	0.010432	0.014726	0.012289
0.092584	0.023856	0.012568	0.017805	0.01471
0.10164	0.0278891	0.014764	0.021005	0.01715
0.11157	0.0316812	0.016832	0.024063	0.019432
0.12248	0.0354748	0.018845	0.027076	0.021737
0.13445	0.0391306	0.020834	0.030092	0.023922
0.1476	0.0425473	0.02278	0.033088	0.025944
0.16203	0.0458158	0.024676	0.03607	0.027855
0.17787	0.0493019	0.026611	0.039181	0.029922
0.19526	0.0529166	0.028642	0.042511	0.032022
0.21435	0.0565382	0.030731	0.046028	0.034091
0.2353	0.0601272	0.032833	0.049689	0.0361
0.25831	0.0638137	0.03489	0.053419	0.038174
0.28356	0.067354	0.036928	0.057209	0.040118
0.31128	0.0706914	0.038847	0.060918	0.041922
0.34172	0.0737821	0.040619	0.064524	0.04355
0.37512	0.0768314	0.042214	0.068024	0.045158
0.4118	0.0797641	0.043794	0.071609	0.04665
0.45206	0.0825791	0.045322	0.075237	0.048031
0.49625	0.0851876	0.046756	0.07885	0.049244
0.54477	0.0876649	0.048044	0.082381	0.050361
0.59803	0.0899863	0.049308	0.085945	0.051348
0.65649	0.0921323	0.050564	0.089538	0.052191
0.72068	0.094006	0.051779	0.093084	0.05284
0.79113	0.0956288	0.052935	0.096541	0.053321
0.86848	0.0970007	0.054096	0.099922	0.053662
0.95338	0.0981103	0.055314	0.103234	0.053851

Channel Diameter	Brevard			
	6/12/2012	7/2/2012	7/5/2012	7/9/2012
1.0466	0.0988822	0.056595	0.106381	0.053883
1.1489	0.0993654	0.05797	0.109369	0.053793
1.2612	0.0996522	0.059479	0.11218	0.053697
1.3845	0.0998613	0.061195	0.114888	0.053654
1.5199	0.100103	0.063185	0.117517	0.053763
1.6685	0.100536	0.065526	0.120178	0.054092
1.8316	0.10143	0.068311	0.123008	0.05483
2.0107	0.10308	0.071625	0.126208	0.056114
2.2072	0.105881	0.075635	0.130058	0.058156
2.423	0.110142	0.080419	0.134776	0.061067
2.6599	0.116287	0.086117	0.140669	0.065054
2.92	0.124667	0.092767	0.147947	0.070273
3.2054	0.135727	0.100493	0.156932	0.076928
3.5188	0.149719	0.109273	0.167699	0.085101
3.8628	0.166882	0.119108	0.180365	0.094843
4.2405	0.187357	0.129936	0.194914	0.10622
4.6551	0.211268	0.141662	0.211375	0.119226
5.1102	0.238768	0.154245	0.229745	0.133923
5.6098	0.269802	0.167497	0.249863	0.150135
6.1582	0.304468	0.181462	0.271755	0.167902
6.7603	0.342629	0.195882	0.29521	0.187016
7.4212	0.384769	0.210989	0.320628	0.20772
8.1467	0.431193	0.226589	0.347949	0.22995
8.9432	0.482843	0.243067	0.377713	0.254061
9.8175	0.540201	0.260294	0.409775	0.280039
10.777	0.604236	0.278923	0.44488	0.308375
11.831	0.6757	0.29934	0.483429	0.339425
12.988	0.756134	0.322633	0.526593	0.373994
14.257	0.847682	0.350258	0.575835	0.413233
15.651	0.953072	0.38423	0.633305	0.458744
17.181	1.076	0.427579	0.702651	0.513038
18.861	1.22002	0.483012	0.787509	0.578606
20.705	1.38919	0.554008	0.892414	0.658504
22.729	1.58533	0.642632	1.01947	0.754598
24.951	1.8075	0.750469	1.16881	0.867955

Channel Diameter	Brevard			
	6/12/2012	7/2/2012	7/5/2012	7/9/2012
27.391	2.04963	0.877003	1.33701	0.997765
30.068	2.30088	1.01992	1.51851	1.14192
33.008	2.54792	1.17571	1.70786	1.29756
36.235	2.77762	1.34051	1.90109	1.46142
39.778	2.98042	1.51264	2.09719	1.63044
43.667	3.15022	1.69254	2.29579	1.80057
47.936	3.28313	1.88263	2.49479	1.96604
52.622	3.37556	2.08504	2.68867	2.11889
57.767	3.42372	2.29948	2.86914	2.2506
63.414	3.42592	2.52229	3.02931	2.35591
69.614	3.38529	2.74652	3.16717	2.43658
76.42	3.3112	2.96362	3.28718	2.50349
83.891	3.21763	3.16493	3.39681	2.57493
92.092	3.11765	3.34239	3.50091	2.6725
101.1	3.01894	3.48823	3.59675	2.81684
110.98	2.92118	3.59334	3.67367	3.02328
121.83	2.81799	3.6463	3.71694	3.29878
133.74	2.6981	3.63062	3.709	3.63412
146.81	2.5479	3.52607	3.63111	3.99805
161.17	2.35115	3.31111	3.45978	4.33037
176.92	2.09306	2.9733	3.17298	4.55013
194.22	1.76978	2.52094	2.76333	4.57509
213.21	1.39911	1.99383	2.25904	4.35364
234.05	1.02821	1.46552	1.73792	3.89235
256.94	0.724207	1.02716	1.30926	3.26317
282.06	0.535114	0.749508	1.06308	2.58703
309.63	0.470627	0.652684	1.0341	1.98995
339.9	0.507537	0.724684	1.21228	1.5581
373.13	0.603944	0.936715	1.53629	1.31297
409.61	0.693433	1.22835	1.875	1.22356
449.66	0.719415	1.51377	2.0686	1.23108
493.62	0.680712	1.72803	2.01774	1.27135
541.88	0.627715	1.86297	1.7359	1.30019
594.85	0.644438	1.95335	1.34908	1.30647
653.01	0.786852	2.04251	1.00649	1.30348

Channel Diameter	Brevard			
	6/12/2012	7/2/2012	7/5/2012	7/9/2012
716.85	1.08531	2.14302	0.788717	1.29773
786.93	1.49573	2.22421	0.686033	1.27331
863.87	1.85744	2.23309	0.622668	1.19561
948.32	2.00095	2.13449	0.509399	1.03983
1041	1.81983	1.94151	0.30746	0.818323
1142.8	1.2302	1.72512	0.11689	0.573673
1254.5	0.578124	1.52409	0.021102	0.359839
1377.2	0.128162	1.34821	0.001338	0.19674
1511.8	0.0128405	1.15506	0	0.0876
1659.6	0	0.994455	0	0.032647
1821.9	0	0.83464	0	0.004446
2000				

Table B.3. Particle size distributions (percentage by volume) from runoff samples at Jack Bennett, NC.

Channel Diameter	Jack Bennett				
	6/11/2012	7/8/2012	7/10/2012	7/11/2012	7/25/2012
0.03999	0.0022225	0.000287	0.000595	0.0007281	0.0014754
0.0439	0.0034279	0.000446	0.0007764	0.000942	0.0019261
0.048191	0.0096258	0.001251	0.0012321	0.0014818	0.0030588
0.052903	0.0246142	0.003289	0.0024806	0.0029665	0.0061475
0.058075	0.0425799	0.005997	0.0051949	0.0062272	0.012863
0.063753	0.0582303	0.00874	0.0096205	0.011591	0.023854
0.069985	0.0717302	0.011689	0.0145651	0.0176538	0.0362434
0.076827	0.0828117	0.015071	0.0191242	0.0232716	0.0477099
0.084338	0.0909589	0.019126	0.0234651	0.0286735	0.0586014
0.092584	0.0946024	0.023855	0.0280528	0.0344065	0.0701132
0.10164	0.0938059	0.029041	0.0326605	0.04024	0.0817196
0.11157	0.0895316	0.034357	0.0369017	0.0457351	0.0923932
0.12248	0.0828515	0.039749	0.041022	0.0512357	0.10261
0.13445	0.0753292	0.04544	0.0449431	0.0565501	0.112391
0.1476	0.0685153	0.051485	0.0485613	0.0614959	0.121517
0.16203	0.0644867	0.057796	0.0519086	0.0662302	0.130004
0.17787	0.0655196	0.064244	0.0553027	0.0712895	0.138433
0.19526	0.0742913	0.070764	0.0587405	0.0765593	0.146997
0.21435	0.0940567	0.077293	0.0620606	0.0818373	0.155346
0.2353	0.127119	0.08345	0.0651847	0.0870815	0.16332
0.25831	0.172868	0.088688	0.0681448	0.0924874	0.170765
0.28356	0.225191	0.092546	0.0709307	0.0976715	0.177909
0.31128	0.274693	0.09479	0.0733922	0.102546	0.184328
0.34172	0.313523	0.095584	0.0754914	0.107071	0.190118
0.37512	0.334933	0.095194	0.0772815	0.111567	0.195198
0.4118	0.333386	0.093937	0.0790042	0.115882	0.200459
0.45206	0.307072	0.092318	0.0805844	0.12	0.205739
0.49625	0.25956	0.090978	0.0819655	0.123816	0.211198
0.54477	0.199187	0.090647	0.0830995	0.127454	0.216625
0.59803	0.1371	0.092037	0.0842454	0.130846	0.222745
0.65649	0.0836567	0.095776	0.085405	0.133931	0.229575
0.72068	0.0463162	0.1023	0.0865402	0.136589	0.237223
0.79113	0.0289355	0.111779	0.0876109	0.13885	0.245544
0.86848	0.0306917	0.124016	0.0887951	0.1407	0.254712
0.95338	0.0524584	0.13839	0.0901811	0.142076	0.264661

Channel Diameter	Jack Bennett				
	6/11/2012	7/8/2012	7/10/2012	7/11/2012	7/25/2012
1.0466	0.0956386	0.153816	0.091773	0.142862	0.275122
1.1489	0.154513	0.168811	0.0935907	0.143102	0.285889
1.2612	0.218598	0.181828	0.0957061	0.14291	0.296548
1.3845	0.277299	0.191492	0.0982591	0.142396	0.306962
1.5199	0.321377	0.196841	0.101332	0.141651	0.316875
1.6685	0.343693	0.197579	0.105058	0.140825	0.326624
1.8316	0.34032	0.194249	0.109563	0.140213	0.336511
2.0107	0.31211	0.188311	0.115091	0.140137	0.347375
2.2072	0.265494	0.181993	0.121928	0.141006	0.360124
2.423	0.212675	0.177982	0.130355	0.143146	0.376097
2.6599	0.170682	0.178973	0.140656	0.147043	0.396849
2.92	0.156627	0.187215	0.153117	0.153136	0.424047
3.2054	0.183217	0.204181	0.168128	0.161961	0.459293
3.5188	0.256715	0.230377	0.185997	0.173863	0.503634
3.8628	0.36943	0.265395	0.20702	0.189213	0.558077
4.2405	0.496069	0.308191	0.231413	0.208327	0.623356
4.6551	0.604695	0.357674	0.25946	0.231522	0.700336
5.1102	0.673747	0.413314	0.291569	0.259158	0.789284
5.6098	0.704153	0.475588	0.328055	0.291365	0.890005
6.1582	0.718281	0.545973	0.369319	0.328449	1.00222
6.7603	0.74792	0.626489	0.415643	0.37055	1.12601
7.4212	0.821495	0.719609	0.467936	0.418529	1.2622
8.1467	0.953046	0.827302	0.527403	0.473231	1.41116
8.9432	1.13973	0.9497	0.596091	0.536354	1.57255
9.8175	1.37893	1.08473	0.675992	0.60952	1.74451
10.777	1.67197	1.22832	0.769403	0.694965	1.9247
11.831	1.98483	1.37553	0.878782	0.794901	2.10994
12.988	2.22333	1.52269	1.00761	0.912523	2.296
14.257	2.28881	1.67185	1.16016	1.05215	2.47792
15.651	2.20158	1.83478	1.34076	1.21897	2.65285
17.181	2.14761	2.03243	1.5535	1.41909	2.82388
18.861	2.34138	2.28846	1.80129	1.65818	2.99952
20.705	2.85299	2.61442	2.08577	1.9418	3.18789
22.729	3.44517	3.00036	2.40452	2.27241	3.3862
24.951	3.56276	3.41988	2.74909	2.64827	3.57433
27.391	3.07274	3.84275	3.10264	3.06068	3.71697

Channel Diameter	Jack Bennett				
	6/11/2012	7/8/2012	7/10/2012	7/11/2012	7/25/2012
30.068	2.86866	4.24354	3.44114	3.49341	3.77749
33.008	3.62215	4.58042	3.73828	3.92498	3.73623
36.235	4.40353	4.77638	3.97093	4.33119	3.60154
39.778	3.49605	4.77776	4.12348	4.68834	3.40702
43.667	1.97847	4.63371	4.18777	4.9735	3.19428
47.936	1.8055	4.47038	4.16033	5.16406	2.99276
52.622	2.91978	4.35327	4.04038	5.23795	2.80883
57.767	3.50303	4.19412	3.8313	5.1777	2.62826
63.414	2.60179	3.8853	3.54506	4.97738	2.43202
69.614	1.88367	3.49266	3.20671	4.64917	2.21377
76.42	2.12629	3.12443	2.85182	4.22636	1.98652
83.891	2.57836	2.74148	2.51737	3.75641	1.77331
92.092	2.35373	2.32613	2.22921	3.29106	1.59204
101.1	1.809	2.01784	1.99599	2.87273	1.4475
110.98	1.48842	1.89791	1.81403	2.52775	1.33963
121.83	1.41884	1.86691	1.67071	2.25587	1.27219
133.74	1.44639	1.80633	1.55022	2.03083	1.2471
146.81	1.39695	1.71166	1.4299	1.81192	1.2548
161.17	1.23248	1.5201	1.27868	1.54907	1.2547
176.92	1.14394	1.03167	1.07379	1.22746	1.18623
194.22	1.08513	0.341843	0.811121	0.870512	1.00605
213.21	0.683146	0.024705	0.522236	0.489267	0.723212
234.05	0.170246	0	0.256012	0.197692	0.394219
256.94	0.0084081	0	0.0844922	0.0397808	0.145899
282.06	0	0	0.0140717	0.0034989	0.0270035
309.63	0	0	0.0008912	0	0.0020121
339.9	0	0	0	0	0
373.13	0.13679	0	0	0	0
409.61	1.73085	0	0	0	0
449.66	3.89284	0	0	0	0
493.62	2.1863	0	0.0009417	0	0
541.88	0.203718	0	0.0209612	0	0
594.85	0	0	0.148997	0	0
653.01	0	0	0.53471	0	0
716.85	0	0	1.20877	0	0
786.93	0	0	2.05775	0	0

Channel Diameter	Jack Bennett				
	6/11/2012	7/8/2012	7/10/2012	7/11/2012	7/25/2012
863.87	0	0	2.82958	0	0
948.32	0	0	3.35917	0	0
1041	0	0	2.78356	0	0
1142.8	0	0	1.54754	0	0
1254.5	0	0	0.373367	0	0
1377.2	0	0	0.0396691	0	0
1511.8	0	0	0	0	0
1659.6	0	0	0	0	0
1821.9	0	0	0	0	0
2000					

Table B.4. Particle size distributions (percentage by volume) from runoff samples at Hanks Chapel, NC.

Channel Diameter	Hanks Chapel			
	6/11/2012	7/6/2012	7/21/2012	7/25/2012
0.03999	0.0002125	0.000172	0.0003154	0.0001707
0.0439	0.000276	0.000227	0.0004139	0.0002197
0.048191	0.000436	0.000363	0.000661	0.0003435
0.052903	0.000876	0.000733	0.001334	0.0006878
0.058075	0.0018367	0.001532	0.0027888	0.0014474
0.063753	0.0034071	0.00283	0.0051563	0.0026933
0.069985	0.0051642	0.00428	0.0078062	0.0040846
0.076827	0.0067811	0.005633	0.0102677	0.0053604
0.084338	0.0083218	0.006939	0.0126236	0.0065859
0.092584	0.0099467	0.008338	0.0151324	0.0078775
0.10164	0.0115805	0.009763	0.0176708	0.0091783
0.11157	0.0130879	0.011098	0.0200237	0.0104008
0.12248	0.0145667	0.012412	0.0223055	0.0116496
0.13445	0.0159708	0.013693	0.0245124	0.0128318
0.1476	0.0172602	0.014921	0.0266072	0.0138924
0.16203	0.0184553	0.016102	0.0285887	0.0148904
0.17787	0.0196922	0.017324	0.0305971	0.0159937
0.19526	0.0209506	0.018593	0.0326708	0.0171224
0.21435	0.0221788	0.019872	0.034743	0.0182189
0.2353	0.0233472	0.021137	0.0367639	0.019283
0.25831	0.0245043	0.022381	0.0387129	0.0204143
0.28356	0.0256022	0.023595	0.0406257	0.0214523
0.31128	0.026623	0.02472	0.0423998	0.0224109
0.34172	0.0275334	0.025738	0.0439953	0.0232888
0.37512	0.0284081	0.026652	0.0454146	0.0242176
0.4118	0.0292798	0.027535	0.0468394	0.0250731
0.45206	0.0301652	0.028351	0.0482251	0.025871
0.49625	0.0310234	0.02907	0.0495048	0.0266091
0.54477	0.0318863	0.029661	0.0506412	0.0273611
0.59803	0.0328187	0.030192	0.0517967	0.0280719
0.65649	0.0338605	0.030641	0.052981	0.0287251
0.72068	0.0349995	0.030984	0.0541316	0.0293342
0.79113	0.0362596	0.031196	0.0552336	0.0299211
0.86848	0.0377291	0.031326	0.056394	0.0305075
0.95338	0.0394897	0.031378	0.0576765	0.0310664

Channel Diameter	Hanks Chapel			
	6/11/2012	7/6/2012	7/21/2012	7/25/2012
1.0466	0.0416025	0.031352	0.0590576	0.031643
1.1489	0.0441111	0.031264	0.0605566	0.0322343
1.2612	0.0470948	0.03118	0.0622384	0.0329214
1.3845	0.0506169	0.031158	0.0641858	0.0336931
1.5199	0.0547725	0.03127	0.066457	0.0346266
1.6685	0.0596231	0.031578	0.0690883	0.035714
1.8316	0.0652732	0.032198	0.0721793	0.0370566
2.0107	0.0717789	0.033245	0.0758299	0.0386762
2.2072	0.0792642	0.03489	0.0802381	0.040664
2.423	0.0877646	0.037253	0.0854436	0.043031
2.6599	0.0973609	0.04049	0.0915764	0.0458441
2.92	0.108042	0.044748	0.0986933	0.0491523
3.2054	0.119855	0.050219	0.107011	0.0529997
3.5188	0.132751	0.057024	0.116535	0.0574266
3.8628	0.146674	0.065243	0.127249	0.0624024
4.2405	0.161546	0.074951	0.139103	0.0679889
4.6551	0.17724	0.08619	0.152082	0.0741164
5.1102	0.193729	0.099041	0.166277	0.0808856
5.6098	0.210835	0.11342	0.181481	0.0881727
6.1582	0.228606	0.129352	0.197732	0.096083
6.7603	0.246799	0.146698	0.214697	0.104449
7.4212	0.265601	0.165623	0.232845	0.113494
8.1467	0.284858	0.186155	0.2521	0.123168
8.9432	0.30488	0.208585	0.272991	0.133741
9.8175	0.325493	0.232913	0.295296	0.145178
10.777	0.347063	0.259346	0.320007	0.157842
11.831	0.369726	0.287996	0.348085	0.171969
12.988	0.394115	0.319194	0.381436	0.188008
14.257	0.42108	0.353438	0.422347	0.20648
15.651	0.451761	0.391353	0.473875	0.228058
17.181	0.488055	0.434073	0.540882	0.253865
18.861	0.531664	0.482712	0.628415	0.284871
20.705	0.585027	0.538772	0.74257	0.322487
22.729	0.649554	0.60304	0.886547	0.367638
24.951	0.726185	0.675601	1.061	0.421581
27.391	0.814082	0.755155	1.2625	0.485235

Channel Diameter	Hanks Chapel			
	6/11/2012	7/6/2012	7/21/2012	7/25/2012
30.068	0.911206	0.839407	1.48604	0.559661
33.008	1.01532	0.926057	1.72846	0.645827
36.235	1.12525	1.01367	1.99077	0.744774
39.778	1.24275	1.10288	2.27956	0.858092
43.667	1.37155	1.19597	2.60253	0.987409
47.936	1.51558	1.29567	2.96247	1.13427
52.622	1.67606	1.40254	3.3506	1.29941
57.767	1.8501	1.51244	3.74401	1.48306
63.414	2.03209	1.61602	4.10973	1.68563
69.614	2.21661	1.70055	4.41408	1.90813
76.42	2.40178	1.75493	4.63342	2.1519
83.891	2.58971	1.77554	4.76017	2.4166
92.092	2.78409	1.7707	4.80164	2.69728
101.1	2.98638	1.76234	4.77402	2.9823
110.98	3.1917	1.78303	4.69511	3.25223
121.83	3.3874	1.87324	4.57964	3.48334
133.74	3.551	2.07531	4.43229	3.65064
146.81	3.65344	2.42926	4.24358	3.73423
161.17	3.66227	2.95884	3.98519	3.72175
176.92	3.55299	3.65498	3.61772	3.61272
194.22	3.31948	4.45657	3.10919	3.4196
213.21	2.98409	5.24973	2.46163	3.16841
234.05	2.59877	5.88968	1.73464	2.8963
256.94	2.23288	6.24131	1.04896	2.64436
282.06	1.95298	6.22287	0.559557	2.4483
309.63	1.79997	5.82962	0.326455	2.32865
339.9	1.7804	5.1334	0.305876	2.28638
373.13	1.86559	4.25344	0.448142	2.30405
409.61	1.99671	3.31726	0.687015	2.3496
449.66	2.1024	2.43063	0.88048	2.3875
493.62	2.12846	1.6673	0.901723	2.38906
541.88	2.06732	1.07899	0.745534	2.34528
594.85	1.95424	0.692699	0.528623	2.26643
653.01	1.84034	0.498415	0.362879	2.17252
716.85	1.75368	0.450239	0.295423	2.07607
786.93	1.68664	0.494274	0.296772	1.97741

Channel Diameter	Hanks Chapel			
	6/11/2012	7/6/2012	7/21/2012	7/25/2012
863.87	1.60313	0.55929	0.296834	1.86447
948.32	1.47188	0.578509	0.222133	1.72938
1041	1.29182	0.52734	0.100381	1.57365
1142.8	1.10615	0.44731	0.0210917	1.43558
1254.5	0.948024	0.388652	0.0014965	1.32203
1377.2	0.827338	0.363459	0	1.22987
1511.8	0.718267	0.358113	0	1.11874
1659.6	0.634135	0.349633	0	1.01971
1821.9	0.54903	0.341811	0	0.926766
2000				

Table B.5. Particle size distributions (percentage by volume) from runoff samples at Faison, NC.

Channel Diameter	Faison		
	9/19/2012	10/8/2012	10/22/2012
0.03999	0.0002451	0.0003297	0.00031962
0.0439	0.0003201	0.0004372	0.00040941
0.048191	0.0005087	0.0007056	0.00063707
0.052903	0.0010244	0.001429	0.00126905
0.058075	0.0021446	0.0029783	0.00267185
0.063753	0.0039728	0.0054978	0.00499156
0.069985	0.0060233	0.0083473	0.00761506
0.076827	0.0079272	0.0110523	0.0100258
0.084338	0.0097559	0.0136918	0.0123375
0.092584	0.0117027	0.0165592	0.0147735
0.10164	0.0136791	0.0195325	0.0172385
0.11157	0.0155238	0.0223682	0.0195609
0.12248	0.0173413	0.0251608	0.0219196
0.13445	0.0190988	0.0279624	0.0241749
0.1476	0.0207616	0.0307781	0.026203
0.16203	0.0223449	0.0336006	0.0281203
0.17787	0.0239923	0.0365376	0.0302211
0.19526	0.0257016	0.0396812	0.0323975
0.21435	0.0274216	0.0430217	0.0345285
0.2353	0.0291178	0.0465378	0.0366102
0.25831	0.0308146	0.0501299	0.0388133
0.28356	0.0324767	0.0538393	0.040848
0.31128	0.0340466	0.0575463	0.0427412
0.34172	0.0354917	0.0612994	0.0444769
0.37512	0.0368606	0.0650423	0.0463049
0.4118	0.0382308	0.0690157	0.0479929
0.45206	0.0395752	0.0732001	0.0495842
0.49625	0.0408453	0.0776715	0.0510522
0.54477	0.0420289	0.082337	0.0525398
0.59803	0.0432186	0.0873376	0.0539315
0.65649	0.0443938	0.0926565	0.0552091
0.72068	0.0455199	0.0983111	0.0563713
0.79113	0.0465641	0.104199	0.057461
0.86848	0.0476098	0.110223	0.0584944
0.95338	0.0486432	0.116235	0.0594233

Channel Diameter	Faison		
	9/19/2012	10/8/2012	10/22/2012
1.0466	0.0496608	0.121997	0.0602974
1.1489	0.0506238	0.127322	0.0611033
1.2612	0.0516043	0.131892	0.0619654
1.3845	0.0525961	0.135542	0.0628624
1.5199	0.0536573	0.138056	0.0639165
1.6685	0.0547538	0.139506	0.0650989
1.8316	0.0559668	0.139926	0.0665751
2.0107	0.0573076	0.139605	0.0683765
2.2072	0.0589073	0.138905	0.0706734
2.423	0.0607658	0.138425	0.0734786
2.6599	0.0629712	0.138894	0.0769156
2.92	0.0655668	0.141012	0.0810645
3.2054	0.0686788	0.145503	0.0860335
3.5188	0.0723663	0.152815	0.0919083
3.8628	0.0766425	0.163527	0.0986636
4.2405	0.0815998	0.177951	0.106408
4.6551	0.0872231	0.196486	0.115052
5.1102	0.093707	0.219155	0.124813
5.6098	0.100948	0.245975	0.135517
6.1582	0.109175	0.277016	0.14736
6.7603	0.118189	0.312437	0.160057
7.4212	0.128448	0.352812	0.174062
8.1467	0.139959	0.398308	0.189355
8.9432	0.153357	0.449567	0.206476
9.8175	0.168694	0.506517	0.225408
10.777	0.186799	0.569838	0.246904
11.831	0.208205	0.63919	0.271511
12.988	0.233912	0.714766	0.300204
14.257	0.264914	0.797314	0.334089
15.651	0.302388	0.890147	0.374592
17.181	0.348139	1.00096	0.424009
18.861	0.403385	1.1395	0.48443
20.705	0.469853	1.3164	0.55878
22.729	0.547842	1.53613	0.649028
24.951	0.637769	1.79498	0.757552
27.391	0.739011	2.0795	0.88583

Channel Diameter	Faison		
	9/19/2012	10/8/2012	10/22/2012
30.068	0.851039	2.3705	1.0353
33.008	0.973675	2.65073	1.20719
36.235	1.10778	2.90909	1.4032
39.778	1.25698	3.14302	1.62679
43.667	1.42703	3.35313	1.88247
47.936	1.62565	3.5364	2.17538
52.622	1.86033	3.68123	2.50907
57.767	2.13683	3.76735	2.88426
63.414	2.45777	3.77398	3.29709
69.614	2.82136	3.6899	3.73772
76.42	3.22097	3.5198	4.18929
83.891	3.64397	3.2873	4.6267
92.092	4.07096	3.02253	5.01677
101.1	4.47533	2.75616	5.32014
110.98	4.82294	2.51935	5.49533
121.83	5.07536	2.32352	5.50663
133.74	5.19201	2.17857	5.32995
146.81	5.1376	2.0644	4.95957
161.17	4.88744	1.93553	4.40874
176.92	4.43848	1.74732	3.71105
194.22	3.8175	1.43716	2.91842
213.21	3.08735	0.972512	2.09831
234.05	2.34541	0.472912	1.3293
256.94	1.70482	0.133461	0.690599
282.06	1.25786	0.0496925	0.288031
309.63	1.03861	0.120683	0.122285
339.9	1.02998	0.544811	0.114934
373.13	1.18386	1.38191	0.228203
409.61	1.42022	2.32343	0.455313
449.66	1.63289	2.87939	0.713697
493.62	1.73343	2.87195	0.911582
541.88	1.69449	2.29285	1.02443
594.85	1.5489	1.38863	1.06383
653.01	1.35845	0.678001	1.05949
716.85	1.17116	0.381444	1.03458
786.93	1.00567	0.4552	0.995197

Channel Diameter	Faison		
	9/19/2012	10/8/2012	10/22/2012
863.87	0.855398	0.790897	0.934529
948.32	0.712203	1.17077	0.848893
1041	0.580174	1.14496	0.747573
1142.8	0.476809	0.707603	0.659372
1254.5	0.407406	0.239509	0.593783
1377.2	0.358662	0.0377868	0.542514
1511.8	0.312082	0.0015088	0.479797
1659.6	0.269548	0	0.419277
1821.9	0.233095	0	0.361781
2000			

Table B.6. Particle size distributions (percentage by volume) from runoff samples at Benson, NC.

Channel Diameter	Benson				
	9/7/2012	9/19/2012	1/18/2013	1/31/2013	2/8/2013
0.03999	0.0003511	0.00042546	0.0006502	0.0006912	0.001494
0.0439	0.000457	0.00055779	0.0008639	0.0009076	0.002275
0.048191	0.0007234	0.00088969	0.0013968	0.0014501	0.006309
0.052903	0.001456	0.00179101	0.0028243	0.0029138	0.016333
0.058075	0.0030517	0.00374374	0.0058813	0.0060858	0.028931
0.063753	0.0056524	0.00693827	0.0108742	0.0113061	0.040531
0.069985	0.0085483	0.0105535	0.0165859	0.0173058	0.051447
0.076827	0.0112079	0.0139347	0.0220506	0.0230026	0.062003
0.084338	0.0137373	0.0171843	0.027395	0.0285479	0.072363
0.092584	0.0164017	0.0206582	0.0332148	0.0345436	0.081884
0.10164	0.0190677	0.0242073	0.0392856	0.0407837	0.090395
0.11157	0.0215141	0.0275285	0.0450969	0.0467535	0.09785
0.12248	0.0239023	0.0307568	0.0507665	0.0526284	0.104821
0.13445	0.0261546	0.0339172	0.0564666	0.0585124	0.112654
0.1476	0.028203	0.0369638	0.0622111	0.0643627	0.122355
0.16203	0.0300748	0.0398946	0.0679434	0.0701817	0.134953
0.17787	0.0319854	0.0428795	0.0737733	0.0762142	0.151474
0.19526	0.0338987	0.0459956	0.0798821	0.0826325	0.173274
0.21435	0.0357121	0.0491638	0.0862089	0.0893509	0.201857
0.2353	0.0373742	0.0523183	0.0925932	0.0962683	0.237006
0.25831	0.0389441	0.055397	0.0987219	0.103182	0.276001
0.28356	0.0403725	0.0584441	0.104597	0.110077	0.313382
0.31128	0.0415911	0.0613021	0.109923	0.116626	0.34272
0.34172	0.0425581	0.0639387	0.114632	0.122795	0.359806
0.37512	0.0433489	0.0663352	0.118602	0.128496	0.361622
0.4118	0.0440548	0.0687584	0.122223	0.134109	0.346121
0.45206	0.044633	0.0711398	0.125482	0.139471	0.314329
0.49625	0.0450314	0.0734282	0.128405	0.144496	0.270421
0.54477	0.0452521	0.0755463	0.130978	0.14899	0.220993
0.59803	0.0454381	0.0777225	0.133552	0.153185	0.173802
0.65649	0.0455697	0.0799579	0.1363	0.156998	0.136262
0.72068	0.0456245	0.082211	0.139308	0.160322	0.11392
0.79113	0.0455872	0.0844349	0.142677	0.163053	0.109835
0.86848	0.045611	0.0867595	0.146604	0.165224	0.124637
0.95338	0.0457237	0.0892387	0.151328	0.166824	0.156826

Channel Diameter	Benson				
	9/7/2012	9/19/2012	1/18/2013	1/31/2013	2/8/2013
1.0466	0.045974	0.0918527	0.156935	0.167735	0.201915
1.1489	0.0463661	0.0945988	0.16358	0.168064	0.251845
1.2612	0.0470413	0.0975115	0.171275	0.167896	0.297341
1.3845	0.0480511	0.100665	0.180194	0.167498	0.330031
1.5199	0.0495099	0.104102	0.190413	0.167033	0.343969
1.6685	0.0514331	0.107888	0.202224	0.166888	0.337299
1.8316	0.0539576	0.112106	0.215853	0.167451	0.313227
2.0107	0.057152	0.116903	0.231728	0.169313	0.280232
2.2072	0.0611944	0.122493	0.250296	0.17309	0.250487
2.423	0.0661101	0.129034	0.272065	0.17939	0.237015
2.6599	0.0720006	0.136744	0.297595	0.18887	0.250507
2.92	0.0789186	0.145821	0.327389	0.202134	0.297369
3.2054	0.0869992	0.156566	0.362011	0.21983	0.378125
3.5188	0.0962759	0.16916	0.401697	0.242282	0.485969
3.8628	0.106711	0.183784	0.44666	0.269793	0.607868
4.2405	0.118346	0.20058	0.496852	0.302488	0.728374
4.6551	0.131123	0.219708	0.55234	0.340591	0.834999
5.1102	0.145206	0.24141	0.61304	0.384237	0.922858
5.6098	0.16042	0.265736	0.678722	0.433425	0.996942
6.1582	0.176938	0.292905	0.749137	0.488265	1.07074
6.7603	0.194513	0.322911	0.823992	0.548881	1.16172
7.4212	0.213653	0.356361	0.903605	0.616125	1.28747
8.1467	0.234373	0.393711	0.988102	0.690858	1.46067
8.9432	0.257353	0.436088	1.07788	0.774566	1.68338
9.8175	0.282687	0.484285	1.17246	0.868435	1.94468
10.777	0.311398	0.539754	1.27173	0.97424	2.22169
11.831	0.344264	0.603948	1.37565	1.09369	2.483
12.988	0.382613	0.679239	1.48551	1.22932	2.69554
14.257	0.427893	0.768778	1.60382	1.38429	2.84477
15.651	0.481898	0.876438	1.73499	1.56247	2.95092
17.181	0.547301	1.00723	1.88651	1.76888	3.0681
18.861	0.626208	1.16614	2.06762	2.00811	3.26083
20.705	0.721206	1.35847	2.28753	2.28344	3.54354
22.729	0.833124	1.5868	2.54862	2.5926	3.85336
24.951	0.962667	1.85	2.84229	2.92629	4.09
27.391	1.10936	2.14098	3.14657	3.26765	4.19879

Channel Diameter	Benson				
	9/7/2012	9/19/2012	1/18/2013	1/31/2013	2/8/2013
30.068	1.27282	2.4474	3.43087	3.59555	4.225
33.008	1.453	2.75466	3.66655	3.89039	4.18297
36.235	1.6506	3.04892	3.83609	4.13712	3.92895
39.778	1.86829	3.31956	3.93824	4.32565	3.36775
43.667	2.10945	3.55744	3.98345	4.44659	2.79053
47.936	2.37773	3.7514	3.984	4.48748	2.67798
52.622	2.67489	3.88595	3.94454	4.43367	3.04781
57.767	2.99944	3.94307	3.85898	4.27518	3.14601
63.414	3.34587	3.90978	3.71604	4.01643	2.34204
69.614	3.70402	3.78765	3.5096	3.68145	1.40029
76.42	4.05995	3.59868	3.24683	3.3092	1.18498
83.891	4.39635	3.3824	2.94973	2.9404	1.55629
92.092	4.69393	3.18399	2.64924	2.60509	1.7644
101.1	4.93229	3.03905	2.37231	2.31714	1.41305
110.98	5.08995	2.96194	2.14414	2.08118	0.980187
121.83	5.14476	2.94326	1.97002	1.89035	0.81507
133.74	5.0721	2.95339	1.83782	1.72928	0.876469
146.81	4.84841	2.95221	1.72097	1.57252	1.04674
161.17	4.45516	2.89641	1.56453	1.37945	1.03214
176.92	3.8912	2.748	1.34349	1.13223	0.543959
194.22	3.18287	2.48048	1.05214	0.83479	0.097836
213.21	2.39145	2.08914	0.689879	0.486898	0.003065
234.05	1.61235	1.6037	0.341414	0.201707	0
256.94	0.962324	1.09591	0.100448	0.0413029	0
282.06	0.542031	0.668269	0.0158055	0.005053	0
309.63	0.359606	0.401097	0.0054906	0.00479	0
339.9	0.366916	0.298169	0.0236312	0.031096	0
373.13	0.520342	0.322134	0.0972114	0.100648	0
409.61	0.761589	0.42384	0.202636	0.173124	0
449.66	0.983288	0.530749	0.290909	0.197656	0
493.62	1.09806	0.568172	0.293272	0.160569	0
541.88	1.09314	0.521285	0.217285	0.149064	0
594.85	1.01165	0.450123	0.108788	0.219045	0
653.01	0.912296	0.418889	0.0324877	0.453049	0
716.85	0.828597	0.46845	0.0047722	0.796341	0
786.93	0.75895	0.60177	0.0002221	0.873345	0

Channel Diameter	Benson				
	9/7/2012	9/19/2012	1/18/2013	1/31/2013	2/8/2013
863.87	0.675242	0.764013	0	0.574977	0
948.32	0.552606	0.866158	0	0.157129	0
1041	0.393676	0.690722	0	0.0186804	0
1142.8	0.215278	0.363574	0	0	0
1254.5	0.0818081	0.0842686	0	0	0
1377.2	0.0154401	0.00833066	0	0	0
1511.8	0.0012252	0	0	0	0
1659.6	0	0	0	0	0
1821.9	0	0	0	0	0
2000					

Table B.7. Particle size distributions (percentage by volume) from runoff samples at Wilson, NC.

Channel Diameter	Wilson					
	10/8/2012	12/16/2012	12/17/2012	1/18/2013	1/31/2013	2/8/2013
0.03999	0.00098368	0.000470812	0.00058346	0.0001476	0.0009451	0.00046
0.0439	0.00127601	0.000613378	0.00076146	0.0002431	0.001233	0.000601
0.048191	0.00201296	0.000971881	0.00120874	0.0007035	0.0019565	0.000954
0.052903	0.00404702	0.00195137	0.0024268	0.0019176	0.0039395	0.001924
0.058075	0.00849458	0.00408647	0.00507904	0.0037344	0.0082542	0.004033
0.063753	0.0157525	0.00758606	0.00943355	0.0058834	0.0152956	0.007462
0.069985	0.0238371	0.0115356	0.0143776	0.0086258	0.0231867	0.01128
0.076827	0.0312726	0.0151959	0.018996	0.012346	0.0305213	0.014821
0.084338	0.0383897	0.0186889	0.023437	0.0175512	0.0375959	0.01824
0.092584	0.0459051	0.02239	0.0281774	0.024588	0.0451417	0.021883
0.10164	0.0534623	0.0261352	0.0330264	0.0332032	0.0528183	0.025581
0.11157	0.0604983	0.0296082	0.0375826	0.0429251	0.0600456	0.029057
0.12248	0.0675164	0.0329804	0.0420488	0.0536674	0.0672563	0.032544
0.13445	0.0741613	0.0362251	0.0464193	0.0657499	0.0742372	0.0359
0.1476	0.0802172	0.0392574	0.0506104	0.0793233	0.08083	0.039056
0.16203	0.085883	0.0421019	0.0546564	0.0942179	0.0871733	0.042082
0.17787	0.0918994	0.044989	0.0588421	0.110142	0.0938994	0.045317
0.19526	0.0980021	0.0479458	0.0632343	0.126931	0.100891	0.048658
0.21435	0.103913	0.0508461	0.0677167	0.144347	0.107933	0.052012
0.2353	0.109569	0.0536235	0.0722269	0.161249	0.114954	0.055335
0.25831	0.115261	0.0562711	0.0767325	0.17579	0.1221	0.058745
0.28356	0.120509	0.0587764	0.0811996	0.186092	0.129028	0.062024
0.31128	0.12523	0.0609963	0.0854365	0.190922	0.135544	0.065116
0.34172	0.129374	0.0628926	0.089422	0.190089	0.141602	0.067976
0.37512	0.133292	0.0644924	0.0931878	0.18384	0.147437	0.070772
0.4118	0.136799	0.0659807	0.0969749	0.172821	0.153065	0.073446
0.45206	0.139869	0.0672748	0.100691	0.158521	0.158388	0.07599
0.49625	0.142381	0.0683055	0.104272	0.143192	0.163275	0.07832
0.54477	0.144428	0.0690273	0.107637	0.129563	0.167722	0.080486
0.59803	0.145973	0.0696138	0.11097	0.120442	0.171772	0.082476
0.65649	0.14696	0.0700358	0.114231	0.118308	0.175327	0.084272
0.72068	0.147253	0.0702238	0.11734	0.124969	0.178216	0.085798
0.79113	0.146848	0.0701602	0.120239	0.141363	0.180389	0.087067
0.86848	0.145784	0.0699487	0.122993	0.167221	0.181857	0.088098
0.95338	0.144068	0.0696232	0.125609	0.200802	0.182577	0.088907

Channel Diameter	Wilson					
	10/8/2012	12/16/2012	12/17/2012	1/18/2013	1/31/2013	2/8/2013
1.0466	0.141621	0.0691452	0.128002	0.238726	0.182396	0.08947
1.1489	0.13857	0.0685738	0.130203	0.27616	0.181415	0.089859
1.2612	0.135153	0.0680049	0.132241	0.307972	0.17981	0.090193
1.3845	0.131716	0.0675668	0.134262	0.329627	0.177908	0.09062
1.5199	0.128532	0.067342	0.13634	0.337983	0.175936	0.091282
1.6685	0.126005	0.067454	0.138689	0.332166	0.174315	0.092358
1.8316	0.124657	0.0680801	0.141528	0.314123	0.173572	0.094104
2.0107	0.125185	0.0694354	0.145236	0.2888	0.174454	0.096804
2.2072	0.128367	0.0717953	0.150238	0.26346	0.177783	0.100812
2.423	0.134955	0.0753157	0.15698	0.246319	0.184369	0.106426
2.6599	0.145744	0.0802417	0.165967	0.244724	0.195095	0.114019
2.92	0.161507	0.0867641	0.177704	0.263618	0.210835	0.123904
3.2054	0.18317	0.095188	0.192781	0.304511	0.232592	0.136471
3.5188	0.211466	0.10557	0.211606	0.364797	0.261116	0.151985
3.8628	0.247003	0.117969	0.234594	0.438014	0.297071	0.170698
4.2405	0.290081	0.132391	0.262015	0.515571	0.340856	0.192767
4.6551	0.341041	0.148899	0.294185	0.589762	0.392946	0.218335
5.1102	0.400247	0.167573	0.33136	0.656729	0.453785	0.247601
5.6098	0.46789	0.188234	0.373644	0.718294	0.523623	0.280618
6.1582	0.544012	0.210906	0.421174	0.781624	0.602619	0.317546
6.7603	0.628445	0.235383	0.473972	0.856904	0.690825	0.358366
7.4212	0.721735	0.262178	0.532613	0.955041	0.789089	0.403597
8.1467	0.824967	0.291342	0.597722	1.08441	0.898757	0.453818
8.9432	0.939912	0.323454	0.670467	1.24674	1.02192	0.510304
9.8175	1.06766	0.358519	0.751664	1.43494	1.1602	0.574148
10.777	1.20885	0.397583	0.842243	1.63339	1.31494	0.64679
11.831	1.36412	0.441534	0.942885	1.8203	1.48737	0.729737
12.988	1.5353	0.491915	1.05499	1.97411	1.67967	0.825521
14.257	1.72483	0.550658	1.18073	2.08774	1.89459	0.937612
15.651	1.93486	0.620507	1.32305	2.18036	2.13476	1.07005
17.181	2.16706	0.706024	1.486	2.2947	2.40261	1.22744
18.861	2.42253	0.81195	1.67394	2.47588	2.69978	1.41397
20.705	2.70153	0.94387	1.89152	2.72972	3.02675	1.63347
22.729	2.99951	1.10484	2.14049	3.00613	3.37875	1.8866
24.951	3.30301	1.29586	2.41782	3.23665	3.74246	2.16914
27.391	3.58589	1.5149	2.71314	3.39981	4.09338	2.46932

Channel Diameter	Wilson					
	10/8/2012	12/16/2012	12/17/2012	1/18/2013	1/31/2013	2/8/2013
30.068	3.81196	1.75848	3.00918	3.54529	4.39834	2.76829
33.008	3.94429	2.024	3.28539	3.68623	4.62378	3.04386
36.235	3.95682	2.31044	3.52134	3.68989	4.74401	3.27519
39.778	3.84459	2.6187	3.69993	3.41196	4.74782	3.44738
43.667	3.62553	2.94754	3.80714	2.98225	4.6382	3.55239
47.936	3.33372	3.28908	3.83101	2.76246	4.42637	3.58692
52.622	3.00809	3.62509	3.76214	2.8895	4.12696	3.55015
57.767	2.68133	3.92743	3.59729	3.02578	3.75706	3.44314
63.414	2.37525	4.1637	3.34508	2.78274	3.33788	3.27181
69.614	2.1023	4.30692	3.02957	2.32435	2.89971	3.05057
76.42	1.86974	4.34374	2.6875	2.02205	2.47809	2.80358
83.891	1.68365	4.27752	2.35863	1.94437	2.1119	2.56098
92.092	1.54777	4.12458	2.07381	1.9727	1.82559	2.34994
101.1	1.46214	3.90547	1.84708	1.93245	1.63545	2.18642
110.98	1.4212	3.64041	1.67836	1.68777	1.53654	2.07031
121.83	1.41463	3.34061	1.55581	1.43065	1.49575	1.98785
133.74	1.42834	3.01278	1.46262	1.43126	1.47051	1.91626
146.81	1.44305	2.65537	1.3779	1.59389	1.38726	1.83169
161.17	1.43332	2.25975	1.27322	1.64937	1.1994	1.71405
176.92	1.37057	1.82672	1.12564	1.61921	0.932862	1.55117
194.22	1.22855	1.3567	0.917379	1.62038	0.625955	1.34426
213.21	1.00246	0.87287	0.649918	1.38717	0.342832	1.11114
234.05	0.720402	0.429488	0.351939	0.693053	0.126603	0.889373
256.94	0.455431	0.14052	0.12697	0.131492	0.0247562	0.724957
282.06	0.283321	0.0454183	0.0379706	0.0048751	0.0016232	0.652563
309.63	0.228049	0.0658694	0.0426637	0	0	0.688224
339.9	0.284568	0.247266	0.153972	0.0316724	0	0.826497
373.13	0.440869	0.623177	0.420891	0.406001	0	1.03861
409.61	0.657248	1.06185	0.766205	1.19464	0	1.26527
449.66	0.858863	1.37211	1.05369	1.60753	0	1.44337
493.62	1.00364	1.51983	1.22287	0.838462	0	1.53782
541.88	1.15766	1.52771	1.28682	0.0792823	0	1.54203
594.85	1.35437	1.46644	1.30484	0	0	1.50432
653.01	1.62562	1.41747	1.36193	0	0	1.47173
716.85	1.82044	1.41491	1.49664	0	0	1.49133
786.93	1.5227	1.42732	1.7453	0	0	1.55391

Channel Diameter	Wilson					
	10/8/2012	12/16/2012	12/17/2012	1/18/2013	1/31/2013	2/8/2013
863.87	0.859799	1.39066	2.0503	0	0	1.578
948.32	0.215653	1.256	2.34314	0	0	1.46532
1041	0.0238634	1.04462	1.96825	0	0	1.13186
1142.8	0	0.833808	1.12932	0	0	0.645686
1254.5	0	0.676973	0.279887	0	0	0.241583
1377.2	0	0.569003	0.0306991	0	0	0.044512
1511.8	0	0.452982	0	0	0	0.003296
1659.6	0	0.351919	0	0	0	0
1821.9	0	0.218942	0	0	0	0
2000						

Table B.8. Particle size distributions (percentage by volume) from runoff samples at Goldsboro, NC.

Channel Diameter	Goldsboro						
	12/12/2012	12/13/2012	12/16/2012	12/17/2012	1/18/2013	1/31/2013	2/8/2013
0.03999	0.00053849	0	0.00070581	0.0007127	0.0049441	0.0013189	0.000661
0.0439	0.00070389	0	0.00092909	0.00093635	0.0065398	0.0017227	0.001032
0.048191	0.00111922	0	0.00148781	0.00149657	0.0105262	0.0027374	0.002911
0.052903	0.00224633	1.90E-06	0.00300274	0.00301747	0.021204	0.0055133	0.007628
0.058075	0.0046982	4.36E-05	0.00627177	0.00630585	0.044143	0.0115407	0.013841
0.063753	0.00873109	0.00025238	0.0116012	0.0116744	0.0816776	0.0213642	0.020113
0.069985	0.013337	0.00078966	0.0176094	0.0177356	0.124482	0.0323439	0.026849
0.076827	0.0176648	0.00189018	0.0232402	0.0234174	0.164498	0.0424723	0.034581
0.084338	0.021842	0.00389357	0.0286675	0.028901	0.20218	0.0521043	0.043885
0.092584	0.0263201	0.00709579	0.0344893	0.0347834	0.241986	0.0622842	0.05481
0.10164	0.0309323	0.0115393	0.0404383	0.0408051	0.282249	0.0725107	0.066933
0.11157	0.0352939	0.0169949	0.0460158	0.0464695	0.318938	0.0819187	0.079575
0.12248	0.039567	0.0234195	0.0514456	0.0520142	0.352474	0.0910165	0.092719
0.13445	0.0437868	0.0310465	0.0567702	0.0574566	0.384724	0.0996941	0.106999
0.1476	0.0478936	0.039991	0.0619196	0.0627235	0.415878	0.10775	0.122669
0.16203	0.0519051	0.050208	0.066882	0.0678245	0.445277	0.115256	0.139655
0.17787	0.0560458	0.0615636	0.0719189	0.0730582	0.472935	0.122861	0.157754
0.19526	0.0604166	0.0740367	0.07715	0.0785206	0.500252	0.130633	0.176913
0.21435	0.0649308	0.0876101	0.0824246	0.0840714	0.527152	0.138265	0.197014
0.2353	0.0695155	0.10161	0.0876248	0.0896091	0.552614	0.145663	0.216823
0.25831	0.0740754	0.114805	0.0925855	0.0950107	0.574455	0.152828	0.234202
0.28356	0.0786164	0.125747	0.0973802	0.100286	0.592578	0.159837	0.246791
0.31128	0.0829425	0.133268	0.1017	0.105157	0.605868	0.166348	0.252723
0.34172	0.0870122	0.137065	0.105502	0.109595	0.613814	0.172428	0.251347
0.37512	0.0907737	0.137047	0.108636	0.113513	0.615501	0.178101	0.242502
0.4118	0.0945259	0.133196	0.111524	0.117259	0.61197	0.183985	0.226561
0.45206	0.0981871	0.125977	0.113969	0.120678	0.604151	0.189904	0.205069
0.49625	0.101674	0.116315	0.115904	0.123714	0.593114	0.195918	0.180664
0.54477	0.104806	0.105467	0.117067	0.126153	0.580271	0.201851	0.156776
0.59803	0.107813	0.0948322	0.117776	0.128245	0.567319	0.208221	0.137074
0.65649	0.110671	0.0857566	0.11794	0.129918	0.556311	0.214948	0.124925
0.72068	0.113291	0.0793284	0.117499	0.131127	0.548622	0.222037	0.122816
0.79113	0.115516	0.0762826	0.116277	0.131725	0.545498	0.229338	0.132208
0.86848	0.11743	0.0768717	0.11439	0.131774	0.547327	0.236987	0.153235
0.95338	0.119042	0.0808666	0.111853	0.131286	0.55439	0.244891	0.184455

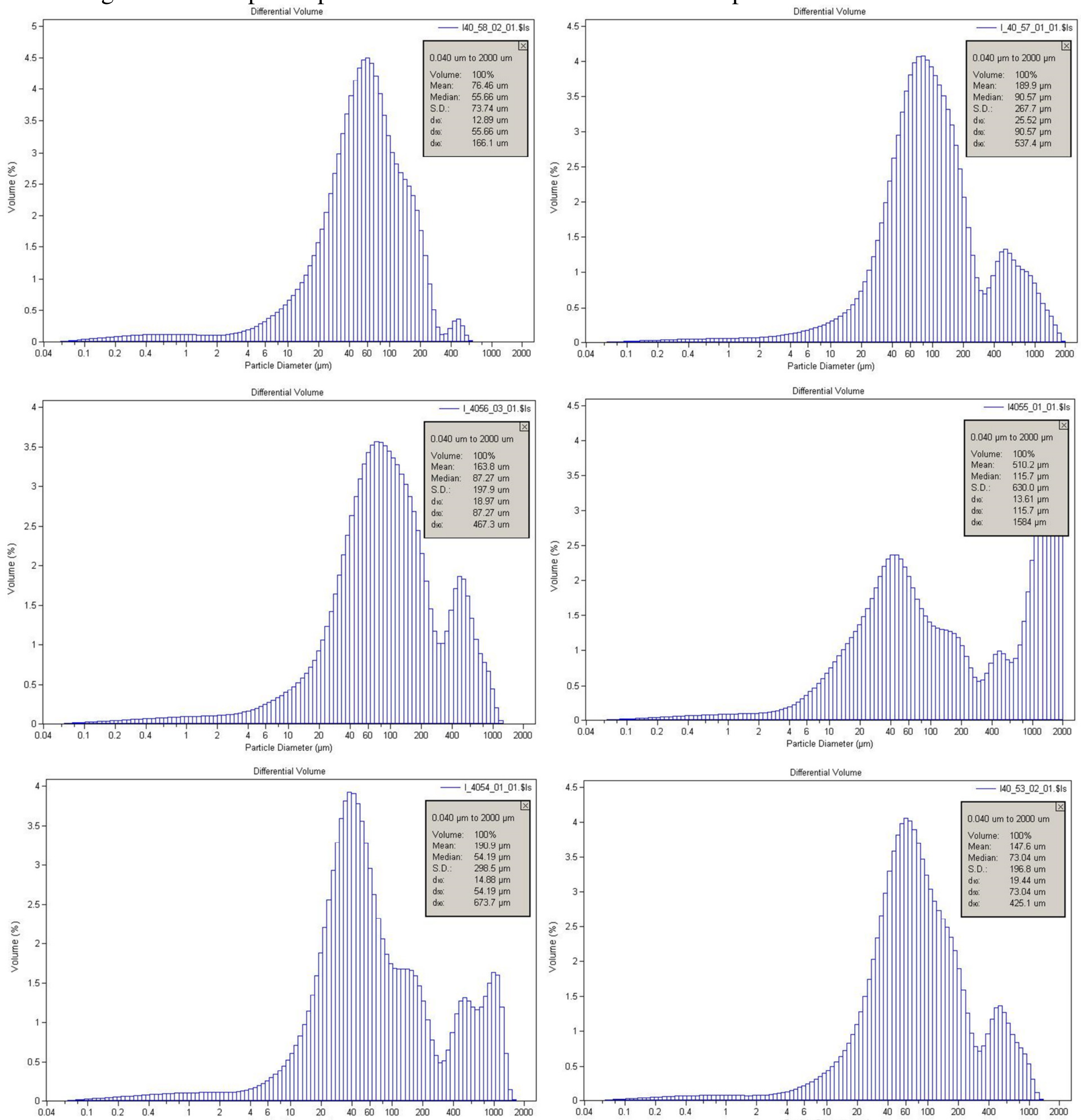
Channel Diameter	Goldsboro						
	12/12/2012	12/13/2012	12/16/2012	12/17/2012	1/18/2013	1/31/2013	2/8/2013
1.0466	0.120255	0.0874786	0.108642	0.130234	0.566043	0.252818	0.222556
1.1489	0.121009	0.0953014	0.104804	0.128675	0.580975	0.260666	0.262313
1.2612	0.121299	0.102689	0.100451	0.126657	0.597067	0.268247	0.297966
1.3845	0.121209	0.108077	0.0958348	0.124394	0.612386	0.275587	0.324261
1.5199	0.120754	0.110252	0.091149	0.122052	0.625327	0.2826	0.337333
1.6685	0.120025	0.108662	0.0866838	0.11994	0.635044	0.289686	0.335699
1.8316	0.119046	0.10362	0.082682	0.118294	0.641356	0.29725	0.320896
2.0107	0.117937	0.0963766	0.0795581	0.117508	0.645409	0.306129	0.297739
2.2072	0.116918	0.0889361	0.0777744	0.118039	0.649671	0.317184	0.273647
2.423	0.116318	0.0836372	0.0778598	0.120478	0.657741	0.331577	0.257269
2.6599	0.116402	0.0826533	0.0802942	0.12542	0.673488	0.350626	0.256587
2.92	0.117415	0.0875139	0.0855306	0.133392	0.700278	0.375754	0.277353
3.2054	0.119789	0.0988679	0.0940851	0.144969	0.740853	0.408319	0.322012
3.5188	0.124114	0.116329	0.1065	0.160773	0.796987	0.449191	0.388984
3.8628	0.131013	0.138558	0.123315	0.181525	0.869619	0.499179	0.472767
4.2405	0.141027	0.163688	0.144897	0.207735	0.958124	0.558871	0.565442
4.6551	0.154796	0.19	0.171554	0.239818	1.06085	0.628946	0.659557
5.1102	0.173266	0.216725	0.203706	0.278225	1.17558	0.709568	0.751045
5.6098	0.197561	0.244453	0.241796	0.323491	1.30082	0.800479	0.841246
6.1582	0.229008	0.275234	0.286362	0.376244	1.43598	0.901347	0.936781
6.7603	0.26885	0.31205	0.337813	0.436949	1.58057	1.01214	1.04763
7.4212	0.319043	0.358601	0.397086	0.506418	1.73344	1.13346	1.18504
8.1467	0.38302	0.418633	0.465833	0.586116	1.89208	1.26558	1.35836
8.9432	0.466495	0.494585	0.54713	0.678955	2.0531	1.40825	1.57043
9.8175	0.576601	0.587108	0.644698	0.78843	2.21089	1.56016	1.81511
10.777	0.721372	0.694345	0.762584	0.91781	2.35654	1.71984	2.0769
11.831	0.910731	0.812652	0.905671	1.07059	2.4765	1.88523	2.33186
12.988	1.15805	0.937725	1.08141	1.25267	2.55675	2.05398	2.5532
14.257	1.47953	1.06879	1.30017	1.47311	2.59131	2.22388	2.72535
15.651	1.89092	1.21362	1.57376	1.74283	2.59007	2.39566	2.85877
17.181	2.404	1.38957	1.91403	2.0731	2.5788	2.57606	2.99343
18.861	3.02316	1.62197	2.33136	2.47469	2.58669	2.77664	3.17998
20.705	3.74152	1.93095	2.83336	2.95743	2.6308	3.00786	3.43835
22.729	4.53461	2.31874	3.42021	3.52632	2.70447	3.26862	3.72979
24.951	5.3543	2.76446	4.0783	4.17504	2.77869	3.54015	3.97872
27.391	6.1261	3.22544	4.77339	4.87632	2.81635	3.7876	4.13762

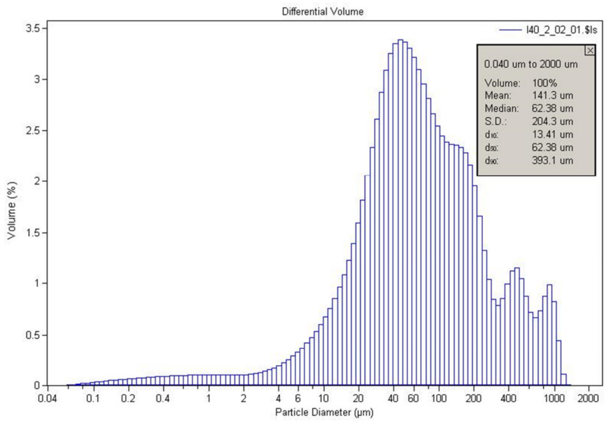
Channel Diameter	Goldsboro						
	12/12/2012	12/13/2012	12/16/2012	12/17/2012	1/18/2013	1/31/2013	2/8/2013
30.068	6.7573	3.6562	5.44945	5.57667	2.79263	3.97229	4.23028
33.008	7.15587	4.01681	6.03679	6.20037	2.70956	4.06831	4.27279
36.235	7.25346	4.28072	6.46583	6.66145	2.59351	4.07169	4.16035
39.778	7.024	4.46978	6.68202	6.8817	2.47709	3.99745	3.76746
43.667	6.49063	4.66394	6.65569	6.8073	2.37693	3.86521	3.21906
47.936	5.71873	4.9471	6.38537	6.42165	2.28167	3.68452	2.86808
52.622	4.80052	5.30413	5.89595	5.75325	2.15818	3.45082	2.86231
57.767	3.83682	5.55866	5.23492	4.87471	1.97482	3.15449	2.91981
63.414	2.92167	5.52169	4.46682	3.89357	1.73086	2.7986	2.70958
69.614	2.13093	5.22624	3.67296	2.93189	1.46868	2.41153	2.30498
76.42	1.51198	4.85848	2.93453	2.10729	1.2525	2.04217	1.88011
83.891	1.07766	4.54025	2.30784	1.49299	1.13073	1.73793	1.48263
92.092	0.811629	4.27164	1.81332	1.10506	1.11045	1.51931	1.2885
101.1	0.67821	3.9209	1.41267	0.902632	1.15496	1.37483	1.39502
110.98	0.637095	3.4663	1.05674	0.805733	1.19424	1.27182	1.50531
121.83	0.645473	3.06349	0.719076	0.733563	1.15346	1.18022	1.33384
133.74	0.655265	2.35962	0.387489	0.614386	0.995546	1.0942	1.16528
146.81	0.619481	0.916856	0.150102	0.427057	0.744288	1.02432	1.22781
161.17	0.511352	0.0740908	0.0290327	0.217289	0.465082	0.98207	1.11646
176.92	0.352018	0	0.00250567	0.0686585	0.222229	0.954448	0.456736
194.22	0.18157	0	0	0.0106807	0.0729277	0.902151	0.036904
213.21	0.064599	0	0	0.00050032	0.012307	0.787099	0
234.05	0.0115539	0	0	0	0.0008274	0.597927	0
256.94	0.00087124	0	0	0	0	0.36613	0
282.06	0	0	0	0	0	0.163503	0
309.63	0	0	0	0	0	0.0448792	0
339.9	0	0	0	0	0	0.0061382	0
373.13	0	0	0	0	0	0.0002294	0
409.61	0	0	0	0	0	0	0
449.66	0	0	0	0	0	0	0
493.62	0	0	0	0	0	0	0
541.88	0	0	0	0	0	0	0
594.85	0	0	0	0	0	0	0
653.01	0	0	0	0	0	0	0
716.85	0	0	0	0	0	0	0
786.93	0	0	0	0	0	0	0

Channel Diameter	Goldsboro						
	12/12/2012	12/13/2012	12/16/2012	12/17/2012	1/18/2013	1/31/2013	2/8/2013
863.87	0	0	0	0	0	0	0
948.32	0	0	0	0	0	0	0
1041	0	0	0	0	0	0	0
1142.8	0	0	0	0	0	0	0
1254.5	0	0	0	0	0	0	0
1377.2	0	0	0	0	0	0	0
1511.8	0	0	0	0	0	0	0
1659.6	0	0	0	0	0	0	0
1821.9	0	0	0	0	0	0	0
2000							

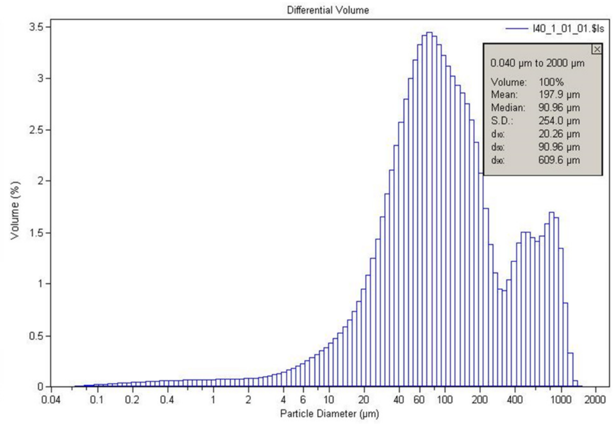
Appendix C: Particle Size Distribution Graphs for Individual Storm Events

Figure C.1. Graphical particle size distributions for runoff samples from Black Mountain.

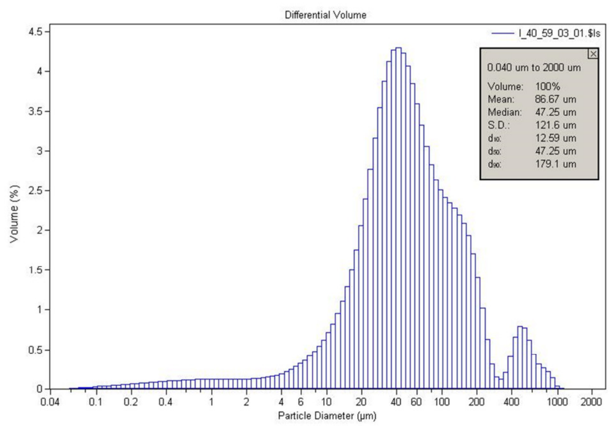




Differential Volume
I40_2_02_01.$ls
0.040 um to 2000 um
Volume: 100%
Mean: 141.3 um
Median: 62.38 um
S.D.: 204.3 um
d10: 13.41 um
d50: 62.38 um
d90: 393.1 um
Volume (%)
Particle Diameter (μm)



Differential Volume
I40_1_01_01.$ls
0.040 μm to 2000 μm
Volume: 100%
Mean: 197.9 μm
Median: 90.96 μm
S.D.: 254.0 μm
d10: 20.26 μm
d50: 90.96 μm
d90: 609.6 μm
Volume (%)
Particle Diameter (μm)



Differential Volume
I_40_59_03_01.$ls
0.040 um to 2000 um
Volume: 100%
Mean: 86.67 um
Median: 47.25 um
S.D.: 121.6 um
d10: 12.59 um
d50: 47.25 um
d90: 179.1 um
Volume (%)
Particle Diameter (μm)

Figure C.2. Graphical particle size distributions for runoff samples from Brevard.

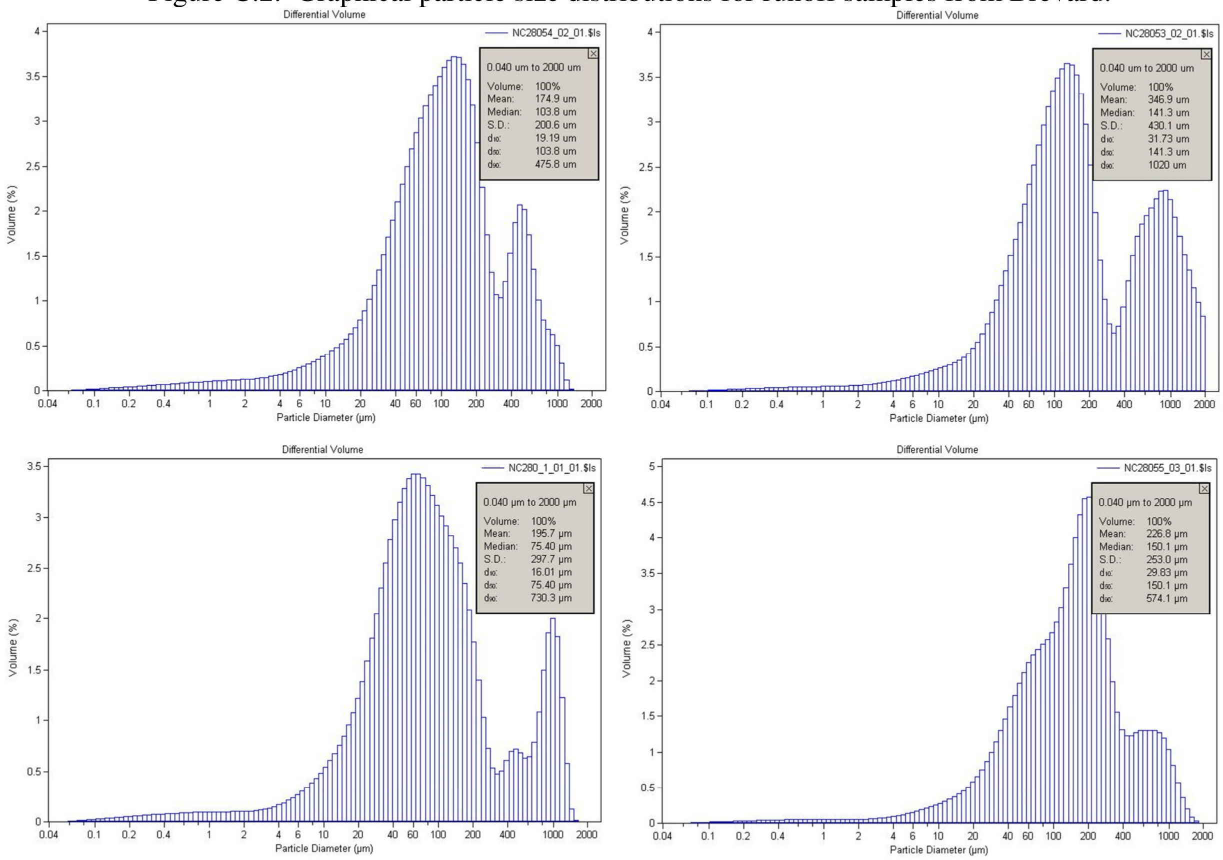


Figure C.3. Graphical particle size distributions for runoff samples from Jack Bennett.

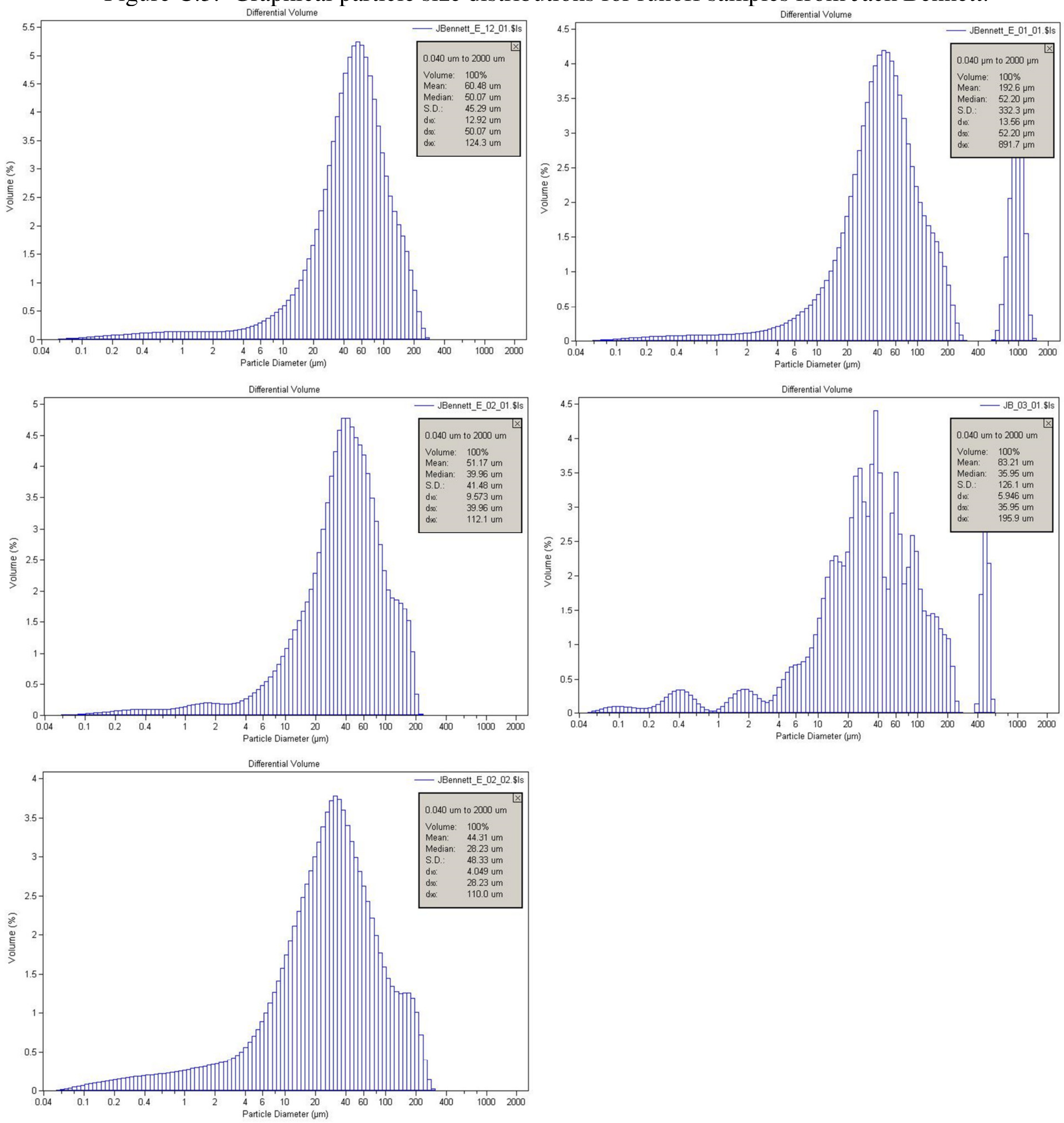


Figure C.4. Graphical particle size distributions for runoff samples from Hanks Chapel.

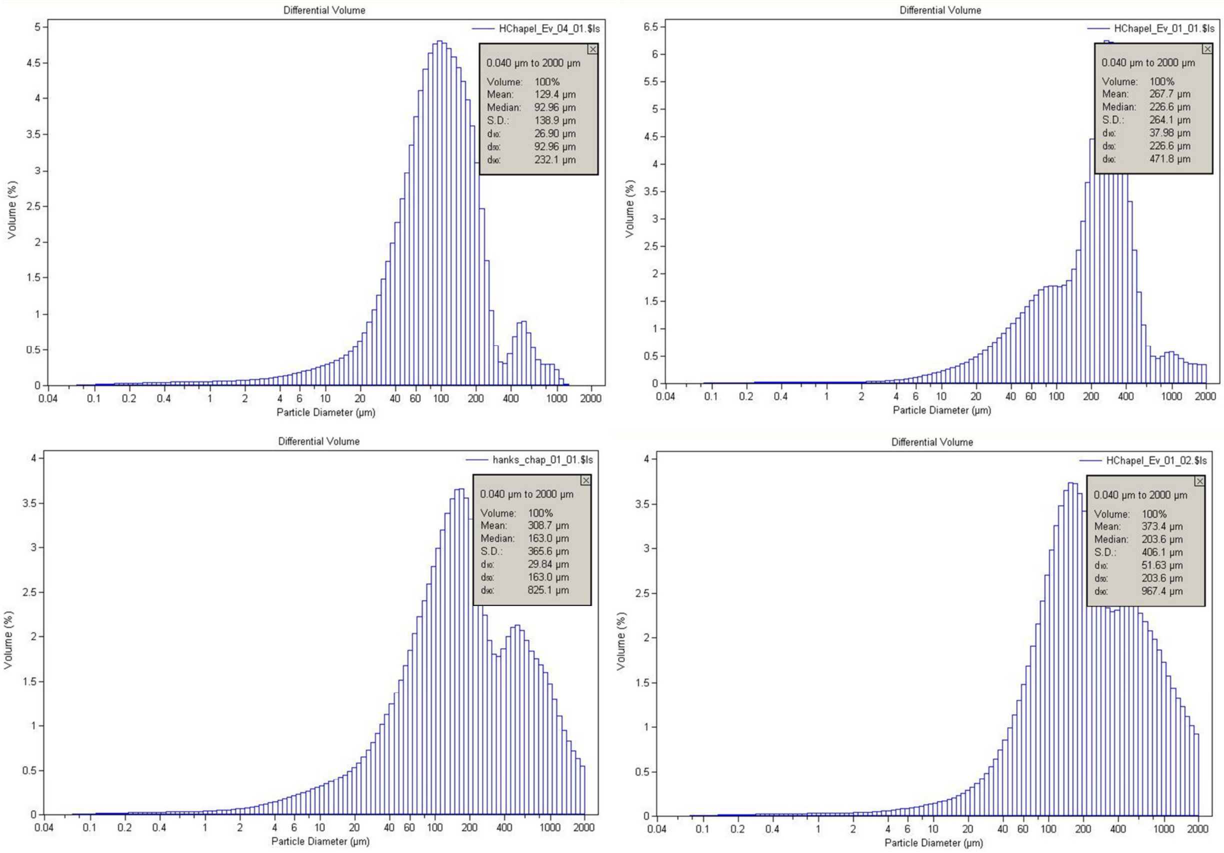
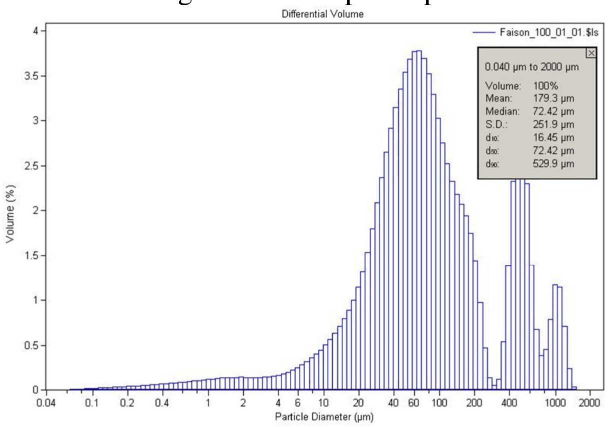
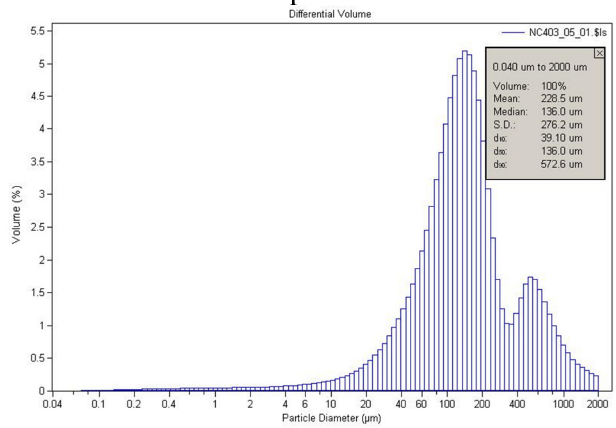


Figure C.5. Graphical particle size distributions for runoff samples from Faison.





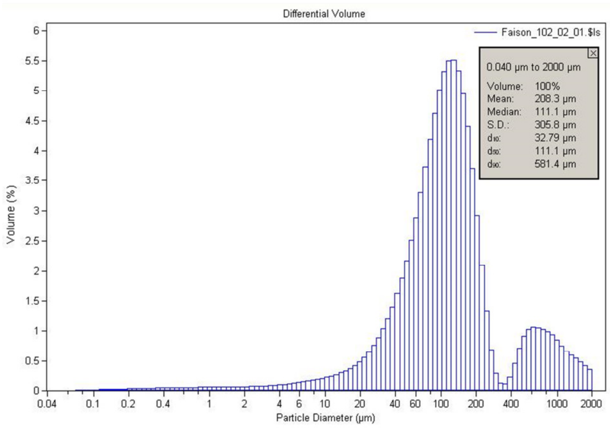
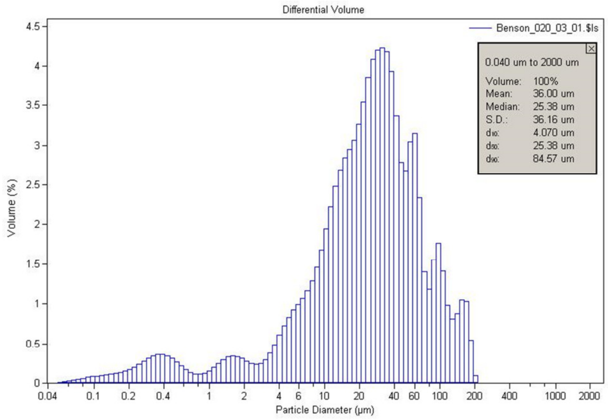
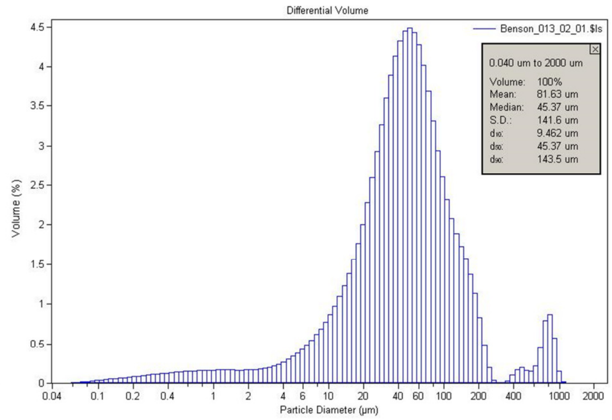
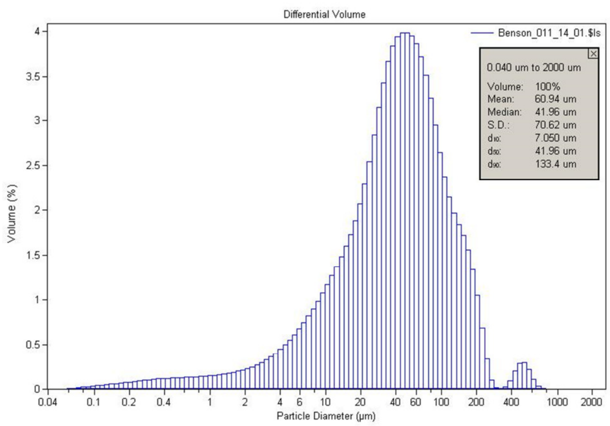
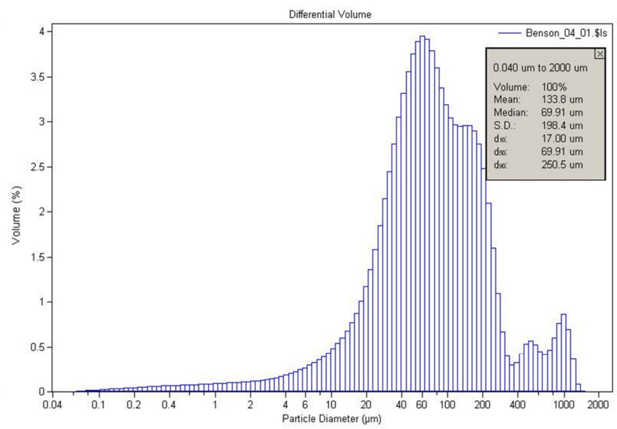


Figure C.6. Graphical particle size distributions for runoff samples from Benson.









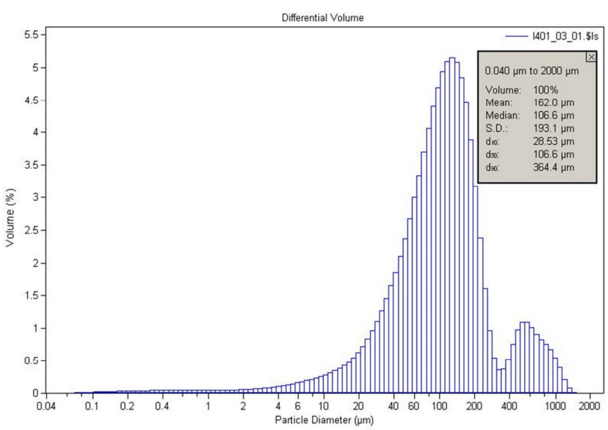


Figure C.7. Graphical particle size distributions for runoff samples from Wilson.

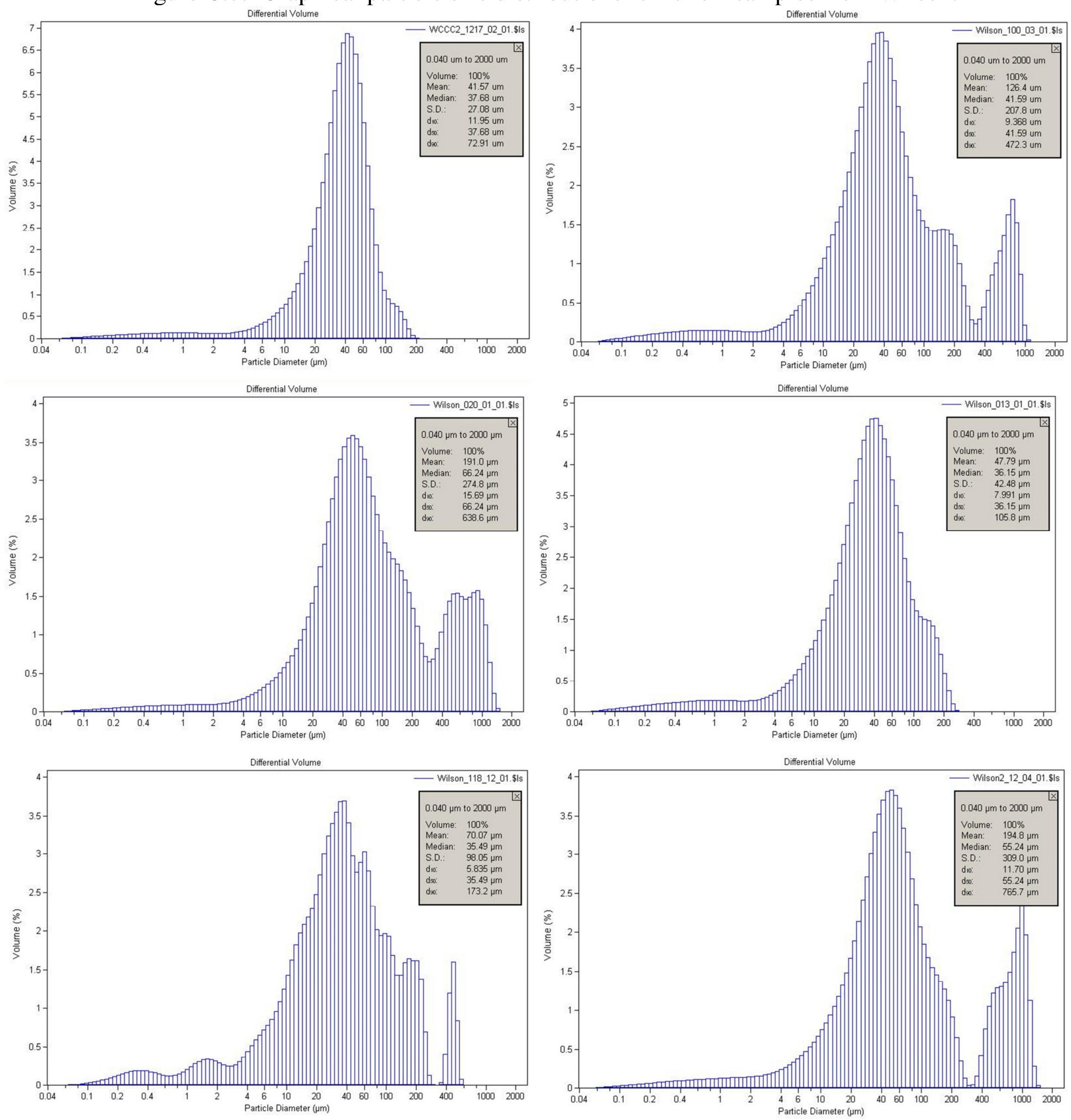
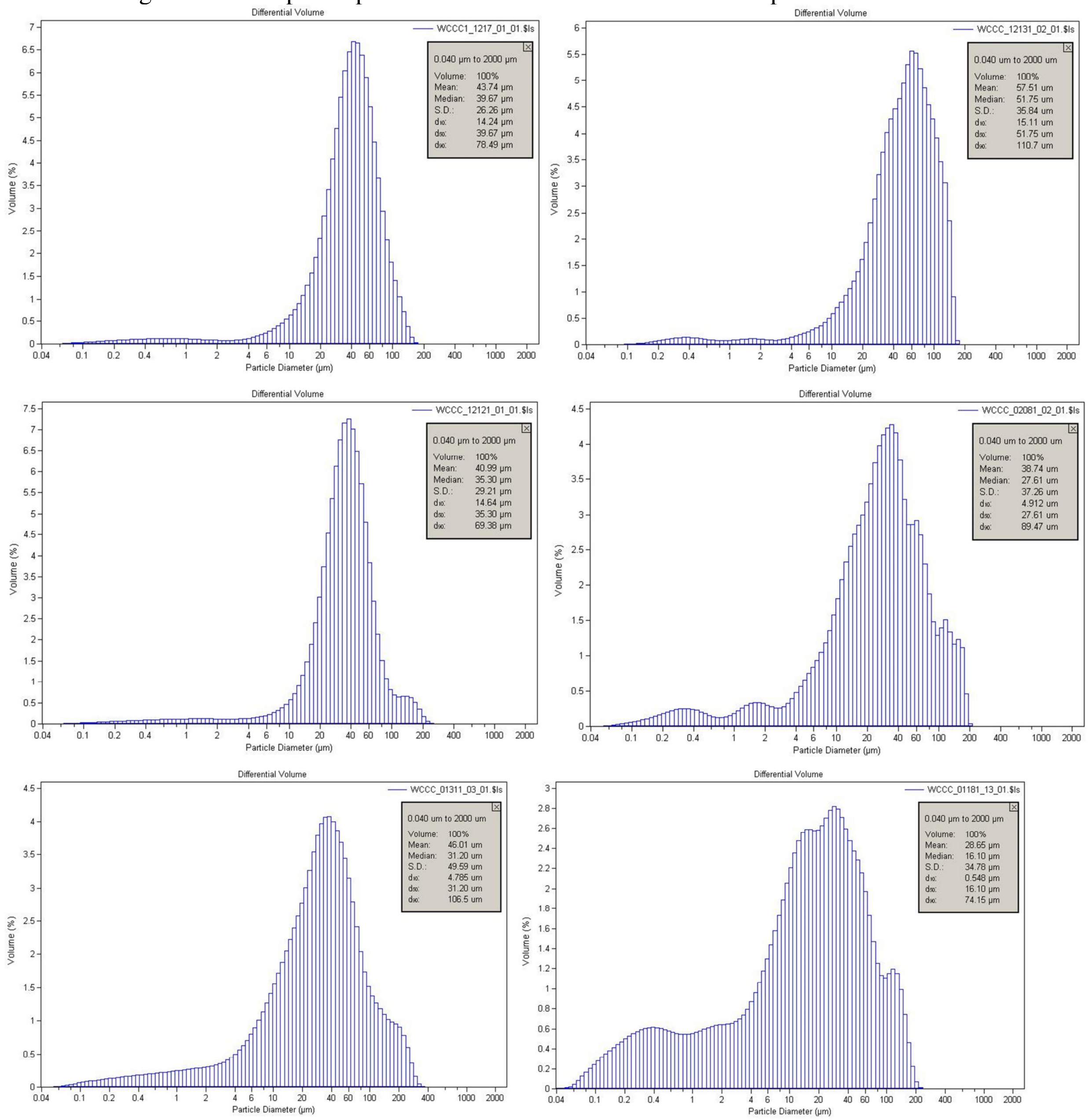
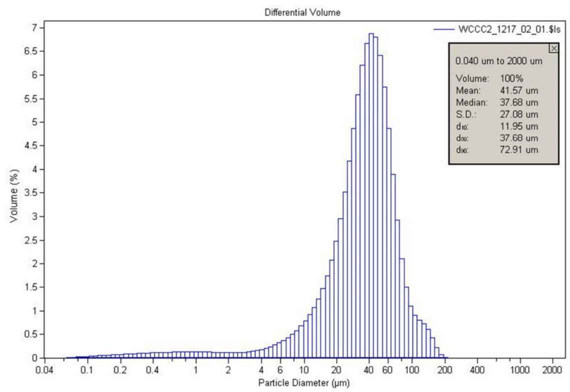


Figure C.8. Graphical particle size distributions for runoff samples from Goldsboro.




Differential Volume
WCCC2_1217_02_01.$ls
0.040 um to 2000 um
Volume: 100%
Mean: 41.57 um
Median: 37.68 um
S.D.: 27.08 um
d10: 11.95 um
d50: 37.68 um
d90: 72.91 um
Volume (%)
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7
0.04 0.1 0.2 0.4 1 2 4 6 10 20 40 60 100 200 400 1000 2000
Particle Diameter (µm)

Appendix D: Aqueous Runoff Sampling Raw Data

Table D.1. Rainfall characteristics for aqueous runoff samples.

Statistic	Event Number	Date	Total Rainfall Depth (in)	Antecedent Dry Period (hrs)	Peak Intensity 5 Min. (in./hr)	Peak Intensity Hourly (in./hr)	Rainfall Duration (hrs)	Avg Intensity
Black Mountain	1	6/1/2012	0.41	ND	2.22	0.4	3.80	0.11
	2	6/6/2012	0.36	105	1.26	0.26	3.40	0.11
	3	6/11/2012	0.17	122	0.3	0.08	4.43	0.04
	4	6/22/2012	0.24	107	0.84	0.23	3.20	0.08
	5	7/2/2012	0.61	225	1.26	0.37	2.70	0.23
	6	7/3/2012	1.15	34	3.24	1.15	0.83	1.38
	7	7/10/2012	0.43	118	1.32	0.34	10.17	0.04
	8	7/11/2012	0.69	11	1.74	0.38	4.87	0.14
	9	7/14/2012	0.71	15	2.1	0.42	7.87	0.09
Brevard	1	6/12/2012	0.69	51	1.5	0.34	3.67	0.19
	2	7/2/2012	0.77	221	0.48	0.24	10.47	0.07
	3	7/5/2012	0.85	86	3.06	0.85	0.83	1.02
	4	7/9/2012	0.61	22	1.86	0.6	2.57	0.24
Jack Bennett	1	6/11/2012	1.23	671	3.42	0.70	5.17	0.24
	2	7/8/2012	0.13	549	0.48	0.13	0.80	0.16
	3	7/10/2012	0.36	12	ND	0.12	2.50	0.14
	4	7/11/2012	0.59	8	ND	0.25	8.00	0.07
	5	7/22/2012	1.38	19	ND	0.14	9.00	0.15
	6	7/25/2012	0.80	72	ND	ND	6.00	0.13
	7	9/3/2012	0.27	8	0.42	0.17	2.63	0.10
Hanks Chapel	1	6/11/2012	0.98	125	1.92	0.38	6.21	0.16
	2	6/23/2012	0.36	77	1.20	0.33	4.96	0.07
	3	7/6/2012	0.43	234	2.28	0.43	0.40	1.08
	4	7/21/2012	0.24	19	0.84	0.20	1.75	0.14
	5	7/22/2012	1.38	19	ND	0.14	9.00	0.15
	6	7/25/2012	0.80	68	2.04	0.71	1.98	0.40
	7	9/7/2012	0.20	62	0.72	0.19	1.25	0.16
Faison	1	9/19/2012	0.36	230	0.36	0.12	7.47	0.05
	2	10/8/2012	1.08	143	1.44	0.49	17.93	0.06
	3	10/22/2012	0.21	157	1.2	0.12	4.43	0.05
	4	11/16/2012	0.24	45	0.24	0.1	4.23	0.06
	5	12/13/2012	0.89	353	0.24	0.18	13.23	0.07
	6	12/17/2012	0.41	68	0.3	0.12	28.53	0.01

Statistic	Event Number	Date	Total Rainfall Depth (in)	Antecedent Dry Period (hrs)	Peak Intensity 5 Min. (in./hr)	Peak Intensity Hourly (in./hr)	Rainfall Duration (hrs)	Avg Intensity
Benson	1	9/7/2012	0.24	216	ND	ND	ND	ND
	2	9/19/2012	0.89	24	4.5	0.69	5.23	0.17
	3	10/8/2012	0.63	142	0.54	0.13	13.30	0.05
	4	10/29/2012	0.37	502	0.18	0.11	8.90	0.04
	5	11/16/2012	0.5	44	0.3	0.2	7.90	0.06
	6	12/13/2012	0.71	356	0.24	0.19	10.43	0.07
	7	12/17/2012	0.68	68	0.42	0.19	31.10	0.02
	8	1/18/2013	0.69	187	0.72	0.34	7.47	0.09
	9	1/31/2013	0.29	80	4.2	0.24	1.83	0.16
	10	2/8/2013	0.98	184	0.42	0.25	12.13	0.08
Wilson	1	10/8/2012	0.77	145	0.78	0.22	14.77	0.05
	2	10/29/2012	0.31	476	0.42	0.15	11.77	0.03
	3	10/29-30/2012	0.18	6	0.18	0.07	8.67	0.02
	4	11/16/2012	0.21	46	0.24	0.10	4.97	0.04
	5	12/16/2012	0.19	120	0.24	0.09	9.20	0.02
	6	12/17/2012	0.45	10	0.30	0.12	10.67	0.04
	7	1/18/2012	0.90	14	0.42	0.24	17.87	0.05
	8	1/31/2012	0.29	127	1.74	0.24	5.33	0.05
	9	2/8/2013	1.19	180	0.30	0.20	12.43	0.10
Goldsboro	1	10/29/2012	0.19	301	0.24	0.11	6.60	0.03
	2	10/29-30/2012	0.24	12	0.12	0.07	8.47	0.03
	3	11/16/2012	0.36	46	0.24	0.16	3.60	0.10
	4	12/12/2012	0.17	338	0.24	0.05	9.67	0.02
	5	12/13/2012	0.87	8	0.24	0.18	13.90	0.06
	6	12/16/2012	0.15	66	0.3	0.06	9.57	0.02
	7	12/17/2012	0.28	6	0.3	0.13	13.17	0.02
	8	1/18/2013	0.78	368	ND	0.2	10.00	0.08
	9	1/31/2013	0.32	104	2.46	0.27	3.03	0.11
	10	2/8/2013	1.27	182	0.3	0.28	11.07	0.11

Table D.2. Pollutant concentrations from sampled storm events at Black Mountain, NC.

Date Sampled	Sample Site	TKN (mg/L)	NO3&NO2 (mg/L)	TN (mg/L)	NH3N (mg/L)	ON (mg/L)	TP (mg/L)	Ortho-P (mg/L)	PBP (mg/L)	TSS (mg/L)
6/1/12	I-40	NA*	NA	NA	NA	NA	NA	NA	NA	52.43
6/6/12		NA	NA	NA	NA	NA	NA	NA	NA	40.06
6/11/12		NA	NA	NA	NA	NA	NA	NA	NA	50.92
6/22/12		NA	NA	NA	NA	NA	NA	NA	NA	47.65
7/2/12		NA	NA	NA	NA	NA	NA	NA	NA	16.98
7/3/12		NA	NA	NA	NA	NA	NA	NA	NA	30.69
7/10/12		NA	NA	NA	NA	NA	NA	NA	NA	40.59
7/11/12		NA	NA	NA	NA	NA	NA	NA	NA	19.28
7/14/12		NA	NA	NA	NA	NA	NA	NA	NA	27.99

*NA = not analyzed

Table D.3. Pollutant concentrations from sampled storm events at Brevard, NC.

Date Sampled	Sample Site	TKN (mg/L)	NO3&NO2 (mg/L)	TN (mg/L)	NH3N (mg/L)	ON (mg/L)	TP (mg/L)	Ortho-P (mg/L)	PBP (mg/L)	TSS (mg/L)
6/12/12	NC-280	NA	NA	NA	NA	NA	NA	NA	NA	35.92
6/13/12		NA	NA	NA	NA	NA	NA	NA	NA	36.84
7/2/12		NA	NA	NA	NA	NA	NA	NA	NA	17.92
7/5/12		NA	NA	NA	NA	NA	NA	NA	NA	27.38
7/9/12		NA	NA	NA	NA	NA	NA	NA	NA	17.48
7/10/12		NA	NA	NA	NA	NA	NA	NA	NA	8.48
7/12/12		NA	NA	NA	NA	NA	NA	NA	NA	13.29

*NA = not analyzed

Table D.4. Pollutant concentrations from sampled storm events at Jack Bennett, NC.

Date Sampled	Sample Site	TKN (mg/L)	NO3&NO2 (mg/L)	TN (mg/L)	NH3N (mg/L)	ON (mg/L)	TP (mg/L)	Ortho-P (mg/L)	PBP (mg/L)	TSS (mg/L)
6/11/12	Jack Bennett	0.656	0.147	0.802	0.279	0.376	0.057	0.012	0.045	10.38
7/8/12		3.687	0.289	3.976	1.810	1.877	0.385	0.185	0.200	55.82
7/10/12		1.834	0.280	2.114	1.006	0.828	0.158	0.099	0.059	5.95
7/11/12		0.679	0.352	1.030	0.357	0.322	0.061	0.026	0.035	11.73
7/22/12		0.395	0.148	0.542	0.168	0.226	0.040	0.023	0.017	7.37
7/25/12		1.695	0.323	2.018	0.703	0.992	0.197	0.082	0.115	56.98
9/3/12		0.957	0.377	1.334	0.331	0.626	0.074	0.032	0.041	30.34

Table D.5. Pollutant concentrations from sampled storm events at Hanks Chapel, NC.

Date Sampled	Sample Site	TKN (mg/L)	NO3&NO2 (mg/L)	TN (mg/L)	NH3N (mg/L)	ON (mg/L)	TP (mg/L)	Ortho-P (mg/L)	PBP (mg/L)	TSS (mg/L)
6/11/12	Hanks Chapel	1.470	0.434	1.904	0.664	0.805	0.110	0.024	0.086	23.73
6/23/12		0.984	0.212	1.196	0.335	0.649	0.054	0.016	0.037	3.60
7/6/12		2.078	0.662	2.740	0.724	1.353	0.106	0.013	0.094	18.83
7/21/12		1.351	0.943	2.294	0.362	0.989	0.061	0.006	0.055	13.20
7/22/12		0.456	0.234	0.690	0.216	0.240	0.022	0.006	0.016	3.51
7/25/12		0.874	0.295	1.169	0.353	0.521	0.052	0.005	0.047	34.10
9/7/12		0.817	0.469	1.286	0.240	0.577	0.063	0.004	0.059	22.98

Table D.6. Pollutant concentrations from sampled storm events at Benson, NC.

Date Sampled	Sample Site	TKN (mg/L)	NO3&NO2 (mg/L)	TN (mg/L)	NH3N (mg/L)	ON (mg/L)	TP (mg/L)	Ortho-P (mg/L)	PBP (mg/L)	TSS (mg/L)
9/7/12	Benson	NA	NA	NA	NA	NA	NA	NA	NA	7.67
9/19/12		NA	NA	NA	NA	NA	NA	NA	NA	7.45
10/8/12		NA	NA	NA	NA	NA	NA	NA	NA	2.60
10/29/12		NA	NA	NA	NA	NA	NA	NA	NA	1.85
11/16/12		NA	NA	NA	NA	NA	NA	NA	NA	2.07
12/13/12		NA	NA	NA	NA	NA	NA	NA	NA	2.92
12/17/12		NA	NA	NA	NA	NA	NA	NA	NA	2.83
1/18/13		NA	NA	NA	NA	NA	NA	NA	NA	12.43
1/31/13		NA	NA	NA	NA	NA	NA	NA	NA	42.58
2/8/13		NA	NA	NA	NA	NA	NA	NA	NA	8.46

*NA = not analyzed

Table D.7. Pollutant concentrations from sampled storm events at Faison, NC.

Date Sampled	Sample Site	TKN (mg/L)	NO3&NO2 (mg/L)	TN (mg/L)	NH3N (mg/L)	ON (mg/L)	TP (mg/L)	Ortho-P (mg/L)	PBP (mg/L)	TSS (mg/L)
9/19/12	Faison	NA	NA	NA	NA	NA	NA	NA	NA	29.63
10/8/12		NA	NA	NA	NA	NA	NA	NA	NA	9.71
10/22/12		NA	NA	NA	NA	NA	NA	NA	NA	19.98
11/16/12		NA	NA	NA	NA	NA	NA	NA	NA	18.52
12/13/12		NA	NA	NA	NA	NA	NA	NA	NA	4.67
12/17/12		NA	NA	NA	NA	NA	NA	NA	NA	7.78

*NA = not analyzed

Table D.8. Pollutant concentrations from sampled storm events at Goldsboro, NC.

Date Sampled	Sample Site	TKN (mg/L)	NO3&NO2 (mg/L)	TN (mg/L)	NH3N (mg/L)	ON (mg/L)	TP (mg/L)	Ortho-P (mg/L)	PBP (mg/L)	TSS (mg/L)
10/29/12	Goldsboro	0.572	0.166	0.738	0.190	0.382	0.074	0.031	0.043	20.78
10/29-30/12		0.619	0.192	0.810	0.243	0.375	0.133	0.095	0.039	12.69
11/16/12		0.822	0.238	1.059	0.410	0.412	0.090	0.034	0.056	16.08
12/12/12		1.790	0.946	2.736	0.515	1.275	0.510	0.310	0.200	22.32
12/13/12		0.625	0.329	0.953	0.358	0.266	0.118	0.069	0.049	8.66
12/16/12		0.809	0.431	1.239	0.426	0.382	0.129	0.063	0.066	8.90
12/17/12		0.555	0.280	0.835	0.344	0.211	0.066	0.021	0.045	9.28
1/18/13		0.836	0.339	1.176	0.344	0.492	0.208	0.019	0.189	49.31
1/31/13		0.869	0.172	1.040	0.322	0.546	0.172	0.076	0.096	85.44
2/8/13		2.947	0.330	3.277	2.511	0.436	0.150	0.026	0.123	41.14

Table D.9. Pollutant concentrations from sampled storm events at Wilson, NC.

Date Sampled	Sample Site	TKN (mg/L)	NO3&NO2 (mg/L)	TN (mg/L)	NH3N (mg/L)	ON (mg/L)	TP (mg/L)	Ortho-P (mg/L)	PBP (mg/L)	TSS (mg/L)
10/8/12	Wilson	0.826	0.256	1.082	0.245	0.581	0.178	0.045	0.133	81.03
10/29/12		0.763	0.224	0.987	0.159	0.605	0.109	0.038	0.072	22.78
10/29-30/12		0.648	0.227	0.874	0.176	0.472	0.085	0.044	0.041	25.69
11/16/12		1.250	0.356	1.606	0.445	0.804	0.181	0.056	0.125	47.63
12/16/12		0.827	0.375	1.202	0.397	0.429	0.114	0.050	0.064	26.61
12/17/12		0.563	0.260	0.823	0.255	0.308	0.118	0.061	0.057	23.89
1/18/13		0.959	0.292	1.251	0.245	0.715	0.223	0.037	0.186	64.31
1/31/13		1.603	0.205	1.809	0.321	1.282	0.363	0.030	0.334	153.61
2/8/13		1.375	0.364	1.739	0.412	0.963	0.182	0.073	0.109	40.50

Appendix E: Aggregated Gross Solids Data

Table E.1. Rainfall characteristics for sampled gross solids events.

Statistic	Date Sampled	Sampling Duration (hrs)	Total Rainfall Depth (in)	Antecedent Dry Period (hrs)	Peak Intensity 5 Min. (in./hr)	Rainfall Duration (hrs)
Black Mountain	6/6/2012	142.43	0.91	134.23	2.22	8.20
	6/14/2012	191.93	0.78	122.50	1.08	15.97
	6/27/2012	311.93	0.44	167.00	0.84	10.77
	7/5/2012	191.93	2.08	281.83	3.24	22.50
	7/11/2012	143.93	0.96	132.1	1.5	12.9
	7/19/2012	193.63	2.17	136.27	2.04	43.73
Garner	12/13/2012	190.98	0.72	357.25	0.24	11.29
	12/17/2012	111.51	0.95	69.32	0.60	29.32
	1/14/2013	672.00	2.97	554.64	1.68	49.52
	1/28/2013	336.00	0.36	220.81	0.12	10.91
	1/31/2013	72.00	0.25	78.49	1.32	6.70
	2/8/2013	192.00	0.87	180.17	0.24	9.70
Newton Grove	12/13/2012	389.87	1.20	539.86	0.36	23.23
	12/17/2012	96.00	0.43	69.28	0.60	29.88
	1/14/2013	672.00	3.66	541.35	1.80	49.45
	1/18/2013	96.00	0.84	150.00	0.84	8.40
	1/28/2013	240.00	0.14	237.60	0.12	13.91
	1/31/2013	72.00	0.22	60.66	1.92	9.38
	2/8/2013	192.00	0.25	189.38	0.36	7.50
Faison	9/7/2012	67.50	0.24	192	0.24	6.52
	9/19/2012	287.93	0.53	267.13	0.24	14.73
	10/6/2012	407.93	1.15	308.37	3.12	22.83
	10/8/2012	71.90	1.08	143.50	1.68	17.93
	10/22/2012	311.90	0.27	163.97	1.20	4.43
	11/16/2012	599.93	0.61	705.90	0.48	39.17
	12/13/2012	746.17	1.73	694.60	0.30	60.67

Table E.2. Gross solids concentrations from samples obtained at four monitoring sites.

Site	Sample No.	Date	Dry weight (g)	N (mg/kg)	P (mg/kg)	Zn (mg/kg)	Cu (mg/kg)	Mn (mg/kg)	Fe (mg/kg)
Faison	1	9/7/2012	40.88	7550	902	404	26.1	76.1	1270
	2	9/19/2012	69.59	10300	1280	151	20.8	115	324
	3	10/6/2012	45.2	6540	931	141	23.8	88.8	318
	4	10/8/2012	36.36	6860	1050	173	23.6	76.4	292
	5	10/22/2012	39.51	9010	780	102	12.7	39.4	203
	6	11/16/2012	22.82	11600	1000	61	11.3	347	342
	7	12/13/2012	25.24	12200	1360	116	48.4	320	459
	Avg			9151	1043	164	24	152	458
	Median			9010	1000	141	23.6	88.8	324
Black Mountain	1	6/6/2012	72.31	14900	1370	461	46.6	158	4450
	2	6/14/2012	74.25	12300	1160	311	34.3	119	2320
	3	6/27/2012	39.7	14800	1410	424	36.7	184	4540
	4	7/5/2012	49.11	11900	881	494	25.2	205	3910
	5	7/11/2012	20.04	20200	3510	341	32.3	327	1830
	6	7/19/2012	56.22	17400	2040	263	38.5	236	4110
	Avg			15250	1729	382	36	205	3527
	Median			14850	1390	382.5	35.5	194.5	4010
Newton Grove	1	12/13/2012	19.06	8920	1070	239	16.3	355	532
	2	12/17/2012	33.41	5010	453	628	20	430	926
	3	1/14/2013	20.35	8270	1140	268	17.3	67.7	366
	4	1/18/2013	16.22	14300	2240	571	44.3	105	618
	5	1/28/2013	29.86	8040	2370	337	23.7	58.5	975
	6	1/31/2013	20.57	11100	956	356	26.6	94.6	851
	7	2/8/2013	28.58	9660	1270	385	50.5	99	932
	Avg			9329	1357	398	28	173	743
	Median			8920	1140	356	23.7	99	851
Garner	1	12/13/2012	17.12	8150	997	244	26.1	947	2260
	2	12/17/2012	16.41	12500	951	269	148	1140	1670
	3	1/14/2013	53.05	7550	997	555	75.5	318	5380
	4	1/28/2013	14.62	10800	931	380	29.7	610	2490
	5	1/31/2013	25.38	9140	925	998	58.5	664	4980
	6	2/8/2013	26.07	6420	901	789	61.8	355	5650
	Avg			9093	950	539	67	672	3738
	Median			8645	941	467.5	60.15	637	3735

Table E.3. Nutrient loading in kg/inch of rainfall on each respective watershed.

Site	Date	Rainfall Depth (in)	N Load (kg/in)	P load (kg/in)	Zn load (kg/in)	Cu load (kg/in)	Mn load (kg/in)	Fe load (kg/in)
Faison	9/7/2012	0.24	0.00129	0.00015	0.00007	0.00000	0.00001	0.00022
	9/19/2012	0.53	0.00135	0.00017	0.00002	0.00000	0.00002	0.00004
	10/6/2012	1.15	0.00026	0.00004	0.00001	0.00000	0.00000	0.00001
	10/8/2012	1.08	0.00023	0.00004	0.00001	0.00000	0.00000	0.00001
	10/22/2012	0.27	0.00132	0.00011	0.00001	0.00000	0.00001	0.00003
	11/16/2012	0.61	0.00043	0.00004	0.00000	0.00000	0.00001	0.00001
	12/13/2012	1.73	0.00018	0.00002	0.00000	0.00000	0.00000	0.00001
	Sum		0.00506	0.00057	0.00012	0.00001	0.00006	0.00033
Black Mountain	6/6/2012	0.91	0.00118	0.00011	0.00004	0.00000	0.00001	0.00035
	6/14/2012	0.78	0.00117	0.00011	0.00003	0.00000	0.00001	0.00022
	6/27/2012	0.44	0.00134	0.00013	0.00004	0.00000	0.00002	0.00041
	7/5/2012	2.08	0.00028	0.00002	0.00001	0.00000	0.00000	0.00009
	7/11/2012	0.96	0.00042	0.00007	0.00001	0.00000	0.00001	0.00004
	7/19/2012	2.17	0.00045	0.00005	0.00001	0.00000	0.00001	0.00011
	Sum		0.00484	0.00049	0.00013	0.00001	0.00006	0.00122
Newton Grove	12/13/2012	1.20	0.00014	0.00002	0.00000	0.00000	0.00001	0.00001
	12/17/2012	0.43	0.00039	0.00004	0.00005	0.00000	0.00003	0.00007
	1/14/2013	3.66	0.00005	0.00001	0.00000	0.00000	0.00000	0.00000
	1/18/2013	0.84	0.00028	0.00004	0.00001	0.00000	0.00000	0.00001
	1/28/2013	0.14	0.00171	0.00051	0.00007	0.00001	0.00001	0.00021
	1/31/2013	0.22	0.00104	0.00009	0.00003	0.00000	0.00001	0.00008
	2/8/2013	0.25	0.00110	0.00015	0.00004	0.00001	0.00001	0.00011
	Sum		0.00471	0.00084	0.00021	0.00002	0.00007	0.00049
Garner	12/13/2012	0.72	0.00019	0.00002	0.00001	0.00000	0.00002	0.00005
	12/17/2012	0.95	0.00022	0.00002	0.00000	0.00000	0.00002	0.00003
	1/14/2013	2.97	0.00013	0.00002	0.00001	0.00000	0.00001	0.00010
	1/28/2013	0.36	0.00044	0.00004	0.00002	0.00000	0.00002	0.00010
	1/31/2013	0.25	0.00093	0.00009	0.00010	0.00001	0.00007	0.00051
	2/8/2013	0.87	0.00019	0.00003	0.00002	0.00000	0.00001	0.00017
	Sum		0.00210	0.00022	0.00016	0.00001	0.00015	0.00095

Appendix F: Gross Solids Raw Data Sheets

Figure F.1. Gross solids nutrient analysis for samples from Faison.

NCDA&CS Agronomic Division | **Phone: (919) 733-2655** | **Website: www.ncagr.gov/agronomi/** | **Report No.** FY13-W001828

Predictive

Waste Report

Sampled: 09/07/2012 **Received:** 09/11/2012 **Completed:** 09/13/2012

Client: Ryan Winston, NCSU Box 7625, Raleigh, NC 276957625
Advisor: ,
County: Sampson
Farm: FAISON 1

[Links to Helpful Information]

Sample Information

Sample ID: FAIS1
Waste Code: MWO
Description: Municipal (Other)
Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	7550
Total Kjeldahl N	
Inorganic N	
NH4-N	
NO3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
902	1110	9230	838	981	1270	76.1	404	26.1	11.5	189	

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE (tons)	C:N
	79.5					

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)

Estimate of Nutrients Available for First Crop (lb / ton) | **Other Elements** (lb / ton)

Application Method	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo	Cl	Na	Ni	Cd	Pb	Al	Se	Li
Broadcast	3.60	1.97	1.69	8.80	0.80	0.94	1.21	0.07	0.39	0.02	0.01			0.30						
Broadcast	3.60	1.97	1.69	8.80	0.80	0.94	1.21	0.07	0.39	0.02	0.01			0.30						

Agronomist's Comments:

The waste contains a large amount of nitrogen. To protect the environment, be careful to apply the waste only at rates needed to meet crop nitrogen requirement.
The waste product contains a large amount of phosphorus. Application rate should still be based on crop nitrogen requirement unless soil test P is very high and the site is vulnerable to movement of this element to nearby surface water. Special care should be taken to avoid overloading problem sites with this element by limiting phosphorus application to no more than crop removal.

NCDA&CS Agronomic Division | **Phone: (919) 733-2655** | **Website: www.ncagr.gov/agronomi/** | **Report No.** FY13-W002007

Research

Waste Report

Sampled: 09/19/2012 **Received:** 09/20/2012 **Completed:** 09/21/2012

Client: Ryan Winston, NCSU Box 7625, Raleigh, NC 276957625
Advisor: ,
County: Sampson
Farm: FAISON 2

[Links to Helpful Information]

Sample Information

Sample ID: FAIS2
Waste Code: MWO
Description: Municipal (Other)
Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	10300
Total Kjeldahl N	
Inorganic N	
NH4-N	
NO3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
1280	3680	7530	1810	1120	324	115	151	20.8	13.1	470	

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE (tons)	C:N
	29.3					

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)

Estimate of Nutrients Available for First Crop (lb / ton) | **Other Elements** (lb / ton)

Application Method	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo	Cl	Na	Ni	Cd	Pb	Al	Se	Li
Broadcast	1.81	1.03	2.07	2.64	0.64	0.39	0.11	0.04	0.05	0.01	0.00			0.28						
Broadcast	1.81	1.03	2.07	2.64	0.64	0.39	0.11	0.04	0.05	0.01	0.00			0.28						

Agronomist's Comments:

Completed: 10/5/2012 4:36 PM

NCDA&CS Agronomic Division | Phone: (919) 733-2655 | Website: www.ncagr.gov/agronomi/ | Report No. FY13-W002324

Research

Waste Report

Client: Ryan Winston
NCSU Box 7625
Raleigh, NC 276957625

Advisor:
,

County: Sampson

Links to Helpful Information

Sampled: 10/06/2012 Received: 10/09/2012 Completed: 10/10/2012 Farm: FAISON 3

Sample Information

Sample ID: FAIS3
Waste Code: MWO
Description: Municipal (Other)
Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	6540
Total Kjeldahl N	
Inorganic N	
NH4-N	
NO3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
931	1840	7720	1210	810	318	88.8	141	23.8	10.1	404	

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE (tons)	C:N
	79.1					

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)

Estimate of Nutrients Available for First Crop (lb / ton) | **Other Elements** (lb / ton)

Application Method	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo	Cl	Na	Ni	Cd	Pb	Al	Se	Li
Broadcast	3.10	2.02	2.79	7.32	1.15	0.77	0.30	0.08	0.13	0.02	0.01			0.64						
Soil Incorporated	4.14	2.53	3.14	9.15	1.44	0.96	0.38	0.11	0.17	0.03	0.01			0.64						

Agronomist's Comments:

Completed: 10/11/2012

NCDA&CS Agronomic Division | Phone: (919) 733-2655 | Website: www.ncagr.gov/agronomi/ | Report No. FY13-W002635

Research

Waste Report

Client: Ryan Winston
NCSU Box 7625
Raleigh, NC 276957625

Advisor:
,

County: Sampson

Links to Helpful Information

Sampled: 10/08/2012 Received: 10/17/2012 Completed: 10/18/2012 Farm: FAISON 4

Sample Information

Sample ID: FAISH
Waste Code: MWO
Description: Municipal (Other)
Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	6860
Total Kjeldahl N	
Inorganic N	
NH4-N	
NO3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
1050	3190	7670	1030	903	292	76.4	173	23.6	11.3	447	

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE (tons)	C:N
	62.5					

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)

Estimate of Nutrients Available for First Crop (lb / ton) | **Other Elements** (lb / ton)

Application Method	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo	Cl	Na	Ni	Cd	Pb	Al	Se	Li
Broadcast	2.57	1.81	3.83	5.75	0.77	0.68	0.22	0.06	0.13	0.02	0.01			0.56						
Broadcast	2.57	1.81	3.83	5.75	0.77	0.68	0.22	0.06	0.13	0.02	0.01			0.56						

NCDA&CS Agronomic Division | Phone: (919) 733-2655 | Website: www.ncagr.gov/agronomi/ | Report No. FY13-W002803

Research

Waste Report

Client: Ryan Winston
NCSU Box 7625
Raleigh, NC 276957625

Advisor:
,

County: Sampson

Links to Helpful Information

Sampled: | Received: 10/24/2012 | Completed: 10/25/2012 | Farm: FAISON 5

Sample Information

Sample ID: FAIS5
Waste Code: MWO
Description:
Municipal (Other)

Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	9010
Total Kjeldahl N	
Inorganic N	
NH_4-N	
NO_3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
780	2070	4980	782	594	203	39.4	102	12.7	9.66	263	

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE (tons)	C:N
	87.9					

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)

Estimate of Nutrients Available for First Crop (lb / ton) | **Other Elements** (lb / ton)

Application Method	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo	Cl	Na	Ni	Cd	Pb	Al	Se	Li
Broadcast	4.75	1.88	3.50	5.25	0.83	0.63	0.21	0.04	0.11	0.01	0.01			0.46						
Soil Incorporated	6.33	2.35	3.94	6.56	1.03	0.78	0.27	0.05	0.13	0.02	0.01			0.46						

NCDA&CS Agronomic Division | Phone: (919) 733-2655 | Website: www.ncagr.gov/agronomi/ | Report No. FY13-W003269

Research

Waste Report

Client: Ryan Winston
NCSU Box 7625
Raleigh, NC 276957625

Advisor:
,

County: Sampson

Links to Helpful Information

Sampled: 11/16/2012 | Received: 11/19/2012 | Completed: 11/20/2012 | Farm: FAISON 5

Sample Information

Sample ID: FAIS5
Waste Code: MWO
Description:
Municipal (Other)

Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	11600
Total Kjeldahl N	
Inorganic N	
NH_4-N	
NO_3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
1000	3660	17300	6940	1430	342	347	60.7	11.3	44.6	205	

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE (tons)	C:N
	42.8					

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)

Estimate of Nutrients Available for First Crop (lb / ton) | **Other Elements** (lb / ton)

Application Method	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo	Cl	Na	Ni	Cd	Pb	Al	Se	Li
Broadcast	2.98	1.18	3.01	8.90	3.57	0.74	0.18	0.18	0.03	0.01	0.02			0.18						
Soil Incorporated	3.97	1.47	3.39	11.1	4.46	0.92	0.22	0.22	0.04	0.01	0.03			0.18						

Agronomist's Comments:

Aaron Pettit 11/21/2012 11:16 AM

NCDA&CS Agronomic Division	Phone: (919) 733-2655	Website: www.ncagr.gov/agronomi/	Report No. FY13-W003974

Research

Waste Report

Sampled: 12/13/2012 Received: 12/14/2012 Completed: 12/17/2012

Client: Ryan Winston
NCSU Box 7625
Raleigh, NC 276957625

Advisor: ,

County: Sampson

Farm: FAISON 6

Links to Helpful Information

Sample Information

Sample ID: FAIS6
Waste Code: MWO
Description: Municipal (Other)
Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	12200
Total Kjeldahl N	
Inorganic N	
NH_4-N	
NO_3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
1360	3040	6640	1610	1190	459	320	116	48.4	22.5	457	

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE (tons)	C:N
	41.4					

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)

Estimate of Nutrients Available for First Crop (lb / ton) / **Other Elements** (lb / ton)

Application Method	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo	Cl	Na	Ni	Cd	Pb	Al	Se	Li
Broadcast	3.04	1.54	2.42	3.30	0.80	0.59	0.23	0.16	0.06	0.02	0.01			0.38						
Injection	4.05	1.93	2.72	4.12	1.00	0.74	0.29	0.20	0.07	0.03	0.01			0.38						

Agronomist's Comments:

Aaron Pettit 12/17/2012 3:50 PM

Figure F.2. Gross solids nutrient analysis for samples from Black Mountain.

NCDA&CS Agronomic Division Phone: (919) 733-2655 Website: www.ncagr.gov/agronomi/ Report No. FY12-W008357

Research

Waste Report

Client: Ryan Winston, NCSU Box 7625, Raleigh, NC 276957625
Advisor: USDA-NRCS-Transylvania, Community Services Bldg., 203 E. Morgan St., Brevard, NC 28712
County: Transylvania
Links to Helpful Information

Sampled: 06/06/2012 Received: 06/11/2012 Completed: 06/14/2012 *Farm:* I-401

Sample Information

Sample ID: I40SI
Waste Code: NCW
Description: Non-Composted - Other
Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	14900
Total Kjeldahl N	
Inorganic N	
NH4-N	
NO3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
1370	4230	10400	1780	1350	4450	158	461	46.6	26.6	476	391000

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE (tons)	C:N
6.30	63.3					26.3 : 1

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)

Estimate of Nutrients Available for First Crop (lb / ton) / **Other Elements** (lb / ton)

Application Method	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo	Cl	Na	Ni	Cd	Pb	Se	Li
Broadcast		1.59	5.14	5.28	0.90	0.68	2.25	0.08	0.23	0.02	0.01			0.60					
Soil Integrated		2.39	5.78	7.93	1.35	1.02	3.38	0.12	0.35	0.04	0.02			0.60					

Agronomist's Comments:

Ryan
I didn't realize that this storm water waste will include drink containers. We can't analyze those types of material with our method.

Completed: June 14, 2012

NCDA&CS Agronomic Division Phone: (919) 733-2655 Website: www.ncagr.gov/agronomi/ Report No. FY12-W008507

Research

Waste Report

Client: Ryan Winston, NCSU Box 7625, Raleigh, NC 276957625
Advisor: USDA-NRCS-Transylvania, Community Services Bldg., 203 E. Morgan St., Brevard, NC 28712
County: Transylvania
Links to Helpful Information

Sampled: 07/14/2012 Received: 06/15/2012 Completed: 06/22/2012 *Farm:* I40 (2)

Sample Information

Sample ID: IL052
Waste Code: NCW
Description: Non-Composted - Other
Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	12300
Total Kjeldahl N	
Inorganic N	
NH4-N	
NO3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
1160	3430	8190	1280	1570	2320	119	311	34.3	16.7	508	444000

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE (tons)	C:N
5.51	79.2					36.1 : 1

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)

Estimate of Nutrients Available for First Crop (lb / ton) / **Other Elements** (lb / ton)

Application Method	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo	Cl	Na	Ni	Cd	Pb	Se	Li
Broadcast		1.69	5.21	5.19	0.81	1.00	1.47	0.08	0.20	0.02	0.01			0.80					

Agronomist's Comments:

Completed: June 22, 2012

NCDA&CS Agronomic Division | Phone: (919) 733-2655 | Website: www.ncagr.gov/agronomi/ | Report No. FY13-W000133

Research

Waste Report

Client: Ryan Winston, NCSU Box 7625, Raleigh, NC 276957625

Advisor: ,

County: Transylvania

Links to Helpful Information

Sampled: 06/27/2012 | Received: 07/02/2012 | Completed: 07/03/2012 | *Farm:* I4053

Sample Information

Sample ID: I4053
Waste Code: NCW
Description: Non-Composted - Other
Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	14800
Total Kjeldahl N	
Inorganic N	
NH4-N	
NO3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
1410	3030	11200	1960	1500	4540	184	424	36.7	25.2	282	369000

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE (tons)	C:N
5.70	90.6	89	0.89			25.0 : 1

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)
0	0	0								

Estimate of Nutrients Available for First Crop (lb / ton) — **Other Elements** (lb / ton)

Application Method	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo	Cl	Na	Ni	Cd	Pb	Se	Li
Broadcast	5.35	2.34	5.28	8.09	1.42	1.08	3.29	0.13	0.31	0.02	0.01			0.51	0	0	0		
Soil Integrated	10.7	3.50	5.94	12.1	2.14	1.63	4.94	0.20	0.46	0.04	0.02			0.51	0	0	0		

Agronomist's Comments:

Please disrgard the zeros for Ni, Cd, Pb. They were not analyzed for this sample and I cannot delete them; we have a new database managment system and are working through some problems still. Thanks for your patience. Brenda R. Cleveland 7/27/2012 12:04 PM

NCDA&CS Agronomic Division | Phone: (919) 733-2655 | Website: www.ncagr.gov/agronomi/ | Report No. FY13-W000189

Research

Waste Report

Client: Ryan Winston, NCSU Box 7625, Raleigh, NC 276957625

Advisor: ,

County: Transylvania

Links to Helpful Information

Sampled: 07/05/2012 | Received: 07/06/2012 | Completed: 07/06/2012 | *Farm:* I40 S4

Sample Information

Sample ID: I40S4
Waste Code: NCW
Description: Non-Composted - Other
Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	11900
Total Kjeldahl N	
Inorganic N	
NH4-N	
NO3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
881	1610	20700	1310	814	3910	205	494	25.2	25.5	191	401000

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE (tons)	C:N
5.94	73.1	43	0.43			33.6 : 1

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)

Estimate of Nutrients Available for First Crop (lb / ton) — **Other Elements** (lb / ton)

Application Method	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo	Cl	Na	Ni	Cd	Pb	Se	Li
Broadcast	3.49	1.18	2.26	12.1	0.76	0.48	2.29	0.12	0.29	0.01	0.01			0.28					
Soil Integrated	6.98	1.77	2.54	18.1	1.15	0.71	3.43	0.18	0.43	0.02	0.02			0.28					

Agronomist's Comments:

Brenda R. Cleveland 7/24/2012 4:20 PM

NCDA&CS Agronomic Division **Phone: (919) 733-2655** **Website: www.ncagr.gov/agronomi/** **Report No.** FY13-W000446

Research

Waste Report

Client: Ryan Winston
NCSU Box 7625
Raleigh, NC 276957625

Advisor:
,

County: Transylvania

Links to Helpful Information

Sampled: 07/11/2012 **Received:** 07/16/2012 **Completed:** 07/16/2012 *Farm:* I4055

Sample Information

Sample ID: I4055
Waste Code: NCW
Description: Non-Composted - Other
Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	20200
Total Kjeldahl N	
Inorganic N	
NH4-N	
NO3-N	
Organic N	
Urea	

P (ppm)	*K (ppm)*	*Ca (ppm)*	*Mg (ppm)*	*S (ppm)*	*Fe (ppm)*	*Mn (ppm)*	*Zn (ppm)*	*Cu (ppm)*	*B (ppm)*	*Na (ppm)*	*C (ppm)*
3510	2740	15000	1810	1670	1830	327	341	32.3	19.8	1230	467000

pH	*DM (%)*	*SS (10^{-5}S/cm)*	*EC (mS/cm)*	*CCE (%)*	*ALE(tons)*	*C:N*
5.87	40.9	61	0.61			23.1 : 1

Ni (ppm)	*Cd (ppm)*	*Pb (ppm)*	*Al (ppm)*	*Se (ppm)*	*Li (ppm)*	*As (ppm)*	*Cr (ppm)*	*Co (ppm)*	*Cl (ppm)*	*Mo (ppm)*

Estimate of Nutrients Available for First Crop (lb / ton) — **Other Elements** (lb / ton)

Application Method	*N*	*P2O5*	*K2O*	*Ca*	*Mg*	*S*	*Fe*	*Mn*	*Zn*	*Cu*	*B*	*Mo*	*Cl*	*Na*	*Ni*	*Cd*	*Pb*	*Se*	*Li*
Broadcast	3.30	2.63	2.15	4.91	0.59	0.55	0.60	0.11	0.11	0.01	0.00			1.01					
Broadcast	3.30	2.63	2.15	4.91	0.59	0.55	0.60	0.11	0.11	0.01	0.00			1.01					

Agronomist's Comments:

Brenda R. Cleveland 8/6/2012 3:28 PM

NCDA&CS Agronomic Division **Phone: (919) 733-2655** **Website: www.ncagr.gov/agronomi/** **Report No.** FY13-W000631

Research

Waste Report

Client: Ryan Winston
NCSU Box 7625
Raleigh, NC 276957625

Advisor:
,

County: Transylvania

Links to Helpful Information

Sampled: 07/19/2012 **Received:** 07/20/2012 **Completed:** 07/23/2012 *Farm:* I-4056

Sample Information

Sample ID: I4056
Waste Code: NCW
Description: Non-Composted - Other
Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	17400
Total Kjeldahl N	
Inorganic N	
NH4-N	
NO3-N	
Organic N	
Urea	

P (ppm)	*K (ppm)*	*Ca (ppm)*	*Mg (ppm)*	*S (ppm)*	*Fe (ppm)*	*Mn (ppm)*	*Zn (ppm)*	*Cu (ppm)*	*B (ppm)*	*Na (ppm)*	*C (ppm)*
2040	1550	13400	1650	1140	4110	236	263	38.5	29.1	299	445000

pH	*DM (%)*	*SS (10^{-5}S/cm)*	*EC (mS/cm)*	*CCE (%)*	*ALE(tons)*	*C:N*
5.37	75.0	37	0.37			25.6 : 1

Ni (ppm)	*Cd (ppm)*	*Pb (ppm)*	*Al (ppm)*	*Se (ppm)*	*Li (ppm)*	*As (ppm)*	*Cr (ppm)*	*Co (ppm)*	*Cl (ppm)*	*Mo (ppm)*

Estimate of Nutrients Available for First Crop (lb / ton) — **Other Elements** (lb / ton)

Application Method	*N*	*P2O5*	*K2O*	*Ca*	*Mg*	*S*	*Fe*	*Mn*	*Zn*	*Cu*	*B*	*Mo*	*Cl*	*Na*	*Ni*	*Cd*	*Pb*	*Se*	*Li*
Broadcast	5.21	2.81	2.23	8.02	0.99	0.68	2.47	0.14	0.16	0.02	0.01			0.45					
Soil Integrated	10.4	4.21	2.51	12.0	1.48	1.03	3.70	0.21	0.24	0.03	0.02			0.45					

Agronomist's Comments:

Brenda R. Cleveland 8/6/2012 4:06 PM

Figure F.3. Gross solids nutrient analysis for samples from Newton Grove.

NCDA&CS Agronomic Division | **Phone:** (919) 733-2655 | **Website:** www.ncagr.gov/agronomi/ | **Report No.** FY13-W003976

Predictive

Waste Report

Client: Ryan Winston
NCSU Box 7625
Raleigh, NC 276957625

Advisor:
,

County: Sampson

[Links to Helpful Information]

Sampled: 12/13/2012 **Received:** 12/14/2012 **Completed:** 12/17/2012 *Farm:* DOT I-40 MM345

Sample Information

Sample ID: MM3451
Waste Code: MWO
Description:
Municipal (Other)

Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	8920
Total Kjeldahl N	
Inorganic N	
NH4-N	
NO3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
1070	2270	9320	1530	996	532	355	239	16.3	26.1	273	

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE (tons)	C:N
	46.1					

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)

Estimate of Nutrients Available for First Crop (lb / ton) / **Other Elements** (lb / ton)

Application Method	N	P2O5	K2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo	Cl	Na	Ni	Cd	Pb	Al	Se	Li
Broadcast	2.47	1.35	2.01	5.16	0.85	0.55	0.29	0.20	0.13	0.01	0.01			0.25						
Soil Incorporated	3.29	1.69	2.26	6.45	1.06	0.69	0.37	0.25	0.17	0.01	0.02			0.25						

NCDA&CS Agronomic Division | **Phone:** (919) 733-2655 | **Website:** www.ncagr.gov/agronomi/ | **Report No.** FY13-W004247

Research

Waste Report

Client: Ryan Winston
NCSU Box 7625
Raleigh, NC 276957625

Advisor:
,

County: Johnston

[Links to Helpful Information]

Sampled: 12/17/2012 **Received:** 01/10/2013 **Completed:** 01/11/2013 *Farm:* DOT-I40 MM 345

Sample Information

Sample ID: MM3452
Waste Code: MWO
Description:
Municipal (Other)

Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	5010
Total Kjeldahl N	
Inorganic N	
NH4-N	
NO3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
453	1130	12300	1150	1160	926	430	628	20.0	14.9	291	

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE (tons)	C:N
	78.4					

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)

Estimate of Nutrients Available for First Crop (lb / ton) / **Other Elements** (lb / ton)

Application Method	N	P2O5	K2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo	Cl	Na	Ni	Cd	Pb	Al	Se	Li
Broadcast	2.36	0.98	1.70	11.6	1.08	1.09	0.87	0.40	0.59	0.02	0.01			0.46						
Irrigation																				

NCDA&CS Agronomic Division **Phone: (919) 733-2655** **Website: www.ncagr.gov/agronomi/** **Report No.** FY13-W004540

Research

Waste Report

Client: Ryan Winston
NCSU Box 7625
Raleigh, NC 276957625

Advisor:
,

County: Sampson

Links to Helpful Information

Sampled: 01/18/2012 **Received:** 01/22/2013 **Completed:** 01/23/2013 *Farm:* DOT I40 MM345

Sample Information

Sample ID: MM3455
Waste Code: MWO
Description:
Municipal (Other)

Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	14300
Total Kjeldahl N	
Inorganic N	
NH_4-N	
NO_3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
2240	3420	12200	1840	1610	618	105	571	44.3	11.4	662	

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE (tons)	C:N
	29.8					

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)

Application Method
Irrigation

Estimate of Nutrients Available for First Crop (lb / ton)

N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo

Other Elements (lb / ton)

Cl	Na	Ni	Cd	Pb	Al	Se	Li

Agronomist's Comments:

Aaron Pettit 1/29/2013 1:16 PM

NCDA&CS Agronomic Division **Phone: (919) 733-2655** **Website: www.ncagr.gov/agronomi/** **Report No.** FY13-W004541

Research

Waste Report

Client: Ryan Winston
NCSU Box 7625
Raleigh, NC 276957625

Advisor:
,

County: Sampson

Links to Helpful Information

Sampled: 01/14/2012 **Received:** 01/22/2013 **Completed:** 01/23/2013 *Farm:* DOT I40 MM345

Sample Information

Sample ID: MM3454
Waste Code: MWO
Description:
Municipal (Other)

Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	8270
Total Kjeldahl N	
Inorganic N	
NH_4-N	
NO_3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
1140	3830	8300	1920	1230	366	67.7	268	17.3	9.25	256	

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE (tons)	C:N
	78.9					

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)

Application Method
Irrigation

Estimate of Nutrients Available for First Crop (lb / ton)

N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo

Other Elements (lb / ton)

Cl	Na	Ni	Cd	Pb	Al	Se	Li

Agronomist's Comments:

Aaron Pettit 1/24/2013 9:40 AM

NCDA&CS Agronomic Division **Phone: (919) 733-2655** **Website: www.ncagr.gov/agronomi/** **Report No.** FY13-W004906

Research

Waste Report

Client: Ryan Winston
NCSU Box 7625
Raleigh, NC 276957625

Advisor:
,

County: Sampson

Links to Helpful Information

Sampled: 01/28/2013 **Received:** 02/01/2013 **Completed:** 02/05/2013 *Farm:* DOT I40 MM345

Sample Information

Sample ID: MM3455
Waste Code: MWO
Description: Municipal (Other)
Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	8040
Total Kjeldahl N	
Inorganic N	
NH_4-N	
NO_3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
2370	2450	10100	930	1330	975	58.5	337	23.7	8.85	33300	

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE (tons)	C:N
5.09	66.3					

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)

Estimate of Nutrients Available for First Crop (lb / ton) — **Other Elements** (lb / ton)

Application Method	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo	Cl	Na	Ni	Cd	Pb	Al	Se	Li
Broadcast	3.20	4.33	3.12	8.00	0.74	1.06	0.78	0.05	0.27	0.02	0.01			44.2						
Injection	4.26	5.41	3.51	10.0	0.92	1.33	0.97	0.06	0.34	0.02	0.01			44.2						

Agronomist's Comments:

Aaron Pettit 2/7/2013 4:16 PM

NCDA&CS Agronomic Division **Phone: (919) 733-2655** **Website: www.ncagr.gov/agronomi/** **Report No.** FY13-W004907

Research

Waste Report

Client: Ryan Winston
NCSU Box 7625
Raleigh, NC 276957625

Advisor:
,

County: Sampson

Links to Helpful Information

Sampled: 01/31/2013 **Received:** 02/01/2013 **Completed:** 02/05/2013 *Farm:* DOT I40 MM345

Sample Information

Sample ID: MM3456
Waste Code: MWO
Description: Municipal (Other)
Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	11100
Total Kjeldahl N	
Inorganic N	
NH_4-N	
NO_3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
956	1430	8350	774	1240	851	94.6	356	26.6	14.1	7580	

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE (tons)	C:N
5.64	28.4					

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)

Estimate of Nutrients Available for First Crop (lb / ton) — **Other Elements** (lb / ton)

Application Method	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo	Cl	Na	Ni	Cd	Pb	Al	Se	Li
Broadcast	1.90	0.75	0.78	2.85	0.26	0.42	0.29	0.03	0.12	0.01	T			4.31						

Agronomist's Comments:

Aaron Pettit 2/7/2013 4:16 PM

NCDA&CS Agronomic Division | Phone: (919) 733-2655 | Website: www.ncagr.gov/agronomi/ | Report No. FY13-W005362

Research

Waste Report

Client: Ryan Winston
NCSU Box 7625
Raleigh, NC 276957625

Advisor: ,

County: Sampson

Links to Helpful Information

Sampled: 02/08/2013 | Received: 02/25/2013 | Completed: 02/25/2013 | Farm: DOT I40 MM 345

Sample Information

Sample ID: MM3456
Waste Code: MWO
Description: Municipal (Other)
Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	9660
Total Kjeldahl N	
Inorganic N	
NH_4-N	
NO_3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
1270	1390	8390	936	1160	932	99.0	385	50.5	4.76	987	

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE (tons)	C:N
5.27	39.4					

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)

Estimate of Nutrients Available for First Crop (lb / ton)

Application Method	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo
Broadcast	2.29	1.38	1.05	3.97	0.44	0.55	0.44	0.05	0.18	0.02	T	
Soil Incorporated	3.05	1.73	1.19	4.96	0.55	0.69	0.55	0.06	0.23	0.03	T	

Other Elements (lb / ton)

Application Method	Cl	Na	Ni	Cd	Pb	Al	Se	Li
Broadcast		0.78						
Soil Incorporated		0.78						

Agronomist's Comments:

Aaron Pettit 2/26/2013 10:38 AM

Figure F.4. Gross solids nutrient analysis for samples from Garner.

NCDA&CS Agronomic Division **Phone: (919) 733-2655** **Website: www.ncagr.gov/agronomi/** **Report No.** FY13-W003975

Research

Waste Report

Client: Ryan Winston
NCSU Box 7625
Raleigh, NC 276957625

Advisor:
,

County: Sampson

Links to Helpful Information

Sampled: 12/13/2012 **Received:** 12/14/2012 **Completed:** 12/17/2012 *Farm:* DOT I-40 MM315

Sample Information

Sample ID: MM3151
Waste Code: MWO
Description:
Municipal (Other)
Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	8150
Total Kjeldahl N	
Inorganic N	
NH4-N	
NO3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
997	4860	18100	2840	1090	2260	947	244	26.1	43.5	199	

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE (tons)	C:N
	46.1					

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)

Estimate of Nutrients Available for First Crop (lb / ton) / **Other Elements** (lb / ton)

Application Method	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo	Cl	Na	Ni	Cd	Pb	Al	Se	Li
Broadcast	2.25	1.26	4.30	9.99	1.57	0.60	1.25	0.52	0.13	0.01	0.02			0.18						
Soil Incorporated	3.00	1.58	4.84	12.5	1.97	0.75	1.56	0.65	0.17	0.02	0.03			0.18						

Agronomist's Comments:

Aaron Pettit 12/17/2012 3:51 PM

NCDA&CS Agronomic Division **Phone: (919) 733-2655** **Website: www.ncagr.gov/agronomi/** **Report No.** FY13-W004248

Research

Waste Report

Client: Ryan Winston
NCSU Box 7625
Raleigh, NC 276957625

Advisor:
,

County: Johnston

Links to Helpful Information

Sampled: 12/17/2012 **Received:** 01/10/2013 **Completed:** 01/11/2013 *Farm:* DOT-I40 MM315

Sample Information

Sample ID: MM3152
Waste Code: MWO
Description:
Municipal (Other)
Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	12500
Total Kjeldahl N	
Inorganic N	
NH4-N	
NO3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
951	1330	14300	1950	1170	1670	1140	269	148	29.2	199	

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE (tons)	C:N
	57.5					

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)

Estimate of Nutrients Available for First Crop (lb / ton) / **Other Elements** (lb / ton)

Application Method	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo	Cl	Na	Ni	Cd	Pb	Al	Se	Li
Broadcast	4.30	1.50	1.47	9.87	1.34	0.81	1.15	0.79	0.19	0.10	0.02			0.23						
Irrigation																				

Agronomist's Comments:

*

NCDA&CS Agronomic Division | Phone: (919) 733-2655 | Website: www.ncagr.gov/agronomi/ | Report No. FY13-W004542

Research

Waste Report

Client: Ryan Winston
NCSU Box 7625
Raleigh, NC 276957625

Advisor:
,

County: Sampson

Links to Helpful Information

Sampled: 01/14/2012 Received: 01/22/2013 Completed: 01/23/2013 Farm: DOT I40 MM315

Sample Information

Sample ID: MM3154
Waste Code: MWO
Description: Municipal (Other)
Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	7550
Total Kjeldahl N	
Inorganic N	
NH4-N	
NO3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
997	1160	15700	1550	3430	5380	318	555	75.5	30.0	203	

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE(tons)	C:N
	87.7					

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)

Application Method
Irrigation

Estimate of Nutrients Available for First Crop (lb / ton)

N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo

Other Elements (lb / ton)

Cl	Na	Ni	Cd	Pb	Al	Se	Li

Agronomist's Comments:

Aaron Pettit 1/24/2013 9:41 AM

NCDA&CS Agronomic Division | Phone: (919) 733-2655 | Website: www.ncagr.gov/agronomi/ | Report No. FY13-W004908

Research

Waste Report

Client: Ryan Winston
NCSU Box 7625
Raleigh, NC 276957625

Advisor:
,

County: Sampson

Links to Helpful Information

Sampled: 01/28/2013 Received: 02/01/2013 Completed: 02/05/2013 Farm: DOT I40 MM315

Sample Information

Sample ID: MM3155
Waste Code: MWO
Description: Municipal (Other)
Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	10800
Total Kjeldahl N	
Inorganic N	
NH4-N	
NO3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
931	1530	13000	1560	1120	2490	610	380	29.7	35.0	6120	

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE(tons)	C:N
5.89	48.1					

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)

Application Method
Broadcast

Estimate of Nutrients Available for First Crop (lb / ton)

N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo
3.13	1.23	1.42	7.49	0.90	0.65	1.44	0.35	0.22	0.02	0.02	

Other Elements (lb / ton)

Cl	Na	Ni	Cd	Pb	Al	Se	Li
	5.89						

Agronomist's Comments:

Aaron Pettit 2/7/2013 4:20 PM

NCDA&CS Agronomic Division **Phone:** (919) 733-2655 **Website:** www.ncagr.gov/agronomi/ **Report No.** FY13-W004909

Research

Waste Report

Client: Wesley Kimbrell
NCSU Box 7625
Raleigh, NC 27695

Advisor:
,

County: Sampson

Links to Helpful Information

Sampled: 01/31/2013 **Received:** 02/01/2013 **Completed:** 02/05/2013 *Farm:* DOT I40 MM3156

Sample Information

Sample ID: MM3156
Waste Code: MWO
Description:
Municipal (Other)

Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	9140
Total Kjeldahl N	
Inorganic N	
NH4-N	
NO3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
925	955	17200	2330	1370	4980	664	998	58.5	36.8	1970	

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE (tons)	C:N
6.41	43.2					

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)

Estimate of Nutrients Available for First Crop (lb / ton) — **Other Elements** (lb / ton)

Application Method	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo	Cl	Na	Ni	Cd	Pb	Al	Se	Li
Broadcast	2.37	1.10	0.79	8.93	1.21	0.71	2.58	0.34	0.52	0.03	0.02			1.70						

Agronomist's Comments:

Aaron Pettit 2/7/2013 4:21 PM

NCDA&CS Agronomic Division **Phone:** (919) 733-2655 **Website:** www.ncagr.gov/agronomi/ **Report No.** FY13-W005363

Research

Waste Report

Client: Ryan Winston
NCSU Box 7625
Raleigh, NC 276957625

Advisor:
,

County: Wake

Links to Helpful Information

Sampled: 02/08/2013 **Received:** 02/22/2013 **Completed:** 02/25/2013 *Farm:* DOT I40 MM 315

Sample Information

Sample ID: MM3156
Waste Code: MWO
Description:
Municipal (Other)

Comments:

Nutrient and Other Measurements

Nitrogen (N) (ppm)	
Total N	6420
Total Kjeldahl N	
Inorganic N	
NH4-N	
NO3-N	
Organic N	
Urea	

P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Na (ppm)	C (ppm)
901	720	19400	2050	1300	5650	355	789	61.8	3.77	2220	

pH	DM (%)	SS (10^{-5}S/cm)	EC (mS/cm)	CCE (%)	ALE (tons)	C:N
6.27	43.0					

Ni (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)	Se (ppm)	Li (ppm)	As (ppm)	Cr (ppm)	Co (ppm)	Cl (ppm)	Mo (ppm)

Estimate of Nutrients Available for First Crop (lb / ton) — **Other Elements** (lb / ton)

Application Method	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo	Cl	Na	Ni	Cd	Pb	Al	Se	Li
Broadcast	1.66	1.07	0.59	10.0	1.06	0.67	2.92	0.18	0.41	0.03	T			1.91						
Soil Incorporated	2.21	1.33	0.67	12.5	1.32	0.84	3.64	0.23	0.51	0.04	T			1.91						

Agronomist's Comments:

Aaron Pettit 2/26/2013 10:39 AM

Appendix G: Outputs of SwaleMOD sensitivity analysis for both swales and filter strips

Table G.1. SwaleMOD modeling runs for triangular grassed swales. (assumed Manning's n=0.35, bottom width = 0 ft)

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.005	0.178125	3	25	1.291685	0.137901	34.02261	3.021902	7.874063	>6
0.01	0.178125	3	25	0.996192	0.178806	32.66353	2.330075	6.915	>6
0.015	0.178125	3	25	0.855668	0.208171	31.88271	2.001413	6.40875	>6
0.02	0.178125	3	25	0.768096	0.231905	31.33555	1.79679	6.071953	>6
0.03	0.178125	3	25	0.659729	0.269997	30.5725	1.543364	5.627344	4-6
0.04	0.178125	3	25	0.592199	0.300786	30.0382	1.38558	5.331563	4-6
0.05	0.178125	3	25	0.544768	0.326974	29.62523	1.274272	5.113594	4-6
0.075	0.178125	3	25	0.467936	0.380661	28.88609	1.094523	4.739297	4-6
0.1	0.178125	3	25	0.420075	0.424031	28.36867	0.982597	4.490391	4-6
0.005	0.35625	3	25	2.172483	0.163983	29.61123	2.541053	10.21172	>6
0.01	0.35625	3	25	1.675218	0.212659	28.35504	1.959418	8.967188	>6
0.015	0.35625	3	25	1.438993	0.247569	27.63506	1.683006	8.310938	>6
0.02	0.35625	3	25	1.291685	0.275803	27.13235	1.510951	7.874063	>6
0.03	0.35625	3	25	1.109733	0.321023	26.43074	1.297729	7.298438	>6
0.04	0.35625	3	25	0.996192	0.357612	25.94166	1.165037	6.915	>6
0.05	0.35625	3	25	0.916287	0.388797	25.56556	1.071492	6.631875	>6
0.075	0.35625	3	25	0.786888	0.452733	24.8937	0.920413	6.145781	>6
0.1	0.35625	3	25	0.706471	0.504267	24.42265	0.826265	5.823281	4-6
0.005	0.534375	3	25	2.944478	0.181484	27.19267	2.29613	11.88844	>6
0.01	0.534375	3	25	2.2707	0.235335	26.00088	1.770507	10.44	>6
0.015	0.534375	3	25	1.950306	0.273995	25.32043	1.520796	9.675469	>6
0.02	0.534375	3	25	1.751016	0.30518	24.8439	1.36523	9.167813	>6
0.03	0.534375	3	25	1.503991	0.355305	24.18359	1.172668	8.496563	>6
0.04	0.534375	3	25	1.349842	0.39588	23.72405	1.052834	8.049375	>6
0.05	0.534375	3	25	1.241734	0.430346	23.36896	0.968255	7.720313	>6
0.075	0.534375	3	25	1.066682	0.500969	22.73501	0.831653	7.155469	>6
0.1	0.534375	3	25	0.95741	0.558146	22.29434	0.746652	6.779063	>6
0.005	0.178125	4	25	1.372742	0.129759	35.88357	3.210995	7.029844	>6
0.01	0.178125	4	25	1.058487	0.168283	34.49031	2.476048	6.172969	>6
0.015	0.178125	4	25	0.909341	0.195884	33.68577	2.126668	5.721563	4-6
0.02	0.178125	4	25	0.816199	0.218237	33.12331	1.909299	5.420625	4-6
0.03	0.178125	4	25	0.701145	0.254049	32.33573	1.639927	5.024063	4-6
0.04	0.178125	4	25	0.629419	0.282999	31.78394	1.472237	4.760156	4-6

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.05	0.178125	4	25	0.578848	0.307724	31.35989	1.354091	4.564922	4-6
0.075	0.178125	4	25	0.49719	0.358263	30.59636	1.163098	4.230703	4-6
0.1	0.178125	4	25	0.446391	0.399034	30.0601	1.044117	4.00875	4-6
0.005	0.35625	4	25	2.3085	0.154321	31.34503	2.70018	9.11625	>6
0.01	0.35625	4	25	1.78014	0.200125	30.0461	2.082107	8.005313	>6
0.015	0.35625	4	25	1.528314	0.2331	29.30482	1.788701	7.4175	>6
0.02	0.35625	4	25	1.372742	0.259517	28.77854	1.605498	7.029844	>6
0.03	0.35625	4	25	1.178921	0.302183	28.05364	1.37911	6.514688	>6
0.04	0.35625	4	25	1.058487	0.336565	27.54433	1.238024	6.172969	>6
0.05	0.35625	4	25	0.97346	0.365963	27.15447	1.138667	5.919844	4-6
0.075	0.35625	4	25	0.836225	0.426022	26.4535	0.978024	5.486719	4-6
0.1	0.35625	4	25	0.750727	0.47454	25.96354	0.877998	5.198672	4-6
0.005	0.534375	4	25	3.129029	0.17078	28.84166	2.439867	10.61344	>6
0.01	0.534375	4	25	2.412925	0.221464	27.60511	1.881365	9.320156	>6
0.015	0.534375	4	25	2.072475	0.257844	26.89783	1.616016	8.637656	>6
0.02	0.534375	4	25	1.860667	0.287195	26.40223	1.450718	8.184375	>6
0.03	0.534375	4	25	1.598052	0.334392	25.71528	1.24613	7.584844	>6
0.04	0.534375	4	25	1.434755	0.37245	25.23384	1.118661	7.186875	>6
0.05	0.534375	4	25	1.319447	0.404999	24.8658	1.028897	6.892031	>6
0.075	0.534375	4	25	1.133559	0.471413	24.20349	0.883708	6.388125	>6
0.1	0.534375	4	25	1.017577	0.525145	23.7423	0.793351	6.0525	>6
0.005	0.178125	5	25	1.443692	0.123382	37.3773	3.377142	6.448125	>6
0.01	0.178125	5	25	1.11333	0.159993	35.95707	2.604061	5.6625	4-6
0.015	0.178125	5	25	0.956262	0.186272	35.13824	2.236769	5.247891	4-6
0.02	0.178125	5	25	0.858371	0.207515	34.5634	2.008102	4.972031	4-6
0.03	0.178125	5	25	0.73737	0.241568	33.75865	1.724792	4.608281	4-6
0.04	0.178125	5	25	0.661926	0.269101	33.19449	1.548434	4.366172	4-6
0.05	0.178125	5	25	0.608678	0.292642	32.76145	1.424224	4.186875	4-6
0.075	0.178125	5	25	0.522933	0.340627	31.9775	1.223244	3.880781	<4
0.1	0.178125	5	25	0.469484	0.379406	31.42819	1.098126	3.677109	<4
0.005	0.35625	5	25	2.427902	0.146732	32.74469	2.839861	8.362031	>6
0.01	0.35625	5	25	1.872194	0.190285	31.414	2.189822	7.342969	>6
0.015	0.35625	5	25	1.608287	0.221509	30.64869	1.880871	6.805781	>6
0.02	0.35625	5	25	1.443692	0.246763	30.11346	1.688571	6.448125	>6
0.03	0.35625	5	25	1.240059	0.287285	29.36729	1.450389	5.976094	4-6
0.04	0.35625	5	25	1.11333	0.319986	28.84395	1.30203	5.6625	4-6
0.05	0.35625	5	25	1.02387	0.347945	28.44306	1.197547	5.430234	4-6

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.075	0.35625	5	25	0.879541	0.405041	27.72127	1.028592	5.032969	4-6
0.1	0.35625	5	25	0.789565	0.451198	27.21695	0.923414	4.768594	4-6
0.005	0.534375	5	25	3.291267	0.162362	30.177	2.565979	9.735938	>6
0.01	0.534375	5	25	2.537725	0.210572	28.90716	1.978689	8.549063	>6
0.015	0.534375	5	25	2.179805	0.245148	28.17888	1.699577	7.923281	>6
0.02	0.534375	5	25	1.956789	0.273088	27.6695	1.525795	7.507031	>6
0.03	0.534375	5	25	1.680754	0.317938	26.96092	1.310581	6.957422	>6
0.04	0.534375	5	25	1.508957	0.354135	26.4647	1.176531	6.592266	>6
0.05	0.534375	5	25	1.387986	0.385	26.08333	1.082046	6.3225	>6
0.075	0.534375	5	25	1.191998	0.448302	25.40236	0.929473	5.859141	4-6
0.1	0.534375	5	25	1.070164	0.49934	24.92501	0.834403	5.551641	4-6
0.005	0.178125	6	25	1.50657	0.118232	38.62386	3.524196	6.013125	>6
0.01	0.178125	6	25	1.161703	0.153331	37.185	2.717543	5.280234	4-6
0.015	0.178125	6	25	0.997866	0.178506	36.35338	2.334202	4.89375	4-6
0.02	0.178125	6	25	0.895859	0.198832	35.76806	2.095463	4.636875	4-6
0.03	0.178125	6	25	0.769437	0.2315	34.95161	1.799934	4.297266	4-6
0.04	0.178125	6	25	0.690734	0.257878	34.37743	1.615875	4.071563	4-6
0.05	0.178125	6	25	0.635351	0.280357	33.93417	1.486114	3.904922	<4
0.075	0.178125	6	25	0.54564	0.326452	33.13911	1.276563	3.61875	<4
0.1	0.178125	6	25	0.489892	0.363601	32.57889	1.145974	3.428906	<4
0.005	0.35625	6	25	2.533781	0.1406	33.91889	2.963467	7.798125	>6
0.01	0.35625	6	25	1.953677	0.182348	32.56398	2.285198	6.8475	>6
0.015	0.35625	6	25	1.678451	0.212249	31.7826	1.962726	6.346875	>6
0.02	0.35625	6	25	1.50657	0.236464	31.23695	1.762098	6.013125	>6
0.03	0.35625	6	25	1.293865	0.275338	30.47622	1.513624	5.5725	4-6
0.04	0.35625	6	25	1.161703	0.306662	29.94092	1.358772	5.280234	4-6
0.05	0.35625	6	25	1.068464	0.333422	29.53021	1.249692	5.063906	4-6
0.075	0.35625	6	25	0.917726	0.388188	28.79289	1.073429	4.693125	4-6
0.1	0.35625	6	25	0.82383	0.432431	28.27677	0.963671	4.446563	4-6
0.005	0.534375	6	25	3.434321	0.155598	31.30253	2.677788	9.07875	>6
0.01	0.534375	6	25	2.648053	0.201799	30.00532	2.064901	7.972031	>6
0.015	0.534375	6	25	2.274542	0.234937	29.26074	1.773636	7.388438	>6
0.02	0.534375	6	25	2.042122	0.261676	28.73841	1.592206	7.000781	>6
0.03	0.534375	6	25	1.753906	0.304677	28.01361	1.367662	6.487969	>6
0.04	0.534375	6	25	1.574737	0.339342	27.50474	1.227747	6.147656	>6
0.05	0.534375	6	25	1.44819	0.368995	27.11549	1.129227	5.895469	4-6
0.075	0.534375	6	25	1.243857	0.429611	26.41622	0.969961	5.46375	4-6

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.1	0.534375	6	25	1.116769	0.478501	25.92613	0.870737	5.177109	4-6
0.005	0.178125	3	50	1.291685	0.137901	41.67331	6.043804	7.874063	>6
0.01	0.178125	3	50	0.996192	0.178806	40.19286	4.66015	6.915	>6
0.015	0.178125	3	50	0.855668	0.208171	39.33601	4.002827	6.40875	>6
0.02	0.178125	3	50	0.768096	0.231905	38.7328	3.59358	6.071953	>6
0.03	0.178125	3	50	0.659729	0.269997	37.88779	3.086728	5.627344	4-6
0.04	0.178125	3	50	0.592199	0.300786	37.29345	2.77116	5.331563	4-6
0.05	0.178125	3	50	0.544768	0.326974	36.83258	2.548544	5.113594	4-6
0.075	0.178125	3	50	0.467936	0.380661	36.00441	2.189045	4.739297	4-6
0.1	0.178125	3	50	0.420075	0.424031	35.42218	1.965193	4.490391	4-6
0.005	0.35625	3	50	2.172483	0.163983	36.81693	5.082106	10.21172	>6
0.01	0.35625	3	50	1.675218	0.212659	35.40681	3.918837	8.967188	>6
0.015	0.35625	3	50	1.438993	0.247569	34.59313	3.366012	8.310938	>6
0.02	0.35625	3	50	1.291685	0.275803	34.02261	3.021902	7.874063	>6
0.03	0.35625	3	50	1.109733	0.321023	33.22311	2.595459	7.298438	>6
0.04	0.35625	3	50	0.996192	0.357612	32.66353	2.330075	6.915	>6
0.05	0.35625	3	50	0.916287	0.388797	32.23195	2.142983	6.631875	>6
0.075	0.35625	3	50	0.786888	0.452733	31.45827	1.840825	6.145781	>6
0.1	0.35625	3	50	0.706471	0.504267	30.91376	1.65253	5.823281	4-6
0.005	0.534375	3	50	2.944478	0.181484	34.09117	4.59226	11.88844	>6
0.01	0.534375	3	50	2.2707	0.235335	32.73139	3.541014	10.44	>6
0.015	0.534375	3	50	1.950306	0.273995	31.95008	3.041592	9.675469	>6
0.02	0.534375	3	50	1.751016	0.30518	31.40079	2.73046	9.167813	>6
0.03	0.534375	3	50	1.503991	0.355305	30.63676	2.345337	8.496563	>6
0.04	0.534375	3	50	1.349842	0.39588	30.10304	2.105668	8.049375	>6
0.05	0.534375	3	50	1.241734	0.430346	29.68951	1.93651	7.720313	>6
0.075	0.534375	3	50	1.066682	0.500969	28.94884	1.663305	7.155469	>6
0.1	0.534375	3	50	0.95741	0.558146	28.43216	1.493304	6.779063	>6
0.005	0.178125	4	50	1.372742	0.129759	43.67802	6.421991	7.029844	>6
0.01	0.178125	4	50	1.058487	0.168283	42.17957	4.952096	6.172969	>6
0.015	0.178125	4	50	0.909341	0.195884	41.30769	4.253336	5.721563	4-6
0.02	0.178125	4	50	0.816199	0.218237	40.69526	3.818598	5.420625	4-6
0.03	0.178125	4	50	0.701145	0.254049	39.83371	3.279854	5.024063	4-6
0.04	0.178125	4	50	0.629419	0.282999	39.22728	2.944474	4.760156	4-6
0.05	0.178125	4	50	0.578848	0.307724	38.75968	2.708182	4.564922	4-6
0.075	0.178125	4	50	0.49719	0.358263	37.91427	2.326195	4.230703	4-6
0.1	0.178125	4	50	0.446391	0.399034	37.31785	2.088234	4.00875	4-6

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.005	0.35625	4	50	2.3085	0.154321	38.74327	5.400359	9.11625	>6
0.01	0.35625	4	50	1.78014	0.200125	37.30225	4.164213	8.005313	>6
0.015	0.35625	4	50	1.528314	0.2331	36.47409	3.577402	7.4175	>6
0.02	0.35625	4	50	1.372742	0.259517	35.88357	3.210995	7.029844	>6
0.03	0.35625	4	50	1.178921	0.302183	35.06668	2.758219	6.514688	>6
0.04	0.35625	4	50	1.058487	0.336565	34.49031	2.476048	6.172969	>6
0.05	0.35625	4	50	0.97346	0.365963	34.04776	2.277333	5.919844	4-6
0.075	0.35625	4	50	0.836225	0.426022	33.24911	1.956047	5.486719	4-6
0.1	0.35625	4	50	0.750727	0.47454	32.68861	1.755996	5.198672	4-6
0.005	0.534375	4	50	3.129029	0.17078	35.9545	4.879733	10.61344	>6
0.01	0.534375	4	50	2.412925	0.221464	34.55919	3.76273	9.320156	>6
0.015	0.534375	4	50	2.072475	0.257844	33.75579	3.232031	8.637656	>6
0.02	0.534375	4	50	1.860667	0.287195	33.19054	2.901437	8.184375	>6
0.03	0.534375	4	50	1.598052	0.334392	32.40389	2.49226	7.584844	>6
0.04	0.534375	4	50	1.434755	0.37245	31.85041	2.237322	7.186875	>6
0.05	0.534375	4	50	1.319447	0.404999	31.42607	2.057794	6.892031	>6
0.075	0.534375	4	50	1.133559	0.471413	30.65983	1.767416	6.388125	>6
0.1	0.534375	4	50	1.017577	0.525145	30.12427	1.586702	6.0525	>6
0.005	0.178125	5	50	1.443692	0.123382	45.26859	6.754284	6.448125	>6
0.01	0.178125	5	50	1.11333	0.159993	43.75668	5.208122	5.6625	4-6
0.015	0.178125	5	50	0.956262	0.186272	42.87821	4.473538	5.247891	4-6
0.02	0.178125	5	50	0.858371	0.207515	42.25854	4.016203	4.972031	4-6
0.03	0.178125	5	50	0.73737	0.241568	41.38687	3.449583	4.608281	4-6
0.04	0.178125	5	50	0.661926	0.269101	40.77289	3.096868	4.366172	4-6
0.05	0.178125	5	50	0.608678	0.292642	40.29999	2.848448	4.186875	4-6
0.075	0.178125	5	50	0.522933	0.340627	39.44027	2.446489	3.880781	<4
0.1	0.178125	5	50	0.469484	0.379406	38.83509	2.196252	3.677109	<4
0.005	0.35625	5	50	2.427902	0.146732	40.28166	5.679722	8.362031	>6
0.01	0.35625	5	50	1.872194	0.190285	38.81943	4.379644	7.342969	>6
0.015	0.35625	5	50	1.608287	0.221509	37.97237	3.761742	6.805781	>6
0.02	0.35625	5	50	1.443692	0.246763	37.3773	3.377142	6.448125	>6
0.03	0.35625	5	50	1.240059	0.287285	36.54405	2.900777	5.976094	4-6
0.04	0.35625	5	50	1.11333	0.319986	35.95707	2.604061	5.6625	4-6
0.05	0.35625	5	50	1.02387	0.347945	35.50601	2.395094	5.430234	4-6
0.075	0.35625	5	50	0.879541	0.405041	34.69077	2.057184	5.032969	4-6
0.1	0.35625	5	50	0.789565	0.451198	34.11877	1.846828	4.768594	4-6
0.005	0.534375	5	50	3.291267	0.162362	37.44805	5.131958	9.735938	>6

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.01	0.534375	5	50	2.537725	0.210572	36.02808	3.957379	8.549063	>6
0.015	0.534375	5	50	2.179805	0.245148	35.20809	3.399155	7.923281	>6
0.02	0.534375	5	50	1.956789	0.273088	34.63214	3.05159	7.507031	>6
0.03	0.534375	5	50	1.680754	0.317938	33.82762	2.621161	6.957422	>6
0.04	0.534375	5	50	1.508957	0.354135	33.26189	2.353063	6.592266	>6
0.05	0.534375	5	50	1.387986	0.385	32.82581	2.164092	6.3225	>6
0.075	0.534375	5	50	1.191998	0.448302	32.04435	1.858946	5.859141	4-6
0.1	0.534375	5	50	1.070164	0.49934	31.49442	1.668805	5.551641	4-6
0.005	0.178125	6	50	1.50657	0.118232	46.58347	7.048392	6.013125	>6
0.01	0.178125	6	50	1.161703	0.153331	45.06475	5.435086	5.280234	4-6
0.015	0.178125	6	50	0.997866	0.178506	44.18007	4.668404	4.89375	4-6
0.02	0.178125	6	50	0.895859	0.198832	43.55434	4.190926	4.636875	4-6
0.03	0.178125	6	50	0.769437	0.2315	42.6773	3.599867	4.297266	4-6
0.04	0.178125	6	50	0.690734	0.257878	42.05753	3.231751	4.071563	4-6
0.05	0.178125	6	50	0.635351	0.280357	41.5774	2.972227	3.904922	<4
0.075	0.178125	6	50	0.54564	0.326452	40.7125	2.553126	3.61875	<4
0.1	0.178125	6	50	0.489892	0.363601	40.1002	2.291948	3.428906	<4
0.005	0.35625	6	50	2.533781	0.1406	41.56082	5.926934	7.798125	>6
0.01	0.35625	6	50	1.953677	0.182348	40.08387	4.570396	6.8475	>6
0.015	0.35625	6	50	1.678451	0.212249	39.22581	3.925452	6.346875	>6
0.02	0.35625	6	50	1.50657	0.236464	38.62386	3.524196	6.013125	>6
0.03	0.35625	6	50	1.293865	0.275338	37.78085	3.027247	5.5725	4-6
0.04	0.35625	6	50	1.161703	0.306662	37.185	2.717543	5.280234	4-6
0.05	0.35625	6	50	1.068464	0.333422	36.72634	2.499385	5.063906	4-6
0.075	0.35625	6	50	0.917726	0.388188	35.89969	2.146857	4.693125	4-6
0.1	0.35625	6	50	0.82383	0.432431	35.31855	1.927343	4.446563	4-6
0.005	0.534375	6	50	3.434321	0.155598	38.69633	5.355576	9.07875	>6
0.01	0.534375	6	50	2.648053	0.201799	37.25681	4.129802	7.972031	>6
0.015	0.534375	6	50	2.274542	0.234937	36.42471	3.547272	7.388438	>6
0.02	0.534375	6	50	2.042122	0.261676	35.83845	3.184412	7.000781	>6
0.03	0.534375	6	50	1.753906	0.304677	35.02145	2.735324	6.487969	>6
0.04	0.534375	6	50	1.574737	0.339342	34.44542	2.455494	6.147656	>6
0.05	0.534375	6	50	1.44819	0.368995	34.00345	2.258454	5.895469	4-6
0.075	0.534375	6	50	1.243857	0.429611	33.20652	1.939921	5.46375	4-6
0.1	0.534375	6	50	1.116769	0.478501	32.64573	1.741474	5.177109	4-6
0.005	0.178125	3	100	1.291685	0.137901	49.75276	12.08761	7.874063	>6
0.01	0.178125	3	100	0.996192	0.178806	48.22244	9.320299	6.915	>6

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.015	0.178125	3	100	0.855668	0.208171	47.32957	8.005654	6.40875	>6
0.02	0.178125	3	100	0.768096	0.231905	46.69783	7.187161	6.071953	>6
0.03	0.178125	3	100	0.659729	0.269997	45.80843	6.173456	5.627344	4-6
0.04	0.178125	3	100	0.592199	0.300786	45.17974	5.542321	5.331563	4-6
0.05	0.178125	3	100	0.544768	0.326974	44.69046	5.097088	5.113594	4-6
0.075	0.178125	3	100	0.467936	0.380661	43.80732	4.378091	4.739297	4-6
0.1	0.178125	3	100	0.420075	0.424031	43.18339	3.930386	4.490391	4-6
0.005	0.35625	3	100	2.172483	0.163983	44.67382	10.16421	10.21172	>6
0.01	0.35625	3	100	1.675218	0.212659	43.1669	7.837673	8.967188	>6
0.015	0.35625	3	100	1.438993	0.247569	42.29065	6.732024	8.310938	>6
0.02	0.35625	3	100	1.291685	0.275803	41.67331	6.043804	7.874063	>6
0.03	0.35625	3	100	1.109733	0.321023	40.8041	5.190917	7.298438	>6
0.04	0.35625	3	100	0.996192	0.357612	40.19286	4.66015	6.915	>6
0.05	0.35625	3	100	0.916287	0.388797	39.71983	4.285966	6.631875	>6
0.075	0.35625	3	100	0.786888	0.452733	38.86829	3.681651	6.145781	>6
0.1	0.35625	3	100	0.706471	0.504267	38.26626	3.305061	5.823281	4-6
0.005	0.534375	3	100	2.944478	0.181484	41.74763	9.18452	11.88844	>6
0.01	0.534375	3	100	2.2707	0.235335	40.26711	7.082028	10.44	>6
0.015	0.534375	3	100	1.950306	0.273995	39.41012	6.083185	9.675469	>6
0.02	0.534375	3	100	1.751016	0.30518	38.80484	5.46092	9.167813	>6
0.03	0.534375	3	100	1.503991	0.355305	37.95912	4.690673	8.496563	>6
0.04	0.534375	3	100	1.349842	0.39588	37.36569	4.211336	8.049375	>6
0.05	0.534375	3	100	1.241734	0.430346	36.9044	3.87302	7.720313	>6
0.075	0.534375	3	100	1.066682	0.500969	36.07488	3.32661	7.155469	>6
0.1	0.534375	3	100	0.95741	0.558146	35.49373	2.986608	6.779063	>6
0.005	0.178125	4	100	1.372742	0.129759	51.80032	12.84398	7.029844	>6
0.01	0.178125	4	100	1.058487	0.168283	50.2725	9.904193	6.172969	>6
0.015	0.178125	4	100	0.909341	0.195884	49.37626	8.506673	5.721563	4-6
0.02	0.178125	4	100	0.816199	0.218237	48.74351	7.637195	5.420625	4-6
0.03	0.178125	4	100	0.701145	0.254049	47.84883	6.559708	5.024063	4-6
0.04	0.178125	4	100	0.629419	0.282999	47.21589	5.888947	4.760156	4-6
0.05	0.178125	4	100	0.578848	0.307724	46.72605	5.416365	4.564922	4-6
0.075	0.178125	4	100	0.49719	0.358263	45.83638	4.65239	4.230703	4-6
0.1	0.178125	4	100	0.446391	0.399034	45.2056	4.176468	4.00875	4-6
0.005	0.35625	4	100	2.3085	0.154321	46.70883	10.80072	9.11625	>6
0.01	0.35625	4	100	1.78014	0.200125	45.18907	8.328426	8.005313	>6
0.015	0.35625	4	100	1.528314	0.2331	44.30879	7.154805	7.4175	>6

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.02	0.35625	4	100	1.372742	0.259517	43.67802	6.421991	7.029844	>6
0.03	0.35625	4	100	1.178921	0.302183	42.80121	5.516438	6.514688	>6
0.04	0.35625	4	100	1.058487	0.336565	42.17957	4.952096	6.172969	>6
0.05	0.35625	4	100	0.97346	0.365963	41.70058	4.554667	5.919844	4-6
0.075	0.35625	4	100	0.836225	0.426022	40.83244	3.912095	5.486719	4-6
0.1	0.35625	4	100	0.750727	0.47454	40.22031	3.511992	5.198672	4-6
0.005	0.534375	4	100	3.129029	0.17078	43.75393	9.759467	10.61344	>6
0.01	0.534375	4	100	2.412925	0.221464	42.25399	7.525459	9.320156	>6
0.015	0.534375	4	100	2.072475	0.257844	41.38376	6.464063	8.637656	>6
0.02	0.534375	4	100	1.860667	0.287195	40.76859	5.802874	8.184375	>6
0.03	0.534375	4	100	1.598052	0.334392	39.90846	4.984521	7.584844	>6
0.04	0.534375	4	100	1.434755	0.37245	39.30045	4.474643	7.186875	>6
0.05	0.534375	4	100	1.319447	0.404999	38.83275	4.115589	6.892031	>6
0.075	0.534375	4	100	1.133559	0.471413	37.98473	3.534833	6.388125	>6
0.1	0.534375	4	100	1.017577	0.525145	37.38933	3.173403	6.0525	>6
0.005	0.178125	5	100	1.443692	0.123382	53.40497	13.50857	6.448125	>6
0.01	0.178125	5	100	1.11333	0.159993	51.88008	10.41624	5.6625	4-6
0.015	0.178125	5	100	0.956262	0.186272	50.98679	8.947076	5.247891	4-6
0.02	0.178125	5	100	0.858371	0.207515	50.35341	8.032407	4.972031	4-6
0.03	0.178125	5	100	0.73737	0.241568	49.45788	6.899167	4.608281	4-6
0.04	0.178125	5	100	0.661926	0.269101	48.82387	6.193736	4.366172	4-6
0.05	0.178125	5	100	0.608678	0.292642	48.3337	5.696896	4.186875	4-6
0.075	0.178125	5	100	0.522933	0.340627	47.4385	4.892977	3.880781	<4
0.1	0.178125	5	100	0.469484	0.379406	46.80515	4.392505	3.677109	<4
0.005	0.35625	5	100	2.427902	0.146732	48.31467	11.35944	8.362031	>6
0.01	0.35625	5	100	1.872194	0.190285	46.78872	8.759288	7.342969	>6
0.015	0.35625	5	100	1.608287	0.221509	45.89768	7.523483	6.805781	>6
0.02	0.35625	5	100	1.443692	0.246763	45.26859	6.754284	6.448125	>6
0.03	0.35625	5	100	1.240059	0.287285	44.38335	5.801554	5.976094	4-6
0.04	0.35625	5	100	1.11333	0.319986	43.75668	5.208122	5.6625	4-6
0.05	0.35625	5	100	1.02387	0.347945	43.27339	4.790188	5.430234	4-6
0.075	0.35625	5	100	0.879541	0.405041	42.39605	4.114368	5.032969	4-6
0.1	0.35625	5	100	0.789565	0.451198	41.77753	3.693655	4.768594	4-6
0.005	0.534375	5	100	3.291267	0.162362	45.34353	10.26392	9.735938	>6
0.01	0.534375	5	100	2.537725	0.210572	43.83262	7.914757	8.549063	>6
0.015	0.534375	5	100	2.179805	0.245148	42.95335	6.798309	7.923281	>6
0.02	0.534375	5	100	1.956789	0.273088	42.33277	6.103179	7.507031	>6

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.03	0.534375	5	100	1.680754	0.317938	41.46176	5.242323	6.957422	>6
0.04	0.534375	5	100	1.508957	0.354135	40.84637	4.706125	6.592266	>6
0.05	0.534375	5	100	1.387986	0.385	40.37037	4.328184	6.3225	>6
0.075	0.534375	5	100	1.191998	0.448302	39.51376	3.717891	5.859141	4-6
0.1	0.534375	5	100	1.070164	0.49934	38.90817	3.337611	5.551641	4-6
0.005	0.178125	6	100	1.50657	0.118232	54.71835	14.09678	6.013125	>6
0.01	0.178125	6	100	1.161703	0.153331	53.20029	10.87017	5.280234	4-6
0.015	0.178125	6	100	0.997866	0.178506	52.3087	9.336807	4.89375	4-6
0.02	0.178125	6	100	0.895859	0.198832	51.67481	8.381852	4.636875	4-6
0.03	0.178125	6	100	0.769437	0.2315	50.78173	7.199734	4.297266	4-6
0.04	0.178125	6	100	0.690734	0.257878	50.14738	6.463501	4.071563	4-6
0.05	0.178125	6	100	0.635351	0.280357	49.65409	5.944454	3.904922	<4
0.075	0.178125	6	100	0.54564	0.326452	48.76136	5.106251	3.61875	<4
0.1	0.178125	6	100	0.489892	0.363601	48.12614	4.583897	3.428906	<4
0.005	0.35625	6	100	2.533781	0.1406	49.63702	11.85387	7.798125	>6
0.01	0.35625	6	100	1.953677	0.182348	48.10916	9.140793	6.8475	>6
0.015	0.35625	6	100	1.678451	0.212249	47.21436	7.850903	6.346875	>6
0.02	0.35625	6	100	1.50657	0.236464	46.58347	7.048392	6.013125	>6
0.03	0.35625	6	100	1.293865	0.275338	45.6955	6.054494	5.5725	4-6
0.04	0.35625	6	100	1.161703	0.306662	45.06475	5.435086	5.280234	4-6
0.05	0.35625	6	100	1.068464	0.333422	44.57745	4.99877	5.063906	4-6
0.075	0.35625	6	100	0.917726	0.388188	43.69528	4.293715	4.693125	4-6
0.1	0.35625	6	100	0.82383	0.432431	43.07208	3.854686	4.446563	4-6
0.005	0.534375	6	100	3.434321	0.155598	46.65955	10.71115	9.07875	>6
0.01	0.534375	6	100	2.648053	0.201799	45.1409	8.259604	7.972031	>6
0.015	0.534375	6	100	2.274542	0.234937	44.25615	7.094545	7.388438	>6
0.02	0.534375	6	100	2.042122	0.261676	43.62973	6.368824	7.000781	>6
0.03	0.534375	6	100	1.753906	0.304677	42.75251	5.470648	6.487969	>6
0.04	0.534375	6	100	1.574737	0.339342	42.13105	4.910988	6.147656	>6
0.05	0.534375	6	100	1.44819	0.368995	41.65254	4.516909	5.895469	4-6
0.075	0.534375	6	100	1.243857	0.429611	40.78601	3.879842	5.46375	4-6
0.1	0.534375	6	100	1.116769	0.478501	40.17338	3.482948	5.177109	4-6
0.005	0.178125	3	200	1.291685	0.137901	57.83605	24.17522	7.874063	>6
0.01	0.178125	3	200	0.996192	0.178806	56.33905	18.6406	6.915	>6
0.015	0.178125	3	200	0.855668	0.208171	55.45838	16.01131	6.40875	>6
0.02	0.178125	3	200	0.768096	0.231905	54.83203	14.37432	6.071953	>6
0.03	0.178125	3	200	0.659729	0.269997	53.94562	12.34691	5.627344	4-6

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.04	0.178125	3	200	0.592199	0.300786	53.31579	11.08464	5.331563	4-6
0.05	0.178125	3	200	0.544768	0.326974	52.82374	10.19418	5.113594	4-6
0.075	0.178125	3	200	0.467936	0.380661	51.93141	8.756181	4.739297	4-6
0.1	0.178125	3	200	0.420075	0.424031	51.29773	7.860772	4.490391	4-6
0.005	0.35625	3	200	2.172483	0.163983	52.80697	20.32843	10.21172	>6
0.01	0.35625	3	200	1.675218	0.212659	51.28094	15.67535	8.967188	>6
0.015	0.35625	3	200	1.438993	0.247569	50.3863	13.46405	8.310938	>6
0.02	0.35625	3	200	1.291685	0.275803	49.75276	12.08761	7.874063	>6
0.03	0.35625	3	200	1.109733	0.321023	48.85616	10.38183	7.298438	>6
0.04	0.35625	3	200	0.996192	0.357612	48.22244	9.320299	6.915	>6
0.05	0.35625	3	200	0.916287	0.388797	47.73018	8.571933	6.631875	>6
0.075	0.35625	3	200	0.786888	0.452733	46.83996	7.363302	6.145781	>6
0.1	0.35625	3	200	0.706471	0.504267	46.20742	6.610122	5.823281	4-6
0.005	0.534375	3	200	2.944478	0.181484	49.82916	18.36904	11.88844	>6
0.01	0.534375	3	200	2.2707	0.235335	48.29956	14.16406	10.44	>6
0.015	0.534375	3	200	1.950306	0.273995	47.40701	12.16637	9.675469	>6
0.02	0.534375	3	200	1.751016	0.30518	46.77342	10.92184	9.167813	>6
0.03	0.534375	3	200	1.503991	0.355305	45.88371	9.381346	8.496563	>6
0.04	0.534375	3	200	1.349842	0.39588	45.25629	8.422672	8.049375	>6
0.05	0.534375	3	200	1.241734	0.430346	44.76681	7.74604	7.720313	>6
0.075	0.534375	3	200	1.066682	0.500969	43.88266	6.653221	7.155469	>6
0.1	0.534375	3	200	0.95741	0.558146	43.2602	5.973216	6.779063	>6
0.005	0.178125	4	200	1.372742	0.129759	59.81485	25.68796	7.029844	>6
0.01	0.178125	4	200	1.058487	0.168283	58.34094	19.80839	6.172969	>6
0.015	0.178125	4	200	0.909341	0.195884	57.4692	17.01335	5.721563	4-6
0.02	0.178125	4	200	0.816199	0.218237	56.85052	15.27439	5.420625	4-6
0.03	0.178125	4	200	0.701145	0.254049	55.9712	13.11942	5.024063	4-6
0.04	0.178125	4	200	0.629419	0.282999	55.34587	11.77789	4.760156	4-6
0.05	0.178125	4	200	0.578848	0.307724	54.86006	10.83273	4.564922	4-6
0.075	0.178125	4	200	0.49719	0.358263	53.97356	9.30478	4.230703	4-6
0.1	0.178125	4	200	0.446391	0.399034	53.34175	8.352936	4.00875	4-6
0.005	0.35625	4	200	2.3085	0.154321	54.84295	21.60144	9.11625	>6
0.01	0.35625	4	200	1.78014	0.200125	53.32516	16.65685	8.005313	>6
0.015	0.35625	4	200	1.528314	0.2331	52.43876	14.30961	7.4175	>6
0.02	0.35625	4	200	1.372742	0.259517	51.80032	12.84398	7.029844	>6
0.03	0.35625	4	200	1.178921	0.302183	50.90823	11.03288	6.514688	>6
0.04	0.35625	4	200	1.058487	0.336565	50.2725	9.904193	6.172969	>6

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.05	0.35625	4	200	0.97346	0.365963	49.78079	9.109334	5.919844	4-6
0.075	0.35625	4	200	0.836225	0.426022	48.88547	7.824189	5.486719	4-6
0.1	0.35625	4	200	0.750727	0.47454	48.25095	7.023984	5.198672	4-6
0.005	0.534375	4	200	3.129029	0.17078	51.8773	19.51893	10.61344	>6
0.01	0.534375	4	200	2.412925	0.221464	50.34875	15.05092	9.320156	>6
0.015	0.534375	4	200	2.072475	0.257844	49.45468	12.92813	8.637656	>6
0.02	0.534375	4	200	1.860667	0.287195	48.81942	11.60575	8.184375	>6
0.03	0.534375	4	200	1.598052	0.334392	47.92666	9.969041	7.584844	>6
0.04	0.534375	4	200	1.434755	0.37245	47.29241	8.949286	7.186875	>6
0.05	0.534375	4	200	1.319447	0.404999	46.80269	8.231177	6.892031	>6
0.075	0.534375	4	200	1.133559	0.471413	45.91072	7.069666	6.388125	>6
0.1	0.534375	4	200	1.017577	0.525145	45.28134	6.346806	6.0525	>6
0.005	0.178125	5	200	1.443692	0.123382	61.34656	27.01713	6.448125	>6
0.01	0.178125	5	200	1.11333	0.159993	59.89138	20.83249	5.6625	4-6
0.015	0.178125	5	200	0.956262	0.186272	59.03193	17.89415	5.247891	4-6
0.02	0.178125	5	200	0.858371	0.207515	58.41939	16.06481	4.972031	4-6
0.03	0.178125	5	200	0.73737	0.241568	57.5488	13.79833	4.608281	4-6
0.04	0.178125	5	200	0.661926	0.269101	56.92924	12.38747	4.366172	4-6
0.05	0.178125	5	200	0.608678	0.292642	56.44841	11.39379	4.186875	4-6
0.075	0.178125	5	200	0.522933	0.340627	55.56611	9.785954	3.880781	<4
0.1	0.178125	5	200	0.469484	0.379406	54.93862	8.785009	3.677109	<4
0.005	0.35625	5	200	2.427902	0.146732	56.42971	22.71889	8.362031	>6
0.01	0.35625	5	200	1.872194	0.190285	54.92232	17.51858	7.342969	>6
0.015	0.35625	5	200	1.608287	0.221509	54.03481	15.04697	6.805781	>6
0.02	0.35625	5	200	1.443692	0.246763	53.40497	13.50857	6.448125	>6
0.03	0.35625	5	200	1.240059	0.287285	52.51404	11.60311	5.976094	4-6
0.04	0.35625	5	200	1.11333	0.319986	51.88008	10.41624	5.6625	4-6
0.05	0.35625	5	200	1.02387	0.347945	51.3893	9.580376	5.430234	4-6
0.075	0.35625	5	200	0.879541	0.405041	50.4942	8.228736	5.032969	4-6
0.1	0.35625	5	200	0.789565	0.451198	49.8599	7.387311	4.768594	4-6
0.005	0.534375	5	200	3.291267	0.162362	53.48013	20.52783	9.735938	>6
0.01	0.534375	5	200	2.537725	0.210572	51.95705	15.82951	8.549063	>6
0.015	0.534375	5	200	2.179805	0.245148	51.06341	13.59662	7.923281	>6
0.02	0.534375	5	200	1.956789	0.273088	50.42943	12.20636	7.507031	>6
0.03	0.534375	5	200	1.680754	0.317938	49.53503	10.48465	6.957422	>6
0.04	0.534375	5	200	1.508957	0.354135	48.89989	9.41225	6.592266	>6
0.05	0.534375	5	200	1.387986	0.385	48.40675	8.656368	6.3225	>6

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.075	0.534375	5	200	1.191998	0.448302	47.51523	7.435782	5.859141	4-6
0.1	0.534375	5	200	1.070164	0.49934	46.88177	6.675222	5.551641	4-6
0.005	0.178125	6	200	1.50657	0.118232	62.58795	28.19357	6.013125	>6
0.01	0.178125	6	200	1.161703	0.153331	61.15211	21.74034	5.280234	4-6
0.015	0.178125	6	200	0.997866	0.178506	60.30192	18.67361	4.89375	4-6
0.02	0.178125	6	200	0.895859	0.198832	59.69435	16.7637	4.636875	4-6
0.03	0.178125	6	200	0.769437	0.2315	58.83391	14.39947	4.297266	4-6
0.04	0.178125	6	200	0.690734	0.257878	58.21956	12.927	4.071563	4-6
0.05	0.178125	6	200	0.635351	0.280357	57.74	11.88891	3.904922	<4
0.075	0.178125	6	200	0.54564	0.326452	56.86801	10.2125	3.61875	<4
0.1	0.178125	6	200	0.489892	0.363601	56.24432	9.167793	3.428906	<4
0.005	0.35625	6	200	2.533781	0.1406	57.72338	23.70774	7.798125	>6
0.01	0.35625	6	200	1.953677	0.182348	56.22761	18.28159	6.8475	>6
0.015	0.35625	6	200	1.678451	0.212249	55.34436	15.70181	6.346875	>6
0.02	0.35625	6	200	1.50657	0.236464	54.71835	14.09678	6.013125	>6
0.03	0.35625	6	200	1.293865	0.275338	53.83269	12.10899	5.5725	4-6
0.04	0.35625	6	200	1.161703	0.306662	53.20029	10.87017	5.280234	4-6
0.05	0.35625	6	200	1.068464	0.333422	52.70985	9.997539	5.063906	4-6
0.075	0.35625	6	200	0.917726	0.388188	51.81782	8.587429	4.693125	4-6
0.1	0.35625	6	200	0.82383	0.432431	51.1844	7.709371	4.446563	4-6
0.005	0.534375	6	200	3.434321	0.155598	54.79399	21.4223	9.07875	>6
0.01	0.534375	6	200	2.648053	0.201799	53.27678	16.51921	7.972031	>6
0.015	0.534375	6	200	2.274542	0.234937	52.38558	14.18909	7.388438	>6
0.02	0.534375	6	200	2.042122	0.261676	51.75132	12.73765	7.000781	>6
0.03	0.534375	6	200	1.753906	0.304677	50.85853	10.9413	6.487969	>6
0.04	0.534375	6	200	1.574737	0.339342	50.22276	9.821975	6.147656	>6
0.05	0.534375	6	200	1.44819	0.368995	49.73139	9.033818	5.895469	4-6
0.075	0.534375	6	200	1.243857	0.429611	48.83744	7.759684	5.46375	4-6
0.1	0.534375	6	200	1.116769	0.478501	48.2022	6.965896	5.177109	4-6
0.005	0.178125	3	300	1.291685	0.137901	62.39118	36.26283	7.874063	>6
0.01	0.178125	3	300	0.996192	0.178806	60.95056	27.9609	6.915	>6
0.015	0.178125	3	300	0.855668	0.208171	60.09904	24.01696	6.40875	>6
0.02	0.178125	3	300	0.768096	0.231905	59.49161	21.56148	6.071953	>6
0.03	0.178125	3	300	0.659729	0.269997	58.62938	18.52037	5.627344	4-6
0.04	0.178125	3	300	0.592199	0.300786	58.01488	16.62696	5.331563	4-6
0.05	0.178125	3	300	0.544768	0.326974	57.53373	15.29126	5.113594	4-6
0.075	0.178125	3	300	0.467936	0.380661	56.65877	13.13427	4.739297	4-6

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.1	0.178125	3	300	0.420075	0.424031	56.03553	11.79116	4.490391	4-6
0.005	0.35625	3	300	2.172483	0.163983	57.51732	30.49264	10.21172	>6
0.01	0.35625	3	300	1.675218	0.212659	56.01899	23.51302	8.967188	>6
0.015	0.35625	3	300	1.438993	0.247569	55.13634	20.19607	8.310938	>6
0.02	0.35625	3	300	1.291685	0.275803	54.50939	18.13141	7.874063	>6
0.03	0.35625	3	300	1.109733	0.321023	53.6194	15.57275	7.298438	>6
0.04	0.35625	3	300	0.996192	0.357612	52.98844	13.98045	6.915	>6
0.05	0.35625	3	300	0.916287	0.388797	52.49721	12.8579	6.631875	>6
0.075	0.35625	3	300	0.786888	0.452733	51.60642	11.04495	6.145781	>6
0.1	0.35625	3	300	0.706471	0.504267	50.97154	9.915183	5.823281	4-6
0.005	0.534375	3	300	2.944478	0.181484	54.58509	27.55356	11.88844	>6
0.01	0.534375	3	300	2.2707	0.235335	53.06531	21.24608	10.44	>6
0.015	0.534375	3	300	1.950306	0.273995	52.17419	18.24955	9.675469	>6
0.02	0.534375	3	300	1.751016	0.30518	51.5397	16.38276	9.167813	>6
0.03	0.534375	3	300	1.503991	0.355305	50.64601	14.07202	8.496563	>6
0.04	0.534375	3	300	1.349842	0.39588	50.01387	12.63401	8.049375	>6
0.05	0.534375	3	300	1.241734	0.430346	49.51961	11.61906	7.720313	>6
0.075	0.534375	3	300	1.066682	0.500969	48.62438	9.979831	7.155469	>6
0.1	0.534375	3	300	0.95741	0.558146	47.99222	8.959824	6.779063	>6
0.005	0.178125	4	300	1.372742	0.129759	64.28235	38.53194	7.029844	>6
0.01	0.178125	4	300	1.058487	0.168283	62.87512	29.71258	6.172969	>6
0.015	0.178125	4	300	0.909341	0.195884	62.03893	25.52002	5.721563	4-6
0.02	0.178125	4	300	0.816199	0.218237	61.44373	22.91159	5.420625	4-6
0.03	0.178125	4	300	0.701145	0.254049	60.59525	19.67912	5.024063	4-6
0.04	0.178125	4	300	0.629419	0.282999	59.99005	17.66684	4.760156	4-6
0.05	0.178125	4	300	0.578848	0.307724	59.51883	16.24909	4.564922	4-6
0.075	0.178125	4	300	0.49719	0.358263	58.65661	13.95717	4.230703	4-6
0.1	0.178125	4	300	0.446391	0.399034	58.04024	12.5294	4.00875	4-6
0.005	0.35625	4	300	2.3085	0.154321	59.50222	32.40215	9.11625	>6
0.01	0.35625	4	300	1.78014	0.200125	58.02403	24.98528	8.005313	>6
0.015	0.35625	4	300	1.528314	0.2331	57.15663	21.46441	7.4175	>6
0.02	0.35625	4	300	1.372742	0.259517	56.52996	19.26597	7.029844	>6
0.03	0.35625	4	300	1.178921	0.302183	55.65166	16.54932	6.514688	>6
0.04	0.35625	4	300	1.058487	0.336565	55.02384	14.85629	6.172969	>6
0.05	0.35625	4	300	0.97346	0.365963	54.53717	13.664	5.919844	4-6
0.075	0.35625	4	300	0.836225	0.426022	53.64855	11.73628	5.486719	4-6
0.1	0.35625	4	300	0.750727	0.47454	53.01686	10.53598	5.198672	4-6

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.005	0.534375	4	300	3.129029	0.17078	56.60561	29.2784	10.61344	>6
0.01	0.534375	4	300	2.412925	0.221464	55.09923	22.57638	9.320156	>6
0.015	0.534375	4	300	2.072475	0.257844	54.21387	19.39219	8.637656	>6
0.02	0.534375	4	300	1.860667	0.287195	53.58286	17.40862	8.184375	>6
0.03	0.534375	4	300	1.598052	0.334392	52.6934	14.95356	7.584844	>6
0.04	0.534375	4	300	1.434755	0.37245	52.05955	13.42393	7.186875	>6
0.05	0.534375	4	300	1.319447	0.404999	51.56905	12.34677	6.892031	>6
0.075	0.534375	4	300	1.133559	0.471413	50.67319	10.6045	6.388125	>6
0.1	0.534375	4	300	1.017577	0.525145	50.03914	9.52021	6.0525	>6
0.005	0.178125	5	300	1.443692	0.123382	65.73605	40.5257	6.448125	>6
0.01	0.178125	5	300	1.11333	0.159993	64.35519	31.24873	5.6625	4-6
0.015	0.178125	5	300	0.956262	0.186272	63.53587	26.84123	5.247891	4-6
0.02	0.178125	5	300	0.858371	0.207515	62.95023	24.09722	4.972031	4-6
0.03	0.178125	5	300	0.73737	0.241568	62.11541	20.6975	4.608281	4-6
0.04	0.178125	5	300	0.661926	0.269101	61.51955	18.58121	4.366172	4-6
0.05	0.178125	5	300	0.608678	0.292642	61.05609	17.09069	4.186875	4-6
0.075	0.178125	5	300	0.522933	0.340627	60.20337	14.67893	3.880781	<4
0.1	0.178125	5	300	0.469484	0.379406	59.59509	13.17751	3.677109	<4
0.005	0.35625	5	300	2.427902	0.146732	61.03805	34.07833	8.362031	>6
0.01	0.35625	5	300	1.872194	0.190285	59.57926	26.27786	7.342969	>6
0.015	0.35625	5	300	1.608287	0.221509	58.71628	22.57045	6.805781	>6
0.02	0.35625	5	300	1.443692	0.246763	58.10198	20.26285	6.448125	>6
0.03	0.35625	5	300	1.240059	0.287285	57.23042	17.40466	5.976094	4-6
0.04	0.35625	5	300	1.11333	0.319986	56.60834	15.62436	5.6625	4-6
0.05	0.35625	5	300	1.02387	0.347945	56.12568	14.37056	5.430234	4-6
0.075	0.35625	5	300	0.879541	0.405041	55.24297	12.3431	5.032969	4-6
0.1	0.35625	5	300	0.789565	0.451198	54.61553	11.08097	4.768594	4-6
0.005	0.534375	5	300	3.291267	0.162362	58.17537	30.79175	9.735938	>6
0.01	0.534375	5	300	2.537725	0.210572	56.68396	23.74427	8.549063	>6
0.015	0.534375	5	300	2.179805	0.245148	55.80466	20.39493	7.923281	>6
0.02	0.534375	5	300	1.956789	0.273088	55.17897	18.30954	7.507031	>6
0.03	0.534375	5	300	1.680754	0.317938	54.29356	15.72697	6.957422	>6
0.04	0.534375	5	300	1.508957	0.354135	53.66288	14.11838	6.592266	>6
0.05	0.534375	5	300	1.387986	0.385	53.17211	12.98455	6.3225	>6
0.075	0.534375	5	300	1.191998	0.448302	52.28241	11.15367	5.859141	4-6
0.1	0.534375	5	300	1.070164	0.49934	51.64832	10.01283	5.551641	4-6
0.005	0.178125	6	300	1.50657	0.118232	66.90777	42.29035	6.013125	>6

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.01	0.178125	6	300	1.161703	0.153331	65.55199	32.61052	5.280234	4-6
0.015	0.178125	6	300	0.997866	0.178506	64.74557	28.01042	4.89375	4-6
0.02	0.178125	6	300	0.895859	0.198832	64.1676	25.14555	4.636875	4-6
0.03	0.178125	6	300	0.769437	0.2315	63.3467	21.5992	4.297266	4-6
0.04	0.178125	6	300	0.690734	0.257878	62.75886	19.3905	4.071563	4-6
0.05	0.178125	6	300	0.635351	0.280357	62.299	17.83336	3.904922	<4
0.075	0.178125	6	300	0.54564	0.326452	61.46058	15.31875	3.61875	<4
0.1	0.178125	6	300	0.489892	0.363601	60.85911	13.75169	3.428906	<4
0.005	0.35625	6	300	2.533781	0.1406	62.28305	35.5616	7.798125	>6
0.01	0.35625	6	300	1.953677	0.182348	60.84298	27.42238	6.8475	>6
0.015	0.35625	6	300	1.678451	0.212249	59.98858	23.55271	6.346875	>6
0.02	0.35625	6	300	1.50657	0.236464	59.38121	21.14518	6.013125	>6
0.03	0.35625	6	300	1.293865	0.275338	58.51931	18.16348	5.5725	4-6
0.04	0.35625	6	300	1.161703	0.306662	57.90203	16.30526	5.280234	4-6
0.05	0.35625	6	300	1.068464	0.333422	57.42224	14.99631	5.063906	4-6
0.075	0.35625	6	300	0.917726	0.388188	56.54716	12.88114	4.693125	4-6
0.1	0.35625	6	300	0.82383	0.432431	55.92389	11.56406	4.446563	4-6
0.005	0.534375	6	300	3.434321	0.155598	59.45467	32.13346	9.07875	>6
0.01	0.534375	6	300	2.648053	0.201799	57.97678	24.77881	7.972031	>6
0.015	0.534375	6	300	2.274542	0.234937	57.10449	21.28363	7.388438	>6
0.02	0.534375	6	300	2.042122	0.261676	56.48181	19.10647	7.000781	>6
0.03	0.534375	6	300	1.753906	0.304677	55.60264	16.41194	6.487969	>6
0.04	0.534375	6	300	1.574737	0.339342	54.97466	14.73296	6.147656	>6
0.05	0.534375	6	300	1.44819	0.368995	54.48822	13.55073	5.895469	4-6
0.075	0.534375	6	300	1.243857	0.429611	53.60079	11.63953	5.46375	4-6
0.1	0.534375	6	300	1.116769	0.478501	52.96825	10.44884	5.177109	4-6
0.005	0.178125	3	500	1.291685	0.137901	67.80336	60.43804	7.874063	>6
0.01	0.178125	3	500	0.996192	0.178806	66.46572	46.6015	6.915	>6
0.015	0.178125	3	500	0.855668	0.208171	65.67057	40.02827	6.40875	>6
0.02	0.178125	3	500	0.768096	0.231905	65.10129	35.9358	6.071953	>6
0.03	0.178125	3	500	0.659729	0.269997	64.29025	30.86728	5.627344	4-6
0.04	0.178125	3	500	0.592199	0.300786	63.7101	27.7116	5.331563	4-6
0.05	0.178125	3	500	0.544768	0.326974	63.25461	25.48544	5.113594	4-6
0.075	0.178125	3	500	0.467936	0.380661	62.4235	21.89045	4.739297	4-6
0.1	0.178125	3	500	0.420075	0.424031	61.82929	19.65193	4.490391	4-6
0.005	0.35625	3	500	2.172483	0.163983	63.23906	50.82106	10.21172	>6
0.01	0.35625	3	500	1.675218	0.212659	61.8135	39.18837	8.967188	>6

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.015	0.35625	3	500	1.438993	0.247569	60.96871	33.66012	8.310938	>6
0.02	0.35625	3	500	1.291685	0.275803	60.36639	30.21902	7.874063	>6
0.03	0.35625	3	500	1.109733	0.321023	59.50812	25.95459	7.298438	>6
0.04	0.35625	3	500	0.996192	0.357612	58.89732	23.30075	6.915	>6
0.05	0.35625	3	500	0.916287	0.388797	58.42045	21.42983	6.631875	>6
0.075	0.35625	3	500	0.786888	0.452733	57.55271	18.40825	6.145781	>6
0.1	0.35625	3	500	0.706471	0.504267	56.93189	16.5253	5.823281	4-6
0.005	0.534375	3	500	2.944478	0.181484	60.43921	45.9226	11.88844	>6
0.01	0.534375	3	500	2.2707	0.235335	58.97184	35.41014	10.44	>6
0.015	0.534375	3	500	1.950306	0.273995	58.10624	30.41592	9.675469	>6
0.02	0.534375	3	500	1.751016	0.30518	57.48757	27.3046	9.167813	>6
0.03	0.534375	3	500	1.503991	0.355305	56.6128	23.45337	8.496563	>6
0.04	0.534375	3	500	1.349842	0.39588	55.99168	21.05668	8.049375	>6
0.05	0.534375	3	500	1.241734	0.430346	55.50466	19.3651	7.720313	>6
0.075	0.534375	3	500	1.066682	0.500969	54.61946	16.63305	7.155469	>6
0.1	0.534375	3	500	0.95741	0.558146	53.99199	14.93304	6.779063	>6
0.005	0.178125	4	500	1.372742	0.129759	69.54492	64.21991	7.029844	>6
0.01	0.178125	4	500	1.058487	0.168283	68.25057	49.52096	6.172969	>6
0.015	0.178125	4	500	0.909341	0.195884	67.47718	42.53336	5.721563	4-6
0.02	0.178125	4	500	0.816199	0.218237	66.92472	38.18598	5.420625	4-6
0.03	0.178125	4	500	0.701145	0.254049	66.13434	32.79854	5.024063	4-6
0.04	0.178125	4	500	0.629419	0.282999	65.56855	29.44474	4.760156	4-6
0.05	0.178125	4	500	0.578848	0.307724	65.12683	27.08182	4.564922	4-6
0.075	0.178125	4	500	0.49719	0.358263	64.31591	23.26195	4.230703	4-6
0.1	0.178125	4	500	0.446391	0.399034	63.73408	20.88234	4.00875	4-6
0.005	0.35625	4	500	2.3085	0.154321	65.11124	54.00359	9.11625	>6
0.01	0.35625	4	500	1.78014	0.200125	63.71875	41.64213	8.005313	>6
0.015	0.35625	4	500	1.528314	0.2331	62.89685	35.77402	7.4175	>6
0.02	0.35625	4	500	1.372742	0.259517	62.30085	32.10995	7.029844	>6
0.03	0.35625	4	500	1.178921	0.302183	61.46237	27.58219	6.514688	>6
0.04	0.35625	4	500	1.058487	0.336565	60.86077	24.76048	6.172969	>6
0.05	0.35625	4	500	0.97346	0.365963	60.39312	22.77333	5.919844	4-6
0.075	0.35625	4	500	0.836225	0.426022	59.53629	19.56047	5.486719	4-6
0.1	0.35625	4	500	0.750727	0.47454	58.92487	17.55996	5.198672	4-6
0.005	0.534375	4	500	3.129029	0.17078	62.37289	48.79733	10.61344	>6
0.01	0.534375	4	500	2.412925	0.221464	60.93311	37.6273	9.320156	>6
0.015	0.534375	4	500	2.072475	0.257844	60.08182	32.32031	8.637656	>6

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.02	0.534375	4	500	1.860667	0.287195	59.4728	29.01437	8.184375	>6
0.03	0.534375	4	500	1.598052	0.334392	58.61105	24.9226	7.584844	>6
0.04	0.534375	4	500	1.434755	0.37245	57.9946	22.37322	7.186875	>6
0.05	0.534375	4	500	1.319447	0.404999	57.51623	20.57794	6.892031	>6
0.075	0.534375	4	500	1.133559	0.471413	56.63946	17.67416	6.388125	>6
0.1	0.534375	4	500	1.017577	0.525145	56.01655	15.86702	6.0525	>6
0.005	0.178125	5	500	1.443692	0.123382	70.8726	67.54284	6.448125	>6
0.01	0.178125	5	500	1.11333	0.159993	69.61167	52.08122	5.6625	4-6
0.015	0.178125	5	500	0.956262	0.186272	68.85945	44.73538	5.247891	4-6
0.02	0.178125	5	500	0.858371	0.207515	68.31988	40.16203	4.972031	4-6
0.03	0.178125	5	500	0.73737	0.241568	67.54805	34.49583	4.608281	4-6
0.04	0.178125	5	500	0.661926	0.269101	66.99518	30.96868	4.366172	4-6
0.05	0.178125	5	500	0.608678	0.292642	66.56404	28.48448	4.186875	4-6
0.075	0.178125	5	500	0.522933	0.340627	65.76817	24.46489	3.880781	<4
0.1	0.178125	5	500	0.469484	0.379406	65.19839	21.96252	3.677109	<4
0.005	0.35625	5	500	2.427902	0.146732	66.54724	56.79722	8.362031	>6
0.01	0.35625	5	500	1.872194	0.190285	65.18354	43.79644	7.342969	>6
0.015	0.35625	5	500	1.608287	0.221509	64.37214	37.61742	6.805781	>6
0.02	0.35625	5	500	1.443692	0.246763	63.79244	33.77142	6.448125	>6
0.03	0.35625	5	500	1.240059	0.287285	62.96691	29.00777	5.976094	4-6
0.04	0.35625	5	500	1.11333	0.319986	62.37549	26.04061	5.6625	4-6
0.05	0.35625	5	500	1.02387	0.347945	61.91536	23.95094	5.430234	4-6
0.075	0.35625	5	500	0.879541	0.405041	61.07096	20.57184	5.032969	4-6
0.1	0.35625	5	500	0.789565	0.451198	60.46849	18.46828	4.768594	4-6
0.005	0.534375	5	500	3.291267	0.162362	63.86179	51.31958	9.735938	>6
0.01	0.534375	5	500	2.537725	0.210572	62.44748	39.57379	8.549063	>6
0.015	0.534375	5	500	2.179805	0.245148	61.6087	33.99155	7.923281	>6
0.02	0.534375	5	500	1.956789	0.273088	61.00959	30.5159	7.507031	>6
0.03	0.534375	5	500	1.680754	0.317938	60.1586	26.21161	6.957422	>6
0.04	0.534375	5	500	1.508957	0.354135	59.55014	23.53063	6.592266	>6
0.05	0.534375	5	500	1.387986	0.385	59.07532	21.64092	6.3225	>6
0.075	0.534375	5	500	1.191998	0.448302	58.21157	18.58946	5.859141	4-6
0.1	0.534375	5	500	1.070164	0.49934	57.59362	16.68805	5.551641	4-6
0.005	0.178125	6	500	1.50657	0.118232	71.93584	70.48392	6.013125	>6
0.01	0.178125	6	500	1.161703	0.153331	70.70503	54.35086	5.280234	4-6
0.015	0.178125	6	500	0.997866	0.178506	69.96902	46.68404	4.89375	4-6
0.02	0.178125	6	500	0.895859	0.198832	69.43972	41.90926	4.636875	4-6

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.03	0.178125	6	500	0.769437	0.2315	68.68533	35.99867	4.297266	4-6
0.04	0.178125	6	500	0.690734	0.257878	68.14324	32.31751	4.071563	4-6
0.05	0.178125	6	500	0.635351	0.280357	67.71806	29.72227	3.904922	<4
0.075	0.178125	6	500	0.54564	0.326452	66.94038	25.53126	3.61875	<4
0.1	0.178125	6	500	0.489892	0.363601	66.38049	22.91948	3.428906	<4
0.005	0.35625	6	500	2.533781	0.1406	67.70329	59.26934	7.798125	>6
0.01	0.35625	6	500	1.953677	0.182348	66.36545	45.70396	6.8475	>6
0.015	0.35625	6	500	1.678451	0.212249	65.56717	39.25452	6.346875	>6
0.02	0.35625	6	500	1.50657	0.236464	64.99763	35.24196	6.013125	>6
0.03	0.35625	6	500	1.293865	0.275338	64.18646	30.27247	5.5725	4-6
0.04	0.35625	6	500	1.161703	0.306662	63.60336	27.17543	5.280234	4-6
0.05	0.35625	6	500	1.068464	0.333422	63.1489	24.99385	5.063906	4-6
0.075	0.35625	6	500	0.917726	0.388188	62.31723	21.46857	4.693125	4-6
0.1	0.35625	6	500	0.82383	0.432431	61.72266	19.27343	4.446563	4-6
0.005	0.534375	6	500	3.434321	0.155598	65.06661	53.55576	9.07875	>6
0.01	0.534375	6	500	2.648053	0.201799	63.67407	41.29802	7.972031	>6
0.015	0.534375	6	500	2.274542	0.234937	62.84734	35.47272	7.388438	>6
0.02	0.534375	6	500	2.042122	0.261676	62.25497	31.84412	7.000781	>6
0.03	0.534375	6	500	1.753906	0.304677	61.41547	27.35324	6.487969	>6
0.04	0.534375	6	500	1.574737	0.339342	60.81356	24.55494	6.147656	>6
0.05	0.534375	6	500	1.44819	0.368995	60.34602	22.58454	5.895469	4-6
0.075	0.534375	6	500	1.243857	0.429611	59.49013	19.39921	5.46375	4-6
0.1	0.534375	6	500	1.116769	0.478501	58.87775	17.41474	5.177109	4-6
0.005	0.178125	3	1000	1.291685	0.137901	74.37869	120.8761	7.874063	>6
0.01	0.178125	3	1000	0.996192	0.178806	73.21966	93.20299	6.915	>6
0.015	0.178125	3	1000	0.855668	0.208171	72.52585	80.05654	6.40875	>6
0.02	0.178125	3	1000	0.768096	0.231905	72.02689	71.87161	6.071953	>6
0.03	0.178125	3	1000	0.659729	0.269997	71.3128	61.73456	5.627344	4-6
0.04	0.178125	3	1000	0.592199	0.300786	70.79965	55.42321	5.331563	4-6
0.05	0.178125	3	1000	0.544768	0.326974	70.39538	50.97088	5.113594	4-6
0.075	0.178125	3	1000	0.467936	0.380661	69.65459	43.78091	4.739297	4-6
0.1	0.178125	3	1000	0.420075	0.424031	69.12244	39.30386	4.490391	4-6
0.005	0.35625	3	1000	2.172483	0.163983	70.38156	101.6421	10.21172	>6
0.01	0.35625	3	1000	1.675218	0.212659	69.10827	78.37673	8.967188	>6
0.015	0.35625	3	1000	1.438993	0.247569	68.34802	67.32024	8.310938	>6
0.02	0.35625	3	1000	1.291685	0.275803	67.80336	60.43804	7.874063	>6
0.03	0.35625	3	1000	1.109733	0.321023	67.02347	51.90917	7.298438	>6

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.04	0.35625	3	1000	0.996192	0.357612	66.46572	46.6015	6.915	>6
0.05	0.35625	3	1000	0.916287	0.388797	66.02869	42.85966	6.631875	>6
0.075	0.35625	3	1000	0.786888	0.452733	65.22986	36.81651	6.145781	>6
0.1	0.35625	3	1000	0.706471	0.504267	64.65548	33.05061	5.823281	4-6
0.005	0.534375	3	1000	2.944478	0.181484	67.86933	91.8452	11.88844	>6
0.01	0.534375	3	1000	2.2707	0.235335	66.53389	70.82028	10.44	>6
0.015	0.534375	3	1000	1.950306	0.273995	65.73997	60.83185	9.675469	>6
0.02	0.534375	3	1000	1.751016	0.30518	65.1697	54.6092	9.167813	>6
0.03	0.534375	3	1000	1.503991	0.355305	64.35933	46.90673	8.496563	>6
0.04	0.534375	3	1000	1.349842	0.39588	63.78104	42.11336	8.049375	>6
0.05	0.534375	3	1000	1.241734	0.430346	63.32592	38.7302	7.720313	>6
0.075	0.534375	3	1000	1.066682	0.500969	62.49486	33.2661	7.155469	>6
0.1	0.534375	3	1000	0.95741	0.558146	61.90276	29.86608	6.779063	>6
0.005	0.178125	4	1000	1.372742	0.129759	75.8726	128.4398	7.029844	>6
0.01	0.178125	4	1000	1.058487	0.168283	74.76393	99.04193	6.172969	>6
0.015	0.178125	4	1000	0.909341	0.195884	74.097	85.06673	5.721563	4-6
0.02	0.178125	4	1000	0.816199	0.218237	73.61852	76.37195	5.420625	4-6
0.03	0.178125	4	1000	0.701145	0.254049	72.93095	65.59708	5.024063	4-6
0.04	0.178125	4	1000	0.629419	0.282999	72.43657	58.88947	4.760156	4-6
0.05	0.178125	4	1000	0.578848	0.307724	72.04932	54.16365	4.564922	4-6
0.075	0.178125	4	1000	0.49719	0.358263	71.33545	46.5239	4.230703	4-6
0.1	0.178125	4	1000	0.446391	0.399034	70.8209	41.76468	4.00875	4-6
0.005	0.35625	4	1000	2.3085	0.154321	72.03563	108.0072	9.11625	>6
0.01	0.35625	4	1000	1.78014	0.200125	70.80732	83.28426	8.005313	>6
0.015	0.35625	4	1000	1.528314	0.2331	70.077	71.54805	7.4175	>6
0.02	0.35625	4	1000	1.372742	0.259517	69.54492	64.21991	7.029844	>6
0.03	0.35625	4	1000	1.178921	0.302183	68.7928	55.16438	6.514688	>6
0.04	0.35625	4	1000	1.058487	0.336565	68.25057	49.52096	6.172969	>6
0.05	0.35625	4	1000	0.97346	0.365963	67.82758	45.54667	5.919844	4-6
0.075	0.35625	4	1000	0.836225	0.426022	67.04914	39.12095	5.486719	4-6
0.1	0.35625	4	1000	0.750727	0.47454	66.49093	35.11992	5.198672	4-6
0.005	0.534375	4	1000	3.129029	0.17078	69.60935	97.59467	10.61344	>6
0.01	0.534375	4	1000	2.412925	0.221464	68.31589	75.25459	9.320156	>6
0.015	0.534375	4	1000	2.072475	0.257844	67.54527	64.64063	8.637656	>6
0.02	0.534375	4	1000	1.860667	0.287195	66.99128	58.02874	8.184375	>6
0.03	0.534375	4	1000	1.598052	0.334392	66.20353	49.84521	7.584844	>6
0.04	0.534375	4	1000	1.434755	0.37245	65.63724	44.74643	7.186875	>6

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.05	0.534375	4	1000	1.319447	0.404999	65.19617	41.15589	6.892031	>6
0.075	0.534375	4	1000	1.133559	0.471413	64.3841	35.34833	6.388125	>6
0.1	0.534375	4	1000	1.017577	0.525145	63.80424	31.73403	6.0525	>6
0.005	0.178125	5	1000	1.443692	0.123382	77.00017	135.0857	6.448125	>6
0.01	0.178125	5	1000	1.11333	0.159993	75.92952	104.1624	5.6625	4-6
0.015	0.178125	5	1000	0.956262	0.186272	75.28662	89.47076	5.247891	4-6
0.02	0.178125	5	1000	0.858371	0.207515	74.82353	80.32407	4.972031	4-6
0.03	0.178125	5	1000	0.73737	0.241568	74.15825	68.99167	4.608281	4-6
0.04	0.178125	5	1000	0.661926	0.269101	73.67964	61.93736	4.366172	4-6
0.05	0.178125	5	1000	0.608678	0.292642	73.3052	56.96896	4.186875	4-6
0.075	0.178125	5	1000	0.522933	0.340627	72.61121	48.92977	3.880781	<4
0.1	0.178125	5	1000	0.469484	0.379406	72.11213	43.92505	3.677109	<4
0.005	0.35625	5	1000	2.427902	0.146732	73.29058	113.5944	8.362031	>6
0.01	0.35625	5	1000	1.872194	0.190285	72.0991	87.59288	7.342969	>6
0.015	0.35625	5	1000	1.608287	0.221509	71.38508	75.23483	6.805781	>6
0.02	0.35625	5	1000	1.443692	0.246763	70.8726	67.54284	6.448125	>6
0.03	0.35625	5	1000	1.240059	0.287285	70.13941	58.01554	5.976094	4-6
0.04	0.35625	5	1000	1.11333	0.319986	69.61167	52.08122	5.6625	4-6
0.05	0.35625	5	1000	1.02387	0.347945	69.19965	47.90188	5.430234	4-6
0.075	0.35625	5	1000	0.879541	0.405041	68.44027	41.14368	5.032969	4-6
0.1	0.35625	5	1000	0.789565	0.451198	67.89584	36.93655	4.768594	4-6
0.005	0.534375	5	1000	3.291267	0.162362	70.93401	102.6392	9.735938	>6
0.01	0.534375	5	1000	2.537725	0.210572	69.67602	79.14757	8.549063	>6
0.015	0.534375	5	1000	2.179805	0.245148	68.92437	67.98309	7.923281	>6
0.02	0.534375	5	1000	1.956789	0.273088	68.38491	61.03179	7.507031	>6
0.03	0.534375	5	1000	1.680754	0.317938	67.61496	52.42323	6.957422	>6
0.04	0.534375	5	1000	1.508957	0.354135	67.06175	47.06125	6.592266	>6
0.05	0.534375	5	1000	1.387986	0.385	66.6285	43.28184	6.3225	>6
0.075	0.534375	5	1000	1.191998	0.448302	65.83682	37.17891	5.859141	4-6
0.1	0.534375	5	1000	1.070164	0.49934	65.26762	33.37611	5.551641	4-6
0.005	0.178125	6	1000	1.50657	0.118232	77.89618	140.9678	6.013125	>6
0.01	0.178125	6	1000	1.161703	0.153331	76.85838	108.7017	5.280234	4-6
0.015	0.178125	6	1000	0.997866	0.178506	76.23383	93.36807	4.89375	4-6
0.02	0.178125	6	1000	0.895859	0.198832	75.78283	83.81852	4.636875	4-6
0.03	0.178125	6	1000	0.769437	0.2315	75.13736	71.99734	4.297266	4-6
0.04	0.178125	6	1000	0.690734	0.257878	74.67157	64.63501	4.071563	4-6
0.05	0.178125	6	1000	0.635351	0.280357	74.30508	59.44454	3.904922	<4

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.075	0.178125	6	1000	0.54564	0.326452	73.6321	51.06251	3.61875	<4
0.1	0.178125	6	1000	0.489892	0.363601	73.14547	45.83897	3.428906	<4
0.005	0.35625	6	1000	2.533781	0.1406	74.29233	118.5387	7.798125	>6
0.01	0.35625	6	1000	1.953677	0.182348	73.13237	91.40793	6.8475	>6
0.015	0.35625	6	1000	1.678451	0.212249	72.43536	78.50903	6.346875	>6
0.02	0.35625	6	1000	1.50657	0.236464	71.93584	70.48392	6.013125	>6
0.03	0.35625	6	1000	1.293865	0.275338	71.22114	60.54494	5.5725	4-6
0.04	0.35625	6	1000	1.161703	0.306662	70.70503	54.35086	5.280234	4-6
0.05	0.35625	6	1000	1.068464	0.333422	70.30139	49.9877	5.063906	4-6
0.075	0.35625	6	1000	0.917726	0.388188	69.55958	42.93715	4.693125	4-6
0.1	0.35625	6	1000	0.82383	0.432431	69.02673	38.54686	4.446563	4-6
0.005	0.534375	6	1000	3.434321	0.155598	71.99644	107.1115	9.07875	>6
0.01	0.534375	6	1000	2.648053	0.201799	70.76771	82.59604	7.972031	>6
0.015	0.534375	6	1000	2.274542	0.234937	70.03288	70.94545	7.388438	>6
0.02	0.534375	6	1000	2.042122	0.261676	69.50387	63.68824	7.000781	>6
0.03	0.534375	6	1000	1.753906	0.304677	68.7506	54.70648	6.487969	>6
0.04	0.534375	6	1000	1.574737	0.339342	68.20793	49.10988	6.147656	>6
0.05	0.534375	6	1000	1.44819	0.368995	67.7849	45.16909	5.895469	4-6
0.075	0.534375	6	1000	1.243857	0.429611	67.00708	38.79842	5.46375	4-6
0.1	0.534375	6	1000	1.116769	0.478501	66.44782	34.82948	5.177109	4-6

Table G.2. SwaleMOD modeling runs for trapezoidal grassed swales (assumed Manning's n=0.35, bottom width = 5 ft)

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.005	0.178125	3	25	1.602863	0.111129	47.06889	3.749509	3.069023	<4
0.01	0.178125	3	25	1.280009	0.139159	46.80263	2.994163	2.507051	<4
0.015	0.178125	3	25	1.1235	0.158545	46.66743	2.628053	2.226035	<4
0.02	0.178125	3	25	1.024693	0.173833	46.57993	2.396954	2.045508	<4
0.03	0.178125	3	25	0.90063	0.197778	46.46655	2.106626	1.815234	<4
0.04	0.178125	3	25	0.822117	0.216666	46.39457	1.923137	1.667344	<4
0.05	0.178125	3	25	0.766191	0.232481	46.34134	1.79224	1.560938	<4
0.075	0.178125	3	25	0.674472	0.264095	46.25201	1.577519	1.384453	<4
0.1	0.178125	3	25	0.616325	0.289012	46.19528	1.441525	1.27125	<4
0.005	0.35625	3	25	2.534603	0.140555	39.74346	2.964552	4.577578	4-6
0.01	0.35625	3	25	2.012727	0.176999	39.38763	2.354024	3.751641	<4
0.015	0.35625	3	25	1.761118	0.202286	39.20557	2.059822	3.336445	<4
0.02	0.35625	3	25	1.602863	0.222259	39.0868	1.874755	3.069023	<4
0.03	0.35625	3	25	1.404809	0.253593	38.93281	1.643077	2.727012	<4
0.04	0.35625	3	25	1.280009	0.278318	38.83269	1.497082	2.507051	<4
0.05	0.35625	3	25	1.19123	0.299061	38.76018	1.393255	2.348372	<4
0.075	0.35625	3	25	1.046032	0.340573	38.63875	1.223445	2.084707	<4
0.1	0.35625	3	25	0.954277	0.373319	38.56101	1.116225	1.915313	<4
0.005	0.534375	3	25	3.332509	0.160352	35.74525	2.598372	5.761875	4-6
0.01	0.534375	3	25	2.636887	0.202654	35.33835	2.05588	4.734375	4-6
0.015	0.534375	3	25	2.30245	0.23209	35.12937	1.795342	4.215703	4-6
0.02	0.534375	3	25	2.092742	0.255347	34.99115	1.631705	3.88125	<4
0.03	0.534375	3	25	1.83063	0.291908	34.81278	1.427358	3.452344	<4
0.04	0.534375	3	25	1.665821	0.320788	34.69636	1.298852	3.176016	<4
0.05	0.534375	3	25	1.548737	0.345039	34.61205	1.207612	2.976387	<4
0.075	0.534375	3	25	1.357681	0.393594	34.4697	1.058629	2.644365	<4
0.1	0.534375	3	25	1.237254	0.431904	34.37728	0.964722	2.430868	<4
0.005	0.178125	4	25	1.643995	0.108349	47.51446	3.845541	3.030352	<4
0.01	0.178125	4	25	1.308347	0.136145	47.18003	3.060455	2.481401	<4
0.015	0.178125	4	25	1.146226	0.155401	47.00857	2.681229	2.205938	<4
0.02	0.178125	4	25	1.044172	0.17059	46.89585	2.442274	2.02875	<4
0.03	0.178125	4	25	0.916047	0.19445	46.75383	2.143034	1.801875	<4
0.04	0.178125	4	25	0.835357	0.213232	46.65876	1.954011	1.656328	<4
0.05	0.178125	4	25	0.777876	0.228989	46.59035	1.819486	1.551328	<4
0.075	0.178125	4	25	0.683645	0.260552	46.47868	1.599373	1.376719	<4

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.1	0.178125	4	25	0.624201	0.285365	46.40259	1.459979	1.264922	<4
0.005	0.35625	4	25	2.619025	0.136024	40.32665	3.062939	4.491563	4-6
0.01	0.35625	4	25	2.071807	0.171951	39.88918	2.42312	3.693516	<4
0.015	0.35625	4	25	1.808987	0.196933	39.66189	2.115715	3.290625	<4
0.02	0.35625	4	25	1.643995	0.216698	39.51303	1.922771	3.030352	<4
0.03	0.35625	4	25	1.437897	0.247758	39.31968	1.681781	2.696543	<4
0.04	0.35625	4	25	1.308347	0.27229	39.193	1.530228	2.481401	<4
0.05	0.35625	4	25	1.216341	0.292887	39.10081	1.422617	2.325952	<4
0.075	0.35625	4	25	1.066163	0.334142	38.94572	1.246957	2.067188	<4
0.1	0.35625	4	25	0.971486	0.366706	38.84535	1.136265	1.900664	<4
0.005	0.534375	4	25	3.458477	0.154512	36.40494	2.696627	5.626875	4-6
0.01	0.534375	4	25	2.726166	0.196017	35.91044	2.125596	4.642031	4-6
0.015	0.534375	4	25	2.375213	0.22498	35.65274	1.85209	4.142344	4-6
0.02	0.534375	4	25	2.155444	0.247919	35.48236	1.680695	3.818906	<4
0.03	0.534375	4	25	1.881467	0.28402	35.25983	1.467025	3.403125	<4
0.04	0.534375	4	25	1.709585	0.312576	35.1135	1.332928	3.134531	<4
0.05	0.534375	4	25	1.5876	0.336593	35.00755	1.237893	2.94	<4
0.075	0.534375	4	25	1.38894	0.384736	34.82802	1.083014	2.615742	<4
0.1	0.534375	4	25	1.264022	0.422758	34.71062	0.985592	2.406796	<4
0.005	0.178125	5	25	1.683283	0.10582	47.93541	3.937626	2.993672	<4
0.01	0.178125	5	25	1.335718	0.133355	47.53925	3.1245	2.456968	<4
0.015	0.178125	5	25	1.168279	0.152468	47.33494	2.732846	2.186719	<4
0.02	0.178125	5	25	1.063003	0.167568	47.20122	2.48657	2.012461	<4
0.03	0.178125	5	25	0.931215	0.191282	47.02893	2.178502	1.789219	<4
0.04	0.178125	5	25	0.848365	0.209963	46.9136	1.984246	1.645781	<4
0.05	0.178125	5	25	0.789285	0.225679	46.83311	1.846344	1.541953	<4
0.075	0.178125	5	25	0.692784	0.257115	46.69642	1.620779	1.369453	<4
0.1	0.178125	5	25	0.631985	0.28185	46.60446	1.478205	1.258828	<4
0.005	0.35625	5	25	2.699399	0.131974	40.86025	3.15476	4.41375	4-6
0.01	0.35625	5	25	2.127861	0.167422	40.35824	2.488655	3.639258	<4
0.015	0.35625	5	25	1.854547	0.192095	40.09228	2.169093	3.247383	<4
0.02	0.35625	5	25	1.683283	0.21164	39.91686	1.968813	2.993672	<4
0.03	0.35625	5	25	1.469773	0.242384	39.68714	1.719025	2.667656	<4
0.04	0.35625	5	25	1.335718	0.266711	39.53677	1.56225	2.456968	<4
0.05	0.35625	5	25	1.240661	0.287145	39.42668	1.451059	2.304551	<4
0.075	0.35625	5	25	1.085691	0.328132	39.24156	1.26987	2.050313	<4
0.1	0.35625	5	25	0.988278	0.360475	39.1195	1.155825	1.886602	<4

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.005	0.534375	5	25	3.575383	0.14946	37.00746	2.787765	5.505	4-6
0.01	0.534375	5	25	2.809821	0.190181	36.43963	2.190957	4.557188	4-6
0.015	0.534375	5	25	2.443829	0.218663	36.14004	1.905605	4.074375	4-6
0.02	0.534375	5	25	2.214953	0.241258	35.94094	1.727036	3.761016	<4
0.03	0.534375	5	25	1.929893	0.276894	35.68051	1.5048	3.356953	<4
0.04	0.534375	5	25	1.751331	0.305125	35.50858	1.365547	3.095273	<4
0.05	0.534375	5	25	1.624841	0.328878	35.38275	1.266943	2.905547	<4
0.075	0.534375	5	25	1.419081	0.376564	35.16943	1.106515	2.588555	<4
0.1	0.534375	5	25	1.289913	0.414272	35.02944	1.005779	2.383846	<4
0.005	0.178125	6	25	1.72077	0.103515	48.33258	4.025299	2.958633	<4
0.01	0.178125	6	25	1.36201	0.130781	47.88153	3.185995	2.433362	<4
0.015	0.178125	6	25	1.189639	0.14973	47.64624	2.78252	2.168203	<4
0.02	0.178125	6	25	1.081271	0.164737	47.49369	2.529347	1.996699	<4
0.03	0.178125	6	25	0.945978	0.188297	47.29368	2.212899	1.776914	<4
0.04	0.178125	6	25	0.860899	0.206906	47.16266	2.013845	1.635234	<4
0.05	0.178125	6	25	0.800504	0.222516	47.06639	1.872423	1.53293	<4
0.075	0.178125	6	25	0.701919	0.253769	46.90352	1.641482	1.362656	<4
0.1	0.178125	6	25	0.639559	0.278512	46.80279	1.496157	1.252734	<4
0.005	0.35625	6	25	2.771998	0.128517	41.37014	3.242192	4.337578	4-6
0.01	0.35625	6	25	2.180764	0.16336	40.79887	2.550611	3.587813	<4
0.015	0.35625	6	25	1.897866	0.187711	40.49797	2.219745	3.20625	<4
0.02	0.35625	6	25	1.72077	0.207029	40.29891	2.01265	2.958633	<4
0.03	0.35625	6	25	1.500281	0.237456	40.03706	1.75468	2.639824	<4
0.04	0.35625	6	25	1.36201	0.261562	39.86511	1.592998	2.433362	<4
0.05	0.35625	6	25	1.26407	0.281828	39.7388	1.478438	2.283809	<4
0.075	0.35625	6	25	1.104646	0.322501	39.525	1.291971	2.034023	<4
0.1	0.35625	6	25	1.004491	0.354657	39.38502	1.174827	1.872773	<4
0.005	0.534375	6	25	3.683828	0.14506	37.56169	2.872286	5.393203	4-6
0.01	0.534375	6	25	2.888301	0.185014	36.93039	2.252017	4.478438	4-6
0.015	0.534375	6	25	2.508416	0.213033	36.59519	1.955891	4.010625	4-6
0.02	0.534375	6	25	2.271073	0.235296	36.37158	1.770769	3.706289	<4
0.03	0.534375	6	25	1.975796	0.270461	36.07763	1.540622	3.313008	<4
0.04	0.534375	6	25	1.791062	0.298357	35.88271	1.396577	3.057773	<4
0.05	0.534375	6	25	1.660406	0.321834	35.73885	1.294641	2.872559	<4
0.075	0.534375	6	25	1.447988	0.369047	35.49512	1.12903	2.562363	<4
0.1	0.534375	6	25	1.314805	0.406429	35.33476	1.025187	2.361636	<4
0.005	0.178125	3	50	1.602863	0.111129	55.20025	7.499018	3.069023	<4

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.01	0.178125	3	50	1.280009	0.139159	54.93612	5.988327	2.507051	<4
0.015	0.178125	3	50	1.1235	0.158545	54.80182	5.256105	2.226035	<4
0.02	0.178125	3	50	1.024693	0.173833	54.71483	4.793908	2.045508	<4
0.03	0.178125	3	50	0.90063	0.197778	54.60204	4.213252	1.815234	<4
0.04	0.178125	3	50	0.822117	0.216666	54.53039	3.846274	1.667344	<4
0.05	0.178125	3	50	0.766191	0.232481	54.47738	3.58448	1.560938	<4
0.075	0.178125	3	50	0.674472	0.264095	54.38838	3.155038	1.384453	<4
0.1	0.178125	3	50	0.616325	0.289012	54.33183	2.88305	1.27125	<4
0.005	0.35625	3	50	2.534603	0.140555	47.75481	5.929103	4.577578	4-6
0.01	0.35625	3	50	2.012727	0.176999	47.38351	4.708047	3.751641	<4
0.015	0.35625	3	50	1.761118	0.202286	47.19318	4.119645	3.336445	<4
0.02	0.35625	3	50	1.602863	0.222259	47.06889	3.749509	3.069023	<4
0.03	0.35625	3	50	1.404809	0.253593	46.90759	3.286153	2.727012	<4
0.04	0.35625	3	50	1.280009	0.278318	46.80263	2.994163	2.507051	<4
0.05	0.35625	3	50	1.19123	0.299061	46.72656	2.786509	2.348372	<4
0.075	0.35625	3	50	1.046032	0.340573	46.5991	2.44689	2.084707	<4
0.1	0.35625	3	50	0.954277	0.373319	46.51744	2.232449	1.915313	<4
0.005	0.534375	3	50	3.332509	0.160352	43.5299	5.196743	5.761875	4-6
0.01	0.534375	3	50	2.636887	0.202654	43.09337	4.111761	4.734375	4-6
0.015	0.534375	3	50	2.30245	0.23209	42.86868	3.590684	4.215703	4-6
0.02	0.534375	3	50	2.092742	0.255347	42.71989	3.26341	3.88125	<4
0.03	0.534375	3	50	1.83063	0.291908	42.52767	2.854717	3.452344	<4
0.04	0.534375	3	50	1.665821	0.320788	42.40209	2.597703	3.176016	<4
0.05	0.534375	3	50	1.548737	0.345039	42.31108	2.415223	2.976387	<4
0.075	0.534375	3	50	1.357681	0.393594	42.15729	2.117258	2.644365	<4
0.1	0.534375	3	50	1.237254	0.431904	42.05738	1.929444	2.430868	<4
0.005	0.178125	4	50	1.643995	0.108349	55.64119	7.691082	3.030352	<4
0.01	0.178125	4	50	1.308347	0.136145	55.31036	6.12091	2.481401	<4
0.015	0.178125	4	50	1.146226	0.155401	55.14046	5.362458	2.205938	<4
0.02	0.178125	4	50	1.044172	0.17059	55.02865	4.884547	2.02875	<4
0.03	0.178125	4	50	0.916047	0.19445	54.88767	4.286067	1.801875	<4
0.04	0.178125	4	50	0.835357	0.213232	54.7932	3.908023	1.656328	<4
0.05	0.178125	4	50	0.777876	0.228989	54.7252	3.638973	1.551328	<4
0.075	0.178125	4	50	0.683645	0.260552	54.61412	3.198747	1.376719	<4
0.1	0.178125	4	50	0.624201	0.285365	54.53838	2.919957	1.264922	<4
0.005	0.35625	4	50	2.619025	0.136024	48.36138	6.125878	4.491563	4-6
0.01	0.35625	4	50	2.071807	0.171951	47.9066	4.84624	3.693516	<4

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.015	0.35625	4	50	1.808987	0.196933	47.66977	4.23143	3.290625	<4
0.02	0.35625	4	50	1.643995	0.216698	47.51446	3.845541	3.030352	<4
0.03	0.35625	4	50	1.437897	0.247758	47.3125	3.363561	2.696543	<4
0.04	0.35625	4	50	1.308347	0.27229	47.18003	3.060455	2.481401	<4
0.05	0.35625	4	50	1.216341	0.292887	47.08356	2.845235	2.325952	<4
0.075	0.35625	4	50	1.066163	0.334142	46.92112	2.493915	2.067188	<4
0.1	0.35625	4	50	0.971486	0.366706	46.81591	2.27253	1.900664	<4
0.005	0.534375	4	50	3.458477	0.154512	44.23506	5.393253	5.626875	4-6
0.01	0.534375	4	50	2.726166	0.196017	43.70679	4.251192	4.642031	4-6
0.015	0.534375	4	50	2.375213	0.22498	43.43077	3.70418	4.142344	4-6
0.02	0.534375	4	50	2.155444	0.247919	43.248	3.361389	3.818906	<4
0.03	0.534375	4	50	1.881467	0.28402	43.00898	2.934051	3.403125	<4
0.04	0.534375	4	50	1.709585	0.312576	42.8516	2.665855	3.134531	<4
0.05	0.534375	4	50	1.5876	0.336593	42.73755	2.475787	2.94	<4
0.075	0.534375	4	50	1.38894	0.384736	42.54411	2.166029	2.615742	<4
0.1	0.534375	4	50	1.264022	0.422758	42.41747	1.971184	2.406796	<4
0.005	0.178125	5	50	1.683283	0.10582	56.05653	7.875251	2.993672	<4
0.01	0.178125	5	50	1.335718	0.133355	55.66567	6.249001	2.456968	<4
0.015	0.178125	5	50	1.168279	0.152468	55.46369	5.465692	2.186719	<4
0.02	0.178125	5	50	1.063003	0.167568	55.33135	4.973141	2.012461	<4
0.03	0.178125	5	50	0.931215	0.191282	55.16064	4.357003	1.789219	<4
0.04	0.178125	5	50	0.848365	0.209963	55.04626	3.968491	1.645781	<4
0.05	0.178125	5	50	0.789285	0.225679	54.96638	3.692688	1.541953	<4
0.075	0.178125	5	50	0.692784	0.257115	54.83063	3.241559	1.369453	<4
0.1	0.178125	5	50	0.631985	0.28185	54.73923	2.95641	1.258828	<4
0.005	0.35625	5	50	2.699399	0.131974	48.91424	6.30952	4.41375	4-6
0.01	0.35625	5	50	2.127861	0.167422	48.39416	4.977311	3.639258	<4
0.015	0.35625	5	50	1.854547	0.192095	48.1179	4.338187	3.247383	<4
0.02	0.35625	5	50	1.683283	0.21164	47.93541	3.937626	2.993672	<4
0.03	0.35625	5	50	1.469773	0.242384	47.6961	3.43805	2.667656	<4
0.04	0.35625	5	50	1.335718	0.266711	47.53925	3.1245	2.456968	<4
0.05	0.35625	5	50	1.240661	0.287145	47.4243	2.902118	2.304551	<4
0.075	0.35625	5	50	1.085691	0.328132	47.23083	2.539741	2.050313	<4
0.1	0.35625	5	50	0.988278	0.360475	47.10313	2.31165	1.886602	<4
0.005	0.534375	5	50	3.575383	0.14946	44.8763	5.575531	5.505	4-6
0.01	0.534375	5	50	2.809821	0.190181	44.27206	4.381914	4.557188	4-6
0.015	0.534375	5	50	2.443829	0.218663	43.9523	3.811211	4.074375	4-6

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.02	0.534375	5	50	2.214953	0.241258	43.73942	3.454071	3.761016	<4
0.03	0.534375	5	50	1.929893	0.276894	43.46053	3.0096	3.356953	<4
0.04	0.534375	5	50	1.751331	0.305125	43.27614	2.731093	3.095273	<4
0.05	0.534375	5	50	1.624841	0.328878	43.14106	2.533886	2.905547	<4
0.075	0.534375	5	50	1.419081	0.376564	42.91177	2.21303	2.588555	<4
0.1	0.534375	5	50	1.289913	0.414272	42.76112	2.011558	2.383846	<4
0.005	0.178125	6	50	1.72077	0.103515	56.44732	8.050599	2.958633	<4
0.01	0.178125	6	50	1.36201	0.130781	56.00343	6.37199	2.433362	<4
0.015	0.178125	6	50	1.189639	0.14973	55.77133	5.56504	2.168203	<4
0.02	0.178125	6	50	1.081271	0.164737	55.62066	5.058695	1.996699	<4
0.03	0.178125	6	50	0.945978	0.188297	55.42287	4.425799	1.776914	<4
0.04	0.178125	6	50	0.860899	0.206906	55.29316	4.027689	1.635234	<4
0.05	0.178125	6	50	0.800504	0.222516	55.19778	3.744846	1.53293	<4
0.075	0.178125	6	50	0.701919	0.253769	55.03626	3.282965	1.362656	<4
0.1	0.178125	6	50	0.639559	0.278512	54.93628	2.992314	1.252734	<4
0.005	0.35625	6	50	2.771998	0.128517	49.44064	6.484385	4.337578	4-6
0.01	0.35625	6	50	2.180764	0.16336	48.85075	5.101222	3.587813	<4
0.015	0.35625	6	50	1.897866	0.187711	48.5391	4.43949	3.20625	<4
0.02	0.35625	6	50	1.72077	0.207029	48.33258	4.025299	2.958633	<4
0.03	0.35625	6	50	1.500281	0.237456	48.06049	3.509361	2.639824	<4
0.04	0.35625	6	50	1.36201	0.261562	47.88153	3.185995	2.433362	<4
0.05	0.35625	6	50	1.26407	0.281828	47.74995	2.956876	2.283809	<4
0.075	0.35625	6	50	1.104646	0.322501	47.52696	2.583942	2.034023	<4
0.1	0.35625	6	50	1.004491	0.354657	47.38078	2.349654	1.872773	<4
0.005	0.534375	6	50	3.683828	0.14506	45.4638	5.744572	5.393203	4-6
0.01	0.534375	6	50	2.888301	0.185014	44.79443	4.504034	4.478438	4-6
0.015	0.534375	6	50	2.508416	0.213033	44.43783	3.911782	4.010625	4-6
0.02	0.534375	6	50	2.271073	0.235296	44.19948	3.541539	3.706289	<4
0.03	0.534375	6	50	1.975796	0.270461	43.88559	3.081244	3.313008	<4
0.04	0.534375	6	50	1.791062	0.298357	43.67711	2.793154	3.057773	<4
0.05	0.534375	6	50	1.660406	0.321834	43.52305	2.589282	2.872559	<4
0.075	0.534375	6	50	1.447988	0.369047	43.2617	2.25806	2.562363	<4
0.1	0.534375	6	50	1.314805	0.406429	43.08951	2.050373	2.361636	<4
0.005	0.178125	3	100	1.602863	0.111129	63.04069	14.99804	3.069023	<4
0.01	0.178125	3	100	1.280009	0.139159	62.79272	11.97665	2.507051	<4
0.015	0.178125	3	100	1.1235	0.158545	62.66647	10.51221	2.226035	<4
0.02	0.178125	3	100	1.024693	0.173833	62.58464	9.587817	2.045508	<4

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.03	0.178125	3	100	0.90063	0.197778	62.47846	8.426504	1.815234	<4
0.04	0.178125	3	100	0.822117	0.216666	62.41096	7.692548	1.667344	<4
0.05	0.178125	3	100	0.766191	0.232481	62.36101	7.16896	1.560938	<4
0.075	0.178125	3	100	0.674472	0.264095	62.2771	6.310076	1.384453	<4
0.1	0.178125	3	100	0.616325	0.289012	62.22376	5.7661	1.27125	<4
0.005	0.35625	3	100	2.534603	0.140555	55.87848	11.85821	4.577578	4-6
0.01	0.35625	3	100	2.012727	0.176999	55.51174	9.416094	3.751641	<4
0.015	0.35625	3	100	1.761118	0.202286	55.32339	8.239289	3.336445	<4
0.02	0.35625	3	100	1.602863	0.222259	55.20025	7.499018	3.069023	<4
0.03	0.35625	3	100	1.404809	0.253593	55.0403	6.572306	2.727012	<4
0.04	0.35625	3	100	1.280009	0.278318	54.93612	5.988327	2.507051	<4
0.05	0.35625	3	100	1.19123	0.299061	54.86057	5.573018	2.348372	<4
0.075	0.35625	3	100	1.046032	0.340573	54.7339	4.89378	2.084707	<4
0.1	0.35625	3	100	0.954277	0.373319	54.65268	4.464898	1.915313	<4
0.005	0.534375	3	100	3.332509	0.160352	51.65	10.39349	5.761875	4-6
0.01	0.534375	3	100	2.636887	0.202654	51.20607	8.223521	4.734375	4-6
0.015	0.534375	3	100	2.30245	0.23209	50.97707	7.181368	4.215703	4-6
0.02	0.534375	3	100	2.092742	0.255347	50.82522	6.526821	3.88125	<4
0.03	0.534375	3	100	1.83063	0.291908	50.62883	5.709434	3.452344	<4
0.04	0.534375	3	100	1.665821	0.320788	50.50038	5.195407	3.176016	<4
0.05	0.534375	3	100	1.548737	0.345039	50.40722	4.830446	2.976387	<4
0.075	0.534375	3	100	1.357681	0.393594	50.24967	4.234517	2.644365	<4
0.1	0.534375	3	100	1.237254	0.431904	50.14722	3.858888	2.430868	<4
0.005	0.178125	4	100	1.643995	0.108349	63.45365	15.38216	3.030352	<4
0.01	0.178125	4	100	1.308347	0.136145	63.14393	12.24182	2.481401	<4
0.015	0.178125	4	100	1.146226	0.155401	62.98459	10.72492	2.205938	<4
0.02	0.178125	4	100	1.044172	0.17059	62.87964	9.769095	2.02875	<4
0.03	0.178125	4	100	0.916047	0.19445	62.74718	8.572135	1.801875	<4
0.04	0.178125	4	100	0.835357	0.213232	62.65836	7.816045	1.656328	<4
0.05	0.178125	4	100	0.777876	0.228989	62.59439	7.277946	1.551328	<4
0.075	0.178125	4	100	0.683645	0.260552	62.48983	6.397494	1.376719	<4
0.1	0.178125	4	100	0.624201	0.285365	62.41849	5.839914	1.264922	<4
0.005	0.35625	4	100	2.619025	0.136024	56.47561	12.25176	4.491563	4-6
0.01	0.35625	4	100	2.071807	0.171951	56.02813	9.69248	3.693516	<4
0.015	0.35625	4	100	1.808987	0.196933	55.79457	8.462859	3.290625	<4
0.02	0.35625	4	100	1.643995	0.216698	55.64119	7.691082	3.030352	<4
0.03	0.35625	4	100	1.437897	0.247758	55.4415	6.727123	2.696543	<4

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.04	0.35625	4	100	1.308347	0.27229	55.31036	6.12091	2.481401	<4
0.05	0.35625	4	100	1.216341	0.292887	55.21479	5.690469	2.325952	<4
0.075	0.35625	4	100	1.066163	0.334142	55.05372	4.98783	2.067188	<4
0.1	0.35625	4	100	0.971486	0.366706	54.9493	4.545059	1.900664	<4
0.005	0.534375	4	100	3.458477	0.154512	52.36428	10.78651	5.626875	4-6
0.01	0.534375	4	100	2.726166	0.196017	51.82949	8.502383	4.642031	4-6
0.015	0.534375	4	100	2.375213	0.22498	51.5493	7.408359	4.142344	4-6
0.02	0.534375	4	100	2.155444	0.247919	51.36347	6.722778	3.818906	<4
0.03	0.534375	4	100	1.881467	0.28402	51.1201	5.868101	3.403125	<4
0.04	0.534375	4	100	1.709585	0.312576	50.95965	5.33171	3.134531	<4
0.05	0.534375	4	100	1.5876	0.336593	50.84325	4.951573	2.94	<4
0.075	0.534375	4	100	1.38894	0.384736	50.64563	4.332058	2.615742	<4
0.1	0.534375	4	100	1.264022	0.422758	50.51612	3.942369	2.406796	<4
0.005	0.178125	5	100	1.683283	0.10582	63.84153	15.7505	2.993672	<4
0.01	0.178125	5	100	1.335718	0.133355	63.47655	12.498	2.456968	<4
0.015	0.178125	5	100	1.168279	0.152468	63.28756	10.93138	2.186719	<4
0.02	0.178125	5	100	1.063003	0.167568	63.16359	9.946282	2.012461	<4
0.03	0.178125	5	100	0.931215	0.191282	63.00353	8.714007	1.789219	<4
0.04	0.178125	5	100	0.848365	0.209963	62.89618	7.936982	1.645781	<4
0.05	0.178125	5	100	0.789285	0.225679	62.82115	7.385376	1.541953	<4
0.075	0.178125	5	100	0.692784	0.257115	62.69356	6.483117	1.369453	<4
0.1	0.178125	5	100	0.631985	0.28185	62.60759	5.91282	1.258828	<4
0.005	0.35625	5	100	2.699399	0.131974	57.01771	12.61904	4.41375	4-6
0.01	0.35625	5	100	2.127861	0.167422	56.50781	9.954621	3.639258	<4
0.015	0.35625	5	100	1.854547	0.192095	56.23621	8.676373	3.247383	<4
0.02	0.35625	5	100	1.683283	0.21164	56.05653	7.875251	2.993672	<4
0.03	0.35625	5	100	1.469773	0.242384	55.82055	6.876099	2.667656	<4
0.04	0.35625	5	100	1.335718	0.266711	55.66567	6.249001	2.456968	<4
0.05	0.35625	5	100	1.240661	0.287145	55.55207	5.804235	2.304551	<4
0.075	0.35625	5	100	1.085691	0.328132	55.36066	5.079481	2.050313	<4
0.1	0.35625	5	100	0.988278	0.360475	55.23418	4.623301	1.886602	<4
0.005	0.534375	5	100	3.575383	0.14946	53.01083	11.15106	5.505	4-6
0.01	0.534375	5	100	2.809821	0.190181	52.40166	8.763828	4.557188	4-6
0.015	0.534375	5	100	2.443829	0.218663	52.07827	7.622421	4.074375	4-6
0.02	0.534375	5	100	2.214953	0.241258	51.86259	6.908142	3.761016	<4
0.03	0.534375	5	100	1.929893	0.276894	51.57954	6.0192	3.356953	<4
0.04	0.534375	5	100	1.751331	0.305125	51.3921	5.462187	3.095273	<4

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.05	0.534375	5	100	1.624841	0.328878	51.25464	5.067771	2.905547	<4
0.075	0.534375	5	100	1.419081	0.376564	51.02101	4.42606	2.588555	<4
0.1	0.534375	5	100	1.289913	0.414272	50.86731	4.023116	2.383846	<4
0.005	0.178125	6	100	1.72077	0.103515	64.20549	16.1012	2.958633	<4
0.01	0.178125	6	100	1.36201	0.130781	63.79201	12.74398	2.433362	<4
0.015	0.178125	6	100	1.189639	0.14973	63.57531	11.13008	2.168203	<4
0.02	0.178125	6	100	1.081271	0.164737	63.43445	10.11739	1.996699	<4
0.03	0.178125	6	100	0.945978	0.188297	63.24933	8.851597	1.776914	<4
0.04	0.178125	6	100	0.860899	0.206906	63.1278	8.055378	1.635234	<4
0.05	0.178125	6	100	0.800504	0.222516	63.03836	7.489692	1.53293	<4
0.075	0.178125	6	100	0.701919	0.253769	62.88678	6.565929	1.362656	<4
0.1	0.178125	6	100	0.639559	0.278512	62.79287	5.984628	1.252734	<4
0.005	0.35625	6	100	2.771998	0.128517	57.532	12.96877	4.337578	4-6
0.01	0.35625	6	100	2.180764	0.16336	56.95556	10.20244	3.587813	<4
0.015	0.35625	6	100	1.897866	0.187711	56.6501	8.87898	3.20625	<4
0.02	0.35625	6	100	1.72077	0.207029	56.44732	8.050599	2.958633	<4
0.03	0.35625	6	100	1.500281	0.237456	56.1797	7.018721	2.639824	<4
0.04	0.35625	6	100	1.36201	0.261562	56.00343	6.37199	2.433362	<4
0.05	0.35625	6	100	1.26407	0.281828	55.87368	5.913752	2.283809	<4
0.075	0.35625	6	100	1.104646	0.322501	55.65354	5.167884	2.034023	<4
0.1	0.35625	6	100	1.004491	0.354657	55.50904	4.699307	1.872773	<4
0.005	0.534375	6	100	3.683828	0.14506	53.6007	11.48914	5.393203	4-6
0.01	0.534375	6	100	2.888301	0.185014	52.92843	9.008068	4.478438	4-6
0.015	0.534375	6	100	2.508416	0.213033	52.56903	7.823563	4.010625	4-6
0.02	0.534375	6	100	2.271073	0.235296	52.32832	7.083077	3.706289	<4
0.03	0.534375	6	100	1.975796	0.270461	52.01072	6.162489	3.313008	<4
0.04	0.534375	6	100	1.791062	0.298357	51.79939	5.586309	3.057773	<4
0.05	0.534375	6	100	1.660406	0.321834	51.64304	5.178563	2.872559	<4
0.075	0.534375	6	100	1.447988	0.369047	51.37741	4.516121	2.562363	<4
0.1	0.534375	6	100	1.314805	0.406429	51.20214	4.100747	2.361636	<4
0.005	0.178125	3	200	1.602863	0.111129	70.2051	29.99607	3.069023	<4
0.01	0.178125	3	200	1.280009	0.139159	69.98419	23.95331	2.507051	<4
0.015	0.178125	3	200	1.1235	0.158545	69.87158	21.02442	2.226035	<4
0.02	0.178125	3	200	1.024693	0.173833	69.79853	19.17563	2.045508	<4
0.03	0.178125	3	200	0.90063	0.197778	69.7037	16.85301	1.815234	<4
0.04	0.178125	3	200	0.822117	0.216666	69.64338	15.3851	1.667344	<4
0.05	0.178125	3	200	0.766191	0.232481	69.59873	14.33792	1.560938	<4

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.075	0.178125	3	200	0.674472	0.264095	69.52368	12.62015	1.384453	<4
0.1	0.178125	3	200	0.616325	0.289012	69.47595	11.5322	1.27125	<4
0.005	0.35625	3	200	2.534603	0.140555	63.67539	23.71641	4.577578	4-6
0.01	0.35625	3	200	2.012727	0.176999	63.33254	18.83219	3.751641	<4
0.015	0.35625	3	200	1.761118	0.202286	63.15613	16.47858	3.336445	<4
0.02	0.35625	3	200	1.602863	0.222259	63.04069	14.99804	3.069023	<4
0.03	0.35625	3	200	1.404809	0.253593	62.89058	13.14461	2.727012	<4
0.04	0.35625	3	200	1.280009	0.278318	62.79272	11.97665	2.507051	<4
0.05	0.35625	3	200	1.19123	0.299061	62.72172	11.14604	2.348372	<4
0.075	0.35625	3	200	1.046032	0.340573	62.60258	9.78756	2.084707	<4
0.1	0.35625	3	200	0.954277	0.373319	62.52614	8.929797	1.915313	<4
0.005	0.534375	3	200	3.332509	0.160352	59.67051	20.78697	5.761875	4-6
0.01	0.534375	3	200	2.636887	0.202654	59.24339	16.44704	4.734375	4-6
0.015	0.534375	3	200	2.30245	0.23209	59.02255	14.36274	4.215703	4-6
0.02	0.534375	3	200	2.092742	0.255347	58.87593	13.05364	3.88125	<4
0.03	0.534375	3	200	1.83063	0.291908	58.68607	11.41887	3.452344	<4
0.04	0.534375	3	200	1.665821	0.320788	58.56175	10.39081	3.176016	<4
0.05	0.534375	3	200	1.548737	0.345039	58.47152	9.660893	2.976387	<4
0.075	0.534375	3	200	1.357681	0.393594	58.3188	8.469033	2.644365	<4
0.1	0.534375	3	200	1.237254	0.431904	58.2194	7.717776	2.430868	<4
0.005	0.178125	4	200	1.643995	0.108349	70.5722	30.76433	3.030352	<4
0.01	0.178125	4	200	1.308347	0.136145	70.29697	24.48364	2.481401	<4
0.015	0.178125	4	200	1.146226	0.155401	70.15515	21.44983	2.205938	<4
0.02	0.178125	4	200	1.044172	0.17059	70.06166	19.53819	2.02875	<4
0.03	0.178125	4	200	0.916047	0.19445	69.94358	17.14427	1.801875	<4
0.04	0.178125	4	200	0.835357	0.213232	69.86434	15.63209	1.656328	<4
0.05	0.178125	4	200	0.777876	0.228989	69.80725	14.55589	1.551328	<4
0.075	0.178125	4	200	0.683645	0.260552	69.71386	12.79499	1.376719	<4
0.1	0.178125	4	200	0.624201	0.285365	69.65011	11.67983	1.264922	<4
0.005	0.35625	4	200	2.619025	0.136024	64.23181	24.50351	4.491563	4-6
0.01	0.35625	4	200	2.071807	0.171951	63.81505	19.38496	3.693516	<4
0.015	0.35625	4	200	1.808987	0.196933	63.59702	16.92572	3.290625	<4
0.02	0.35625	4	200	1.643995	0.216698	63.45365	15.38216	3.030352	<4
0.03	0.35625	4	200	1.437897	0.247758	63.26678	13.45425	2.696543	<4
0.04	0.35625	4	200	1.308347	0.27229	63.14393	12.24182	2.481401	<4
0.05	0.35625	4	200	1.216341	0.292887	63.05432	11.38094	2.325952	<4
0.075	0.35625	4	200	1.066163	0.334142	62.90318	9.97566	2.067188	<4

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.1	0.35625	4	200	0.971486	0.366706	62.80511	9.090119	1.900664	<4
0.005	0.534375	4	200	3.458477	0.154512	60.35507	21.57301	5.626875	4-6
0.01	0.534375	4	200	2.726166	0.196017	59.84285	17.00477	4.642031	4-6
0.015	0.534375	4	200	2.375213	0.22498	59.57374	14.81672	4.142344	4-6
0.02	0.534375	4	200	2.155444	0.247919	59.39498	13.44556	3.818906	<4
0.03	0.534375	4	200	1.881467	0.28402	59.16052	11.7362	3.403125	<4
0.04	0.534375	4	200	1.709585	0.312576	59.00574	10.66342	3.134531	<4
0.05	0.534375	4	200	1.5876	0.336593	58.89335	9.903146	2.94	<4
0.075	0.534375	4	200	1.38894	0.384736	58.70232	8.664115	2.615742	<4
0.1	0.534375	4	200	1.264022	0.422758	58.57699	7.884738	2.406796	<4
0.005	0.178125	5	200	1.683283	0.10582	70.91608	31.501	2.993672	<4
0.01	0.178125	5	200	1.335718	0.133355	70.59252	24.996	2.456968	<4
0.015	0.178125	5	200	1.168279	0.152468	70.42467	21.86277	2.186719	<4
0.02	0.178125	5	200	1.063003	0.167568	70.31446	19.89256	2.012461	<4
0.03	0.178125	5	200	0.931215	0.191282	70.17201	17.42801	1.789219	<4
0.04	0.178125	5	200	0.848365	0.209963	70.0764	15.87396	1.645781	<4
0.05	0.178125	5	200	0.789285	0.225679	70.00954	14.77075	1.541953	<4
0.075	0.178125	5	200	0.692784	0.257115	69.89575	12.96623	1.369453	<4
0.1	0.178125	5	200	0.631985	0.28185	69.81903	11.82564	1.258828	<4
0.005	0.35625	5	200	2.699399	0.131974	64.73503	25.23808	4.41375	4-6
0.01	0.35625	5	200	2.127861	0.167422	64.26175	19.90924	3.639258	<4
0.015	0.35625	5	200	1.854547	0.192095	64.009	17.35275	3.247383	<4
0.02	0.35625	5	200	1.683283	0.21164	63.84153	15.7505	2.993672	<4
0.03	0.35625	5	200	1.469773	0.242384	63.62129	13.7522	2.667656	<4
0.04	0.35625	5	200	1.335718	0.266711	63.47655	12.498	2.456968	<4
0.05	0.35625	5	200	1.240661	0.287145	63.37029	11.60847	2.304551	<4
0.075	0.35625	5	200	1.085691	0.328132	63.19106	10.15896	2.050313	<4
0.1	0.35625	5	200	0.988278	0.360475	63.07251	9.246601	1.886602	<4
0.005	0.534375	5	200	3.575383	0.14946	60.97187	22.30212	5.505	4-6
0.01	0.534375	5	200	2.809821	0.190181	60.39081	17.52766	4.557188	4-6
0.015	0.534375	5	200	2.443829	0.218663	60.08136	15.24484	4.074375	4-6
0.02	0.534375	5	200	2.214953	0.241258	59.8746	13.81628	3.761016	<4
0.03	0.534375	5	200	1.929893	0.276894	59.60281	12.0384	3.356953	<4
0.04	0.534375	5	200	1.751331	0.305125	59.42254	10.92437	3.095273	<4
0.05	0.534375	5	200	1.624841	0.328878	59.29018	10.13554	2.905547	<4
0.075	0.534375	5	200	1.419081	0.376564	59.06495	8.85212	2.588555	<4
0.1	0.534375	5	200	1.289913	0.414272	58.91659	8.046232	2.383846	<4

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.005	0.178125	6	200	1.72077	0.103515	71.23796	32.20239	2.958633	<4
0.01	0.178125	6	200	1.36201	0.130781	70.87222	25.48796	2.433362	<4
0.015	0.178125	6	200	1.189639	0.14973	70.68015	22.26016	2.168203	<4
0.02	0.178125	6	200	1.081271	0.164737	70.55515	20.23478	1.996699	<4
0.03	0.178125	6	200	0.945978	0.188297	70.39069	17.70319	1.776914	<4
0.04	0.178125	6	200	0.860899	0.206906	70.28262	16.11076	1.635234	<4
0.05	0.178125	6	200	0.800504	0.222516	70.20303	14.97938	1.53293	<4
0.075	0.178125	6	200	0.701919	0.253769	70.06803	13.13186	1.362656	<4
0.1	0.178125	6	200	0.639559	0.278512	69.98432	11.96926	1.252734	<4
0.005	0.35625	6	200	2.771998	0.128517	65.21073	25.93754	4.337578	4-6
0.01	0.35625	6	200	2.180764	0.16336	64.67743	20.40489	3.587813	<4
0.015	0.35625	6	200	1.897866	0.187711	64.39398	17.75796	3.20625	<4
0.02	0.35625	6	200	1.72077	0.207029	64.20549	16.1012	2.958633	<4
0.03	0.35625	6	200	1.500281	0.237456	63.95636	14.03744	2.639824	<4
0.04	0.35625	6	200	1.36201	0.261562	63.79201	12.74398	2.433362	<4
0.05	0.35625	6	200	1.26407	0.281828	63.67091	11.8275	2.283809	<4
0.075	0.35625	6	200	1.104646	0.322501	63.4652	10.33577	2.034023	<4
0.1	0.35625	6	200	1.004491	0.354657	63.33001	9.398614	1.872773	<4
0.005	0.534375	6	200	3.683828	0.14506	61.53226	22.97829	5.393203	4-6
0.01	0.534375	6	200	2.888301	0.185014	60.89342	18.01614	4.478438	4-6
0.015	0.534375	6	200	2.508416	0.213033	60.55069	15.64713	4.010625	4-6
0.02	0.534375	6	200	2.271073	0.235296	60.32069	14.16615	3.706289	<4
0.03	0.534375	6	200	1.975796	0.270461	60.01664	12.32498	3.313008	<4
0.04	0.534375	6	200	1.791062	0.298357	59.81396	11.17262	3.057773	<4
0.05	0.534375	6	200	1.660406	0.321834	59.66383	10.35713	2.872559	<4
0.075	0.534375	6	200	1.447988	0.369047	59.4084	9.032241	2.562363	<4
0.1	0.534375	6	200	1.314805	0.406429	59.2396	8.201494	2.361636	<4
0.005	0.178125	3	300	1.602863	0.111129	73.97286	44.99411	3.069023	<4
0.01	0.178125	3	300	1.280009	0.139159	73.77094	35.92996	2.507051	<4
0.015	0.178125	3	300	1.1235	0.158545	73.66793	31.53663	2.226035	<4
0.02	0.178125	3	300	1.024693	0.173833	73.6011	28.76345	2.045508	<4
0.03	0.178125	3	300	0.90063	0.197778	73.5143	25.27951	1.815234	<4
0.04	0.178125	3	300	0.822117	0.216666	73.45907	23.07764	1.667344	<4
0.05	0.178125	3	300	0.766191	0.232481	73.41818	21.50688	1.560938	<4
0.075	0.178125	3	300	0.674472	0.264095	73.34943	18.93023	1.384453	<4
0.1	0.178125	3	300	0.616325	0.289012	73.3057	17.2983	1.27125	<4
0.005	0.35625	3	300	2.534603	0.140555	67.92945	35.57462	4.577578	4-6

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.01	0.35625	3	300	2.012727	0.176999	67.60781	28.24828	3.751641	<4
0.015	0.35625	3	300	1.761118	0.202286	67.44214	24.71787	3.336445	<4
0.02	0.35625	3	300	1.602863	0.222259	67.33366	22.49706	3.069023	<4
0.03	0.35625	3	300	1.404809	0.253593	67.19254	19.71692	2.727012	<4
0.04	0.35625	3	300	1.280009	0.278318	67.10049	17.96498	2.507051	<4
0.05	0.35625	3	300	1.19123	0.299061	67.03368	16.71905	2.348372	<4
0.075	0.35625	3	300	1.046032	0.340573	66.92154	14.68134	2.084707	<4
0.1	0.35625	3	300	0.954277	0.373319	66.84956	13.3947	1.915313	<4
0.005	0.534375	3	300	3.332509	0.160352	64.1449	31.18046	5.761875	4-6
0.01	0.534375	3	300	2.636887	0.202654	63.73772	24.67056	4.734375	4-6
0.015	0.534375	3	300	2.30245	0.23209	63.52691	21.5441	4.215703	4-6
0.02	0.534375	3	300	2.092742	0.255347	63.38685	19.58046	3.88125	<4
0.03	0.534375	3	300	1.83063	0.291908	63.20537	17.1283	3.452344	<4
0.04	0.534375	3	300	1.665821	0.320788	63.08647	15.58622	3.176016	<4
0.05	0.534375	3	300	1.548737	0.345039	63.00013	14.49134	2.976387	<4
0.075	0.534375	3	300	1.357681	0.393594	62.85392	12.70355	2.644365	<4
0.1	0.534375	3	300	1.237254	0.431904	62.75871	11.57666	2.430868	<4
0.005	0.178125	4	300	1.643995	0.108349	74.30803	46.14649	3.030352	<4
0.01	0.178125	4	300	1.308347	0.136145	74.05679	36.72546	2.481401	<4
0.015	0.178125	4	300	1.146226	0.155401	73.92723	32.17475	2.205938	<4
0.02	0.178125	4	300	1.044172	0.17059	73.84178	29.30728	2.02875	<4
0.03	0.178125	4	300	0.916047	0.19445	73.7338	25.7164	1.801875	<4
0.04	0.178125	4	300	0.835357	0.213232	73.66132	23.44814	1.656328	<4
0.05	0.178125	4	300	0.777876	0.228989	73.60907	21.83384	1.551328	<4
0.075	0.178125	4	300	0.683645	0.260552	73.5236	19.19248	1.376719	<4
0.1	0.178125	4	300	0.624201	0.285365	73.46523	17.51974	1.264922	<4
0.005	0.35625	4	300	2.619025	0.136024	68.45052	36.75527	4.491563	4-6
0.01	0.35625	4	300	2.071807	0.171951	68.06035	29.07744	3.693516	<4
0.015	0.35625	4	300	1.808987	0.196933	67.85596	25.38858	3.290625	<4
0.02	0.35625	4	300	1.643995	0.216698	67.72148	23.07325	3.030352	<4
0.03	0.35625	4	300	1.437897	0.247758	67.54606	20.18137	2.696543	<4
0.04	0.35625	4	300	1.308347	0.27229	67.43068	18.36273	2.481401	<4
0.05	0.35625	4	300	1.216341	0.292887	67.34647	17.07141	2.325952	<4
0.075	0.35625	4	300	1.066163	0.334142	67.20439	14.96349	2.067188	<4
0.1	0.35625	4	300	0.971486	0.366706	67.11215	13.63518	1.900664	<4
0.005	0.534375	4	300	3.458477	0.154512	64.79607	32.35952	5.626875	4-6
0.01	0.534375	4	300	2.726166	0.196017	64.309	25.50715	4.642031	4-6

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.015	0.534375	4	300	2.375213	0.22498	64.0527	22.22508	4.142344	4-6
0.02	0.534375	4	300	2.155444	0.247919	63.88231	20.16834	3.818906	<4
0.03	0.534375	4	300	1.881467	0.28402	63.65864	17.6043	3.403125	<4
0.04	0.534375	4	300	1.709585	0.312576	63.51086	15.99513	3.134531	<4
0.05	0.534375	4	300	1.5876	0.336593	63.4035	14.85472	2.94	<4
0.075	0.534375	4	300	1.38894	0.384736	63.22091	12.99617	2.615742	<4
0.1	0.534375	4	300	1.264022	0.422758	63.10104	11.82711	2.406796	<4
0.005	0.178125	5	300	1.683283	0.10582	74.62157	47.25151	2.993672	<4
0.01	0.178125	5	300	1.335718	0.133355	74.32657	37.49401	2.456968	<4
0.015	0.178125	5	300	1.168279	0.152468	74.1734	32.79415	2.186719	<4
0.02	0.178125	5	300	1.063003	0.167568	74.07276	29.83885	2.012461	<4
0.03	0.178125	5	300	0.931215	0.191282	73.94263	26.14202	1.789219	<4
0.04	0.178125	5	300	0.848365	0.209963	73.85525	23.81095	1.645781	<4
0.05	0.178125	5	300	0.789285	0.225679	73.79411	22.15613	1.541953	<4
0.075	0.178125	5	300	0.692784	0.257115	73.69005	19.44935	1.369453	<4
0.1	0.178125	5	300	0.631985	0.28185	73.61985	17.73846	1.258828	<4
0.005	0.35625	5	300	2.699399	0.131974	68.92079	37.85712	4.41375	4-6
0.01	0.35625	5	300	2.127861	0.167422	68.47853	29.86386	3.639258	<4
0.015	0.35625	5	300	1.854547	0.192095	68.24201	26.02912	3.247383	<4
0.02	0.35625	5	300	1.683283	0.21164	68.08516	23.62575	2.993672	<4
0.03	0.35625	5	300	1.469773	0.242384	67.87872	20.6283	2.667656	<4
0.04	0.35625	5	300	1.335718	0.266711	67.74296	18.747	2.456968	<4
0.05	0.35625	5	300	1.240661	0.287145	67.64324	17.41271	2.304551	<4
0.075	0.35625	5	300	1.085691	0.328132	67.47495	15.23844	2.050313	<4
0.1	0.35625	5	300	0.988278	0.360475	67.36357	13.8699	1.886602	<4
0.005	0.534375	5	300	3.575383	0.14946	65.38126	33.45318	5.505	4-6
0.01	0.534375	5	300	2.809821	0.190181	64.83001	26.29148	4.557188	4-6
0.015	0.534375	5	300	2.443829	0.218663	64.53592	22.86726	4.074375	4-6
0.02	0.534375	5	300	2.214953	0.241258	64.33922	20.72443	3.761016	<4
0.03	0.534375	5	300	1.929893	0.276894	64.0804	18.0576	3.356953	<4
0.04	0.534375	5	300	1.751331	0.305125	63.90858	16.38656	3.095273	<4
0.05	0.534375	5	300	1.624841	0.328878	63.78235	15.20331	2.905547	<4
0.075	0.534375	5	300	1.419081	0.376564	63.5674	13.27818	2.588555	<4
0.1	0.534375	5	300	1.289913	0.414272	63.4257	12.06935	2.383846	<4
0.005	0.178125	6	300	1.72077	0.103515	74.91466	48.30359	2.958633	<4
0.01	0.178125	6	300	1.36201	0.130781	74.5816	38.23194	2.433362	<4
0.015	0.178125	6	300	1.189639	0.14973	74.4065	33.39024	2.168203	<4

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.02	0.178125	6	300	1.081271	0.164737	74.29248	30.35217	1.996699	<4
0.03	0.178125	6	300	0.945978	0.188297	74.14238	26.55479	1.776914	<4
0.04	0.178125	6	300	0.860899	0.206906	74.04368	24.16613	1.635234	<4
0.05	0.178125	6	300	0.800504	0.222516	73.97097	22.46908	1.53293	<4
0.075	0.178125	6	300	0.701919	0.253769	73.8476	19.69779	1.362656	<4
0.1	0.178125	6	300	0.639559	0.278512	73.77106	17.95389	1.252734	<4
0.005	0.35625	6	300	2.771998	0.128517	69.36448	38.90631	4.337578	4-6
0.01	0.35625	6	300	2.180764	0.16336	68.86701	30.60733	3.587813	<4
0.015	0.35625	6	300	1.897866	0.187711	68.60218	26.63694	3.20625	<4
0.02	0.35625	6	300	1.72077	0.207029	68.42591	24.1518	2.958633	<4
0.03	0.35625	6	300	1.500281	0.237456	68.19271	21.05616	2.639824	<4
0.04	0.35625	6	300	1.36201	0.261562	68.03875	19.11597	2.433362	<4
0.05	0.35625	6	300	1.26407	0.281828	67.92525	17.74126	2.283809	<4
0.075	0.35625	6	300	1.104646	0.322501	67.73232	15.50365	2.034023	<4
0.1	0.35625	6	300	1.004491	0.354657	67.60544	14.09792	1.872773	<4
0.005	0.534375	6	300	3.683828	0.14506	65.9117	34.46743	5.393203	4-6
0.01	0.534375	6	300	2.888301	0.185014	65.30691	27.0242	4.478438	4-6
0.015	0.534375	6	300	2.508416	0.213033	64.98182	23.47069	4.010625	4-6
0.02	0.534375	6	300	2.271073	0.235296	64.7634	21.24923	3.706289	<4
0.03	0.534375	6	300	1.975796	0.270461	64.47436	18.48747	3.313008	<4
0.04	0.534375	6	300	1.791062	0.298357	64.2815	16.75893	3.057773	<4
0.05	0.534375	6	300	1.660406	0.321834	64.13853	15.53569	2.872559	<4
0.075	0.534375	6	300	1.447988	0.369047	63.8951	13.54836	2.562363	<4
0.1	0.534375	6	300	1.314805	0.406429	63.7341	12.30224	2.361636	<4
0.005	0.178125	3	500	1.602863	0.111129	78.21908	74.99018	3.069023	<4
0.01	0.178125	3	500	1.280009	0.139159	78.04248	59.88327	2.507051	<4
0.015	0.178125	3	500	1.1235	0.158545	77.95233	52.56105	2.226035	<4
0.02	0.178125	3	500	1.024693	0.173833	77.89381	47.93908	2.045508	<4
0.03	0.178125	3	500	0.90063	0.197778	77.81779	42.13252	1.815234	<4
0.04	0.178125	3	500	0.822117	0.216666	77.7694	38.46274	1.667344	<4
0.05	0.178125	3	500	0.766191	0.232481	77.73356	35.8448	1.560938	<4
0.075	0.178125	3	500	0.674472	0.264095	77.67329	31.55038	1.384453	<4
0.1	0.178125	3	500	0.616325	0.289012	77.63494	28.8305	1.27125	<4
0.005	0.35625	3	500	2.534603	0.140555	72.85794	59.29103	4.577578	4-6
0.01	0.35625	3	500	2.012727	0.176999	72.56815	47.08047	3.751641	<4
0.015	0.35625	3	500	1.761118	0.202286	72.41871	41.19645	3.336445	<4
0.02	0.35625	3	500	1.602863	0.222259	72.32078	37.49509	3.069023	<4

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.03	0.35625	3	500	1.404809	0.253593	72.19332	32.86153	2.727012	<4
0.04	0.35625	3	500	1.280009	0.278318	72.11013	29.94163	2.507051	<4
0.05	0.35625	3	500	1.19123	0.299061	72.04973	27.86509	2.348372	<4
0.075	0.35625	3	500	1.046032	0.340573	71.9483	24.4689	2.084707	<4
0.1	0.35625	3	500	0.954277	0.373319	71.88317	22.32449	1.915313	<4
0.005	0.534375	3	500	3.332509	0.160352	69.41889	51.96743	5.761875	4-6
0.01	0.534375	3	500	2.636887	0.202654	69.04504	41.11761	4.734375	4-6
0.015	0.534375	3	500	2.30245	0.23209	68.8512	35.90684	4.215703	4-6
0.02	0.534375	3	500	2.092742	0.255347	68.7223	32.6341	3.88125	<4
0.03	0.534375	3	500	1.83063	0.291908	68.55514	28.54717	3.452344	<4
0.04	0.534375	3	500	1.665821	0.320788	68.44554	25.97703	3.176016	<4
0.05	0.534375	3	500	1.548737	0.345039	68.36592	24.15223	2.976387	<4
0.075	0.534375	3	500	1.357681	0.393594	68.23101	21.17258	2.644365	<4
0.1	0.534375	3	500	1.237254	0.431904	68.1431	19.29444	2.430868	<4
0.005	0.178125	4	500	1.643995	0.108349	78.51182	76.91082	3.030352	<4
0.01	0.178125	4	500	1.308347	0.136145	78.29242	61.2091	2.481401	<4
0.015	0.178125	4	500	1.146226	0.155401	78.17918	53.62458	2.205938	<4
0.02	0.178125	4	500	1.044172	0.17059	78.10445	48.84547	2.02875	<4
0.03	0.178125	4	500	0.916047	0.19445	78.00998	42.86067	1.801875	<4
0.04	0.178125	4	500	0.835357	0.213232	77.94654	39.08023	1.656328	<4
0.05	0.178125	4	500	0.777876	0.228989	77.90079	36.38973	1.551328	<4
0.075	0.178125	4	500	0.683645	0.260552	77.82593	31.98747	1.376719	<4
0.1	0.178125	4	500	0.624201	0.285365	77.7748	29.19957	1.264922	<4
0.005	0.35625	4	500	2.619025	0.136024	73.32645	61.25878	4.491563	4-6
0.01	0.35625	4	500	2.071807	0.171951	72.97575	48.4624	3.693516	<4
0.015	0.35625	4	500	1.808987	0.196933	72.79177	42.3143	3.290625	<4
0.02	0.35625	4	500	1.643995	0.216698	72.67062	38.45541	3.030352	<4
0.03	0.35625	4	500	1.437897	0.247758	72.51246	33.63561	2.696543	<4
0.04	0.35625	4	500	1.308347	0.27229	72.40836	30.60455	2.481401	<4
0.05	0.35625	4	500	1.216341	0.292887	72.33235	28.45235	2.325952	<4
0.075	0.35625	4	500	1.066163	0.334142	72.20402	24.93915	2.067188	<4
0.1	0.35625	4	500	0.971486	0.366706	72.12067	22.7253	1.900664	<4
0.005	0.534375	4	500	3.458477	0.154512	70.01519	53.93253	5.626875	4-6
0.01	0.534375	4	500	2.726166	0.196017	69.56935	42.51192	4.642031	4-6
0.015	0.534375	4	500	2.375213	0.22498	69.33431	37.0418	4.142344	4-6
0.02	0.534375	4	500	2.155444	0.247919	69.17789	33.61389	3.818906	<4
0.03	0.534375	4	500	1.881467	0.28402	68.97235	29.34051	3.403125	<4

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.04	0.534375	4	500	1.709585	0.312576	68.83643	26.65855	3.134531	<4
0.05	0.534375	4	500	1.5876	0.336593	68.73762	24.75787	2.94	<4
0.075	0.534375	4	500	1.38894	0.384736	68.56946	21.66029	2.615742	<4
0.1	0.534375	4	500	1.264022	0.422758	68.45898	19.71184	2.406796	<4
0.005	0.178125	5	500	1.683283	0.10582	78.78524	78.75251	2.993672	<4
0.01	0.178125	5	500	1.335718	0.133355	78.528	62.49001	2.456968	<4
0.015	0.178125	5	500	1.168279	0.152468	78.39429	54.65692	2.186719	<4
0.02	0.178125	5	500	1.063003	0.167568	78.30638	49.73141	2.012461	<4
0.03	0.178125	5	500	0.931215	0.191282	78.19265	43.57003	1.789219	<4
0.04	0.178125	5	500	0.848365	0.209963	78.11623	39.68491	1.645781	<4
0.05	0.178125	5	500	0.789285	0.225679	78.06276	36.92688	1.541953	<4
0.075	0.178125	5	500	0.692784	0.257115	77.97169	32.41559	1.369453	<4
0.1	0.178125	5	500	0.631985	0.28185	77.91024	29.5641	1.258828	<4
0.005	0.35625	5	500	2.699399	0.131974	73.74825	63.0952	4.41375	4-6
0.01	0.35625	5	500	2.127861	0.167422	73.3516	49.77311	3.639258	<4
0.015	0.35625	5	500	1.854547	0.192095	73.13911	43.38187	3.247383	<4
0.02	0.35625	5	500	1.683283	0.21164	72.99807	39.37626	2.993672	<4
0.03	0.35625	5	500	1.469773	0.242384	72.81227	34.3805	2.667656	<4
0.04	0.35625	5	500	1.335718	0.266711	72.68998	31.245	2.456968	<4
0.05	0.35625	5	500	1.240661	0.287145	72.60009	29.02118	2.304551	<4
0.075	0.35625	5	500	1.085691	0.328132	72.44831	25.39741	2.050313	<4
0.1	0.35625	5	500	0.988278	0.360475	72.34778	23.1165	1.886602	<4
0.005	0.534375	5	500	3.575383	0.14946	70.54945	55.75531	5.505	4-6
0.01	0.534375	5	500	2.809821	0.190181	70.04622	43.81914	4.557188	4-6
0.015	0.534375	5	500	2.443829	0.218663	69.7772	38.11211	4.074375	4-6
0.02	0.534375	5	500	2.214953	0.241258	69.59704	34.54071	3.761016	<4
0.03	0.534375	5	500	1.929893	0.276894	69.35973	30.096	3.356953	<4
0.04	0.534375	5	500	1.751331	0.305125	69.20201	27.31093	3.095273	<4
0.05	0.534375	5	500	1.624841	0.328878	69.08607	25.33886	2.905547	<4
0.075	0.534375	5	500	1.419081	0.376564	68.88845	22.1303	2.588555	<4
0.1	0.534375	5	500	1.289913	0.414272	68.75806	20.11558	2.383846	<4
0.005	0.178125	6	500	1.72077	0.103515	79.04046	80.50599	2.958633	<4
0.01	0.178125	6	500	1.36201	0.130781	78.75041	63.7199	2.433362	<4
0.015	0.178125	6	500	1.189639	0.14973	78.59774	55.6504	2.168203	<4
0.02	0.178125	6	500	1.081271	0.164737	78.49825	50.58695	1.996699	<4
0.03	0.178125	6	500	0.945978	0.188297	78.36719	44.25799	1.776914	<4
0.04	0.178125	6	500	0.860899	0.206906	78.28097	40.27689	1.635234	<4

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.05	0.178125	6	500	0.800504	0.222516	78.21742	37.44846	1.53293	<4
0.075	0.178125	6	500	0.701919	0.253769	78.10954	32.82965	1.362656	<4
0.1	0.178125	6	500	0.639559	0.278512	78.04259	29.92314	1.252734	<4
0.005	0.35625	6	500	2.771998	0.128517	74.14532	64.84385	4.337578	4-6
0.01	0.35625	6	500	2.180764	0.16336	73.70006	51.01222	3.587813	<4
0.015	0.35625	6	500	1.897866	0.187711	73.46258	44.3949	3.20625	<4
0.02	0.35625	6	500	1.72077	0.207029	73.30434	40.25299	2.958633	<4
0.03	0.35625	6	500	1.500281	0.237456	73.09479	35.09361	2.639824	<4
0.04	0.35625	6	500	1.36201	0.261562	72.95632	31.85995	2.433362	<4
0.05	0.35625	6	500	1.26407	0.281828	72.85416	29.56876	2.283809	<4
0.075	0.35625	6	500	1.104646	0.322501	72.68038	25.83942	2.034023	<4
0.1	0.35625	6	500	1.004491	0.354657	72.56601	23.49654	1.872773	<4
0.005	0.534375	6	500	3.683828	0.14506	71.03238	57.44572	5.393203	4-6
0.01	0.534375	6	500	2.888301	0.185014	70.48165	45.04034	4.478438	4-6
0.015	0.534375	6	500	2.508416	0.213033	70.18494	39.11782	4.010625	4-6
0.02	0.534375	6	500	2.271073	0.235296	69.98532	35.41539	3.706289	<4
0.03	0.534375	6	500	1.975796	0.270461	69.72084	30.81244	3.313008	<4
0.04	0.534375	6	500	1.791062	0.298357	69.54414	27.93154	3.057773	<4
0.05	0.534375	6	500	1.660406	0.321834	69.41306	25.89282	2.872559	<4
0.075	0.534375	6	500	1.447988	0.369047	69.18964	22.5806	2.562363	<4
0.1	0.534375	6	500	1.314805	0.406429	69.04172	20.50373	2.361636	<4
0.005	0.178125	3	1000	1.602863	0.111129	83.06864	149.9804	3.069023	<4
0.01	0.178125	3	1000	1.280009	0.139159	82.92605	119.7665	2.507051	<4
0.015	0.178125	3	1000	1.1235	0.158545	82.8532	105.1221	2.226035	<4
0.02	0.178125	3	1000	1.024693	0.173833	82.80588	95.87817	2.045508	<4
0.03	0.178125	3	1000	0.90063	0.197778	82.74439	84.26504	1.815234	<4
0.04	0.178125	3	1000	0.822117	0.216666	82.70524	76.92548	1.667344	<4
0.05	0.178125	3	1000	0.766191	0.232481	82.67623	71.6896	1.560938	<4
0.075	0.178125	3	1000	0.674472	0.264095	82.62744	63.10076	1.384453	<4
0.1	0.178125	3	1000	0.616325	0.289012	82.59638	57.661	1.27125	<4
0.005	0.35625	3	1000	2.534603	0.140555	78.6683	118.5821	4.577578	4-6
0.01	0.35625	3	1000	2.012727	0.176999	78.42614	94.16094	3.751641	<4
0.015	0.35625	3	1000	1.761118	0.202286	78.30108	82.39289	3.336445	<4
0.02	0.35625	3	1000	1.602863	0.222259	78.21908	74.99018	3.069023	<4
0.03	0.35625	3	1000	1.404809	0.253593	78.11225	65.72306	2.727012	<4
0.04	0.35625	3	1000	1.280009	0.278318	78.04248	59.88327	2.507051	<4
0.05	0.35625	3	1000	1.19123	0.299061	77.9918	55.73018	2.348372	<4

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.075	0.35625	3	1000	1.046032	0.340573	77.90665	48.9378	2.084707	<4
0.1	0.35625	3	1000	0.954277	0.373319	77.85194	44.64898	1.915313	<4
0.005	0.534375	3	1000	3.332509	0.160352	75.76506	103.9349	5.761875	4-6
0.01	0.534375	3	1000	2.636887	0.202654	75.44554	82.23521	4.734375	4-6
0.015	0.534375	3	1000	2.30245	0.23209	75.27956	71.81368	4.215703	4-6
0.02	0.534375	3	1000	2.092742	0.255347	75.16907	65.26821	3.88125	<4
0.03	0.534375	3	1000	1.83063	0.291908	75.02565	57.09434	3.452344	<4
0.04	0.534375	3	1000	1.665821	0.320788	74.93153	51.95407	3.176016	<4
0.05	0.534375	3	1000	1.548737	0.345039	74.86311	48.30446	2.976387	<4
0.075	0.534375	3	1000	1.357681	0.393594	74.7471	42.34517	2.644365	<4
0.1	0.534375	3	1000	1.237254	0.431904	74.67145	38.58888	2.430868	<4
0.005	0.178125	4	1000	1.643995	0.108349	83.30467	153.8216	3.030352	<4
0.01	0.178125	4	1000	1.308347	0.136145	83.12782	122.4182	2.481401	<4
0.015	0.178125	4	1000	1.146226	0.155401	83.03644	107.2492	2.205938	<4
0.02	0.178125	4	1000	1.044172	0.17059	82.9761	97.69095	2.02875	<4
0.03	0.178125	4	1000	0.916047	0.19445	82.89979	85.72135	1.801875	<4
0.04	0.178125	4	1000	0.835357	0.213232	82.84851	78.16045	1.656328	<4
0.05	0.178125	4	1000	0.777876	0.228989	82.81153	72.77946	1.551328	<4
0.075	0.178125	4	1000	0.683645	0.260552	82.75098	63.97494	1.376719	<4
0.1	0.178125	4	1000	0.624201	0.285365	82.70961	58.39914	1.264922	<4
0.005	0.35625	4	1000	2.619025	0.136024	79.05886	122.5176	4.491563	4-6
0.01	0.35625	4	1000	2.071807	0.171951	78.76662	96.9248	3.693516	<4
0.015	0.35625	4	1000	1.808987	0.196933	78.61305	84.62859	3.290625	<4
0.02	0.35625	4	1000	1.643995	0.216698	78.51182	76.91082	3.030352	<4
0.03	0.35625	4	1000	1.437897	0.247758	78.37956	67.27123	2.696543	<4
0.04	0.35625	4	1000	1.308347	0.27229	78.29242	61.2091	2.481401	<4
0.05	0.35625	4	1000	1.216341	0.292887	78.22877	56.90469	2.325952	<4
0.075	0.35625	4	1000	1.066163	0.334142	78.12122	49.8783	2.067188	<4
0.1	0.35625	4	1000	0.971486	0.366706	78.05132	45.45059	1.900664	<4
0.005	0.534375	4	1000	3.458477	0.154512	76.2731	107.8651	5.626875	4-6
0.01	0.534375	4	1000	2.726166	0.196017	75.89343	85.02383	4.642031	4-6
0.015	0.534375	4	1000	2.375213	0.22498	75.69284	74.08359	4.142344	4-6
0.02	0.534375	4	1000	2.155444	0.247919	75.55916	67.22778	3.818906	<4
0.03	0.534375	4	1000	1.881467	0.28402	75.38332	58.68101	3.403125	<4
0.04	0.534375	4	1000	1.709585	0.312576	75.2669	53.3171	3.134531	<4
0.05	0.534375	4	1000	1.5876	0.336593	75.18221	49.51573	2.94	<4
0.075	0.534375	4	1000	1.38894	0.384736	75.03794	43.32058	2.615742	<4

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.1	0.534375	4	1000	1.264022	0.422758	74.94307	39.42369	2.406796	<4
0.005	0.178125	5	1000	1.683283	0.10582	83.52474	157.505	2.993672	<4
0.01	0.178125	5	1000	1.335718	0.133355	83.31771	124.98	2.456968	<4
0.015	0.178125	5	1000	1.168279	0.152468	83.20996	109.3138	2.186719	<4
0.02	0.178125	5	1000	1.063003	0.167568	83.13907	99.46282	2.012461	<4
0.03	0.178125	5	1000	0.931215	0.191282	83.04731	87.14007	1.789219	<4
0.04	0.178125	5	1000	0.848365	0.209963	82.98562	79.36982	1.645781	<4
0.05	0.178125	5	1000	0.789285	0.225679	82.94243	73.85376	1.541953	<4
0.075	0.178125	5	1000	0.692784	0.257115	82.86885	64.83117	1.369453	<4
0.1	0.178125	5	1000	0.631985	0.28185	82.81916	59.1282	1.258828	<4
0.005	0.35625	5	1000	2.699399	0.131974	79.40948	126.1904	4.41375	4-6
0.01	0.35625	5	1000	2.127861	0.167422	79.07979	99.54621	3.639258	<4
0.015	0.35625	5	1000	1.854547	0.192095	78.90284	86.76373	3.247383	<4
0.02	0.35625	5	1000	1.683283	0.21164	78.78524	78.75251	2.993672	<4
0.03	0.35625	5	1000	1.469773	0.242384	78.63017	68.76099	2.667656	<4
0.04	0.35625	5	1000	1.335718	0.266711	78.528	62.49001	2.456968	<4
0.05	0.35625	5	1000	1.240661	0.287145	78.45286	58.04235	2.304551	<4
0.075	0.35625	5	1000	1.085691	0.328132	78.32587	50.79481	2.050313	<4
0.1	0.35625	5	1000	0.988278	0.360475	78.24169	46.23301	1.886602	<4
0.005	0.534375	5	1000	3.575383	0.14946	76.72661	111.5106	5.505	4-6
0.01	0.534375	5	1000	2.809821	0.190181	76.29948	87.63828	4.557188	4-6
0.015	0.534375	5	1000	2.443829	0.218663	76.07056	76.22421	4.074375	4-6
0.02	0.534375	5	1000	2.214953	0.241258	75.91705	69.08142	3.761016	<4
0.03	0.534375	5	1000	1.929893	0.276894	75.71454	60.192	3.356953	<4
0.04	0.534375	5	1000	1.751331	0.305125	75.57979	54.62187	3.095273	<4
0.05	0.534375	5	1000	1.624841	0.328878	75.48064	50.67771	2.905547	<4
0.075	0.534375	5	1000	1.419081	0.376564	75.31147	44.2606	2.588555	<4
0.1	0.534375	5	1000	1.289913	0.414272	75.19973	40.23116	2.383846	<4
0.005	0.178125	6	1000	1.72077	0.103515	83.72982	161.012	2.958633	<4
0.01	0.178125	6	1000	1.36201	0.130781	83.49673	127.4398	2.433362	<4
0.015	0.178125	6	1000	1.189639	0.14973	83.37386	111.3008	2.168203	<4
0.02	0.178125	6	1000	1.081271	0.164737	83.29374	101.1739	1.996699	<4
0.03	0.178125	6	1000	0.945978	0.188297	83.18812	88.51597	1.776914	<4
0.04	0.178125	6	1000	0.860899	0.206906	83.11858	80.55378	1.635234	<4
0.05	0.178125	6	1000	0.800504	0.222516	83.06731	74.89692	1.53293	<4
0.075	0.178125	6	1000	0.701919	0.253769	82.98022	65.65929	1.362656	<4
0.1	0.178125	6	1000	0.639559	0.278512	82.92613	59.84628	1.252734	<4

Longitudinal Slope (%)	Flow Rate (cfs)	Side Slope (z:1)	Swale Length (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Removal (%)	Hydraulic Retention Time (min)	Flow Depth (in)	Flow Depth Category (in)
0.005	0.35625	6	1000	2.771998	0.128517	79.73868	129.6877	4.337578	4-6
0.01	0.35625	6	1000	2.180764	0.16336	79.36947	102.0244	3.587813	<4
0.015	0.35625	6	1000	1.897866	0.187711	79.17212	88.7898	3.20625	<4
0.02	0.35625	6	1000	1.72077	0.207029	79.04046	80.50599	2.958633	<4
0.03	0.35625	6	1000	1.500281	0.237456	78.8659	70.18721	2.639824	<4
0.04	0.35625	6	1000	1.36201	0.261562	78.75041	63.7199	2.433362	<4
0.05	0.35625	6	1000	1.26407	0.281828	78.66515	59.13752	2.283809	<4
0.075	0.35625	6	1000	1.104646	0.322501	78.51998	51.67884	2.034023	<4
0.1	0.35625	6	1000	1.004491	0.354657	78.42435	46.99307	1.872773	<4
0.005	0.534375	6	1000	3.683828	0.14506	77.1352	114.8914	5.393203	4-6
0.01	0.534375	6	1000	2.888301	0.185014	76.66915	90.08068	4.478438	4-6
0.015	0.534375	6	1000	2.508416	0.213033	76.41736	78.23563	4.010625	4-6
0.02	0.534375	6	1000	2.271073	0.235296	76.2477	70.83077	3.706289	<4
0.03	0.534375	6	1000	1.975796	0.270461	76.02256	61.62489	3.313008	<4
0.04	0.534375	6	1000	1.791062	0.298357	75.87193	55.86309	3.057773	<4
0.05	0.534375	6	1000	1.660406	0.321834	75.76008	51.78563	2.872559	<4
0.075	0.534375	6	1000	1.447988	0.369047	75.56921	45.16121	2.562363	<4
0.1	0.534375	6	1000	1.314805	0.406429	75.4427	41.00747	2.361636	<4

Table G.3. SwaleMOD modeling runs for vegetated filter strips. (assumed Manning's n=0.35, bottom width = 100 ft)

Longitudinal Slope (%)	Flow Rate (cfs)	Width (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Reduction (%)	Hydraulic Retention Time (min)	Depth (inches)	Flow Depth Category (in)
0.005	0.178125	16.404	2.28401	0.077988	72.97142	21.38106	1.630313	<4
0.01	0.178125	16.404	1.848739	0.096349	72.9262	17.2991	1.325625	<4
0.015	0.178125	16.404	1.633882	0.10902	72.90609	15.28952	1.174219	<4
0.02	0.178125	16.404	1.497351	0.11896	72.88922	14.00626	1.077656	<4
0.03	0.178125	16.404	1.323606	0.134576	72.87483	12.38442	0.954375	<4
0.04	0.178125	16.404	1.215584	0.146534	72.83187	11.33342	0.8775	<4
0.05	0.178125	16.404	1.133416	0.157158	72.85903	10.60814	0.818906	<4
0.075	0.178125	16.404	1.002899	0.17761	72.83907	9.379254	0.725625	<4
0.1	0.178125	16.404	0.91914	0.193795	72.83313	8.598118	0.665625	<4
0.005	0.35625	16.404	3.49799	0.101844	66.3046	16.36483	2.466189	<4
0.01	0.35625	16.404	2.825634	0.126078	66.23367	13.2191	2.005723	<4
0.015	0.35625	16.404	2.49499	0.142786	66.19898	11.67299	1.777031	<4
0.02	0.35625	16.404	2.28401	0.155976	66.18074	10.69053	1.630313	<4
0.03	0.35625	16.404	2.01837	0.176504	66.14717	9.442924	1.444688	<4
0.04	0.35625	16.404	1.848739	0.192699	66.12888	8.649548	1.325625	<4
0.05	0.35625	16.404	1.727557	0.206216	66.11207	8.079884	1.240313	<4
0.075	0.35625	16.404	1.52648	0.23338	66.09584	7.143541	1.098281	<4
0.1	0.35625	16.404	1.39884	0.254675	66.07977	6.545039	1.007813	<4
0.005	0.534375	16.404	4.49732	0.118821	62.05543	14.02498	3.139688	<4
0.01	0.534375	16.404	3.627578	0.147309	61.96253	11.31416	2.554248	<4
0.015	0.534375	16.404	3.200994	0.16694	61.91528	9.983619	2.263535	<4
0.02	0.534375	16.404	2.929774	0.182395	61.88487	9.137643	2.077441	<4
0.03	0.534375	16.404	2.586772	0.20658	61.84638	8.068022	1.840664	<4
0.04	0.534375	16.404	2.368497	0.225618	61.82166	7.387328	1.689141	<4
0.05	0.534375	16.404	2.212092	0.24157	61.80453	6.899996	1.580156	<4
0.075	0.534375	16.404	1.954856	0.273358	61.77072	6.095335	1.400156	<4
0.1	0.534375	16.404	1.790441	0.29846	61.75396	5.583858	1.284609	<4
0.005	0.178125	24.606	2.661074	0.066937	76.38823	24.90233	1.281094	<4
0.01	0.178125	24.606	2.156362	0.082604	76.37315	20.19111	1.040625	<4
0.015	0.178125	24.606	1.907357	0.093388	76.36415	17.86149	0.921563	<4
0.02	0.178125	24.606	1.749829	0.101796	76.3477	16.36616	0.846094	<4
0.03	0.178125	24.606	1.547642	0.115094	76.34414	14.48303	0.749063	<4
0.04	0.178125	24.606	1.418916	0.125536	76.33916	13.27868	0.687188	<4
0.05	0.178125	24.606	1.326371	0.134295	76.3372	12.41524	0.642656	<4
0.075	0.178125	24.606	1.173609	0.151775	76.33244	10.98719	0.569063	<4
0.1	0.178125	24.606	1.078369	0.16518	76.3002	10.06097	0.523125	<4

Longitudinal Slope (%)	Flow Rate (cfs)	Width (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Reduction (%)	Hydraulic Retention Time (min)	Depth (inches)	Flow Depth Category (in)
0.005	0.35625	24.606	4.055712	0.087839	70.21371	18.97499	1.939688	<4
0.01	0.35625	24.606	3.284689	0.108458	70.17712	15.36545	1.576641	<4
0.015	0.35625	24.606	2.904943	0.122636	70.1552	13.58283	1.396875	<4
0.02	0.35625	24.606	2.661074	0.133874	70.15065	12.45117	1.281094	<4
0.03	0.35625	24.606	2.353828	0.151349	70.13356	11.01037	1.134844	<4
0.04	0.35625	24.606	2.156362	0.165209	70.1329	10.09555	1.040625	<4
0.05	0.35625	24.606	2.016102	0.176702	70.12232	9.434982	0.973594	<4
0.075	0.35625	24.606	1.784054	0.199686	70.10665	8.34493	0.8625	<4
0.1	0.35625	24.606	1.635501	0.217823	70.10023	7.650513	0.79125	<4
0.005	0.534375	24.606	5.195475	0.102854	66.17843	16.20416	2.471689	<4
0.01	0.534375	24.606	4.204048	0.12711	66.13071	13.11233	2.009238	<4
0.015	0.534375	24.606	3.716562	0.143782	66.10205	11.58655	1.780313	<4
0.02	0.534375	24.606	3.404287	0.156971	66.0909	10.61731	1.633125	<4
0.03	0.534375	24.606	3.009771	0.177547	66.07112	9.386647	1.446563	<4
0.04	0.534375	24.606	2.758259	0.193736	66.05804	8.601779	1.327266	<4
0.05	0.534375	24.606	2.577774	0.207301	66.04931	8.039129	1.241484	<4
0.075	0.534375	24.606	2.280103	0.234364	66.03233	7.109391	1.099688	<4
0.1	0.534375	24.606	2.089641	0.255726	66.02558	6.517285	1.00875	<4
0.005	0.178125	49.212	3.486683	0.051087	81.52232	32.61859	0.846563	<4
0.01	0.178125	49.212	2.827994	0.062986	81.52545	26.49004	0.687188	<4
0.015	0.178125	49.212	2.506783	0.071057	81.50698	23.42638	0.609375	<4
0.02	0.178125	49.212	2.297938	0.077515	81.51052	21.49144	0.55875	<4
0.03	0.178125	49.212	2.0351	0.087526	81.50333	19.01918	0.495	<4
0.04	0.178125	49.212	1.880568	0.094719	81.41739	17.35686	0.4575	<4
0.05	0.178125	49.212	1.74347	0.102167	81.5135	16.32412	0.424219	<4
0.075	0.178125	49.212	1.544664	0.115316	81.50312	14.44404	0.375938	<4
0.1	0.178125	49.212	1.417325	0.125677	81.49753	13.24444	0.345	<4
0.005	0.35625	49.212	5.293799	0.067296	76.33461	24.76842	1.2825	<4
0.01	0.35625	49.212	4.295992	0.082926	76.32308	20.09631	1.042031	<4
0.015	0.35625	49.212	3.800902	0.093728	76.32219	17.78914	0.9225	<4
0.02	0.35625	49.212	3.486683	0.102174	76.31433	16.30929	0.846563	<4
0.03	0.35625	49.212	3.085532	0.115458	76.31269	14.43709	0.749531	<4
0.04	0.35625	49.212	2.827994	0.125973	76.31817	13.24502	0.687188	<4
0.05	0.35625	49.212	2.653812	0.134241	76.26738	12.35587	0.645	<4
0.075	0.35625	49.212	2.340472	0.152213	76.31501	10.96406	0.569063	<4
0.1	0.35625	49.212	2.149104	0.165767	76.2965	10.04746	0.522656	<4
0.005	0.534375	49.212	6.761804	0.079028	72.81963	21.09171	1.635234	<4
0.01	0.534375	49.212	5.484688	0.09743	72.80688	17.11069	1.328438	<4

Longitudinal Slope (%)	Flow Rate (cfs)	Width (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Reduction (%)	Hydraulic Retention Time (min)	Depth (inches)	Flow Depth Category (in)
0.015	0.534375	49.212	4.853922	0.110091	72.79822	15.14014	1.176563	<4
0.02	0.534375	49.212	4.451437	0.120046	72.79137	13.88114	1.079531	<4
0.03	0.534375	49.212	3.938691	0.135673	72.78892	12.28661	0.955781	<4
0.04	0.534375	49.212	3.61176	0.147954	72.78548	11.26701	0.876797	<4
0.05	0.534375	49.212	3.378121	0.158187	72.77818	10.53277	0.820313	<4
0.075	0.534375	49.212	2.988694	0.178799	72.78057	9.32545	0.726094	<4
0.1	0.534375	49.212	2.740894	0.194964	72.77768	8.552149	0.666094	<4
0.005	0.178125	73.818	4.092237	0.043528	84.08028	38.30448	0.66375	<4
0.01	0.178125	73.818	3.322097	0.053618	84.07973	31.10595	0.539063	<4
0.015	0.178125	73.818	2.940163	0.060583	84.0816	27.54426	0.477188	<4
0.02	0.178125	73.818	2.700089	0.06597	84.06864	25.24316	0.438281	<4
0.03	0.178125	73.818	2.390689	0.074508	84.06686	22.34762	0.388125	<4
0.04	0.178125	73.818	2.194116	0.081183	84.06037	20.48984	0.35625	<4
0.05	0.178125	73.818	2.043824	0.087153	84.09876	19.21222	0.331875	<4
0.075	0.178125	73.818	1.812653	0.098268	84.08111	16.99053	0.294375	<4
0.1	0.178125	73.818	1.662424	0.107148	84.08201	15.58605	0.27	<4
0.005	0.35625	73.818	6.210558	0.057362	79.4824	29.05182	1.006172	<4
0.01	0.35625	73.818	5.042774	0.070646	79.47542	23.58187	0.8175	<4
0.015	0.35625	73.818	4.463061	0.079822	79.47573	20.87842	0.72375	<4
0.02	0.35625	73.818	4.092237	0.087055	79.47754	19.15224	0.66375	<4
0.03	0.35625	73.818	3.623127	0.098327	79.4744	16.95388	0.587813	<4
0.04	0.35625	73.818	3.322097	0.107236	79.47685	15.55298	0.539063	<4
0.05	0.35625	73.818	3.119536	0.1142	79.4252	14.5046	0.50625	<4
0.075	0.35625	73.818	2.749256	0.129581	79.47969	12.88012	0.44625	<4
0.1	0.35625	73.818	2.529472	0.14084	79.44078	11.78964	0.410625	<4
0.005	0.534375	73.818	7.926474	0.067416	76.31654	24.72338	1.282969	<4
0.01	0.534375	73.818	6.435581	0.083034	76.30625	20.06449	1.0425	<4
0.015	0.534375	73.818	5.692488	0.093874	76.31276	17.76887	0.9225	<4
0.02	0.534375	73.818	5.22256	0.102321	76.30566	16.29222	0.846563	<4
0.03	0.534375	73.818	4.622446	0.115604	76.305	14.42369	0.749531	<4
0.04	0.534375	73.818	4.239969	0.126033	76.30172	13.22774	0.687656	<4
0.05	0.534375	73.818	3.9648	0.13478	76.3009	12.36991	0.643125	<4
0.075	0.534375	73.818	3.513124	0.152108	76.28647	10.94433	0.57	<4
0.1	0.534375	73.818	3.220811	0.165913	76.29112	10.04094	0.522656	<4
0.005	0.178125	98.424	4.589372	0.038813	85.6926	42.93813	0.55875	<4
0.01	0.178125	98.424	3.725947	0.047807	85.69344	34.87468	0.45375	<4
0.015	0.178125	98.424	3.302112	0.053943	85.6839	30.8566	0.402188	<4
0.02	0.178125	98.424	3.024752	0.058889	85.69554	28.32877	0.368438	<4

Longitudinal Slope (%)	Flow Rate (cfs)	Width (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Reduction (%)	Hydraulic Retention Time (min)	Depth (inches)	Flow Depth Category (in)
0.03	0.178125	98.424	2.67812	0.066511	85.69483	25.08169	0.32625	<4
0.04	0.178125	98.424	2.454774	0.072563	85.70085	23.01747	0.299063	<4
0.05	0.178125	98.424	2.30076	0.07742	85.68109	21.49481	0.280313	<4
0.075	0.178125	98.424	2.03897	0.08736	85.6725	19.02008	0.248438	<4
0.1	0.178125	98.424	1.869599	0.095274	85.67554	17.45096	0.227813	<4
0.005	0.35625	98.424	6.958436	0.051197	81.51168	32.56733	0.846563	<4
0.01	0.35625	98.424	5.650008	0.063053	81.50913	26.44418	0.687656	<4
0.015	0.35625	98.424	5.001973	0.071222	81.50797	23.41179	0.608906	<4
0.02	0.35625	98.424	4.589372	0.077625	81.50347	21.46907	0.55875	<4
0.03	0.35625	98.424	4.06124	0.08772	81.50776	19.01361	0.494531	<4
0.04	0.35625	98.424	3.725947	0.095613	81.50453	17.43734	0.45375	<4
0.05	0.35625	98.424	3.487044	0.102164	81.4957	16.2992	0.424688	<4
0.075	0.35625	98.424	3.07868	0.115715	81.52649	14.45792	0.375	<4
0.1	0.35625	98.424	2.83217	0.125787	81.49317	13.2359	0.345	<4
0.005	0.534375	98.424	8.88246	0.060161	78.59191	27.69881	1.08	<4
0.01	0.534375	98.424	7.209435	0.074122	78.59195	22.49336	0.877031	<4
0.015	0.534375	98.424	6.383216	0.083716	78.58828	19.91109	0.776719	<4
0.02	0.534375	98.424	5.854501	0.091276	78.58729	18.26247	0.7125	<4
0.03	0.534375	98.424	5.190957	0.102943	78.56636	16.15168	0.631875	<4
0.04	0.534375	98.424	4.755171	0.112378	78.5815	14.82703	0.578906	<4
0.05	0.534375	98.424	4.442865	0.120277	78.59234	13.87423	0.540938	<4
0.075	0.534375	98.424	3.937906	0.1357	78.57688	12.2744	0.479531	<4
0.1	0.534375	98.424	3.618051	0.147697	78.55477	11.24599	0.440625	<4
0.005	0.178125	100	4.619666	0.038558	85.77491	43.20322	0.553594	<4
0.01	0.178125	100	3.754219	0.047447	85.76714	35.06745	0.45	<4
0.015	0.178125	100	3.32362	0.053594	85.76715	31.04932	0.398438	<4
0.02	0.178125	100	3.041833	0.058558	85.78637	28.52213	0.364688	<4
0.03	0.178125	100	2.689667	0.066226	85.79746	25.27532	0.3225	<4
0.04	0.178125	100	2.470578	0.072099	85.78475	23.1626	0.29625	<4
0.05	0.178125	100	2.314104	0.076974	85.77073	21.63951	0.2775	<4
0.075	0.178125	100	2.063776	0.08631	85.70617	19.06791	0.2475	<4
0.1	0.178125	100	1.750919	0.101732	86.38472	18.42359	0.21	<4
0.005	0.35625	100	7.002932	0.050872	81.61773	32.77202	0.838594	<4
0.01	0.35625	100	5.685446	0.06266	81.61671	26.61291	0.681094	<4
0.015	0.35625	100	5.038844	0.070701	81.60342	23.54425	0.60375	<4
0.02	0.35625	100	4.619666	0.077116	81.60756	21.60161	0.553594	<4
0.03	0.35625	100	4.08703	0.087166	81.61468	19.13427	0.489844	<4
0.04	0.35625	100	3.754219	0.094893	81.59774	17.53372	0.45	<4

Longitudinal Slope (%)	Flow Rate (cfs)	Width (ft)	Flow Area (ft^2)	Flow Velocity (ft/s)	Predicted TSS Reduction (%)	Hydraulic Retention Time (min)	Depth (inches)	Flow Depth Category (in)
0.05	0.35625	100	3.503675	0.101679	81.62036	16.4199	0.42	<4
0.075	0.35625	100	3.104448	0.114755	81.61099	14.53043	0.372188	<4
0.1	0.35625	100	2.850089	0.124996	81.60057	13.32028	0.341719	<4
0.005	0.534375	100	8.937901	0.059788	78.7135	27.87514	1.069688	<4
0.01	0.534375	100	7.257922	0.073626	78.70769	22.62974	0.869063	<4
0.015	0.534375	100	6.422483	0.083204	78.71137	20.03957	0.769219	<4
0.02	0.534375	100	5.893195	0.090677	78.7047	18.37487	0.705938	<4
0.03	0.534375	100	5.215165	0.102466	78.70845	16.27211	0.624844	<4
0.04	0.534375	100	4.788108	0.111605	78.69509	14.91533	0.57375	<4
0.05	0.534375	100	4.474741	0.11942	78.70282	13.95463	0.53625	<4
0.075	0.534375	100	3.957813	0.135018	78.71417	12.36289	0.474375	<4
0.1	0.534375	100	3.636772	0.146937	78.69072	11.32622	0.435938	<4